ELECTRONIC SERVICING

JULY 1957

50¢

Marine Direction Finders

Transistor Theory

Industrial TV

Philco TV Receivers for 1957

Voltage Amplifiers in Hi-Fi

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ELECTRONIC SERVICING

VOL. 18, NO. 7 — Member — JULY, 1957

FEATURE ARTICLES

CIRCUIT AND SERVICE FORUM

DEPARTMENTS

THIS MONTH'S FRONT COVER

The photograph illustrates one of the delicate steps in the fabrication of a modern transistor. Shown here is the process of spot welding the base tab to the transistor header.

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

by S. R. COWAN

Ad Libs

Low TV Prices and Low Morale

Dr. Allen B. Du Mont, when introducing his firm's 1958 line of TV receivers recently, reviewed the history of TV, showing how picture tube sizes became increasingly large, growing from 7" to 24" with 21" tubes becoming most popular. Now with the introduction of portable TV models, tube sizes have gone down and down. The 14" portable seems to be most popular. List price levels and profit margins—and even quality of TV sets have been squeezed in the bitterly competitive battle for mass quantity production and volume sales. According to Dr. Du Mont, at present neither manufacturers, distributors, dealers, nor servicemen are making money nor are they satisfied with their earning status.

By riding prices down and down, some of the big producers have undoubtedly forced some competitors out of business, but they themselves are not realizing the profits they had hoped to come by, as most portable TV sets are sold on an extremely narrow profit margin. In fact, some manufacturers are operating at serious losses because their portable volume has supplanted their standard size models in sales volume. One very important TV executive told me recently that "the entire TV manufacturing field seems demoralized but no one has had sense enough to pull his hand out of the fire that is burning him."

All of this "squeezing" at the manufacturing and selling levels has had its effect on all radio/TV servicemen. A man paying $179.00 for a console TV set does not consider a $30 service bill excessive after using his set one year. That same man, if he paid $79 for a portable set, would probably consider $20 too steep a bill for servicing after a year of use. The average man, for no logical reason, believes there should be a parallel relation between original cost and subsequent maintenance cost.

Actually, a serviceman might enjoy a normal profit by charging $20 to fix an older type easy-to-get-at chassis, and find himself losing money when he charges $30 to fix some of the poorly designed, hard-to-work-on, cheaply sold portables appearing on the market. Meanwhile, the public is not aware of the difficulty in servicing these hard-to-get-at receivers and "takes it out", so to speak, on the serviceman.

In contrast, for the past 10 years, automobile manufacturers have added improvements to their newer models and although they are more compact and more complex, manufacturers have raised their selling prices accordingly. Compare this practice with TV set makers who have continuously added improvements but at the same time have dropped selling prices and profit markups in a prime desire, it would seem, to outsell in volume all of their competitors. Today's automobile mechanic gets paid much more for any given repair job compared to what he got for that same job ten years ago mainly because today's cars and replacement components sell for higher prices than they did formerly. Car owners recognize this fact. A radio/TV serviceman—in absolute contrast—does not get anywhere near what he should get for repairing the present-day vintage TV set because they were priced too low to begin with; and in addition, replacement tube and parts prices have gone down steadily.

So, TV set manufacturers, why not increase the quality of your lines—up their selling prices—up your profit margins. This will benefit you, and at the same time increase the possibility of your service dealers and servicemen of being able to make profits and enjoy normal growth. It's not too late to get out of the price-dropping doldrums we've been in for too long a time. ■■

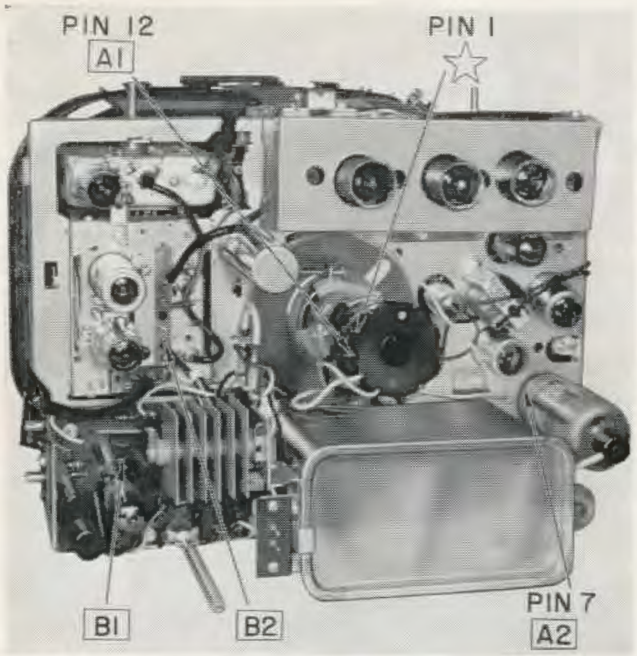


Fig. 1—Checking filament continuity is facilitated by the use of test points shown above.

1957 Philco TV Receivers

by H. S. King

Supervisor, Electronic Training Dept.
Philco Corporation

PHILCO Corporation's 1957 television line features over one hundred and twenty models including portables, table models and consoles, with three basic chassis series. All chassis are vertically mounted.

Serviceability

The following service features are true of all models.

1—The picture tube safety glass is removable from the front of the cabinet for cleaning purposes.

2—All tubes and fuses are easily accessible with the removal of the cabinet back.

3—Tuner oscillator adjustments can be accomplished from the front with removal of the channel selector knob.

4—All service controls are accessible from the front or through openings in the rear of the cabinet.

5—Most of the circuitry is contained on three of four printed-wire panels permitting the replacement of many components without removing the chassis.

6—Servicing the printed-wire panels is facilitated by the inclusion of composite views of each panel in the service manuals showing signal waveforms and voltages to be found at the various tie lugs and test points on the panels.

Portable Models—Chassis 7E10, 7E11, and 7H20

Selenium rectifiers (one in the 7E10 and 7E11, two in the 7H20) are mounted with spring clips while the wires are attached with pin connectors making replacement a simple operation. A looped flexible resistor-fuse is mounted directly over the selenium rectifier, with pin connectors.

Chassis of the 7E10 series contain three printed-wire panels. The vertical oscillator, vertical output and horizontal oscillator stages are on one panel; another panel contains the *if* stages and video detector and the third panel contains the video amplifier, audio amplifier, sound *if*, limiter and detector, audio output and sync separator stages. The third panel is mounted on the other side of the chassis in back of the *if* panel. The tubes, however, project to the rear through openings in the chassis and are therefore accessible with removal of the cabinet back.

Filament Circuit Service Procedure

The filaments of all tubes including the CRT, in portable models, are in series across the 117 volt, 60 cycle power source. In view of the problem that the series filament string can present to the service technician, in locating a burned out tube, a means has been provided to facilitate locating such defective tubes. A series of test points are provided which make possible a simple trouble-shooting procedure.

The location of these test points on the chassis is illustrated in *Fig. 1.* The main test point is indicated by the star and is pin 1 on the CRT socket. The remaining test points are along the filament string so that effectively the entire string is divided by the test points into groups of from 2 to 4 stages. In *Fig. 2* all of the stages are illustrated in block diagram form in relation to the series filament connections and the various test points.

Assume that a tube on the oscillator panel (vertical or horizontal) is burned out. To locate the particular tube, first connect an ohmmeter between chassis ground and pin 1 of the CRT socket, the star test point. This test would determine the continuity of all filaments between the CRT and ground. Receiver power, of course, should be turned off during this test. Since the defective tube is on the oscillator panel, the ohmmeter would give no reading. The next test point is B1 on the oscillator panel. At this test point the meter would still give no reading indicating that the defective tube is between that pin and the remaining tubes to ground which would include the tubes on the oscillator panel and those of the tuner. An ohmmeter check at the next test point, B2, would give a meter reading

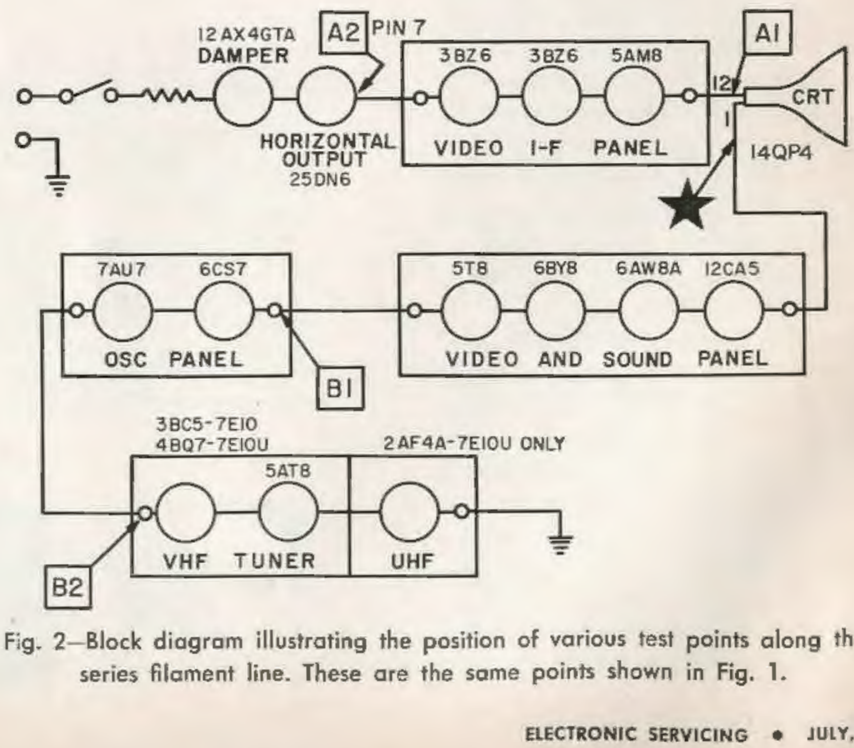


Fig. 2—Block diagram illustrating the position of various test points along the series filament line. These are the same points shown in Fig. 1.

A description of new features in the 1957 Philco line. Servicing and adjustment procedures are also treated.

indicating that one of the tubes on the oscillator panel is defective. Since only 2 tubes are on the panel it is relatively easy to check those tubes for an open filament.

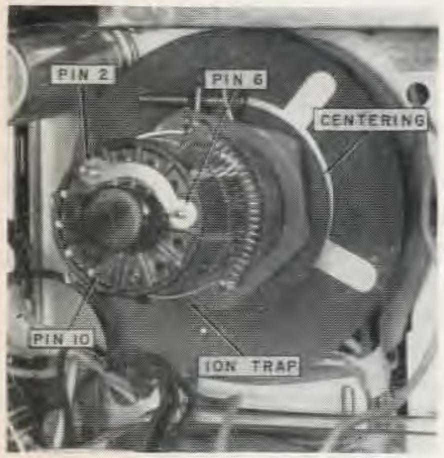


Fig. 3—Two position metal strap for focusing adjustment.

If the original meter check at the star test point (CRT pin no. 1) had shown continuity, the procedure would have been to work back through the other leg of the filament circuit, through test pins A1 and A2.

Focusing Procedure

The picture tube is an electrostatic focus type. On the base of the CRT, a metal strap connects pins 2 and 6 (*Fig. 3*). Pin 6 is the focus anode and pin 2 is the control grid which is near ground potential. Thus the focus anode is near ground potential. In some instances, better focus can be achieved with a higher voltage on the focus anode. This is accomplished by remov-

[*Continued on page* 34]

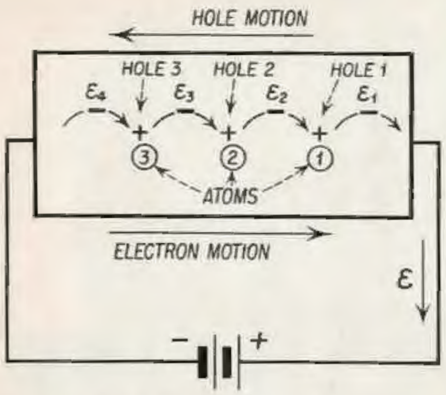


Fig. 5—Hole motion sets up an equivalent electron flow in the opposite direction.

Introduction to Transistor Theory

Part 2

by George Browne

This second installment analyzes the mechanism of the semiconductor as a rectifier.

A *"pure"* crystal of germanium is one in which no impurity atoms are present. At a temperature of absolute zero (–273°C) a pure crystal of germanium contains no free electrons or holes, and therefore is a non-conductor. At room temperature (approximately 300°C above zero) the heat imparted to the crystal liberates some electrons from their electron-pair bonds leaving holes in the vacated atoms. Thus, as an electron is freed a hole is generated, giving rise to *"electron-hole pairs."*

Intrinsic Conductivity

The number of electrons and holes freed in this manner is obviously equal. These free charges, sometimes called *"carriers,"* move about with random motions, except when subjected to an external electric field. Such a field may be set up by connecting a battery across the opposite ends of the crystal. Under these conditions the hole motion in the semiconductor is toward the negative terminal and the electron motion toward the positive terminal.

The presence of electron and hole carriers enables the semiconductor to conduct electricity. The conductivity in a pure semiconductor acquired as a result of heat energy (or any other disturbance that frees electrons and generates holes), is called *"instrinsic conductivity."* It should be emphasized at this point that the intrinsic holes and electrons present in the semiconductor are separate and distinct from the holes and electrons generated by impurity atoms.

Current Produced by Holes and Electrons

The manner in which holes and electrons produce a current flow in an external circuit of a semiconductor connected across a battery is shown in *Fig. 5*. A little reflection will reveal that hole flow is equivalent to conventional electron flow in the opposite direction. Thus, in *Fig. 5*, we start with atom No. 1 in which we assume that a hole (hole 1) has been generated by heat or some other form of energy. This hole now steals electron e_2 from atom 2 leaving hole 2 in atom 2. Now hole 2 steals an electron e_3 from atom 3 leaving hole 3 in atom 3. Notice that in this process the hole motion is from right to left, whereas the electron motion is from left to right. Thus, hole motion in one direction is equivalent to electron flow in the opposite direction.

Majority and Minority Carriers

In the previous installment it was established that N-type semiconductors are those in which the addition of impurity atoms results in the production of a small number of free or unbound electrons. Similarly, P-type semiconductors are those in which the addition of impurity atoms produces a small number of holes.

Holes and electrons in semiconductors, contributed by impurity atoms, add to the number of electrons and holes intrinsically present in the material. The total number of carriers present is the sum of the carriers contributed by both the impurity atoms and the intrinsic electron-hole pairs.

It follows then, that in a P-type semiconductor there will be many more holes than intrinsic electrons. Similarly, in an N-type semiconductor there will be many more electrons than intrinsic holes. The electrons in an N-type semiconductor and the holes in a P-type are called *"majority carriers."* On the other hand, electrons in P-type semiconductors, and holes in N-type semiconductors are called *"minority carriers."*

Thus, when donor atoms are added to a semiconductor the number of free electrons (majority carriers) increases but the number of holes (minority carriers) remains the same. On the other hand, when acceptor atoms are added to a semiconductor the number of holes

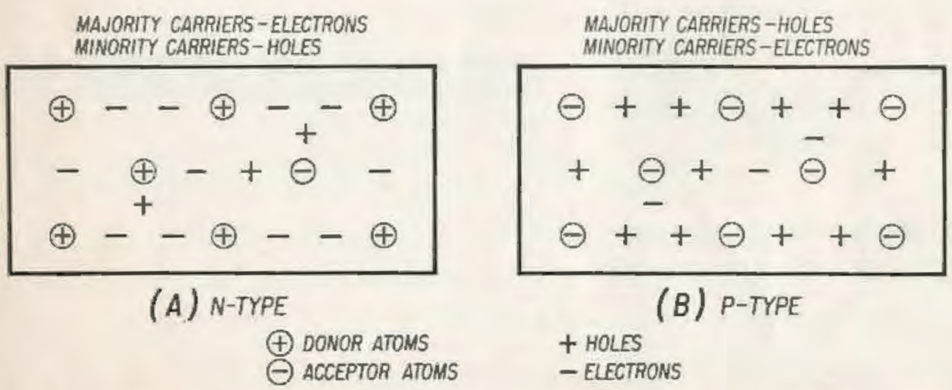


Fig. 6—How N- and P-type semiconductors are shown pictorially.

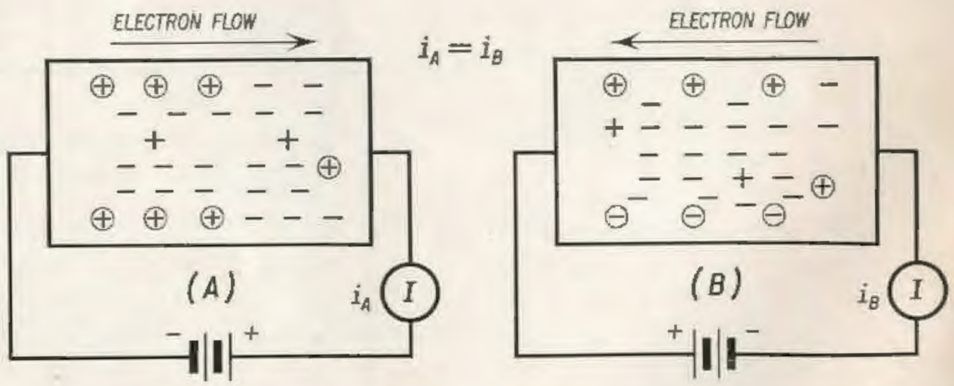


Fig. 7—Direction of electron flow for different battery polarities.

(majority carriers) increases but the number of electrons (minority carriers) remains the same. It is evident, therefore, from the above, that P-type semiconductors will always contain a certain number of free electrons in addition to holes, and N-type semiconductors a certain number of holes in addition to free electrons.

Effect of Battery Polarity Across N- and P-Type Semiconductors

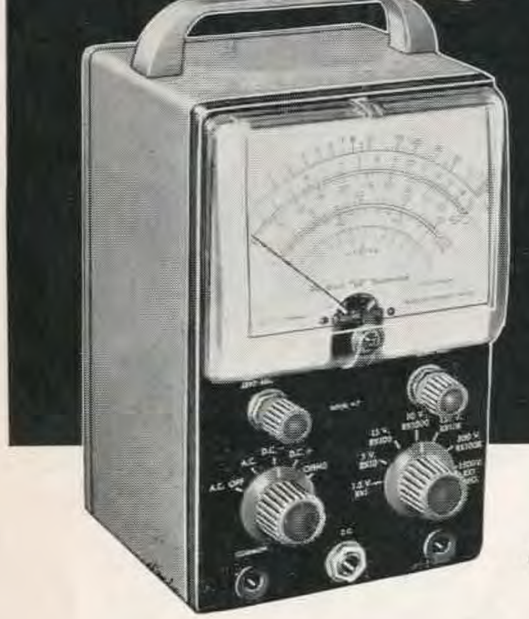
N- and P-type semiconductors are conventionally illustrated in the manner shown in *Figs. 6A* and *6B* respectively.

In *Fig. 6A* we observe that the majority carriers are distributed at random throughout the germanium crystal. Here and there we show a hole in order to depict the few minority carriers present. The electrons are indicated by minus signs, the holes by plus signs, and the donor atoms by plus signs with circles drawn around them.

It will be recalled that a donor atom is an impurity atom which replaces a germanium atom, and in this process frees an electron. The impurity atom remains with a net positive charge as shown in this figure.

In *Fig. 6B* we show a similar condition for the charges present in a P-type semiconductor except that in this case the majority carriers are holes instead of electrons. The holes and electrons are symbolized as in *Fig. 6A*, and the negatively charged atoms are identified by minus signs with circles drawn around them. Here and there we show an electron to depict a few minority carriers present.

When a battery is connected across an N-type semiconductor as shown in *Fig. 7A*, the electron flow in the semiconductor is from left to right. If the battery is reversed as in *Fig. 7B*, the electron flow is from right to left. We previously demonstrated (*Fig. 5*) that hole flow was an equivalent electron flow in the opposite direction. Therefore, the net current in the ammeter includes the electron flow which comprises the majority carriers, and the hole flow which comprises the minority carriers. The currents in *Figs. 7A* and *7B* are equal, the battery reversal merely causing a current reversal. A semiconductor, by itself, does not favor current flow in any



given direction; that is, it conducts equally in both directions.

P-type semiconductors behave in the same manner except that the holes, which are now majority carriers, give rise to an equivalent electron flow, which, when combined with the few intrinsic minority carriers (free electrons), constitutes the total current flow in the circuit.

N-P Junctions

We are now ready to study the action of semiconductors as rectifiers. In *Fig. 8* we show a diagram of an N-type semiconductor joined intimately along one of its surfaces with a P-type semiconductor. The surface along which both semiconductors are joined is called a *"junction."*

Electrical measurements indicate that the ratio of charged atoms to carriers along a junction is comparatively high. This condition may be explained in the following way. To begin with, the N-type material possesses no net charge, since the number of intrinsic holes and electrons are equal, and the negative charges on the free electrons are balanced by the positive charges on donor atom cores. By similar reasoning, it can be seen that the P-type material is also without any net charge. When the two are brought together, however, to form a junction, there is an initial flow of electrons from the N- to the P-type material, and a flow of holes from the P- to the N-type material. As a result of this initial flow, the N-type material acquires a net positive charge and the P-type a net negative charge. A field is set up in the process which tends to oppose further flow. This action continues until a condition of dynamic equilibrium is attained between the strength of this field and the flow of carriers due to thermal and other possible sources of energy. The field thus created repels the electrons in the N-type material away from the junction and similarly repels the holes in the P-type material. In this manner, the area in the immediate vicinity and on each side of the junction is conspicuous by a preponderance of charged atom cores, and a scarcity of electrons and holes. Thus, in the donor region of an N-P unit a positively charged area comprising donor atoms is

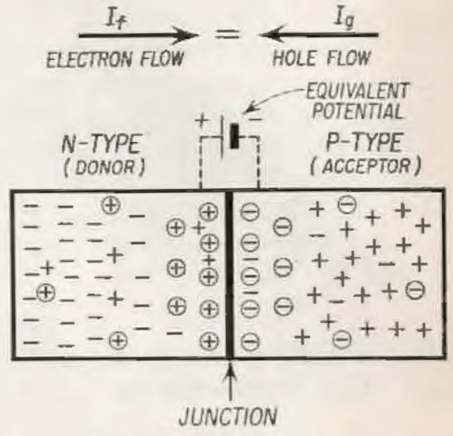


Fig. 8—N-P junction charge distribution. Equivalent battery depicts polarity of charges on atom cores along junction.

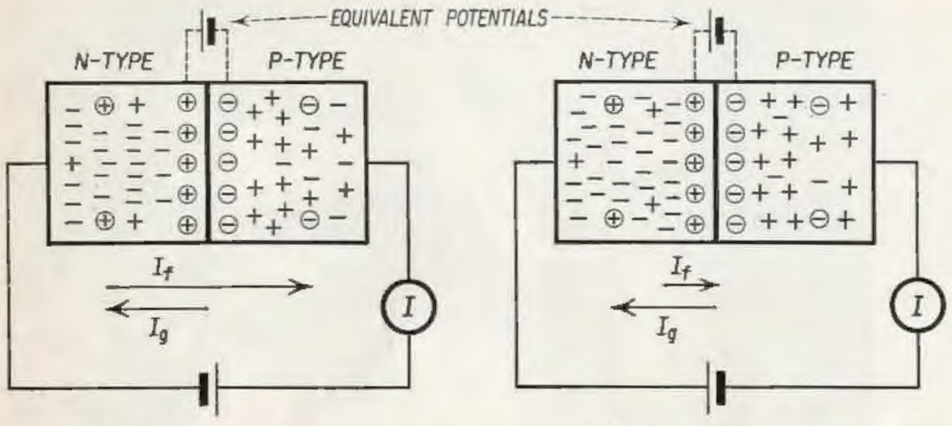
found concentrated along the junction. Similarity, in the acceptor portion of this unit a negatively charged area comprising acceptor atoms is found concentrated along the junction.

These charged areas at the junction oppose the flow of majority carriers across the junction. Thus, the positively charged atoms in the donor material oppose the free flow of holes from the acceptor material into the donor material, and the negatively charged atoms in the acceptor material oppose the free flow of the electrons from the donor material into the acceptor material. For this reason the area in the immediate vicinity of the junction acts like a charged capacitor, with a polarity as indicated by the equivalent battery drawn in the figure. This battery is shown connected across the junction in dashed lines.

Forward and Reverse Current

Notwithstanding the opposition offered by the charged atoms at the junction there is sufficient energy contained in some of the majority carriers to overcome this retarding field potential so that some of the electrons in the N-type material manage to diffuse into the P region and some of the holes in the P region manage to diffuse into the N region. This majority carrier diffusion is referred to as *"forward current"* and is usually indicated by the symbol I_f as shown at the top of the figure.

As far as the effect of this field on the minority carriers is concerned, we find



(A) FORWARD BIAS (B) REVERSE BIAS

Fig. 9—Battery connections for forward and reverse bias.

that a different situation exists. In this case the minority carriers are the few electrons present in the acceptor material and the few holes in the donor material. Minority electrons in the acceptor material may easily diffuse into the donor material because the positive charge layer of the donor atoms at the junction is always a source of attraction to these electrons. The same reasoning applies to holes in the donor material. The junction layer of negatively charged acceptor atoms is a source of attraction to the holes on the other side, and results in a diffusion of these holes into the acceptor material.

This minority carrier diffusion is referred as *"reverse current"* and is symbolized by I_g. It must be kept in mind that the total number of minority carriers is very small so that only a few oppositely charged atoms are required to attract all of them. The resulting "saturation" current is also small and independent of the magnitude of the retarding field potential.

As a final consideration on this topic it might be pointed out that with no external field applied, the N-P junction is in a state of thermal equilibrium, that is, equal and opposite thermal forces exist in all directions. Because of this the forward and reverse currents are equal, that is, the electron and hole flow for forward and reverse currents are equal, or I_f is equal to I_g as shown in *Fig. 8*. The net current flow through the P-N junction is therefore zero. This must be the case, otherwise we would have to conceive of a situation where electrons or holes are being constantly emitted out of the material into the outside space.

Forward and Reverse Biasing

It is obvious that removal of the field created by the charged atoms along the junction will promote the flow of holes from the P-type into the N-type material, and free electrons from the N-type into the P-type material. This constitutes an increase in I_g, the forward current, and may be accomplished by connecting an external battery to the open ends of the N-P junction in the manner shown in *Fig. 9A*. The battery connected as shown is said to provide a *"forward bias"* to the N-P junction. Under these conditions the previous balance between I_f and I_g no longer exists, and a net forward current I_f minus I_g will flow in the circuit.

It should be kept in mind that even with the reduced field resulting from forward bias, the total number of minority carriers present in the material will diffuse across the junction. Thus, the reverse current is independent of applied voltage, representing, as before, saturation. At first it may seem strange that saturation reverse current should persist in spite of the reduced attractive force on the flow of reverse carriers. However, if we will recall that the small number of reverse carriers which exist requires a very small force of attraction to set them in motion, the reason for the saturation reserve current will become obvious.

If, instead of connecting the external battery as in *Fig. 9A*, we were to connect

[*Continued on page 35*]

Radio Direction Finding in Marine Electronics

Part 3

The orientation and calibration of direction finding equipment are treated in this installment. Sources of error and possible remedies are also dealt with.

Fig. 1—A cardboard arrow pasted along the null line for visual bearings.

by Elbert Robberson

THE radio direction finder is actually a navigational instrument; consequently, great care should also be taken in orienting it so that the bearing-observation mechanism is exactly squared up with the keel of the vessel. Ordinarily, chart tables and other possible resting places for the direction finder are fairly well "squared up" with the keel line, and equipment can be aligned by mounting it squarely on the surface. However, it is obvious that if the table or shelf is at a slight angle, a constant error of this magnitude will automatically exist in all bearings taken.

Orienting Procedure

In an irregularly shaped position of support, avoid gross errors in equipment orientation as follows. Lay out a point on the boat forward or aft of the direction finder, as far away as possible, but at the same height and the same distance from the center line of the keel as is the center of the direction-finder bearing circle and pointer. Then sight through the zero line of the direction-finder bearing scale and align the direction-finder cabinet so this point is exactly on the nose. The direction-finder cabinet will then be lined up with the keel.

For a number of reasons, the best spot for the direction finder is over the center line of the boat. However, if a location is not available on the center line, a direction finder can perform satisfactorily in any other location aboard.

Calibration

On a wooden boat with no mast, wire rigging, or other elevated wires or metal, a radio direction finder should provide accurate bearings without any deviation error whatever. However, it is not a good idea to make this bold assumption without performing some kind of test to back it up. A rough check may be made, without recourse to special transmitters or elaborate procedures, which will, at the least, advise you whether some unforseen circumstance is affecting the bearing accuracy.

Ordinarily, calibration checks on radio-direction-finding equipment require precise knowledge of the location of both the vessel and the radio transmitting station, and require either swinging the ship in the vicinity of the station, or using a portable transmitter in a boat which can be kept in sight on a circular course around the vessel. However, here is a system which permits checks to be made with a minimum of preparation and trouble. This check can be performed while the boat is lying alongside a dock. In fact, while the test is being made, the boat must remain in the same location and at the same heading.

With your location as a center, measure the angle between several radio stations within range with a course protractor. Stations should be chosen which lie at fairly large angles to one another, and which also have frequencies in the same approximate portion of the spectrum. For example, airway range stations and marine beacons should be used together; broadcast stations below 1000 *kc.* could be used together; or stations above 1000 *kc.* could be used as a group for checking. For best results do not attempt to use stations having more than a few-hundred kilocycles separation.

The location of the transmitting towers of marine and airways beacons are noted on marine and airways navigational charts. Some broadcast stations and towers are marked on Hydrographic Office charts, but if yours are not, their location may be found by contacting the broadcasting station publicity director, or else the local Civil Aeronautics Authority offices, who keep such information on file. Now, knowing the angle between the various radio stations, take a set of radio bearings on them to see if the angles between observed radio bearings result in the same figures. Using three or more stations, located at widely spaced angles, an error of only one or two-degrees between the different stations indicates a fair and usable accuracy. A very great difference in any of the radio angles versus the chart angles shows that the installation suffers from deviation, and indicates the necessity for an accurate calibration of the direction-finding equipment.

A full-dress radio-direction-finder calibration is not a difficult operation and should be in the repertoire of any agency installing direction-finding equipment. This is an operation which can usually be conducted using existing radio facilities. To do the job, personnel to man the boat should be aboard, as well as at least one observer to assist in measuring the bearing errors.

The equipment should be calibrated when located in its permanent spot on the boat, and after being calibrated, it should not be moved. Wire halyards and other rigging nearby should be strapped in the position which they will ordinarily have while the direction finder is being used, and everything metallic which could possibly affect bearings should be in a location to which it can be returned when accurate bearings are desired.

Actually, all direction-finder calibration amounts to is determination of the difference between a line-of-sight bearing and a radio bearing at a given instant. Because of the fore-and-aft and athwartship alignment of the rigging, the error is usually the least on bearings from stations located directly ahead and directly astern and directly abeam on each side. On the various quarters, there may be a difference of from one or two degrees up to very many.

If the location of the direction finder permits sighting over its bearing circle, there is a very simple method of determining this error. Paste a sighting arrow along the null line on the loop itself, over which visual bearings can be taken, using the direction-finder rose to obtain the degree reading. See *Fig. 1.* If the direction finder is located so that visual bearings over it are not possible, it will be necessary to use a pelorus by which accurate visual bearings may be taken. This is illustrated in *Fig. 2.*

[*Continued on page* 33]

Fig. 2—Accurate visual bearings may be made with a pelorus.

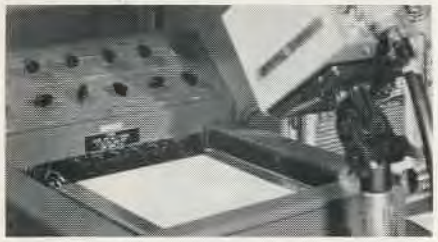


Fig. 1—G.E. "Intra Tel" reading data from a plotting table.

Fig. 2—Engineer viewing the data received from the "Intra Tel."

Fig. 8—Live shells are taken apart with camera looking on.

Fig. 9—Disassembly being observed by operator at monitor.

Television in Industry

A description of some of the ever increasing applications of television in industry.

by Allen Lytel
Supervisor—Technical Information Unit
General Electric Co.

TELEVISION is actually only beginning to show its vast potentialities for industrial uses. In telemetering for remote installations, such as isolated pumping stations on a cross-country pipe-line, various conditions such as line pressure, fuel level for the power equipment, or outside temperatures are monitored automatically. The readings are sent by TV so that the operator can see the actual operating conditions as they exist at the remote location.

Television is used to observe industrial operations and provide a visual presentation in a different location. A TV monitor can watch a railroad yard, a steel furnace, or protect an area against intruders. This use of TV has grown very fast and several organizations make specialized equipment for this use.

An example of data transmission is shown in *Figs. 1* and 2. Test data from the pen recorder (at the Jet-Engine Development Center of General Electric, in Cincinnati, Ohio) are sent to the engineer more than 200 feet away.

Schools are also prime users of television. *Fig. 3* shows dental techniques and actual work on patients being transmitted, at the New York University Dental College. Large groups of students, *Fig 4*, can see the techniques while they are actually being used. In some cases, projection receivers produce large pictures for a full theatre audience.

Commercial broadcast TV is related to ITV and many of the techniques and methods for ITV have evolved directly from broadcast experience. ITV is much simpler primarily because the signal is directed to only a few receivers which are relatively close to the transmitter.

Basic Units

Figure 5 illustrates, in block-diagram form, the stages required for ITV. Since only horizontal pulses, vertical pulses, and video are needed and low power output is required, the equipment is less complex than that at a broadcast transmitter. The camera tube can be a Vidicon, an Iconoscope, or an Image Dissector which is provided with the required power and pulses from the sync and sweep block. Amplification of the camera output in the video amplifier is the third block.

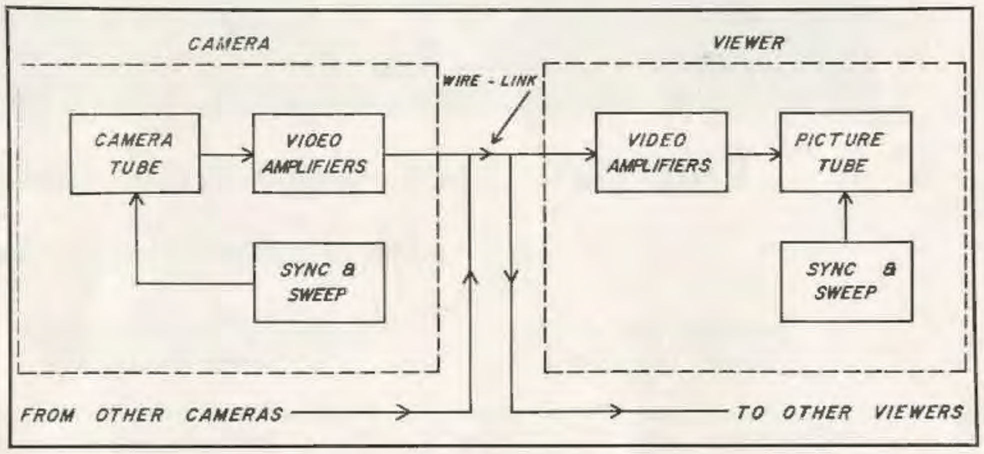


Fig. 5—Block diagram showing basic units used in closed circuit applications.

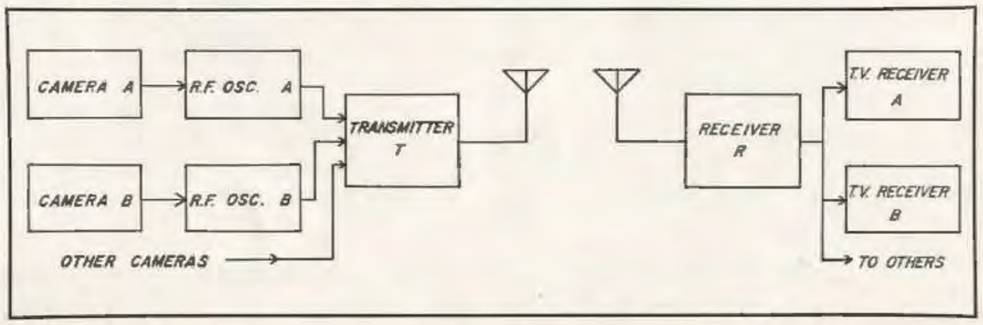


Fig. 7—A more elaborate system using microwave transmission to the receivers.

A wired link, in this case, carries the signal to the viewer-receiver. A single coax can carry the pulses and video or several cables can be used, in which case the video and pulses are not mixed.

Again only a simplified receiver is needed; the *rf* and *if* amplifiers are not required. A special receiver, built for wired ITV will need only a video amplifier, a picture tube, and the sync and sweep blocks, in addition to a power supply. A monitor for ITV needs only these blocks but a normal broadcast receiver can be used by bringing the video input directly to the video amplifier input.

Several viewers or monitors can share a single camera to allow viewing at several locations. By remote switching, several cameras can also be used to view different parts of an industrial

Fig. 3—Dental operation being televised for viewing by class.

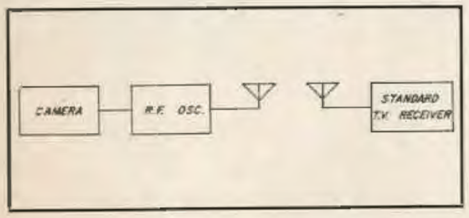


Fig. 6—Arrangement for pick-up by standard TV receivers.

operation. This is not the same as channel switching (no *rf* is being used here) but a selector switch at each viewer permits the choice of any of several camera outputs by actually switching the input lines to the individual viewers.

Another type of flexibility is shown in *Fig. 6* where the camera is used to modulate a low-powered *rf* oscillator.* If the oscillator is on one of the commercial channels, which is unused in the local area, a standard TV receiver can be used as the viewer without impairing the use of the receiver on existing local TV broadcast channels. This procedure is a simple and direct use of ITV at the lowest possible cost because of the use of existing receivers without modification.

Elaborate systems can be made, as in *Fig 7*, by using a number of units such as those in *Fig. 2* plus a microwave transmitter, T. Several cameras (A, B, and others) can each modulate an *rf* oscillator on one of the standard channels. These modulated signals are then used to modulate a single microwave transmitter. At the receiving end, the receiver, R, heterodynes each of the single channels back to the original *rf*

* Subject to FCC regulations.

[*Continued on page* 27]

Fig. 4—Visual presentation to a large class in dentistry.

Voltage Amplifiers in Hi-Fi

by Lawrence Fielding

Circuit operation, configuration and typical service problems in Hi Fi voltage amplifiers are dealt with in this installment.

LAST month we analyzed the block diagram of a "Power Amplifier" and saw that the first circuit element was the voltage amplification stage, or stages. This section of an amplifier, while not easily divorced from the rest of the circuit, has certain functions and design similarities which make it worthy of separate treatment, both from a theoretical and servicing viewpoint. The functions of the voltage amplifying section are to provide:

1. Additional amplification of the signal, prior to application to the phase inverter and power output stages.

2. A convenient point for the application of overall distortion-reducing negative feedback.

3. A high impedance input, to which signals may be applied to the amplifier from low impedance sources such as cathode followers.

4. The correct impedance and output level for convenient application of the signal to the phase-inverter stage, which will be discussed in the next article of this series.

Since there are literally as many circuit configurations for the voltage amplifier stages as there are commercial amplifiers on the market, the best method of analysis would be to investigate in detail several of these circuits, keeping in mind the elements common to each as well as the differences between them.

The Fairchild Model 255A Power Amplifier

This "power package" is shown pictorially in *Fig. 1.* The unit has a power rating of 30 watts which it delivers at less than 1% harmonic distortion. The amplifier requires 1 volt of signal input to produce full rated power output. The voltage amplifying section is shown in *Fig.* 2 and consists of a 6AB4, low noise triode input stage, followed by ½ of a 12AU7, dual triode. *C1,* the input capacitor, serves no other purpose than to block any possible *dc* which might be present at the output of the preamplifier used to drive this unit. In all likelihood, the preamp will have a similar capacitor in its output circuit, but since the manufacturer cannot know which preamplifier will be used to drive his unit, he must protect the first grid of the unit from any possibility of positive *dc* voltage. On the other hand, he must make the capacitance of *C1,* quite large. Normally, a .1 *mf* capacitor would be large enough to provide full frequency response down to 20 cycles. However, the manufacturer must consider the possibility that this capacitor will have another capacitor in series with it, from the output of the preamplifier. If such were the case, and if this second capacitor were also .25 *mf* in value, the net capacitance in series with R1 would be only .12 *mf.* Even this lowered value would still pass all frequencies within the audible range.

Fig. 1—Fairchild Model 255A 30 watt power amplifier.

Application of feedback

The cathode of V1 is used as the point of application of feedback from the output transformer, through *R7* and *C13.* This method of feedback application is fairly standard even though it is possible to apply feedback to the grid, through a suitable network. If the latter design were employed, a problem would arise every time the level control R1 was varied. With changes in the grid-to-ground impedance, the amount of feedback applied would vary greatly and could not be controlled easily. The cathode circuit, on the other hand, provides a constant impedance to ground and so the amount of overall feedback is easily determined.

Signal levels are symbolized by a small sine wave next to the figure and you will note that the *apparent* gain of this first stage is only slightly more than three (from .9 volts input to 3.2 volts output). Actually, the gain is many times greater, but the addition of feedback in the cathode circuit reduces it considerably. This is the only point in an amplifier circuit where this condition can be seen and measured, for at other stages *within* the feedback loop, the gain will appear to be normal (as, for example, in the next stage, where an input of 3.2 volts produces an output signal of 29 volts—a gain of nearly 10).

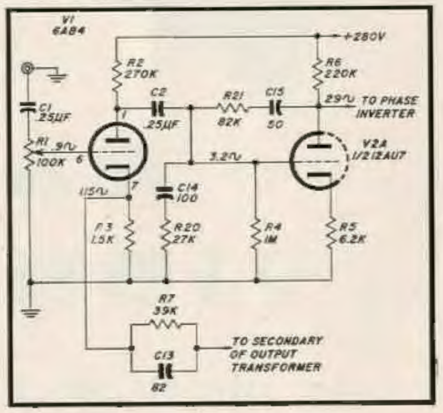


Fig. 2—Schematic of Fairchild Model 255A voltage amplifier.

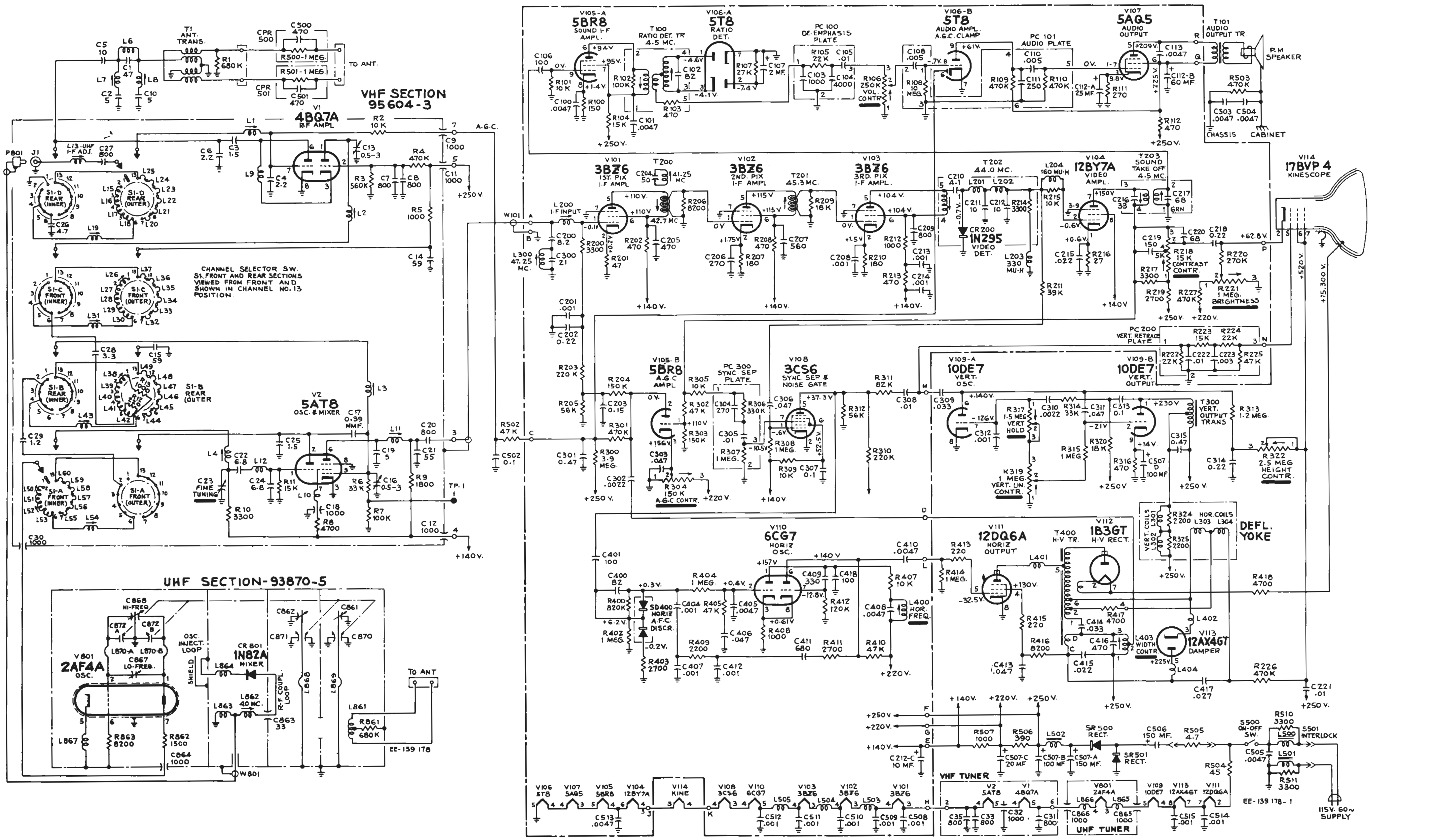
Disregarding *C14, C15, R20* and *R21* for the moment, let us follow the main signal path. The amplified signal is coupled through *C2* to the grid of V2A. Notice that again a fairly large value of coupling capacitor is used, but this time for a different reason. Each time the signal is passed through a capacitor and resistor combination, at very low frequencies, a small phase shift occurs. That is, the capacitive reactance of the coupling capacitor, if appreciable compared to the succeeding grid resistor, causes a phase displacement between input and output of several degrees. In an amplifier without feedback, this would be unimportant, since the ear is not sensitive to phase differences. With feedback, however, it is important that the output be exactly 180 degrees out of phase with the input signal, for proper application of feedback in the negative direction. Now, suppose that at some low frequency, say ten cycles, each coupling capacitor and resistor causes a phase shift of 36 degrees. Suppose further that there are five such stages in the amplifier. Then the total phase shift will be 180 degrees more than the planned phase reversal, or right back to 360 degrees. In other words, instead of negative feedback, at this particular frequency of 10 cycles, *positive* feedback would result and so would low frequency regeneration or "motor-boating."

V2A is a conventional triode amplifier, except that the cathode resistor *R5* is unbypassed, which is another means of achieving degeneration (and lower distortion of high grid-signal swings.)

Phase Correction

Just as the designer must insure good

[*Continued on page* 23]



CIRCUIT SCHEMATIC DIAGRAM 5378 CHASSIS

Important Warning and Service Precautions . . .

THE CHASSIS OF THESE RECEIVERS ARE CONNECTED TO ONE SIDE OF THE AC SUPPLY. SERVICE SHOULD NOT BE ATTEMPTED BY ANYONE NOT THOROUGHLY FAMILIAR WITH THE PRECAUTIONS NECESSARY WHEN WORKING ON THIS TYPE EQUIPMENT.

1. AN ISOLATION TRANSFORMER SHOULD BE INSERTED IN THE POWER LINE BETWEEN THE RECEIVER AND THE AC SUPPLY, BEFORE ANY SERVICE IS PERFORMED ON THE RECEIVER, INCLUDING TUBE REPLACEMENT.

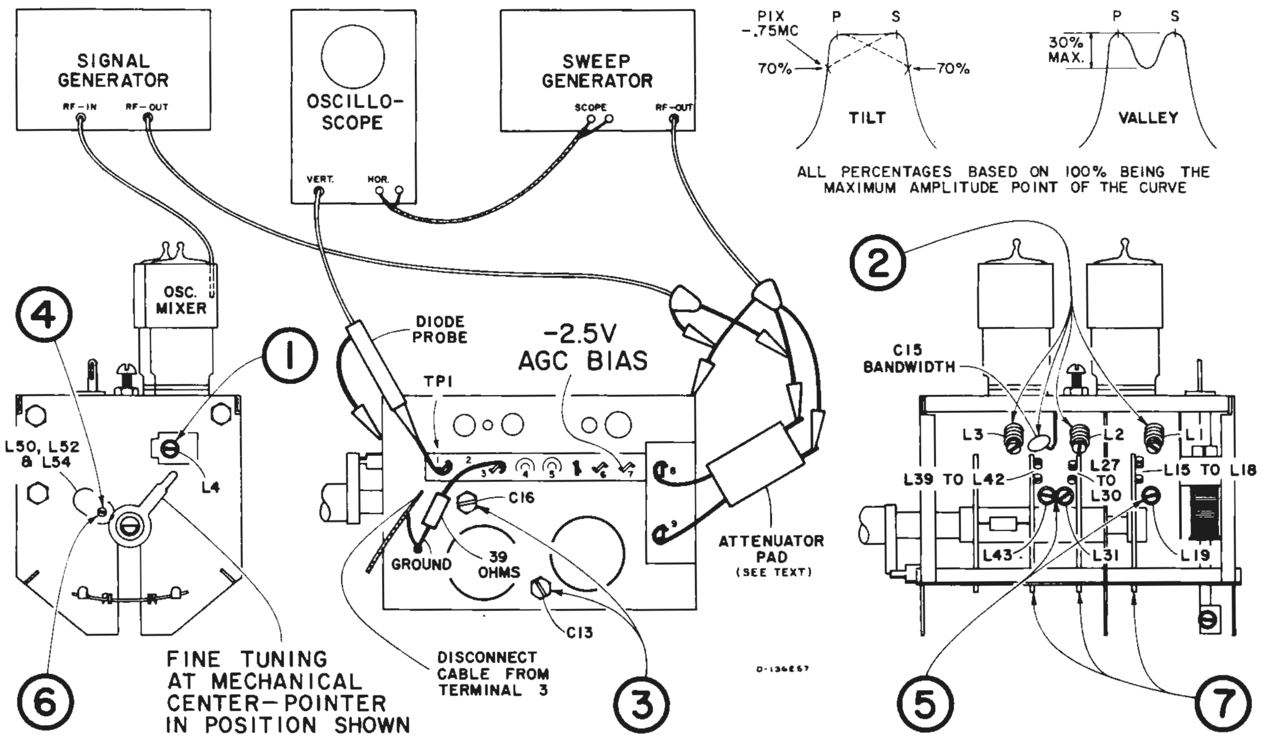
2. THE ON-OFF, BRIGHTNESS, CONTRAST AND VOLUME CONTROL KNOBS ARE HELD CAPTIVE TO THE CABINET. DO NOT FAIL TO REPLACE THE KNOB RETAINERS AS FAILURE TO DO SO WILL ALLOW ACCESS TO THE CHASSIS THROUGH THE KNOB OPENINGS IF THE KNOBS ARE REMOVED.

3. REPLACEMENT OF THE ANTENNA LEAD(S), BETWEEN THE TUNER(S) AND THE ANTENNA TERMINALS, MUST NOT BE MADE WITHOUT REPLACING THE ISOLATING RESISTORS AND CAPACITORS IN SERIES WITH THE LEAD(S). REFER TO SCHEMATIC DIAGRAMS ON PAGES 10 & 12.

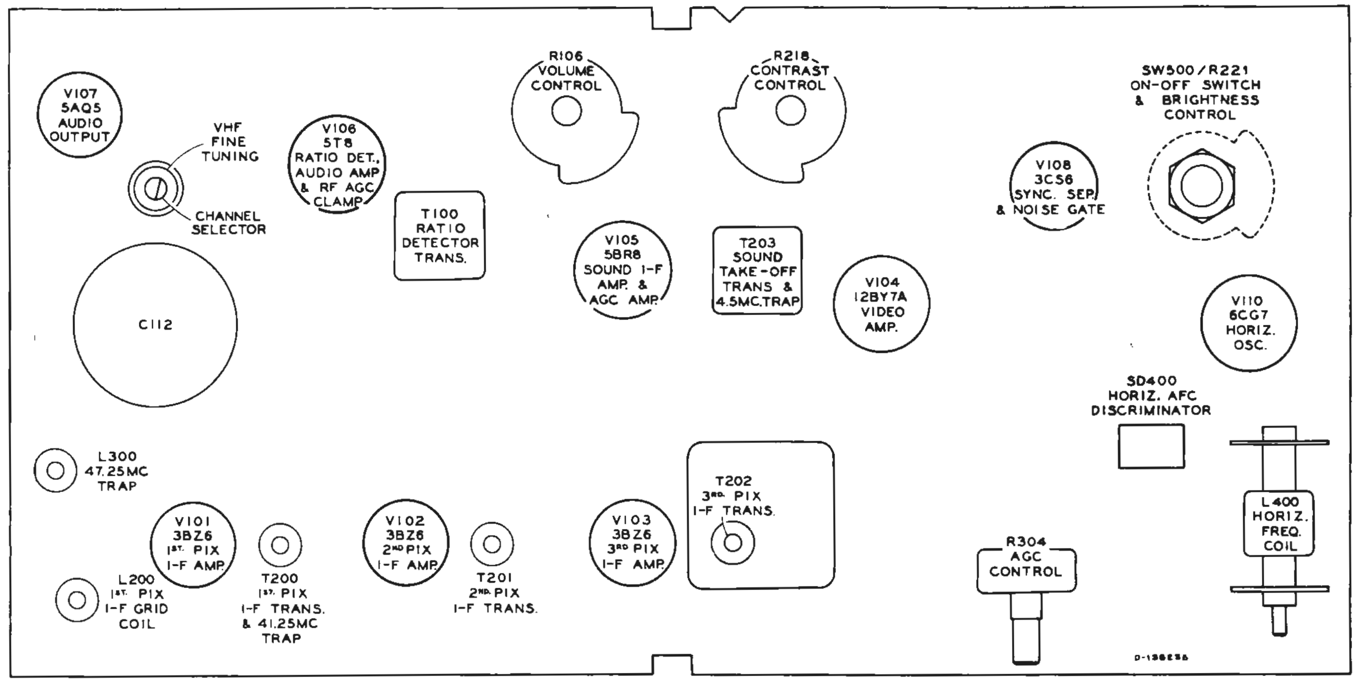
4. THE TWO INSULATING BOARDS — ONE BETWEEN THE LOWER CHASSIS AND THE PRINTED CIRCUIT, THE OTHER FASTENED TO THE BOTTOM OF THE CABINET BACK — MUST BE REPLACED IF REMOVED FOR ANY REASON.

5. IT IS RECOMMENDED THAT THE RECEIVER POWER PLUG BE INSERTED IN THE PROPER DIRECTION, TO CONNECT THE CHASSIS TO THE GROUND SIDE OF THE AC SUPPLY. CHECK WITH AN AC VOLTMETER BETWEEN THE CHASSIS AND THE POWER OUTLET PLATE, OR THE MOUNTING SCREWS IF THE PLATE IS NOT METAL. NO READING SHOULD BE OBTAINED. IF A READING IS OBTAINED, REVERSE THE POWER PLUG AND RECHECK FOR ZERO METER READING.

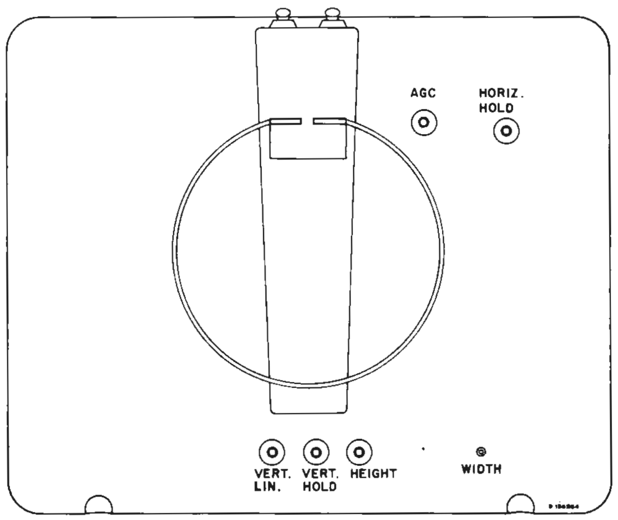
6. A FINAL CHECK SHOULD BE MADE WHEN SERVICING THE RECEIVER, TO INSURE THAT NO LOOSE METAL OBJECT IS SHORTING BETWEEN THE RECEIVER CHASSIS AND THE CABINET.

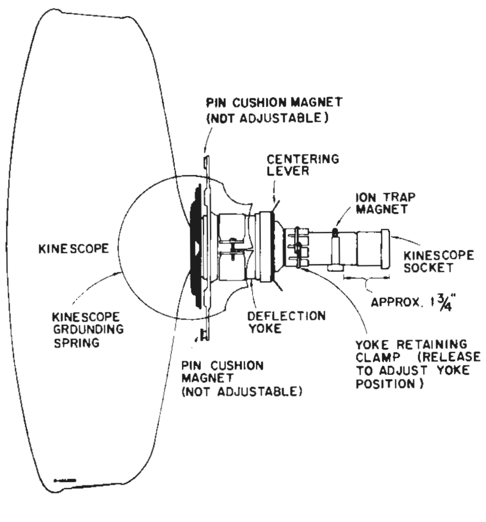


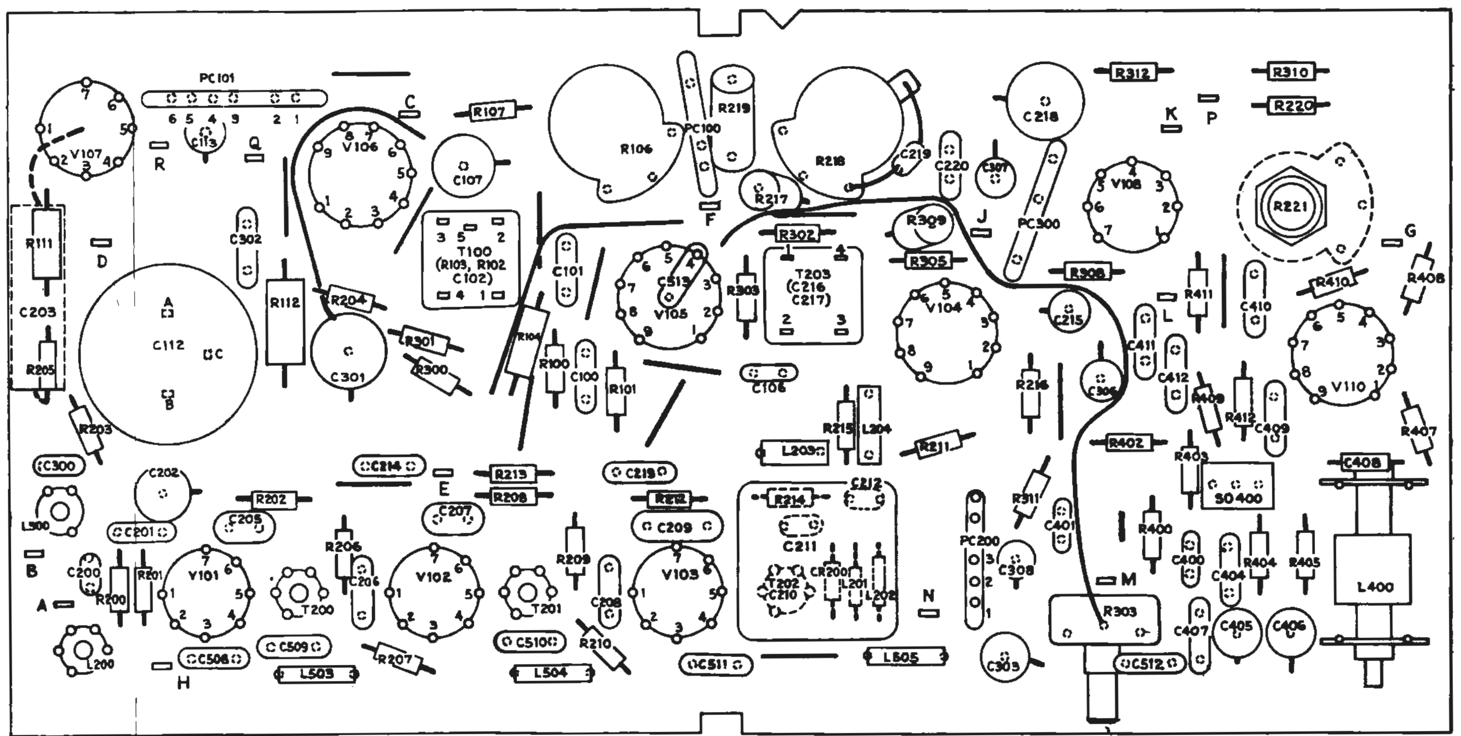
95604-3 & 95604-4 VHF Tuner R-F Alignment



Printed Board Top View





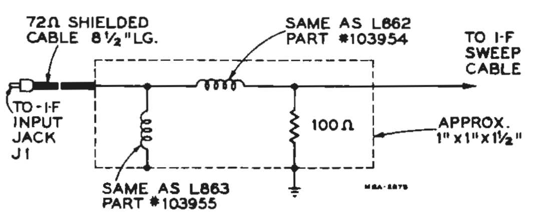


PRINTED BOARD UNIT LAYOUT

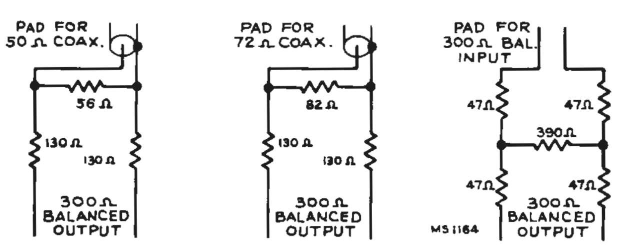
The assembly represented above is viewed from the component side of the board and is oriented as it will usually be viewed on the chassis.

The printed wiring, on the reverse side of the board, is presented in a "phantom" view superimposed on the component layout.

Component replacement, when necessary, should be made following the techniques outlined in Printed Circuit Board Service Data 1955 No. T13 dated 11/15/55.

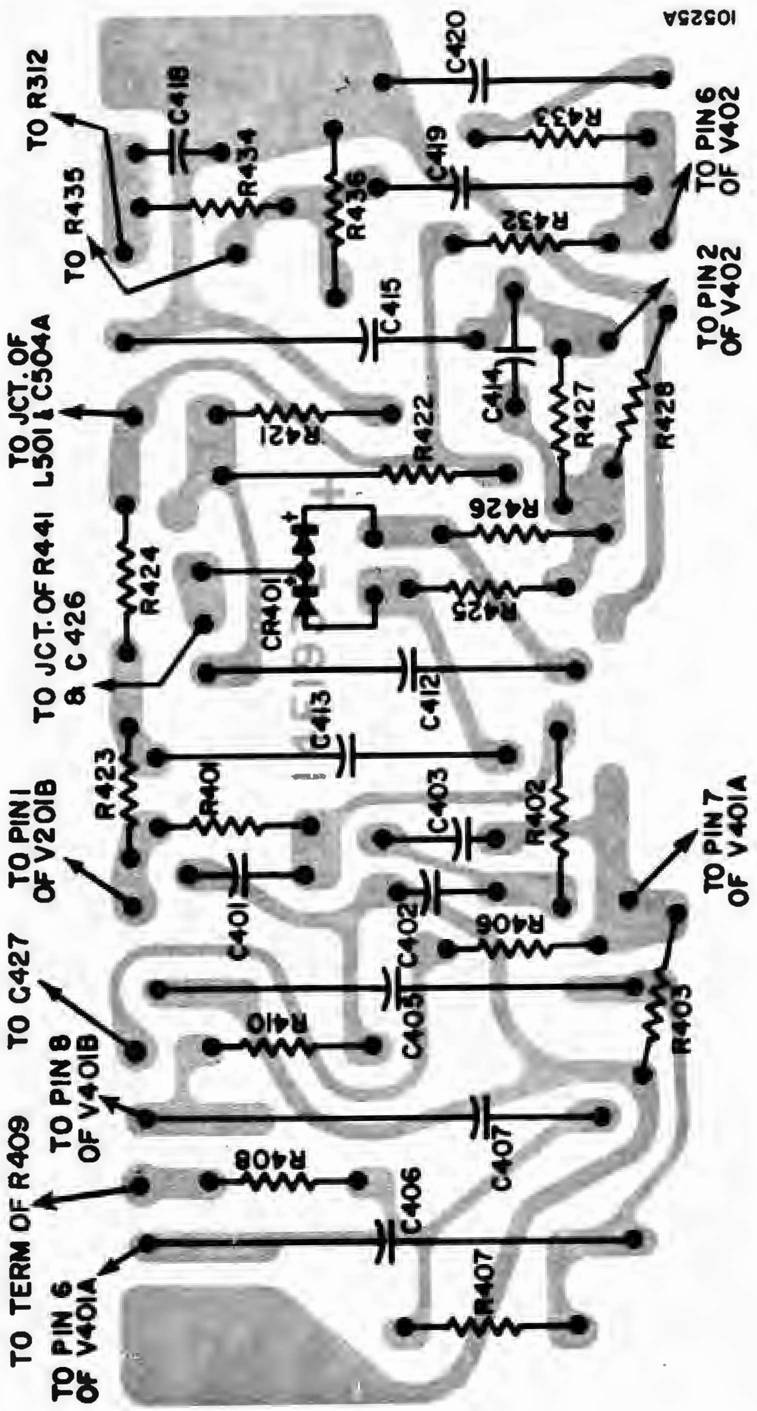


Tuner I-F Input Head

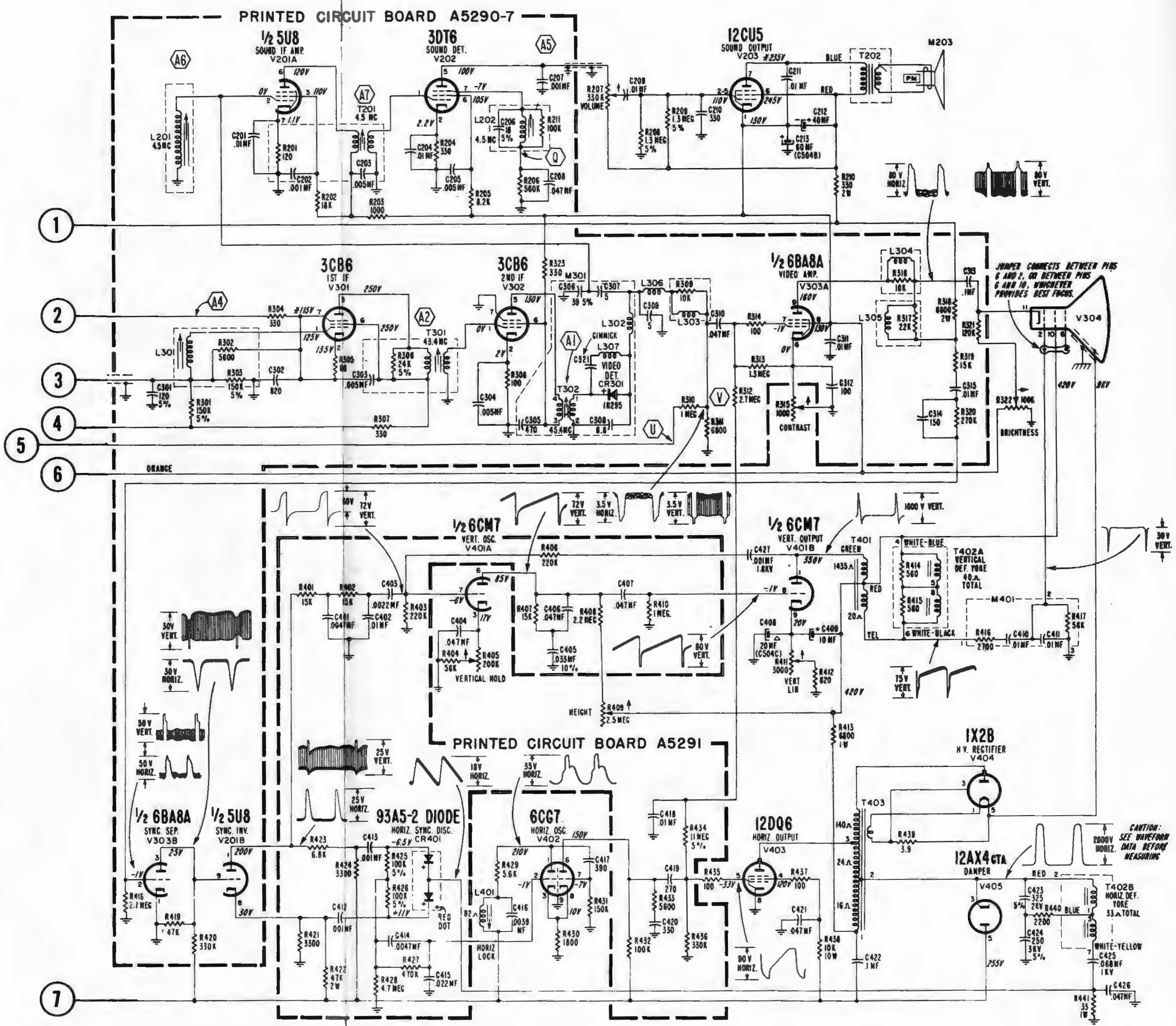


Sweep Attenuator Pads

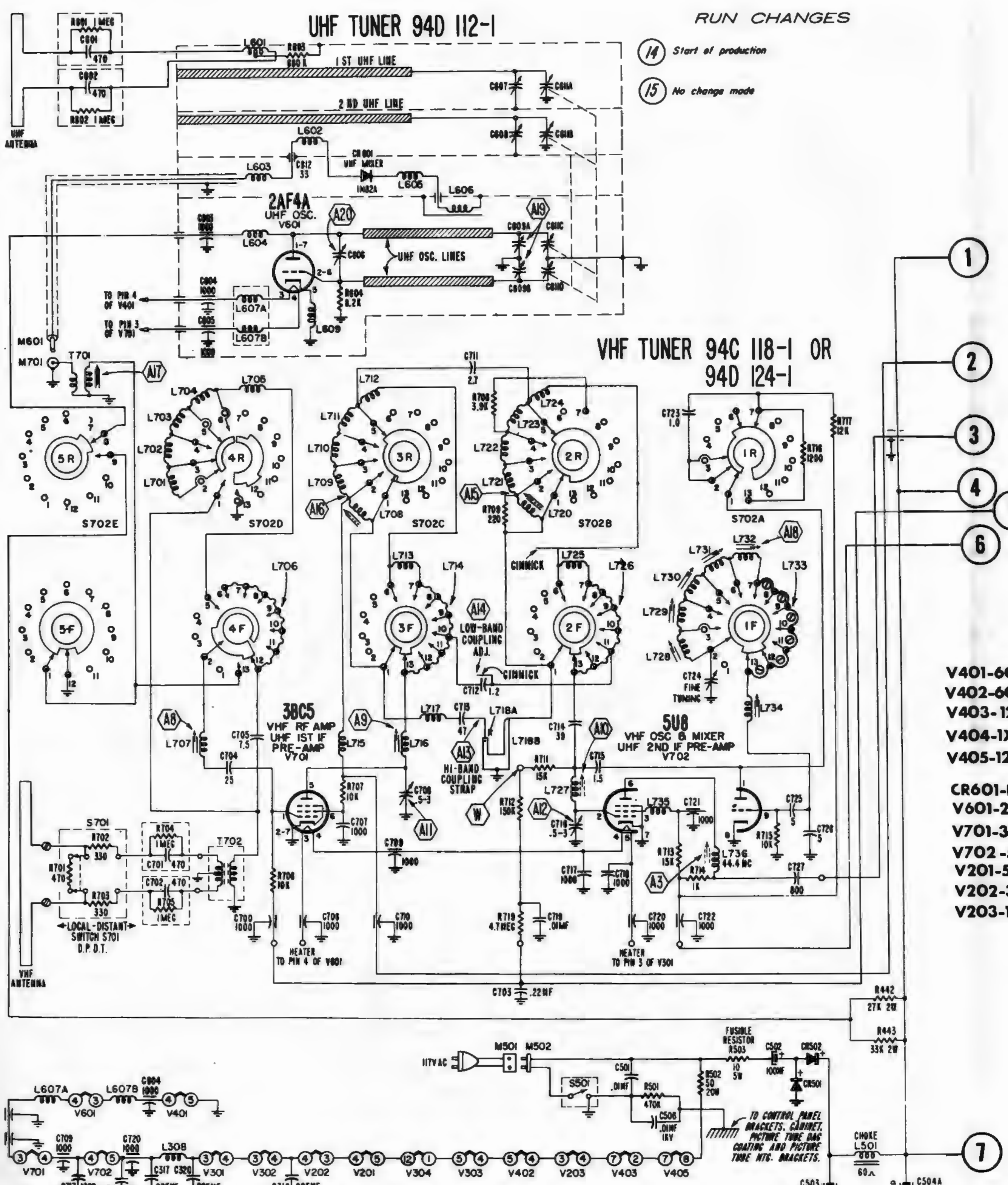
CHASSIS 14UY3B, 14UY3C and 14UY3D



View of Wiring Side of Bottom Printed Circuit Board Used in Sets With 10" or 14" Picture Tube.

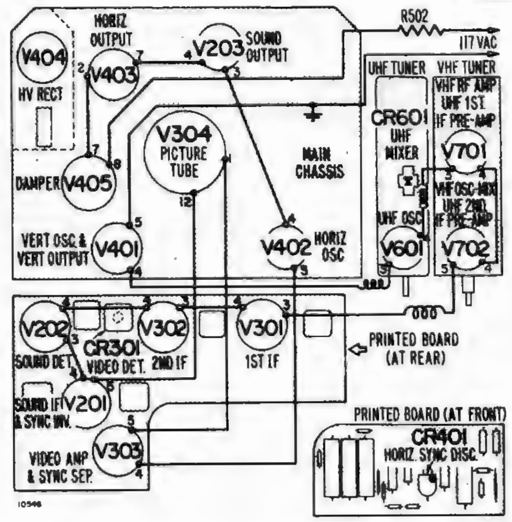


Schematic for 14UY3B and 14UY3C
Chassis Television Chassis Stamped Run 14 through 15



V401-6CM7
V402-6CG7
V403-12DQ6
V404-1X2B
V405-12AX4GTA

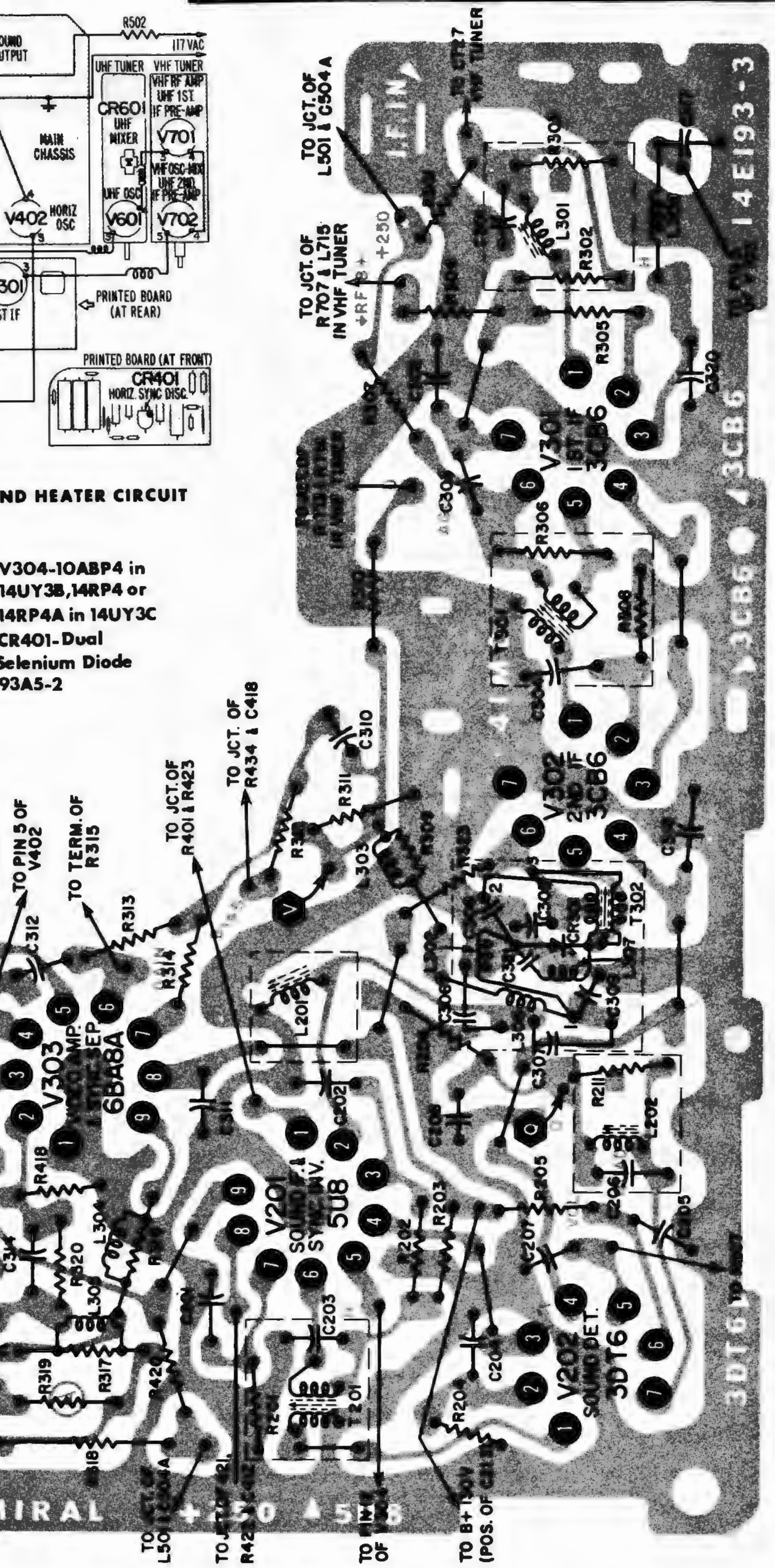
CR601-1N82A
V601-2AF4A
V701-3BC5
V702-5U8
V201-5U8
V202-3DT6
V203-12CU5



TUBE LOCATIONS AND HEATER CIRCUIT

CR301-Crystal Diode 1N295
V301-3CB6
V302-3CB6
V303-6BA8A

V304-10ABP4 in 14UY3B,14RP4 or 14RP4A in 14UY3C
CR401-Dual Selenium Diode 93A5-2



View of Wiring Side of Rear Printed Circuit Wiring Board Used in Sets With 41 MC IF System.

phase response at the low frequency end, so must he make certain that the phase situation at high and supersonic frequencies does not "take a turn" towards oscillation. In this case the problem is infinitely more complex, for the output transformer enters into the picture. Every high-fidelity output transformer will, at some frequency, become resonant. That is, the inductance of the windings resonates with the distributed capacitance of those same windings. In a good unit, this will occur well outside the audible range but it must still be controlled and prevented from causing oscillations which, though inaudible, might easily burn out an expensive "tweeter." The presence of *C13* across the feedback resistor *R7* as well as the two networks consisting of *C14* and *R20* and *C15* and *R21* all combine to correct the high frequency resonance and phase shift effects. Each of the networks has one thing in common with the others: they all reduce supersonic frequency response. *C13* does so by reducing the effective impedance of the total feedback network. This increases total feedback and thereby *reduces* overall gain. *C15* and *R21* comprise a secondary high frequency feedback loop around V2A and acts similarly (though it is designed to be effective at a somewhat lower frequency) and *C14* and *R20* comprise a shunting impedance across *R4*, which, at high frequencies acts to attentuate possible "bumps" in the response curve and further correct the phase of the entire system, from input to output. The presence of such networks, far from indicating haphazard design, indicates that the design engineer knew what he was about and carefully introduced as many corrective networks as were necessary to insure utmost amplifier stability under even the most difficult conditions of speaker loading.

The Dynakit Voltage Amplifier Circuit

A very popular power amplifier with servicemen is the 50 watt Dynakit, manufactured by the Dyna Company. This unit, sold in kit form, has been wired by many servicemen entering the high-fidelity market. The unit is very easily wired (it features a fully wired printed circuit board which "pops"

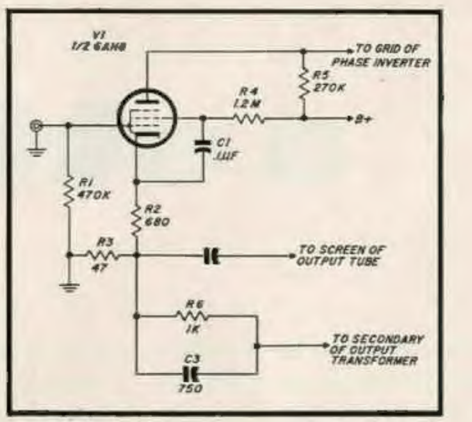


Fig. 3—Schematic of voltage amplifier stage in Dynakit.

right into the chassis) and affords a means of additional profit for the service dealer interested in this work. A partial schematic of the voltage amplifying section is shown in *Fig. 3*. Here the pentode section of a 6AN8, pentode-triode, is used to amplify the incoming signal sufficiently to pass it on to the phase inverter.

The principles embodied in this circuit are essentially the same as those outlined above, with certain important exceptions. The overall feedback network consisting of *R6* and *C31* is so chosen as to provide the proper amount of feedback when applied to a tapped-down point (the junction of *R2* and *R3*) in the cathode circuit. One of the inherent advantages in this method lies in the fact that the elements of the feedback network will necessarily be lower in impedance (note 1000 ohms for *R6* as opposed to 39K in the previous amplifier discussed) and therefore lead dress will not be as critical. This is particularly important in the design of a kit, where uniformity of wiring is not to be expected. The screen grid circuit is conventional in design and is bypassed to the cathode by means of *C1*. The plate circuit, however, has a novel feature which you are apt to enconnter in many amplifier designs. It is *dc* coupled to the following stage. The absence of a coupling capacitor insures the ultimate in low frequency response and virtually zero phase shift in this part of the circuit. This type of arrangement is only possible when used with a particular type of phase inverter, which will be discussed in greater detail in the next installment. *C2* comprises a form of phase

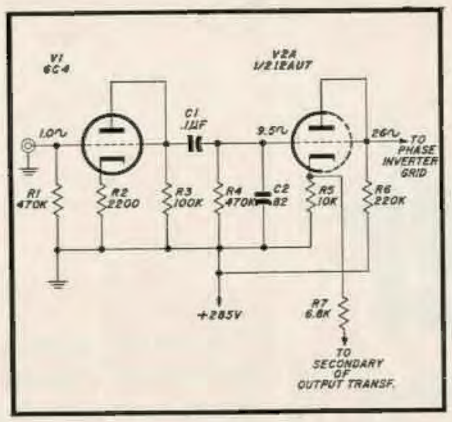


Fig. 4—First stage of Pilot amplifier not in feedback loop.

correction in the form of high frequency feedback originating from the screen circuit of the output stage having the proper phase relationship with the input to affect this type of correction. Since a pentode has much higher gain than a triode, the signal derived from this single stage is of sufficient amplitude to be fed to the phase inverter directly.

Pilot AA-410A Voltage Amplifier Section

Another common configuration of voltage amplifier circuitry is illustrated by the partal schematic of *Fig. 4*. This unit is a product of the Pilot Radio Corporation. Here, two triode sections are used. The first is a 6C4 single triode tube while the second is ½ of a 12AU7 dual triode. While substantially the same as previously discussed designs, the difference lies in the fact that no overall feedback is applied to the first stage. Since one volt is all that is needed to produce full output from this twenty watt basic amplifier, it was relatively simple to design a triode stage which would have virtually non-measurable distortion for 1 volt input even without including that stage in the overall feedback loop. By reducing the number of stages encompassed by the feedback system, the phase correction problems are greatly simplified. This is immediately apparent by the fact that no roll-off capacitor was found necessary across the feedback resistor *R7*. Actually, the 6C4 stage has its *own* distortion redncing feedback in the form of cathode degeneration (*R2* is not bypassed) which permits adequate signal swing on the grid without a trace of clipping or saturation. While the gain of the stage is thereby limited to only 9.5, the second stage easily makes up the needed difference, even with feedback applied. *C2* provides a small amount of gradual attenuation at supersonic frequencies and is the only corrective network needed in the entire amplifier circuit.

Servicing Voltage Amplifiers

From the servicemen's point of view, the voltage amplifier section of a high fidelity amplifier is functioning properly if:

1. It is providing the gain it should
2. It is doing so without introducing distortion and/or spurious signals such as oscillations or hum and noise.

As for the first criterion, many manufacturers have seen fit to publish gain figures from stage to stage right on the schematic, which is most helpful. When trying to measure the audio signal in plate circuits, be sure to use only a high-impedance meter or a low capacitance oscilloscope. In general, the oscilloscope method is more reliable and faster. Remember that scope deflection is linear whereas decibels are logarithmic. Thus, if gain is given in decibels (and it often is), it will be necessary to convert from one to the other. A couple of good numbers to commit to memory are 6 *db* is a voltage gain of 2; 10 *db* is a voltage gain of 3; and 20 *db* is a voltage gain of 10.

In analyzing waveforms of a voltage amplifier, it is often helpful to disconnect the overall feedback circuit. Very often, an oscillation or other defect is picked up at the voltage amplifier when a later stage is at fault. That is because the feedback circuit ties the two sections together, making it difficult to isolate the trouble. Removal of all feedback makes signal tracing much easier and makes each stage pretty much independent of the previous or following one. One word of caution in this connection. Removal of the feedback will, of course, greatly increase the gain of the amplifier. An amplifier having twenty *db* of loop feedback and requiring 1 volt to drive it to full output will require only 0.1 volt for full power output when the feedback is removed.

[*Continued on page* 28]

trade

Robert I. Mendels has been elected president of Electronic Devices, Inc., Brooklyn, N. Y., manufacturers of a complete line of rectifiers for automatic controls, business machines, computers, radio-TV receivers and transmitters. The company also holds the patent rights to the unique Ventisel selenium rectifier.

• • •

The phonograph record industry, through self-propulsion, is gradually assuming a major role in the American economy. This assertion was made by George R. Marek, Vice-President and General Manager of the RCA Victor Record Division. "The record industry, which dawdled in the doldrums of economic lethargy during part of the 30's and 40's, has revitalized itself," he said. "The results speak for themselves. In 1956, industry sales totaled $300,000,000—the greatest in history.

• • •

Announcement of Charles P. Culbert as representative for Harman-Kardon high-fidelity consoles in California, Arizona and Nevada marks this company's entry as a contender for packaged high-fidelity sales. Harman-Kardon plans to actively merchandise console sales through the Culbert Organization.

• • •

The General Electric Company disclosed that production of a new line of silicon transistors is being stepped up to meet increasing military and industrial demand. The new high frequency, high temperature transistors were developed under contract with the United States Air Force. They are designed for use in military electronic equipment like guided missile computers and controls, automatic pilots, bomb-sighting computers, and military communication receivers. The new silicon transistors are also finding application in industrial equipment control circuits for nuclear reactors, steel mills, and various servomechanisms.

• • •

International Resistance Company, Philadelphia, announces the recent appointment of Mr. Gregory Peters to Controller of IRC's subsidiary, Circuit Instruments Inc., St. Petersburg, Florida.

Cumulative TV output during the first four months of this year amounted to 1,835,975 receivers compared with 2,394,264 made during the like 1956 period. Cumulative television sales totaled 2,020,876 compared with 2,036,808 sold during the first four months of last year, the RETMA computation showed. Sales and production of radio sets increased substantially over the first four months of 1956. Cumulative radio output during the first four months of this year totaled 5,075,180 compared with 4,525,-225 radios made during the corresponding months of 1956. Cumulative radio sales during the first four months of this year totaled 2,362,068 compared with the 1,984,915 radios sold during the corresponding 1956 period. Cumulative receiving tube sales for the first four months of this year totaled 153,011,000 tubes worth $130,192,000 compared with 155,604,-000 tubes worth $125,535,000 sold during the corresponding period last year. Cumulative TV picture tube sales during the first four months of this year totaled 2,952,318 tubes worth $52,974,193 compared with 3,469,405 tubes worth $65,008,912 sold during the corresponding period of last year.

• • •

Transistor sales during the first four months of this year were considerably over the corresponding period of 1956, RETMA announced. Over four million more of the semiconductor devices have been sold thus far this year compared with sales last year. Cumulative sales of such semiconductor devices during the first four months of this year totaled 6,899,300 units with a dollar value of $19,492,000 compared with 2,730,000 transistors with a dollar value of $7,884,000 sold during the corresponding four-month period of last year.

• • •

A full-scale plan of action to combat the rising tide of receiving tube counterfeiting, which already has reached the estimated $100 million mark, is under consideration by RETMA, it was announced. The proposed program is the direct outgrowth of the recent joint meetings of the RETMA Receiving Tube Section, Tube Division, and its Tube Counterfeiting Committee. Spearheaded by a hard-hitting motion picture dramatizing the evils of tube counterfeiting, the action plan would be backed up by public relations and advertising campaigns based on the theme, "You never get something for nothing."

flashes

Oren Harris, House Interstate Chairman, questioned the FCC's tentative decision to authorize subscription television on an experimental basis. Harris based the delay on remarks made at the recent NARTB convention, when panelists agreed they did not know the status of TV. "It is not quite a common carrier," one speaker said, "yet it has many attributes of a public utility. Help will have to be found from Congress."

• • •

Several hundred visitors from staffs of Multi-Tron distributors, attended an open house at their cathode-ray tube manufacturing plant. Nicholas Glyptis, president and research director, demonstrated the Multi-Tron "Pure Signal" picture tube in a television set from which the video amplifier circuits had been removed. Glyptis stated that he expected to see it utilized by several manufacturers in fall models.

• • •

Robert G. Walcutt, President of Electrovox Co., Inc., manufacturer of Walco phonograph needles, announced the appointment of Herbert A. Bodkin to position of Sales Manager. In his new post, Mr. Bodkin will supervise and develop sales for the entire line of Walco diamond, jewel and precious metal tipped phonograph needles.

• • •

Nine California Gray Whales were successfully stuck with harpoons attached to a 49-strand specially made stainless steel cable. Over this cable, made by Sevenstrand Tackle Company, using Allegheny Ludlum Steel Corporation's stainless steel, whale heartbeats were taken. The project was under the direction of the famed Boston heart specialist, Dr. Paul Dudley White, who hoped to gain further basic understanding of human heart action by studying animal pulse rates. The harpoons had electronic pick-ups. The heartbeat impulses were directed to floating shortwave transmitters, which in turn sent the signals to shore and ship based receivers. The delicate impulses were transcribed onto cardiograph tape for later study.

• • •

The appointment of K. E. Weitzel, Schenectady, N. Y., as regional commercial engineer in Chicago for the General Electric Receiving Tube Department has been announced by G. E. Burns.

The Electronics division of Elgin National Watch Company announces the appointment of Albert Binash as sales supervisor in charge of its American Microphone product line. E. C. Carlson, division sales manager, said the appointment completes re-organization in the American line after manufacturing operations were recently transferred from Pasadena, Calif., to Elgin.

• • •

The Magnetic Recording Industry Association at its annual meeting named Irving Rossman, of Pentron Corporation, Chicago, as President; Arnold Hultgren, American Molded Products Co., Chicago, Vice President; Charles L. Dwyer, Webster-Chicago Corp., Chicago, Treasurer, and reelected Herman Kornbrodt, Audio Devices, Inc., New York as Recording Secretary. Joseph F. Hards, of Magne-Tronics, Inc., New York, retiring President, and Victor Machin of Shure Brothers, Inc., Chicago, were named to the Board of Directors.

• • •

A plant estimated to be capable of meeting the recording demands of the entire world for the next 10 years—officially was put into 24 hour-a-day production this month by Minnesota Mining and Manufacturing Co. (3M), St. Paul, Minn. It is a factory built and maintained almost like a hospital in order to achieve near-sterile conditions required to produce "essentially perfect" magnetic tapes necessary for such critical applications as video tape recording, electronic computers and instrumentation recording. The fact that the 3M Company was able to produce special video recording tape for the Ampex recorders which enabled the nation's television networks to switch to magnetic tape by the 1957 daylight saving deadline "can be attributed, at least in part, to the facilities provided by the new plant," the firm said.

• • •

Announcement of the entry of RCA Victor into the growing imported radio market was made with the unveiling of two new AM-FM Shortwave models, a table model and a console, manufactured in Europe to Radio Corporation of America specification. James M. Toney, Vice-Persident and General Manager of the Company's Radio and "Victrola" Division revealed that the radios would be marketed under a new label, RCA International.

POWER AMPLIFIERS In Hi-Fi

By Lawrence Fielding

Part 2

Intermodulation Distortion

Originally, the only measurements of distortion made on an amplifier were of harmonic distortion, or in other words, the effective departure in shape from a true sine wave expressed as a percentage. It was later found that another, perhaps more meaningful type of measurement was possible if *two* sine waves of different amplitude and frequency were applied to an amplifier simultaneously. Any non-linearity of any circuit in the chain will cause a "beating" effect between the two signals which will produce spurious sum and difference frequencies, in much the same way as does the heterodyning process used in superheterodyne receivers. These frequencies, not present in the original input signal, are expressed as a percentage and this figure is known as the intermodulation distortion. Inasmuch as different instruments have a different procedure for making this measurement it would be impossible to describe the routine for every case. *IM* measurements give a quick evaluation of an amplifier's distortion. It should be noted that the *IM* distortion of a given amplifier will generally be about three to four times the figure given for harmonic distortion, so be careful in reading manufacturers specifications to notice whether harmonic or *IM* distortion limits are being specified.

Frequency Response

The frequency response test is conducted in the same manner as the power response test, except that the level of output should be kept low—about 1 watt for an amplifier rated at 10 or more watts. Since the wattage level is not critical, many servicemen find it convenient to use the "0 db" setting on the 1 volt or three volt scale since it is easier to interpolate points above and below that mark on most meter scales.

Damping Factor Measurements

The damping factor of an audio amplifier is a measure of its ability to "damp out" or restrict any overshoot or self-reverberation that the mechanically suspended speaker cone might exhibit if left on its own. Since a loudspeaker in this instance, acts as somewhat of a voltage generator and a back e.m.f. is developed, the more nearly we can place a short circuit across the speaker terminals, the more perfectly will we "damp out" these secondary, non-musical reverberations. The impedance that a loudspeaker "sees" as it looks back into the amplifier is considerably lower than the so-called "nominal" impedance (8 ohms, 16 ohms etc.) because of negative voltage feedback employed in most present day amplifiers. This "source impedance" divided into the nominal loudspeaker impedance is called the damping factor. A simple way of calculating this factor (and thus determining if a given speaker has the recommended amount of electrical damping by virtue of the amplifier) is to first feed a signal into the amplifier so as to produce a *very low* output voltage as read by the *ac* VTVM with *no load* whatsoever placed across the output terminals other than the VTVM itself. Suppose this voltage is .1 volts. Proceed to place as many 5 ohm, ½

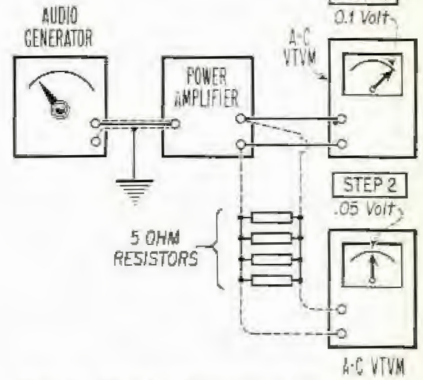


Fig. 3—Block diagram of set-up for damping factor measurement.

watt resistors as necessary across the output terminals to reduce this reading by ½ or .05 volts. Solder all the resistors to each other in parallel, as even a fraction of an ohm of contact resistance makes a considerable difference in the calculated results. When a reading of .05 volts is obtained, count the number of parallel resistors used and divide into 5. This will give the source impedance of the amplifier in question. Now divide this figure into the speaker impedance to obtain the damping factor of the system. See *Fig. 3* ■■

INDUSTRIAL T.V.

[*from page 13*]

which may now be tuned in by any of the several standard receivers. This method is used for longer hops than are possible with a single *rf* oscillator. Remote links use this method.

Industrial Applications

Applications of ITV are growing very quickly and are still rather new.

U. S. Steel uses ITV to monitor steel furnaces and production lines of tin plate at their Gary, Indiana plant. Combination stores and repair shops use ITV to watch the store counter while the technicians are busy in the shop.

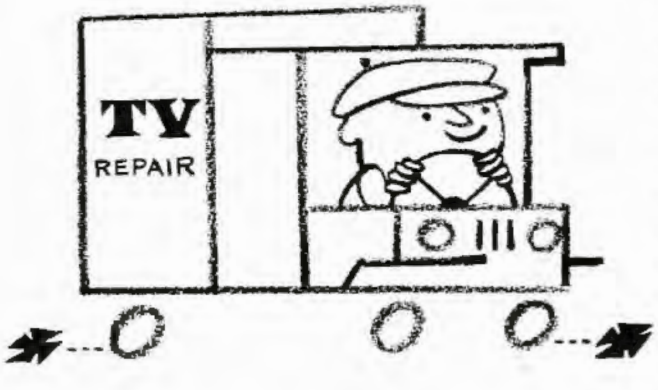
Plant protection uses several cameras to watch fences for intruders. A single operator can watch the fence-line for a large industrial plant, thus saving manpower. Badges can be checked at several points as workers enter or leave a plant.

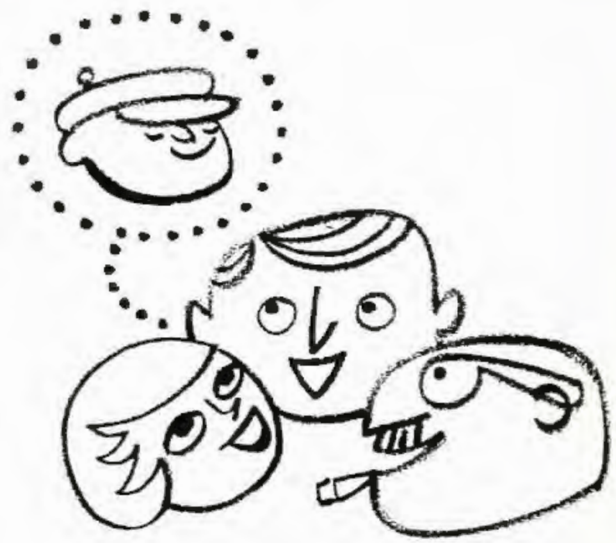
Traffic Control in large cities can be augmented by ITV. A view of the most important intersections can help direct traffic and prevent traffic-jams.

Banks use ITV to view records sent from a central location to many different monitors so balances and signatures may be verified.

Some of the many nses for ITV are:

Materials Handling
Assembly Aid—Large Parts
Assembly Aid—Small Parts
Observing Automatic Processes
Hazardous Observation in Steel Plants or Arsenals
Boiler Ignition Inspection
Microscope Projection
Quality Control Checks





Atomic Assembly
Traffic Control
  a) Automobile
  b) Railroad
  c) Airplanes
  d) Pedestrians
Patient Observation in Hospitals
Reading Gauges
Checking Burner Flames and Stacks
Fire Detection in Factories
Observing Wind-Tunnel Tests
Remote Time and Motion Study
Inspecting and Identifying Railroad Cars
Loading Scrap in Railroad Cars
Locating Spaces in Parking Lots
Detecting Forest Fires
Guard Service
Factory Area Observation
Military Reconnaisance
Watching Children
Watching Toll Booths
Dental Training
On-the-job Training
Medical Training
Promotion of Store Displays
Remote Viewing of Meetings
Transfer of:
  Blue-print information
  Prodnction information
  Signature verification
  Passenger and freight
  Elevator scheduling

ITV has perhaps its greatest usefulness in dangerous areas and difficult viewing probems. Dangerous locations in industry where radio-activity, heat, the possibility of explosion, or exposure to chemical fumes limit actual exposure are naturals for ITV. The viewer can see the process and yet be perfectly safe at a different and protected location.

Another area of great usefulness is in locations where human observers just cannot physically be located. ITV cameras in smoke stacks, under-water, or other difficult locations provide clear TV pictures to remote viewers.

Dangerous Operations

The Seneca Ordnance Depot, Romulus, New York, is using closed circuit TV to observe and control a highly dangerous operation—the disassembly of "live" but obsolete bombs, ranging in size from 155-millimeter artillery shells, to 2000-pound aerial blockbusters. *Fig. 8* shows a bomb being placed in position. Since tremendous, heat-producing pressure must be exerted when removing the boosters from the bombs, this most hazardous step in the salvage operation is closely observed by the camera which transmits the information to a monitor as in *Fig. 9,* located 300 feet away in a bunker with concrete walls three feet thick. Here the munitions handlers can view the operation and at the first sign of excessive pressure, a tell-tale wisp of smoke, the disassembly machine can be idled by remote control while water pours on the projectile.

More than thirty bombs a day are disassembled under the watchful eye of this system and, as one munitions handler states, "we haven't lost a bomb or a TV camera yet."

Alignment of Heavy Equipment

Closed circuit Television is presently in use in conjunction with a jig alignment telescope, to correctly and accurately position four and five-ton gas turbine sections at the General Electric Gas Turbine Department in Schenectady, New York.

In this application of TV, when turbine shells are being aligned, the camera is bolted, leveled and centered on the first, or master, shell. When another shell is to be attached, a target is centered in the new shell and the camera lens focused to the known distance from the target. Then, by watching the monitor, located some fifteen feet from the camera, the operator notes where the target lies in relation to the camera lens and is able to carefully adjust the shell-connecting bolts and align the new shell.

This technique replaces the old method of aligning turbine shells by stretching a taut wire through the turbine and estimating when the shells were in position. ■■

HI FI VOLTAGE AMPLIFIERS

[*from page 23*]

Lead Dress

While the signal level at the input to an amplifier is usually large enough to be beyond the hum problem normally encountered in preamplifiers, it is still possible to introduce hum by improper techniques. Normally accepted wiring techniques are still very much in order. New chassis grounds are to be avoided when making a parts replacement. Many amplifiers employ a single ground bus which is returned to chassis only at one point in the vicinity of the input. Still others use grounding systems which may appear strange, at first, but which can usually be justified after careful study. For example, the ground normally associated with the speaker output terminal strip is very often *not* grounded at that point on the chassis, but returned, by means of a separate lead, all the way to the triode or pentode cathode where overall feedback is applied. This is done to prevent the setting up of a "ground hum loop" through the feedback circuitry and can often mean a difference in hum of 10 or more decibels. In general, try to restore the exact lead dress and routing originally built in by the manufacturer. This practice will prevent the appearance of high frequency oscillations, which can complicate an otherwise simple repair job. Use quality replacement components throughout. Crackling and hissing in an otherwise perfect amplifier is often traced to an inferior noisy resistor in a low level, high gain voltage amplifier stage and can be found only by substitution.

Microphonics

As in preamplifiers, the first stage of a power amplifier must be free from microphonics. Very often, a new tube which was free from this defect can develop the trouble after months of aging. It should be replaced and the new tube should be tapped gently to make certain that it is free of this fault.

Next month we shall follow the signal into the phase inverter, and discuss the many ways in which an audio signal is split into two signals, opposite in phase, for ultimate use in push-pull power amplifier stages.

Mfr: Admiral **Chassis No.** 20AX5

Card No: A20AX5-1

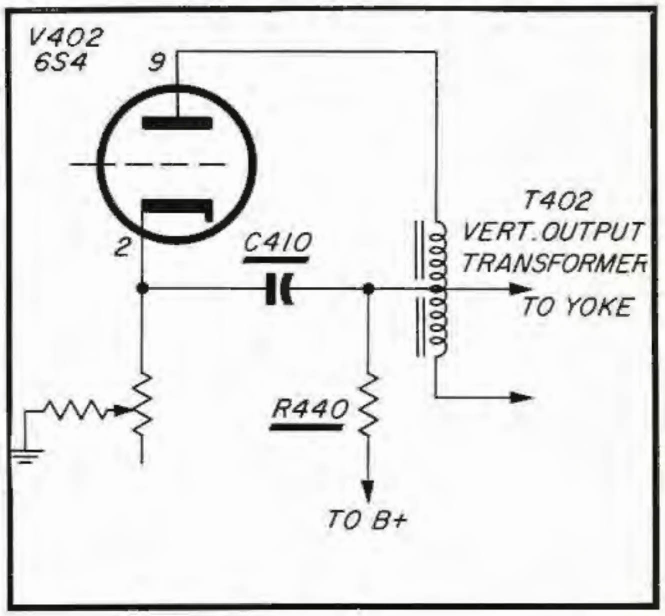
Section Affected: Raster

Symptoms: No vertical deflection.

Cause: Shorted *C410*

What To Do:

Replace *C410, 20mf* 475 volts.
Also: change *R440* (1.2K 1 watt) to 3.3K 2 watts. This change lowers the voltage on *C410*. (Chassis so modified are coded Run 4.)



Mfr: Admiral **Chassis No.** 20AX5

Card No: A20AX5-2

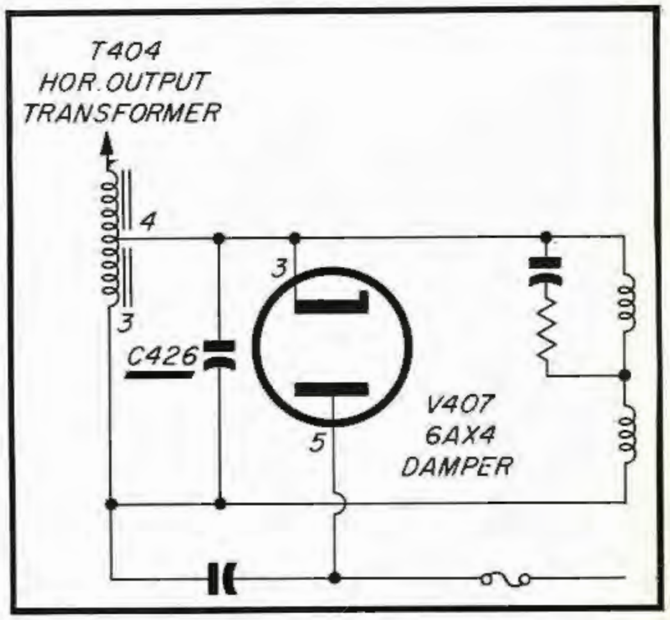
Section Affected: Raster

Symptoms: Lack of width.

Reason For Change: Circuit improvement.

What To Do:

Add: *C426* (47 *mmf*, 3000 volts, *N150* Temp. Coeff.) (This change has been incorporated in some models.)



Mfr: Admiral **Chassis No.** 20AX5

Card No: A20AX5-3

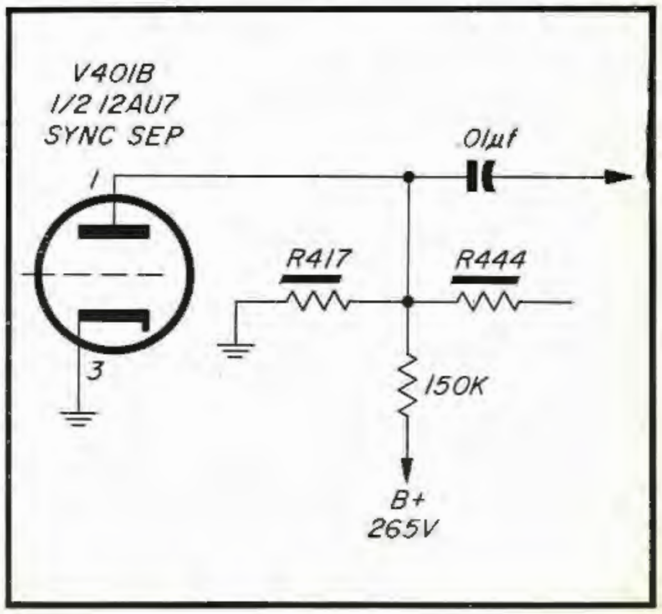
Section Affected: Sync.

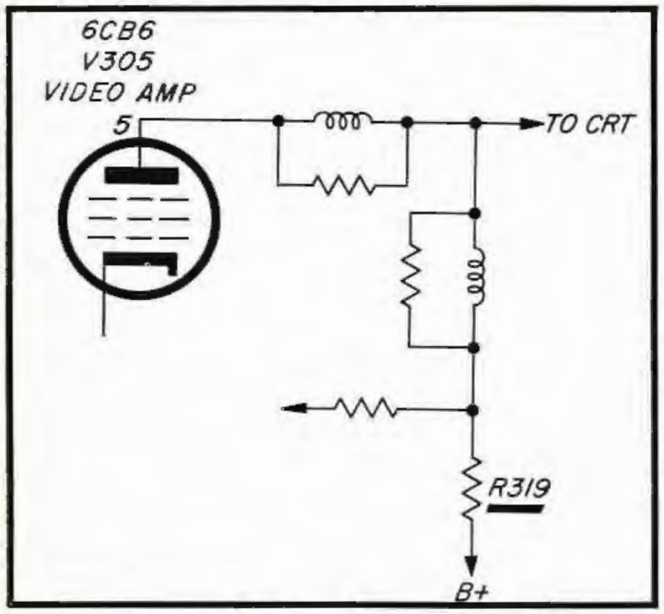
Symptoms: Poor horizontal sync.

Reason For Change: Circuit improvement.

What To Do:

Change: *R417* (27K 5%) to 39K ½ watt.
Also: *R444* (2.7 meg) to 3.3 meg.





Mfr: Admiral **Chassis No.** 20AX5

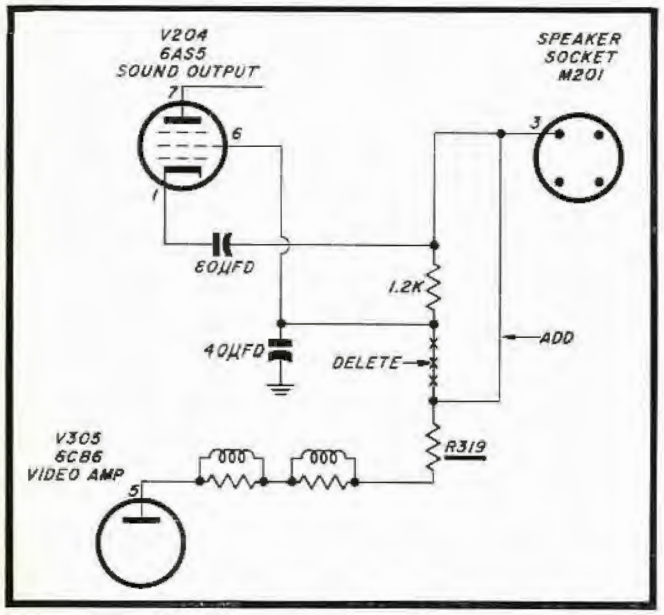
Card No: A20AX5-4

Section Affected: Pix

Symptoms: Flashing and streaks in picture.

Cause: Intermittent video plate load resistor.

What To Do:
Replace *R319* (5.6K 1 watt) with a 5.6K 2 watt.



Mfr: Admiral **Chassis No.** 20AX5

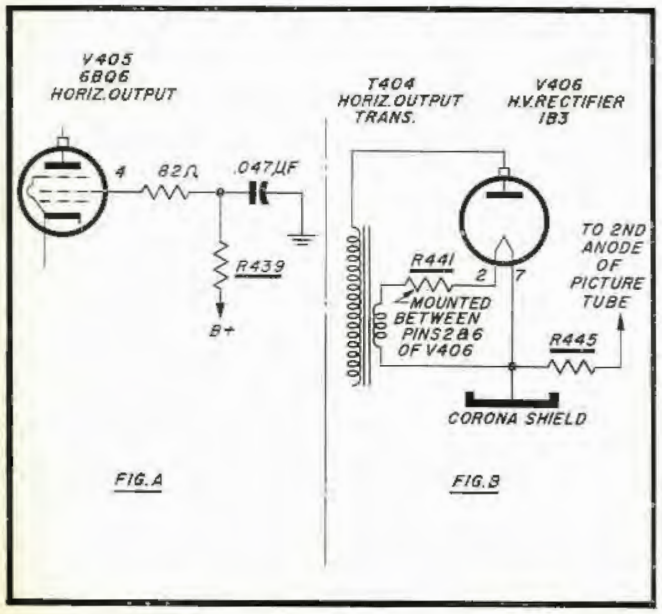
Card No: A20AX5-5

Section Affected: Raster and Pix.

Symptoms: Interaction between audio and video signals.

Reason For Change: Circuit modification to reduce interaction between pix and sound.

What To Do:
Remove: *R319* (5.6K 2W) from pin 6 of V204 and reconnect to pin 3 of *M201* socket. (This change has been incorporated in some models.)



Mfr: Admiral **Chassis No.** 20AX5

Card No: A20AX5-6

Section Affected: Raster

Symptoms: Lack of width.

Reason For Change: Circuit improvement.

What To Do:
Change: *R439* (18K 2W) to 15K, 2W (*Fig. A*). Also: *R441* (4.7 ohms) to 3.3 ohms (*Fig. B*). Add: *R445* (180K ½W) between pin 7 of *V406* and the second anode of the CRT (*Fig. B*). (This change has been incorporated in some models).

Mfr: CBS **Chassis No.** 3000 Series

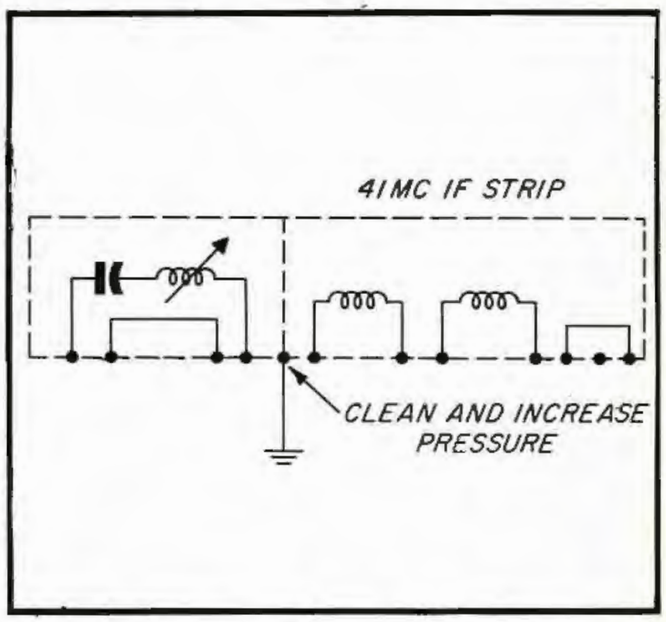
Card No: CBS 3000-1

Section Affected: Pix

Symptoms: Black and white bars when channel selector is placed in UHF position.

Cause: Regeneration in *if* due to poor contact of ground strip in the 41 *mc* feed through tuner strip.

What To Do:
Clean contact area and increase spring pressure.



Mfr: CBS **Chassis No.** 3000 Series with Robot Tuning

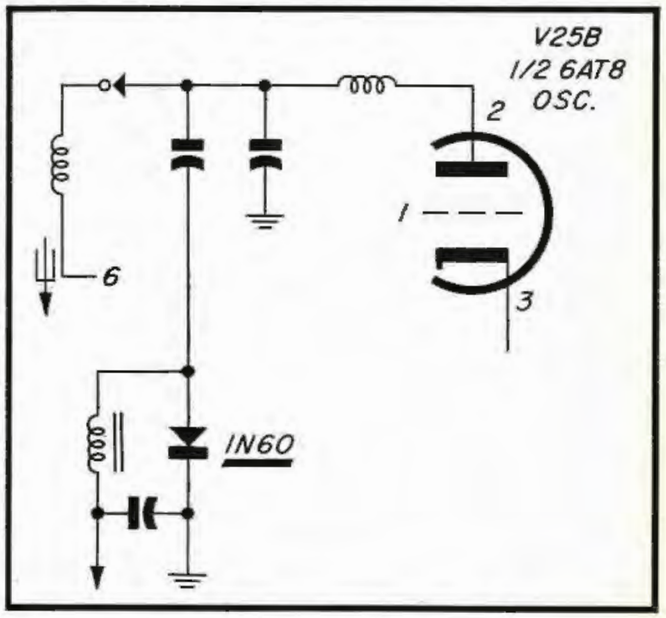
Card No: CBS 3000-2

Section Affected: Sound and Pix

Symptoms: Fine tuning control does not function.

Cause: Poor contact in fine tuning crystal holder.

What To Do:
Clean contacts of crystal holder and seat firmly.



Mfr: CBS **Chassis No.** 3000 Series

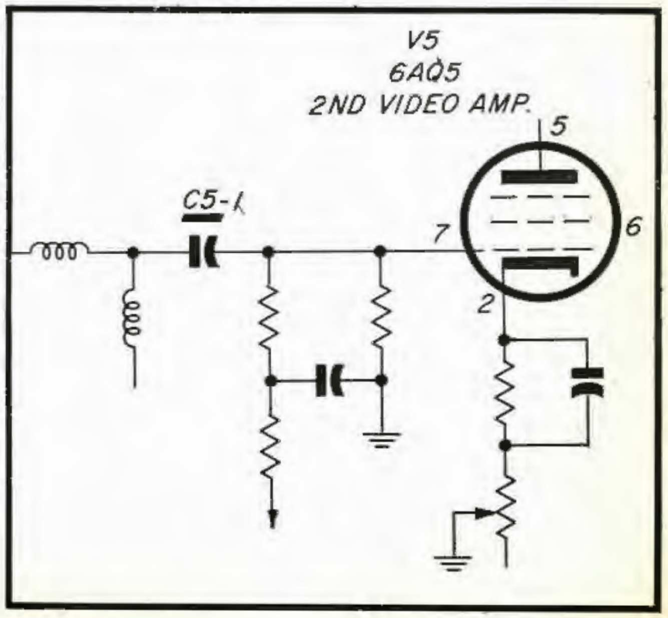
Card No: CBS 3000-3

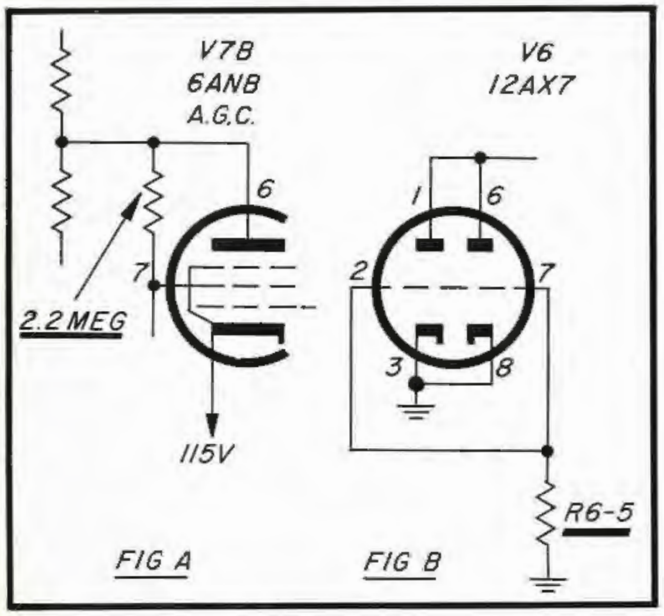
Section Affected: Pix

Symptoms: No pix, raster and sound o.k.

Cause: *C5-1* Shorted.

What To Do:
Replace C5-*1* with a *.1 mf* 400 V condenser.





Mfr: CBS **Chassis No.** 3000 Series

Card No: CBS 3000-4

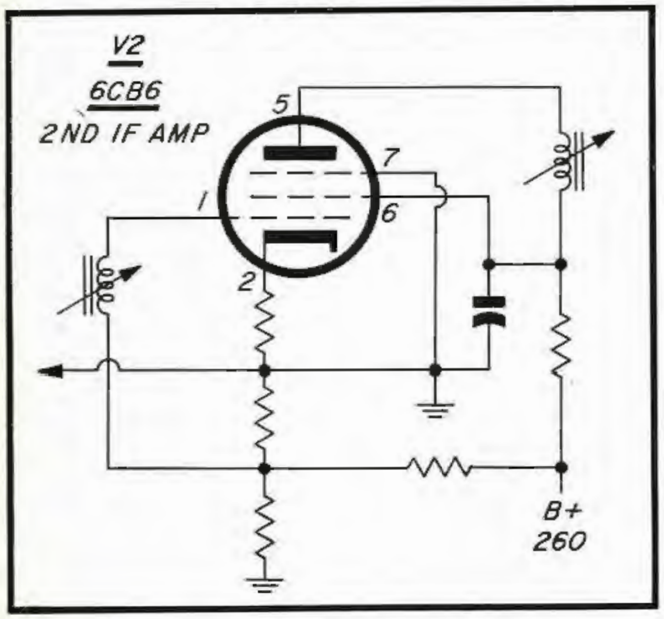
Section Affected: Sync.

Symptoms: Horizontal pull on strong signals.

Reason For Change: Circuit improvement.

Reason For Change: Circuit improvement.

What To Do:
Add: *2.2 meg* ½ watt resistor *Fig. A.*
Change: *R6-5* (2.2 meg.) to *4.7 Meg. Fig. B.*



Mfr: CBS **Chassis No.** 3000 Series

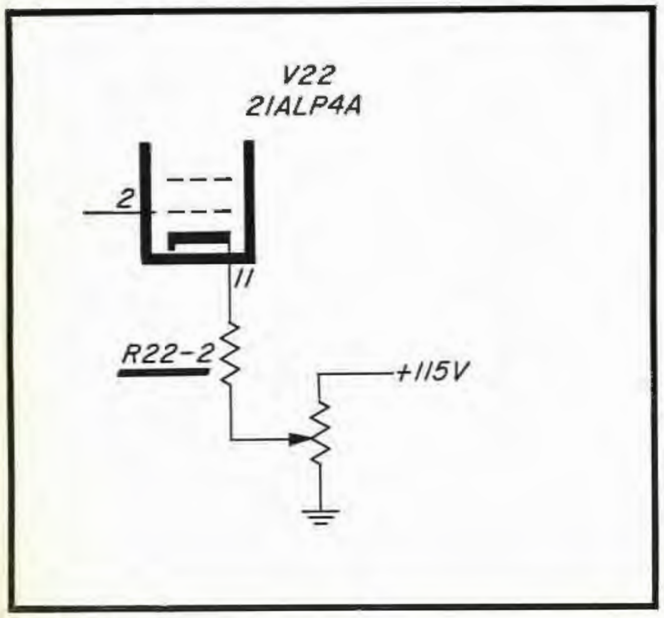
Card No: CBS 3000-5

Section Affected: Pix

Symptoms: Low sensitivity on very weak signal.

Cause: Parasitic oscillation in the second *if* stage developing negative grid bias.

What To Do:
Replace 6CB6-V2 second *if* amplifier.



Mfr: CBS **Chassis No.** 3000 Series

Card No: CBS 3000-6

Section Affected: Raster

Symptoms: Limited brightness control.

Cause: Defective resistor.

What To Do:
Change *R22-2* a 150K ½ watt resistor.

MARINE ELECTRONICS

[*from page 11*]

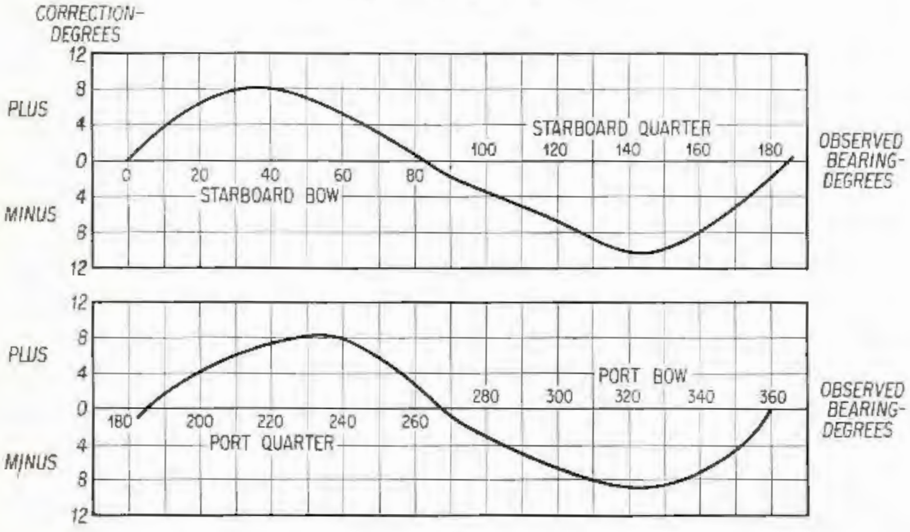


Fig. 3—The chart shows the number of degrees a reading must be corrected to insure accurate bearings when the visual and radio readings differ.

Regardless of how the visual bearings are determined, however, the procedure is the same.

A radio beacon, such as that on a lightship, makes an excellent signal source for calibration. In many instances I have found it possible to sail up to such a station and hail the people on board with a request that they turn on the radio beacon for calibrating purposes or I have made this request over the radiotelephone, using the Coast Guard or International Calling Frequency. If this system is employed, be sure to advise station personnel when the calibration is completed in order that they may shut down the transmitter.

Now, align the radio-direction finder scale and the visual pelorus so that zero degrees is dead ahead. Take the boat off a mile or so from the beacon station, then head it directly for the transmitting antenna. When in exact alignment, a bearing should be taken by radio and by the visual means, and a recorder should write down the exact number of degrees for both observations. Then, the boat should be slowly swung around and settled down on course at separations of ten-degrees "around the clock." At each of these points, a radio and a visual bearing should be taken. It is usually found that a graphic plot of the difference between radio and visual bearings will result in a sine curve. Such a graph can be posted with the radio direction finder for the correction of observed to true relative bearings; or else the information may be posted in tabular form, similar to the list of differences made at the time of calibration. The curve, or graph, will then show the number of degrees, plus or minus, to apply to a radio bearing to obtain a correct reading. Such a graph is shown in *Fig. 3*.

In localities lacking a convenient marine-beacon transmitter, you can use broadcasting or airway-beacon towers near the water for calibration. However, it should be noted that figures obtained on widely differing frequencies from those on which navigational bearings are going to be obtained should be

Fig. 4—Suspended installation is always physically level.

used only for temporary guidance until the boat is in an area where a station is available for more accurate calibration. By showing the skipper the procedure, this later calibration may be performed by the boat's own personnel.

It may occasionally be found that a very great deviation is experienced due to the closeness of lifelines, rigging, or other top hamper. Deviation in excess of ten degrees or so is serious enough to make accurate observations very difficult. In such cases, the best procedure is to analyze the rigging and wiring around the direction finder, then to move or break up with insulators any spans which form closed loops or which appear to have resonant effects at the frequencies being used. By this means it should be possible to get bearing deviation down to a tolerance of one or two-degrees.

In the actual operation of the direction finder, other unavoidable errors may be experienced. One possible source is "night effect," when reflected signals "mush up" or distort the null. In such case, radio bearings cannot be trusted, and the operator must wait until satisfactory nulls are again obtained before placing reliance on his observations.

Bearings taken over distances greater than 50 miles are subject to plotting error due to the distortion of Mercator Projection charts. Accordingly, a correction must be applied to the radio bearing before laying out the line on the chart. This procedure is described in navigational books and tables under information on laying out a great-circle line on Mercator charts.

Sailing vessels are also subject to heeling error. This must be taken into account, and can be corrected mathematically. It may also be corrected physically by levelling the direction finder while taking bearings, by changing course or slacking off the sheets momentarily to right the boat, or by the special installation shown in *Fig. 4.*

But all of these tricks are actually in the navigator's province, and not the radio technician's. Do a careful job of installing and making the initial calibration, and the navigator can do the rest. This suggests a sideline for salt-water servicemen; become a radio-navigation expert. This is a field in which I have never seen any crowding! ■ ■

1957 PHILCO

[*from page 5*]

ing the plug from the CRT socket and changing the strap to pins 6 and 10. Pin 10 is approximately 200 volts positive. Due to the manner in which the pins on the CRT base are located these are the only 2 positions of the strap, eliminating any possible error. Focus is also affected to some degree by the adjustment of the ion trap and/or adjustment of the centering assembly which has 2 metal tabs directly in back of the yoke.

UHF—VHF Tuner

The *vhf* tuner on those chassis adaptable for a *uhf* tuner is an incremental type with a modified wafer switch. The *rf* and oscillator coils are mounted on discs which are attached to the rotor shaft. The *rf* stage is a cascade amplifier. The output of the tuner, as in all *vhf* tuners employed in Philco models, is a 45.75 *mc* signal.

The *uhf* portion of the tuner consists of a small sub chasis which plugs into the front of the *vhf* tuner and is activated when the *vhf* tuner's channel selector is placed in *uhf* position. The *uhf* tuner tunes through all *uhf* channels.

On those chassis not adaptable to *uhf*, the *vhf* tuner is physically similar to the one previously described but does not have the switching arrangement for *uhf* and is not interchangeable with the combination tuner.

Sound Section—Dynamic Limiter

Sound is separated at the output of the video amplifier by means of a transformer, the primary of which serves as a 4.5 *mc* trap. The 4.5 *mc* intercarrier sound system incorporates a dynamic limiter employed for the first time in the 1957 Philco models. The remainder of the audio system is conventional and contains discriminator, audio amplifier and audio output stages.

Since the dynamic limiter is relatively new a description of its operation is included here. The dynamic limiter provides reduction to both upward and downward amplitude modulation (or noise) of a particular signal carrier while at the same time it's operating threshold (bias) is self adjusted with the particular carrier level. The dynamic limiter may be either single or double sided and employ one or two diode tubes respectively. The single sided limiter is employed in Philco receivers.

The single-sided limiter employs a single diode which in conjunction with the associated tuned circuit provides the necessary limiting of the positive and negative signal excursions. The circuit of the dynamic limiter and associated stages is illustrated in *Fig. 4.*

The values of resistance and capacitance in the cathode circuit of the diode are chosen for a relatively long time constant compared to modulation (noise) that might appear on the *rf* carrier signal. Thus the bias developed across the *RC* cathode circuit is established by the circuit values and the car-

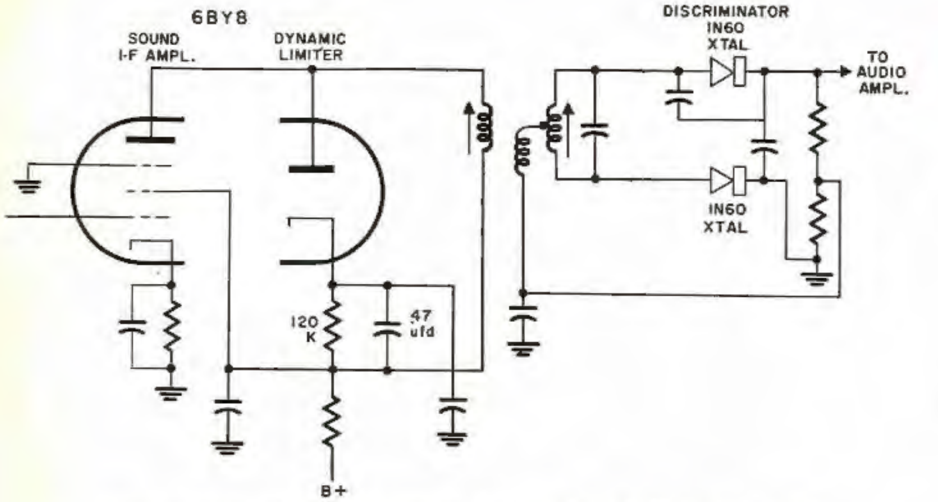


Fig. 4—Partial schematic showing the "single sided" limiter circuit.

rier level. An increase or decrease in carrier level affects the bias proportionately and in turn the resultant output signal.

Modulation which appears on the positive side of the carrier is leveled by the diode in what might be described as an action of loading and unloading the tuned circuit. Positive modulation above the carrier level (diode bias) is reduced since the diode conducts and appears as a load shunted across the tuned circuit at this time. Modulation that goes below the carrier level causes a decrease in diode current. The effect is one of unloading the tuned circuit, resulting in a leveling of modulation below carrier level.

On the negative side of the carrier, reduction of amplitude modulation is associated with the Q of the resonant or tuned circuit. If the tuned circuit has a low Q, the impedance would be relatively the same for the fundamental carrier frequency and all significant harmonics. In this instance, diode conduction would limit positive modulation but negative modulation would be unaffected. If the Q of the tuned circuit were infinite (very sharply tuned), the negative signal modulation would be limited by filtering action to the same degree that the modulation in the positive region was limited by diode conduction. This is brought about by the ringing action of the high Q tuned circuit which redistributes the modulation about zero so that some of the negative modulation appears on the positive side to be leveled by the diode action. This action occurs in a rapidly decreasing fashion (almost instantaneous) until the negative modulation is leveled. The circuit Q must be above a certain value (critical value) before the tuned circuit becomes effective in reducing negative amplitude modulation. The output signal, a relatively undistorted sine-wave signal, is applied to the discriminator for detection of the audio intelligence. The discriminator employs crystal diodes in place of diode tubes.

[*To be Continued*]

TRANSISTOR THEORY

[*from page 9*]

it as in *Fig. 9B,* we would increase the opposition to the flow of forward current without affecting the reverse current, which remains at saturation. In effect we would be reducing the flow of majority electrons and holes across the junction because we would be supplementing the number of opposing charges at the junction. This method of connection is called *"reverse bias."*

Increasing or decreasing the forward bias increases or decreases the forward current. The reverse current, however, remains the same, saturation having already been effected.

In this figure we show the relative forward and reverse currents for forward and reverse bias. Notice that the reverse

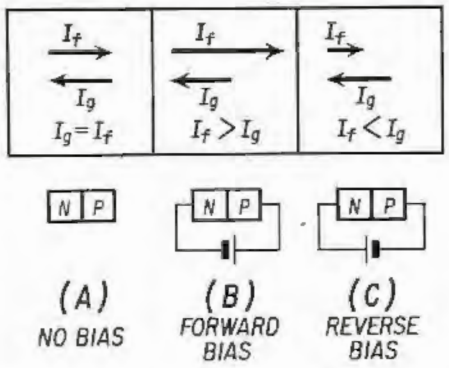


Fig. 10—I_g is constant for all values of bias. I_f varies with bias. Total current equals: $I_f - I_g$ or $I_g - I_f$.

current I_g remains the same for forward and reverse bias.

Figure 10 summarizes the relative values of I_f and I_g for the various biases discussed. Here we show that for all values of bias, including zero, the reverse current I_g remains at a constant value representing saturation. On the other hand the forward current, I_f, varies with the amount and polarity of the bias connected across the junction.

Rule for Forward and Reverse Biasing

From the foregoing discussion a rule may be advanced which determines how a battery should be connected across an N-P junction to increase or decrease the forward current. This rule is as follows:

"If it is desired to *promote* the forward flow of current through an N-P junction, the battery should be connected for forward bias, so that it neutralizes the charged layer along the junction. If it is desired to reduce the forward flow of current the battery should be connected for reverse bias so that it adds to the charge along the junction."

N-P Junction Rectification Characteristics

The manner in which current varies with voltage for conditions of forward and reverse bias is shown for a particular sample of germanium in *Fig. 11*. At the outset it should be pointed out that conventionally the voltage is plotted along the horizontal axis and the current along the vertical axis. However, when plotting transistor characteristics we most often find the opposite to be the case. This is an offshoot of the manner of presentation preferred by physicists, and with increasing familiarity should be easily followed. The portion of the curve to the right of the zero current line represents the manner in which the total current varies with voltage when the battery is connected for forward bias. The portion of the curve to the left of the zero current line represents that variation of the total current with applied voltage when the battery is connected for reverse bias. Notice that in this portion of the curve a constant saturation current exists for a wide range of applied voltages. This portion corresponds to the constant reverse current flow due to the intrinsic carriers present in the material. Notice that the forward current is given in amperes and the reverse current in milliamperes, which indicates the high forward to reverse current ratio existing in N-P junctions.

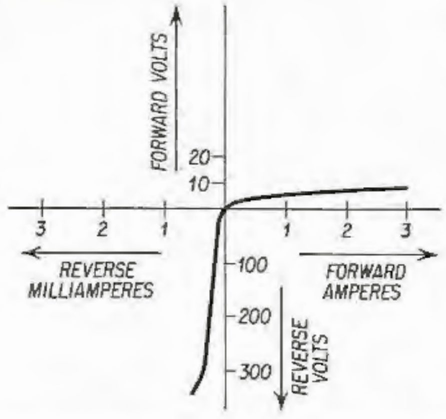


Fig. 11—Rectification characteristics of typical germanium unit.

It is obvious that if instead of using a biasing battery, a source of *ac* were connected across the junction the resulting carrier flow would be high for one half the cycle and low for the other half. Thus, an N-P junction is, in effect, a rectifier, just as a diode vacuum tube. In contrast to vacuum tube action, which permits only unidirectional electron flow from cathode to anode, and in which no reverse current flows, in semiconductors there is always a certain amount of reverse current flow due to the intrinsic carriers present. Naturally, in normal rectification applications the ratio of forward to reverse current is kept as high as possible.

[*To be continued*]

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