RADIO & TELEVISION DATA

for

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Serviceman's Analysis of

Simplified Outline of the NTSC Standards for

By Irving Shulman

• Servicemen may recall the excitement generated in 1951, when the FCC announced that it had approved a set of "spinning wheel" standards for commercial color - television transmissions. Controversial interest died when the Government issued an order that all color-television manufacturing be stopped, in order to conserve vital materials and manpower needed for defense.

The color-television transmission standards approved at that time were for a *field sequential system*, which was non-compatible with existing monochrome (black and white) transmissions. This meant that color telecasts could not be received on the millions of monochrome receivers already in use. To receive color transmissions in monochrome, the vertical and horizontal deflection circuits of the black-and-white receiver would have had to be altered; other circuit changes would have been necessary as well.

There were various objections to the field sequential system from an engineering viewpoint. Let us briefly review the field sequential system. A little history of this sort will enable us to better understand the system the FCC approved.

Three fields were transmitted in succession in the field sequential system: first red, then green and last blue. These fields represented the light falling on the camera tube from the color scene being televised. Two sets of the above-mentioned three fields were interlaced, producing a complete color picture or frame. Twenty-four frames were transmitted each second.

Defects of Old System

Now, the existing monochrome television channel has a bandwidth of 6 MC. In order to transmit three complete color pictures, with an amount of detail in each color equivalent to that present in the regular monochrome transmissions, much more than 6 MC is needed. Since only 6 MC was available, however, the amount of detail contained in each color picture was reduced, in order to permit the color transmissions to be squeezed into a 6 MC channel. As a result, picture detail was impaired. The low twenty-four frames per second rate introduced objectionable flicker, and color instability was noted in scenes where rapid motion was present.

The radio and television industry's NTSC (National Television Systems Committee) for the past two years has been developing and field testing a color television system. In July, 1953, this committee's proposal was submitted to the FCC for approval. When the FCC approved the NTSC color system, excitement was renewed in the television industry. Public sale of color television receivers was a fact in the early portion of 1954. Let us see what the NTSC has done to overcome the shortcomings of the field sequential system.

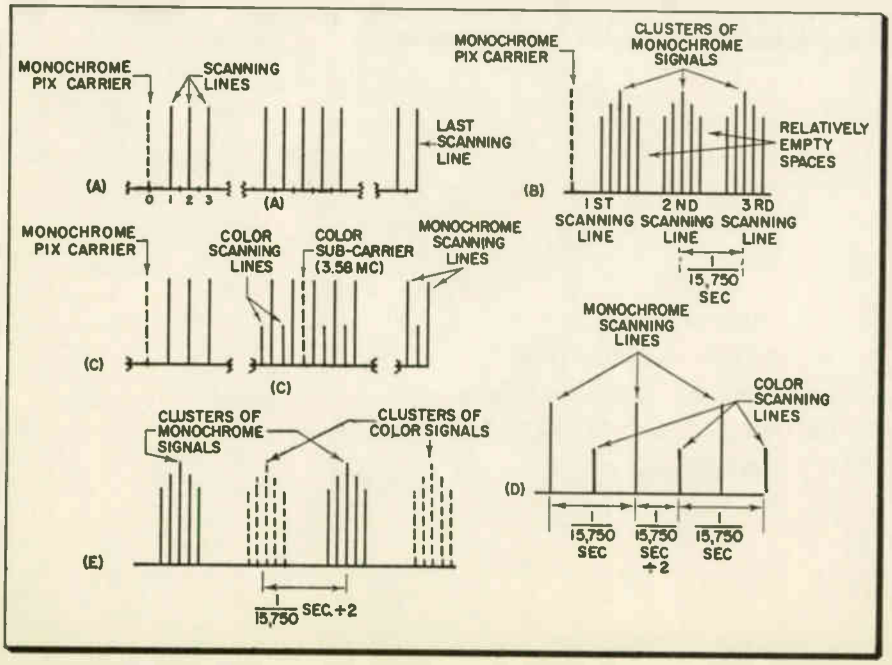
Definition and Compatibility

In the first place, the NTSC color system is a compatible one. A color broadcast can be received in monochrome, on a conventional black-and-white set. No alterations or circuit changes are needed.

Secondly, NTSC color transmissions will provide all the detail present in monochrome transmissions. The NTSC transmission is actually a high-definition monochrome picture with color added; yet it needs only the 6 MC allocated for the regular black-and-white television transmission. How was this miracle accomplished, when only a few years ago it was thought that 12 MC of bandwidth would be required for a color transmission of equivalent fidelity? We'll soon see.

The engineers had a tough nut to crack. These were the problems that confronted them: 1—The color system had to be compatible with monochrome TV. 2—It had to provide pictures containing detail equivalent to that present in black-and-white TV. 3—The colors had to be convincing to the eye. 4—The system had to provide freedom from flicker, and color instability. 5—The

Fig. 1—A) If no video information is being transmitted, the horizontal scanning lines may be represented as a series of pulses, equal in amplitude and separated from each other by 1/15,750 of a second. Only a few lines are shown. B) When video information is being transmitted, a cluster of video signals is associated with each scanning line. Note the empty spaces between clusters. C) If color scanning lines were mixed with monochrome ones, the result could be pictorially indicated as shown above. D) Close-up view of monochrome and color scanning lines. E) Enlarged view showing appearance of modulated scanning lines when color signals are inserted between the monochrome ones.



the New TV Color System

Color Transmission That Have Been Approved by the FCC

color system had to stay within the existing 6 MC monochrome TV channel.

Investigations disclosed that the human eye had certain characteristics of which advantage could be taken:

1—In the case of large areas, the eye has three-color vision. That is, any color scene can be reproduced by blending in the proper proportions of light from three "primary" colors, usually red, green and blue.

2—With respect to areas containing medium-sized detail, the eye needs only two-color vision. Blues become indistinguishable from greys or yellows of equal brightness in such cases. Browns tend to blend in with crimsons. Light from only two primary colors is needed in these instances to reproduce the color scene.

3—The eye is practically color-blind when viewing small detail.

Adding Color

These findings, abetted by a great deal of experimentation, resulted in the conclusion that if a high-definition monochrome signal were transmitted, only a relatively small amount of coloring information would have to be added to create an acceptable color picture. Tests showed that only 1.5 MC of bandwidth would be required to transmit the necessary color information. The process of superimposing a low-definition color picture on a high-definition black and white one, incidentally, is known as *"mixed highs."*

Now, where can the additional 1.5 MC of radio-frequency spectrum needed to transmit the color information be obtained?

In seeking an answer to this question, engineers mulled over the fact that the normal monochrome system does not utilize the radio-frequency spectrum assigned to it efficiently. Many unused gaps exist in the range of frequencies covered by each channel.

Researchers long ago pointed out that for most scanned subjects, almost all the signal energy present is concentrated at frequencies that are whole multiples of the line-scanning frequency. About mid-way between these heavily-occupied areas are comparatively vacant ones. At odd multiples of half the line frequency, in other words, relatively unused stretches of spectrum are available (see Fig. 1A, B). Color information can be inserted into these gaps.

Band-Width Conservation

If the color carrier frequency is correctly chosen, the color signal sidebands (which contain the color information) will fall between the sidebands that contain the black and white information (see Fig. 1C, D, E). This process, which is known as *band-sharing* or *frequency interleaving,* was the one actually adopted by the NTSC.

In practice, it was discovered that mutual interference is present when band-sharing is practiced—that is, color signals interfere with the monochrome ones, and vice versa. The dot interference pattern created is, however, not objectionable at normal viewing distances (just as the presence of the scanning lines in a black and white picture is not annoying).

The frequency chosen to represent the color carrier is 3.57945 MC. It is referred to more conveniently as 3.58 MC. This frequency is an odd multiple of half the horizontal scanning rate ($\frac{15{,}750 \times 455}{2} = 3.58$ MC, app.). 3.58 MC is a video frequency; the corresponding radio frequency can be obtained by adding 3.58 MC to the black and white RF carrier.

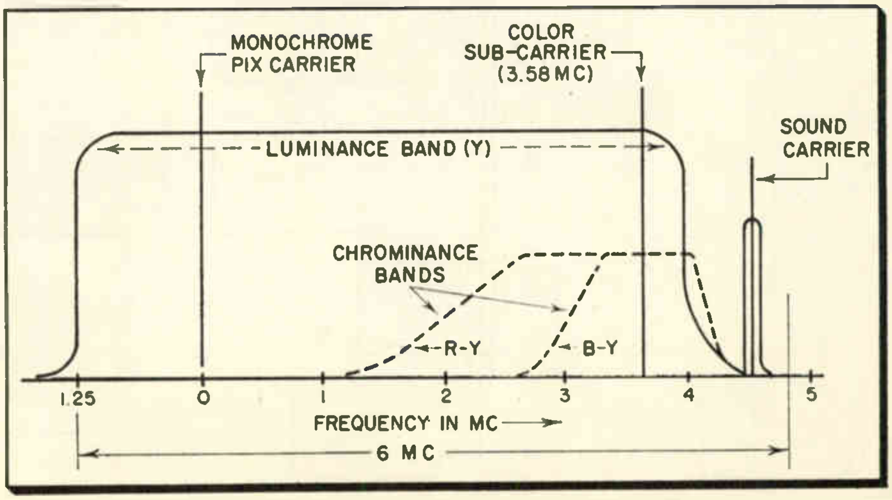
Band-sharing or frequency interleaving does not make the color sub-carrier components completely invisible in the black and white spectrum, due to non-linearities that exist in the TV system, as well as insufficient persistencies of vision. These components are visible but not readily apparent at normal viewing distances, when 3.58 MC is used as the sub-carrier frequency. There are reasons why a lower frequency might be more desirable (to minimize cross-talk between color signals at the receiver, for instance); 3.58 MC was, however, determined by tests to be the best compromise frequency.

Band-Width Relationships

The band-width relationships of the NTSC color system to the black and white information are shown in Fig. 2. Note that only 1.5 MC, app., is allotted to the color or *chrominance* signal; 4.2 MC is given to the black and white or *luminance* signal (the latter is also referred to as the monochrome signal).

The information transmitted is limited to the amount that the

Fig. 2—Bandwidth relationships of color and monochrome signals. Approximately 1.5 MC is allotted to color signals; monochrome information gets 4.2 MC.



human eye can readily perceive. The eye distinguishes between three separate, distinct visual sensations: 1—Brightness (relative intensity of light, or *luminance*). 2—Hue (the color or colors present—red, green and/or blue). 3—Saturation (purity of color present. A very deep red would represent a high degree of saturation. White would be equivalent to zero saturation.) The eye is sensitive to changes in brightness, but relatively insensitive to changes in hue.

Blue Band-Width

Coming back to Fig. 2, note the relatively small area allotted to the blue (B-Y) signal. The allotment is small because the eye is relatively insensitive to blue. High-frequency blues (fine detail) can't be detected as blues by the eye—only low-frequency blues (representing large areas) up to about 600 KC are recognized as blue by the eye.

Double sidebands are allotted to the blue signal—each blue frequency is, so to speak, transmitted in duplicate. The red (R-Y) signal, on the other hand, is sent out with one sideband and a vestige of another one (vestigial sideband transmission). Suitable response curves in the receiver's tuned circuits take care of the differences in amplitude of the blue and red signals, and provide compensation, if any is needed, for the mode of transmission used in each case. These signals, incidentally, need not be equal in amplitude (assuming that they were equal in the scene being scanned), since the eye does not respond to them in equal measure.

Before the operation of the color receiver can be understood, some idea of how the transmitter functions is necessary. We will therefore present, in simplified and outline form, a possible transmitting system (see Fig. 3.)

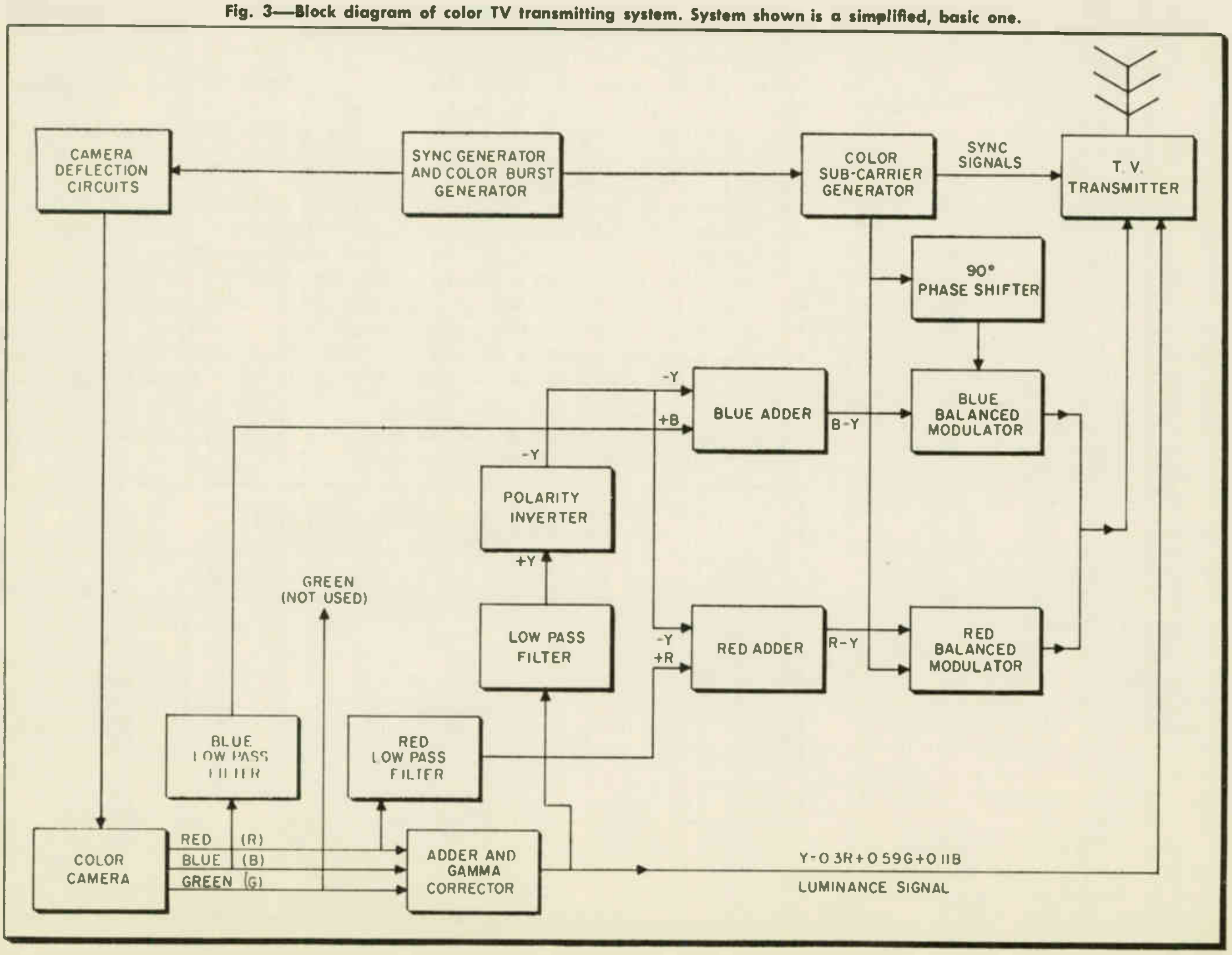
Referring to Fig. 3—the output of the color camera is composed of three electrical signals: red (R), green (G) and blue (B). These signal voltages are counterparts of the colored light being reflected from the televised scene into the camera. The signal components representing the scene contain both brightness and color information. To permit black and white receivers to receive the color signals in monochrome, the brightness information must be transmitted as an AM signal, in the same way that a monochrome transmitter would send out such a signal.

Color Signal Paths

The color signals take two paths when they leave the color camera. One path takes them to an *adder and gamma corrector block*, in which they are suitably processed for transmission as a luminance or monochrome signal. In the second path, they are worked over by appropriate circuits and made into the desired chrominance (color) signals. Let's analyze the first operation a bit.

The adder part of the *adder and gamma corrector block* assigns cor-

Fig. 3—Block diagram of color TV transmitting system. System shown is a simplified, basic one.



System

rect proportions to the red, blue and green signals. Thus blue is assigned to a value of 11% of the total, red to 30% and green to 59%. The assignments are such, that the resultant picture seen at a monochrome receiver looks the same to the viewer, as the original scene would, when viewed by a color-blind man. Aplication of the individual color signals to suitable taps on voltage dividers permits the percentage assignations just described to be made.

The gamma corrector compensates for distortions introduced in various parts of the television system. One distortion that might be cited is that introduced at the receiver's cathode-ray tube. The CRT is not linear at all levels of operation—i.e., the light output of its screen is not linearly proportional to the input signal at all input signal levels. Compensation is therefore needed, just as compensating filters are required in photography, to counteract the non-linearity of film and printing paper.

The signal output of the *adder and gamma corrector block* is the luminance or Y Signal. This signal contains all the brightness information and detail of the televised scene, as we previously indicated. It goes to the transmitter, and is sent out into space. Monochrome receivers will utilize only this portion of the total transmission.

Color Signal Processing

Let us now analyze how the color signals are processed. The red and blue signals go to the red and blue adder, respectively. The green signal is not separately transmitted—it is, instead, transmitted as a part of the luminance signal (.59G), and recovered at the receiver by subtracting the sum of the red and blue signals from this luminance signal. Green rather than red or blue is sent out with the luminance signal because the separate transmission of green would necessitate the use of a larger bandwidth than is required by the separate transmission of red or blue.

Before the red and blue signals enter their respective adders, they pass through low-pass filters. The function of these filters is to remove undesired color frequencies. The blue filter removes blue information above 600 KC; the red filter removes red information beyond 1.5 MC. The reader will remember that the NTSC system dispenses with the transmission of such frequencies. The unneeded frequencies must be filtered out, to conserve bandwidth; the filters take care of this job, permitting only the desired 1.5 MC range of color signal that the channel has room for, to get through.

The reader will note that the input to the blue and red adders consists not only of the blue and red signals (indicated by +B and +R) but also of the luminance signal. The luminance signal has been inverted 180 degrees in phase in a *polarity inverter*, so that it is opposite in polarity to the blue and red signals; this explains the respective polarity markings in front of the B, R and Y

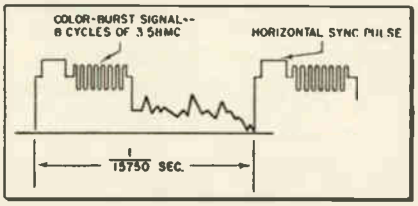


Fig. 4—Color-burst signal used to provide synchronization of chrominance signals at the color receiver.

signals at the input to the blue and red adders.

Why is the luminance or Y signal combined with the red and blue signals in the adder circuits? The reason is, we want to get rid of the brightness information present in these signals. No need exists to transmit this information that is mixed with the red and blue signals, since the black-and-white (luminance) signal already contains this intelligence. By subtracting Y from B, and Y from R, the brightness component of the color signals is removed.

Modulator Functions

The output of the blue and red adders (B-Y and R-Y) is applied to the *blue balanced modulator* and the *red balanced modulator*, respectively. The function of the modulators is to remove the color carrier, or color *sub-carrier*, as it is often called (since it is suppressed—i.e., eliminated), and pass only the sidebands. The question now arises, why is it necessary to eliminate the color carrier?

One of the reasons the color carrier is suppressed is that a better signal-noise ratio is possible with this type of transmission. In an AM transmitter (which is the kind used for sending out the picture signal in TV) a good deal of power is wasted by transmitting the carrier, which carries no intelligence (the intelligence lies in the sidebands). If the carrier can be gotten rid of, the power that went into it can be added to the sideband power, increasing the signal-noise ratio of the desired intelligence.

The color carrier is also suppressed to minimize interference that may be created by the heterodyning of color and sound carriers. The interfering signals created as a result of this condition would fall into the video bandpass and impair picture detail, especially in monochrome receivers, where the sound carrier is not as greatly attenuated as it is in color receivers.

Sideband Generation

From an examination of Fig. 2, the reader will note that the blue and red signals, which are relatively low in frequency to begin with (blue signals go up to 600 KC, red ones to 1.5 MC) fall at the high-frequency end of the channel. To translate these originally low frequencies into the higher ones required by the band-sharing system employed, we beat them against the color subcarrier in the balanced modulators, so that they appear as sidebands above and below the subcarrier frequency (3.58 MC). The process is similar to the one taking place in an AM broadcast transmitter, when audio signals are changed into RF sideband frequencies. The balanced modulators make this process possible; they also suppress the undesired color subcarrier.

The suppressed carrier is restored at the color receiver; it is needed in the color 2nd detector, to beat with the color sideband signals and cause the latter to be demodulated. Restoration of the carrier in the receiver is achieved by having a local oscillator generate a signal of the proper frequency—i.e., that of the suppressed color carrier.

Two kinds of signal are fed to each balanced modulator—the color subcarrier signal (which comes from the color subcarrier generator) and the blue (B-Y) signal to one modulator; the subcarrier and red (R-Y) signal, to the other. The reader will note that, while the color subcarrier is applied *directly* to the red balanced modulator (Fig. 3), it is applied to the blue balanced modulator through a block labeled *90-degree phase-shifter*. The reason for this block may be outlined as follows:

To simultaneously transmit blue and red color information representing *two* separate signals, *two* carriers are needed. Only *one* carrier is, how-

(*Continued on page* 41)

Color vs BLACK & WHITE

Block Diagram of First Color Set. Similarities and Differences

By Peter W. Orne

• In this article we will consider the block diagram of the NTSC color television receiver and discuss the functions and purposes of the new circuits. The circuits themselves will not be discussed in detail. It might be added that the receiver under discussion is the equivalent of the famous RCA 630 black and white chassis. Like the 630 chassis, this receiver is designed to take as much advantage as possible of the capabilities of the system. It should be kept in mind that present-day monocrome receivers do not follow the 630 design, and it is likely that there will be many short-cuts introduced in later color receivers. This prototype is expensive and good, its main purpose aimed at getting customer acceptance of color.

Comparing Figs. 1a and 1b, the sectional block diagrams of a monochrome and an NTSC color receiver, respectively, we find a number of similarities. Note that all the sections used in the monochrome receiver are also necessary in the color receiver. It should be understood that the sections are *not* the same in circuitry; the fact that they serve the same functions, however, is important to remember for servicing. This is so because symptoms produced by defects in various sections of the color receiver will be similar to those produced by comparable faults in the corresponding sections of a black and white set.

Service Predictions

The reader will note that the color receiver has a number of sections that have no parallel in the black and white set. Furthermore, the sound signal is taken off at a different point, in a way similar to the one used in older split-sound receivers.

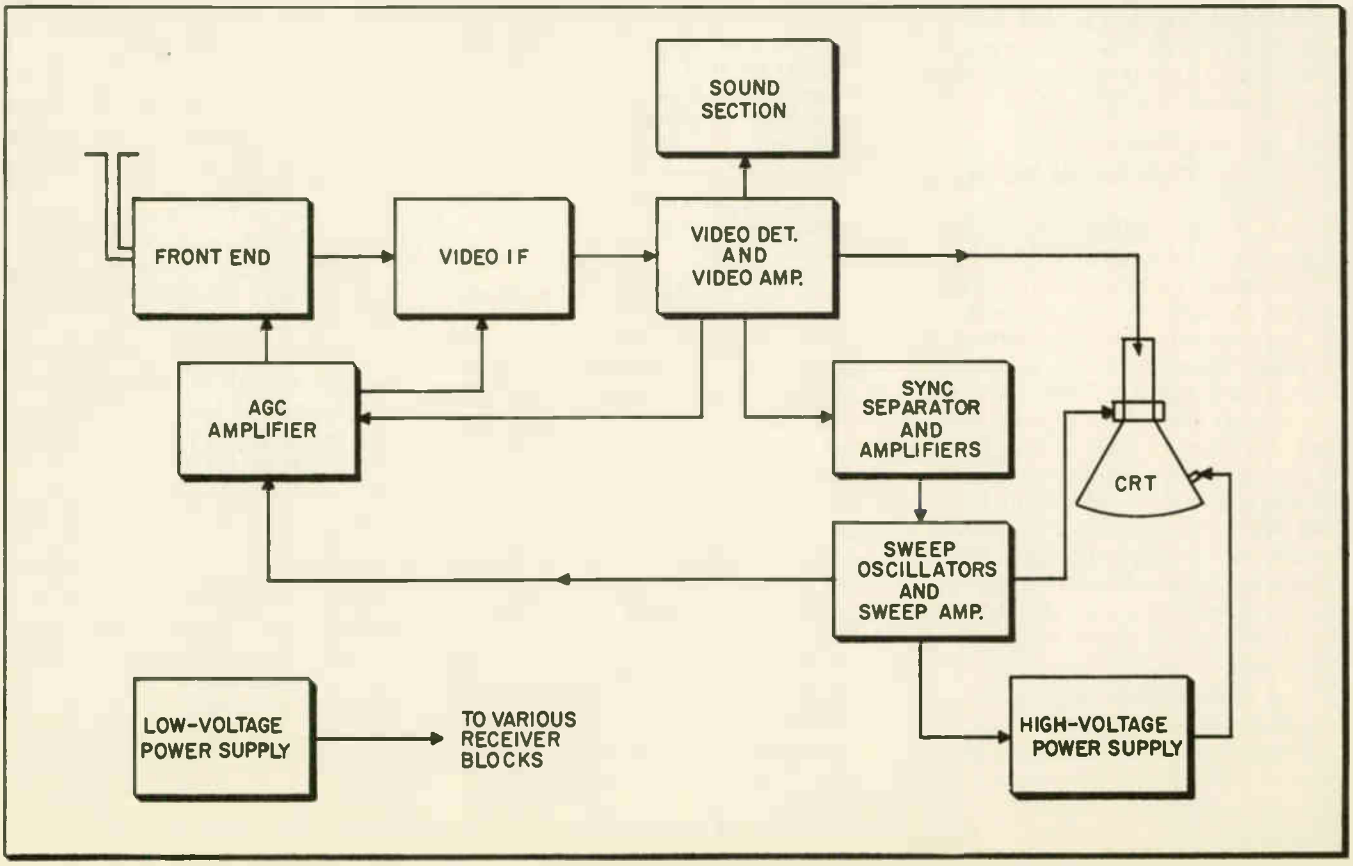
It may be interesting to give service-wise consideration to some of the familiar-looking color TV sections, and try to predict the symptoms that would be produced by a dead stage in these sections. We will do this from time to time as we proceed.

Since the front end of the color receiver is very similar to that of the black and white set, a dead stage in either set's tuner section will tend to eliminate or severely attenuate picture and sound, without affecting the raster. Trouble in the video IF section of each set will similarly tend to produce corresponding sets of symptoms.

The color receiver's IF system is somewhat different from the one present in the black and white set. Color information is transmitted interleaved with the high video frequencies; the frequency response of the color receiver's video IF stages should therefore be the full 4.2 MC transmitted, if a good color picture is to be reproduced.

The color receiver's video detec-

Fig. 1—A) Sectional block diagram of monochrome receiver. B) Page opposite—Block diagram of NTSC color receiver. Note the similar blocks.



TV Receiver Circuits

Between Monochrome and Color Chassis. Sectional Troubles

tor should be as linear as possible. This necessitates a relatively large output from the IF section. As a result of these considerations, the IF system in the color receiver contains five stages, compared to the corresponding three or four stages in a monochrome set.

The wide frequency response of the video IF stages in the color receiver necessitates the incorporation of a very efficient sound trap. The trap is needed to eliminate the 920 KC beat that tends to be produced in the video detector by the heterodyning of the sound carrier and the color subcarrier.

To prevent such a beat note from producing an interference pattern on the screen, there must be very little or no sound signal present in the video detector. The sound signal is, consequently, taken off at some point in the video IF section (rather than at the video detector or amplifier) and fed to the sound stages. A sound rejection trap is present in the last video IF stage, to insure against the presence of an appreciable sound signal in the video detector.

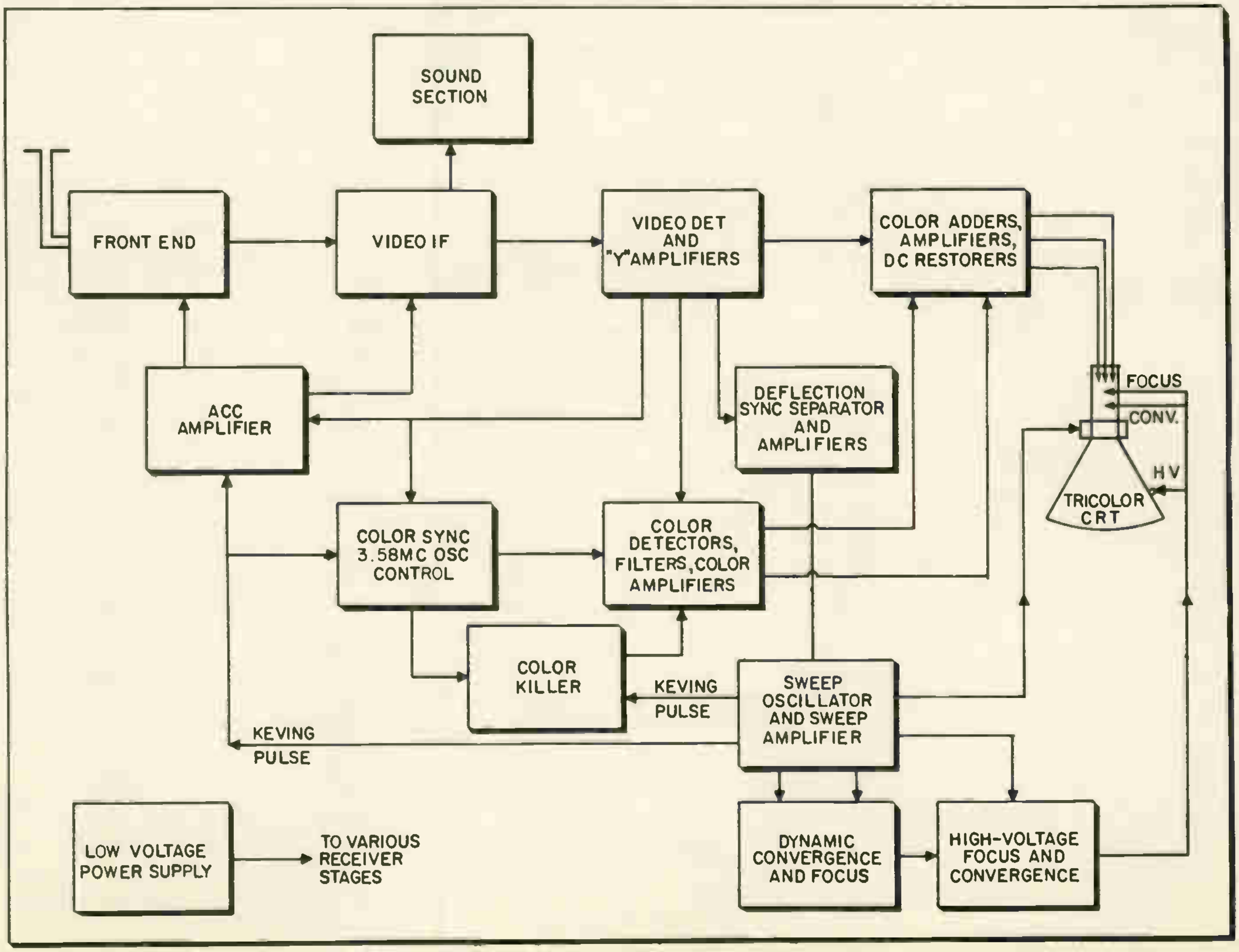
Sound Section

We should point out that it is not the sound signal alone that is taken off in the video IF section; a portion of the sound *and* video signal is removed, for application to the sound section. This is done to permit the advantages of intercarrier operation to be obtained—i.e., good tuning, better stability, etc.

Two detectors are required in the sound section. The first one operates like the video detector in a black-and-white intercarrier set, converting the high-frequency sound IF signals down to 4.5 MC. The other detector removes the modulation from the sound IF signals. From this point on, the sound stages in the color and black and white receivers are practically identical.

We may point out that, in the intercarrier set, the symptoms *no picture, no sound, good raster* indicate the presence of trouble in the front end, or the video IF, video detector, or video amplifier stages. In the color receiver, on the other hand, the same set of symptoms points to trouble in the front end or video IF section only, since neither the video detector or amplifier affect the sound.

The video detector and "Y" amplifiers correspond to the video detector and video amplifier sections in the monochrome receiver. The



"Y" signal is the luminance information of the color signal—that is, it contains information regarding the brightness of each pictorial unit. This "Y" signal is, incidentally, the only one of the several video signals present in the color transmission that a monochrome set will also respond to, and is equivalent to a monochrome video signal.

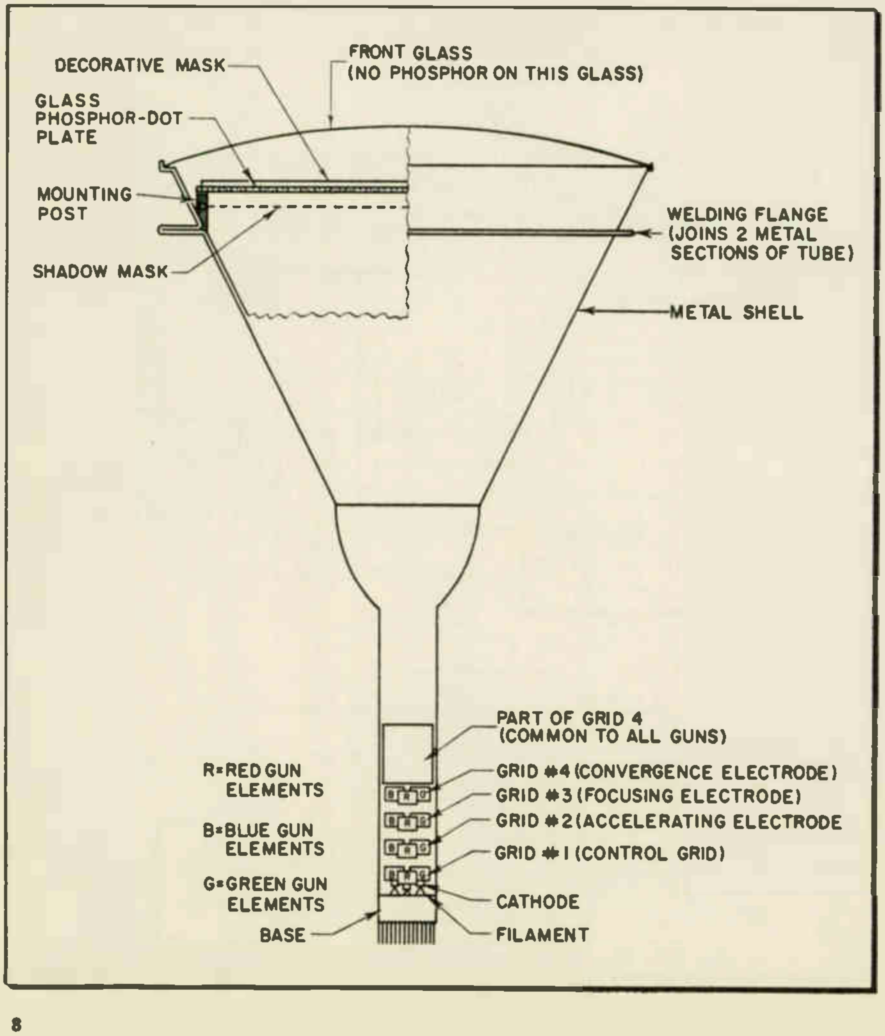
The only difference between the video amplifiers in the color set, and the ones used in the monochrome receiver, lies in the better linearity of the color set's video amplifier. By linearity we are not, of course, referring to deflection linearity, but the faithfulness with which the output signal reproduces the input one. Any non-linearity (i.e., any deviation from Class A amplifier operation) will tend to cause cross-talk or interaction between chrominance or color information, and "Y" or monochrome signals. This cross-talk or cross-modulation will severely affect the reproduction of color on the CRT screen. Whereas in a monochrome receiver, video amplifier non-linearity that causes cross-talk (between video and sound signals, or between different video signals) tends to introduce an almost unnoticeable fine interference pattern, in the color receiver the picture is far more visibly affected, since the colors deteriorate. More than one video amplifier is necessary in the color receiver, because of signal losses in various circuits.

From the video amplifier, signal is fed to the sync separator, which is the exact equivalent of the corresponding sync stage in the monochrome receiver. Just as in the monochrome receiver, many different sync circuits may be present. Symptoms such as picture rolling, tearing, or both will have similar sources in both the monochrome and color receiver.

The Deflection Sync Separator and Amplifiers block corresponds to the *Sync Separator and Amplifiers* block in the black and white receiver. The word *deflection* is used in front of *Sync Separator* to differentiate this sync section from the color sync section.

The sweep sections of the color and monochrome receivers are very much alike. The vertical oscillator and amplifier, and the horizontal oscillator stages, are or can be identical. The horizontal output stage is similar in both receivers; in the color receiver, however, better linearity is demanded of this stage. This is so because the necessary convergence of the three electron beams exciting the red, blue and green phosphors cannot be obtained over the length of a horizontal line if the linearity is not good; improper color reproduction will be produced in such a case. This business of convergence will be treated in detail a bit later. Because of the more stringent linearity requirements, components in the sweep section such as the yoke, vertical and horizontal output transformers, and width coil differ in design from corresponding units in black and white sets.

Fig. 2—RCA tricolor three-gun kinescope. A part of the metal shell is cut open to show the internal assembly of the phosphor-dot plate and shadow mask. The gun mounting supports and connecting wires have been omitted. For a more accurate sketch of the shadow mask, see Fig 3.



Keying Pulses

Keying pulses are derived from the horizontal sweep section which are used in a number of circuits in the color receiver. The keyed AGC system, which uses one of these pulses, employs it in the same manner as the corresponding system in a monochrome set. The keying pulse applied to the block labeled *Color Killer* will be discussed later.

We can take a breath at this point and consider some familiar symptoms that will be produced in a color receiver by failure in some of the sections we have been discussing. An inoperative vertical sweep stage will produce a horizontal line; a defective horizontal sweep will eliminate the raster (since a kickback type high-voltage power supply is used in the color receiver); an improperly-functioning AGC system will tend to introduce buzz and poor or no syncing of the picture (as well as contrast troubles, negative pix, etc.).

Considerable differences are present in the color receiver's kickback high-voltage power supply (as compared to the monochrome set's HVPS). The regulation of the color receiver's HVPS must be very good —i.e., the high voltage must remain constant or unchanging. This is so because the cathode-ray tube requires a constant high voltage to provide correct coloring and brightness to the picture. This constancy must be maintained in the presence of, or in spite of, brightness level changes.

In the monochrome receiver, a change in brightness tends to cause a change in picture size. The high voltage rises when the brightness is reduced (due to reduced loading on the HVPS), causing the picture to shrink. The reverse happens when the brightness goes up. While such effects are hardly noticeable in a monochrome set, they affect a color picture very seriously. This is so because the correct rendition in color of one pictorial unit depends on the impingement on the CRT screen of three correctly-oriented color beams. If the raster size changes, the points struck by the color beams change as well, and improper color reproduction thus tends to result. The color receiver's HVPS must, consequently, be a regulated one.

The *High Voltage Focus and Convergence* section supplies the tricolor cathode-ray tube with voltages it requires for correct beam formation. The focus voltage is in the high-voltage range (4,000 v). The focus electrode in the picture tube helps produce a correctly-sized spot on the screen of the cathode-ray tube. The convergence electrode (which is at a potential of 14,000 v with respect to chassis) makes the 3 color beams converge at one point on the screen. Since the focus electrode draws appreciable current, a single HV rectifier is not sufficient to supply *its* needs, as well as those of the HV second anode; a separate rectifier therefore is used for the focus circuit.

The low-voltage power supply in the color receiver differs from the one employed in the monochrome set in that it delivers a higher output voltage and more current. The higher voltage is required mainly to provide a more linear sweep system. (The greater the voltage applied to a sweep amplifier plate, the less is the plate current required for the same watts output. A smaller plate current means that the tube will operate on a smaller part of its Eg-Ip characteristic, avoiding the extreme or non-linear part of this characteristic. A more linear output is thus possible.) The larger current-handling ability of the low-voltage power supply is needed because of the greater number of tubes used in the color receiver. An inoperative low-voltage supply will, of course, result in no raster and sound in the color receiver.

Color Tube

To understand the functions of color receiver sections that have no equivalent in the monochrome set, some understanding of the color CRT is necessary. Many different types of color tubes are currently being experimented with. The only one that will be discussed here is the RCA tricolor kinescope, since the NTSC receiver is really built around this CRT. Fig. 2 shows constructional features of the tube.

The tube contains three electron guns, one for each "primary" color: red, green, and blue. In the front of the tube there is a flat glass plate on which an orderly arrangement of red, green, and blue phosphor dots is deposited. Three dots—one of each color—form a triangle; about 195,000 such triangles cover the viewing area in the tube.

The latter is a 16-inch metal-shell round tube; its viewing area is about 11½ by 8½ inches. Behind the phosphor-dot plate there is a shadow mask with as many holes as there are dot triangles. The shadow mask is so arranged with respect to the three guns and the phosphor dots that the beam from each gun can only strike a phosphor dot of its own color. This precision set-up indicates why a high degree of accuracy is required in the yoke, and the high voltage and focus supplies; any variation in the focusing or direction of the beam may cause it to hit the wrong color spot. To avoid stray magnetic fields from affecting the beams, a magnetic shield is placed around the tube's metal cone.

We may point out, in passing, that an improper yoke adjustment may produce not only neck shadow, or a tilted picture, but also improper color reproduction. The last-named fault is due to the fact that the yoke determines the starting point from which the beams are reflected; a change in the starting point may cause the beams to hit the wrong-color phosphor dots.

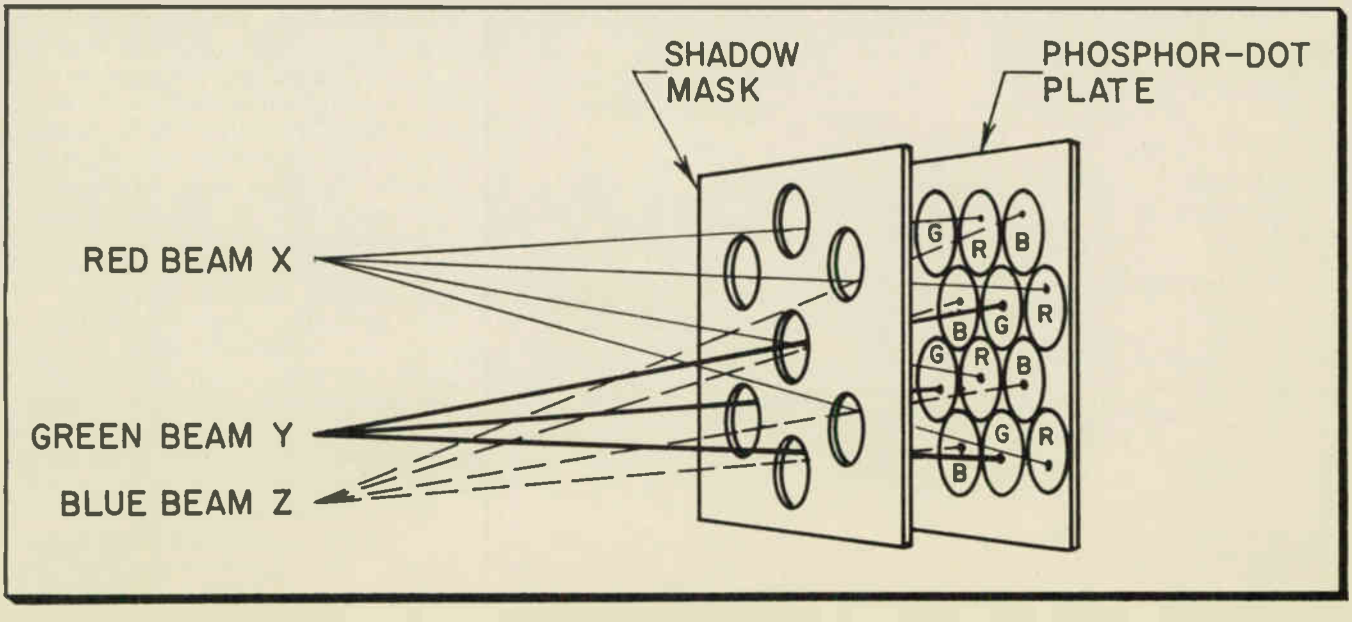
The construction of the tricolor CRT is the reason for the presence of the section in Fig. 1b labeled *Dynamic Convergence and Focus.*

The need for and function of this section may be explained as follows: Because of the flatness of the color dot plate, the distance from each gun to the center of the plate is shorter than the distance to the edges. Now, a focus voltage that assures proper focus at the center will not provide it at the ends of the plate, under such conditions. An additional potential must therefore be introduced, to provide suitable compensation.

The principle is similar to the one

(*Continued on page* 43)

Fig. 3—Detailed sketch showing how the beam from each gun can only hit a phosphor dot of its own color when the tube has been properly adjusted. High adjustment accuracy is obviously vital. X, Y, and Z indicate points where deflection begins for each beam.



Picture Tubes for

Aperture-Mask Form, with Color-Phosphor Triads, Is Most

• At the recent Waldorf demonstration of color TV, presented by the National Television System Committee for the benefit of the Federal Communications Commission, thirteen different color TV sets were displayed in operation. These sets had been designed and built in 13 different competing factories, and involved various special circuits developed by their individual designers.

All of the 13 color sets thus shown, however, employed the "aperture-mask" type of color tube which has been under development in the RCA laboratories for more than a decade. The basic principle of the aperture-masking tube, one of the major types being considered for use in color sets, was invented by Dr. Alfred N. Goldsmith, consulting engineer, back in 1940. Dr. A. B. DuMont has patents on the triad grouping of color phosphors. In both its 3-gun and single-gun forms, the RCA masking tube has been shown in many color-TV demonstrations during the last four years, and several hundred such tubes have been furnished to TV manufacturers for experimental use.

Recently, striking structural improvements have been made in the aperture-mask type tube by the engineers of CBS-Hytron. Their new CBS color tube has color-screen parts weighing only ½ pound, as contrasted with the 6-lb. weight of the earlier model color screen.

In view of the resulting cost reduction for mass output, some former skeptics of color TV have declared that the new CBS construction may result in savings that will bring a future 21-inch color set down to $400, instead of the $800 to $1,000 price range often cited.

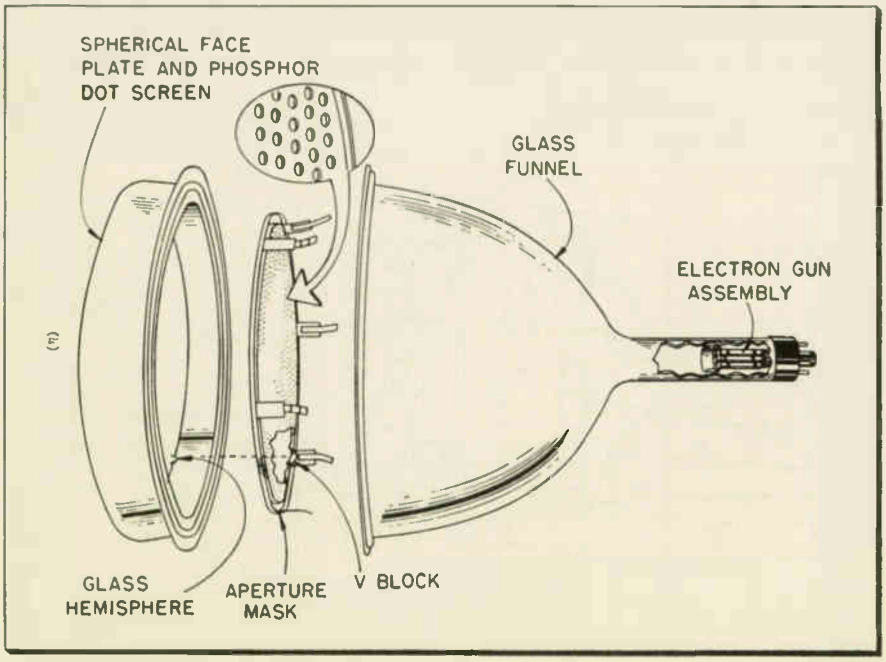
Principle of Operation

In principle, the basic aperture-mask type of color tube (see Fig. 1) contains three identical electron guns arranged in a triangular configuration. The resultant beams are also in the same triangular arrangement relative to the tube axis.

Each of the three electron beams is individually modulated by a composite voltage that consists of color and brightness signals. This voltage is applied between the control grid and cathode. The proper color signal is applied between the control grid and ground; the common brightness signal is applied between all cathodes and ground. By utilizing this method, the individual beams are modulated in accordance with the transmitted signal, and are of the proper intensities for their respective colors.

The modulated beams are also focused by their respective guns. This focusing, similar to that in conventional black-and-white tubes, is accomplished by the electrostatic lens formed grids 2 and 3 (Fig. 2, p. 48). Since the focusing electrodes (grid No. 3 of each of the three guns) are internally connected together, a common focusing voltage may be used. This feature simplifies the associated circuitry.

Fig. 1—"Exploded" view of the CBS-Colortron. Aperture mask is curved, unlike the flat mask in the RCA tube. Colortron is very much lighter than the RCA tube; it weighs approximately ½ lb.



Convergence of Beams

As the three electron beams emerge from the convergence electrode (grid No. 4), they are acted upon by the electrostatic convergence lens. This lens is formed by the potential gradient that exists between the convergence electrode and the inner conductive coating in the neck of the tube. This conductive coating is electrically part of the accelerating anode. It is the function of this lens to converge the three beams at the aperture mask. Convergence is necessary to insure that the three color images will be superimposed.

Adjustment of convergence is accomplished by varying the voltage applied to the convergence electrode. This voltage is a combination of a static voltage and a dynamic voltage derived from the horizontal and vertical deflection circuits. It varies the focal length of the convergence lens in accordance with the positions of the beams as they scan the phosphor screen. In the new CBS tube, the spherical shape of the mask and screen reduces the dynamic-convergence voltage needed, and facilitates easy convergence adjustment in the receiver. (Adjustment of the focus and convergence potentials will probably be achieved by using potentiometers in the HV divider network.)

In the ideal case, the three beams leave the convergence lens so aligned that, when deflected, they

Color-Television

Widely Used in Experimental Color-Sets Built So Far.

approach the aperture mask at the correct angles properly converged. In the practical case, however, this is not always true. For this reason, it is necessary to employ external components to align the beams.

External Alignment

The first of these external components is a combination of three small, moveable permanent magnets, one for each beam (see Fig. 3). These magnets provide for adjustment of each of the beams, so that they will be properly acted upon by the convergence lens. The three magnets are mounted nominally 120° apart on the circumference of a non-ferrous ring. The ring is located approximately 1½ inches from the tube axis in the grid No.2 region.

The other external component necessary for proper beam alignment is the color-purifying coil. The magnetic field produced by this coil is perpendicular to the tube axis. This field acts upon the three beams simultaneously and, by proper adjustment of its strength, as well as its axial and rotational position, the common axis of three beams can be positioned to achieve optimum color purity. The coil is located on the neck of the tube in the region of grids 2 and 3. The construction of the coil will, when it has been correctly designed, allow it to be rotated and moved along the CRT neck.

After the beams have been acted upon by the alignment components and the convergence lens, they enter the deflection area. Here, the deflection yoke provides the required uniform magnetic fields that simultaneously deflect the three beams.

As in black-and-white tubes, the deflection yoke consists of four electro-magnetic coils. These coils function in pairs, each coil of a pair located diametrically opposite the other. Since this deflection yoke acts simultaneously on three beams, the electromagnetic field requirements are more stringent than those in black-and-white tubes. In particular, a more uniform field is required for deflection in the tri-color tube.

The electron beams travel in straight line paths from the deflection area to the screen. Between the phosphor screen and the deflection area is the aperture mask. This mask is positioned so that, when viewed from the deflection point of any of the beams, only the dots of a single color can be seen through the perforations in the mask (see Fig. 4).

With the mask in the position described above, one beam will strike only the red dots, another beam will strike only the blue dots, and the third beam will strike only green dots. The mask, consequently, allows each beam to reproduce the exact hue of one of the primary colors present in each portion of the televised scene. The combination of the three primary colors recreates the televised scene in full color.

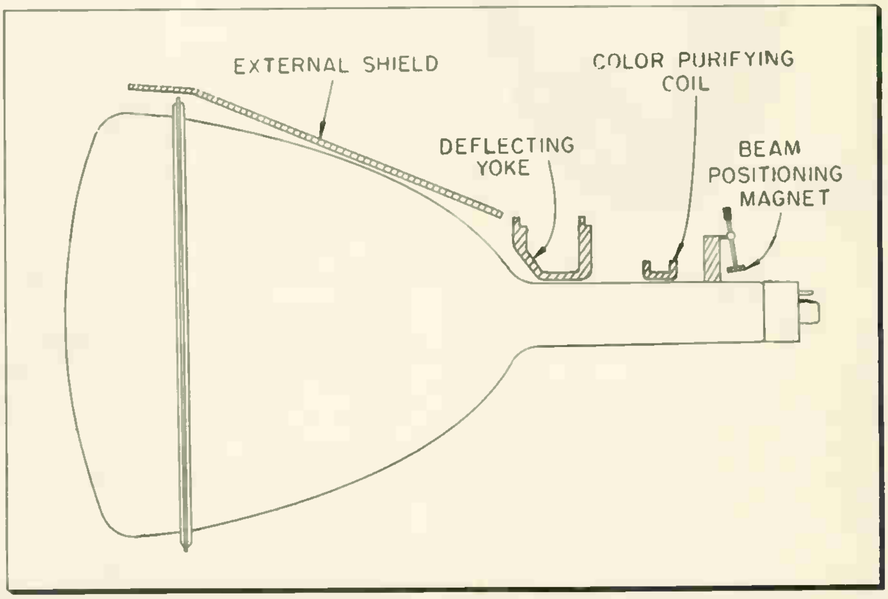


Fig. 3—Cross-sectional view of external components used with the tri-color tube. Note component arrangement. Only one of the three beam-positioning magnets present is shown in sketch.

Color-purifying Coil; Positioning Magnets

The approximate position of this coil on the neck of the CBS tube is shown in Fig. 3. By rotating the coil around the neck of the tube, the transverse magnetic field will move the beams in different directions. Conversely, the current through the coil determines the magnitude of the movement.

Fig. 3 indicates the location of the beam-positioning magnets on the neck of the tube. The field strength of each magnet is approximately 8 gauss.

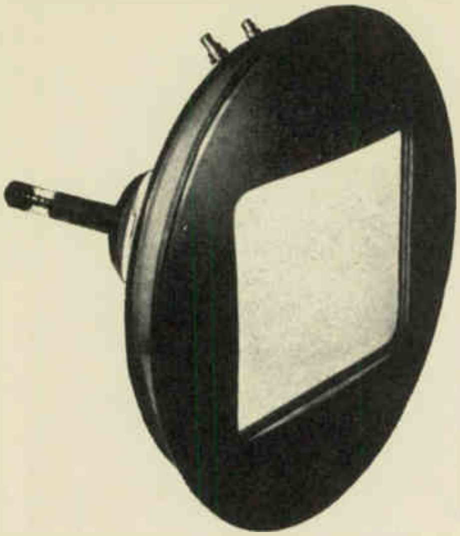
Grid No. 1 Drive

The three electron guns of the Colortron have similar transfer characteristics. Due to the differences in phosphor luminescence efficiencies, however, the cutoff voltage of each gun must be adjusted to produce equal phosphor brightness or color balance. If color balance is not maintained when the tube is reproducing black-and-white pictures, for instance, color tinting of the gray scale will result. Individual grid-No. 2 voltage controls and grid-No. 1 drive controls will probably be provided in sets using the CBS tube, with grid-No. 2 controls allowing a voltage adjustment of from 100 to 450v.

Installation and Adjustment Procedure

After mounting, the color-purity coil, convergence magnets, and deflection yolk are placed on the neck of the tube. Once these components are positioned on the neck of the tube, the socket and high-voltage

(*Continued on page* 48)



The Chromatron:

How This CRT Works. Comparison

By Sidney C. Silver
Associate Editor, Technician

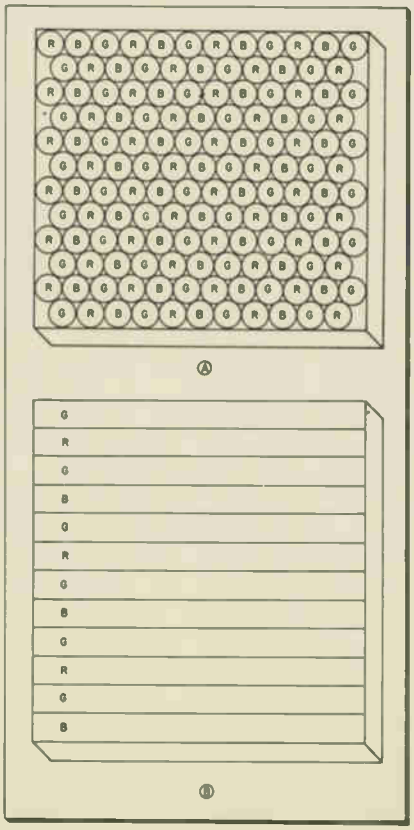
The existence of a single-gun structure, the Lawrence gun, has been known for some time. Use of this structure in the *Chromatron*, designed by Chromatic Television Laboratories, is not a development of the last few weeks or months; recent events, however, make it worth while to call attention to this tube and to its possible impact on set design. In the first place, two or more important manufacturers of black-and-white crt's have been licensed to produce the tube. In addition, at least two manufacturers of nationally-sold name-brand receivers are making plans to use the Chromatron, and are working on associated circuit design.

As may be seen in Figure 1A, color phosphors in three-gun shadow-mask tubes are deposited in dots on the inside surface of the tube's viewing screen. The dots are arranged in triangles of three each, one for each of the primary colors. The electron beams from the tube's cathodes are so directed that, in passing through apertures in the mask, the beam from each gun can only strike dots of the correct color phosphor—or strike no dots at all. Electrons that are not propelled directly onto the desired dots are blocked by the mask altogether. As a result, such tubes are highly inefficient devices; it is estimated that only 15 per cent of the electrons that leave the three cathodes actually strike the picture-tube screen. With an aperture mask, then, three guns are needed to insure enough total electron emission, if for no other reason. Also, because of the low efficiency, higher second-anode voltages are required than are common in black-and-white receivers, and overall brightness of the picture is reduced.

The Chromatron, which uses no aperture mask, is said to permit 85 per cent of all electrons beamed from the single gun to strike the phosphor-coated screen. Elimination of the mask is made possible by a dynamic *lensing* or *beam-bending* system. When information of any particular color is to be displayed in the picture, a varying voltage applied to elements inside the crt bends the beam coming from the single cathode so that it strikes phosphors of that color only.

To see how this is done, a look inside the tube is necessary. The manner in which the color phosphors are placed on the inside surface of the tube's viewing screen differs from the triad-dot arrangement common to three-gun types. The arrangement in the latter is shown on one segment of the tube's inner surface in Fig. 1A. In Fig. 1B, which is a comparable segment of the surface in the Chromatron, these phosphors are deposited in adjacent horizontal strips extending across the faceplate.

Fig. 1A—Phosphors for three primary colors are deposited in dot-triangle arrangement in 3-gun tubes. B—Horizontal phosphor strips are used in Chromatron.



It will be noted that there are twice as many strips of green phosphor (G) as there are of blue (B) or red (R). Such an arrangement is used because most of the luminance information is associated with the green signal. This design feature does not upset color balance. See explanation in caption for Fig. 3.

Grid Wires Act As Lenses

Between the gun assembly and the phosphor-coated screen, but closer to the screen, is an assembly of horizontal grid wires, as shown in Fig. 2. Alternate horizontal wires are connected together and brought out as two fundamental connections, marked red and blue.

In Fig. 3A, a cross section view shows the electron beam passing between one red and one blue wire when there is no potential difference between them; that is, when the voltages applied to the connections marked red and blue in Fig. 2 are equal. The like positive charges on the grid wires have only one effect, in this instance: they tend to focus the beam sharply onto the green phosphor strip. When the structure of red grid wires is made *positive* with respect to the blue assembly, the electron beam is deflected *upward*, as shown in Fig. 3B, and the beam strikes the red phosphor strip. In like manner, when the potential between adjacent wires is reversed, only the blue strip is struck (Fig. 3C). Note that, even when there is no voltage difference between the red and green wires, the potential on both sets of wires still has a lensing effect on electrons propelled toward the screen.

A keying or switching arrangement is used inside the receiver to develop the varying potential that is applied to the grid wires. In this

A Single-Gun Color Tube

with 3-Gun Types. Associated Receiver Considerations

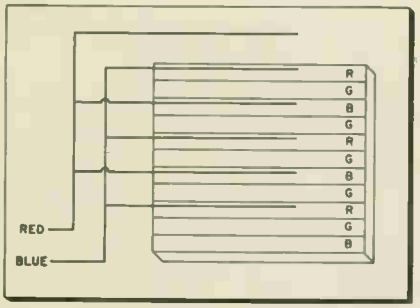


Fig. 2—Instead of an aperture mask, a screen of horizontal wires is placed behind the phosphor-coated faceplate. This lensing structure directs electrons to the proper color strips.

way, beam lensing is constantly switched from one color to another. Obviously some means must exist, controlled by color information, for varying the emission from the gun's cathode as the beam is being lensed or bent to the various color strips.

More than one circuit has been devised to accomplish this. The most elaborate one makes use of a color section in the receiver that is comparable in size to the specialized color sections already developed for receivers using three-gun tubes, although it operates in an entirely different fashion. On the other hand, one laboratory talks of incorporating the entire color-processing section into a single stage. This single-tube section will work in conjunction with the color tube; actual decoding of color information will take place in the latter. Such circuits, interesting in themselves, are broad enough to merit independent examination. Evaluation of the possibilities introduced by Lawrence-gun tubes, however, need not wait for such information.

Since many of the tube's possibilities depend on its physical characteristics and some electrical characteristics not yet mentioned, this data is presented here. Maximum diameter of the tube in its present form is about 22 in. The diagonal of the rectangular viewing screen is about 18 in. Overall tube length is about 22 in. Length is comparable to that of 19-in. black-and-white crt's; the Chromatron is considerably shorter than a three-gun color tube providing a comparable picture size would be (in the present state of design).

The 22-in. overall length is made possible by the use of a 72-degree deflection angle. Still wider deflection angles are said to be possible. Magnetic deflection and magnetic focus are accomplished with standard yoke and focus assemblies. The larger and more expensive yokes required for three-gun tubes are thus eliminated.

The Chromatron requires 18 kv of second-anode voltage in its present size. This is only slightly higher than the value required for black-and-white tubes that produce pictures of the same dimensions. The three-gun tube, on the other hand, needs 20,000 v to produce a picture with a diameter of app. 12 in.

Regulation of the hv section in a receiver using a Chromatron is not highly critical. The same statement may be applied to the normal B+ supply, for that matter. In three-gun tubes, we are dealing, in one sense, with three tubes that happen to use a common shell and phosphor screen. For proper functioning (particularly with respect to convergence), the three guns and their associated external circuits must be critically adjusted with respect to each other. Voltage changes beyond certain narrow limits upset this delicate balance.

Non-critical Tolerances

In the Chromatron, the relationship between the voltages on the single cathode, the wire-grid structure, the second anode, and other tube elements remains essentially unchanged over a fairly wide range of overall increase or decrease in the low and high dc supplies. Receiver tolerances in general are comparable to existing tolerances in b & w sets. This means that conventional flyback transformers may be used in familiar horizontal-output circuits. Low-voltage supplies will also tend to resemble those now in use.

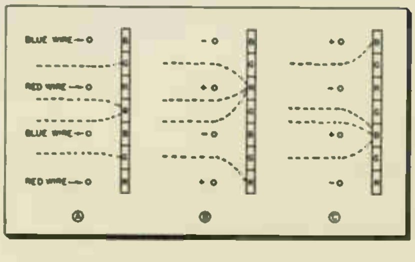
With the use of a single electron beam, the problem of convergence is eliminated as it exists in shadow-mask tubes. There will simply be no convergence controls. There will also be no need for critical balancing adjustments to match the outputs of three guns. These factors are particularly important when the receiver is required to reproduce a black-and-white picture, free of color fringing (color "ghosts") on the one hand, and of overall color tinting on the other.

Limitations of Chromatron

A sober estimate of this color tube's potential indicates some disadvantages. In the current version of its associated receiver, a 25-watt oscillator is used at the frequency of the color subcarrier (3.58 mc). Interference radiation from this stage is a possibility. Measurements with a field-strength meter at 100 ft. indicate radiation of 5 microvolts per meter in the present state of circuit design. In addition, the limited number of phosphor strips now used (450 for green, half that number for red or for blue) make for coarse definition of blue or red detail, although subjective reaction to this phenomenon varies.

It is impossible to say at this time that the Chromatron, or any other color crt, enjoys a clear advantage over its rivals. Changes in all tube types, as well as in the design of associated circuits, will determine whether one tube will obsolete the others, or whether more than one type will come into general use for an indefinite period.

Fig. 3—The potential difference between adjacent grid wires bends the electron beam. The paths of four electrons in the beam are shown when (A) green, (B) red and (C) blue phosphor strips are being activated. Despite the fact that fewer strips are struck in the last two cases than in the first, note that *the same number of electrons* are activating phosphors in all three cases. Uniform saturation is thereby maintained for the three primary colors.



Tracking Down TVI to

How to Troubleshoot External and Internal Interference,

By James A. McRoberts

• When interference is present in a set, the serviceman must determine whether the symptoms are internally or externally caused. Some technicians are apt to dismiss what is apparently a case of external interference with a statement like:

"Local interference is the cause of those lines, Mr. Smith. I'm afraid we can do nothing for you."

Have you heard this approach before? Contrast it with the following:

"We're not certain where you're

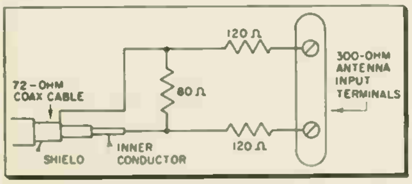


Fig. 1—Suggested matching network for connecting probe to receiver's antenna input.

symptoms originate, Mr. Smith. Suppose we leave this Superbo set with you for a few days—if the interference symptoms appear on this set too, we'll know for sure that the trouble is *outside* the set, and we can then go on to locate its source. If the symptoms *don't* appear on the Superbo, on the other hand, the trouble is probably originating *inside* your set. When our final test verifies this, we'll haul the set into the shop for repair."

Not only is this a practical method for determining whether the TVI present is originating inside or outside the customer's receiver—it is also a way of *demonstrating* this fact to the customer; and, in cases where an improperly designed set is responsible for TVI pickup, the demonstration may help sell a new set. Still another pleasant feature of this lend-a-set technique may be mentioned: considerable time is saved by having the customer monitor the symptoms, without pay.

When it has been determined—by the lend-a-set method or some other technique—that the source of the TVI is external to the set, the possible routes of entry of the undesired signal should be considered. Determination of the route of entry will indicate whether the transmission line and antenna system, or the power line, must be signal-traced for the source of TVI, or whether direct pickup of the TVI via the chassis must be investigated.

While a cure may be effected during the course of such signal-tracing, TVI cures are not the subject of this article, which concerns itself primarily with TVI localization tests.

Tests to determine the TVI route of entry may be made by the technician; the customer (suitably guided by the technician, of course) may, in some cases, also make the tests.

The first check might logically be one to determine whether the TVI is entering via the power line. To make this test, install a commercial power-line filter between the set and the electric outlet. It is desirable to attach suitable plugs to the filter, so that it may be connected, not to the receiver line cord, but to the point where the line cord connects to the receiver proper. When an external ground connection is provided at the filter, a wire should be run between it and a good ground, to get maximum effectiveness from the filter.

If the symptoms of interference are now eliminated or greatly reduced, entry of the TVI via the power line is indicated. If the TVI is diminished to some extent—but not greatly—by the filter, signal tracing may start at the power line, using techniques to be described later; it should be kept in mind, though, that additional points of entry may be involved.

The check just described should be made before any of the others to be listed, to eliminate the possibility of TVI getting into the set *indirectly* (via radiation), from the line cord, as well as *directly* from the line cord, through the receiver's AC input terminals.

To determine whether the TVI is entering by way of the antenna system, disconnect the transmission line from the receiver's antenna-input terminals. If the intensity of the TVI symptoms is diminished, the interference is entering via this path. (The station signal will, of course, be attenuated when the antenna is disconnected.)

Sources, Tests, Remedies

If the TVI route of entry is the antenna-transmission line system, several possibilities must be considered:

1. *The frequency of the interfering signal is the same as that of the desired signal.* If this is the case, the TVI cannot be eliminated by filtering and trapping methods (such as those described in succeeding steps) without also eliminating or attenuating the desired signal. Sometimes re-orienting the antenna, re-routing the transmission line, or using a shielded lead-in will eliminate the symptoms. At other times, it may be necessary to trace the unwanted signal to its source (which is usually nearby) and apply control measures at the latter point.

2. *The interference is present on all station channels.* This symptom

Fig. 2—Length of the probe may be between 6 and 100 feet (see text). Basic probe for tracking down television interference.

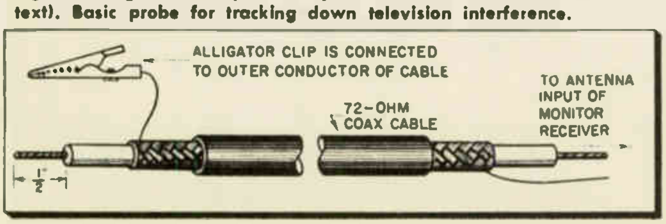
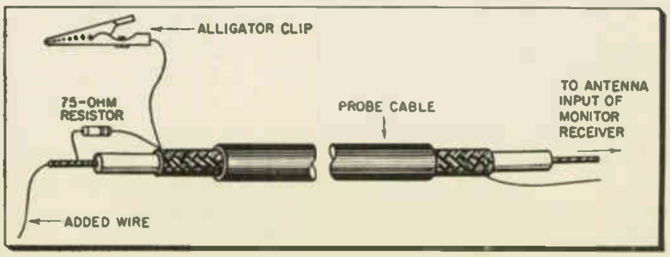


Fig. 3—TVI probe with a wire added to increase its pickup.



Its Source

Using a Probe and a TV Receiver.

indicates that the frequency of the offending TVI lies within the IF band of the receiver. To check whether this is the case, install at the antenna terminals a commercial trap that is tunable over the TV intermediate-frequency bandpass. If the TVI is reduced or eliminated by appropriate tuning of the trap, a cure as well as a localization of the trouble has been effected. If the interference is attenuated, but remains troublesome, signal tracing of the transmission-line antenna system will be necessary.

3. *The interference is due to some harmonic of an undesired signal.* A commercial trap at the antenna terminals will eliminate or attenuate this kind of TVI. Obviously, the trap must cover the frequency range of the possible interfering signals. The offending frequency will be some subharmonic (½, ⅓, ¼, etc.) of the frequency of the channel(s) on which the symptoms appear.

4. *The interference falls within the image-frequency band of the receiver, and is produced by a signal source operating outside the band of VHF TV channels. Ordinarily,* the undesired image will be separated from the station signal by a frequency of twice the receiver video IF. In cases where the oscillator operates *below*, rather than *above* the incoming signal, however, this will not be true. The set's schematic and service data should be checked, to determine what conversion system is actually being used. Try a suitable trap at the antenna input, to remedy this kind of TVI.

A relatively powerful, closely-situated source of TVI may cause unwanted signals to be picked up directly, by chassis wiring or other chassis components. This means of entry can be checked by moving the receiver from place to place about the room and observing whether the TVI intensity changes. Often, movement of the technician, or other people in the room, will produce this same intensity variation, eliminating the need for moving the receiver.

Troubleshooting Clues

Manipulation of a metal sheet (such as the mirror used in making raster adjustments) in the vicinity of the set, can provide clues to the origin of the interfering signal. This is so because the interfering signals travel in relatively straight lines. The ability of the metal sheet to reduce TVI, when positioned between the receiver and the TVI source, suggests chassis shielding as a possible cure for the trouble.

It is not at all unusual for some portion of the interference to be entering by all of the three routes previously mentioned: via the power source, the antenna-transmission line system, and direct chassis pickup. In this event, the tracing procedures to be described will start with that source of entry which seems responsible for most of the TVI; but the other routes will be kept in mind for subsequent investigation.

With respect to the tracing procedure itself, equipment is required which will pick up the interference and monitor its intensity, as we probe various locations. This equipment comprises, in most cases, a set which can tune in the interference (the customer's set, for example) and a shielded probe which permits only a small amount of the pickup energy to enter the set used as a monitor device. A 72-ohm coax cable is well suited for use as a probe; this type of shielded unit is desirable because we want the probe to pick up a minimum of interference signal.

We attach one end of the probe cable to the monitoring set *directly*, if the set has a 72-ohm antenna input; if a 300-ohm input is present, a matching pad (Fig. 1) is inserted between the probe and the receiver. The pad may be either a commercial or home-made unit (same type as the ones used for matching signal generators to antenna inputs).

To make the probe proper, simply remove some (about a half-inch) of the outer coaxial shield from one end of the coaxial cable (see Fig. 2). To the shield (at the end from which the half-inch section has been removed) attach a short length of lead, preferably shield braid; terminate the free end of this lead in a clip, as illustrated in Fig. 2.

Probe Length

The length of this elementary probe should be a minimum of one hundred feet, to be suitable for most cases of external interference; a minimum length of six feet is suggested for troubleshooting internal TVI (interference originating in set). The cable end opposite the clip-terminated one is connected to the input of a set which can pick up and display the TVI.

The end of the probe forms one plate of a condenser, the metallic parts of the circuit near it comprise the other plate. Capacitative coupling is thus used to transfer the TVI from the circuit (or several circuits) being tested, to the probe.

The signal pickup of the probe may be insufficient at some stages of the test procedure. To increase it, attach a wire to the probe (see Fig. 3). The longer the wire, the greater the TVI pickup will become. The 70-ohm resistor connected between shield and inner conductor terminates the cable; this termination increases the probe pickup by preventing loss due to mismatching. You may remove this resistor if you choose, to decrease the sensitivity of the probe's TVI pickup.

(*Continued on page* 43)

Fig. 4—Probe used with series condenser (C-1) in checking the power line for TVI. Additional connection of probe shield to line through C-2 will increase TVI pickup. C-2 may be .1 mfd.

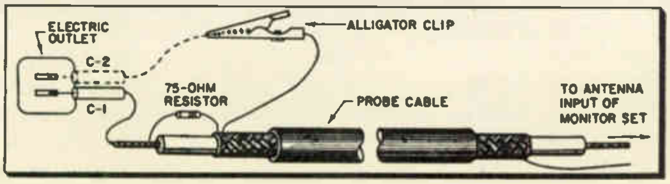
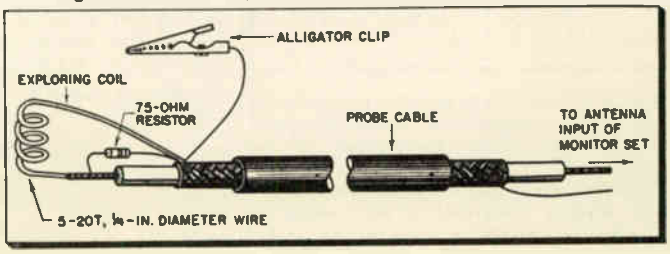


Fig. 5—How an exploring coil is connected to the probe.



Troubleshooting Parasitic

Basic Theory of How "Parasites" Tend to Arise;

By James A. McRoberts

• The serviceman is frequently called on to eliminate internal TVI (interference originating in the TV set itself). As a prerequisite, he should be able to recognize an oscillating circuit, whenever localization tests indicate the existence of such a circuit in some section of the receiver. (TVI localization tests were discussed in *Tracking Down TVI to its Source*, in the article preceding this one.)

We are going to discuss in this article undesired oscillation of the parasitic type. Such oscillation is invariably produced by some form of shock-excited ringing circuit.

The broad definition of a parasitic element is either an inductance, a capacitance, or a resistance which is not present on the schematic diagram as a separate component, but is effectively in the circuit nevertheless. A parasitic element can best be explained, perhaps, by considering several examples.

Inductance. A *straight* round wire, such as the lead from an ordinary paper bypass condenser, or the ordinary bus wire employed in circuit wiring, may have a (parasitic) inductance of about .02 microhenry per inch. If this wire is bent, then the inductance increases. All metallic parts possess some inductance; even the foil of a condenser or the plate of a vacuum tube has a small although sometimes significant inductance.

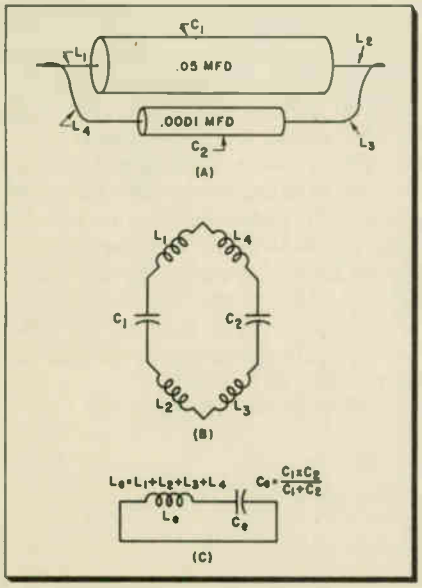


Fig. 1A—Capacitors in parallel, together with their lead inductance, may make up a parasitic resonant circuit. B—Elements of the parasitic circuit, schematically shown. C—Simplified, equivalent L-C series resonant circuit. Effective inductance is represented by L_e; effective capacitance is represented by C_e.

The lead to a tube element is a common parasitic inductance. While the technician may not be concerned with exact values, a couple of illustrative examples will be given:

1. The base pins of a 12AT7 are approximately .04 in. in diameter and about .65 in. long. Each pin has an inductance of about .095 microhenry.

2. The element leads, excepting the plate lead, of a 6BG6-G are about 2.25 in. long, to which is added a base pin approximately a half inch in length. The inductance present is about .065 microhenry minimum; some of this inductance is due to bending. The socket pin and terminal add more inductance.

Even the metallic chassis has some inductance, although we need not ordinarily consider it in service applications.

Capacitance. The most common parasitic capacitance element is the interelectrode capacitance of a tube or tube section. These interelectrode capacitances are not regarded as parasitic when used as all or part of the tuning capacitance for a stage. Nevertheless, these capacitances are, in the strictest sense, parasitic in nature, and enter into the problem of oscillation.

Interelectrode Capacitances

By way of statistics, the output capacitance of a 6BG6 is 6.5 mmfd; its input or grid-to-cathode capacitance is 11 mmfd; and its screen-to-cathode capacitance is about 8 mmfd. The 12AU7 and the 12AT7 have a grid-to-cathode capacitance of about 1.6 mmfd, while the plate-to-cathode capacitance is in the order of .3 to .5 mmfd.

All coils possess self-capacitance, which may be visualized as a shunting or parallel parasitic capacitance across the coil. This shunt capaci-

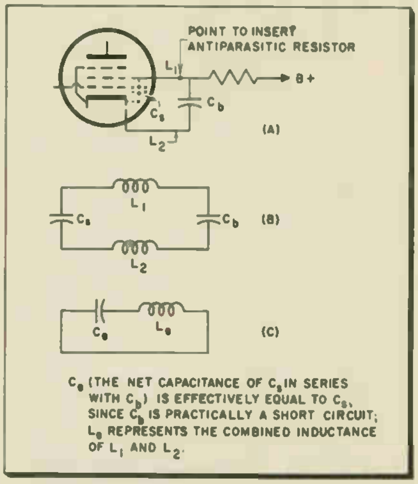


Fig. 2A—Partial schematic of a stage, showing location of bypass (C_b) and interelectrode (C_a) capacitances; also stray inductances (L_1 and L_2). B—Parasitic elements of circuit shown in (A). C—Simplification of circuit shown in (B). C_e and L_e are the effective net capacitance and inductance, respectively.

tance forms the tuning capacitance of the horizontal deflection coils, which oscillate for a half cycle during retrace at a frequency of app. 100 KC.

Circuit wiring generally introduces an extremely small capacitance which may nevertheless not be neglected when the cause of spurious oscillation in UHF tuners is being sought.

Resistance. While resistance tends to damp out parasitic or other oscillation, the presence of resistance in parasitic form in all wires—particularly coils or inductances—should be noted.

Resonant Circuits. The elements just described may constitute portions of a resonant circuit. Such a circuit may oscillate if suitably excited. The principal forms such circuits can take will be described, so that the technician can learn to recognize them. More complex forms of such resonant circuits are often difficult to analyze; case histories involving such complex circuits will therefore follow the consideration of the more simple cases.

Parallel Condensers. The danger of spurious oscillation always lurks in instances where one condenser shunts another (see Fig. 1). The capacitances of the two condensers

Oscillation in TV Receivers

Common Sources of Trouble; Remedies

constitute a single effective capacitance; the series combination of the two provides a net capacitance smaller than that of either condenser. The leads form a set of parasitic inductances in series.

Interlectrode and Bypass Capacitances; Parasitic Inductance. Fig. 2 illustrates a very common case of a parasitic resonant circuit. Here we have two capacitances in series, as before. The bypass condenser (C_b) is, however, much larger in value than the interelectrode capacitance (C_s), and is practically a short-circuit; the effective series capacitance in the parasitic circuit (C_e) is,

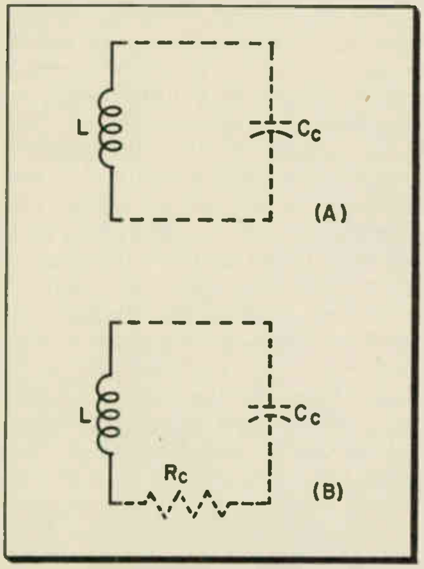


Fig. 3A—Capacitance (C_c) present between the turns of a coil forms a resonant circuit with the coil's inductance. B—Circuit of (A) with parasitic resistance of coil (R_c) added.

therefore, only a trifle less than the smaller interelectrode capacitance. The inductance is provided by the circuit leads, including leads to the tube elements, and some slight inductance in the condenser and tube elements themselves. Since these inductances are in series, they add up to form a single larger or effective inductance (L_e). The effective inductance and the effective capacitance determine the resonant frequency of the parasitic oscillatory circuit.

Inductance and Self Capacitance. Fig. 3 shows the typical case of a coil (inductance) resonating with its own self-capacitance. (We might note that there is a parasitic resistance effectively in series with the coil's inductance, due to the resistance of the wire with which the coil is wound.) In shunt with the self-capacitance is the circuit capacitance.

Inductance of One Coil in Series with Self-Capacitance of Another. Fig. 4 shows a case less common than those previously discussed; this case and its variations are well worth remembering. The parasitic capacitance of a second coil, L_2, is in series with the inductance of the first coil, L_1. The circuit may be completed through direct connection or through capacitances which may themselves be parasitic. An example of such parasitic capacitances, as they may exist between the contacts of a switch, is illustrated in Fig. 4B.

Paralleled Tubes. A frequent offender is the paralleled tube. Fig. 5 shows such a circuit for a parasite involving only two elements of each tube. In addition to the cathode-grid parasite shown in Fig. 5B, other parasites may be formed between the plate and cathode or between plate and grid of each tube section. Note that interelectrode capacitances and connecting leads (including tube element leads) form the parasitic elements.

Remedies. Once the technician is able to recognize potential parasitic circuits, similar to those illustrated up to this point, he can proceed to the next consideration: the cure of TVI resulting from parasites, either by elimination of the unwanted oscillation, or by its effective suppression.

If we can eliminate the parasitic circuit altogether, we can cure the complaint. The two condensers of Fig. 1, for example, may be replaced by a single unit of the appropriate value. This measure eliminates or greatly reduces the lead inductance and thus eliminates the parasitic circuit.

Another remedy derives from the fact that a resonant circuit may be damped by increasing its series resistance, or decreasing its parallel resistance. Addition of such a resistance, especially by the insertion of

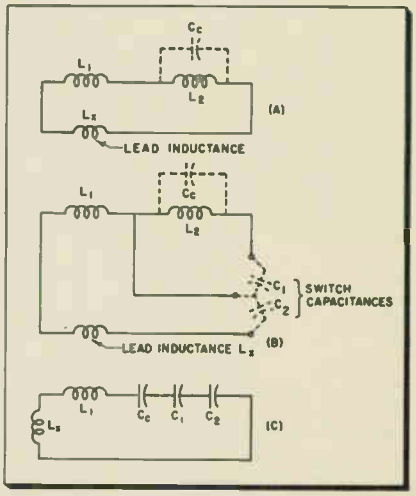


Fig. 4A—Coil inductance (L_1) in series with parasitic capacitance (C_c) of a 2nd coil (L_2) and the lead inductance (L_x). B—Basic circuit of (A), in series with, and completed by, capacitance introduced by switch contacts. C—Equivalent of one of the parasitic circuits in (B). Several others are possible.

a resistor in series with the parasitic circuit, is a common means of eliminating parasitic oscillation. In Fig. 2, for example, an 'antiparasitic' resistor is inserted between the screen grid terminal and the bypass capacitor. The value of the inserted resistance is usually about a hundred ohms or less—often 47 ohms. Such a value kills the parasite without introducing other significant effects on circuit operation. Inspection of circuit diagrams will show that these antiparasitic resistors are generally used between similar elements of paralleled tubes—that is, between paralleled grids, plates, screens, etc.

Frequency-Shifting TVI

There is a third way of dealing with parasitic TVI. The frequency of the oscillation causing the offending symptoms may be shifted by increasing or decreasing the capacitance or inductance of the parasitic circuit, producing a new frequency of oscillation which does not cause interference. This method is employed in cases where the interference is relatively weak. We may cite, as an example, the case where a

(*Continued on page* 44)

Eliminating Television

Practical Methods of Attack on Spurious Oscillation

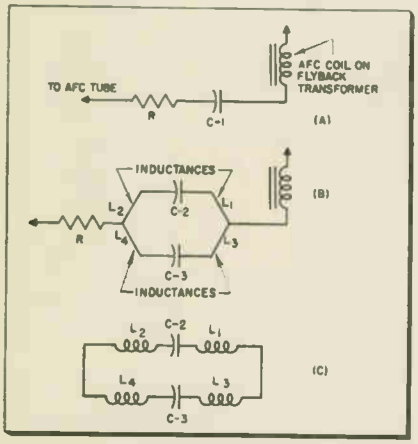


Fig. 1A—Schematic sketch of afc feedback loop. B—Parasitic circuit formed by the two ceramic capacitors used to replace C-1. C—Circuit of (B) showing leads as inductances.

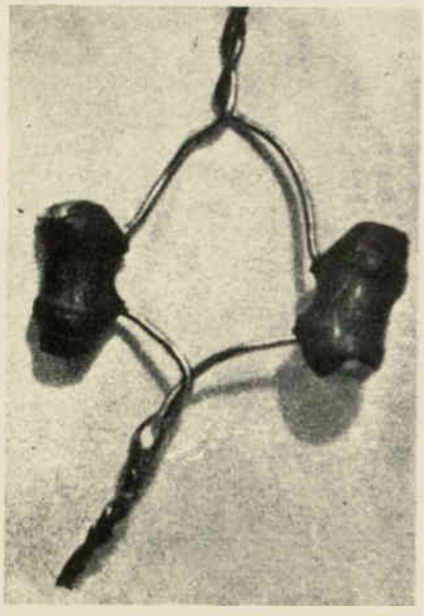
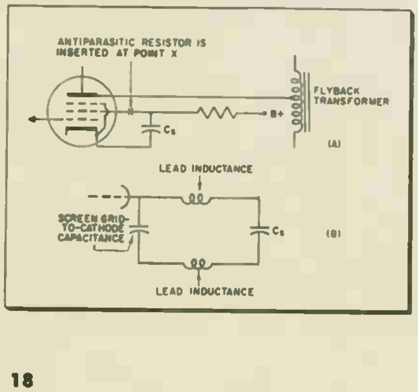


Fig. 2—Photo of two ceramic capacitors used to replace C-1 (schematically shown in 1A).

Fig. 3A—Portion of horizontal output tube circuit. B—Parasitic that may develop here.



By James A. McRoberts

• In this treatment of parasitic oscillation, we will consider some typical case histories. Before this is done, however, it would be well to sum up some pertinent points on this phenomenon.

Parasitic oscillation produces the same aural and visual symptoms as any other interfering signal. The TVI must first be proven to originate in the receiver, rather than outside of it. Further localization by an exploring probe in conjunction with a signal tracing set will localize the trouble to a definite area of the chassis.

The technician must inspect the chassis, as well as study the set schematic, to help him determine whether parasitic or ordinary oscillation is present. Just as a chess player visualizes moves, the technician must visualize parasitic circuits that do not appear on his schematic.

Typical cases of parasites are those due to paralleled condensers, paralleled tubes, paralleled interelectrode capacitances, parasitic self-capacitance, parasitic capacitance of one coil in series with another coil's inductance, and combinations of the preceding. Remedies consist of elimination of the parasitic resonant circuit, over-damping by the addition of resistance, reduction of transmission and/or radiation, frequency shifting to an unused channel or band, excitation reduction, and combinations of these procedures.

Case of the Paralleled Condensers. The first serviceman to work on this set had pulled the chassis, which was subsequently serviced in the shop. The finding was that C-1, a 390 mmfd capacitor (see Fig. 1A) was short-circuited. Since no 390 mmfd condenser was in stock, two capacitors of 100 and 180 mmfd, respectively, had been tied in parallel, and inserted in place of the original unit—a common enough practice. Replacement of C-1 with the equivalent condenser combination shown in Fig. 2 had resulted in normal operation on all channels except Channel 11. Heavy bars appeared in the picture at this channel setting.

The author, who didn't learn about these doings until some time after he had located the trouble, was next called in to service the set. Other sets, it was discovered, did not exhibit the TVI present on the receiver being serviced when they were connected to the same antenna and power line. The conclusion was therefore reached that the source of the TVI lay inside the set.

Our second step was to signal-trace the TVI to the area where its intensity was maximum, as indicated on another set used as a signal tracer, in conjunction with a signal-tracing probe.

The "dog" and the tracer were turned on. ("Dog" refers to the set with the TVI trouble; *tracer* refers to the auxiliary TV set with probe and cable used as a TVI locater, as described in *Tracking Down TVI to its Source*, in the article beginning on page 14. The rear end of the probe cable was connected to the antenna of the tracer. The probe was placed near the feed from the mixer to the video i-f, to pick up the interference, as well as the Channel 11 signal on which the interference existed.

Exploring with the probe by moving it about gave increasing interference on the tracer screen as the probe came into the vicinity of the flyback transformer, the afc section and the afc feedback lead (see Fig. 1A). The ground clip of the probe was now attached to the chassis, to reduce probe pickup and thus permit a more precise determination of where the intensity of the TVI was greatest. The search for the point of maximum intensity was narrowed down to the locality where the two parallel condensers had been installed. The replacement of these two units with a single capacitor resulted in the elimination of the parasitic circuit that the two condensers, in conjunction with their pigtails, had formed (see Fig. 1B, C).

Parasite at Horizontal Output Tube Screen Grid. Fig. 3A illustrates this (horizontal) circuit; in 3B, the parasitic components are schematically shown. The inductance of the bypass

Interference Due to Parasitics

in Sweep, Sync and Other Circuits. Case Histories

condenser leads, tube and socket lead inductances, etc., provide the inductance of the resonant circuit present, while the effective capacitance is approximately the screen grid-to-cathode capacitance.

Symptoms of the interference produced by such a parasite are generally vertical bars at the left hand side of the raster—the most intense bar being farthest to the left, with succeeding bars of lesser intensity, at uniform spacings. The interference appears on all channels, as its frequency is approximately 25 mc. The second harmonic of this TVI signal may cause trouble on newer sets with 40 mc video i-f stages.

If this form of TVI is not readily identified by its appearance, the signal tracing procedure previously cited will unmask it. The ring or oscillation present is started by the sudden cutoff of the screen grid current of the tube at the onset of horizontal retrace, which periodically re-starts the in-phase oscillation.

The typical cure for these cases of parasitics due to interelectrode capacitance is the insertion of a resistance in series with the parasitic circuit, at the point indicated in Fig. 3A. (In many recent sets, a 47-ohm antiparasitic resistor has been incorporated into the circuit at the factory.) This antiparasitic resistor prevents oscillation by overdamping the circuit.

Excessive drive may cause such a parasitic to occur. The overdriving may be the result of another trouble such as an old tube, excessive tube loading due to condenser leakage, etc., necessitating increased drive to maintain deflection and high voltage. The insertion of an antiparasitic resistor (when one is not already present) will suppress parasitic oscillation in such instances; removal of the primary trouble is, however, a better service procedure.

The preceding discussion applies with equal force to all cases of interelectrode capacitances paralleling circuit capacitances. Parasites may appear at the grid and plate of the horizontal output tube, for example. Other tubes may harbor a parasite if a parasitic circuit is present and the excitation is great enough.

In two instances the author knows about, oscillation in the horizontal output tube was due to feedback from a parasitic plate or screen circuit, to a parasitic grid circuit. The oscillation in the horizontal output tube, interestingly enough, furnished sufficient grid drive to the tube itself to enable it to function without the horizontal oscillator. Both high voltage and horizontal deflection were present, although the deflection was not synchronized. The cure consisted, of course, of inserting an antiparasitic resistor in the grid circuit.

Parallel Tubes. Whenever a tube is placed in parallel with another one to provide additional output, antiparasitic resistors are or should be inserted in the leads between the plates, screen grids and control grids of the two tubes. Otherwise a pair of these elements may form a complex parasitic circuit with the cathodes. As an example, consider the two 6BG6G's strapped together to form a parallel circuit in Fig. 4A. Fig. 4B shows the parasitic circuit. Present in this circuit are the screen-to-cathode capacitances of the two tubes; the leads between screen grids plus the internal screen leads form one inductance, while a similar inductance is made up of the cathode-to-cathode lead, plus the internal tube leads to the two cathodes.

Similar parasitic trouble may develop due to grid-to-cathode and connecting lead capacitance, in which case resistor insertion in the grid-to-grid lead is proper. Similarly, the plate circuit may develop a parasite; a resistor in the plate-to-plate lead is employed to prevent this. Usual practice places a resistor in each lead excepting the cathode-to-cathode lead, although one may be placed here; the points where the resistors go are marked "x" in Fig. 4A.

All paralleled tubes should be objects of suspicion relative to possible parasitics if the precautionary antiparasitic resistors are not present. (Even when they are present, they may have decreased in value and should be checked, if a parasite

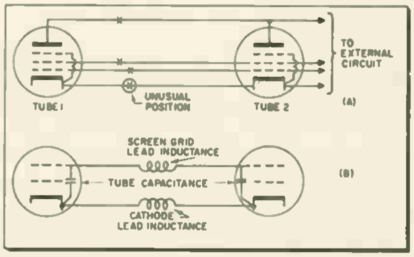


Fig. 4A—Simplified circuit of two tubes in parallel. Antiparasitic resistors are inserted at points indicated by X. B—Circuit of (A) re-drawn to show parasitic network present.

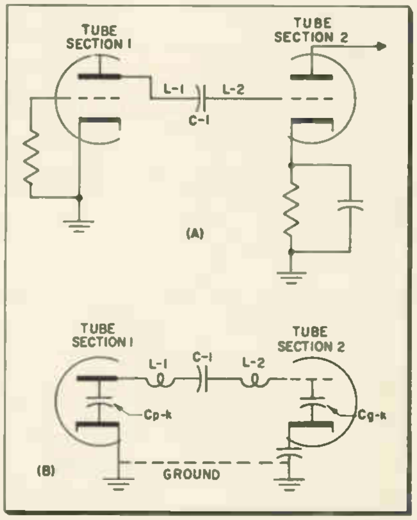
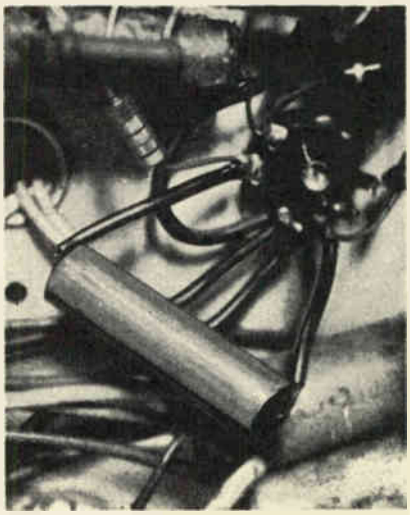


Fig. 5A—Section of sync circuit. B—Parasitic circuit of (A). Cp-k and Cg-k are the plate-cathode and grid-cathode capacitances.

Fig. 6—Photo illustrating circuit components shown in Fig. 5. Large condenser is C-1.



seems to exist in the circuit.—Ed.) Paralleled audio output tubes have also been frequent offenders, as have been push-pull oscillators, or paralleled oscillators.

Sync Circuit Parasite. Illustrative of another complex case of parasitic oscillation, is the sync circuit shown in Figs. 5 and 6. The tube is a dual-section 12AT7 employed as sync amplifier-clipper. The TVI produced by the parasitic was noticeable as a mottled bar effect on Channel 7 only. (The parasitic signal was apparently beating against the Channel 7 picture carrier to produce a beat-note of approximately 4 mc.) The interference appeared when the customer moved to a new location.

Localization tests via signal tracing led to the area shown in Fig. 6 becoming suspect. Signal tracing also indicated that the wires passing under condenser C-1 through the metal grommet were "hot"—i.e., they had picked up the TVI from the parasitic circuit by capacitance coupling between them and C-1. The wires were, in turn, radiating the signal to the antenna lead-in to the tuner, on the opposite side of the chassis.

The cure for this parasite consisted of lengthening the condenser leads, to provide additional parasitic inductance. One lead was made into a one-turn coil for this purpose. The resultant increase in inductance decreased the parasitic resonant frequency so that the beat note fell below Channel 7. This is an example of frequency-shifting to an unused channel or band, to eliminate parasitic effects.

As a further precaution, condenser C-1 was dressed at right angles to the chassis (it is shown in Fig. 6 as *parallel* to the chassis), and away from the wires under it, which acted as transmission lines when they picked up the resonant circuit's energy.

In some cases, the filament or heater wires leaving a tube carry the TVI with them. A bypass to ground with or without a series choke may help. In the case just cited, the reduction in symptoms was so slight when such a remedial measure was tried, that filament bypassing was not added.

Filament Choke and Its Parasite. The photograph in Fig. 7 shows a filament or heater choke which formed the principal inductance of a parasitic circuit. The parasite became noticeable when the customer moved to a weak-signal area. The frequency fell within the i-f band, causing TVI on all channels that were relatively weak. Localization of the fault was effected by using a signal-tracer set and probe.

The cure comprised replacement of the choke with one having about four more turns; this procedure lowered the resonant frequency below the i-f band. As an additional precaution (and to eliminate a trace of TVI on Channel 4 when the new choke was installed) a parallel resistance was installed. This resistor of 150 ohms, inserted in parallel with the choke (and its shunt capacitance) provided overdamping in addition to the frequency shift.

The case history just described illustrates an important point, viz., check to see if you have created new TVI whenever you try to minimize or eliminate TVI by the frequency-shifting technique.

Miscellaneous Cases. A capacitance tuner with a band-switch for high and low channels in a Pilot electrostatically-deflected set (see Fig. 8) exhibited a parasite on the high-frequency band. The self-capacitance of the low-frequency oscillator coil,

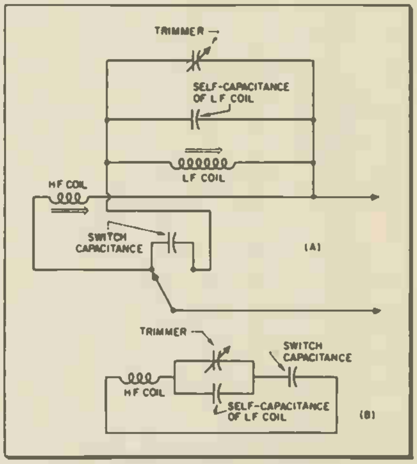


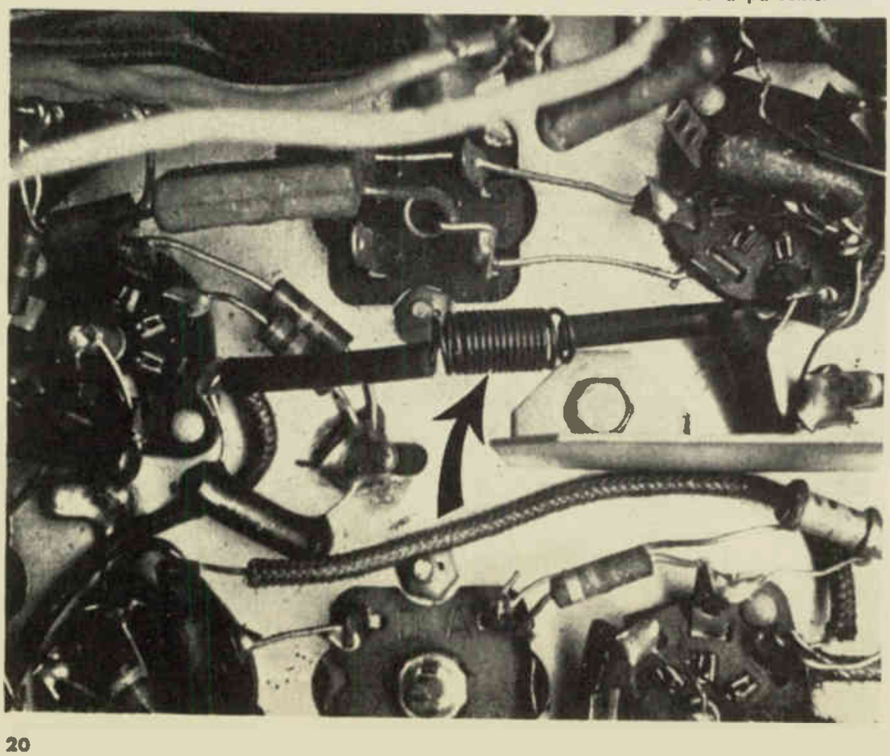
Fig. 8A—Schematic of section of tuner circuit. B—Parasitic circuit of tuner shown in (A).

in series with the inductance of the high-frequency coil and the self-capacitance of the band-switch contacts and the wiring, was forming a parasitic circuit. Frequency shifting was used to remedy the trouble.

The shunt capacitance was varied by moving the shunt trimmer on the low-frequency coil slightly, but sufficiently to shift the TVI beyond the point where it could produce interference on the h-f band. The low frequency tuning was restored to normal by another adjustment, that of the inductance slug. The dial calibration was sufficiently broad to permit this procedure. Note that the self-capacitance of the low frequency coil is in shunt with the trimmer capacitance on that coil, which explains why the TVI frequency could be shifted by resetting this trimmer.

In another case, the heater "hot" leg of a 6J6 oscillator tube was bypassed to ground by a condenser. The inductance formed by the heater itself, plus that of the wiring and element leads, produced a parasitic circuit. The cure was a change in the value of the bypass condenser, which shifted the frequency of the TVI, making symptoms invisible.

Fig. 7—Photo showing circuit in which filament choke contributed to a parasitic.



Ringing Problems in TV Sets

By James McRoberts

• Ringing circuits embrace all networks which oscillate or ring due to shock excitation. Television receivers employ the ringing circuits in some horizontal oscillator circuits (multivibrators and blocking oscillators) under several aliases: oscillator coil, stabilizer, phasing coil, etc.

Signal excitation usually causes rings in the peaking coils of video amplifiers. The resonant circuit of the peaking coils includes parasitic circuit capacitance (not shown on schematic) and interelectrode tube capacitances; hence, peaking coil circuits might also be classified as parasitic oscillatory circuits. Other television circuits, such as those in which the horizontal deflection coils lie, may also be placed in this category, due to their ability to resonate with their self-capacitance and produce excessive amounts of ringing.

The technician is concerned with how such circuits oscillate, practical means for increasing or decreasing the intensity of the ring or oscillation, and ways of suppressing the ring completely.

Simple Ringing Circuit. The simple series-resistance ringing circuit of Fig. 2 is derived from the multivibrator circuit shown in Fig. 1. The reader will recall that multivibrator and blocking oscillator tubes act like switches, that is, these tubes change very rapidly from no conduction (open-circuit condition resembling an open switch) to full conduction (closed switch condition). The tube's plate-to-cathode resistance is in series with the switch (Fig. 2B). The plate load resistor is in series with the plate resistance and the switch, and we are therefore justified in adding these together to form resistance R_x in Fig. 2A.

We may liken the incoming sync pulses shown in Fig. 1 to a mechanical arm attached to switch SW of Fig. 2A. The analogy may also be thought of with respect to Fig. 2B. The internal resistance of coil L in Fig. 1 becomes series resistance R in Fig. 2A. Capacitance C in Fig. 2A comprises shunting capacitor C-1 shown in Fig. 1, plus the self-capacitance (not shown) of coil L.

Analysis of Series Ringing Circuit. Having simplified the circuit of Fig. 1 to the one shown in Fig. 2A, we may proceed to analyze its operation. For the benefit of those readers who are not familiar with the subject of ringing, we will further simplify Fig. 2A by considering that R is absent (R can never be eliminated in actual practice, it should be noted). We assume at the outset that switch SW is closed, permitting battery B to send a current through the coil L, and to charge condenser C.

Opening the switch causes this passage of current through coil L to cease. The current that previously passed through coil L stored up energy in the coil in the form of a magnetic field around it. This magnetic field now tries to dissipate itself, or collapse. In so doing, it sends a current through the circuit in a direction *opposite* to the one which originally flowed there. This new current charges C in the opposite direction.

When the coil has transferred its energy to C (storing a charge on C), the condenser will discharge, sending a current through L in the same direction as that of the original current. This recreates the field that originally appeared around coil L, and causes C to acquire a charge whose polarity is the same as the initial charge developed across it. One cycle of oscillation is thus completed. This cycle repeats itself (see Fig. 3A).

Since R (Fig. 2A) is assumed to be absent, and no energy is dissipated in the coil or condenser in this hypothetical case, each succeeding cycle is an exact duplicate of the first one. We call this the undamped case, due to the fact that no resistance is present to damp out the oscillatory energy. This theoretical case is approached in practice only in some extremely high "Q" circuits

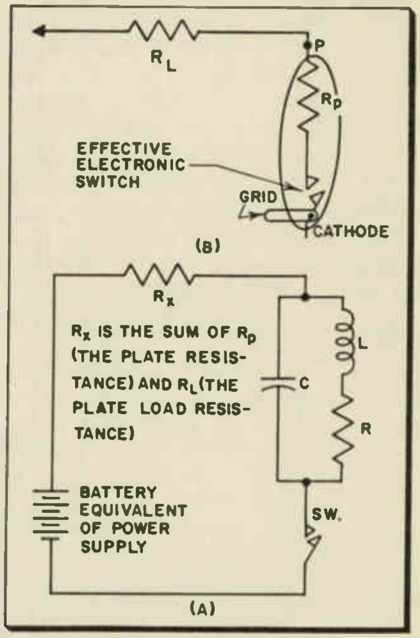
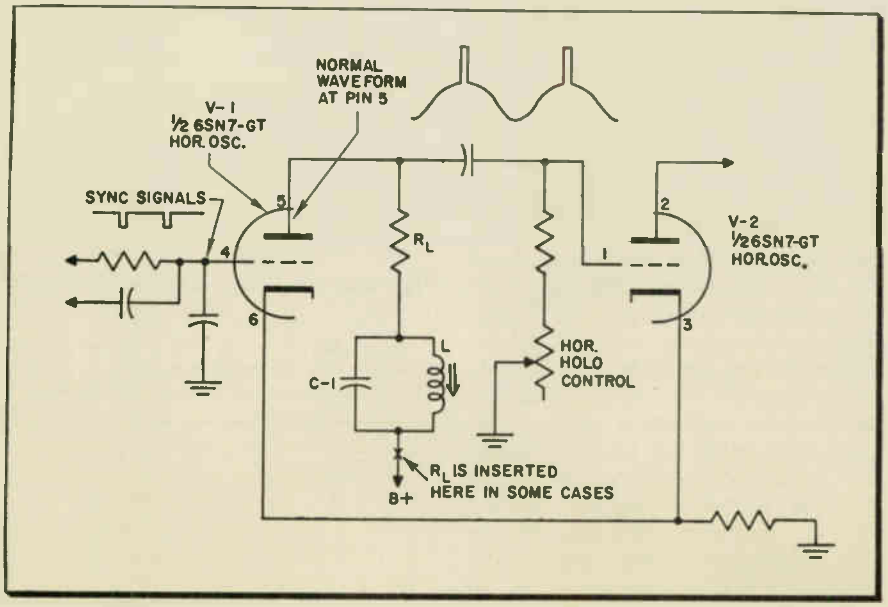


Fig. 2A—Simple ringing network (L, C, R) and associated circuit. R is made up chiefly of the resistance of the coil winding. B—Equivalent circuit of triode-switch tube. Grid-cathode voltage acts like a mechanical switching arm that opens or closes the switch.

Fig. 1—Section of horizontal multivibrator circuit. L and C-1 make up the ringing circuit.



What the Technician Should Know about the Theory and Servicing of Ringing Circuits

(such as the lightly-damped networks associated with quartz crystals that are used to "ring" in some radar applications).

We now proceed to the case where series resistance R (Fig. 2A) is relatively small. The passage of current through the resistor causes a dissipation of energy (I^2R loss) that manifests itself as heat in the resistor. Not all of the energy is now transferred from the inductance (coil L) to the capacitance (condenser C) or vice versa. In each succeeding cycle the oscillatory peak amplitude consequently becomes progressively smaller (Fig. 3B).

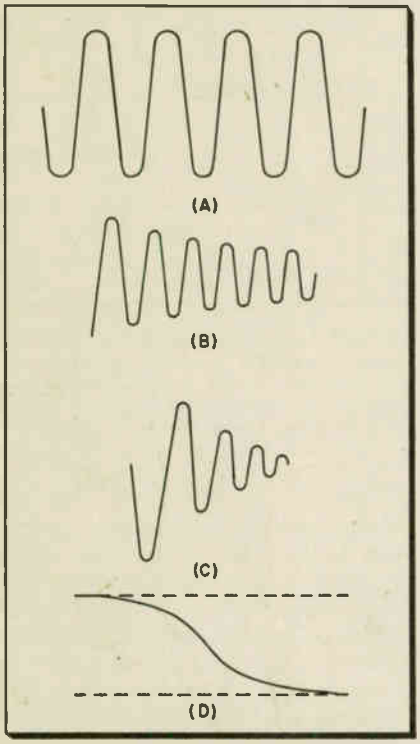


Fig. 3—Waveform of a ringing circuit when the latter is (A) undamped, (B) slightly damped, (C) heavily damped, (D) over-damped.

If series resistance R is increased further in value, more energy will be dissipated per cycle, or every half cycle, and the waveform now produced will resemble the one shown in Fig. 3C. Note the rapid decay of the oscillation in this case.

Increasing series resistance R beyond a certain critical value will cause the waveform shown in Fig. 3D to be produced. In this case, no oscillation whatsoever is present, and the current simply decays to zero without reversing. This "over-damping," as it is called, serves as a means for eliminating parasitic oscillation, such as the ring sometimes encountered when the horizontal output tube is overdriven. (To permit greater drive without ringing, antiparasitic damping resistors are inserted in horizontal output stages.)

We turn now to the parallel resistance case shown in Fig. 4, typical of video peaking coils and their shunting resistors. We are considering a simple instance here. When resistance is in *parallel* with an "excited" coil, the ringing that takes place will vary *in direct proportion* with the value of the parallel resistance (whereas ringing varies *inversely* with the resistance present, when the latter is in *series* with the coil). The absence of shunting resistance (we assume the absence of series resistance as well) produces the undamped wave of Fig. 3A; when parallel resistance is inserted in decreasing amounts, damping increases, and the ringing present goes through the changes shown in Figs. 3B, C and D.

Let's now apply the information we have developed to practical problems.

The Stabilized Multivibrator. The purpose of a ringing coil (regardless of its alias) in the plate circuit of the stabilized multivibrator, is to provide a means for triggering the retrace tube (2nd half of multivibrator) when incoming sync pulses have been lost, or are weak. Its further purpose is to prevent such retrace tube triggering at times other than at the end of exactly one horizontal line.

The circuit is appropriately resonated by adjusting the slug of coil L (Fig. 1) to produce one cycle of oscillation for every horizontal line. This one-cycle ring is very lightly damped, as indicated by the waveform (see Fig. 1) at pin 5 (plate) of V-1, carried over, also, to the grid of V-2, the 2nd tube section. We note further that the retrace spike occurs on or near the crest of the sine-wave ring; this spike, incidentally, starts the ring.

If the circuit is heavily damped for any reason, the waveform will resemble the one shown in Fig. 5. Note that the peak amplitude of the composite waveform is now considerably smaller. The stabilizing action becomes as ineffective under such conditions as if the stabilizer were not tuned, or could not be tuned (due to change or improper values of L or C) to produce a single-cycle ring. When any of the troubles just mentioned are present, symptoms of instability and exceedingly critical horizontal hold will be produced.

The source of the trouble may be identified in each case with the aid of scope waveform checks. Too much damping will produce the waveform of Fig. 5, in which the spike starts from the sine wave valley; the absence of the sine wave or similar waveform, on the other hand, indicates either improper coil adjustment or improper component values (you can distinguish between these causes of trouble by trying to tune the slug). When a component's value is improper, its replacement is obviously indicated.

The author ran into a case where overdamping was due to water absorption by the stabilizing coil. A cold solder joint, which increased the resistance in series with this coil, was responsible for another overdamping condition.

Pulse Width Stabilizer Coil. The stabilizing coil used in a blocking oscillator pulse-width controlled circuit is similar in function to the stabilizing unit employed in the multivibrator. Only the waveform is different (see Fig. 6). The same troubles and symptoms occur in this as in the preceding case, and we will therefore not treat it further.

Parasitic Oscillation Providing Horizontal Retrace. The self-capacitance of the horizontal deflection coils resonates with their inductance

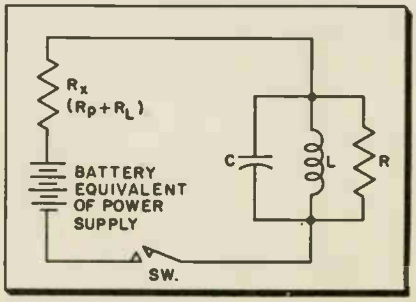
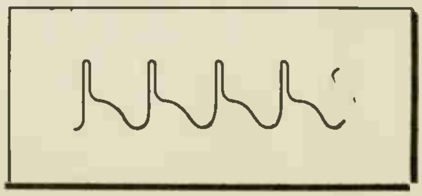


Fig. 4—Ringing circuit with shunt resistance.

Fig. 5—Waveform at first plate of multivibrator with excessive resistance in ringing circuit (compare with pin 5 waveform, Fig. 1).



to form an oscillatory circuit whose frequency is about 95 kc; the frequency is such that one half-cycle of oscillation occupies an interval approximately 5-6 microseconds long (retrace time duration). The energy stored in these coils tends to dissipate itself as an oscillation when the horizontal amplifier plate current stops flowing at the end of the trace interval. The absence of (excessive) damping allows the oscillation to start and go through one half-cycle; the oscillation is normally stopped at this time by the conduction of the damper tube, which acts as a parallel damping resistance.

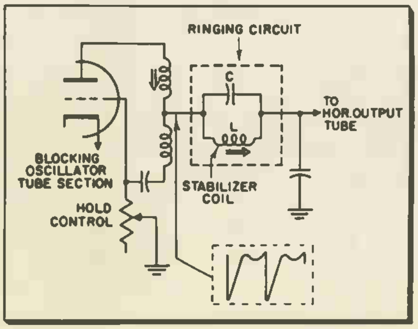
The waveform produced in the absence of damping is shown at Fig. 7B. With proper damping, the waveform will resemble the one shown in Fig. 7C (a very slight amount of oscillation is present in this case). The essential damper circuit is illustrated in Fig. 7A. Note the two (parasitic) self-capacitances.

One group of troubles in this circuit develops because of an increase in self-capacitance; the resonant frequency is lowered as a result of this increase, thereby increasing retrace time. If the retrace time becomes excessive, foldover will result. Troubleshooting is simple: try another yoke.

Tubes are frequent sources of trouble. Old or even new damper tubes may have a high plate resistance, causing damping to be insufficient. The capacitor from damper cathode to ground may develop a high resistance, increasing the effective impedance in shunt with the horizontal coils during retrace, and thus producing insufficient damping. Try replacing the capacitor, to check for this condition.

The rings produced by the troubles just cited (vertical lines at left of screen, most intense line at extreme left, with each successive line progressively weaker) may arise from other causes, such as parasitic oscillation in the screen or plate circuit of the horizontal output tube(s).

Fig. 6—Section of blocking-oscillator pulse-width circuit showing ringing network used.



Localization of, and remedies for, this type of fault have been considered in a previous article. Barkhausen-Kurtz oscillations may also produce similar symptoms. A magnet moved about the horizontal output tube will eliminate, and thus serve as a check for, this source of trouble.

Pronounced changes in the series resistance of the deflection circuit (including the flyback secondary) will result in too rapid a decay of the half-cycle oscillation or ring. Since the oscillation is rectified by the damper and converted into a dc boost voltage, the reduction in amplitude produced by its too-rapid decay will lower the B boost voltage

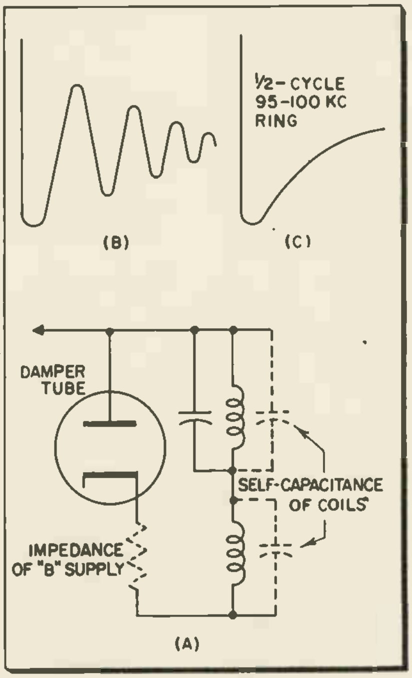


Fig. 7A—Section of damper circuit. B—Ringing waveform if damper tube were not used. C—Ringing waveform with damper present.

and decrease the width and high voltage; the need for increased drive in such a case may also cause the parasitic previously mentioned to be produced.

Ringing in Vertical Deflection Coil. Fig. 8 illustrates part of a conventional vertical coil circuit. Parallel damping is provided by the shunt resistors, whose customary value is 560 ohms each. From our previous discussion, we know that an appreciable increase in the value of these resistors will result in increased ring intensity; this often happens in practice.

The ring appears as a bar, similar to a sound bar but stationary, at the upper edge of the picture screen; it is followed by lower bars of successively-diminishing intensity. These symptoms give the appearance of a wrinkle to a picture or test pattern; the condition is often referred to as a wrinkle in consequence. (Wrinkles are distortions of lines that are normally straight; the lines assume a sine-wave shape.) The remedy is, of course, replacement of the resistor at fault with one of the correct (lower) value, to decrease the ringing intensity.

Trouble may develop due to excessive capacitance across the vertical coils; this is, however, apt to be less pronounced than in the case of the horizontal circuit. Extreme cases of excessive capacitance will cause foldover, due to integration of the sweep signal; milder cases will produce (vertical) non-linearity.

Substitution of a new yoke is the proper test procedure, although this is not recommended until other circuit tests have been tried without success.

Trouble in the 56 mmfd (anti-wrinkle) condenser shunting half of the horizontal winding may cause wrinkle symptoms similar to those resulting from an increase in the value of the resistors shunting the vertical deflection coils. Check for such a defect by condenser substitution, making sure to connect the replacement across the *same* half winding.

Peaking Coils as Ringing Circuits. Another ring that frequently manifests itself is the one following an abrupt change in picture content—i.e., when a predominently dark scene becomes very light, or vice-versa. Ringing in this case may be caused by the peaking coils of the video amplifier (see Fig. 9A). Symptoms include ghosts of lines in the picture.

A ghost due to a ringing peaking coil is very similar to a reflection caused by an improperly-oriented antenna, except that the spacing of the direct and ghost signals remains the same at all channel settings, when a peaking coil is the source of the trouble; this spacing generally varies, on the other hand, when improper antenna orientation is causing the symptoms.

Several ghosts may be seen following an object in the picture, when a peaking coil ring is present, with each ghost less intense than the one immediately preceding it.

Some ringing is usually permitted in video peaking circuits. Certain customers may, however, object to the ringing intensity. The technician can alter the damping provided by the shunting (parallel) damping resistor in such cases.

The serviceman should check all

(*Continued on page* 47)

By Cyrus Glickstein

Lead Dress Problems

Incorrect Placement of Wiring Can Cause

• Some TV sets may not look like it, but it can be taken for granted that the wiring layout, especially in critical circuits, has been carefully planned by the engineering department. However, experience has shown that poor wiring (improper lead dress) does creep in, both in the initial manufacture and in subsequent servicing. This produces a wide variety of troubles.

To emphasize the importance of the subject, it might be noted that improper dress of leads, as well as incorrect placement of parts like resistors and condensers, can cause: 1) audio defects such as buzz and hum; 2) video defects such as a weak (snowy) picture, interference, regeneration, poor sync, bending, impaired interlace, and ragged edges on the raster; 3) circuit breakdown as a result of heat and arcing; and 4) interference with other receivers —for instance, AM home radios.

As an aid in troubleshooting, the above symptoms can be reclassified on a more useful basis. Proper lead dress is necessary (see Fig. 1) to avoid:

1) Breakdowns due to heat.
2) Breakdowns due to arcing or corona.
3) Defective operation due to unwanted bypass action.
4) Defective operation due to undesired coupling between stages.

Each of the above classifications, together with the circuits usually affected, will be discussed in turn.

Troubles in the first two categories are familiar to most servicemen. Heat breakdowns can be avoided by routing leads away from hot tubes, resistors, or similar parts which may burn the insulation and eventually cause trouble. It is also necessary to place parts which become hot away from other parts (like condensers) that may change in value or break down more readily because of the heat.

This does not mean that the routing of leads and the placement of small parts should be radically shifted around in every set that comes to the service bench. As will be seen shortly, this would simply be asking for trouble, not preventing it. A good rule to follow is: if the set has been working ok prior to the breakdown, follow the original wiring and parts location as closely as possible in making the replacement, but avoid placing the new part and its connecting wires close to a hot spot. If a wire or part in another section of the chassis is seen to be overheating because of its location, change the location, observing the precautions indicated in the next paragraphs.

Arcing Troubles

Arcing can be caused by defective lead dress in either the low-voltage or the high-voltage circuits; the fault, however, usually occurs in the high-voltage circuit. In low-voltage supply circuits, servicemen are usually careful not to dress a B+ tie-point too close to chassis or a ground wire. Low-voltage B+ wires generally have adequate insulation, so there is no arcing even if they touch the chassis.

In high-voltage circuits, there is a much greater problem. Arcing can take place between points which are not touching if there is a large enough potential difference between them. In addition, corona (ionization of the air) may occur, particularly in the vicinity of a pointed or sharp-edged hv connection.

The following rules summarize the precautions which should be taken in high-voltage circuits:

1—Terminals of the high-voltage rectifier socket should be dressed toward the inside of the corona ring and be free from sharp protrusions.

2—The corona ring should be dressed so that it will function properly; that is, centered, and about ⅛-in. below the socket terminals.

3—All leads in the high-voltage circuit should be kept as far apart from each other as possible. They should be short and direct, but without strain, and dressed as far as possible from the flyback transformer windings. The leads should also be dressed as far as possible from the chassis, and away from low-voltage leads, or leads at or near ground potential. Particular precautions should be taken to keep the high-voltage rectifier and horizontal output plate-cap leads as far as possible from the cage (chassis). It is good practice to wax these leads at both ends, to minimize corona spray.

4—Make certain no sharp points are present, after soldering replacement parts in the high-voltage circuit, to minimize the possibility of corona. It is advisable to operate the receiver in a darkened room after completing the repair, checking for the smell of ozone or audible arcing.

The next important type of trouble caused by incorrect lead and component dress is defective bypass action. This is most likely in r-f, i-f and video amplifier circuits, and can result in defective output because of regeneration, reduced output, or poor high-frequency response.

In video amplifier circuits, coupling condensers and peaking coils are mounted away from the chassis to minimize stray capacitance to ground and possible reduction of high-frequency response.

In video i-f circuits, the leads of i-f coils (because of their length and position) become part of the circuit tuning. The distance of these leads from the chassis helps determine the amount of stray capacitance in the tuned circuit. When a video i-f coil is aligned to a given frequency, the capacitance of the lead dress becomes an integral part of the circuit tuning. Changing the lead dress may therefore change the resonant frequency of the circuit. If done on a wholesale basis, the video i-f section may be sufficiently detuned to make realignment necessary.

Replacement Cautions

Special care must be exercised in replacing bypass condensers in r-f and i-f stages. It is advisable to use the same type of condenser, with the same pigtail length at both ends, as originally present. Furthermore, the condenser should be replaced in exactly the same position.

A condenser in these circuits acts not simply as a condenser, but rather as a tuned circuit. The capacitance of the condenser plus the stray capacitance of the pigtails to chassis, together with the inductance of the pigtails, plus the inductance introduced by the internal construction of the condenser, all combine to make any capacitor a resonant circuit at some particular frequency. This affects the bypass action of the condenser at the desired frequencies, and in turn the frequency response of the stage. Changing the type of condenser and its pigtail length may change the response of the stage with which it is associated, possibly caus-

in Television Receivers

Buzz, Hum, Poor Interlace, Improper Holding, and Other Symptoms

ing some degeneration of the incoming signal, or regeneration, because of a peak in the response. In addition, failure to replace the part in its previous position may introduce other problems, which we are going to discuss shortly. It is important to use the same ground points when replacements are soldered in.

To summarize, don't disturb lead dress in r-f and i-f circuits unless there is a reason (say, elimination of undesired coupling) for doing so. When leads must be moved, keep this caution (which applies to all circuits) in mind: When moving leads to find out if they are causing undesired coupling, don't move them around at random. Move only those leads that can possibly cause the defect. Then, if the trouble is not eliminated, *return them to their original position.*

The largest group of lead dress troubles is probably caused by coupling. An unwanted signal may be coupled from one circuit to another *capacitively* (adjacent wires or parts can form the plates of a condenser, functioning like a conventional coupling condenser); *inductively* (ac voltages in one wire may induce a voltage in an adjoining one) or both. In some cases, a signal may be *radiated* from one circuit into another one.

Because of the many possible defects caused by coupling, this condition will be discussed under a) audio effects and b) video effects.

The most common audio troubles caused by improper lead dress are hum and buzz. Since each of these defects may also be caused by other faults, it is important to narrow down the possible sources of trouble before starting to shift leads around.

Troubleshooting Procedure

A suggested troubleshooting procedure to determine whether hum in the sound is due to lead dress may be roughly outlined as follows: First, note if the hum is heard on all channels. If it is, turn the volume control to minimum. If the hum is still heard, the most likely source of trouble is either the low-voltage power supply or an audio tube (in which cathode-to-heater leakage is present). If the hum, on the other hand, is eliminated by turning the volume control down, turn the control up about half way, so the hum can be heard. Now short the "hot" terminal of the volume control to ground. If the hum is still heard, it is no doubt being picked up by the leads to the first audio stage (from the volume control, tone control, etc.).

Carefully move the suspect leads, noting whether hum increases or decreases. If these leads are near filament or line input wires, reroute the appropriate wires, if necessary. In general, ac leads are kept close to the chassis, and away from circuits particularly susceptible to pickup, or whose operation may be affected by pickup.

In redressing audio leads to reduce hum, be careful to avoid buzz pickup and regeneration. Regeneration (which often manifests itself as a high-pitched squeal) can result from placing the plate lead of the audio output stage too close to the grid lead or grid circuit of the first audio stage.

When it is not possible to entirely eliminate hum pickup by redressing the leads, it may prove helpful to shield (unshielded) leads going to the volume control and the first audio stage. When a shield is added, not more than ¼ in. of wire should extend from each end of the shield. Both ends of the shield should be well grounded.

If hum is heard on only one or a few channels, try placing a .01 mfd ceramic or mica condenser across the antenna terminals. If this reduces the hum, it is probably being fed into the tuner. The first likely thing to check in this case would be the agc tube and its associated circuit.

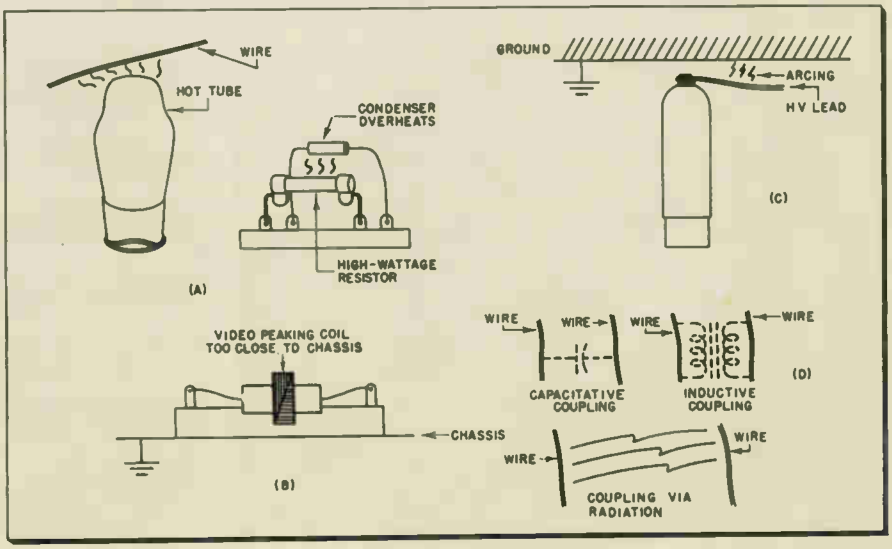
Buzz may have many different causes. Common classifications of buzz include sync pulse pickup, intercarrier buzz, vertical sawtooth pickup, and mechanical vibration of laminations in a vertical sweep or power transformer. To determine whether the buzz is caused by the vertical circuit, vary the vertical hold control. If a change in the pitch of the sound is now heard, then the buzz is originating in the vertical circuit.

Tracing Source of Buzz

If there is any question whether the buzz is coming directly from the speaker, or indirectly from a transformer in the vertical sweep circuit, turn down the volume control completely. If the buzz is still audible, it is no doubt being caused by the mechanical vibrations of a vertical transformer (blocking oscillator or output). To eliminate the vibration, crimp the lamination

(*Continued on page* 44)

Fig. 1A—Placing wires or components too close to units that generate heat, such as high-current tubes or large resistors, invites subsequent breakdowns. B—When an hv lead is too near a ground point, arcing or corona is likely to occur. C—Dressing a video peaking coil too close to chassis will introduce an undesired bypassing effect. D—Undesired coupling between leads.



Eliminating Tweet Interference

Some Suggestions on Lead Dress Troubles

By Cyrus Glickstein

The most important video defect which can be caused by lead dress is *tweet*—an r-f interference pattern generated internally in the receiver. The tweet frequency is a harmonic of the video or sound i-f carrier. This harmonic is fed from the video detector back to the tuner, beats with the incoming picture or sound r-f carrier, and causes an interference pattern to be visible on the screen.

The tweet pattern is usually a continuously changing one. It can generally be distinguished from external interference by a simple test. Vary the fine tuning control. If the TVI pattern seen changes from thin diagonal or vertical lines, to broad horizontal lines, and back to diagonal lines, as the fine tuning is slowly varied (see photos), the interference pattern is probably due to an internally-generated tweet.

To verify this, figure out whether any harmonic of either the sound or picture i-f is close in frequency to either the sound or video r-f carrier, on the channel(s) where the interference is present. If it is, a tweet is probably the cause of the TVI.

In most cases, the tweet is caused by pickup of the i-f harmonic in the section of transmission line between the antenna terminals and the tuner. The trouble may be due to the insufficient spacing of this antenna lead-in from audio or video i-f stages, particularly the video detector. If moving the lead-in reduces the tweet symptoms seen on the screen, it is advisable to staple the lead-in along the top of the cabinet, as far from the video i-f section as possible. It may be necessary to lengthen the lead-in, to obtain the maximum reduction in interference.

If the tweet is not caused by pickup in the antenna lead-in, it is advisable to determine whether it is originating in the sound or video i-f section. This can be done, as described previously, by simply checking mathematically — determining whether the sound or video i-f harmonic falls in the channel tuned in. Another check consists of removing the first sound i-f tube and noting if the tweet effect disappears. If it does, it is originating in the sound i-f section.

Possible procedures for clearing up tweet interference originating in the sound i-f section include the following:

a) Check sound i-f and discriminator transformer shield cans and wiring. The cans should be tight in place and well grounded to the chassis.

b) Lead dress in the discriminator stage, especially that of discriminator transformer wiring, should be short and direct.

c) All bypass capacitors in the sound i-f section should have leads as short as possible; the capacitors themselves should be dressed close to the chassis.

For clearing tweet interference originating in the video i-f section, the following is recommended:

a) Try shielding the 4th video i-f, video detector, and video amplifier stages, when such shielding is absent.

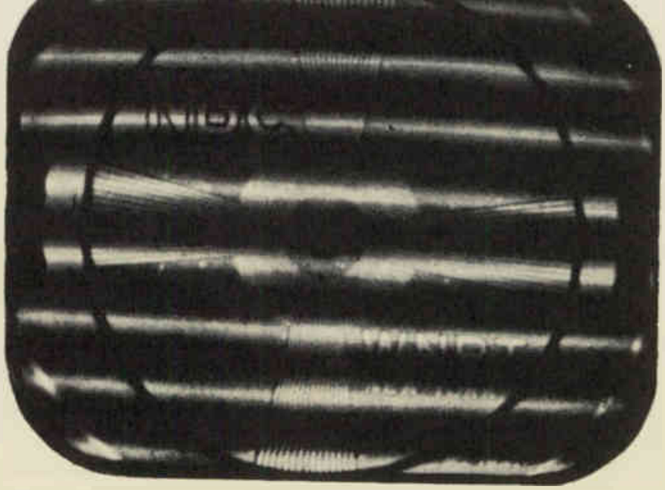
b) Wires from the video detector circuit should be short, dressed close to the chassis, and away from other wiring.

c) Determine, by bridging and resistance tests, whether bypass condensers in the 4th picture i-f plate circuit, the r-f bias circuit, and the video i-f plate and screen circuits are in good condition.

d) An outdoor antenna should be tried on receivers using built-in antennas, since the outdoor unit provides a better signal, less susceptible to interference. A built-in antenna is apt to pick up more tweet interference than an outdoor one.

In the case of particular receiver models, where the tweet problem is present in aggravated form, service bulletins of the set manufacturer should be consulted.

TVI caused by tweet varies from narrow diagonal lines (left) to broad horizontal lines (right), as fine tuning control is rotated slowly.



Switch Tuned UHF-VHF Antenna

Indoor unit for TV reception achieves large electrical volume with minimum physical size. Circuit compensates for mismatch at different frequencies

By GUY HILLS
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The trend in indoor TV antennas the last few years has been toward smallness and easily operated tuning means or the complete lack of any tuning adjustment. These two properties seem in demand even at the expense of considerable loss in performance.

Regardless of the particular design of the small antenna there is at least one fundamental limitation to which

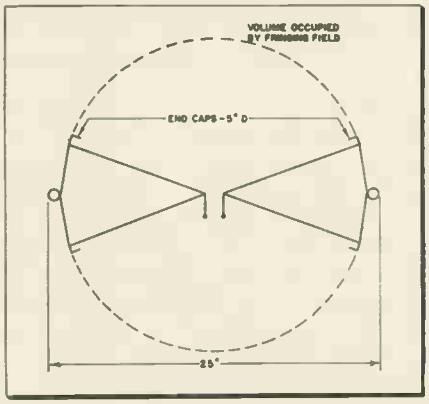


Fig. 1: Indoor TV antenna with end caps is physically small, has large electrical volume

it is subject: its possible band width decreases very rapidly as its size is decreased. Its impedance can still always be matched to say a 300 ohm transmission line at any one frequency but the match rapidly deteriorates for frequencies different from that of good match. This means the antenna band width is small. Wheeler shows that the possible band width varies as the 4th power of frequency for a constant small antenna size (and is proportional to the volume of space occupied by the antenna).

In order to construct an antenna that has as much volume electrically as possible yet is small physically the dipole with end caps, Fig. 1, was chosen.

According to Wheeler's formulae considering the antenna to consist of two condenser plates of the size and positions of the end caps of Fig. 1 an effective volume of 6,220 cubic inches is obtained. This is equivalent to that of a sphere of diameter 91% of the length of the antenna of Fig. 1. On the basis of this volume the theoretical 6 db. band widths obtainable (irrespective of the circuits used for matching) are shown in Table I. A 16:1 voltage standing wave ratio indicates a 6 db. loss in transmission. Wheeler's formulae are for "small" antennae by which is meant antennae less than $1/2\pi$ times the wavelength as their greatest dimension. As the present 25-in. long antenna can therefore be considered small for frequencies less than 75 MC the theoretical band widths of Table I for channels 5 and 6 are less accurate than the others but are given to show the trend.

The measured band widths are always higher than the theoretical because of inevitable heat losses. The band width of course could always

Channel	Theoretical 6 db. band width M. C.	Measured 6 db. band width M. C.
2	2.0	6
3	3.0	6
4	4.3	7
5	7.5	15
6	10.3	18
7 to 83	Antenna can no longer be considered small—see VSWR curves	

Table I: Theoretical and measured 6 db band-widths of antenna for UHF and VHF reception

be increased by the process of resistive damping the antenna, but only at loss of signal. The theoretical band widths of the antenna indicate that for an antenna of this size only one VHF channel can be covered well in the low end of the band without a tuning adjustment no matter how the antenna is designed.

Matching—Low VHF Band

It is theoretically possible to match any impedance to any other impedance at one frequency by use of only two elements (such as a coil and a condenser). Since a short dipole has an impedance equivalent to a small resistance in series with a small capacitance the problem is to tune out the reactance of the capacitance and transform the resistance up to 300 ohms so that the antenna impedance will be purely resistive and

(*Continued on page* 44)

Fig. 2: Antenna with portion of outer covering cut away. Knob for rotating antenna eliminates need to grasp device in region sensitive to hand capacity

Troubleshooting Vertical

Fast Checks for Defective Tubes, Vertical Output Transformer,

By M. M. Gershuny

• The vertical deflection circuits of a television set are probably the simplest circuits to service in the receiver. There are usually only two stages involved, both of which are relatively uncomplicated. An understanding of some simple facts about these circuits should enable the technician to service them with a minimum waste of time and parts.

Possible symptoms produced by defects in vertical deflection systems may be classified as follows: 1. Complete loss of vertical deflection; 2 Insufficient height; 3. Foldover; 4. Loss of synchronization; 5. Distortion (non-linearity).

Although it is entirely possible that a single defect may cause more than one of the above symptoms to appear, it has been the writer's experience in the majority of cases that one symptom alone has generally had to be dealt with.

The vertical circuit shown in Fig. 1 is typical of many television sets in use today. Another circuit in common use is illustrated in Fig. 2. The troubleshooting suggestions for these circuits may be easily adapted to other similar ones.

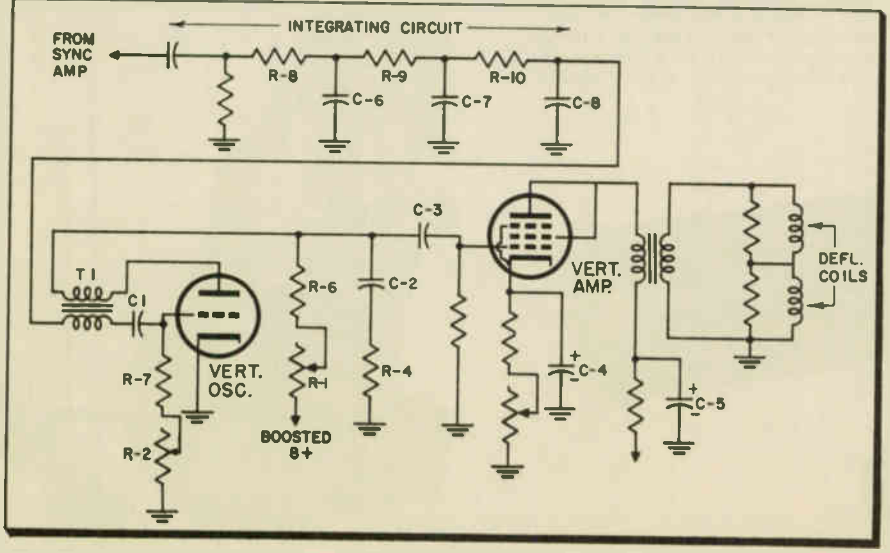
Let us consider the first possibility, complete loss of vertical deflection. This problem involves two approaches. One is the procedure of the serviceman in the customer's house, carrying a minimum of test equipment and parts. The other is that of the benchman who has a wide assortment of equipment and parts readily available.

The usual procedure in the customer's house is to check the tubes in the vertical circuits by substitution. Most cases of vertical trouble are due to defective tubes. In checking this circuit, it is desirable to replace both oscillator and amplifier tubes at the same time; if the trouble disappears, replace the old tubes *one at a time*. In this way, if both tubes happen to be defective, they will be quickly found.

Should the tube substitution test prove inconclusive, the next logical procedure would be a check of the height and vertical linearity controls. (Some servicemen might prefer to check the setting of these controls *before* substituting tubes—Ed.) Each of these controls should be turned from one extreme to the other, while the CRT screen is observed, to determine whether the control action is normal. It is not too uncommon to find that a defect in one of these controls is responsible for a loss of vertical deflection. The same is true, of course, of the vertical hold control. If one of the controls is found to be defective, an emergency repair can sometimes be made in the customer's home.

It will be found that, in most sets, potentiometers are used for vertical controls. Usually one side of the pot will be tied to the variable arm, or left unconnected. If the wire on one end of the defective pot is transferred to the unused terminal, the circuit will frequently work quite satisfactorily. If the serviceman has an ohmmeter with him, this need not be a matter of guesswork.

Fig. 1—Typical vertical circuit using blocking oscillator. R-1 is height, R-2 hold control.



Defective New Tubes

If the foregoing procedures do not bring desired results, the next logical procedure is to "pull" the chassis to the shop for repair. Once the chassis is set up on the bench, the experienced benchman will usually check the tubes again. All too often, the new tubes in the service kit are found to be defective.

While checking the tubes, the technician can also test the output transformer and yoke by rocking the output tube in its socket. If the disturbance makes the bright line on the CRT jump up and down (total loss of vertical deflection is assumed), these components are probably in good condition. If not, they should be first on your list of suspects.

The amplifier stage can be rapidly checked by placing a finger on its control grid. (Applying a 60-cycle hum signal through a .1 mfd condenser would be a safer procedure —Ed.) The easiest way to do this is to hold a long, thin screw-driver by the handle, placing one finger on the blade; the tip of the blade is then touched to the grid pin. The AC voltage picked up by your body is thus applied to the vertical amplifier; if the amplifier is functioning properly, some deflection will now be seen on the screen of the CRT. This will isolate the trouble to the oscillator, which can now be checked with a vacuum-tube voltmeter.

The typical vertical oscillator has comparatively few components, which simplifies the technician's job. Since the tube, vertical hold control and height control have already been tested, only a few components remain to be checked.

If the preliminary test indicates trouble in the vertical output circuit, simple voltage checks at the plate and cathode of the output tube will speedily indicate the source of the de-

Deflection Circuits

Yoke, and other Components. Troubles, Tests.

fect in most cases. On the rare occasions that, by the process of elimination, the yoke becomes suspect, the writer has found that the best check is to substitute another yoke. If one of the correct inductance is not available at the moment, any unit can be used, provided that it is kept in the circuit only long enough to verify the diagnosis.

The problem of insufficient height has plagued the serviceman since the onset of television. This trouble has two variations. One is the condition in which, with height and linearity controls fully advanced, the picture does not fill the screen. The other is the less obvious but equally annoying condition of being able to fill the screen, but only by severely distorting the picture. (The writer has noticed that the average person is much more disturbed by vertical than horizontal distortion.)

Tube Substitutions

The approach to this problem can be split up into field and shop techniques. The field technician is limited, in the average service operation, to tube substitution. In addition to replacing the oscillator and amplifier tubes, the low-voltage rectifier tube or tubes should be replaced. If the set uses selenium rectifiers, these should be checked in the shop.

In some cases, where the amount of picture shrinkage is small, and ordinary substitution does not help, substitution of a different tube type may be worth trying. Types 6V6 or 6W6 have been successfully used in place of a 6K6 vertical amplifier to give just the extra bit of deflection needed. In circuits using a 6SN7 vertical amplifier, a 6BL7 has been used with good results.

This practice is desirable only in the field, in cases when the customer does not want to stand the expense of a shop repair. The set owner should, incidentally, be made aware of what has been done, and why. Over several years, the writer has never seen any ill effect resulting from this type of substitution. We must confess having encountered a small minority of cases where the method did not work.

If the problem proves too much for the outside serviceman, the benchman comes into the picture. He can simplify his problem by first inspecting a picture, or, preferably, a test pattern. The benchman will find that either the height control or the vertical linearity control will lack sufficient range to bring the picture into good linearity at the proper size. If the height control is found wanting, the trouble is most likely in the oscillator or the grid circuit of the output tube. If the vertical linearity control does not have enough range, the trouble is in the cathode or plate circuit of the amplifier.

A trouble commonly encountered is a leaky coupling capacitor (C-3, Fig. 1; C-71, Fig. 2). This defect usually causes a compression at the bottom of the picture, and possibly a short foldover. One very confusing problem can be caused by a defective C-1 (Fig. 1). The writer has seen cases where, with C-1 partially shorted, the vertical sweep frequency went up to over 400 cycles per second. In addition to severe loss of height, the resulting jumble on the screen resembled a loss of horizontal sync. Only close inspection of the raster, showing uneven spacing of scanning lines, especially the oddly-rambling vertical retrace lines, gave a hint of the real trouble.

Vertical Amp. Tests

The output circuit of the vertical amplifier is best checked by substituting parts. The author does not recommend substituting parts from junked sets for test purposes. If the vertical output transformer is not a good impedance match between the amplifier and the yoke, adequate height may not be attained. In the case of permanent replacement, it is a false economy to use any but an exact replacement part.

In many cases, where the height is almost, but not quite satisfactory, replacement of the vertical amplifier's plate decoupling and cathode bypass condensers (after a bridging test) will bring it up to par.

Among the easiest symptoms to recognize are some of those produced by a defective yoke. When we have loss of height due to yoke trouble, a trapezoidal raster will almost always be seen. When one side of the raster is noticeably different

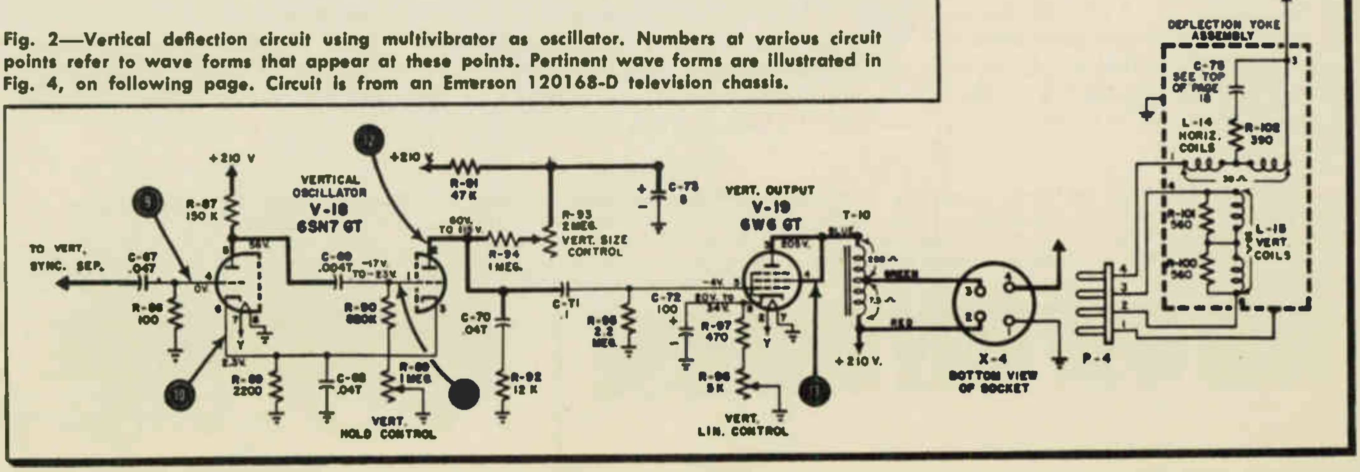


Fig. 2—Vertical deflection circuit using multivibrator as oscillator. Numbers at various circuit points refer to wave forms that appear at these points. Pertinent wave forms are illustrated in Fig. 4, on following page. Circuit is from an Emerson 120168-D television chassis.

in size from the other, look no further; replace the yoke. (It would seem wise to check components in parallel with yoke windings, before condemning the yoke—Ed.)

Vertical foldover is caused by distortion in the vertical sawtooth wave applied to the deflection coils, or by a slow vertical retrace. In the first case there will be foldover at the bottom of the picture; in the second, a foldover will appear at the top. Bottom foldover can usually be cleared by replacing tubes. Sometimes, an improperly-adjusted vertical linearity control will introduce foldover; the condition is, of course, eliminated by proper control adjustment.

When vertical foldover seems present, the settings of all vertical controls should be carefully checked. Sometimes, when the vertical oscillator locks in at an incorrect frequency, the picture looks as though it has a bad vertical foldover.

Next to the tubes, the most common cause of foldover, in our experience, is a leaky coupling capacitor. Even when leakage in C-3 (Fig. 1) is so slight that a resistance of several megohms is measured across it, an annoying foldover at the bottom of the picture is apt to be produced. The best way to check this capacitor is to disconnect it at the grid of the output tube and measure for DC voltage between the open side of the capacitor and ground. With a good capacitor, the meter may fluctuate around some low reading, no higher than about three volts. A bad capacitor will cause an appreciably larger reading. A leak in the charge-discharge capacitor (C-2, Fig. 1; C-70, Fig. 2) can cause a severe compression at the bottom of the picture, resembling a foldover. This condenser may be checked in the same manner as the coupling capacitor.

Foldover at the top of the picture is relatively rare. It may be caused by an increase in the value of the peaking resistor (R-4, Fig. 1; R-92, Fig. 2), or a bad output transformer or yoke. Unfortunately many customers prefer to live with this condition rather than pay for its cure.

When the all-too-frequent complaint, "The picture jumps," is heard, the experienced technician goes to the customer's house prepared for anything, from fixing the antenna to suggesting new glasses for the customer. There is probably no other television defect with as many possible causes as unstable vertical hold. To mention just a few, this condition can be caused by electrical interference, incorrect antenna orientation, improper adjustment of the fine tuning control, and video IF misalignment. We will discuss only defects in the vertical circuits which may be the cause of this condition.

Vertical Amp. Tests

Under the normal operating conditions, in the case of most television sets, the vertical sync pulses are separated from the horizontal ones by a low-pass filter—the integrating circuit. These pulses are fed to the vertical oscillator, and lock it into synchronization with the corresponding oscillator at the transmitter. The normal or free-running frequency of the vertical oscillator should be somewhat less than sixty CPS for optimum control by the sync pulse. The oscillator's free-running frequency is adjusted by the vertical hold control. The height control also has some effect on frequency; it should be possible to compensate for this effect by re-setting the hold control.

There are three possible conditions pointing to a defect in the vertical hold circuit. One would be the condition in which the vertical oscillator is not locked in. The hold control can be adjusted to approximately sixty CPS, but the picture continues to drift up or down. A second condition would be where the vertical hold setting does not bring the oscillator close enough to sixty cycles to permit it to lock in. In this case, the picture can frequently be locked at a multiple of sixty cycles, or even at thirty cycles, depending on whether the frequency is too high or too low. The third problem exists when the vertical oscillator frequency drifts, requiring readjustment of the hold control; eventually, the drift in frequency is too great for hold control re-setting to correct, and condition two results.

It should be immediately apparent that the vertical sync pulse is not reaching the oscillator in the first condition described. If the picture is not out of horizontal sync at the same time, then the likeliest place for the pulse to be lost is the integrator. Since the fault is a sync rather than a vertical circuit defect, we will not discuss it further.

For condition two—oscillator too far out of range—the oscillator grid components (C-1, R-7 and R-2 in Fig. 1; C-69, R-90 and R-89 in Fig. 2) are the ones to check, since they control the oscillator frequency. The technician should note whether the picture is rolling up or down. If the picture rolls *up*, the oscillator frequency is *less* than sixty cycles. If it rolls *down*, the frequency is *above* sixty cycles.

An increase in the time constant of C-1, R-7, and R-2 would make the oscillator frequency too low. This is commonly caused by an increase in the value of the resistor in series with the hold control (R-7, Fig. 1). Conversely, an increase in oscillator frequency would be caused by a *decrease* in the time constant just mentioned. This could very well be due to a loss in the capacitance of C-1 (Fig. 1).

Condition number three (drift) can usually be cured by replacing both C-1 and R-7 (Fig. 1). We have seen cases where a defect in the hold control was responsible for drift; this is, however, very unusual.

Distortion in the vertical direction is relatively rare. It can be caused by a defective vertical amplifier tube, or an open coupling capacitor. Strong hum in the B supply can cause apparent stretching and compression of the picture in the vertical direction. If the transmitter is powered from a different source than the receiver, the stretched and compressed areas will slide up or down, causing an effect like trick mirrors at a carnival. The open capacitor can be found, of course, by successively bridging the different electrolytics in the B supply.

Fig. 3—Normal waveforms and their amplitudes in a typical vertical circuit using a blocking oscillator. A—Grid of vertical oscillator (135v p-p) B—Plate of vertical oscillator (105v p-p) C—Grid of vertical output tube (105v p-p) D—Plate of vertical output tube (900v p-p) E—Cathode of vertical output tube (1v p-p). (Courtesy, RCA)

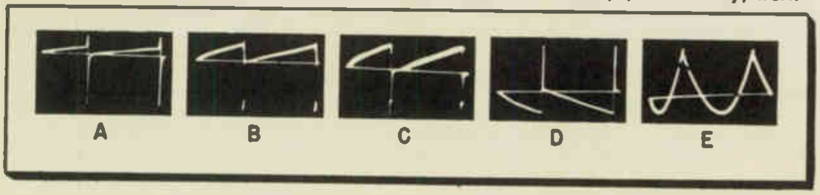
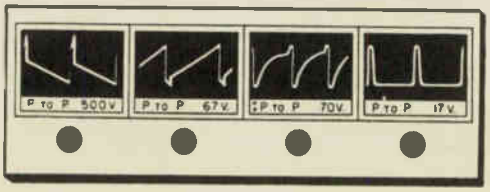


Fig. 4—Waveforms and their amplitudes in the circuit of Fig. 2 (preceding page). Numbers under the waveforms refer to the circuit points in Fig. 2 at which the waveforms were obtained.



Vertical Circuit Troubles

Common Defects, and How They Affect the Test Pattern

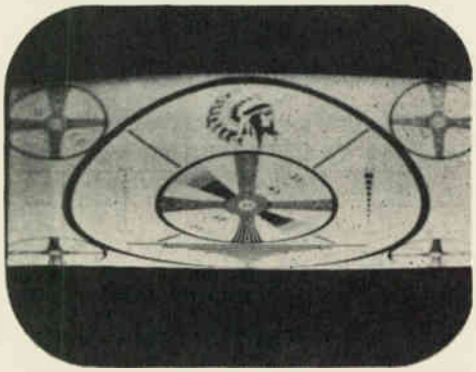


Fig. 1—Loss of height, vertical linearity poor. Possible sources of the trouble include: Low emission in the vertical sweep amplifier tube; insufficient signal input to this amplifier; defective sweep output transformer; insufficient B-voltage feed to the vertical amplifier; loss of capacitance in the vertical amplifier cathode bypass condenser.

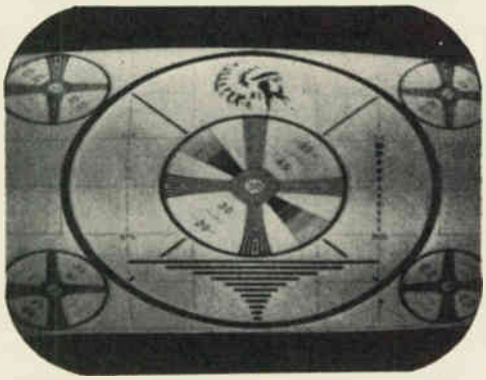


Fig. 2—Insufficient picture height, vertical linearity approximately normal. Possible sources of trouble: Loss of emission in the vertical oscillator or sweep amplifier; increase in value of oscillator (multivibrator) plate resistor; defective vertical output transformer; improper plate or grid voltages on output tube; loss of capacitance in the vertical amplifier cathode bypass condenser.

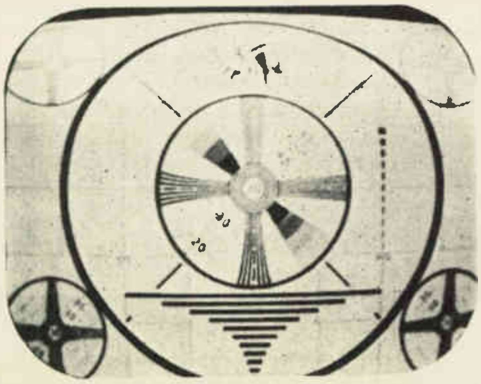


Fig. 3—Poor vertical linearity; height can be adjusted satisfactorily. Possible sources of trouble: Improper setting or defect in linearity control potentiometer or other linearity circuit components; vertical amplifier tube may require replacement; loss of capacitance or leakage in the cathode bypass condenser of the vertical amplifier.

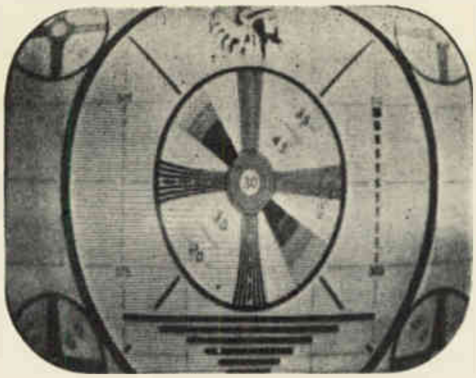


Fig. 4—Excessive height. Usually caused by excessive "drive" at grid of vertical amplifier. Check for decrease in value of charge resistor in plate circuit of vertical oscillator; reduced capacitance in charging capacitor; defective height control.

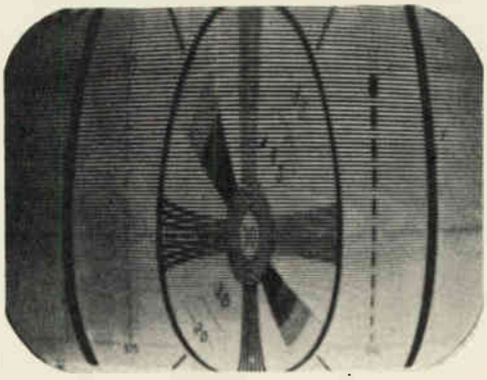


Fig. 5—Excessive height, vertical linearity poor, foldover at bottom of raster. Possible sources of trouble include: Leakage in the coupling capacitor between the vertical oscillator plate and amplifier grid; loss of capacitance in the oscillator's charging capacitor.

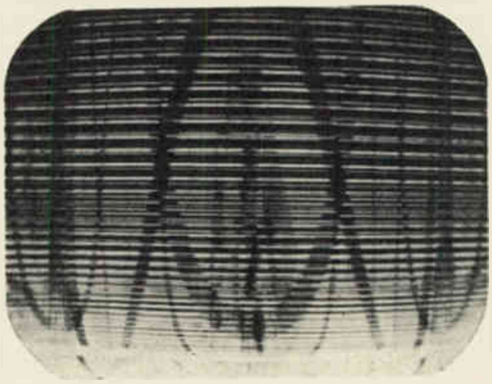


Fig. 6—Excessive height. Sweep is so great that the horizontal scanning lines are pulled apart. Severe leakage in the coupling condenser between vertical oscillator and amplifier may cause this.

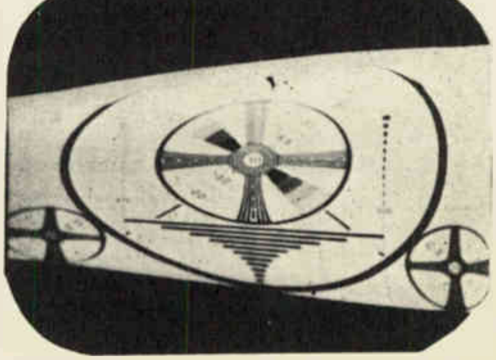


Fig. 7—Vertical keystone effect. Possible trouble sources: Change in value of a shunt resistor across one of the vertical yoke coils; shorted turns in vertical yoke. (Photos on this page courtesy GE; captions based on GE text.)

Servicing Intermittent Receivers

A Logical System, Using Oscilloscopes and Voltmeters,

By Edward W. Kesgen

• The problem of servicing intermittent radio and television receivers, although difficult, can become far less time-consuming when approached in a logical and systematic manner. Time-honored methods of attacking the problem, such as heating or refrigerating the chassis, wiggling and tapping components at random and raising or lowering the line voltage, while occasionally effective, cannot produce consistent results. A more effective technique consists of monitoring suspected stages or the entire receiver, if necessary. This is another version of the familiar technique of dynamic signal tracing.

With respect to instrumentation requirements: a scope, signal generator, vacuum-tube voltmeter and two other voltmeters will take care of practically any intermittent; in many cases, one voltmeter alone may prove adequate. When grid circuits in sync, RF or video IF stages are being monitored for DC voltage changes, a VTVM will be needed.

Discontinuous Signal Paths

Before developing the technique of dynamic signal monitoring, let us consider what actually happens when a receiver becomes intermittent. A receiver consists of a number of signal paths, each of which channels intelligence to its ultimate destination. These paths may be common to more than one type of intelligence, or signal, as in the case of television receivers.

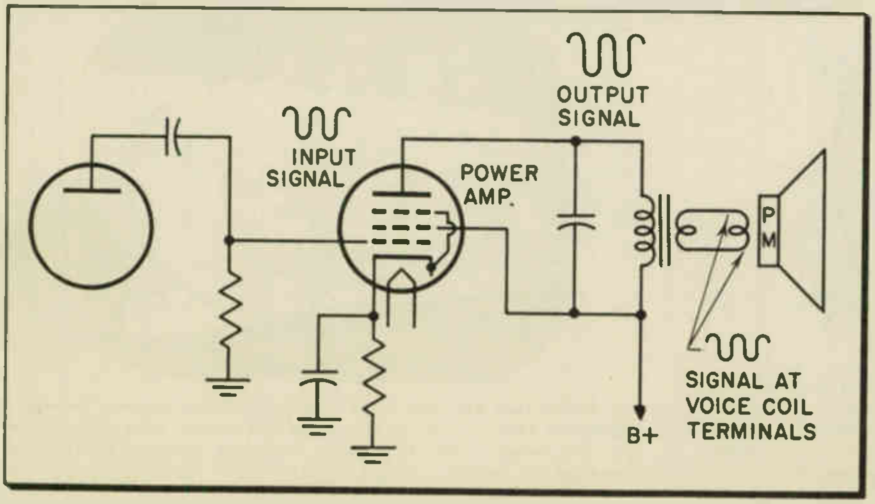
When the receiver is operating normally, the signal paths are *continuous.* Defects in tubes and other components, or cold-soldered connections, however, may cause a signal path to become intermittently *discontinuous.* Dynamic signal monitoring may be defined as the technique of monitoring a signal, or intelligence, at strategic points throughout its path, to locate such discontinuities, as well as intermittent short-circuits or high impedances that may develop in signal routes.

Minimizing Time Waste

It has been stated that the ability to measure marks the beginning of understanding. It will be seen that it is this ability to measure the changed conditions in a signal path that minimizes the drudgery and waste of time generally associated with the servicing of intermittent receivers. It should be noted that while a change in a signal path may or may not manifest itself as a DC voltage change, as measured at appropriate tube sockets, it will ALWAYS manifest itself as a *signal voltage* change in the defective stage.

An illustration may make this point somewhat clearer. A completely inoperative receiver is checked in a conventional manner by measuring DC electrode potentials at the tube sockets. These potentials appear to be normal. The trouble is actually an open speaker voice coil. A dynamic check would have immediately indicated a discontinuous signal path between the plate of the final audio amplifier and the speaker voice coil (see Fig. 1).

Fig. 1—Signal distribution in audio output stage when voice coil is open. Note that signal voltage will be measured at all the proper points, and will even appear across the voice coil. Sound, however, will be absent, pointing to the voice coil as the source of the fault.



Let us now develop the technique of dynamic signal monitoring by applying it to a typical intermittent radio and then to a television receiver. We shall begin with the amplitude-modulated radio receiver. In this instance we are concerned with only one form of intelligence, i.e., that contained in the amplitude-modulated RF carrier.

We cannot monitor this kind of a transmitted signal, since its amplitude is subject to continuous variation. We are, however, able to monitor the path taken by such a signal by substituting an amplitude-modulated signal generator as the signal source.

Test Equipment Set-Up

The receiver to be monitored is set up on the service bench. The signal generator is connected or coupled to its input, as appropriate. The generator output is modulated. The scope input is connected between the second detector load resistor and B-minus (point A and ground, respectively, in Fig. 2); the AC input of the first voltmeter is connected between the first audio amplifier plate and B-minus, and the AC input of the second voltmeter is connected across the speaker voice coil. (A blocking condenser (.1 MFD) may be used in series with one lead of each voltmeter, to keep DC out of the meter.) The volume control is now adjusted until the audio output of the receiver is at a normal level. A china pencil marking should be made around the scope wave-form, to make future changes in its amplitude more noticeable.

The range switch of the voltmeter at the plate of the first audio amplifier is set at the highest possible volt-

by Dynamic Signal Monitoring

for Dealing with the Most Difficult of Repair Problems.

age range, to minimize the meter's loading effect on the circuit. The same precaution is recommended whenever a meter with a relatively low input impedance (1,000 ohms-per-volt) is connected across a high-impedance circuit.

Once monitoring has been started, the receiver requires no further attention until a change of audio level is noted. It is suggested that the technician attend to other duties, keeping within earshot of the receiver, however, as monitoring progresses.

When a change of audio level is noted, a check of the instruments will indicate the vicinity of the trouble. If, for example, all readings show a substantial reduction, we may conclude that the trouble lies either ahead of the second detector load resistor, or possibly in the power supply. If, on the other hand, the voltages across the demodulator load resistor, and between the first audio plate to ground, remain substantially unchanged, but a pronounced decrease is noted across the voice coil, we know that a source of signal discontinuity exists between the first audio plate and the voice coil.

In either case, the area to be investigated has been narrowed down considerably. Dynamic signal *tracing* (not *monitoring*) may now be advantageously employed to pin-point the source of the trouble. If the receiver begins to function normally before these signal-tracing tests have been concluded, as so often happens, monitoring is resumed, but at different points.

Taking the last case as an example, we know that there is no signal discontinuity up to the first amplifier plate. Following the basic procedure previously outlined, we might now connect our scope between grid and ground of the audio output tube, a voltmeter between plate and ground of the audio output tube, and another voltmeter across the voice coil.

It should be noted that monitoring is merely a watch-and-wait procedure. When the monitor instruments indicate that the intermittent is in its active phase, monitoring is abandoned, and signal tracing via a signal generator and scope or voltmeter is resorted to. When the set operation becomes normal, signal tracing is abandoned, and monitoring is resumed.

While the time consumed during monitoring may be considerable, this does not represent wasted manpower, as other work is being done while the receiver is being monitored. The time actually spent on trouble shooting is negligible when compared to other less systematic methods. Results are also positive—i.e., definite—when dynamic signal monitoring techniques are employed.

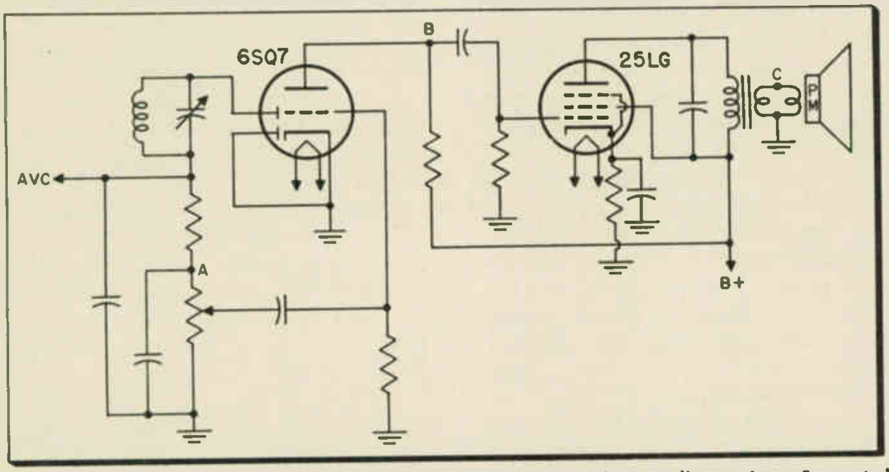


Fig. 2—Initial monitoring setup for intermittent AC-DC broadcast radio receiver. Suggested monitor points are: A and ground; B and ground; C and ground.

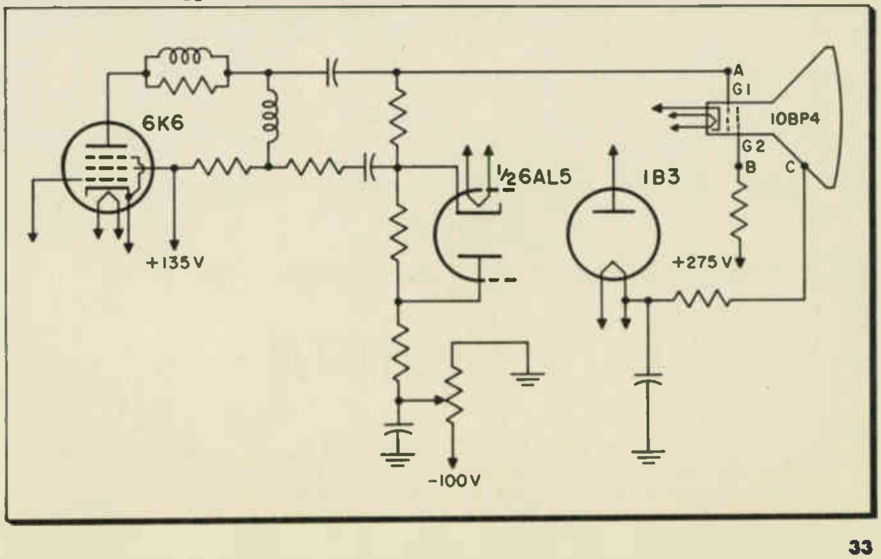
Monitoring CRT Socket

Let's now consider a common television receiver complaint. An intermittent TV receiver may operate normally for a long period of time, then the screen will suddenly go dark. Audio output remains unaffected; this would indicate that the low-voltage power supply is probably functioning normally.

The CRT socket would appear to be a likely place to begin monitoring. The common leads from all the voltmeters are connected to the cathode of the CRT; the positive DC voltage leads are connected to points A, B and C respectively (see Fig. 3). A

(*Continued on page 45*)

Fig. 3—Initial monitoring setup for TV receiver with intermittent raster. Part of an RCA 630TS circuit is shown. Suggested monitor points are: A and ground; B and ground; C and ground.



The ABC of Transistors

What the Technician Should Know About These New Devices.

• The idea of controlling the flow of electrons in a particle of solid material is almost as old as the radio art itself. In the early part of this century the galena crystal detector was the most popular means of detecting radio signals. This crystal detector consisted of a small chunk of galena (a lead ore), mounted in a lead cup with one irregular surface exposed. A "cat-whisker" wire was used to probe the exposed galena surface for the

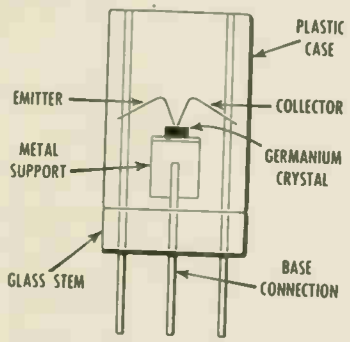


Fig. 1—Enlarged point-contact transistor. The base connection is made to a large-surface crystal area. The emitter and collector wires touch the other large-surface area.

most sensitive spot, the one which produced greatest audio response. The terminals of this crystal detector were the lead cup and the cat-whisker wire. The modern equivalent of this arrangement is the germanium crystal diode detector unit; the 1N34 is a well-known example.

With the development of vacuum tubes in the second decade of this century, researchers turned their attention to these new electronic tools. New circuits, particularly in radar and other high-frequency applications, have pointed up the shortcomings of vacuum tubes in modern electronic equipment. Experimenters, now equipped with a good knowledge of electron behavior in vacuums, have turned again to solid materials to help them to solve problems in modern electronic circuit design. One of the results of current research into the properties of solids as semi-conductors is the transistor.

The first transistor (developed by Bell Telephone Laboratories in 1948) had two cat-whiskers touching the crystal instead of the old single-wire probe. By the addition of a second cat-whisker wire and the use of a different material (germanium), the old crystal detector was made into an amplifier.

Germanium compounds have lent themselves, with relative ease, to modern manufacturing processes which can be controlled to produce desired electronic properties. The structure of the germanium crystal can be altered by these processes so that a wafer of the crystal may become an *N-type* or *P-type* unit. The N-type germanium has an atomic structure which produces a surplus of electrons ready to form a current; it is called N-type because it resembles the negative pole of a battery—the pole with an electron surplus. The P-type germanium has an atomic structure which leaves vacancies or *holes* for electrons. These holes act like positive charges in that they attract electrons from adjacent atoms; thus, there is the effect of the holes moving through the germanium during current flow. The holes move in an opposite direction to that of the electrons.

All transistors may be said to fall into one of two groups: point-contact transistors and junction transistors. Within each of these groups there are different types with different operational characteristics. The point-contact transistor will be considered first.

A transistor of the point-contact

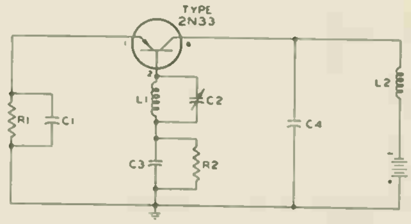


Fig. 3—50 MC oscillator circuit using a point-contact transistor.

group contains a germanium pellet, usually of N-type material, with three electrical contacts made to it. The largest contact is called the base contact; this contact touches the pellet along its large surface (see Fig. 1). The other two contacts are made to the surface opposite the base contact area; they are composed of cat-whisker wires whose points just touch the germanium and are spaced about 1/500-in. apart. One of these wires is called the *emitter*, the other is called the *collector*. The three contacts are firmly positioned and the unit is sealed in a plastic.

In the most elementary point-contact transistor amplifier circuit, the emitter and base connections are made to a DC source in series with the input signal (Fig. 2). The DC minus terminal is connected to the transistor base terminal; the DC plus goes through the signal source, to the emitter terminal. The emitter appears to produce holes in the germanium at the wire contact point. These holes act like positive charges and drift across the small distance to the collector, attracted by the negative voltage (electron

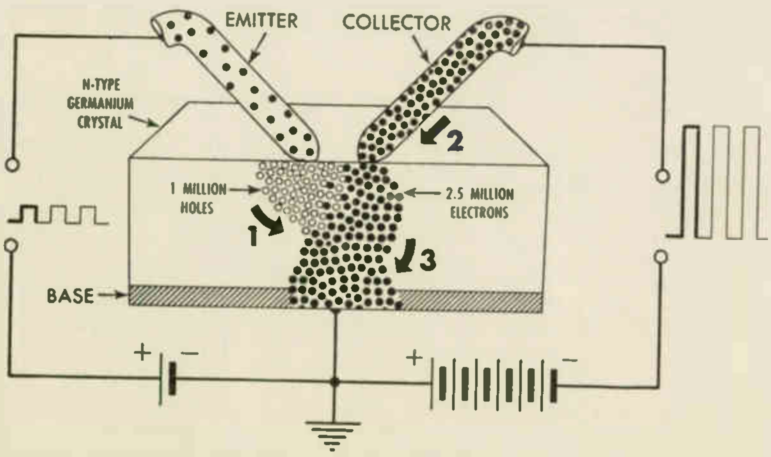


Fig. 2—Enlarged point-contact transistor: If a signal injects 1 million holes at emitter, they will be attracted towards collector (1). Near collector, holes reduce barrier to electron flow (2) allowing some 2.5 million electrons to pass into crystal. Of these, 1 million neutralize the holes ;the others flow to base (3).

for TV and Radio

Their Incorporation into Compact Chassis Is Not Far Away.

surplus) on the collector. The collector and base are connected to a second DC source in series with the output circuit. The plus terminal of this second DC voltage source is connected to the transistor base connection; the DC minus goes through the output circuit to the collector. The hole drift to the collector lowers the resistance of the germanium

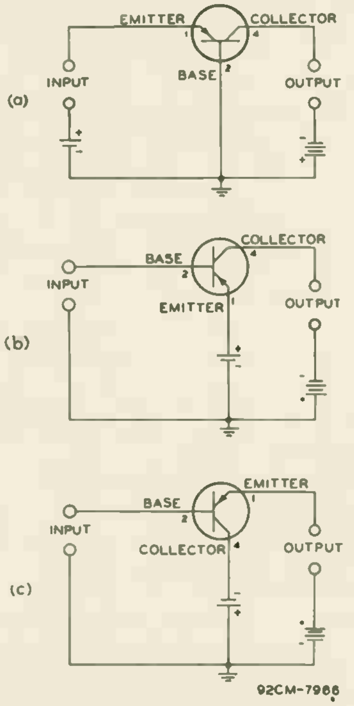


Fig. 4—Three circuits showing how point-contact or junction transistors may be connected for use as amplifiers.

around the collector contact point, and a heavy electron flow in the collector circuit results (see Fig. 2).

The collector circuit corresponds to the *output*, and the emitter circuit to the *input*, of a conventional vacuum-tube amplifier. The current flow in the collector circuit is greater than the flow in the emitter circuit; the difference between the currents represents the gain of the transistor amplifier. Point-contact transistors are able to produce from 2 to 2.5 times the emitter circuit current in the collector circuit. Power gain, however, is greater than this because the collector circuit resistance is much higher than the resistance of the emitter circuit, and the work done in this circuit (I^2R) is correspondingly higher. In practice, point-contact resistors can boost the power of a signal about 20 DB, which represents a signal power gain of 100.

Because some of the collector circuit current from the base connection flows to the emitter wire, current feedback exists in the transistor. Point-contact transistors, therefore, are used as oscillators; oscillator frequencies above 300 MC have already been attained, and this ceiling is being pushed higher in laboratory experiments. The schematic of a transistor oscillator circuit for operation in the 50 MC region is shown in Fig. 3.

In the conventional vacuum-tube amplifier, the cathode is at ground signal potential or "cold," the control grid is at input signal potential or "warm," and the plate is the "hot" electrode at which the amplified output signal appears. These relative designations ("warm," "hot" and "cold") are different in a grounded-grid amplifier and again in a cathode follower circuit. All three circuit arrangements are possible with transistors (see Fig. 4).

The phase relationships between input and output signals which exist in grounded-cathode, grounded-grid and grounded-plate vacuum-tube stages have their counterparts in transistor circuits. The following phase relationships between input and output signals will be present in such circuits: Transistor base connection grounded—signals are in phase; Transistor emitter grounded—signals are 180 degrees out of phase; Transistor collector grounded—signals are in phase.

Point-contact transistors have their main applications in high-frequency circuits such as FM and television RF amplifiers, oscillators and IF amplifiers; they are particularly useful for high-speed switching and pulse circuits in electronic computers.

Junction transistors are made by constructing a tiny sandwich of three layers of germanium. The sandwich is arranged with a section of N-type, a section of P-type and a section of N-type germanium; this is called an *N-P-N junction transistor*. The *P-N-P transistor* has its sandwich made of sections of P-type enclosing the single N-type germanium layer. For both N-P-N and P-N-P transistors, three connecting wires are brought out, one from each section. The complete germanium sandwich with connecting wires is sealed in an opaque plastic casing. This unit is then enclosed in a slightly larger plastic container with the leads protruding

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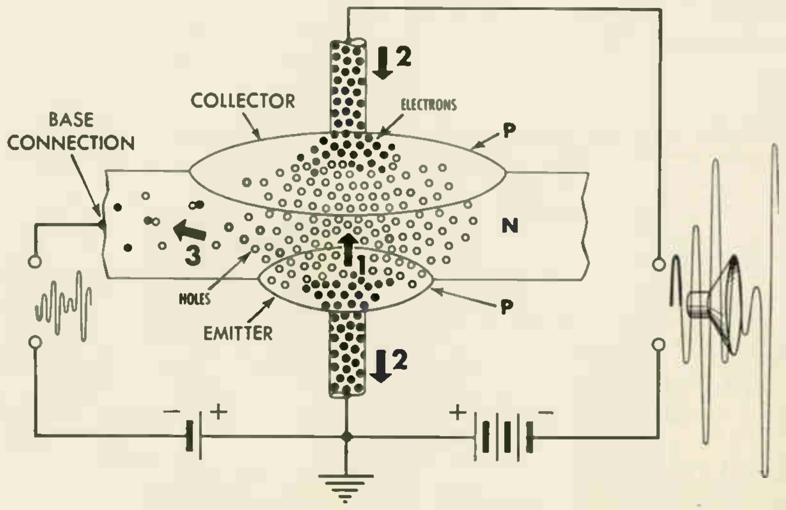


Fig. 5—Enlarged junction transistor. Small signal from phonograph, amplified to activate loudspeaker is assumed. If the signal changes by 1 million electrons, there will be a voltage difference between emitter and base which starts 50 million holes flowing out of emitter (1). All but 1 million holes get to collector, inducing 49 million electrons to flow and carry current in collector circuit (2). The remaining holes flow to the base completing base-emitter circuit (3). (This and other sketches, courtesy RCA.)

Servicing Phono Motors and

Wow, Rumble, and Scraping Problems in Single-Speed

By Harry Mileaf

• Of the many elements that go to make up a home music system, this article will confine itself to only one: the record player.

The record player is primarily a mechanical device. It is more important to prevent the introduction of noise and distortion at the record player than in any other part of the overall audio system. This is so because distortion or noise developed at the player passes through the entire system and is greatly amplified; more so than the distortion or noise that is developed at any other point in the audio system. The chief troubles that develop at the player are wow, rumble, and scraping.

The basic parts of the record player are: 1—The motor. 2—The drive assembly. 3—The turntable. 4—The pickup arm and cartridge. The last-named units will be discussed in another article.

The Motor. Noise and distortion can be developed by the motor in many ways. If the armature (see Fig. 1) is not seated properly in a vertical position, it will rub against the field poles. If it is only slightly off the vertical plane, it may merely cause a scraping sound to be audible. If the armature is too far off, however, and there is too much pressure applied to it by the field poles, the speed of the armature will decrease, possibly causing wow; or the armature may not turn at all.

Ordinarily, this condition is brought about when the screws holding the bearing bracket have worked loose. The trouble can easily be remedied by shifting the position of the bearing bracket (while rotating the armature) until the armature rotates freely. Hold the bearing bracket in this position and tighten the bracket screws, to complete the repair.

If the bearing portion of the bearing bracket wears too much, the armature will tend to vibrate from side to side, introducing excessive noise. A worn bearing can easily be located by inspection. The only remedy for the condition is replacement of the bearing bracket.

Armature Vibration

Armature vibration can also occur in the vertical direction. This condition is brought about by worn, bent or broken washers (see Fig. 1). The purpose of the washers is to hold the armature firmly in position and prevent it from bobbing up and down. If any of these washers are bent, broken, or missing, the armature will tend to vibrate and cause noise. The washers referred to usually snap into grooves that are cut around the armature shaft. On some motors, the armature is held in place by the front and rear of the armature itself; there are usually a number of "shim" washers between the armature and the bearing bracket, to hold the armature in position as firmly as possible

Phono motors require lubrication periodically, not only to prevent unnecessary wear on the armature and bearings, but to keep the armature as free-running as possible. If there is a lack of lubrication at the bearings, the armature shaft will tend to bind. The extra pressure exerted due to the lack of lubrication tends to slow down the motor and may cause wow. A light grease should be used for lubricating purposes; oil splatters and is easily lost. A heavy grease tends to slow down the motor, and should not be used for this reason.

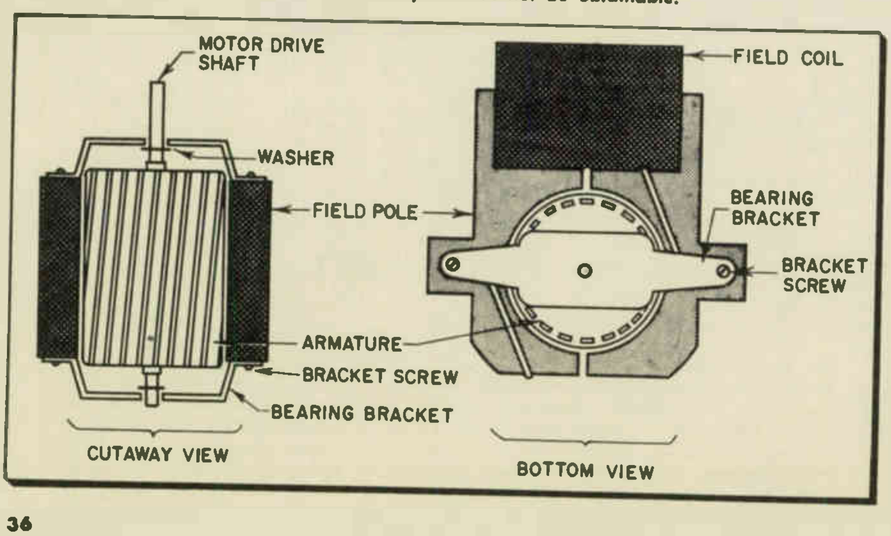
The phono motor may develop a high resistance in its windings, or a low magnetic field, causing it to slow down. The only remedy for such a condition is to replace the motor. Use only a direct factory replacement. This is necessary because the diameter of the motor drive shaft helps determine the speed of rotation of the turntable.

The Drive Assembly. The drive assembly is generally the most troublesome section of the record player. The purpose of the drive assembly is to couple the motor drive shaft to the turntable, and keep the turntable rotating at a proper, constant speed. Never apply oil or grease to the drive assembly. This unit depends on friction for its proper operation; the application of a lubricant will cause slipping, and may result in the turntable not rotating at all. Fig. 2 illustrates a basic one-speed drive assembly.

The drive wheel has a rubber tire that is the coupling surface between the motor drive shaft and the rim of the turntable. This rubber tire develops various defects that affect the operation of the record player. In its normal condition, the tire provides friction and is perfectly round. If either one of these characteristics changes, noise, or wow due to slipping, may result.

The rubber tire is so constructed that it provides good traction at the rim of the turntable. If the outer edge of the rubber tire becomes excessively smooth, it will slip and cause the turntable to rotate at a slower speed, or possibly not at all. After the rubber tire is in use for a while, it may wear irregularly and develop flats or indentations (see Fig. 3A). This condition will cause a

Fig. 1—Shaded 4-pole squirrel-cage phonograph motor. If this assembly is not properly seated in the vertical direction, correct turntable speed will not be obtainable.



Drive Assemblies

and Three-Speed Record Players.

thump or rumble whenever the tire comes in contact with the motor drive shaft and the turntable. Fig. 3B shows how the rubber tire may be removed from the drive wheel.

If the drive wheel binds on the drive wheel shaft, it will cause the turntable to rotate slowly or not at all. Lubricating the drive wheel shaft will ordinarily prevent this. Care must be taken, when applying the lubricant, to prevent the latter from coming in contact with the drive wheel rubber surface.

Slipping may also be caused by a weak drive wheel spring. The purpose of the spring is to pull the drive wheel tightly against the turntable rim. A weak spring will cause the drive wheel to slip, resulting in the turntable rotating slowly or not at all.

The purpose of the cotter pin is to prevent the drive wheel from rising. If the cotter pin is missing, the drive wheel will be pushed up, causing it to rub against the underside of the turntable.

A 3-speed record player system is shown in Fig. 4. The basic difference between a 3-speed and 1-speed player lies in the use of three idler wheels in the 3-speed unit (one for each speed). When the control arm is moved to the speed position desired, the idler wheel for that speed is moved between the motor drive shaft and the drive wheel. The three-speed record player is subject to the same troubles as the single-speed unit. The lower section of the idler wheels are rubber-rimmed, and develop the same defects drive wheels do.

The Turntable. The turntable has definite requirements to fulfill, to provide adequate operation. It must be flat, parallel to the mounting board and able to rotate freely; it should also grip the record being played.

If the turntable is warped, the record being played will wobble, causing the pickup needle to skip and jump grooves.

If the turntable is not parallel to the mounting board, it will probably come in contact with the mounting board, resulting in scraping. This turntable scraping is usually the result of the spindle not being properly seated in a vertical position. A simple bend-adjustment can easily remedy the condition.

The turntable center-hole can become enlarged due to wear, causing the turntable to rest too loosely on its support; the turntable will tend to slant and scrape the mounting board in consequence. If the spindle wears excessively, a similar condition will be produced.

In some cases, the turntable may show a tendency to bind on the spindle, causing it to slow down or jam. Applying grease to the bearing portion of the spindle will solve the problem in most instances. If it does not, the spindle or the center-hole

(*Continued on page 46*)

Fig. 2—Single-speed drive assembly. The drive wheel makes contact with the turntable rim.

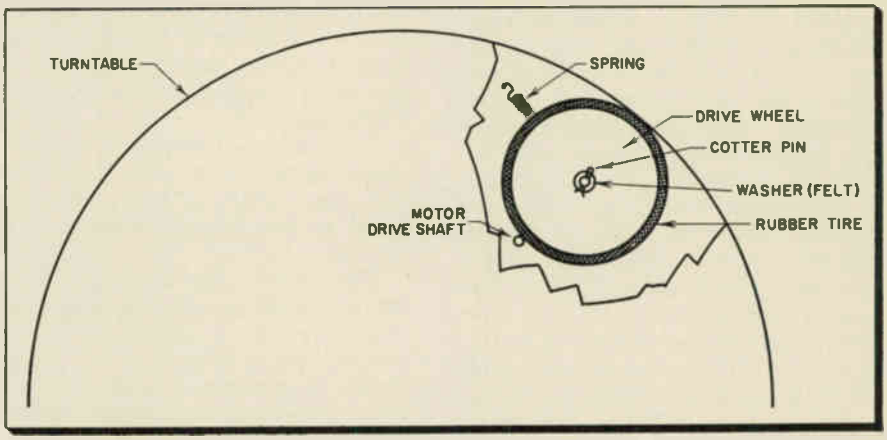


Fig. 3A—Flat and identation on drive-wheel tire. B—Removing tire from drive wheel.

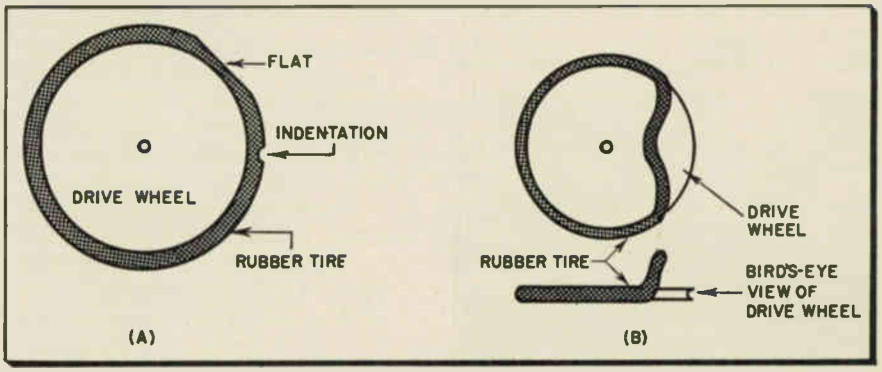
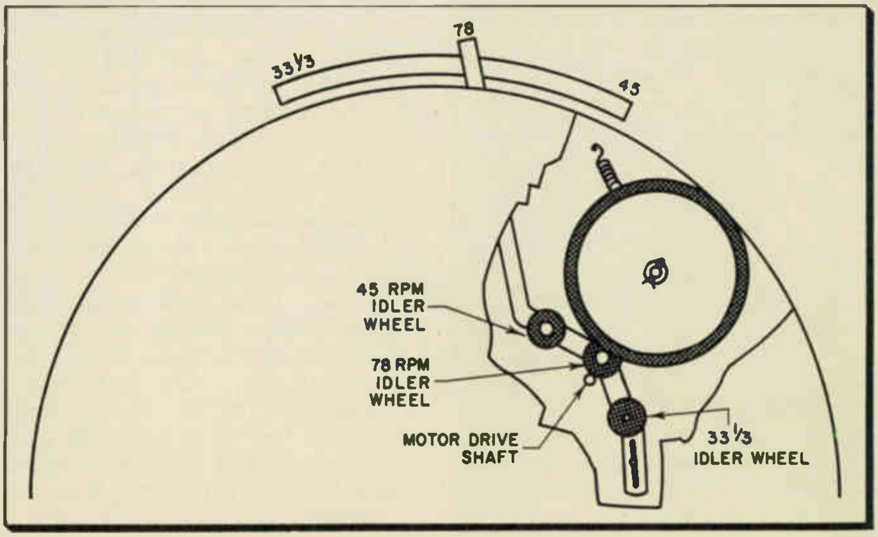


Fig. 4—Three-speed drive assembly showing separate idlers mounted on selector lever.



Servicing Printed Chassis

Recommended Soldering Technique for "Etched-Metal" Radios

By Jack Bayha

Chief Engineer, Phen-O-tron, Inc., New Rochelle, N. Y.

• The rash of etched-metal radio sets appearing on the market, and the millions to come soon, have placed many servicemen in somewhat of a dilemma. Actually a blessing in disguise, the printed chassis seems like a Frankenstein monster to many technicians. Some of them, in fact, are even refusing to service sets of this type.

The etched-metal, or as some call it, *printed-circuit* radio, is actually easier to service than a conventional set, once you know the tricks of the trade, and can put them into practice. There is no great secret to successful etched-metal service work. Follow the simple methods outlined here, and you will find servicing a pleasure.

Photo of unsoldering job in progress on a late-model Admiral printed-chassis radio.

Several types of etched-metal, embossed-circuit and printed-circuit sets exist. In the true printed-circuit receiver, the wiring is electroplated on a layer of conductive (metallized) ink, printed on a sheet of phenolic plastic material, and deposited by a printing or silk-screening process. The bond between the chassis and wiring is very delicate, and special care is therefore necessary during servicing.

The embossed circuit is made by stamping metal or metallic powder into the surface of the plastic; the bond to the base material is quite strong.

The most popular form, the etched-metal panel, is made by etching away from a solid sheet of copper, which is bonded to the plastic, those areas where wiring is not wanted, leaving solid copper wiring. Bond strength is excellent.

The following tools and accessories are needed to service any of the three receiver types just mentioned:

1. A good pair of long-nose pliers.
2. 60-40 low-temperature solder with rosin core.
3. A glue brush (app. cost, five cents) purchasable at the local hardware store.
4. A 25-watt soldering iron. A higher-wattage will *not* do.
5. Tinned wire, such as resistor or capacitor pigtail clippings.
6. Carbon tetrachloride.

Solder Removal

As you probably know, etched-metal sets are assembled by either automatic or dip soldering in a matter of seconds; getting them apart, however, is not as speedily achieved, as you may well have found out. Maybe you are one of the servicemen who have turned the air blue in your immediate area with words not meant for tender ears, as you smashed tubes and speaker, and broke chassis boards, trying to extract a particularly stubborn i-f can from the death grip in which the chassis held it. The answer to the problem lies in getting the solder away from the joint between the etched conductor and the component.

Removing the solder from a joint is readily accomplished with the glue brush and the low-wattage iron. Heat the joint cautiously; if the set manufacturer has bent the prongs of some unit in forty directions, as sometimes happens, straighten them with your long-nose pliers. By heating the joint again and rapidly brushing it, you can brush off the still molten solder. Since the solder present in the set has a very low melting point, and a low-wattage soldering iron is being used, the conductor will not generally be lifted from the base plate during this operation.

Component Installation

After eliminating all the solder by brushing, remove the component carefully, using your iron to smooth out the solder left on the pattern. Be sure to leave the component holes open for insertion of a replacement. Clean the chassis area around the repair zone with carbon tetrachloride, before installing the replacement part.

Install the new component with care, so as to not lift the pattern; then solder it in place with the special low-temperature solder. Leave coating of rosin in place, to act as a protective layer.

Successful removal and replacement of a component without damage to the conductors is not always possible, and occasionally a conductor section will break off. Repairs are readily made in such a case by soldering a short piece of tinned wire to the damaged conductor. Resistor or condenser pigtails are ideal for this purpose.

At all times use only a low-wattage soldering iron, always brush all joints free from solder, use only 60-40 solder, and be just a little careful—and etched-metal radio servicing will be a cinch. You will soon find the excellent accessibility, and absence of conventional wires, more than makes up for the extra care needed to service these sets.

By all means learn to service these units—you'll be getting plenty of this type of work soon, as almost every major manufacturer is currently putting such sets on the market, or will do so in the near future.

Servicing AC-DC Radios

Part 1 Hard-To-Find Troubles.

BY M. G. GOLDBERG

• With the advent of television, many technicians have treated radio as though it belonged in a museum along with the hand-wound phonograph. Millions of radios, however, still find their way each year to service shops.

Most radios sold and serviced today are of the AC-DC type, using 4, 5, or even 6 tubes. Probably 75% or more of all troubles on AC-DC receivers are caused by either shorted or burned-out tubes, with other less frequent complaints due to dried-out

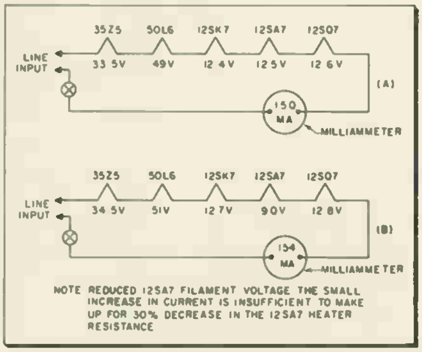
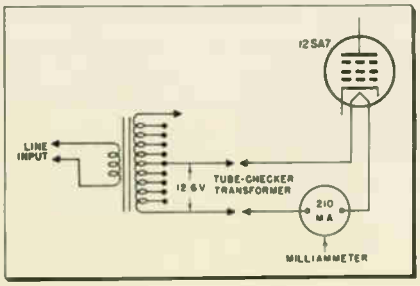


Fig. 1A—Normal heater voltage readings. B—Readings with defective 12SA7 in set.

filter capacitors, rubbing speaker cones and torn or slipping dial drive cords. All of these troubles have quite obvious symptoms and their cures are almost all self-evident. A small percentage of sets, however, turn out to be brain teasers and gray-hair inducers; these are the sets to which we shall direct our attention in this article, as well as in the ones to follow.

Let us consider, for a start, the case of a standard-brand 5-tube AC-DC set which comes into the shop for repair, with the complaint that the set either cuts out after playing a while, or

Fig. 2—Above-normal current flows in defective 12SA7 heater, due to its connection across the 12.6v supply of the tube-checker.



doesn't start working at all. When the set quits working, the pilot light remains on, ruling out the possibility of an open tube heater. All tubes check good on the tester. Although the set sounds "alive", no station is received.

Test Results

A quick pass with the signal generator output lead (generator set at 455 KC, 400-cycle modulated signal used) shows plenty of output in the speaker; the IF trimmers peak normally, indicating that the trouble originates in the oscillator-mixer circuit. Oscillator and mixer plate voltages are near normal, but no negative voltage is present at the oscillator grid.

The signal generator is next tuned to 1955 KC and its output lead clipped to the oscillator grid terminal. A strong local station comes in fine at 1500 KC, proving that something in the oscillator circuit is wrong. The 12SA7 is rechecked, and still tests good; we try another tube in the set anyway, and everything works fine and stays that way. To find out why the old tube didn't work, we put it back in the set and check all heater voltages. Nine volts appear across the 12SA7 filament terminals, and normal or slightly above normal voltages are measured on the other heaters.

Wattage Too Low

A resistance check on the 12SA7 filament shows it to be below normal, with the heater partially shorted out. Since the current thru the tube is limited to slightly more than 150 ma by the presence of the other tube filaments in the series-string, the wattage (E x I) consumed by the heater is only 9 x .15 or 1.35 watts, compared with the 12.6 x .15 or 1.89 watts that is normally present.

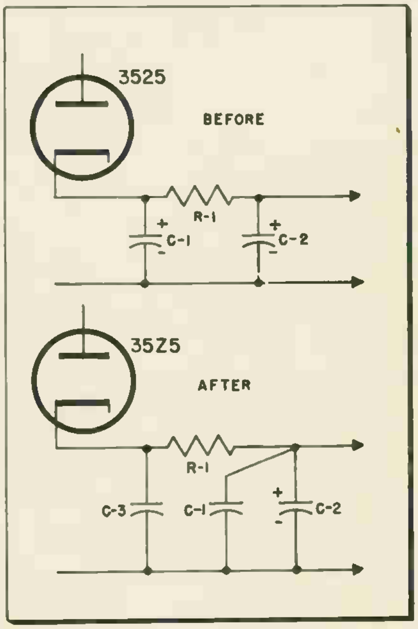
When the defective tube is placed in the tube checker, the transformer winding of the latter is in *parallel* with the heater, and delivers 12.6 volts to its terminals. Since the resistance of the tube has dropped to approx. 60 ohms from 84 ohms normal, the current it draws in the tester is 210 ma, producing a power consumption of 2.6 watts—more than enough for proper cathode emission (see Figs. 1, 2). A "fooler," eh?

When a hard-to-find trouble is present in an old midget set that needs a new tube, electrolytic, etc., the profit margin moves toward the vanishing point. One of the ways to economize on such an old "dog" set, when a filter replacement is required, is indicated in fig. 3.

If the hum level of the receiver is unusually high, and shunting a new filter of, say, 30 mfd across C-1 and C-2 in turn has little effect in reducing the hum, turn off the set and resistance-check the filter resistor R-1 (see Fig. 3). Often this resistor has been overheated and its resistance is below normal, reducing its filtering effect. Or the "hot" leads of the capacitor may have shorted together internally, effectively reducing the pi-section filter to a single capacitor.

Both troubles can be checked for by measuring the voltage drop across R-1 when the set is operating. If the drop is very low, it indicates that either one or the other fault mentioned is present, and must be corrected. Resistance and condenser substitution checks (with the original filter capacitor disconnected) will readily localize the trouble.

Fig. 3—Tying "hot" leads of reduced-value dual filter together makes it possible to add only a single capacitor (C-3) as replacement.



Part 2 Alignment Pointers

• Technicians making home service calls are often called upon to check a small receiver in the home, perhaps one that the man of the house

Servicing AC-DC Radios

(Continued)

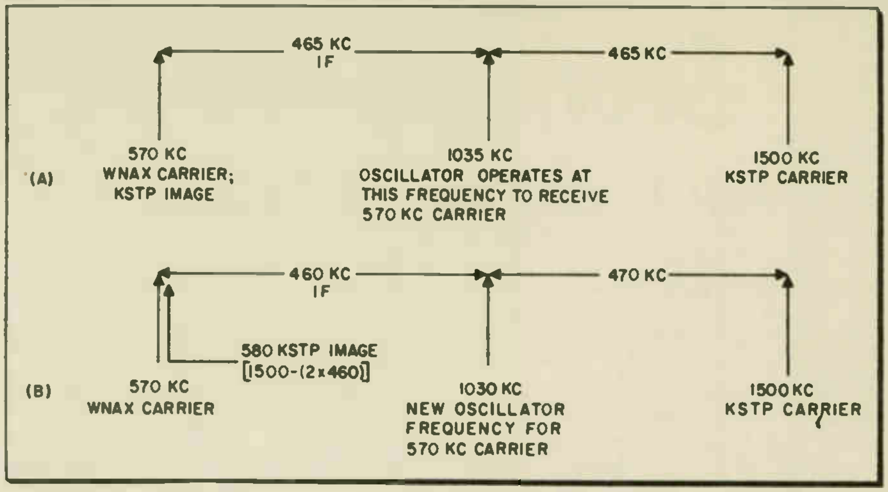


Fig. 2A—How the image of a 1500 kc transmission heterodynes with a 570 kc station to create beat interference. B—How shift to a new i-f eliminates image of undesired station.

has messed up by turning all the i-f and tuning gang trimmer screws. Since few technicians carry signal generators around in their cars, the following hints regarding the procedure necessary to quickly bring the set back to reasonably accurate alignment and sensitivity may be helpful.

First, set the dial pointer on the dial cord so that it travels to the proper end points when the tuning condenser is 1—in full mesh and 2—wide open. If there is any doubt as to just where the extreme points of travel on the slide plate are, examine the front and rear of the plate. In traveling back and forth during tuning, the pointer will have left a path of gummy deposit on the slide plate, and a tiny mound of dirt at each end of its travel. The pointer can be clamped to the cord at such a point that it travels the same path. Before doing this, clean the slide-plate surface with carbon tet.

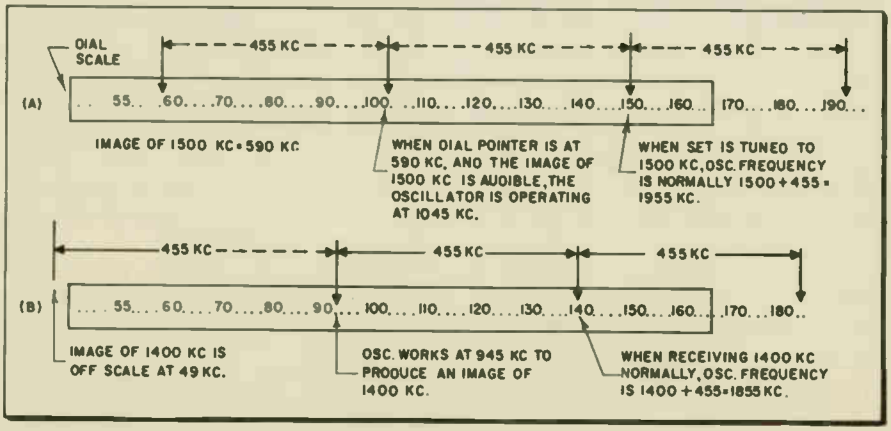
Now tune in some station between 1450 and 1600 kc on the dial. If the set is so far out of alignment that no station can be received, clip a 5-ft. length of wire to the stator lug on the tuning gang mixer section. This will provide sufficient pickup to permit the necessary adjustments.

If a station that should appear at 1500 kc is picked up at, say, 1570 kc, adjust the oscillator trimmer until it comes in at the correct point on the dial; then peak the i-f's by ear. If the i-f is to be adjusted to 455 kc, the image of 1500 kc should be heard at 1500 minus (2 x 455), or 590 kc, when the alignment is correct. If, however, the station comes in at 560 kc, instead of at 590 kc, it indicates that the i-f trimmers are set to (1500-560)/2 or 470 kc. Turn the screws outward 1/8th turn in such a case, and adjust the oscillator so that the station again comes in at 1500 kc. Re-peak the i-f trimmers for maximum and check the image again. If it is still off a bit, repeat the above procedure until the image is received correctly at 590 kc. We can now remove the extra length of wire and adjust the mixer section trimmer for maximum audible output from the speaker.

If the receiver has a tuned r-f stage and uses a 3-gang condenser, the attenuation of the image signal is apt to be so great that the latter is not audible, unless the receiver is very close to the transmitting antenna, and direct pickup occurs through the oscillator or mixer wiring. Connecting the short wire to the mixer section temporarily bypasses the r-f stage, preventing such image signal attenuation.

For a final adjustment, tune in a very weak station between 1400 and 1600 kc and peak all trimmers, or tune off station between these settings and peak for maximum noise output. The advantage of the latter procedure is that the avc (automatic volume control) circuit in the receiver is inoperative, and the ear can recognize small changes in noise intensity more readily. The reason for choosing a station in the tuning range between 1450 and 1600 kc is that the image of a station lower than 1450 kc (app.) will fall beyond the range of the dial scale (see Fig. 1 A, B).

Fig. 1A—The normal relationship of the r-f carrier, oscillator frequency and the image frequency. B—Why images of stations below 1450 kc (app.) cannot usually be received.



Images of strong local stations between 1600 kc and 1400 kc can give rise to objectionable beat interference on 2-gang receivers, when the set is tuned to receive a weak or distant station between the low-frequency end of the dial and 600 kc (see Fig. 2A). Many farmers beyond the limits of the city in which the writer lives tune in on WNAX, which comes in from about 250 miles away on 570 kc. Some of the receivers are older types with i-f's at 460 to 470 kc. If the i-f's happen to be set to approximately 465 kc, the image of KSTP, a strong local on 1500 kc, will be heard along with WNAX, spoiling the reception of the latter.

The oscillator in this case beats with the frequencies of both stations to produce the same i-f. If the trimmers are repeaked 5 kc either lower or higher than 465 kc, the image of KSTP will move 10 kc away from 570 and the interference will disappear (see Fig. 2B). If the new i-f is chosen as 460, the oscillator will work at 1030 to receive WNAX at 570, and the image of KSTP at 1500 will be 580 kc—too far away to be tuned in at 570 kc.

This remedy can be applied in other localities around the country, where the same problem exists.

To eliminate the possibility of damage to both test equipment and receiver, always use an isolation transformer between the ac line and the ac-dc receiver being serviced. Since most of these sets consume only about 30 watts, any standard transformer will be satisfactory.

Part 3. Odd Fading Case.
Locating Intermittent Filaments Quickly

By M. G. Goldberg

• An intermittent in any receiver is somewhat of a headache, but a periodic fading or cut-out in an ac-dc receiver is even worse, because these receivers cost the customer comparatively little; service charges must therefore be kept low, and any job which consumes a lot of bench time means money lost. Let's consider a case in point.

The output of this 5-tube set dropped just enough to be annoying several times during a program, cutting in and out with a volume change of 15 or 20%. After trying all new tubes and making other tests, the trouble was finally narrowed down to the second i-f and detector circuits illustrated in Fig. 1.

During the fading period, the frequency of the received station re-

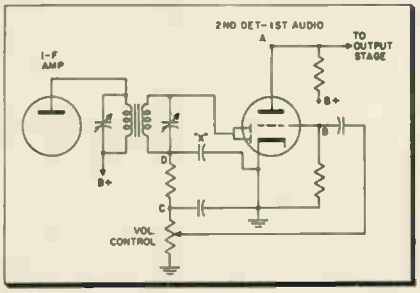


Fig. 1—I-f and second-detector circuit of 5-tube ac-dc receiver. Intermittent open-circuiting of condenser "X" resulted in fading.

mained constant (the oscillator didn't shift); the tone was not appreciably affected, and there was no click when the set cut in and out. Connecting the scope input cable to points *A*, *B*, and *C* in turn showed no change in response during the fading; *with the scope connected from point* D *to chassis ground, however, the set did not cut out.* The connection just cited was made several times, with the same result.

The writer finally concluded that the small capacitor marked "X" in Fig. 1 (a 50 mmfd unit) was opening and closing periodically. With the scope disconnected and the capacitor open, the i-f signal was not sufficiently bypassed, causing the audio output to drop. With the scope connected, however, the 75 mmfd capacitance of the latter's input cable was more than sufficient to substitute for capacitor "X" in the circuit, and no fading was therefore noticeable.

Intermittent heaters in ac-dc receivers are often troublesome. An undue amount of time may be wasted in determining which tube in the series string is opening up. This applies especially to receivers in which the trouble occurs only spasmodically, and then for only a few seconds at a time. Naturally, the technician can't spend an hour or two on one of these low-priced sets, waiting around for a heater to open. The writer has worked out a simple and speedy system for locating the defective tube in such cases, without spending more than a few minutes of bench time on the job.

Let's refer to Fig. 2A. Here we have a conventional 5-tube heater string in which an intermitent filament is present—one which won't stay open long enough for a routine check, and which cuts out perhaps only three or four times during an hour's program. Note the two ac voltmeter connections. One meter (VM-1) is attached across the two higher voltage heaters; the other connects across the three lower voltage filaments.

Place the meters where they can be readily seen and turn the set on then go to work on another bench job. As long as the continuity of the heater circuit is intact, VM-1 will read approximately 85 volts; VM-2 will read about 35 volts. When the cutout occurs, attracting the serviceman's attention, a glance at the meters will reveal that one meter is now indicating practically full line voltage, while the other has dropped to zero.

Assume that VM-1 has gone to zero and VM-2 to full line voltage, on the first fade. This means that the intermittent is in one of the 12-volt heaters. Now connect the meters as shown in Fig. 2B. If, on the next fade, *both* meters go to zero, it will prove that the 12SA7 is the bad tube. On the other hand, if one of the meters goes to zero, while the other reads full line voltage, the defective tube will be the one across which full line voltage is measured. This simple arrangement checks *all* five tubes in only *two* fades, and almost makes child's play out of what could be a time-consuming headache.

If, on the first fade, VM-1 goes to full line voltage (Fig. 2A) while the VM-2 reading drops to zero, connect one meter across each of the two higher voltage heaters for the 2nd test.

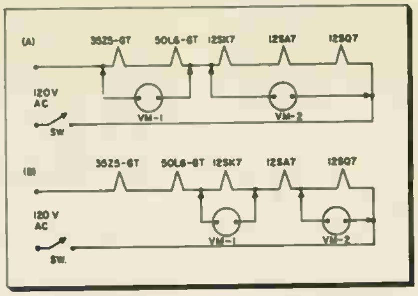


Fig. 2A—Connection of 2 ac voltmeters across tube filaments for first fading check. B—Voltmeter connections for the second fading check.

Color-TV System

(*Continued from page* 5)

ever, available. The ingenious solution to this problem worked out by engineers was to shift the phase of the carrier 90 degrees, *effectively creating another carrier.* One carrier signal is modulated by the blue signal, while the second is modulated by the red one.

If a vectorial representation was made of the situation, two vectors at an angle of 90 degrees would be drawn, one for each of the sub-carriers. The *phase angle* of the resultant vector would represent the hue information; the *amplitude* of the resultant would stand for the saturation intelligence.

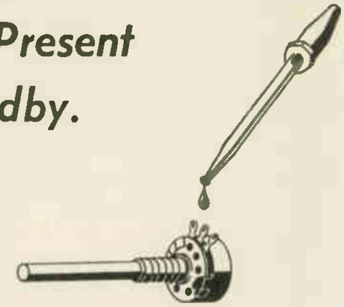
The output of the blue and red balanced modulators are combined with the luminance and sync signals to make up the composite transmitted signal.

The reader will note (Fig. 3) that the sync generator has a color-burst generator circuit associated with it. The circuit permits a sample of the subcarrier output to be transmitted along with the horizontal sync information. This subcarrier signal sample is transmitted (along with the horizontal sync information) as a short 8-cycle, 3.58 MC signal burst (see Fig. 4). The burst occurs during the time interval occupied by the back porch of the horizontal sync pulse. The receiver uses this color sync information to keep a color oscillator operating at the correct phase and frequency, in a manner somewhat similar to the automatic frequency control of horizontal deflection circuits.

The color oscillator signal is applied to the receiver's red and blue color demodulators, along with the chrominance signals. The blue and red color information is recovered at the output of the color demodulator (just as black and white video signals are extracted from the video IF information in the video detector).

What's Wrong with Carbon Tet?

An Engineer and a Chemical Consultant Present the Case Against an Old Service Standby.



BY HARRY E. SHULMAN
AND MURRAY JELLING, PH. D.

• Several articles have been written during the past two years on the use of carbon tetrachloride as a cleaner for controls and tuners. Having devoted a considerable amount of time to this subject, we believe it would be enlightening to the serviceman to explain what happens when carbon tetrachloride is used, and to list its disadvantages. Also, as improved cleaners have been developed, an explanation of their action and the methods by which they should be applied should be valuable to the serviceman.

Under no circumstances should carbon tetrachloride be used on electronic parts. Controls are usually lubricated, and carbon tetrachloride is such an excellent solvent that the lubricant is completely removed. The part may be in working order for a day or two, but the removal of the lubricant leads to frictional wear, and the trouble will appear and remain thereafter.

In addition, carbon tetrachloride causes corrosion. Even traces of this solvent will react with moisture and produce hydrochloric acid. Moisture is present in the air, and the cooling effect of the carbon tetrachloride as it evaporates will cause condensation on the metal surface. The absence of the lubricant, and the presence of the moisture and the acid, will cause corrosion of the metal, leaving a white film. This is probably zinc oxychloride, as the metals present are generally zinc alloys. This film and the corrosion will effect the characteristics of the control, and lead to more trouble than existed before the part was cleaned.

Cleaners have recently been developed which eliminate these difficulties. Essentially these are based on several ingredients.

1. A solvent is used which is an excellent cleaner, but is non-corrosive in contrast to carbon tetrachloride. The evaporation rate is slower, which reduces the tendency for cooling and condensation of moisture on the metal surface.

2. A lubricant is incorporated. This is left as a thin film to replace the original lubricant, which has been removed during the cleaning. It should be noted that gradual removal of lubrication and consequent deterioration has been going on during the years the control has been in operation.

3. A corrosion preventative is present to insure the protection of the unit after the servicing.

4. A conductor is incorporated to counteract any resistance introduced by the lubricant. This ingredient should not, of course, affect the characteristics of the component part. One manufacturer uses a material known as "Metacote" to impart this property to his product (Mute-Tone).

An efficient product should contain ingredients to perform all of the above functions in an expedient manner for the serviceman. The product should be supplied with a dropper attachment, and the serviceman should be equipped with a small brush, a cloth, a pipe cleaner, and a toothbrush, so that all types of controls may be cleaned easily and properly.

Cleaning Controls

In applying the cleaner to controls, such as volume, horizontal hold and contrast potentiometers, a few drops from a dropper are permitted to fall on the spaces around the pot terminals; the knob is then turned back and forth several times. This procedure will usually clean the dirty control effectively. In most cases the control may be cleaned without removing the chassis from the cabinet. This is done by tilting the cabinet, and allowing a few drops to run down the control shaft into the control. After a few turns of the knob, the control is cleaned.

Cautions on Cleaning Tuners

Greater care must be exercised in cleaning tuners. When cleaning wafer-type tuners, an excessive amount of the cleaner must not be permitted to be absorbed by the wafer material, as this may cause the tuner to drift. This caution is especially applicable in the case of some RCA tuners.

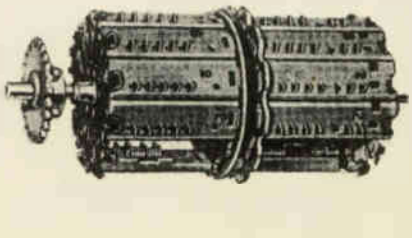
The proper method is to use an artist-type paint brush or a pipe cleaner, and only apply the cleaner to the contact areas of the wafer switch. This procedure is effective, and permits use of the unit for a considerable length of time before servicing is again required. Application of the cleaner by spraying should be avoided, as this method cannot be restricted to the contact areas alone, and a definite drift is apt to follow such improper cleaning.

On the Standard Coil type tuner, the use of a cloth was found effective. A small quantity of the cleaner was placed on the cloth, and the contact areas were rubbed. After a few complete revolutions of the tuner, the contacts were cleaned and lubricated.

On the Zenith type tuner it was found that the use of a toothbrush was the most efficient method of servicing the contact areas.

Regardless of the method of application, carbon tetrachloride was found to be a detriment to servicing controls and tuners. This cleaner may eliminate the trouble for a short time, usually a day or two, but the trouble returns and servicing is required again. This type of servicing is of course unsatisfactory, as it is time-consuming and causes a loss of confidence in the serviceman. Since improved cleaners are now readily available, servicemen should make use of them.

Drum of Zenith turret tuner. Stationary contact surfaces may be cleaned with toothbrush.



Color vs Black & White

(Continued from page 9)

used in dynamic focus in monochrome sets, in which an AC current derived from the horizontal sweep section is suitably modified and added to the focus current. In the color receiver, suitable amounts of horizontal and vertical sweep voltages, appropriately modified in waveshape, are applied to the focus and convergence electrodes; these additional voltages assure correct and uniform focus over the whole screen. Any defect in this section of the color receiver will tend to cause blurring and/or incorrect coloring in some portion of the picture.

The three guns of the tricolor kinescope must be supplied with signals of the proper color. This job is taken care of by the color adders. These stages add the right amount of "Y" signal to the detected color information, in the proper phase, thus providing the correct color for each gun. The color amplifiers in this section build up the color signals to levels required by the CRT for proper operation. The DC restorers function in the same way that they do in the monochrome sets. Individual DC restorers, as well as individual amplifiers, are required for each color. Since the colors in this part of the receiver (color adder, DC restorer, color amplifier section) are separate from each other, any (single) trouble in a stage will affect one color alone, providing a clue to the faster localization of the circuit at fault. For example, if the picture contains no reds, then suspicion is narrowed down to the red adder, the red amplifier, the red DC restorer, and the red gun of the CRT.

Since the color receiver is intended to receive black and white transmissions as well as color programs, receiver stages that process color signals must be disabled, to prevent them from giving black and white signals an undesired going-over. The *color killer* has this watch-dog type function. It performs this function by biasing an amplifier tube to cut-off when no color sync burst is received. The resultant action of this tube prevents the black and white signal from reaching the color detectors.

Defects in Color Killer

There are basic symptoms that defective operation of the color killer may introduce: 1—If the monochrome signal is permitted to get to the color detectors, the picture will probably have a meaningless, constantly-shifting coloring. 2—If the color signal is cut off from the color detectors, it will be reproduced as a black and white picture. Which basic symptom will manifest itself depends on what component goes bad.

The keying pulse applied to the color killer prevents it from being triggered by the wrong signals, and improves its performance in the presence of noise.

The blocks labeled *Color Detector, Filters, and Color Amplifiers* and *Color Sync, 3.58 MC and Control* will be discussed in the article to follow. For the present, it will suffice to point out that the color detectors (also called *decoders*) remove or detect color information from the carrier-modulated signal applied to them; the color amplifiers amplify the (unseparated) colors; and the filters remove cross-talk and spurious signals. The color sync section keeps the color detectors working in proper phases with respect to the transmitted color sync signal.

Tracking Down TVI

(Continued from page 15)

If the addition of a piece of wire provides insufficient pickup of the TVI, connect the inner conductor directly to the circuit under test, through a condenser.

Such a hook-up, for use in power line tests, is illustrated in Fig. 4. Pickup may be increased by the connection of the shield to the grounded part of the circuit directly, or through a series condenser; the dotted lines in Fig. 4 illustrate the latter set-up.

In exploring a magnetic (interference) field, such as the one set up by oscillation in a TV front end, a coil may be of service as an accessory unit. Such an exploring coil is connected between the inner conductor and the shield of the probe, in parallel with the 70-ohm terminating resistor (see Fig. 5). The more turns on the exploring coil, the greater the pickup; you can use this fact as a guide in determining the number of turns to wind.

You may wish to pick up a signal that, you have discovered, is entering the chassis by way of the antenna, say by way of another antenna on the roof. A dipole (possibly an indoor type) could be attached to the probe terminals, as shown in Fig. 6, to form a signal-collecting unit. The dipole may be mounted on a pole for ease of manipulation, as well as to keep it away from your body, and prevent you from affecting the pickup appreciably. The 70-ohm resistor is omitted in this application, as the antenna furnishes the match to the transmission line.

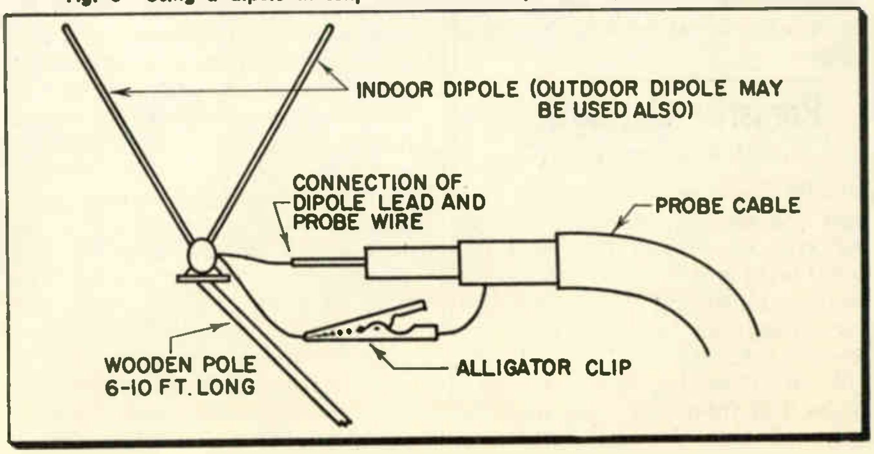
Localizing TVI

To elaborate on some procedures mentioned previously: the process of localizing TVI necessitates the determination of whether the interference is of internal or external origin, as step number one. If external, we trace the route by which it has entered the set, said route including the circuits contributing the TVI—for example, power line to basement to landlord's oil burner, when the latter is the source of trouble.

The maximum intensity of TVI pickup is always sought; when the area of maximum interference is located, it should be a simple matter to identify the TVI source.

To make the technique entirely valid, some additional precautions are necessary with respect to the monitoring receiver. To avoid misleading indications, it is essential that TVI enter the latter set *only through its connecting probe and cable*. Entry from the AC source can be prevented by inserting a good commercial filter between the receiver and its power outlet. To avoid pickup along the length of the power line

Fig. 6—Using a dipole in conjunction with the probe to pick up TVI signals.



cord, the filter is inserted as close to the monitor receiver as possible. An extension cord can be used from the filter to the outlet.

If the TVI is radiating directly into the affected chassis, it may have the same action on the monitor receiver. To prevent this, the latter is physically separated from the set under examination as much as possible. The entire monitoring set may have to be shielded in addition. If the monitor continues to pick up TVI after both these measures are applied (with no coupling present between the monitor and the set under test), the interference is so strong that it can generally be tracked to its (nearby) source without the use of the tracing techniques described here.

If internal TVI seems present, we move our probe about the chassis to locate the point of maximum intensity; this procedure discovers the circuit(s) which generate or transmit the TVI. (Example: parasitic oscillation of the horizontal amplifier and its B-feeds, the latter feed-lines acting as transmitters.)

Stage Gain

A word of caution is necessary concerning the troubleshooting of internal TVI. The factor of stage gain must be considered in such cases. For example, once interference is present in the audio or video systems, it is likely to be stronger, after amplification, at some point following the point of entry. In a case like this, tracing would have to proceed back, not to the area of maximum TVI intensity, but to the point of entry of the undesired signals in the circuit section that has been invaded. This is the point preceding which no TVI can be picked up.

The probe described here, together with its accessories, is useful for tracing other types of signals besides TVI. It may be used in conjunction with an oscilloscope to locate the cause of hum, video or sweep signal pickup by audio stages, or sweep signal pickup by video stages.

Parasitic Oscillations

(*Continued from page* 17)

parasite becomes objectionable only after the set has been moved from one area to another in which the signal level is lower. The increase in receiver sensitivity due to reduced AGC biasing now permits the TVI to become noticeable.

When attempting to effect a shift in the TVI frequency, care must be exercised that the new frequency

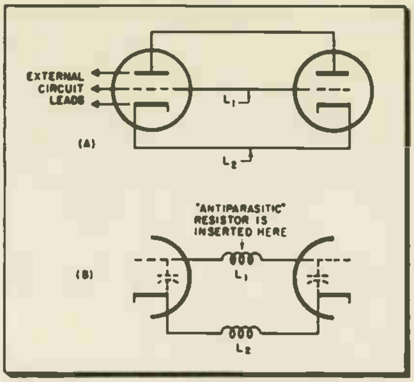


Fig. 5A—Partial schematic of two tubes, or tube sections, in parallel. B—Circuit of (A) showing parasites in grid-cathode circuit.

doesn't also result in noticeable TVI. (A parasitic circuit may be "retuned" by changing the lead dress, or by replacing tubes and other components, to change interelectrode and other capacitances present.—Ed.)

Reduction of the transmission or radiation of the offending oscillation may also be attempted. The remainder of the circuit wiring connected to a parasitic oscillatory circuit may transmit or radiate the oscillation. Weak parasitics may frequently be "cured" by reduction of such radiation. Altering lead dress has helped in some instances. A long lead which acts as a radiator may often be shortened. A screen dropping resistor, to cite an example, may be a foot or so away from the tube terminal to which it connects, with a long length of wire in between. Physically transferring the resistor to the tube socket terminal may eliminate noticeable TVI symptoms.

Addition of shielding may reduce pickup by the grid wiring of a first video IF stage; shielding a radiating lead may not only reduce its radiation, but also cause some attenuation of the oscillatory energy due to the bypassing effect of the shield wire. (This bypassing effect will introduce losses in the desired signal; detuning of the circuit may also have to be corrected—Ed.) This method is often employed in conjunction with frequency shifting, already described.

Reduction of excitation is still another method that is often successful. If the shock which excites the oscillation is reduced (or eliminated), then a cure may be effectively made. Reduction of drive to a horizontal amplifier tube may reduce the excitation of a parasitic present at its screen grid (refer to Fig. 2) to a negligible level; it should, however, be noted that an antiparasitic resistor is a more certain, as well as more lasting cure.

A combination remedy involving more than one of the techniques described here is often necessary. To make full use of this information, the technician should memorize the typical parasitic circuits illustrated. He should also memorize the cures. Only when the various possibilities are mentally "on tap" can he learn to "see" parasitic resonances that are not shown on the schematic diagram.

Lead Dress Problems

(*Continued from page* 25)

strap of the transformer at fault with pliers.

If, on the other hand, turning down the volume control eliminates the buzz, then there is coupling from the vertical stages to the audio circuit. This is usually the result of faulty lead dress. The most likely causes are: 1—Volume control lead(s) too close to the vertical oscillator or vertical output tube or components (dress volume control lead(s) as far from the vertical circuit as possible, to correct the trouble). 2—Vertical hold control lead too close to the audio tubes, or to the volume control leads.

Other possibilities are: 3—Sync pulses coupled to the first audio tube by means of the cathode (or grid) lead of the crt (dress crt lead away and/or shield the audio tube). 4—Sync buzz in the sound caused by video hash radiated from the leads or the coupling condenser to the first sync amplifier (reroute leads and condenser well away from audio circuit). 5—Vertical retrace suppressor circuit leads passing close to first audio stage (reroute).

To reduce residual hum and buzz after all checks have been made and obvious troubles corrected, it may be helpful in some cases to add a condenser—100 to 500 mmfd—from the grid of the first audio stage to ground.

UHF-VHF Antenna

(*Continued from page* 27)

equal to the impedance of the 300 ohm lead in.

While a minimum of two reactive elements must be changed to move the point of perfect match from one frequency to the next it was decided for this antenna to use three in order to keep the antenna balanced. A simplified circuit of the matching network is shown in Fig. 3. As indicated in the figure the antenna dipole with end caps looks, in the low VHF band, like a resistance in series with a capacitance impedance wise. Two coils L have more reactance than the antenna capacitance so that the impedance at the lead in terminals in the absence of C_1 would look inductive. The values of L are chosen such that

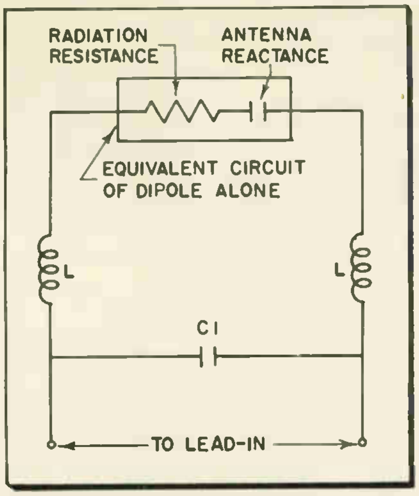


Fig. 3: Simplified circuit of matching network

when a value of C_1 is used which parallel resonates the antenna-coil combination the parallel resonant impedance is not only purely resistive but equal to 300 ohms.

The complete circuit of the antenna

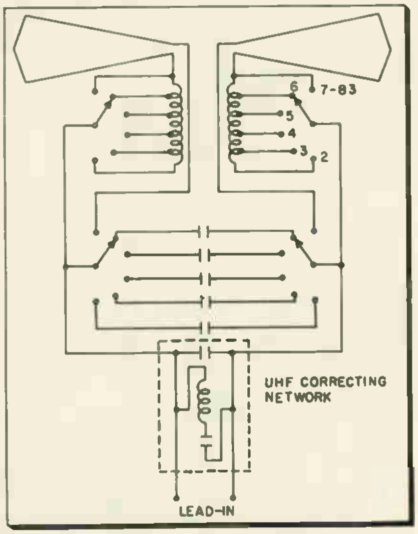


Fig. 4: Double-wafer four-pole selectro switch selects channels in complete circuit

is shown in Fig. 4. A two wafer four pole selector switch is used for selecting different channels.

Since the antenna is nearly one half wave length long in the high VHF band all that was necessary to

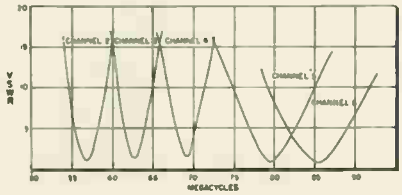


Fig. 5: SWR for low VHF band positions

obtain a good impedance match was to so shape the dipole elements from diverging metal straps as shown in Fig. 1 that effectively two cones with end caps are formed. No external matching network was needed here.

Matching—UHF Band

The connections for receiving channels 7-13 are the same as for channels 14-83. The standard selector switch has too much series inductance and distributed capacitance for good UHF switching however and destroys the good UHF impedance match that the antenna would otherwise have. In order to correct for this mismatch a one μμf condenser, C_2 of Fig. 4 is placed across the lead in one inch from the switch terminals and a series reso-

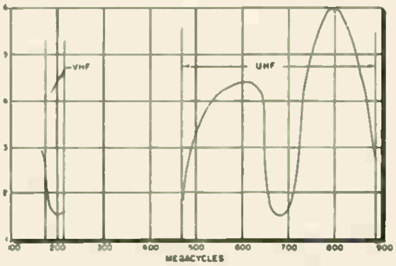


Fig. 6: SWR for high band VHF and UHF

nant circuit, C_3, L_3, resonant at 400 MC is shunted across the lead-in 7 in. from C_2. These elements are so small as to have negligible effect in the VHF bands.

The VSWR of the completed antenna is shown in Fig. 5 and Fig. 6.

A photograph of the unit is shown in Fig. 2 with a portion of the top of the outer radome covering tube cut away. The antenna is mounted to the base by means of a rotating joint for ease of orientation. A knob is mounted at the top of the unit to be used in rotating the antenna so that it will not be necessary to grasp the antenna in a region where hand capacity will effect the operation.

Intermittent Receivers

(Continued from page 33)

meter with a suitable high-voltage probe should be used to measure the voltage between C and ground.

In this case we shall use the transmitted composite video signal instead of a signal generator. Connect the receiver input to an antenna, then adjust the controls until a normal picture is displayed on the screen. Adjust the voltmeters for one-third or half-scale deflection.

If the monitored electrode voltages remain substantially unchanged when the screen becomes dark, the CRT is probably at fault. If the high voltage should fail, a good point at which to start checking is the control grid of the horizontal output tube. (This point can be considered a line of demarcation between horizontal oscillator and horizontal output tube malfunctioning.) A scope should be used for the check. If the amplitude and waveform of the observed sweep signal are normal, the trouble probably lies in the horizontal output stage; if abnormal, the horizontal oscillator stage becomes suspect.

Further Tests

If the receiver should begin to function normally before further localization tests have been concluded (but after a monitoring test has shown the signal at the input to the horizontal output stage to be normal) it is suggested that the second anode be monitored as before, and that the control grid and plate of the horizontal output tube be monitored as well. A capacitative voltage divider will be required at the plate, as this voltage is beyond the range of the average VTVM. (A VTVM, incidentally, is needed for this last check.) If still another voltmeter is available, the DC voltage at the screen grid of the horizontal output tube may be monitored as well.

Our exposition of dynamic signal monitoring thus far has been confined to basic techniques. It is expected that the technician will elaborate on these basic techniques to suit his needs. The remainder of this article will concern itself with general information which, it is hoped, will be helpful in diagnosing intermittent troubles.

Choosing Monitor Equipment

The nature of the signal to be monitored will dictate the choice of monitoring equipment to be used. DC voltages may be monitored with a voltmeter. AC signals up to about half a volt or so may be monitored with a scope; higher AC voltages may be monitored with a scope or voltmeter; if the circuit's impedance is much higher than the input resistance of the meter (on the voltage range at which it is to be used) the scope should be used instead of the voltmeter. The use of a demodulator probe is indicated if the frequencies to be monitored are beyond the range of the monitoring instrument.

The stage of the receiver being monitored will determine whether the output of a signal generator or the composite video signal should be used as a signal source. It should be noted that if the RF or IF stages of an FM receiver are being monitored, an AM signal should be injected into the receiver. The use of a demodulator probe is indicated at these frequencies. Such probes will not demodulate an FM signal. If the audio stages of the same receiver are to be monitored, a frequency-modulated signal should be injected at the receiver's antenna input.

Monitoring intermittent sync stages suggests the use of the commercially - transmitted composite video signal. It is a convenient signal source, and is far more stable, in our opinion, than most test equipment found outside the laboratory.

It has been assumed that three voltmeters are available in the technician's shop. If this is not the case. two voltmeters, or a scope and a volt meter, may be used, at the expense of the amount of intelligence that may be simultaneously obtained. When a scope is used, the outline of the intelligence being displayed should be indicated with a china pencil, for future comparison purposes.

The home servicing of intermittent receivers is not recommended, as it is not practical, economically, to wait for a receiver to become intermittent in the customer's house.

Clues from Set Owner

Information obtained from the owner of the intermittent receiver is often of material value in diagnosing trouble. If, for example, a receiver of the intercarrier sound type has intermittent sound, information as to whether the picture is simultaneously affected would be helpful. If the picture is not affected, we may conclude that the source of trouble is between the sound take-off point and the speaker. We now have two definite points between which to monitor the sound signal.

Thus far, we have considered cases where only the amplitude of the signal has changed. Signal monitoring need not be confined to this type of intermittent. Waveform distortion, frequency changes, etc. may also be monitored. Such monitoring involves only a minor extension of the techniques previously discussed. A minimum of two scopes and two voltmeters are required for this type of monitoring. A VTVM with a properly isolated DC probe should, of course, be used when a tuned circuit—the RF oscillator tuned grid circuit, for instance—is monitored. The scopes are connected between the points where it is suspected that the signal modification is taking place. The signal waveform originally displayed should be outlined with a china pencil. Appropriate electrode voltages should be simultaneously monitored with the voltmeters to indicate a definite correlation between the signal modification and electrode voltage changes, if any.

It should be noted that while a voltmeter and scope, with or without a demodulator probe, will load a receiver to some degree, this loading is constant, Although the output of the receiver will consequently be attenuated. the attenuation, being a function of the loading, will also be constant and will not interfere with signal monitoring. In rare instances, critical circuits (a horizontal AFC circuit, for instance) may require temporary readjustment to compensate for this loading, but this is ordinarily not necessary.

Although we have discussed only basic monitoring instruments, more elaborate equipment may be used to monitor and record information. An audible alarm to indicate a signal change may be incorporated, if desired. Such equipment has been designed and built by the writer, and can be similarly worked out by technicians, without too much difficulty.

Phono Motors

(*Continued from page 37*)

of the turntable should be smoothed down with emery cloth.

The turntable must "grip" the record, so that the latter turns at the exact same speed as the turntable. If there isn't enough grip, the weight of the pickup arm will cause the record to slip, producing wow. This grip is brought about by the flock (furry substance) that is sprayed over the top of the turntable. If the flock wears off, the turntable should be re-flocked or replaced.

Sometimes mechanical noises, referred to as rumble, are too slight to be heard at their point of origin; when transferred to the pickup cartridge and amplified, however, they become annoyingly noticeable at the speaker. The presence of rumble may be checked for as follows: 1—Set the record player in operation. 2—Place the pickup arm on the run-off grooves of the record. 3—Turn up the volume only so far that the surface noise of the record is barely noticeable. 4—No rumble should now be heard.

It is important to note that the size of the various parts of the record player helps determine the speed of rotation of the turntable. Because of this fact, the identical replacement parts supplied by the player manufacturer should be used.

ABC's of Transistors

(*Continued from page* 35)

from the base.

The circuit arrangements for both types of junction transistors are the same as for the point-contact type. Electron motion within the junction types is different, however (see Fig. 5). In P-N-P units, electron holes are produced by the emitter. These holes flow through the center crystal layer to the collector contact which is the minus terminal of a DC source voltage. The signal voltage applied to the emitter-base circuit governs the number of electron holes which move from emitter to collector. The number of holes flowing at any instant determines the current conductivity of the collector circuit. In normal operation the collector (output) circuit current is many times that of the emitter (input) circuit.

In N-P-N transistors, the action is similar to that of the P-N-P type except that: 1—the battery polarities to the emitter and collector are reversed; 2—the action of holes and electrons within the germanium is reversed, and 3—the direction of current flow in the emitter and collector circuits is reversed. This opposite but similar electron action of P-N-P and N-P-N transistors makes it possible to develop complementary circuits using pairs of P-N-P and N-P-N units.

Two-Stage Audio Amplifier

A recent development utilizing these complementary properties has four junction transistors, with no other components, working as a two-stage audio amplifier feeding a loudspeaker.

Junction transistors can boost output signal power up to 10,000 times the power of the input signal, a gain of 40 DB. Junction transistors make more stable amplifiers than do the point-contact variety and introduce much less noise. They are most effective as low and medium-frequency amplifiers and require much less operating power than point-contact types. Junction transistors will probably be most useful in the low-frequency circuits of radio and television receivers, in all types of audio amplifiers and hearing aids and wherever good amplification of the low-to-medium frequency spectrum is desired.

Transistors are not now directly interchangeable with vacuum tubes and there is little likelihood that they will be for some time. The principal reasons for this are that transistors are low-impedance current amplification devices; their characteristic curves are different (more linear) from those which are associated with tubes; and their input and output impedances and gains vary at different operating frequencies. All of these facts mean that circuits must be redesigned to take advantage of the benefits offered by transistor use. These benefits are:

1. They have no filaments.
2. They consume very little operating power.
3. Heat output is very low because of absence of filaments and low operating power consumption.
4. The life expectancy, in normal operation, will be three to four times longer than for tubes.
5. Physical size is very much less than that of most tubes.
6. No warm-up period is required. Operation starts as soon as power is applied.
7. Rugged construction. Transistors can withstand vibration and shock well.
8. Improved circuit designs are possible because of N-type and P-type germanium characteristics.
9. Simplified circuit design is possible, since fewer components are required when transistors are used, and the latter are readily adapted to printed-circuit arrangements.

Transistor Drawbacks

The disadvantages of transistors are few. The principal ones are:

1. High temperatures will permanently alter a transistor's characteristics.
2. Moisture and dampness will produce similar characteristic changes. This obstacle has been overcome by hermetic sealing of the outer casing.

New Circuits

For most electronic technicians, the commercial use of transistors will mean that new circuits will have to be mastered. There will probably be no sudden revolution, with transistors suddenly displacing all tubes. The indications are rather, that chassis will appear with one or two germanium transistors at first, the number increasing over the next few years. Most important will be the new applications for electronic equipment made possible by new circuits developed around transistors. Small personal radios, TV receivers and two-way communication sets are a few of the products which may appear in the immediate future, as a result of chassis miniaturization using transistors and printed circuits. There is every prospect that vast new fields may be opened up, as happened when vacuum tubes first made their appearance. For the alert technician, this is going to mean new challenges, opportunities and sources of profit.

Ringing Problems

(*Continued from page* 23)

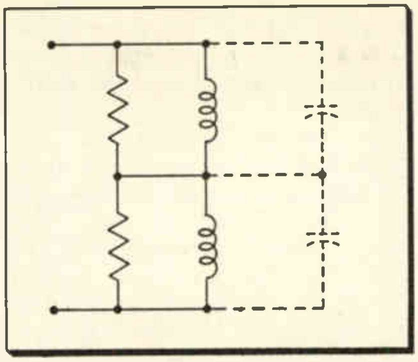
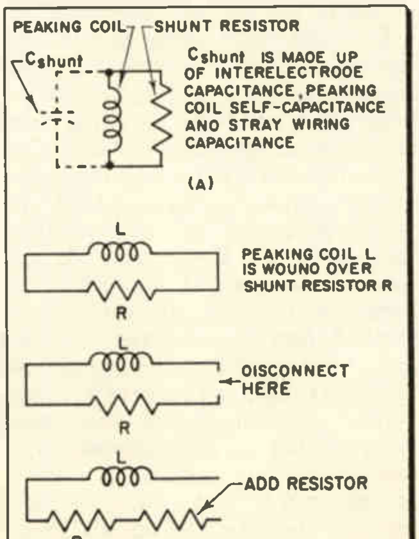


Fig. 8—Sketch showing resistance and capacitance associated with deflection coil circuit.

the individual peaking coils, using a bridging resistor in a manner similar to the bridging condenser used in checking for open condensers. This bridging resistor should have a value about eight times as great as the resistance in shunt with the peaking coil; a resistor ten times as large may not always produce enough of a change. Note that conventional resistors have a tolerance of about 20 per cent.

The bridging check just described will determine whether or not some coil circuit is not sufficiently damped, and is primarily responsible for the ringing. In cases where bridging *any* coil produces about the same decrease of ringing intensity as when the others are so tested, it is advisable to reduce *all* the damping resistors by about the same value—do not excessively overdamp one coil circuit alone, in order to get by with only one resistor.

Fig. 9A—Sketch showing resistance and capacitance associated with peaking coil circuit. B—Increasing resistance in shunt with coil.



Conversely, in some areas of low signal strength, an *increase* in ring intensity may be desired, to improve the picture contrast; the procedure in such a case would be to increase the value of the parallel damping resistors, preferably raising all of them the same amount. A practical way of doing this is to disconnect the peaking coil lead from the pigtail of the resistor around which it is wound; attach the resistor to be added to the freed resistor pigtail; then connect the free end of the peaking coil lead to the pigtail of the new resistor (see Fig. 9B).

It should be noted that ringing may arise in the video i-f amplifier; this receiver section should be checked for proper alignment, if resistor bridging tests similar to the ones just described yield negative results.

Summary. Some important points relative to ringing circuits are enumerated below for the convenience of the reader:

1. A circuit must possess inductance and capacitance in order to be able to ring, regardless of whether or not such parameters are shown on the schematic.
2. The frequency of the ring is determined by the inductance and capacitance of the (resonant) circuit.
3. Ringing circuits are excited by a change in the current flowing though them; a change of voltage across such a circuit will obviously cause such a change in current.
4. Proper frequency adjustment of a ringing circuit permits it to ring in phase with the shock producing the ring.
5. Since ringing circuits do not amplify, the initial half cycle is the *maximum* half cycle or alternation. Succeeding alternations must decay relative to this first alternation, due to voltage dissipation across the resistive element present.
6. The rate of decay of a ringing circuit—i.e., its damping effectiveness—is determined by the ratio of resistance to the inductance and capacitance present in the circuit.
7. Damping—decay rate—is *increased* by *increasing* the *series* resistance, or by *decreasing* the *parallel* resistance. Both shunt and series resistance, when present in the same circuit, may be altered to produce the desired damping rate.
8. A circuit which possesses resistance, inductance and capacity cannot ring or oscillate if the damping exceeds a certain critical value; a condition known as *overdamping* is present in this case.

Color Picture Tubes

(Continued from page 11)

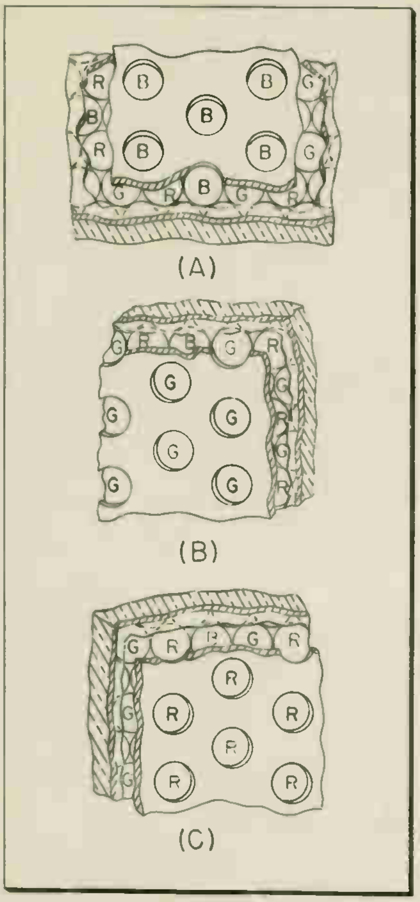


Fig. 4—Views of mask-and-screen assembly as seen from the deflection points of the three beams. View from deflection point of (A) blue gun, (B) green gun, (C) red gun.

connections may be made.

Before applying voltages to the tube, the grid-No. 2 controls are turned to zero and the grid-No. 1 controls to their maximum negative positions. Then, the proper potentials are applied to the electrodes of the tube, and sweep power is permitted to reach the deflection yoke. Initially, some arcing or sputtering may be observed. This is a normal reaction.

After allowing sufficient time for the various supplies to stabilize, the grid-No. 2 voltage of the red gun is slowly increased, and the grid-No. 1 bias simultaneously reduced until the screen is illuminated.

The next step is the adjustment of the purity coil. The servicer will probably be told to make this adjustment as follows:

1. Pull the deflection yoke back from the funnel of the tube approximately ½ inch. 2 Energize the color-purity coil. 3. Move the purity coil along the neck of the tube, while simultaneously rotating it, until the purest red field is obtained in the center of the screen. It will be noted that the pattern on the screen also contains alternate blue and green fields extending radially out from this red center. 4. Slide the deflection yoke in the direction of the face plate until the most uniform red field is obtained over the entire screen.

Once the most uniform red field is obtained, slight readjustment of the color purity coil may be required to achieve optimum color purity. The adjustment may be made by varying the current through the purity coil or by additional movement of the coil.

After obtaining optimum purity of the red field, the blue and green fields should be separately checked. No further adjustment of the color-purity coil should be necessary.

Convergence Adjustment

Convergence is the next characteristic to be adjusted. This adjustment procedure must be made in two separate parts. Convergence adjustment is facilitated by use of a spot generator. This spot generator should be capable of producing equally-spaced horizontal and vertical rows of spots on the phosphor screen. Each of these spots contains individual red, blue, and green components. Proper convergence is attained when the three color components are superimposed.

Initially, the static convergence voltage is adjusted so that spots near the center portion of the screen are converged. If this condition is not obtained, the beam-positioning magnets should be adjusted until the spots within a small central area of the screen are converged.

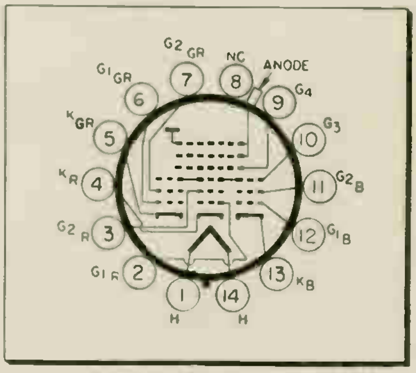
Dynamic convergence can be optimized after the static convergence is attained. Horizontal dynamic convergence is obtained by adjustment of the waveform and amplitude of the horizontal-dynamic-convergence voltage. This voltage should be varied until each spot of a horizontal row near the center of the screen is converged. Vertical convergence is attained by varying the vertical-dynamic-convergence voltage until each spot of a vertical row near the center of the screen is converged. Because of the interaction between the horizontal-and-vertical-convergence adjustments, it is recommended that these adjustments be performed alternately until optimum convergence is obtained.

The final adjustment of the Colortron is the setting of the color balance. As was previously stated, the transfer characteristics and bias voltages of the three guns must be adjusted to produce a grey scale with no color tinting.

The following steps should be taken to achieve color balance:

1. Set each grid-No. 2 voltage at the same value. 2. Set each grid-No. 1 voltage so that a low-level grey field is obtained on the screen. 3. Increase the brightness level of the composite field on the screen. This may be done by varying a master brightness control. or by varying a signal voltage simultaneously applied to all No. 1 grids. 4. As the brightness is increased during Step 3, observe which color becomes dominant. 5. Reduce the brightness of the field to the level in Step 2. 6. Reduce the Grid-No. 2 voltage of the gun controlling the dominant color. 7. Repeat steps 3 through 6 until no color tinting is observed over the required brightness level.

The foregoing adjustment procedure represents the method that achieves the fastest alignment consistent with optimum operational quality. After these steps have been completed, further adjustment should not be required. But further adjustment of the various components can be made to overcome any undesirable characteristics that may result from improper initial adjustment.



Pin 1: Heater
Pin 2: Grid No. 1 of red gun
Pin 3: Grid No. 2 of red gun
Pin 4: Cathode of red gun
Pin 5: Cathode of green gun
Pin 6: Grid No. 1 of green gun
Pin 7: Grid No. 2 of green gun
Pin 8: No connection
Pin 9: Grid No. 4
Pin 10: Grids No. 3
Pin 11: Grid No. 2 of blue gun
Pin 12: Grid No. 1 of blue gun
Pin 13: Cathode of blue gun
Pin 14: Heater
Metal Flange: Anode

MAXIMUM RATINGS—Design-Center Values

Anode voltage	20,000 volts DC
Grid-No. 4 (convergence) voltage	11,000 volts
Grid-No. 3 (focus) voltage	5,000 volts
Grid-No. 2 (accelerating) voltage, each gun	500 volts DC
Grid-No. 1 (control) voltage, each gun:	
Negative-bias value	200 volts DC
Positive-bias value	0 volts DC
Positive-peak value	2 volts
Peak heater-cathode voltage, each gun:	
Heater negative with respect to cathode:	
During warm-up period not to exceed 15 seconds	410 volts
After warm-up	180 volts
Heater positive with respect to cathode	15 volts

Fig. 2—Basing diagram of Colortron. Maximum voltage ratings of the tube are also shown.

RADIO & TELEVISION DATA
for
RADIOTRICIANS* & TELETRICIANS*

(*Registered U. S. Patent Office)

Prepared as a Service
Especially for Members of the

NATIONAL RADIO INSTITUTE ALUMNI ASSOCIATION
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Compiled by John H. Battison,
Director of Education, National Radio Institute

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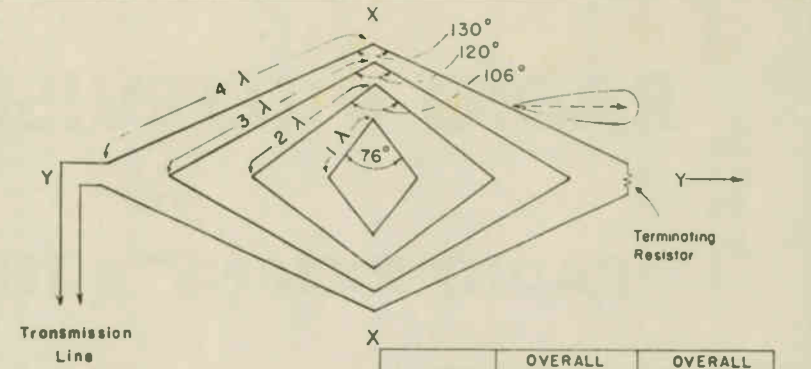
Antenna Considerations

Bandwidth, Beam Width and Gain Must All Be



	LEG LENGTH	OVERALL LENGTH: Y AXIS	OVERALL WIDTH: X AXIS
	1 λ	1.1 λ	1.3 λ
	2 λ	2.9 λ	2.2 λ
	3 λ	5.0 λ	2.7 λ
	4 λ	7.0 λ	3.2 λ
CHANNEL 13: 2λ LEGS→	8'-10"	12'-6"	9'-5"

Fig. 2—Typical rhombic designs based on interior angles which complement those shown in fig. 3. When the legs or sides are larger multiples of a wave length at the operating frequency, the antenna gets longer and narrower as does the beam, and the gain goes up. Similarly, when the size remains the same but the frequency goes up: a leg which is 2λ long at 100 MC is 4λ at 200 MC.

● The old saying that there's nothing new under the sun applies to TV antennas as well as anything else. There's hardly a type available which wasn't long ago employed by hams, commercial broadcast stations or the military.

Nevertheless, when a type appears which has hitherto not been used, or not been used much, in TV, we tend to think of it as "new." For instance, when the Yagi array was described it was considered to be an innovation, although it was really older than TV itself. And even then, it did not come into widespread use for probably at least another year.

It seems that dealers in the fringe areas, using typical American ingenuity, will try *anything* to get a few more DB out of the mud (noise to you). Manufacturers are to be complimented for their courage in presenting many elaborate new designs in an effort to satisfy the enthusiasm of the DX crowd.

Two relatively recent entries in the DB Derby are the rhombic and the corner reflector antennas. While these have been around for some time, there seems to have been an increase in interest in them last summer, with many technicians trying their hands at construction, and some manufacturers offering new models.

The rhombic is a paradoxical product which has some wonderful advantages which would fire the enthusiasm of any wooer of weak signals, but also some disadvantages which would cause any old time radio man to say that it is totally impractical for TV.

Its advantages are broad bandwidth, excellent directivity, good signal-to-noise ratio and high gain. A well designed rhombic can have a gain of 16 DB over a standard dipole, a frequency bandwidth to the half power point (3 DB down) of as much as ± 50% from the frequency for which it is cut, and a beam width of about 20 degrees—which is narrow enough for sharp orientation and high gain, but not so narrow as to be supercritical. The impedance is about 600 ohms, a good match for the increasingly popular open wire line.

And before you get out the pencil to figure the bandwidth, let's take an example: with a center frequency of 150 MC, plus or minus 50% would take it down to 75 MC and up to 225.

All the above is on the plus side. What about the disadvantages? The rhombic is basically a long wire antenna. In broadcast, communications and amateur work it is often used for extremely long distance transmissions because of its high gain and sharp directivity. In such situations, it would be mounted on four high, heavy poles, and could run from 200 to 400 feet in overall length and width, and about 50 to 75 feet high.

You might jump to the conclusion that TV antennas would be much smaller because of the frequency (and you're right), but you'll run into dimensions such as those mentioned above in the 5-30 MC band.

A rhombus is an equilateral parallelogram having its angles oblique. In plain English, that is a four-sided figure whose sides are parallel and equal, and whose angles are *not* right angles (that is, a square is excluded from the definition).

In the form in which it is usually seen, the rhombic antenna resembles a diamond. It is longer than it is wide, and an imaginary line drawn through the long way is called the major axis; through the short way is the minor axis.

The direction of maximum reception is along the major axis; the "front" point is towards the station and the transmission line is connected at the rear point of the diamond. Typical rhombic antenna shapes can be seen in figure 2.

The four sides of the rhombic are called "legs," and *each leg* is a number of wave lengths long at the frequency for which the antenna is designed. The longer the legs, the narrower the beam and the higher the gain.

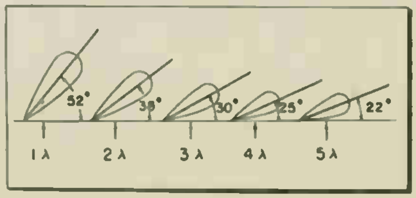
A corollary to this is that as the frequency gets higher, the legs get relatively longer, and the gain goes up.

We said earlier that the rhombic is a "long wire" antenna, and the behavior of such antennas is that the lobes of the radiation pattern form at an angle to the wire. The longer the wire is (in relation to the wave length of the frequency to be received) the smaller the angle is that the lobe makes with it, up to 8 wavelengths (see fig. 3).

What we desire is to have the lobes "point" straight ahead toward the station, and all together (there is one major lobe on each leg). If we consider one leg only, we know that when it is on a line with the station, the lobe is pointing away from the station by a certain angle, as shown in fig. 3, according to the number of wavelengths long it is. If we move it away from "straight ahead" we will arrive at an angle where the lobe is on line with the station.

So the first step in designing a rhombic is to decide how many wavelengths long a leg will be. In TV receiving antennas, where both space and money are at a premium, the designer would select the shortest leg he could, while still achieving enough gain over other antennas to make the job worth while. Remember that the shorter the legs, the wider the beam and the less the gain. A probable likely minimum would be 2 wavelengths: L (length of leg) = 2λ (wavelengths). A properly terminated

Fig. 3—Formation of radiation lobes on long wire antennas of different lengths with respect to a wave length at the operating frequency.



in Fringe Area Reception

Taken Into Account to Achieve Optimum Results

2λ rhombic could have a gain of 13 DB; 4λ would give 16 DB.

If the design center frequency were 150 MC. for instance, λ is about 6.24 feet and 2λ would be 12.48 feet. In figure 2 we see that the overall length of such an antenna would be 3.4λ or 21.2 feet, the width would be 2 or 12.48 feet.

These figures will give the reader some idea of the dimensions of a properly designed rhombic. They're rather large, but not impractical. The size of the rhombic really gets cozy when you get up into UHF (and we'll probably see a lot of them later on). At 500 MC, λ would be 1.86 feet, a 2λ antenna would have an overall length of 6.3 feet and width of 3.72 feet. A typical UHF rhombic is shown in fig. 4.

In discussing the size and shape of antennas, and their gain, bandwidth, etc., we refer, of course, to theoretical designs. In actual practice, manufacturers may alter the size, shape, diameter of elements, etc., to improve on the theoretical design and/or to fit commercial requirements.

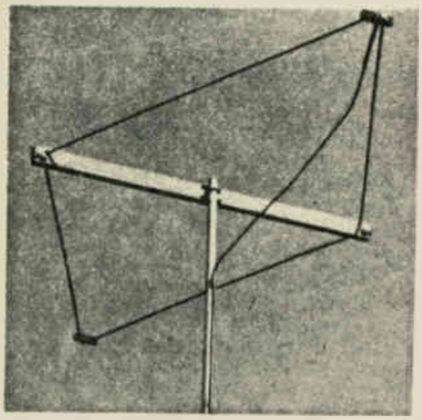


Fig. 4—A typical UHF rhombic antenna. The antenna is "pointing" in the direction opposite the end to which the lead-in is attached.

Design of the rhombic calls for "termination" of the antenna across the front "point" with a resistor of specified size. When properly terminated, the antenna is unidirectional, with high front to back ratio. When unterminated, it is bidirectional with a consequent loss of gain in the forward direction. The terminating resistor tends to absorb reflections which would otherwise destroy the unidirectional characteristic of the antenna.

Height of the rhombic, an important factor at lower frequencies, can be ignored at VHF, since getting the antenna higher than one or two wavelengths above the ground is no problem at such frequencies.

Having considered the physical appearance of the rhombic, we might refer again to its characteristics. When constructed properly and installed under optimum conditions, gain can be as great or greater than most antennas and arrays available, and the bandwidth is quite broad—not usually characteristic of directional high gain arrays.

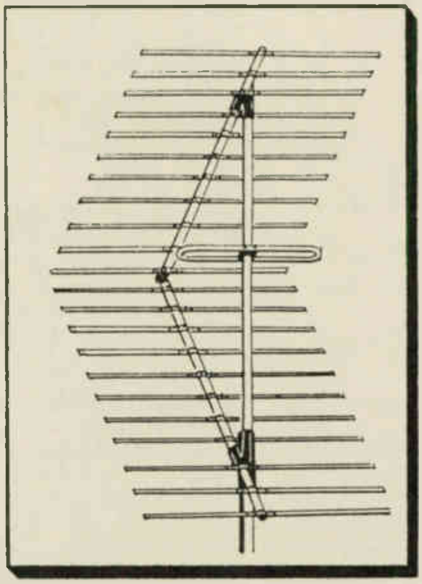


Fig. 5—A typical Corner Reflector antenna. Although a very effective high gain unit, this antenna is fairly large and heavy, and therefore is most practical on the high-band channels.—*Illustration courtesy Radio Merchandise Sales, Inc.*

In many fringe area installations, optimum conditions might be achieved and considerable advantage attained with a rhombic. As for wide band operation, the writer has not had the opportunity to observe the reactions of the rhombic under such conditions. Most VHF antennas exhibit resonances at certain harmonics of their design frequency, and a change in the lobe formation which changes the direction of maximum gain. It is also true that most VHF antennas work poorly *below* their design center frequency. The rhombic is not supposed to display such characteristics, as some tests have shown.

The corner reflector antenna is another special type, which is a straight or folded dipole (usually folded, for impedance reasons) with a rather large reflector consisting of a number of elements arranged in two planes so that they resemble a book half open. The dipole is placed at the center within the included angle, or in other words, inside the corner. Gain and bandwidth are relatively high on this type of antenna, too. Physical size and weight of the reflector, however, suggest that its use would be confined to high band VHF, or to UHF.

The corner reflector is actually closely related to the parabolic reflector, which will probably be used considerably in UHF (as it is already in radar), when the size of the "dish" becomes practicable. Gain of an antenna with a parabolic reflector is slightly more than the corner reflector, but the bandwidth is only half as wide.

Vertical pickup on the corner reflector antenna is practically nil (not so with the rhombic) and front-to-back ratio is very high.

A typical antenna for approximately Channel 13 would have a reflector consisting of two sheets or planes at right angles to each other. Each sheet would be about four feet long, each made up of 10 reflector elements 31 inches long, ¼ inch in diameter and 5 inches apart. A commercial corner reflector antenna is shown in fig. 5.

Beam width of the corner reflector type antenna is relatively wide (compared to the rhombic, for instance) with a blunt front, which would make it possible to receive several stations slightly different in orientation from the site. Vertical pickup is smaller than almost any other type of antenna which can be selected, and should be advantageous where noise pickup from the ground (as with auto ignition, for instance) is a problem.

The sheet reflector antenna is a dipole with a simulated flat sheet behind it (as opposed to the folded sheet of the corner reflector). The sheet consists of a number of reflector elements in a hayrack formation very similar to certain types of radar antenna we used during the last war; but with the radar antenna, there were also a great number of driven elements, several elements wide as well as high. Gain of the sheet antenna, of which the Gonset Radaray is an example, is not, in theory, as high as either the rhombic or the corner reflector, nor is the bandwidth as wide. But these factors, in actual field performance, would depend on the intricacies of the manufacturer's design. Front

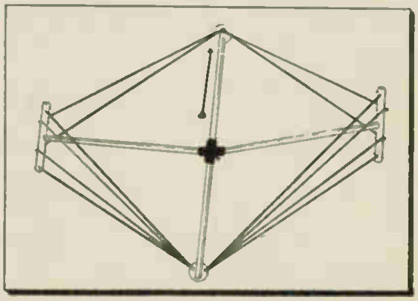


Fig. 6—An unusual rhombic in which the long axis is broadside to the station. Extra elements on the back are designed to improve pickup on the low band. By increasing the diameter of the elements, it is said to be possible to utilize shorter legs.—*Courtesy Roger Phillips Research Labs.*

TV Antennas

to back ratio is very high, and the theoretical antenna would have *no* pickup either from the ground or from the rear. Beam width is quite broad and blunt, even more so than the corner reflector.

Part 2:

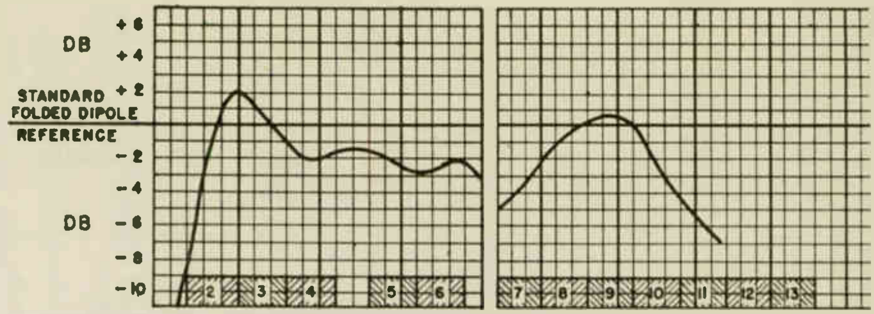


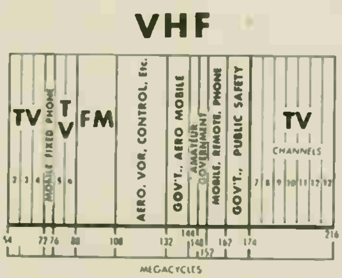
Fig. 2: Gain of a simple dipole (90" long) and reflector over the 12 channels, compare to "standard" cut for each frequency. Compare this broad-band, low-gain antenna with th norrow-band, high gain Yagi shown in fig. 3. Illustration courtesy American Phenolic Corp

● The importance of TV antennas in the overall reception chain from transmitter to picture tube can be graphically illustrated by citing the example of a certain TV transmitter: the transmitter delivers 2.68 KW of video power to the antenna, while the effective radiated power is 18.5 KW. The antenna itself thus provides a power gain of 6.9 times (8.4 DB).

Gains of as high as 10 DB are not unattainable with receiving antennas. Since we are more accustomed to consider volts (or rather, microvolts) at this stage of reception, we can interpret this as a voltage gain of 3.16 times.

The importance of antenna gain can be appreciated from a brief analysis of picture reception in the fringe areas. Picture quality can be (and usually is) marred by (1) Lack of contrast, (2) Snow, (3) Interference and (4) Poor sync. All of these troubles can be summed up by the expression "weak signal." Snow and external interference will degrade the contrast by breaking up the solid blacks and whites as if a screen were put over them. Interference can upset sync by injecting relatively high amplitude noise peaks over the weak sync signals.

Therefore it can be seen that snow and external interference can be the seat of most of the troubles. The sources of external interference need not be explained at great length. They are such things as ignition, motors (particularly with arcing brushes), unwanted RF signals, etc., and are familiar to the technician.



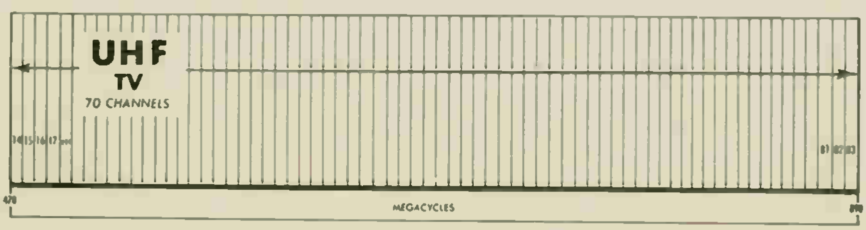


Fig. 1: UHF TV band is 2-4 times higher in frequency and almost 3 times as wide as VHF.

Snow is, however, internal. A certain level of noise in tubes and resistors is inherent in the design of electronic equipment. Ordinarily this noise is kept at a minmum and is well over-ridden by the signal. In the presence of a weak signal, however, the receiver is operating "wide open" and the higher the gain of the stage, the greater the tube hiss and noise (which manifests itself as snow). In other words, the signal-to-noise (S/N) ratio is already low with a weak signal, and by running the gain wide open, we increase the noise and lower the ratio still further. This ratio should be at least 10:1 at the output of the tuner, which is one of the principal limiting factors on the sensitivity of a receiver.

The acceptance of both external and internal noise is increased as the bandwidth increases. This makes sense if we consider random noise as occupying a broad band of frequencies. The wider the bandwidth of the receiver, the more of the noise spectrum it will accept. This is why a TV receiver with a 6 MC bandwidth is so much more susceptible to noise than, for instance, a high sensitivity AM set.

Improvement of the signal to noise ratio must take place prior to the grid of the first IF amplifier, or in other words, in the front end or at the antenna. Or to put it another way, this is the most critical spot for S/N, since the signal level is low and the gain is relatively low. Any noise passed on by the tuner will be tremendously amplified by the IF amplifier and, if the level is high enough, will appear in the picture.

Assuming for the moment that we do not intend to make any changes in the receiver, then it is obvious that the only way to increase the S/N ratio at the output of the tuner is to increase the signal input to it. This could be done with a better antenna or with a booster.

Considered purely as an amplifier, however, a booster would contribute noise of its own, and in addition would amplify any noise present at the antenna. A booster has certain advantages, however, which will be taken up later. But for improving the S/N ratio, the antenna is the likeliest place.

Let us assume some hypothetical values for the sake of clarification. Suppose we have a tuner with a gain of 10 from input to converter plate, and internal noise at the output of 50 microvolts. A signal input (pure, without external noise) of 50 microvolts would produce an output of 500 microvolts, and this would give us our desired S/N of 10:1.

But now let us suppose that the input signal were not clean, but instead that there was a 10 microvolt noise signal present (actually a very small amount). The signal to noise ratio in the input would then be 50:10 or 5:1. After 10 times amplification by the tuner, we would have 500 microvolts of signal plus 100 microvolts of noise. This added to the 50 microvolts of internal noise would give a total of 150 microvolts of noise. The noise ratio at the output of the tuner would now be 500:150 or about 3.3 to 1, a very unsatisfactory ratio.

To overcome a situation such as this would require a signal of 150 microvolts. With the same 10 microvolts of external noise and a tuner gain of 10, we would have an output signal of 1500 microvolts and a noise signal of 100. This latter, added to the internal noise (50) would give 150 microvolts of noise. 1500 to 150, then, would give the desired 10:1 ratio.

To achieve this result, namely to increase the input signal from 50 to 150 microvolts, would require an antenna voltage gain of 3, or about 9.5 DB. A Yagi could do it, or a corner reflector, or several other types of antennas previously mentioned in these pages.

Thus it can be seen that an improvement in the signal to noise ratio must be achieved early in the game in order to effect a really worthwhile improvement in the picture. Although increases in amplification may produce more black and white, if the snow and interference are not reduced, detail will not be improved and annoyance and eyestrain will be the only results.

Antennas may increase gain by cutting down in beamwidth and bandwidth, or both, for they can "reach out" farther. They can also cut down on noise pickup with narrow beamwidth, low front-to-back ratio and low vertical pickup, since they tend to eliminate the possible areas of noise origination. Reduced bandwidth also helps to cut down noise pickup, since as we mentioned earlier, it tends to discriminate against some of the noise frequencies.

A typical Yagi response is shown in figure 3. It can be seen that the useful bandwidth of this antenna is hardly wider than the channel it is intended to cover. The antenna is cut for the low side of the channel, which emphasizes the picture carrier, a desirable feature in the fringe. The gain of the antenna, of course, is high.

Compare the above with the response curve shown in figure 2, for a simple dipole and reflector. While not nearly so high in gain, this type of antenna is usable over a great deal of the VHF-TV spectrum.

Beamwidth vs Gain

The polar response patterns (horizontal plane) in figure 4 show the relationship of beam width between a 6-element Yagi (left) and a simple dipole and reflector (right).

These two comparisons, of bandwidth and beam width, tell the general story for high gain antennas, with a few exceptions. The rhombic has a narrow beam (narrower than the Yagi) but a broad bandwidth (in addition to high gain). The corner reflector antenna, also discussed last month, has both a broad beam *and* a broad bandwidth, while still a high gain antenna. These two antennas, probably too cumbersome for general use in VHF-TV (especially the low band) will no doubt be more widely used come UHF, along with a number of other specialized types not used at all in VHF.

UHF will make many exacting demands on the antenna installer, when it arrives. In the first place, the spectrum (470-890 MC) is 420 MC wide, 2½ times the size of the present VHF band from channel 2-13. UHF will furnish 70 channels, from 14 to 83. In the second place, signal powers attained at the transmitter are as yet relatively low compared with VHF. At the same time, attenuation of the signal is greater, so that signal strengths are low comparatively, and 20 miles will probably be a "fringe" area. In addition, reflections and shadows are more of a problem, and attenuation due to rain, leaves, etc. is much greater. Consequently, antennas will need to be very high gain and very directional, but due to the frequency, need not be large. A half wave length at 500 MC is less than a foot. Attenuation in flat twin-lead due to weathering has been quite serious, but tubular twin-lead seems to stand up better, and it is likely that the latter will be used extensively in UHF. Attenuation in coax is rather high, but it weathers well, and it is also recommended. Impedance matching will be critical at UHF, and even special lightning arresters are recommended, so that losses and unbalance will not result.

Getting back to our fringe reception problems, it is of course, axiomatic that gain is inversely proportional to bandwidth in amplifiers. It is also true that noise is inversely proportional to bandwidth. Therefore it can be seen that by cutting down the bandwidth (that is, by tuning more sharply, or peaking the response), we can not only increase the gain but also cut down on the noise so that we make a two-fold improvement in S/N ratio. In TV, naturally, this means cutting down on picture definition. But if by sacrificing some definition we can improve contrast, cut down on snow and interference and make the sync more stable, it may often be worth it. This is actually done by many TV set owners in setting the fine tuning control for the brightest picture, usually at the expense of the sound as well as picture definition. It is also done, more skillfully of course, by some fringe area servicers, who peak-align the sets for higher gain. There are also some receivers which incorporate a circuit which automatically reduces the bandwidth when the signal strength is down.

This is the point to which we were referring when we said that amplification is not the only function of boosters. Many tunable boosters not only permit the user to peak-tune the input for higher gain and narrower bandwidth, but are actually built to provide a narrower bandwidth signal. Adding a preselector ahead of the front end of the receiver also tends to cut out some interference signals.

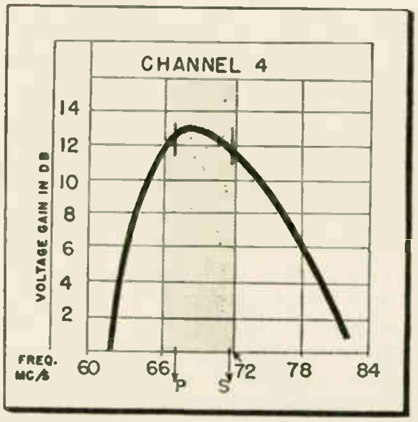
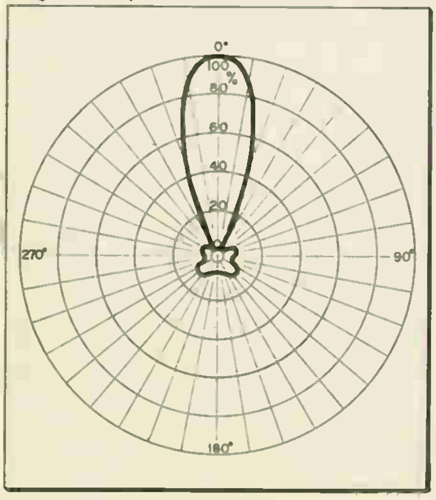


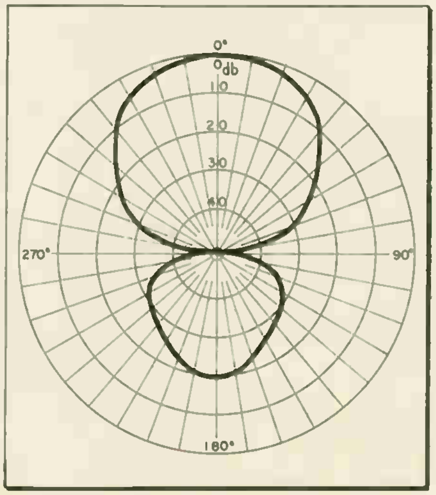
Fig. 3: Response of Telrex Y5X1-4, a 5-element Yagi cut for channel 4. "P" and "S" are pix and sound carriers. This high gain antenna shows less than 1 DB variation over the channel.

Before aligning the receiver, however, the installer would do well to do all he can with the antenna installation. This, of course, includes picking the highest gain array which will suit the local situation (as to number of channels, frequency of channels, etc.); trying additional height; using low-loss lead-in well matched at both ends; keeping lead-in away from roofs and walls (with long standoffs) where they might be subject to excessive moisture; experimenting with tilt of the antenna, both in the horizontal and vertical planes, etc.

Regardless of what is used after the antenna—whatever make set, booster, etc.—best results will be obtained with the optimum antenna installation. Attention lavished on this detail will pay off in better picture quality, more satisfied customers, and more dollar profits in the end.

Fig. 4: Comparison of a narrow beam (left—a 6-element Yagi, from Tele-Tech) and a broad-beam antenna (right, a simple dipole and reflector, from TV and Other Receiving Antennas by Arnold B. Bailey). These patterns do not indicate the difference in gain between the two (see fig. 2 and 3).





SHOP HINT

Scope Requirement for TV Alignment

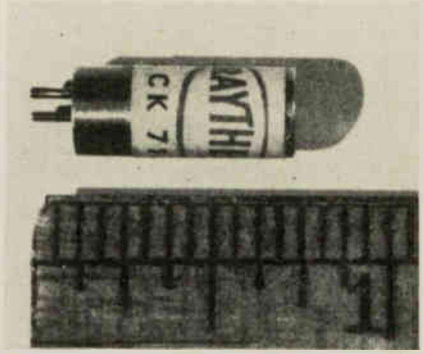
"While a wide-band response is essential for the observation of sync and blanking pulse shapes, it is well to point out that a scope having a response of plus or minus 10% to 40KC is ample for all sweep alignment work on TV and FM. The sweep curve observed is not RF but is derived from the frequency-modulated RF or IF signal by detection, and so it is actually well within the audio range.

Latest Transistor Units

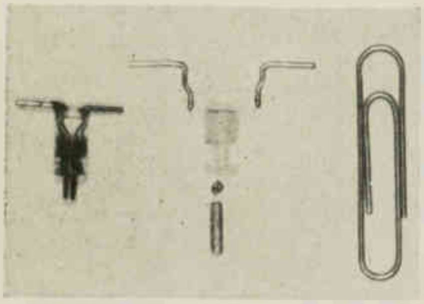
Preview of point-contact germanium types now in developmental and pilot production stages by five manufacturers

WHILE poring through the daily newspaper one may be highly impressed with the imminence of wrist watch radios and pocket-size TV receivers, devices made possible by the advent of the transistor. As one non-engineering enthusiast put it, "The vacuum tube is a cooked goose!" However, the transistor is presently in a developmental phase, and the state of the art does *not* warrant the zealous acclamations of an immediately forthcoming technological revolution. No one is more impressed with the imposing potentialities of the transistor than the scientists actively engaged in its study, but their sober evaluations tell us that although the future holds a key role in store for the crystal triode, much more must be learned before its marvelous abilities become commonplace in our daily lives.

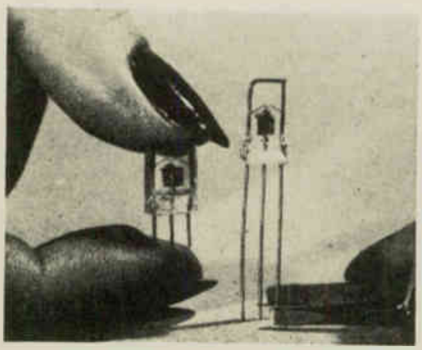
So without sensational fanfare, here are several point-contact germanium transistors fabricated by different manufacturers. Generally speaking, these units are in a developmental or pilot production stage and not commercially available in the mass production meaning of the word. Junction-type transistors have undergone less development to date, and may be considered as being in an even earlier prenatal state so far as well controlled mass production for civilian use is concerned.



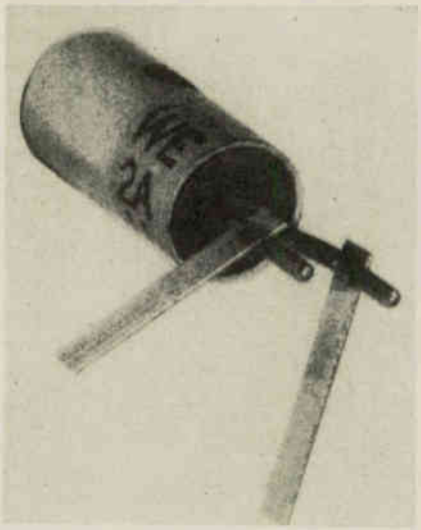
RAYTHEON'S Type CK716 transistor is housed in a brass case, 0.65 in. long and 0.255 in. diameter, which acts as the base. The nickel pins are 0.078 in. apart. The maximum electrical ratings are: collector current — 4 ma; emitter current 10 ma; collector voltage — 40 v.; collector dissipation 100 mw. Operating characteristics with grounded base are: collector current 2.5 ma; emitter current 1.0 ma; collector voltage — 15 v.; emitter voltage 0.5 v.; minimum current amplification 1.2; minimum frequency response 100 KC; maximum noise figure at 1 KC, 65 db. Considered as a three-terminal network, the maximum to minimum range of direct input resistance is 150-450 ohms; transfer input resistance 25-140 ohms; direct output resistance 10,000-40,000 ohms; transfer output resistance 15,000-70,000 ohms.



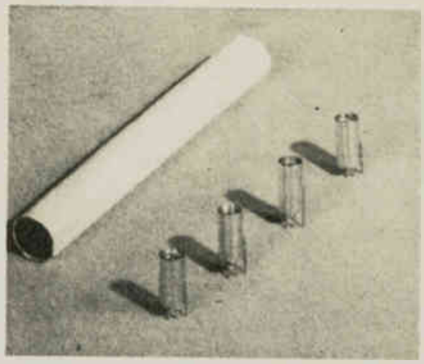
PHILCO'S potted transistor for video and r-f carrier amplification is enclosed in an impregnating plastic. The above picture shows the emitter and collector leads, base pin, germanium block from which the crystal wafer is cut, and the plastic case. Whisker crimp provides predetermined contact pressure on the crystal. Electrical characteristics are comparable to preliminary specifications for similar types.



RCA transistors are imbedded in a thermo-setting resin to maintain power gains within a 2 db variation over extreme conditions of moisture, shock and temperature. Unit measures 0.6 x 0.3 x 0.2 in. and is shown at the right in an advanced stage of construction before being encased in plastic. Operating characteristics of two representative transistors at 25°C are as follows: emitter volts 0.42 and 0.5; emitter current 1.1 and 0.55 ma; collector volts 20 and 17.5; collector current 4.6 and 3.6 ma; power gain 17.9 and 26.5 db.



WESTERN ELECTRIC'S Type 2A transistor functions as an amplifier in the "card translator" used with the new 4A toll crossbar system for automatic selection of routes in long distance telephone dialing. These units are used in conjunction with Type 3A phototransistors which are activated by light passing through a series of punched cards. The cartridge Type 2A has its base contact connected to the metal shell.



GENERAL ELECTRIC'S Types G11 (amplifier and oscillator) and G11A (counter) transistors have the following physical specifications: brass case maximum size, 0.35 in. high, 0.16 in. diameter; impregnated with moisture resistant wax; silver plated phosphor bronze pins; connections, base soldered to case, emitter center pin, collector opposite base pin. Electrical characteristics are collector dissipation 100 mw, collector voltage (V_c) 30 v., collector current 7 ma, emitter current (I_e) 3 ma, emitter peak-inverse voltage 50 v., ambient temperature 40°C. Operating characteristics for the G11 with grounded base and $V_c=25$, $I_e=0.5$ at 25°C, are as follows: base resistance 200 ohms; collector resistance 22,000 ohms; input resistance 475 ohms; current gain 2.2; power gain 17 db; cut-off frequency 2 MC; noise figure 57 db; minimum dc resistance in emitter circuit 500 ohms. For the G11A the characteristics are: base resistance 450 ohms; collector resistance 30,000 ohms; input resistance 900 ohms; current gain 2.2; turn-off time less than 2 μ sec.

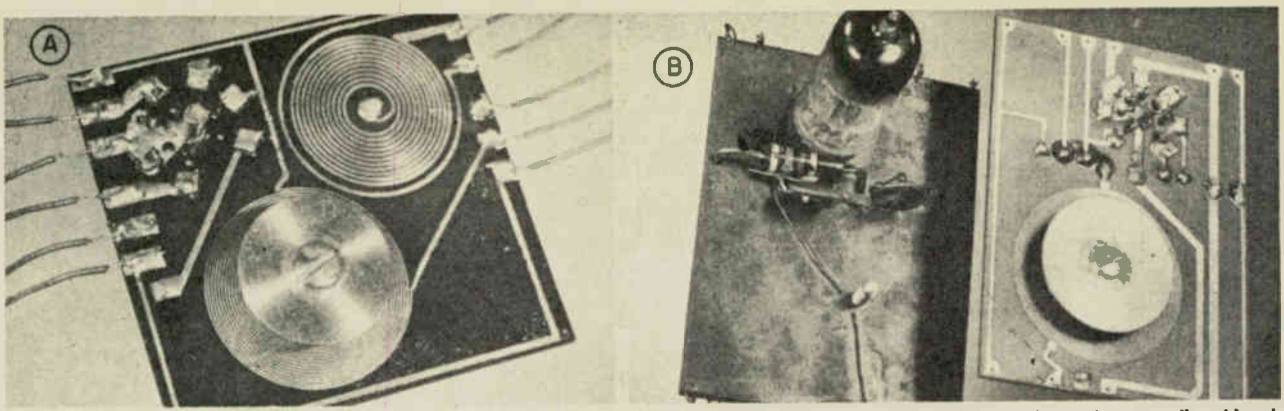


Fig. 1a, b: Two developmental printed i-f stages for 25 MC. Connectors and inductors are photo-etched; resistors and capacitors are dip-soldered

Printed Unit Assemblies for TV

Etching and silk screening techniques reduce costs and conserve critical materials in receiver manufacturing. Performance of printed stages compares favorably with standard circuits

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RESEARCH in new construction for TV equipment faces strong conflict with existing methods which have established themselves in practice through gradual evolution. Materials, design practice, and methodology are so intertwined that significant changes introduced into chassis structure must necessarily be done with exacting consideration for the assembly line, purchased materials, and above all the net effect upon costs. Nevertheless, circumstances are pressing for the development of circuit printing methods suitable for TV. The impetus to improve manufacture comes not only from cost competition but also from shortages of metals and sporadically from components.

The application of unitizing to equipment design has generally followed two approaches, (1) the functional subchassis and (2) assemblies built around a single tube stage. The functional type designed as a plug-in containing several tubes, such as i-f amplifier, power supply, etc., has received some usage in TV construction. However, its primary contributions to convenience of repair and replacement are of greater importance where a great number of identical equipments are presented to closely knit service organizations, as in military or telephone central office operations. Single stage unit assemblies are primarily a means to improve assembly.

Two notable attempts to introduce a more logical uniformity in the assembly of radio and TV circuits may be seen in the single stage modules patented by Evans (Pat. 1,973,248) in 1934, and more recently by Mitchell (Pat. 2,472,021). Both of these are pre-assembled groups of conventional resistors and capacitors related in purpose to the performance of a tube and incorporated in the tube socket. A more familiar type of unit assembly is the "printed" interstage coupling unit built of silk screened resistors and capacitors on a high-dielectric ceramic base. This form has become well known through the Bureau of Standards—Centralab work and is now present in many sets as the integrator circuit. The silk screened unit in its commercial form is, of course, attached to tube sockets by wire leads.

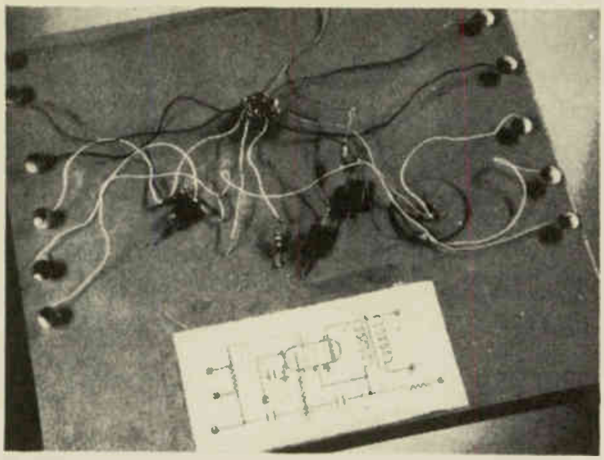
Adapting Technique to Circuit

Each of the silk screening or etching techniques, as we now see them, is best adapted to particular circuit elements. The screening of resistors and capacitors of commercial tolerances on high dielectric plates has become commonplace. However, inductors for 40 MC and less occupy too much area to be screened on ceramic and are of doubtful use on plates of high dielectric. On the other hand, selective etching of metal-clad laminates and die-stamping processes are producing inductors and interconnecting wiring competitive to wire wound elements. The ease of soldering to etched circuits is also attractive but it is not generally feasible to etch bypass and coupling capacitors from clad-laminates. The cure of resistors screened on etching stock is also limited by the thermal stability of the plastic base.

By utilizing the intrinsic process and material advantages of the silk screen and selective etching methods in the development of a unit assembly, *completely printed* TV circuits are possible.

In Fig. 1 are shown two developmental models of a printed 25 MC video i-f stage. The connectors and inductors, both single spiral and bifilars, are photo-etched in an essentially planar, cascade design and the clips from a wafer type tube socket are incorporated directly into the plastic base. The above-deck placement of resistors and capacitors permits assembly to be accomplished by a dip-soldering operation, during which the coils are protected with a high-temperature tape mask. Both models have bifilar transformers under the brass tuning slug and one has also an r-f choke in the heater line.

The choice of flat etching stock as a base for the unit was not an arbitrary one. Eighteen three-dimen-



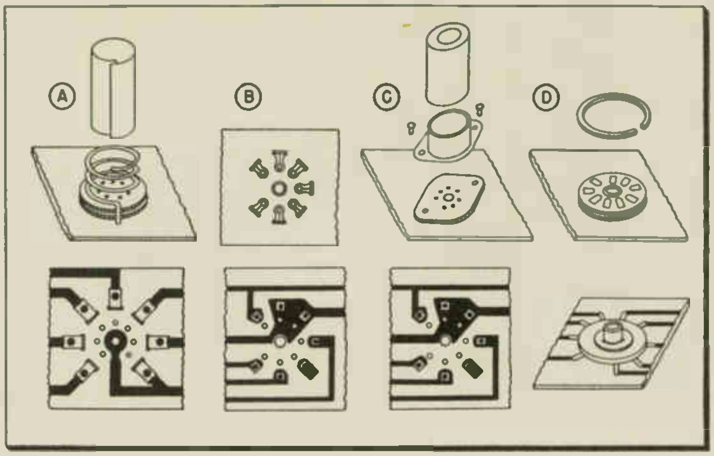


Fig. 2: (L) Pasteboard models for visual study of various shapes. Fig. 3: (R) Design sketches of dip-soldered assemblies incorporating tube sockets

sional pasteboard models of various shapes were constructed for examination, four of which are shown in Fig. 2. Flat stock was selected because of its ready availability, because of the facility of dip-soldering and riveting additional components thereto, and the convenience of a flat master negative. A doubt might arise as to the actual saving of critical material achieved through the use of sheet copper but the photo-etching process provides opportunity for accurate design of each conductor and inductor dimensions to the actual current carrying loads, which usually results in a slight saving in copper when compared with the universal use of one or two sizes of hookup wire. While design standards have not yet been established, the current carrying capacity of etched conductors is remarkably high when compared with a wire of corresponding cross-sectional area.

TABLE I: CURRENT CAPACITY OF AN ETCHED COIL

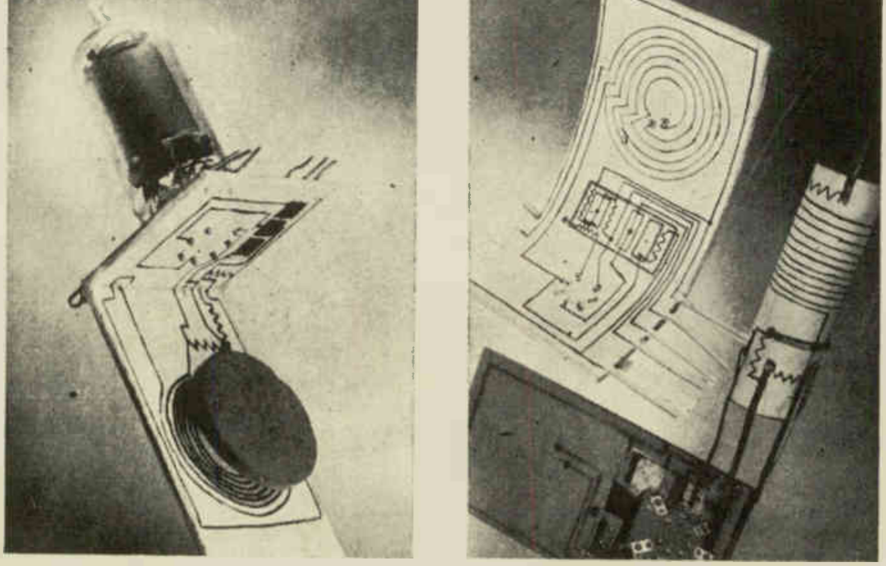
Coil data:

Material .... Copper on 1/16 in. XXXP laminate
Coil Diam. .. 1 in.
Line width .. .024 in.
Line depth .. .0012 in.
Space between lines .... .009 in.
Inductance .... 2.0 μh
Conductor cross-section .. 29×10^{-6} in.
Nearest comparable wire size #35 AWG

Current, Amps. AC	1.5	2.0	3.0	4.0	5.0
Duration of test	2 hours	2 hours	2 hours	5 min.	5 sec.
Remarks	Coil cool to touch	Slightly warm	Copper became dis-	Plastic backing smoking	Coil did not open or buckle

Current density at 1.5 amps = 52,000 amps/sq. in. of conductor cross-section.

Fig. 4: Puzzleboards consisting of a harness made up of all elements speed circuit design



Temperature Check Results

In Table I are shown the results of temperature check made on a 2 μh spiral, which indicates that it could be operated with a current density in excess of 52,000 amp/sq. in. of conductor cross-section without excessive temperature rise.

The problem of designing masters for fine, etched bifilar coils has no doubt been one of the factors retarding a more general acceptance of etched circuits. A draftsman has to spend considerable time with compass and straightedge to draw a spiral, and at best accuracy of design is poor. To eliminate this handicap, a turntable apparatus resembling a transcription machine has been fitted with two pens to enable the drawing of master spirals, either single or bifilar, to be made in a matter of minutes. A wide selection of diameters, line width, space width and turns ratio makes possible a rapid improvement in design.

Master drawings are reduced photographically to a negative transparency of exact dimensions and this transparency is used to photoetch the coils by the now well known process. Table II gives specifications and test data for several etched coils designed for video i-f use. Tuning is accomplished by a brass screw with an oversize head. Although the presence of the disc tends to lower Q, the reduction is fairly constant over the tuning range necessary to stagger-tuned circuits.

Of general interest to engineers concerned with printed circuits, four methods of incorporating tube

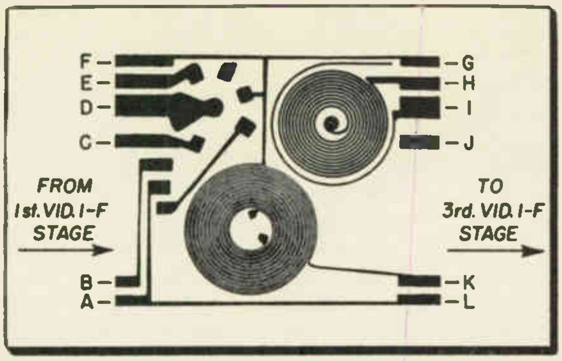
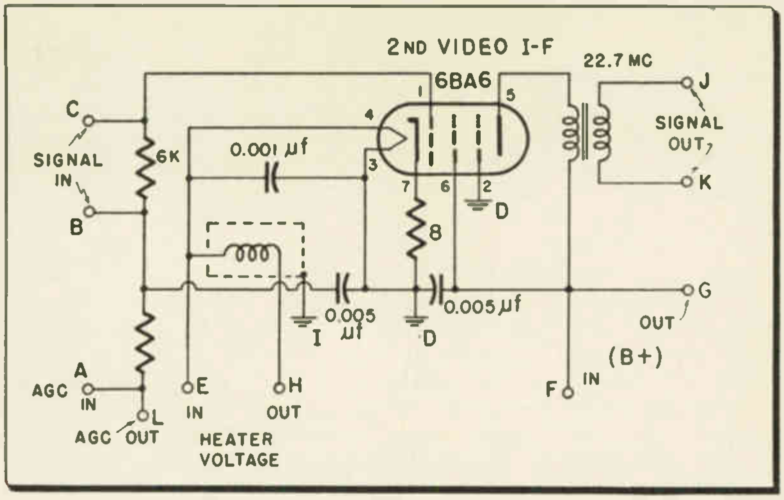


Fig. 5: Printed circuit layout and schematic of 25 MC i-f stage. Jump connections, except from center of coils, have been eliminated. Feed-through busbars go to B+ and agc



sockets in assemblies to be dip-soldered have been devised by modifications of commercial sockets and parts. Sketches are shown in Fig. 3.

Two basic construction features are essential:

1. The socket must have mechanical retention to supplement soldering; and

2. The lug ends of the clips have to emerge horizontally and in contact with the conductors on the base material for soldering to be possible. The designs illustrated accomplish this with a minimum of riveting or fastening.

The most direct approach, Fig. 3a, is to use a type of wafer socket having long lugs which may be inserted through punched holes in the deck and bent flat against the conductors. A very neat arrangement results if similar but smaller clips are separately inserted into the etched laminate. This construction, Fig. 3b, was used in the module under discussion. Some pin clips require compression between two wafers for proper functioning and with this type of clip the upper wafer may be retained as shown in 3c. Molded sockets may be adapted by revising these so that they insert from beneath the deck as in Fig. 3d. To do this the top flange is replaced by a snap-ring and an underside flange is provided by addition of an insulated washer which also serves to compress the lugs flush against the circuit connections.

Conventional Tube Shielding

Tube shielding, when required, may be of the conventional type, riveted to a grounding strip or area provided in the etch pattern, or, as shown in Fig. 3. shield fastening can also be adapted to solder-dip assembly without recourse to rivets.

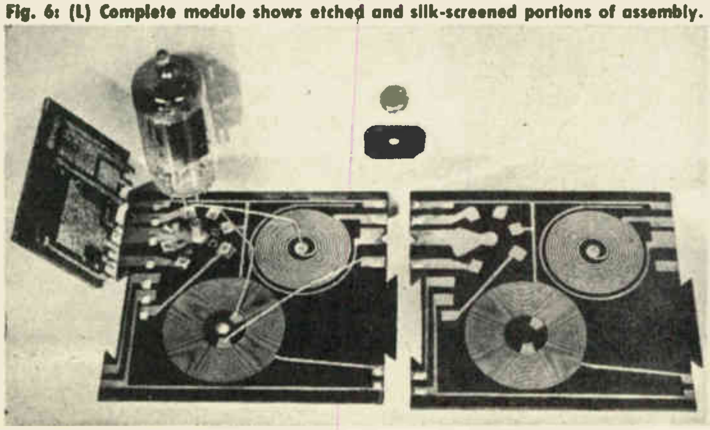
Planning the circuit layout for two-dimensional reproduction is an essential step in printed circuit design and much of this effort is spent in the elementary but time-consuming process of eliminating cross-overs. Sketches are helpful, but three-dimensional models as previously shown are almost mandatory for proper evaluation of a proposed configuration. To facilitate the reduction of layouts to simplest form a "puzzleboard," Fig. 4, was created. This consists of a harness made up of all the circuit elements

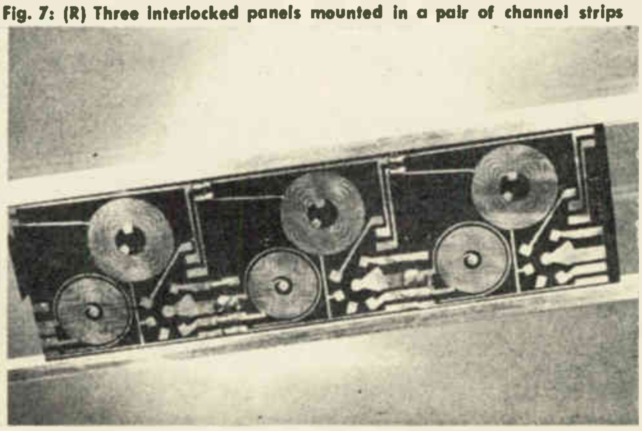
TABLE II: ETCHED COILS FOR 25 MC IF

Winding	Etching Stock	O.D. In.	I.D. In.	Line width In.	Total number of turns	Q	L h
Single	XXW laminate 1 oz. copper	1	19/64	0.018	11	62	2.35
Single	XXXP laminate 1 oz. copper	1	19/64	0.020	11	70	2.18
Single	XXXP laminate 1 oz. copper	1	19/64	0.024	11	65	2.05
Bifilar	XXP laminate 2 oz. copper	1 1/8	15/32	0.020	8 8	P-46 S-45	P-2.0 S-1.9
Bifilar	XXW laminate 1 oz. copper	1 1/2	31/64	0.010	12 1/2 12 1/2	P-48 S-49	P-4.8 S-4.75
Bifilar	XXW laminate 1 oz. copper	1 7/32	29/64	0.020	10 10	P-58 S-54	P-2.9 S-2.75

P = Primary Winding S = Secondary Winding

Fig. 6: (L) Complete module shows etched and silk-screened portions of assembly. Fig. 7: (R) Three interlocked panels mounted in a pair of channel strips





involved, connected at the high potential end only by long flexible hookup wire. The starting point is the conventional breadboard circuit separate from any chassis. This is used as a fluid three-dimensional model, in which the free ground ends of the components permit rapid manipulation to the simplest layout. Use of the puzzleboard permits both development and design of printed circuits to proceed at a rate comparable with standard chassis layout.

The circuit and a layout for an etched 25 MC i-f stage is shown in Fig. 5. Provision has been made for feed-through busbars for heater, B+ and agc. Jump connections from the centers of the coils are unavoidable, but all other crossovers have been eliminated by relegating this function to the resistors and capacitors.

Silk Screening

In order to have a fully printed module retaining the advantages inherent in the etched deck, silk screening has been employed to produce an RC unit on a high dielectric plate (Fig. 8). This unit is fabricated on material with a dielectric constant of 4,000 and thickness 0.05 in. The material used exhibits a rather high temperature coefficient; the dielectric constant at 85°C being approximately double the value at 25°C, with the "Curie" inflection falling at 74°C. However, this material is adequate to nearly all bypassing and coupling functions. In the card shown for a 2nd video i-f stage there are a 0.001 µf heater bypass and two 0.005 µf bypass capacitors for cathode and screen. The capacity areas on the face of the ceramic as well as all connective wiring have been produced by silk screen stencilling with conductive silver ceramic decorating paint. The second plate for all capacitors is formed by a substantially continuous silvering of the reverse side of the high dielectric card. On this, the ground side, windows are provided in the metallization opposite resistor areas on the front to reduce what might be a prohibitive stray capacitance. The pattern on the ground side is non-critical and is, therefore, produced by a permanent spray painting mask of simple design rather than by a second silk screen printing. Curing of the metallizing paint is feasible by batch firing in a muffle or in a continuous ceramic decorating lehr.

The three resistors on the card are produced by silk screening printing of a resin-graphite-lampblack mixture. Curing and protective coating as well as the composition of the mixture are closely controlled in processing to give resistors of acceptable commercial stability. The screening is done by an all-metal screening fixture of improved design in which the motion, angle, pressure and speed of the squeegee are controlled with precision adjustments. Attempt is thus made to remove all variables in the process which might result from manual operation. After screening, the resistors are cured, insulated, and again baked.

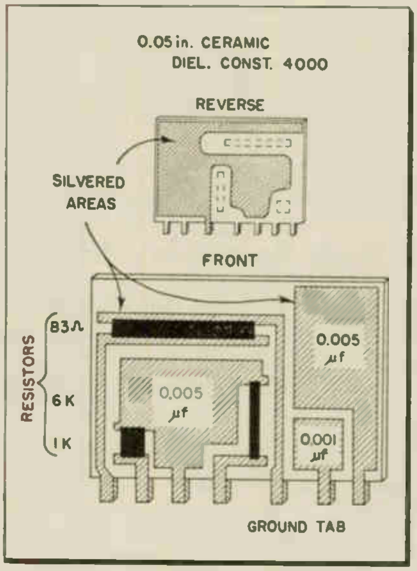


Fig. 8: RC card silk screened on dielectric

The resistors on the card illustrated are simultaneously printed from the same mixture, and three values being determined by variation of the length-width ratio only. This is sometimes referred to as the "aspect ratio." The 1 K agc resistor has a square aspect which shows that the mix used basically produces carbonaceous films having an area resistivity of 1,000 ohms per square. Lengthening the resistive area so that the aspect ratio is 6:1 gives the 6 K input resistor; and making a very wide but short area enables the production of the 83 ohm cathode resistor, which has an aspect ratio of about 1:12. The total range of resistor value on this card, from 83 to 6,000 ohms, is thus a little over 72 times. This approaches the practical limit of variation in resistors which may be printed on the card from one mixture. Consideration must also be given in the design of printed resistors to see that there is a total area adequate to dissipate produced heat; a conservative standard is 1 watt/sq. in.

Resistor Functioning Lengths

It may be noted in the layout of the RC plate above that the functioning lengths of the resistors are set by the spacing of the contacts formed by the conductor pattern, while the widths are set by the pattern in the resistor stencil. This presents an additional problem of printing metallization and resistor mix in registration. Absolute registration between the two superimposed patterns is not of great interest but control of the de facto registration of successively printed samples is necessary to keep resistor variation within tolerance limits. This is accomplished by two register pins on the work holder of the screening fixture plus vacuum clamping which holds the work against these pins. Screen stencils for both capacitor and resistor areas are made on conventional bichromate sensitized film which adheres to the screen after contact exposure and washing out. Preparation of masters by drawing and photo reduction is identical to the procedure used for the etched copper laminate section.

Performance

The performance of unitized stages made up of the combined etched and silk screened components was checked by measuring overall response and i-f response in a Sylvania Model #1-387 receiver, with substitution of printed for standard stages. The performance of the second video i-f module is represented by test results shown in Fig. 9. The solid curves are for a circuit containing the printed stage, and the broken curves for a set with all standard components. Measurement of i-f response was made by injection of signal at the mixer plate in the tuner, and the point-by-point plot of dc potential produced at the 2nd video detector. Overall response was checked by a 30% modulated signal fed into the tuner on Channel 4 setting and the output of the second video detector read by VTVM.

The performance of the printed stage in terms of response is equal to or better than the standard assembly. The skirts of both responses are down on the sound side and the bandwidths through the printed stage are adequate at the —3 db level. The difference at the top of the curves is of little significance except that it indicates that the

(*Continued on page* 43)

Germanium Diodes for Indicating Instruments and Relays

DC meters with germanium rectifiers have high sensitivity, wide frequency range and small size. "Chatter" and "arcing" can be minimized with dc relays; circuits require small actuating currents

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BY adding one or two germanium diodes in a suitable rectifier circuit, dc indicating instruments and sensitive dc relays can be used on ac and r-f through 150 MC. Both instruments and sensitive relays utilize similar techniques for the proper use of diodes, and for this reason both applications are covered in this article.

In measurement applications, a dc meter with a rectifier has several advantages over an ac meter. The biggest one is the increased sensitivity. For example, a 0-150 v. moving iron ac voltmeter will take approximately 10 ma. for full scale deflection. A diode type rectifier meter on the other hand can be made with a full scale current of less than 0.1 ma. Other advantages of rectifier type dc meters are wide frequency range, good pointer response, small size and availability for multi-function testers such as ac-dc voltohm milliammeters.

In control applications, ac relays will often chatter and cause arcing. With a dc relay and a properly designed diode rectifier circuit, these troubles are eliminated. In addition, the relay can be made to operate on at least ⅛ the current and has the advantage of size and weight over an ac relay.

The following list indicates the principal scope of the circuits in the figure indicated:

Figs. 1-3: Temperature effects on diode impedance.

Figs. 4-8: Frequency range limited to 25 cycles to 250 MC by pointer oscillation and relay chatter.

Fig. 9: Meter protection from high reverse voltages. . .

Fig. 10: Sensitivity change with different rectifier types.

Fig. 11: Relay operation with increased sensitivity and no chatter.

Figs. 12-13: Elimination of contact sparking.

Fig. 14: Rectifier arrangements for microameters.

Fig. 15: Dimensions of plug-in sealed assembly.

Figs. 16-19: Typical characteristic curves for different diodes.

Table 1: Condensed specifications for some germanium diodes.

Temp. vs Z — Low

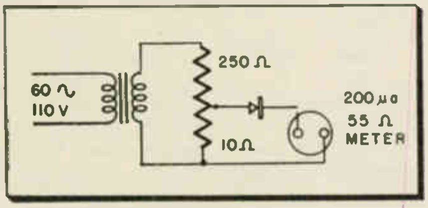


Fig. 1: When a diode operates from a low resistance source into a low resistance meter load, the meter deflection increases with increased temperature, because the diode forward resistance decreases with increased temperature. The decrease in back resistance which occurs at the same time does not influence the indication to any great extent because the diode back resistance at elevated temperature is still very large in comparison with that of the rest of the circuit.

Temp. vs Z — High

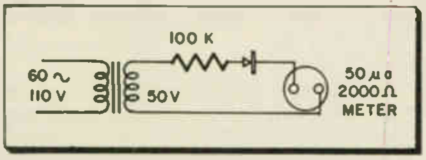


Fig. 2: When a diode operates from a high resistance source into a high resistance load, the meter deflection decreases with increased temperature, because the diode back resistance decreases with increased temperature. The reduced forward resistance has little effect on the meter deflection in this circuit because it is swamped out by the high resistance of the meter load.

Temp. vs Z — Constant

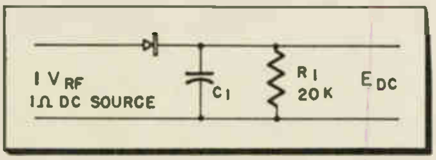


Fig. 3: A condition in which the meter deflection remains practically constant with temperature results from the combined action of two effects. First, the meter deflection tends to increase with increased temperature since the diode is working from a low impedance source into the relatively low impedance load of the condenser C_1. Second, the decrease in back resistance acts as a load in parallel with R_1 to effectively decrease the pointer deflection because of the increased temperature. The two factors work together to produce a more or less constant meter deflection with change in temperature. The load resistance in Figs. 1 and 2 can also be chosen to obtain similar temperature compensation.

Freq. vs Uniform Output

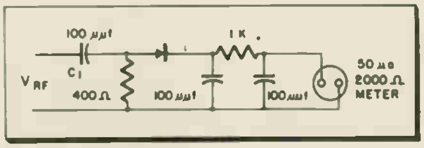


Fig. 4: The series condenser offers a gradual decreasing input impedance with increased frequency and tends to provide more uniform output with change in frequency.

Multirange Rectifier

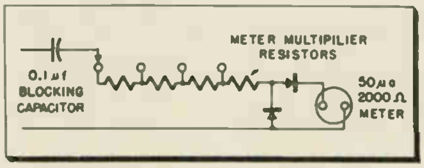
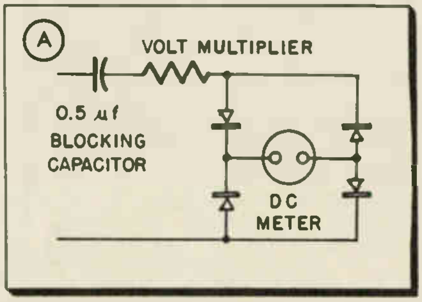
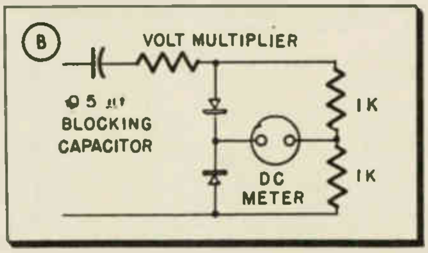


Fig. 5: With well spaced components and with resistors of low distributed capacitance and inductance, a multirange rectifier type instrument with sensitivity of approximately 10,000 ohms/v may give an accuracy within ± 10% over the frequency range of 60 cycles to 6 MC.

Maximum Output





Figs. 6a, b: Where maximum output with minimum input is of primary importance, these circuits are suggested for frequencies between 25 cycles and 25 K.C. The circuit of Fig. 6a gives about 10% greater deflection than Fig. 6b, but Fig. 6b is less expensive, takes less room and has somewhat better temperature and frequency characteristics.

Advantages of Germanium Rectifiers Over Copper Oxide

Until the last few years, the best rectifiers for instrument and relay applications were the small copper oxide types. With the advent of inexpensive, stable, small size germanium diodes, such as the GE Types IN48 and IN51, still more advantages have been added to rectifier type ac meters and relays.

Germanium diode rectifiers have the following advantages over copper oxide rectifiers:

1. Completely insulated so they can be mounted in a small space.
2. Enclosed in a sealed protective housing so they are not as susceptible to fumes and humidity as copper oxide.
3. High peak back voltage rating for probe type testing.
4. High back voltage and low forward resistance, which makes it possible to use temperature compensating resistance swamping circuits. This avoids one of the big disadvantages of copper oxide, namely poor temperature coefficient.
5. Wide frequency range running from 25 cycles through 150 MC in the one size unit.

Increased Sensitivity

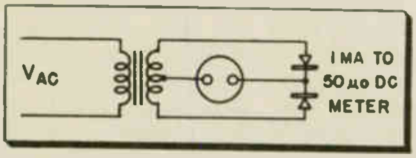


Fig. 7: For increased sensitivity over somewhat limited frequency range, a center tapped potential transformer arrangement may be used.

Temp. — Freq. Response

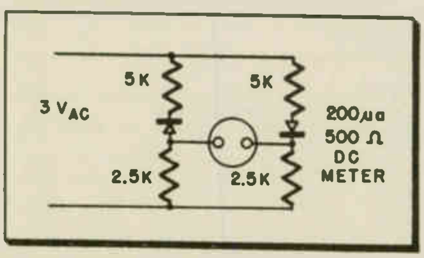


Fig. 8: Good temperature and frequency characteristics have been obtained with this circuit. Here advantage is taken of the high peak back voltage of the diode as compared to copper oxide. This permits adding temperature compensating resistors in series with each diode to effectively swamp out the change in diode forward resistance with temperature.

Low Forward-To-Back Resistance Ratio

Germanium diodes can be used for instrument and sensitive relay rectifiers in a number of circuits. The best diode types are generally those with low forward to back resistance ratio and low forward resistance, such as the IN51 and IN48. This is because the instrument or relay is generally a relatively low resistance load, and diodes with a low forward resistance and a fair back resistance work best. The higher back resistance types, such as IN52 and IN63, also work well for this service but are more costly.

The data shown may be applied directly to applications of sensitive relays, in which case the meter is replaced by the relay coil.

Meter Protection

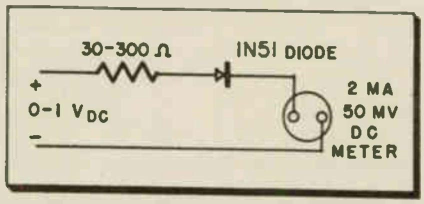
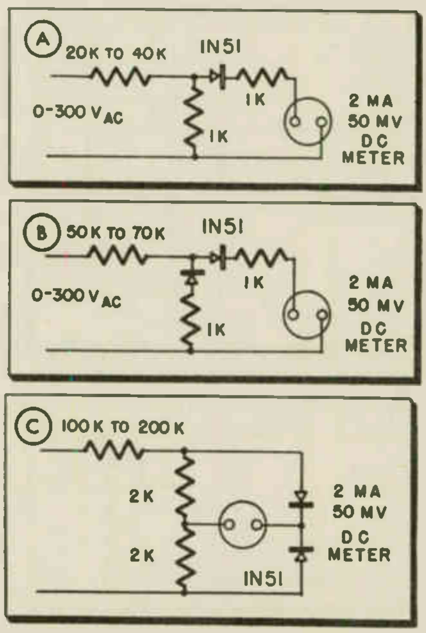


Fig. 9: Where meter protection from high reverse voltages is desired, a diode may be connected so the reverse current is limited to 3 ma with negative 30 v applied in place of the normal positive 0-1 v. The 30-300 ohm resistor is adjusted to calibrate the meter to 1 v full scale. The normal uniformly divided scale of the meter will be changed by the addition of the diode to one with the divisions contracted near the zero and approximately shown below:

Volt	MA	Volt	MA
1	2	.4	0.41
.8	1.4	.2	0.1
.6	0.9		

Where the peak back voltage exceeds 50 v, the higher peak back voltage diodes such as the IN52 or IN63 are preferred.

Sensitivity changes



Figs. 10 a, b, c: Actual 30 v. meter rectifier circuits using 2 ma and 50 mv dc meters are good for frequencies from 60 to 5000 cycles with less than ±3% change for the temperature range —25 to +125°F (—32 to +87°C). The main difference in each of the three circuits is the increase in sensitivity in going from the single diode half wave rectifier to the double center tap type. The resistors should be good quality non-inductive type. The scale characteristics will approximate those shown below:

Volt.	MA	Volt.	MA
300	2	120	0.75
240	1.6	60	.4
180	1.1		

The exact amount of series resistance will depend upon the individual diode.

Chatter Prevention

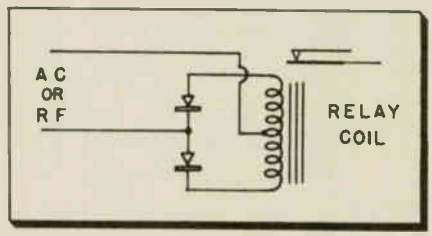


Fig. 11: Good 400-800 cycle relay operation has been obtained using a center tap brought from the relay coil with three wires connected to the diodes as shown. In this circuit the flux is held constant over both halves of the ac cycle. Greater freedom from chattering and increased sensitivity result from this arrangement.

Sparking Elimination

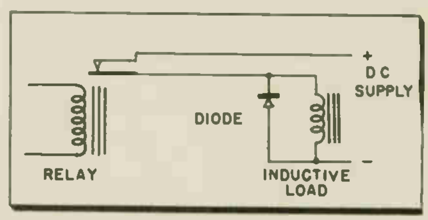


Fig. 12: Contact sparking can be practically eliminated by the use of a germanium diode connected across the load. With the relay contact closed as shown very little current is drawn by the diode because the voltage drop across the load is in the back direction for the diode. When the relay contact opens, the magnetic field in the load inductance collapses. This causes a forward voltage to appear across the diode and the diode conducts. Sparking is eliminated because the inductive energy of the load is dissipated in the diode forward resistance rather than in the relay contact gap. For most low voltage communication type relay loads a single IN51 or IN48 will be satisfactory. For higher voltage loads use type IN52 or IN63.

Heavy Loads

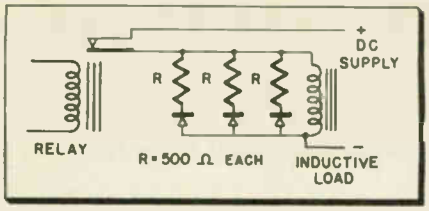
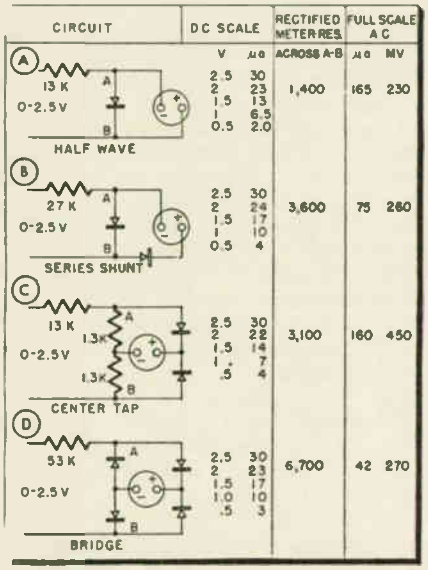


Fig. 13: For large relay of motor loads several diodes are connected in parallel, still preventing contact sparking. The series resistors help distribute the current more evenly among the several parallel diodes.

Microammeters



Figs. 14 a, b, c and d: The meter rectifier circuits shown are suggested for a 30 μa 2000 ohm meter. They may be transposed to either 20 μa or 50 μa by changing the sensitivity in direct proportion. For example, if the full scale with a μa 30 meter is 2.5 v., then the full scale sensitivity with a 20 μa meter will be 2/3 × 2.5 or 1.7 v. This simple ratio does not hold for higher meter currents due to the change in diode resistance. The meter resistance for the three sensitivities is assumed to be 2000 ohms. The ac sensitivity, the series resistance and the rectified meter resistance (i.e. with zero series resistance) may each vary ± 15 percent depending upon the individual diodes. All data shown is based on IN51 diodes, although any other diode with equal or better forward and back resistance will give about the same characteristics. There is some painter vibration near full scale in all circuits using the 3 in. undamped meter.

Plug-in Assembly

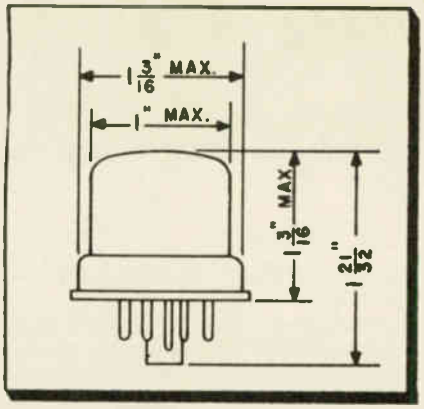


Fig. 15: Where the increased sensitivity of the 4 diode bridge rectifier shown in Fig. 14 d is desirable, a plug-in hermetically sealed assembly may be used. Some typical units are the type G9B, IN73 and IN74 with overall dimensions shown.

E-I Characteristic

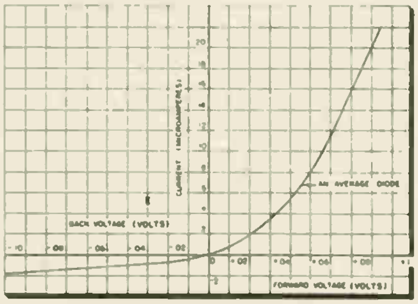


Fig. 16: Typical low voltage-current characteristic of type IN48 at 25°C.

Eff. Characteristic

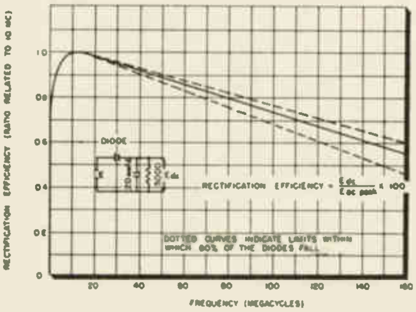


Fig. 17: Typical rectification efficiency-frequency ratio characteristics of types IN48, IN52, and IN63 at 25°C.

I-Temp Characteristic

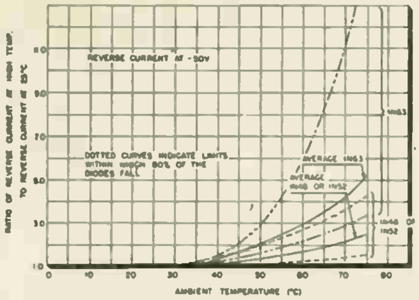


Fig. 18: Typical reverse current-temperature ratio characteristics with respect to 25°C.

E-Temp. Characteristic

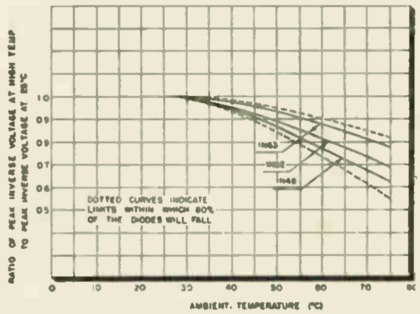


Fig. 19: Typical peak inverse voltage-temperature ratio characteristics with respect to 25°C.

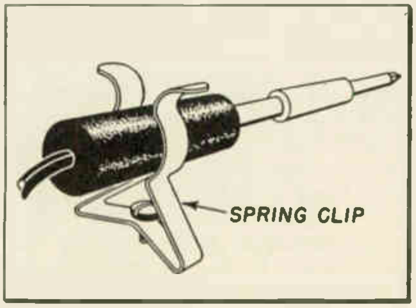
Condensed Specifications for Some Germanium Diodes

Type	*MAX.* Forward Resistance *(Ohms)* at +1 V.	*MIN.* Back Resistance *(Ohms)* at —50V.	*MAX.* Inverse Voltage *(Volts)*
IN48	250	60,000	85
IN51	400	30,000	50
IN52	250	333,000	85
IN63	250	1 meg.	125
IN65	400	250,000	85
IN69	200	59,000	75
IN70	333	122,000	125
IN72	Tested for efficiency at 500 MC.		
IN73	Balanced quad. Very closely matched.		
IN74	Balanced quad. Very closely matched.		
IN75	400	1 meg.	125

Bench Shortcut for Faster Repairs

Soldering Iron Stand

This "tip" is so simple that I imagine a lot of servicemen may have thought of it already. The market has been flooded lately with these spring-clip type holders for holding tools, brooms, etc., on a wall. It occurred to me, when I saw a friend of mine using one to hold his shaving brush in the medicine cabinet, that it might work to hold a soldering iron up off



the bench, and so do away with the rather cumbersome sling that I had. So I screwed one of these clips down on the bench, and I find that it has quite adequate strength to hold my 125-watt iron. You can either hold the iron or the handle, depending on how large a clip you get. The handle is better, as then the clip doesn't conduct the heat away from the iron and into the bench. *M. LeGoff, New Orleans, La.*

Installing PA Equipment

Demanding Only Comfortable Listening and Realism, a Well Functioning

• "Often the name *auditorium* clings to a room which is a marvel of structural engineering; which is perfectly illuminated, heated and ventilated; which is provided with every comfort and luxury; which is a monument to architectural art and beauty; but which is so burdened with acoustical defects that the audition of music is reduced to a confusion of sound and the audition of speech is an utter impossibility." (from "Architectural Acoustics," by Vern O. Knudsen).

While this citation is of a rather extreme case, it is nevertheless true that many auditoriums were designed for appearance rather than good acoustical results. And it is also true that many rooms are being used to present music, drama, political speeches, lectures and the like to an audience—or in other words, are being used as an auditorium —which were never meant to do so in the first place.

It is also true that a relatively small number of persons appearing on the stage or at the lecture stand have the requisite control over their voices—as to loudness, sonority and clarity—to make themselves heard by a large audience.

As a matter of fact, it is no longer considered good practice for players to speak their lines so as to "split the ears of the groundlings," as Shakespeare put it.

Sales Potential Seen

For these several reasons, speech and music reinforcement systems have come into somewhat general use. Such systems might be said to differ from the ordinary PA function only in that an attempt is usually made to make such systems inconspicuous—to contribute to the illusion that the listener in the audience is actually hearing the person, the performers or the musicians who are before his eyes.

As a matter of fact, many in the audience will actually hear the original sound, without reinforcement. Usually reinforcement will be provided only to fill blind spots and to "boost" the sound to reach distant points.

The alert PA dealer will keep his eyes and ears open to situations which suggest the need of a sound reinforcement system, in order to build up his business with this type of work.

A system of this sort will provide a relatively limited amount of facilities. First, there must be sound pickup at the source of the live performance. The number and placement of microphones will depend on the nature of the sound source emanating from the stage platform.

For instance, a lecturer or a political speaker could have a microphone at the speaker's stand. In a dramatic performance, however, microphones should be invisible, and would have to be placed so that they could not be seen by the audience. In the case of musicians or singers, microphones would have to be placed so as to pick up a balanced coverage of the whole unit.

In the latter case, you must assume that we are not referring to a symphony orchestra, which would probably require no reinforcement, except perhaps in a very large, very poorly designed opera or symphony hall. Rather, however, one might suppose a chamber music group, or individual soloists.

In addition to the live, on-stage pickup, provision might be required for (1) off-stage pickup of live sound, and (2) off-stage pickup of an electrical sound source such as telephone lines, radio, phonograph records, etc. These would depend, as we used to say in the service, "on the tactical situation," or rather on the demands of the users. A third sound pickup need might be in the audience itself, as for instance, for audience participation programs, lectures and meetings where the audience is permitted to ask questions, etc.

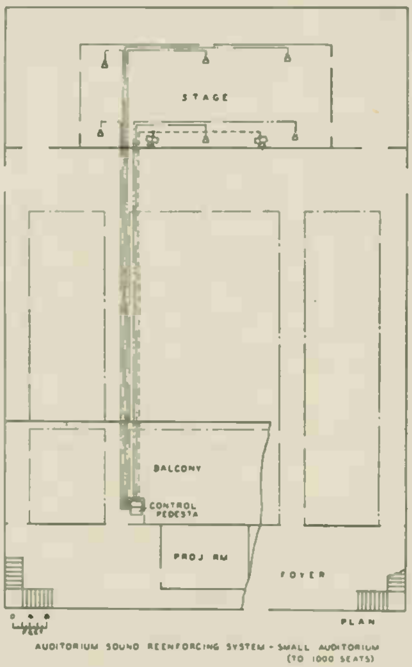


Fig. 1: Auditorium sound reinforcement system with 2 speakers and 4 mikes on stage.—Courtesy RCA.

All the sound pickup sources would feed to a control panel where an operator could mix them, fade them in or out, adjust the level of each, etc. This would preferably be located in the audience area, so that the operator can judge the results with his own ears.

A power amplifier would then be required, of course, and finally loudspeakers, located so as to accomplish the desired reinforcement.

The possible need for and employment of preamplifiers between the sound sources and the mixing-control panel will be covered below.

For a number of reasons, the use of several loudspeakers operating at low levels is indicated. For one thing, echoes and interferences between speakers is held to a minimum when the level is low. In the second place, realism is better attained when the PA system doesn't sound like a PA system—in other words, like an artificial sound source. In the third place, this system is designed to *reinforce* the sound, not to be a substitute for it.

Many Auxiliary Functions

One other function that this system may be called on to perform—a subsidiary feature, and not part of its main function—is to feed the sound which has been picked up and amplified to other places besides the auditorium itself. In other words, it might feed a recorder, a telephone line, or other rooms in the building, or all three. Here again, the desires of the users will determine.

We mention these various added features of the input and output circuits of the reinforcement system as a suggestion to the PA man who is selling the job to the customer. He may be able to "sell up" the job to much more than the customer originally had in mind if he suggests uses which the customer would appreciate but hadn't thought of.

Fig. 1 shows a simple speech reinforcement system for a small auditorium. In this installation, six microphones feed to a control console on the balcony in the rear of the auditorium. The seating area is roughly 88 feet from the stage to the rear of the balcony and about 96 feet wide. The average height of this auditorium is about 35 feet. Thus the volume of the listening area is roughly 300,000 cubic feet. To produce the level of ordinary speech would take relatively little power output from an amplifier (perhaps 1 watt), whereas to simulate the power of a symphony orchestra (as for instance,

for Sound Reinforcement

System of This Type Should Not Be Conspicuous to the Audience

from a phonograph record, or from the radio), as much as 100 watts might be needed. In this particular case, an amplifier producing 30 watts with relatively low distortion was recommended.

Low impedance microphone lines could be, in this case run all the way from the stage to the control station (88 feet) without undue losses. For ease and versatility of control, it is usually good practice to have a preamplifier stage and an input attenuator for each signal source, feeding into a mixer circuit. In this case there are six microphones, and amplifiers with six mike inputs are not very common; as a matter of fact, even preamplifiers of this capacity are rare. Consequently, at least a couple of preamps would probably be necessary.

A more elaborate setup is shown in figure 2. Here mikes 1, 2 and 3 are for

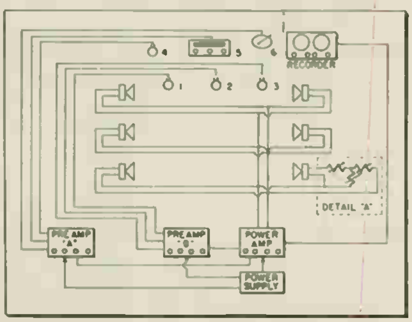


Fig. 2: Wiring diagram for auditorium reinforcement system similar to fig. 1. Placement of mikes and speakers is described in text.

speech reinforcement on the stage. Mike 4 is for off-stage (live) sound effects and voices (for instance, simulated telephone conversations or radio voices). Input 5 is a radio tuner and input 6 is a phonograph turntable, which might be used for sound effects or recorded voices. Either 5 or 6 or both might be used to provide music when a radio-phonograph on-stage is supposed to be turned on.

All the inputs are fed to the control position in the rear of the auditorium, since the operator at that position is in a better spot to judge the level coming out to the audience. In a detailed setup, an intercom would be provided between the back-stage and the control positions. Preamp "A" covers the backstage sound sources, whereas preamp "B" covers the on-stage mikes. The two preamps feed into the power amplifier, which is also located at the control position. A separate power supply is shown, although the preamps and the power amplifier might be self-powered.

The power amplifier feeds six small, low level loudspeakers, well spread around on the sides of the auditorium. These are kept at a low level so as (1) Not to create an unreal, amplified sound where the source is actually supposed to be live performers; (2) To prevent feedback to the microphones, and (3) To prevent room echoes and cancellation effects between loudspeakers.

Detail "A" in figure 2 shows a ganged T-pad across the loudspeaker. This type of attenuator maintains a constant impedance both in and out, while permitting the level to the speaker to be adjusted.

Selecting Microphone Types

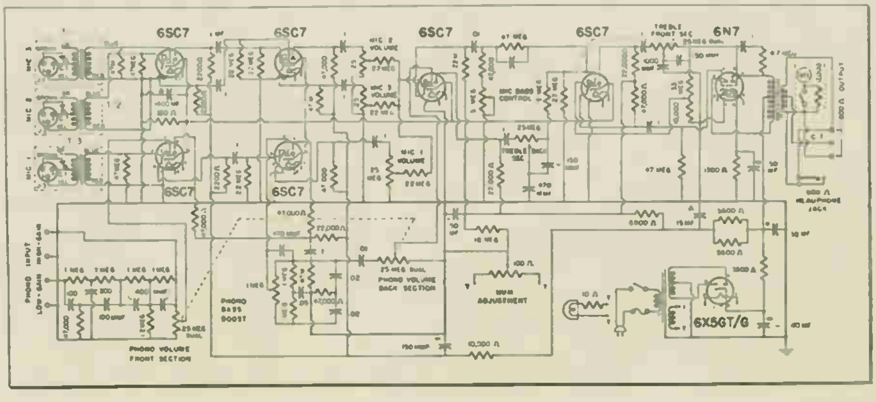
Attenuators of this type on each speaker would permit their level to be adjusted to suit local conditions in the vicinity of the speaker (such as hanging drapes, etc.). They would also make it possible to adjust the speakers in descending loudness as they got farther away from the stage, which would contribute realism since it simulates the decay of sound in air which would naturally occur. It is usually advised, however, not to place any speakers too far back from the stage, else the illusion of sound coming from the stage would be destroyed.

Fig. 3 shows the circuit of a typical high quality preamplifier with 3 mike input channels and one phono input. As shown, the unit provides for 30-50 or 150-500 ohm low impedance microphones. A similar unit, minus the input transformers, is available for high impedance mikes. Gain of the amplifier with low impedance microphones is 86 DB at 400 cycles, which is equivalent to an input sensitivity of 121 microvolts for rated output (63 milliwatts). Tone controls and volume controls are provided for both microphones and phonograph, and the output of mikes and phono can be mixed. A phone jack is provided so that the operator can monitor the amplifier aurally, and an output meter is provided for visual monitoring of the level. As mentioned earlier, the operator would have to depend to a certain extent on his judgment as to the actual sound in the auditorium. It can be seen, however, that with several different input sources, it would be necessary to adjust these individually in order to avoid continuous adjustment of the power amplifier to compensate for the variations in the inputs. It would probably prove most convenient to adjust all inputs to a predetermined output-meter level, and leave the power output level to the speakers more or less constant.

Omnidirectional mikes are handy for picking up sound over a wide area and from all directions. A difficulty may arise, however, which would indicate the need for very directional mikes. This is the fact that omnidirectional, high gain mikes will pick up a lot of extraneous noises, such as the moving of scenery, closing of doors, whispered directions between stage-hands, prompters, etc. This difficulty is often observed on TV programs, where necessity for concealment of not only the mike but its shadow limits the producer in obtaining optimum results.

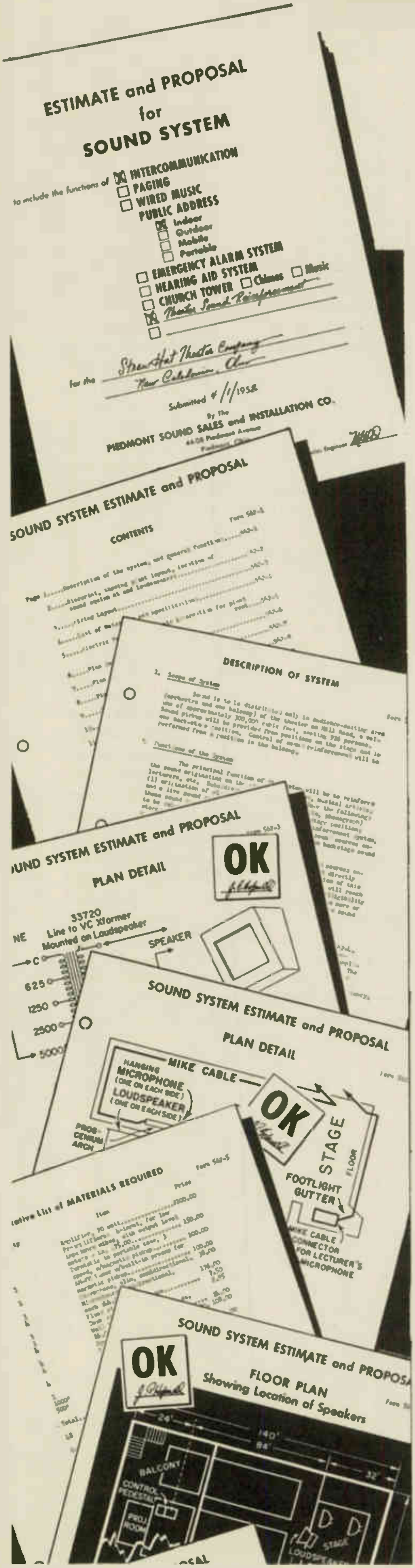
Such details (concerning the operation of the system) are, of course, up to the user and not the installer. But the installer should be aware of them so as to properly advise the customer of his needs and avoid future complaints.

Fig. 3: Stromberg-Carlson AV-38 preamp such as might be used in fig. 2, provides input for 3 low impedance mikes.



Installing PA

Part 2: Step-by-Step Outline for Planning,



• The first part of this article outlined the general considerations for auditorium, theater and other indoor sound reinforcement jobs, and showed how a typical system might be laid out.

Now we will take the same typical installation, and show how the work would be planned, estimated and priced for proper presentation to the customer.

The system is shown in Figure 1. As outlined in part 1, this would be a reinforcement system for a small auditorium or "little theater." Flexibility and versatility have been added to the simple reinforcement requirement, as shown by the addition of the off-stage mike, tuner and turntable. These could be for supplying sound effects for a play; for supplying "demonstration" material for a lecture; for supplying "between-the-acts" entertainment, etc.

Five mikes are provided (four on stage and one off). In this instance, 4 unidirectional mikes are provided (to avoid the pickup of extraneous noises on stage and to avoid feedback and pickup from the audience) and one "slim" type omnidirectional mike. The latter could be used in the backstage position but would be substituted for one of the stage mikes, should the platform be used for a lecturer or musical performer (where an unobtrusive-appearing mike would be desireable).

The turntable is a 16" transcription type, 3-speed, with tone arm and magnetic pickup. The tuner is equipped with a preamp stage for a magnetic pickup, and the turntable feeds through it. The tuner is an AM-FM type. No provision is made in the installation and estimating sections of this plan for antennas. If the location is such that antennas would be required, appropriate additions should be made to the parts list, the labor schedule and the overall price.

Features of System

Amplification and control is performed in a position located in the balcony. This position enables the operator to judge the results of the system as it reaches the audience. He also has a good view of the stage so that he can follow a cue sheet if there is one.

The on and off stage sound sources feed to two preamplifiers at the control point. Individual level controls are provided for each source (mikes, phono, tuner), and provision is made for mixing them in any desired manner.

The preamplifiers (A and B of figure 1) feed into a power amplifier (C) which in turn feeds four loudspeakers at the front of the auditorium. For purposes of concealment and also for realism of sound, these are fairly good quality 12-inch cone-type speakers, mounted in wall baffles. The two which appear to be on the stage are actually above the proscenium arch.

A recorder is shown as optional equipment.

Two preamplifiers are shown for two reasons: first, amplifiers with more than four inputs are hard to find; second, control is facilitated by having one preamp for off-stage sound sources and one for on-stage; and third, flexibility is provided in that there can be a couple of spare inputs for future changes.

Writing The Proposal

The proposal or "prospectus" presented to the customer should outline the general features of the system as sketched above and in last month's article and should include a plan as shown in figure 1. The list of equipment to be provided can be specific on the actual job, stating make and model number, and some of the manufacturer's specs on the equipment (such as frequency response, power output, power consumption, etc.). Some details may be over the customer's head, but will protect the installer from later complaints that he didn't provide equipment as originally promised in the estimate.

A typical estimate is shown below. The prices listed are not actual, but merely exemplary of what might appear on a real job.

Estimate	
1 Omnidirectional mike	$ 38.22
4 Unidirectional mikes @ 44.10	176.40
1 Mike floor stand	7.64
1 Mike desk stand	2.95
4 Mike wall brackets @ 6.76 ...	27.04
4 12-in speakers @ 27.00	108.00
4 line-voice coil matching transformers @ 3.50	14.00
4 wood wall baffles @ 7.50	30.00
1 Turntable in portable case, 3-speed, with magnetic pickup	100.00
1 AM-FM tuner with built-in preamp for magnetic pickup	100.00
2 4-input preamps for low-imped. mikes, with output meters @ 75	150.00
1 15-20 watt power amplifier ..	100.00
1 Headset for monitoring	15.00
1000 feet microphone cable, lowloss	56.00
500 feet speaker cable, 2-conductor	12.50
Total	937.75
48 Man-hours labor @ 5.00	240.00
Grand total (ESTIMATE)	1177.75

OPTIONAL EXTRA

Tape recorder	$300-$500
Intercom between balcony and back-stage, with wiring and labor, about	$75.00

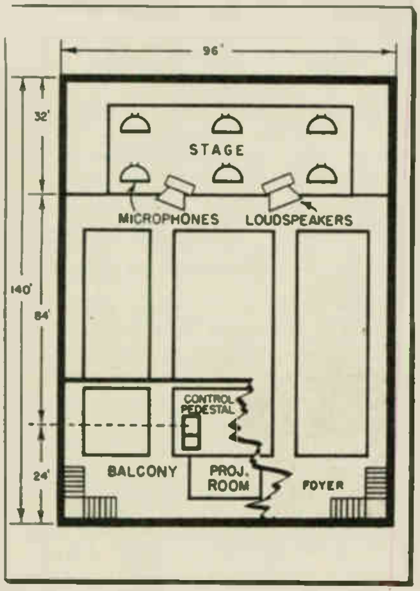
Estimating and Pricing a Typical Auditorium Installation

The labor would, of course, vary all over the lot depending on the nature of the job, the local electrical requirements, etc. Since this particular job is a low-power one, the voltage on the speaker lines could be kept under 70 volts and conduit should not be needed. As mentioned on page 15, an intercom system could be provided between the back-stage sound effects position and the control position for the purpose of passing on cues, instructions, etc. This is listed as "optional."

For the PA dealer to provide such a complete estimate (we will presume that the list, in actuality, would show actual makes and model numbers) to the customer in advance would actually save him time in two ways. First he would have an actual working list for use in installing the system, and second, a ready-made list for computation of the final bill. The latter would probably only need minor corrections to cover the work actually done and the equipment actually installed.

Up to this point, certain more or less technical aspects of the job have been skimmed over. They are: (1) estimating audio power required, (2) determining power handling capacity of loudspeak-

Fig. 1: A typical layout for sound reinforcement in a small auditorium or little theater. Speakers are above Proscenium arch.



ers, (3) loudspeaker matching problems, and (4) details of wiring layout.

The first three of these points have been simplified by the relatively limited scope of the installation. High power is not required because (1) the size of the auditorium (roughly 100 x 100 x 30) is small, and the audience is small (under 1000); (2) It is an indoor location, and (3) It is only a sound reinforcement system, not a PA system.

In this 300,000 cubic foot auditorium, 10 watts would probably supply sufficient acoustic power for the needs, and the 15 to 20 watts recommended in the list of equipment should be able to provide *any* needs that would arise.

This may sound small to the dealer who is accustomed to supply 10 to 20 watts for a home installation. Full power of that magnitude is practically *never* actually used in the home, although as much as half of it may be consumed in equalization and feedback. If 10 watts of fairly distortion-free power were available (which might require a 15 or 20 watt amplifier), it should be ample to fill an auditorium of this size.

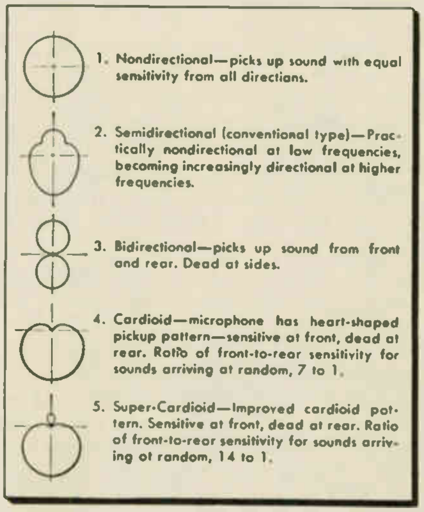
As for the loudspeakers, good quality 12-inch speakers are usually rated for at least 10 watts, and therefore this would present no problem. Actually, connected in parallel, each of the four speakers would draw no more than a fourth of the power.

Speaker Impedance Matching

For the impedance problem, let us suppose that there would be a maximum of 20 watts available, to be on the safe side. There are two ways to figure out the speaker matching problem: one is the old constant impedance method, the other is the newer constant voltage method. The latter is the RTMA-recommended system, and is infinitely simpler for the installer. However, we shall figure out the problem both ways, for the benefit of those who are not using the 70-volt line (the RTMA system) and also to show how simple the latter is.

Under the old way, it would be common to use a 500-ohm output tap, to take a for instance. Each of the four line-to-voice coil transformers would have 2000-ohm secondaries so that the resultant of the four in parallel would be 500 ohms. If it were desired to have unequal powers among the loudspeakers, the problem would be a little more difficult. Let us suppose that we wanted 4 watts each in two of the four, and 2 watts each from the other two, from a 15 watt amplifier. This would be 12 watts, or 12/15 of the total power. If the amplifier output were 500 ohms, then the four speakers should reflect back an impedance which is to 500 as 12:15. 500:X=12:15, then X=625 ohms. The two-watt speakers will absorb 1/6 of the power, the four-watt jobs will absorb 1/3 of the power. The impedances, of course, will be just the reverse of this, so the 2-watt speakers will require 6 x 625 or 3750 ohm line transformer primaries and the 4-watters will require 3 x 625 or 1875 ohm primaries.

With the constant voltage, or 70-volt line system, the output tap of the amplifier is selected for the number of watts required (if it is adjustable; more often, there will be just one output, for maximum output). This is calculated to provide no more than 70.7 volts on the line at maximum output, and lower at



Microphone types.—Courtesy Shure Bros., Inc.

anything less than full output. Line to voice coil transformers for 70-volt lines are also marked in watts at the taps, with the impedance arranged for connection to a 70-volt line. One has only to select the desired watts for each speaker at its transformer, without regard to any mathematics (except that the total watts to all speakers should not exceed the output of the amplifier). Thus in our example, if all four speakers were to get equal power from a 16-watt amplifier, each would be tapped at 4-watts. If unequal powers were desired: for instance, two speakers at 2 watts and two at 6-watts, the appropriate taps would be selected without any figuring.

So much for the impedance problem. As to the wiring, this will be done with three requirements in mind: (1) The physical make-up of the building, (2) The desires of the customer, and (3) Local codes. It may be that it will not be permissible to put any wires on the exterior surface of walls; or it may be, on the other hand, that it is not permissible to conceal any wires in the walls; or it may be that existing conduit must be used, or new conduit installed.

It can easily be seen that the choice of one of these alternatives over another could change the cost of the job by 100% or more. Therefore it is obvious that there can be no guesswork here when making an estimate. The wiring plan shown for the job illustrated in figure 1 is merely assumed to be laid by the most direct route along the exterior of the walls.

The How and Why of

Basic Theory Reviewed and Brought Up to Date by Analysis

• In DC restoration (also called DC *reinsertion* or *clamping*) something is given back to the video signal, which it lost on its trip to the cathode-ray tube. To know what this something is, we must first make sure that we understand the nature of the video signal, as well as its effect on the CRT.

The video signal contains units of picture information representing light intensities varying from white to black. The white sections of the signal are those that have the smallest amplitude, reckoning from the baseline of the total signal (see fig. 1); the black sections of the signal are those that have the greatest signal amplitude. The sync pulses have a greater amplitude than the blackest picture signals, and appear in the "blacker-than-black" region.

Nature of Video Signal

The video signal must be negative-going, when it is applied to the grid of the cathode-ray tube (that is, most negative at greatest amplitude). (If the signal is applied to the *cathode*, which is 180-degrees out of phase with the grid, it must be positive-going.) Then the black portions of the video signal will drive the CRT grid *most negative*, causing *minimum* current to flow through the CRT, and thus producing least light, or no light, on the fluorescent screen; the white parts of the signal will drive the CRT *least negative*, allowing *maximum* current to flow through the CRT, and thus producing maximum illumination of the picture screen. In this way, the picture recreated on the CRT will have the same light values as the televised scene.

Now, such a charming state of affairs will not occur unless the DC level of the received video signal is the same as the DC level of the corresponding video signal at the transmitter. To clarify this statement, let's analyze what we mean by DC and AC signal levels.

DC Is Reference Level

When an AC signal (fig. 2) is applied to some circuit point, like the grid of a tube, that is at zero potential to chassis, it will cause the grid-to-ground voltage to vary above and below zero, in accordance with the signal's AC fluctuations. When the positive half of the signal is coming in, the grid voltage will rise above zero in the positive direction; when the negative half of the signal makes its bow, the grid voltage will drop below zero—that is, move in the negative direction. The average level, or the DC level, of the grid signal voltage will be zero, because the voltage excursions above and below the zero level are equal.

If the grid to chassis voltage is not zero, but is, say, —3V, the situation will change. The AC signal will now cause the grid voltage to fluctuate around a level of —3V, not zero. That is, the AC signal will add to, or increase, the grid's —3V DC level during the negative part of its cycle; it will subtract from, or decrease, the grid's —3V DC level during the positive part of its cycle. The average voltage on the grid, or the DC voltage, will now be —3, not 0, as in the preceding case.

Now the video signal, after detection, has AC and DC components. The AC component is the picture information itself, which is varying constantly due to the amount of light (or absence of it) which the camera at the Xmitter "sees" in the subject. The DC component is the reference level from which the picture signal varies (fig. 3). This DC component is added to the AC signal at the Xmitter, and establishes the brightness level of the televised scene, since it is the average of all the excursions from light to dark in all the lines in one frame. It is therefore also considered to be the level of background illumination of a scene.

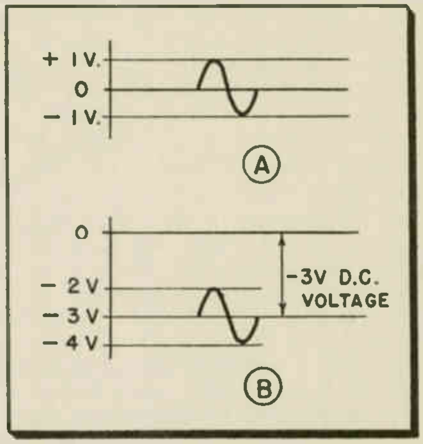


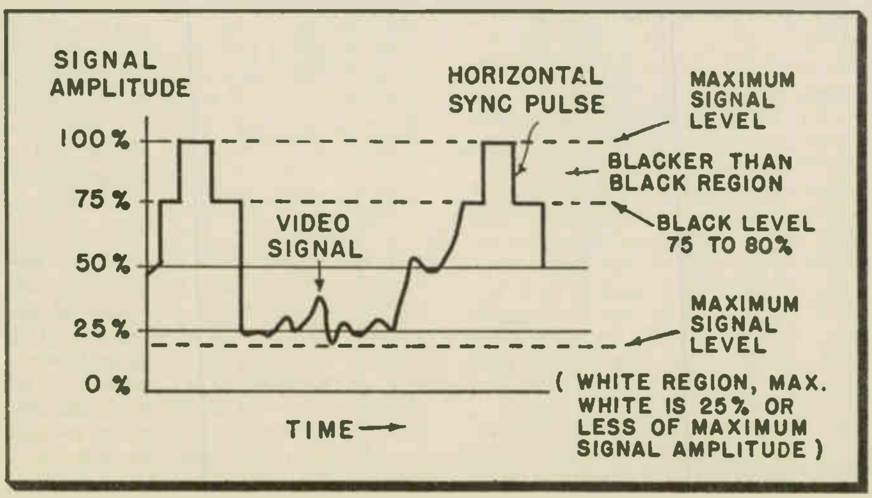
Fig. 2. (A) An AC signal superimposed on zero DC voltage. (B) An AC signal superimposed on minus 3 VDC.

DC Component Is Lost

This DC component, when added to the fixed bias on the kine of the receiver (which is established by adjustment of the brightness control) establishes the operating point of the kine so that the blanking pulses will cut off the beam. In this way we can be sure not only that the average background illumination of the scene is correctly reproduced, but also that the kine will always be cut off during retrace, and retrace lines will not appear.

If we did not have this DC reference level (and it can be lost, as is explained later on), we should have to adjust the brightness control every time the average background illumination of the scene changed. As it is, the only time we have to change the receiver fixed bias on the kine (or in other words, the setting of the brightness control) is when changing from one station to another with a vastly different received signal strength. And

Fig. 1. Amplitudes of different sections of the composite video signal.

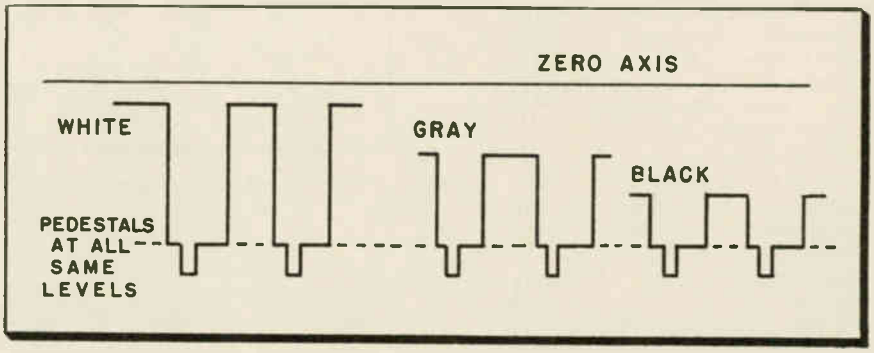


DC Reinsertion in TV Sets

of Practices Employed in Current Model Sets of Various Makers

even this change is made unnecessary (to a great degree) in sets with AGC and/or Automatic Black Level.

Now, the indispensable DC signal level is present at the output of the video detector. Between the video detector and the cathode-ray tube, however, the video signal generally passes through one or more R-C (resistance-capacitance) coupling networks. Since a condenser blocks DC, the DC level of the video signal is lost (fig. 4). It must therefore be restored or replaced. This is done by the DC restoration circuit. (It should be noted that in some receivers, no condensers are used in the coupling employed between the detector and the cathode-ray tube. No DC restorer is generally found in such sets.)



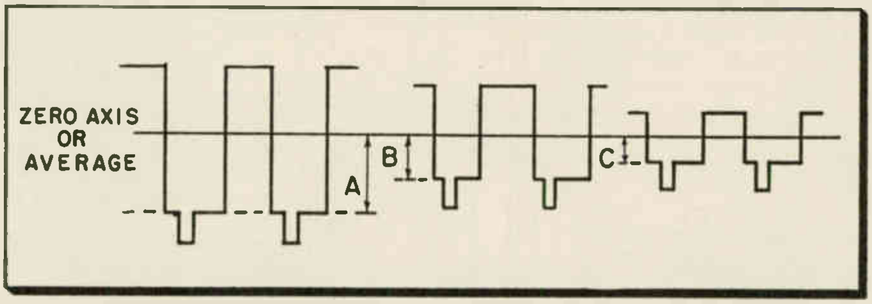


Fig. 3 (above, top). Light, medium and dark background pictures as they are transmitted. With the correct DC component included, the black and blacker-than-black information will, as shown, always cut off the kine in the receiver. Fig. 4 (above, bottom). The same signals as in fig. 3, but with the DC component removed, and the signals shown averaged around a zero axis as they would be after passing through a condenser. A, B and C show the DC components which must be added in each case to properly line up the black levels once more.

Restoring DC Manually

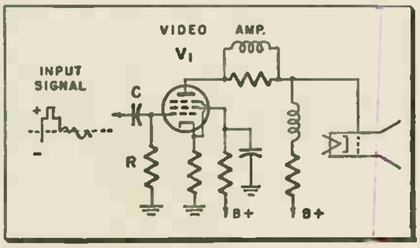
To better understand the action of the DC restoration circuit, let's consider in detail what would happen if it weren't present.

Suppose that light scene was followed by a dark scene. The set viewer has adjusted the brightness control while the light scene is coming in, to eliminate vertical retrace lines, and to give an approximately correct rendition of the tonal values present. The scene now changes to a much less brightly lit one. The vertical blanking pulses received during such a scene will no longer drive the CRT bias to cut-off, and vertical retrace lines will be visible on the picture screen (fig. 4). Furthermore, black signals will not drive the CRT grid negative enough to reproduce black on the picture screen. Black and grey tones will therefore be too light.

If the viewer reduces the brightness setting, thereby increasing the CRT bias, the undesired symptoms just described will be eliminated. When the scene illumination increases considerably, however, white and grey picture information will appear too dark, and the background illumination will similarly be too dark. Another resetting of the brightness control will now become necessary.

The DC restoration circuit eliminates the symptoms cited by restoring the correct DC level to the video signals. Two types of DC restorers are in common use: 1—The grid-leak DC restorer; 2—The diode restorer. Let's consider first how the grid-leak restorer (fig. 5) functions.

Fig. 5. Typical circuit showing how DC restoration can be restored by grid-leak bias in the final video amplifier, provided direct coupling is used from the plate of that tube to the grid of the kine.



Grid Leak DC Restorer

No special circuit is needed for this type of restoration. The DC signal level is restored because of the grid-leak action of R and C. When the composite video signal arrives at the grid of V_1, its polarity is positive (courtesy of the preceding stage or stages).

The positive portions of the signal will drive the grid positive with respect to the cathode during the first few cycles, causing grid current to flow, and a negative grid-leak bias to be developed. During subsequent cycles, only the positive peaks of the signal—that is, the sync pulses—will exceed or overcome the negative grid-leak bias, and cause grid current to flow momentarily.

Now, the grid-leak bias developed is a DC voltage. This DC voltage establishes a reference level for the video AC voltage coming in. For correct DC restoration to occur, the DC level must be proportional to the DC level originally present. Let's see how this is achieved.

If we examine the predominantly black and predominantly white signals shown in figs. 3 and 4, we see that the white signal—that is, the signal with a bright background—will, after the loss of its DC component, have a much greater peak-to-peak amplitude than the signal with the dark background. The light background signal has lost more DC voltage than the dark background one, and will need more to be restored to it. In other words, the darker the background of the signal, the smaller is the DC voltage that must be restored to it, and vice versa. Let's see how the grid-leak restorer fulfills this requirement.

When a light background signal is coming in, this high-amplitude signal will produce the largest DC grid-leak bias (since the grid-leak bias is proportional to the amplitude of the incoming signal). On the other hand, with a dark background signal coming in, a small DC voltage will be added to the video signal voltage. Thus the correct DC levels are restored to the signal, and since direct coupling to the CRT is used, no loss of the restored DC component occurs.

The DC restoration process

not only restores the video signal's DC level—it also lines up the vertical blanking and sync pulses, so that they attain the same amplitude. This is the way these pulses are transmitted, and this is how they must be received. If the vertical pulses weren't uniform in amplitude, an inadequately-sized vertical blanking pulse might not blank out the cathode-ray tube, causing vertical retrace lines to be seen on the screen.

The necessary lining up of sync and blanking pulses occurs during the same process that restores the video signal's correct DC level. The grid-limiting action of the video amplifier produces the alignment.

Suppose a large-amplitude vertical sync pulse is coming in. Since the pulse is the most positive part of the video signal applied at the video amplifier grid, and the cathode is grounded, the grid will be driven positive, and grid current will flow. The grid current will be relatively large, because the positive pulse is large. It will produce a voltage in the grid circuit that is opposite in polarity to the sync pulse voltage. The *net* sync voltage will therefore be relatively low.

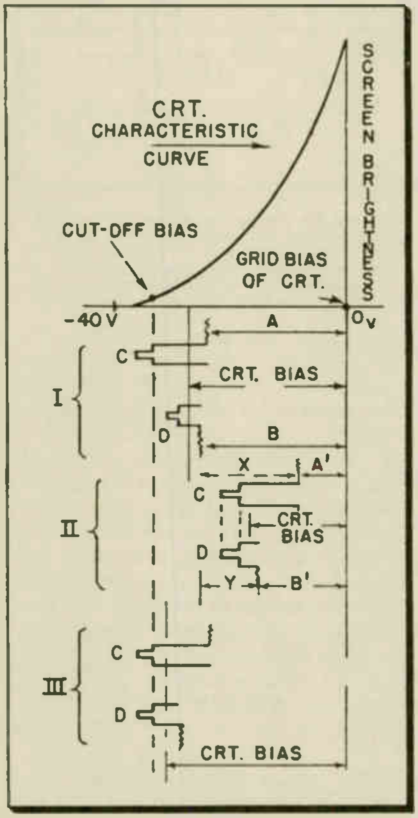


Fig. 2—Effect of diode DC restorer on CRT bias. C represents a large-amplitude or white-background signal; D represents a small-amplitude or dark-background signal. In sketch I, C and D are shown with unrestored DC levels. Note that the CRT bias gives C a DC level of A; D's level is B. In sketch II, C, bucked by a large DC restoration bias, is reduced to level A[1]. D, bucked by smaller DC restoration bias Y, is reduced to level B[1]. The blanking levels of the two signals are now lined up, but do not reach cut-off. In sketch III, the CRT bias has been adjusted with the brilliance control to bring both blanking levels to cut-off.

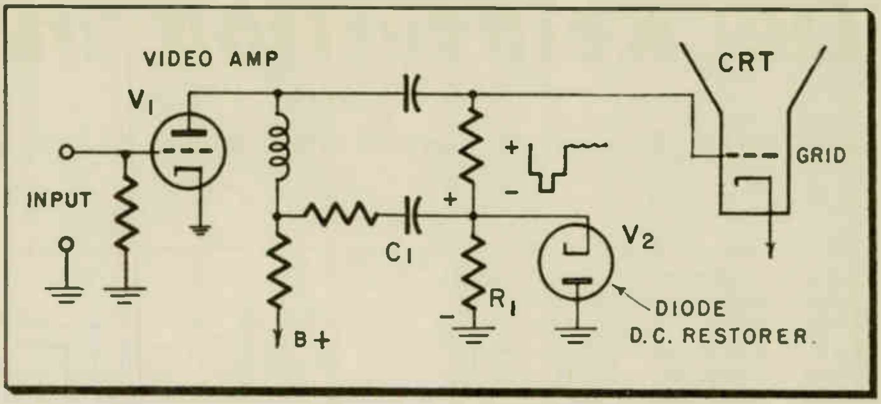


Fig. 1—Simplified sketch of positive diode DC restorer.

Say the sync pulse voltage is +5 V, and the bucking voltage it produces is —4 V. The net sync pulse voltage will be +1 V.

Now let's say that a small-amplitude vertical sync pulse follows its big brother. This pulse will not drive the grid as positive as its predecessor. Less grid current will flow, and the bucking voltage produced will be smaller. Suppose the positive sync pulse voltage is +2 V, and the bucking voltage created is —1 V. The net voltage will be +1 V.

The two originally unequal pulses are thus lined up, or brought to the same amplitude, by the grid-limiting action. Small-amplitude pulses are bucked least, and large-amplitude pulses are bucked most, causing all the pulses to line up at the same approximate height.

The operation of the diode DC restorer (fig. 1) is basically similar to the grid-leak type of restorer. Negative or positive DC restorers may be employed, depending on the polarity of signal needed for correct CRT operation. The positive DC restorer illustrated in fig. 1 works as follows:

The composite video signal is applied through C_1 between cathode and plate of the restorer (V_2). V_2 will conduct only when its cathode is driven sufficiently negative to its plate (which is another way of saying that the plate must be driven positive to the cathode), so a negative-going video signal is needed here. During the first few cycles of V_2's conduction, a positive charge is built up across C_1, making V_2's cathode positive to plate. (This positive voltage between cathode and plate is, in effect, a bias voltage.) When the subsequent video signals applied between cathode and plate are large enough to overcome the positive voltage between cathode and plate, V_2 conducts. Only the most negative portions of the composite video signal — i.e., the sync pulses — will be large enough to overcome the bias voltage and cause V_2 to conduct. The resultant DC voltage developed across R_1 will be proportional to the amplitude of the sync pulses. This voltage is in series with the AC signal voltage applied across R_1. Thus a DC level is added to the video signal.

This DC level is proportional to the DC level originally present in the signal, for the same reasons that the DC voltage developed in the grid of the grid-leak DC restorer is proportional to the signal's original DC level (explained last month).

You may remember that, in our last article, we pointed out that the darker the original background of a signal, the larger is its DC level; the more DC level it loses in passing through RC coupling networks; and the larger the DC level, therefore, that must be restored to it. Also, vice-versa.

This requirement is satisfied by the diode restorer, because the restorer develops a *small* positive DC voltage when a dark-background, or small-amplitude signal is coming in (see fig. 2). The negative bias between the grid and cathode of the CRT is lowered only slightly by this positive bucking voltage that is formed in the grid circuit. The CRT bias therefore remains large, or highly negative, at this time, and the scene is correctly reproduced as dark.

When a signal with an originally light background, or a large-amplitude video signal arrives, the greater conduction of the DC restorer produces a relatively *large* positive DC voltage in the CRT grid circuit. This positive voltage substantially reduces the negative bias of the CRT, causing the picture to be correctly reproduced as light.

How the sync and blanking pulses are restored to the same amplitude by the diode restoration process may be explained as follows: The diode restorer may be considered—in fact, it actually is—a half-wave rectifier, similar to the half-wave rectifiers used in the power supply of AC-DC broadcast receivers. A large AC input voltage will produce a large DC output voltage, and vice-versa. The DC voltage produced by the restorer is opposite in polarity to the sync voltage in series with it, and therefore bucks this voltage. From here on, the explanation is the same as in the case of the grid-leak restorer. A large sync signal will produce a large bucking voltage, and

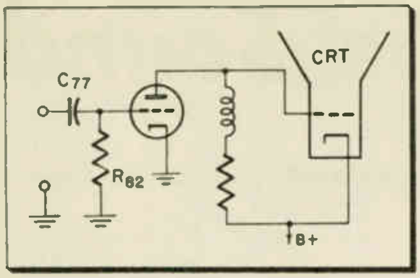


Fig. 3—Simplified grid-leak restoration circuit. Restoration action is achieved through the action of C_{77} and R_{82}. This type of restorer has two basic faults: 1—The plate current of the video amplifier is heavy in the absence of a signal input, which does this tube no good. 2—The control grid and cathode of the CRT will be at the same potential when the video amplifier conks out, causing zero CRT bias and permitting a possibly damaging current to flow through the CRT.

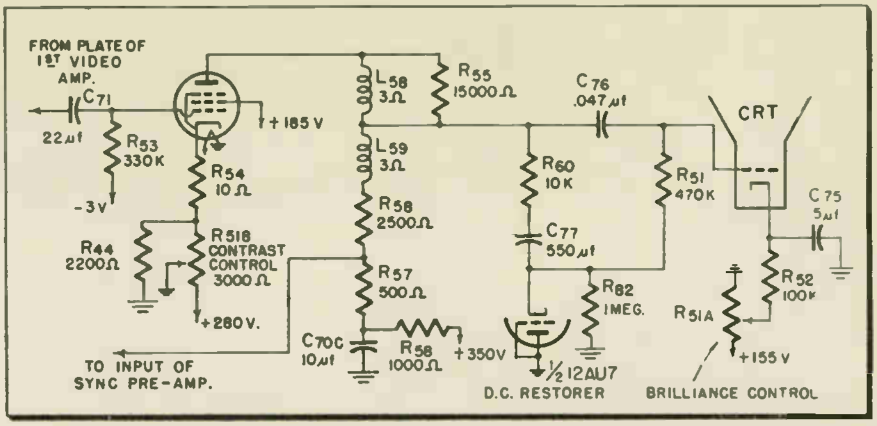


Fig. 4—DC diode restorer used in Philco models 50-T1400, 50-T1401, 50-T1402, 50-T1403. One-half of a 12AU7 is used as a vertical oscillator; the other half as a DC restorer. The triode section used as a restorer is made a diode by connecting grid and plate. A portion of the video amplifier's output signal is fed through R_{60} and C_{77} to the cathode of the restorer.

a relatively small net sync voltage. A small sync voltage will produce a small bucking voltage, and a net voltage approximately equal to that of the preceding sync pulse, etc.

This restorer is called a *positive* DC restorer because it inserts a positive DC voltage in series with the video signal. In a negative-type of DC restorer, the action is the same, except that a positive-going signal is needed at the restorer input, and a *negative* DC voltage is inserted in series with the video signal.

The time constant of the DC restorer is worth mentioning. R_{82} and C_{77} in the grid-leak restorer (fig. 4), and R_{82} and C_{77} in the diode restorer (fig. 5) determine this time constant.

If the time constant is too short (due to changes—i.e., reductions—in the value of R_{82} or C_{77}, or insertion of the wrong value of component), the condenser will charge and discharge too rapidly, compared to the time of one horizontal line. The sync and blanking pulses will therefore build up from differently-sized voltage bases, and their effective amplitudes will consequently vary.

Normally, the time of C_{77}'s charge and discharge is so long, compared to the duration of one horizontal line, that the level of the sync pulses is substantially constant.

Too short a time constant is apt to result in a distortion, or incorrect reproduction, of the picture's background illumination. Also, white picture information may appear too dark, and black information too light. Retrace lines may appear in the picture at different times, due to the differing amplitudes of vertical sync pulse peaks.

If the time constant of R_{82} and C_{77} is too long (due to an increase in R_{82}, or the use of the wrong—i.e., too large—value of R_{82} or C_{77}, DC reinsertion may not occur quickly enough, and retrace lines may be seen for a short time after a change in the picture's background illumination takes place. The picture's tonal values might also be incorrect in this brief interval of time.

The correct time constant—T (in seconds) = R (in megohms) x C (in MFD)—varies from a time equal to the duration of 10 to 20 horizontal lines (the theoretical optimum) to about the time needed for 1 picture frame.

DC restorer trouble should be checked for when retrace lines are seen in the picture after changes in scene lighting occur. To test the restorer, apply a modulated RF signal, (of the correct frequency for the channel to which the front end is tuned) to the antenna input of the receiver. Then measure the DC restoration voltage developed. This is the DC voltage across R_{82}, fig. 4; and R_{82}, fig. 5. Compare the reading to the voltage developed across the corresponding unit in a similar or identical receiver that is operating normally, when the same amount of modulated RF voltage is applied to the latter. If the two measurements are substantially different, trouble in the DC restorer should be looked for.

Since a DC restoration circuit uses very few components, the few possible defects—changes in the value of a condenser or resistor, or a defective tube—should be readily localized. When a crystal is used in place of a diode, the crystal may become defective. To check it, substitute a known good crystal of the same type.

When grid-leak DC reinsertion is employed, trouble in the condenser or resistor will generally introduce other symptoms besides those associated with poor DC restoration. That is, if condenser C_{77} (fig. 4) becomes leaky or loses capacitance, smearing may become noticeable in the picture. If C_{77} shorts, no picture or a very weak picture will be seen. If R_{82} increases greatly in value, smearing may occur. If R_{82} opens, no picture or a very weak picture is apt to be seen. If R_{82} short-circuits, no picture will be seen. If R_{82} decreases considerably in value, the picture will become weaker, and smearing may be present.

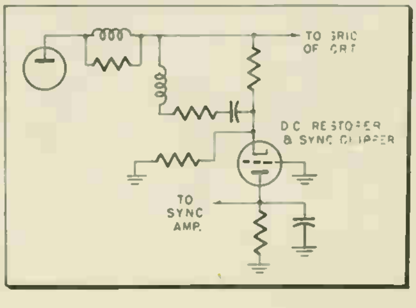
In the diode DC restorer shown in fig. 5: If R_{82} loses all or most of its value, the absence of DC restoration may be secondary to the weaker picture that will result, since a large loss in R_{82}'s value will reduce the signal input to the CRT. An open in R_{82} will not only impair DC restoration, but is apt to eliminate the picture as well, since the CRT grid return to cathode is opened.

A shorted tube (plate-to-cathode short) will produce the same symptoms as a short in R_{82}. A weak or burnt-out tube will cause inadequate DC restoration. An open or considerable loss of capacitance in C_{77} will result in the transfer of an insufficient input in the DC restorer, causing inadequate restoration.

Sometimes the DC restorer and sync clipper are combined in a single triode (see fig. 7). If trouble develops in such a circuit, the impairment of synchronization is apt to be far more serious than the absence of DC restoration, and the troubleshooter will no doubt be concerned primarily with this first symptom.

In some receivers, the appearance of retrace lines in the picture may be due, not to a defect in the DC restorer, but to a fault in a special circuit whose job it is to eliminate the vertical retrace lines from the picture.

Fig. 5—Circuit commonly employed when DC restoration and sync clipping functions are performed by the same tube.



Improving the Sound

These Modifications Can Better the Response

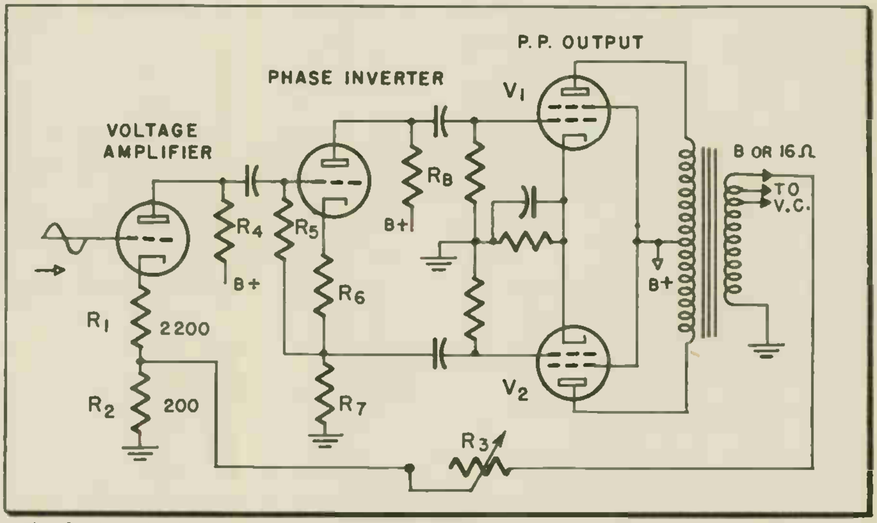


Fig. 1. In adjusting inverse feedback R_3 is a variable potentiometer. R_1 and R_2 may vary. Some designers recommend omitting R_2 and connecting R_3 to cathode. R_7 equals R_5.

• For most American homeowners present-day FM-AM combinations are satisfactory, else people would not continue to buy them. But for a continually increasing number of consumers, many sets in the middle price range do not produce sound quality as good as these consumers would like. Yet new high-fidelity combinations are expensive, costing $400-500, or more.

The wide-awake service department can step in and do a job on existing instruments that is highly profitable, and still save money for the customer. Modernizing his old set may mean only an hour's labor installing a high quality "tweeter" or loudspeaker. Or it may involve replacing everything except the cabinet (in the case of some inexpensive chassis installed in an impressive cabinet). Usually, though, the changer and tuner section of the set at least, and most of the time even the audio section, can be made use of. It is in such cases that the greatest advantages to both the service shop and the set owner are to be had from the improvements discussed in this article.

The first step to take in improving a set with inadequate or distorted response is to examine it carefully. If a small output transformer is noted, it may be that a larger, better quality transformer is all that is needed. But if the transformer looks OK, is working into a good loudspeaker, and has a *pair* of tubes driving it, then the circuit details must be checked.

Simple Repair May Do Job

The set may sound bad because of a change in value of almost any component, or perhaps because of a combination of values each just a few percent out of the way from the design centers originally engineered. Therefore a voltage check should be run on the audio stages with the manufacturer's voltage chart. Often changing one or two resistors to give proper voltage readings will improve the linearity and undistorted (5%) output enormously.

Assuming that the voltages are in line with manufacturer's specifications, the first improvements will be the addition of a good output transformer or of inverse feedback from the present transformer. If inverse feedback is presently employed, but the transformer has a small core, take note of the secondary tap which the feedback comes from. Then employ the same tap on the new transformer, if the feedback is of the type which uses the transformer secondary.

The output transformer is most often the weak link in the set. Cheap transformers fail both at the low and high end of the band. They have a tendency to distort and attenuate frequencies over 5 KC. They also attenuate the transfer below 150 cycles very sharply.

Also, the speaker often has a pronounced rise in the near-bass region, between 180 and 200 cycles. This rise produces a thump, or "one-note" boominess, an effect which is often made use of to supply the impression of good bass. In fact, a great portion of the public has become so accustomed to this false bass that it sounds good to them!

If the installation is one in which a very high quality loudspeaker is to be used, then one of the top grade transformers, of broadcast quality, should be employed. However, in most situations a good medium grade (usually called "standard", or "commercial," which are better than "replacement" grade) output will do, being flat to over 10 KC and good within 4 or 5 db to 50 cycles. This is more than adequate for all but the very best loudspeakers. There is little point in paying for response of 1 or 2 db flat from 20 cycles to 20 or or 30 KC when it can't be used! Appended is a table showing the impedance and approximate price of output transformers for various push-pull output stages.

If a medium grade output transformer, correctly rated at 20-25 watts, is run at 10 or so watts and less, it will usually display good power transfer characteristics.

If the output tubes are running wide open, that is, if no inverse feedback loop is applied around them, feedback can be added with the assurance that it will materially improve the performance of the receiver. Inverse feedback is one of the most powerful tools known for the reduction of the many types of distortion that arise in audio circuits.

There are many ways of adding this feedback, but the safest method, and the method which is employed today in all conventional top grade amplifiers will be outlined here.

Applying Inverse Feedback

In one of these methods a very small portion of the output signal is taken from the secondary of the output transformer and applied back to the cathode of the first voltage amplifier (or the stage just before the phase inverter). The procedure for determining how much feedback to use, and exactly how to apply it, is much easier than it may sound at first.

Referring to fig. 1, it will be seen that a 200 K potentiometer is connected from one side of the secondary to the un-bypassed cathode of the voltage amplifier. (Use the 8 or 16 ohm tap.) An oscilloscope (AC voltmeter will do—need not be VTVM; this is a low impedance circuit) is connected across the voice coil and a tone injected at the first grid, either from a phono test record or an audio generator. The potentiometer is va-

# of FM-AM Combinations

and Performance of Any Amplifier

ried to reduce the resistance between the cathode and the secondary of the transformer to as small a value as is possible without setting up oscillation, and without reducing the gain of the amplifier too much. When the proper setting has been found the resistance of the pot is measured and a fixed resistor is soldered in place. Care must be taken before settling definitely on a value for the feedback resistor that there is enough gain left for proper maximum output from the amplifier with the usual program materials, both radio and phonograph.

Alternate Feedback Method

Another method, safer where any but the very highest quality output transformer is employed, takes the feedback voltage off one of the push-pull output plates. In this case again, the feedback voltage is taken back to the un-bypassed cathode of the nearest (to the inverter) single-ended voltage amplifier stage. The pot used here should be larger, since the source of feedback voltage is much greater. Also, a blocking condenser of .1 to .5, 600 V. should be placed between the resistor and the plate.

Oscillation will be shown by any sudden large increase in the output at the secondary terminals. If the circuit oscillates at almost all settings with no signal going in at the input either the primary or the secondary connections must be reversed. This will reverse the phase of the feedback. (Or use plate of other p.p. tube.)

Power Supply Changes

A more serious defect in some power output stages is the limitation placed on the low frequency output by an inadequate power supply. If this is due to a power transformer having insufficient voltage output, one having proper power and voltage rating may be put in. Such a deficiency may readily be determined by comparing the screen, cathode and plate voltages with the values shown in the tube manual.

If the filter of the power supply uses one or two heavy resistors instead of chokes, the regulation and the efficiency of the power supply can be increased by substituting one or two iron core chokes for the resistors. This is a good modification if the applied voltage to the output tubes is not raised too much thereby. Most of the time this will not happen and the change can be made safely, but

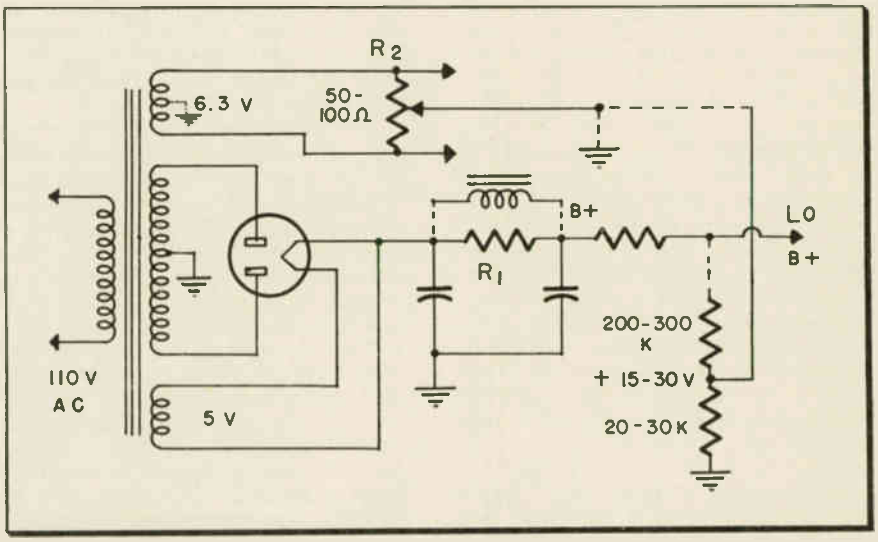


Fig. 2. Dotted lines show various methods for reducing hum due to design (not for hum due to component failures). 15-30 V may be applied to 6.3 winding centertap.

check the tube manual to be sure, before making the change. In raising the voltages applied to the screen and plate, be particularly careful to keep the screen voltages no higher than specified.

Another even easier way of getting a little better efficiency, cooler running, and more current out of the transformer without lowering the voltage output is to substitute a rectifier which draws less current for its heater supply. Where 5U4s have been used, usually a 5V4 will help. (This method should not be employed in the power supply section of television or other receivers, where the current drain on the original 5U4 approaches its nominal limit of 225 ma. The 5V4, being rated at 175 ma, is more than adequate for most audio amplifiers, but will become low on emission if made to supply most TV sets.)

Also, the slow heating properties of the 5V4 (and 5T4—a higher current-output tube) allow the other tubes in the set to warm up first, and thus keep from possibly straining the filter condensers. Furthermore, the 5V4 and 5T4 have lower internal impedance. Usually, simply plugging one in in place of the 5U4 will give from 5 to 15 volts more on the plates of the output tubes simply because of the lower voltage drop across the rectifier. This is a very easy and frequently effective way of getting a little better operation (check that tube manual) from the output stage.

Many economically designed combinations have condensers running from the plates of voltage or power amplifier stages to reduce oscillations which would otherwise be encountered. And it is frequently found that there are condensers or R-C combinations off the output tube plates. These measures are taken to reduce the operation of the amplifier at the extreme higher frequencies which can often result in distortion or singing. When a new output transformer has been installed all such counter measures should be removed.

P. P. Output	Load (ohms)	Approx. Cost Medium Grade (20-25 watt)	Approx. Cost Top Grade Transformer
6L6	6,600	6.00	17.00
2A3, 6B4 / 6A5, etc.	3,000 / 5,000	8.00	18.00
6V6	8,000	5.00	16.00
6K6	12,000	5.00	16.00
6F6	10,000	5.00	16.00

FM Sound

The most commonly employed method for 60 cycle hum is the use of a wire-wound pot across the heater winding of the power transformer and the adjustment of the center tap connection to ground for minimum hum level. See fig. 2. This is usually effective, but in high-gain preamplifiers additional steps may be called for. Instead of grounding the adjustable tap of the 50 or 100 ohm pot, it may be connected to a point of 15 to 25 volts positive. This potential is easily obtained by bridging two ¼ or ½ watt resistors across the B supply. Typical values are 20 to 30 K and 200 to 300 K. Fig. 3 shows this connection clearly. The placing of a positive voltage on the heaters ensures that there will be no heater to cathode emission. Since the heater is made positive in relation to the cathode, current can flow, if at all, only *from* the cathode.

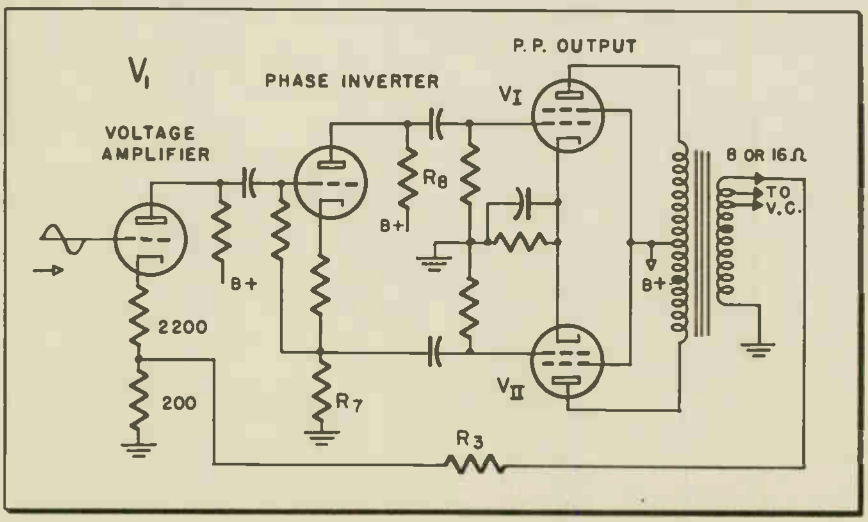
To determine if there is a significant amount of unbalance in the output of a set, all that is needed is a pair of headphones (or an extra loudspeaker coupled to an extra output transformer) and a source of audio tone, either phono frequency record or generator. Bridge the phones (or primary of extra output) across a 1 K, 20 w. resistor connected from the center tap of the receiver output transformer and B plus and feed a tone intot he receiver. If the circuit is unbalanced *some* sound will be produced in the phones or test speaker. The size of the resistors governing the amount of signal fed into the phase inverter tube are then adjusted to produce *no signal* in the test phones or test speaker. In Fig. 1, R_7 or R_8 would be the resistor to be adjusted. In fig. 3, R_2 would be the proper one.

Improper methods of phase inversion to obtain driving voltages for the two output tubes cannot be allowed in a good amplifier section. It is assumed that there will be no trick phase inverter circuits left in. One which was employed not long ago in a commercial combination took the driving signal for the grid of output tube No. 2 directly off the cathode of tube No. 1. Another method, not nearly so bad, but still not satisfactory, is to take the grid No. 2 signal from the unbypassed screen dropping resistor of output tube No. 1.

The best amplifiers today employ the *split load* (also known as *cathodyne,*) phase inverter, shown in fig. 1. Entirely acceptable results have been obtained with the *self-balancing or floating paraphase* inverters also. All other phase inverters should be viewed with suspicion if the audio quality is unsatisfactory.

The conventional phase inverter most often commercially-used in the past has closely resembled the self-balancing inverter. But in the self-balancing type the grid of the driver for V2 was grounded through the same resistor as the driver for V1. In either the conventional type which has the grids grounded separately, or the self-balancing type, the first triode section is the stage which should employ the un-bypassed cathode for application of the inverse feedback. It is highly desirable to apply this feedback voltage back over as few stages (and consequently over as few coupling capacitors) as possible. The cathode most nearly immediately before phase inversion takes place is therefore the cathode to be used. Particularly where the cathode has been grounded and grid-leak bias employed in the voltage amplifier, the cathode should have cathode bias applied, and a suitable (consult the resistance-coupled amplifier tables in tube manual) smaller grid return inserted.

Fig. 1. Split load phase inverter shown is widely used in high-quality audio amplifiers. Simple to install, inherently balanced for all but extreme high frequencies. Feedback is applied through R_3 to V_1.



Since most big sets today use octal or loctal tubes, usually one of the present tubes can be removed and a twin triode installed and wired in place. The phase inverter will become the stage immediately preceding the output grids, and the cathode of the triode preceding it should be left unbypassed so that the feedback may be conveniently applied here.

If the phase inversion in the original circuit is acceptable but there is insufficient gain for the application of feedback, the gain of one of the voltage amplifier stages may be increased by increasing the size of the load resistors. (In general the plate loads should not be made larger than 500,000 ohms.)* Or a twin triode may be installed for the purpose of adding one more stage of amplification.

Tube Choice for Extra Stage

In choosing a twin triode for either of the above applications the 6SL7 (or 7F7 for loctal) is the best choice. Not only does it draw less plate current (typically 3 ma. per plate) instead of about 10 ma. per plate, but it requires less heater current (.3 amp.) than the 6SN7(7N7) (.6). Also, it has a much higher amplification factor—70, instead of 20. The 6SC7 would be acceptable but for the fact that it has a common cathode.

If the phase inverter is of the type shown in figure 3, referred to here as the "conventional" type (because until recently it was widely used), it may be operating unbalanced due to unequal aging of the load resistors or tubes. *If* the circuit had been carefully balanced when constructed and did not change due to aging, this circuit would allow excellent push-pull driving. But this sort of balancing is not practical in production, due to assembly-line tube and resistor variations. Improvement in this circuit can be made by converting it to the "self-balancing," or "floating paraphase" type. This conversion is simple, involving only one change in the circuit diagram. In figure 3, the ground return of resistor R_3 is lifted, and the grid resistor is returned to the junction of R_2 and R_1, which is marked point X in the diagram. In the circuit of Figure 1, the cathode of V_1 would be the proper one to receive the feedback voltage. (In Figure 3, the cathode of the voltage amplifier.)

Today the best sets have both treble and bass tone controls. They must be capable not only of *cutting* the amount of treble or bass, but of *boosting* the bass or high tones, separately. If the receiver being modernized or improved is not equipped with good tone controls, they may be added by inserting the network of Fig. 2, (A) in front of the last voltage amplifier before the phase inverter. Such a tone control network will introduce about 15 to 20 db loss of gain in the set, so an additional triode stage must be added to compensate for the loss.

Placement of Stage

The extra stage should be placed before the tone controls if possible, so that any possible hum pickup by the components being added for the tone controls will be amplified as little as possible. This tone control network is extremely flexible, and will give about 15 or more db of either bass or treble boost or cut (settings of each control are entirely independent). It may be installed in extremely small space, with the two potentiometers mounted on the control panel—one in place of the old type treble cut knob — and the additional resistors and condensers mounted off the lugs of the pots. One precaution to take is to see that the ground returns in this network are all made to points isolated from chassis, connected with a piece of bus wire, and this run to the ground return of the grid and cathode for the stage they are feeding into.

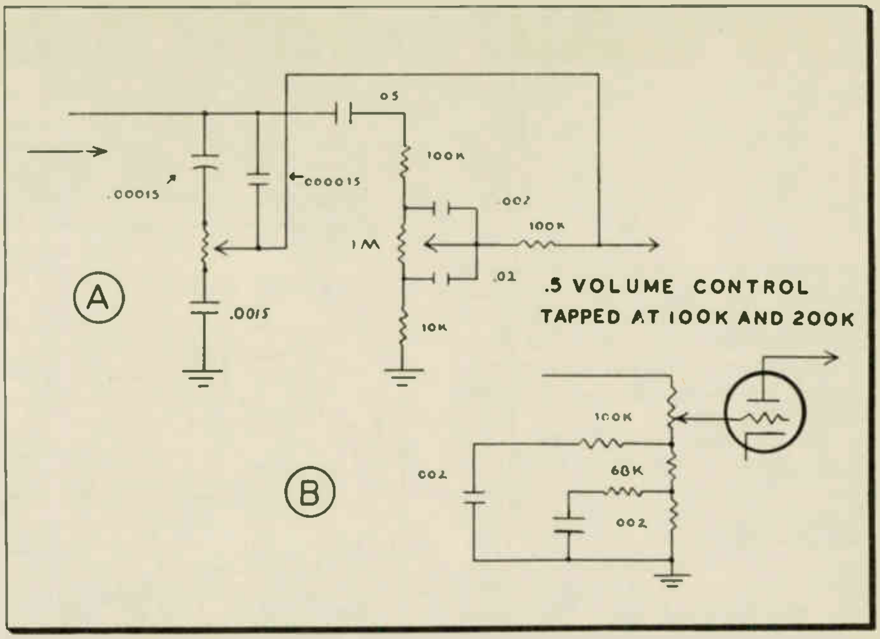


Fig. 2. (A) Independent bass and treble cut or boost controls. Both pots are 1 M, flat taper. (B) "Loudness" control which boosts bass smoothly as volume is decreased. (Circuits engineered by Howard T. Sterling.

In many large sets the tone is pleasing to the customer only when the volume is at fairly high levels. If this is because there seems to be a deficiency of bass at the low settings of the volume control, a so-called "loudness" control may be added to the combination, in place of the original volume control. The loudness control works on the principle that the human ear hears less and less of the low notes as the volume is lowered. Consequently the loudness control is designed to give more and more bass boost as the volume is lowered, to keep the *apparent* balance between bass and treble constant at all volume levels.

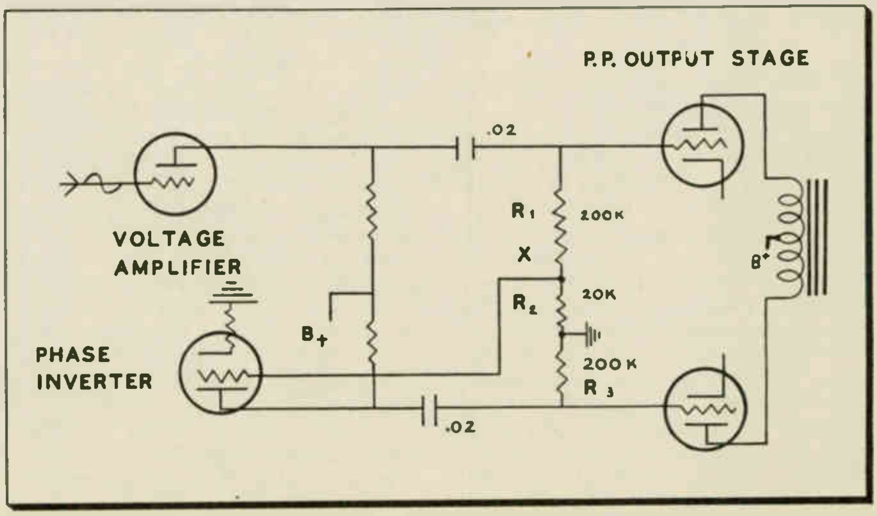
Some of the better big combinations have had tapped volume controls built in for years. But usually they had only one tap, and so only did the job partly. The most expensive loudness controls have twenty-three taps. But it has been found that very smooth action and bass compensation can be had from the proper use of a 500 K potentiometer with only two taps. The diagram in Fig. 1 (B) shows the schematic for this control. The parts may be mounted right on the pot, and inserted on the control panel or chassis in place of the original volume control.

Many of the earlier FM receivers employed 6C4 tubes, particularly as local RF oscillators. These were later found to have considerable drift, and frequently became microphonic. So if an FM set has a 6C4, and is giving trouble, try replacing the 6C4 tube. A new 6C4 will usually only clear up the trouble temporarily. Therefore the 9001 or the 6AB4 should be used. Except for pin 5 connection, which is made internally in the 6C4, but not in the other two tubes, the pin connections are the same. Be certain to use a jumper from pin 1 to 5 if the plate connections under the socket are going only to 5.

In addition to the electronic improvements which can be made in improving the sound of FM sets or FM-AM combinations, the possibilities of the electro-acoustic improvements are great. There is not space here to consider in detail the characteristics of the loudspeakers usually employed in the medium range sets. It may be noted though, that the addition of a medium-price extended-range speaker costing from 12-17 dollars will considerably improve the range of a set, once it has been cleaned up *electronically*. It goes almost without saying, of course, that substitution of a good low-frequency speaker will help any set. Among the physical characteristics to look for are a large magnet, and a big voice coil (2 to 4 inches; the bigger the better.) Stick to reputable makes. "Bargains" are never cheap in speakers.

**It is inherent in the theory of the split-load inverter that its gain to either side of its load cannot exceed unity, so attempts to increase output by altering its circuit will not succeed.*

Fig. 3. Conventional phase inverter frequently employed until recently. Circuit has high gain; is easily unbalanced. Simple change can improve balance considerably.



Automatic Gain Control

Need for AGC; How the Basic

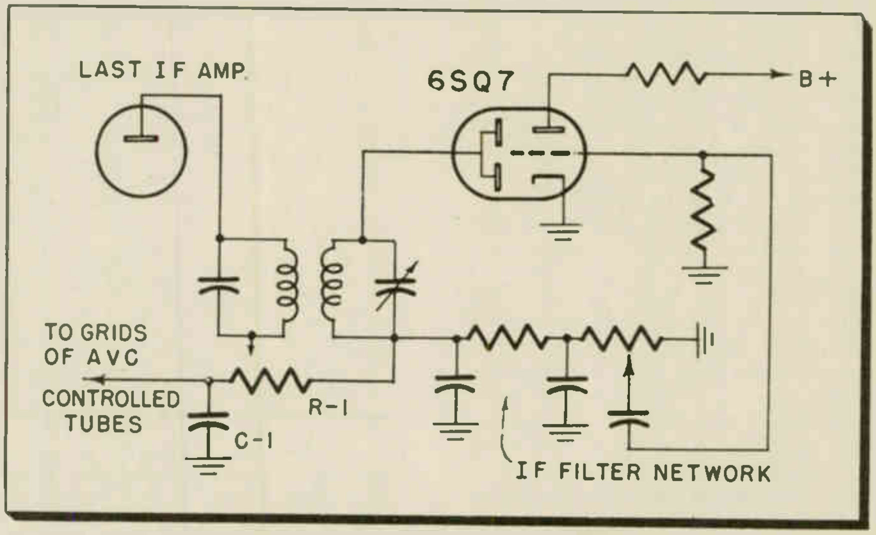


Fig. 2—Typical AVC circuit used in broadcast AM receivers.

The automatic gain control circuits in the television receiver keep the output of the video detector as nearly constant as possible. To better appreciate their contribution to optimum set performance, let's consider what might happen if they were absent.

In the first place, when the set viewer switched from a weak station to a strong one, an excessively contrasty picture might result. Worse, the picture might jump, roll, or tear out horizontally, due to overloading of sync stages. Still worse, the picture might suffer a complete loss of synchronization. Such an impairment of sync might be due to a loss of the sync pulses in an overloaded IF amplifier (see fig. 1).

If the set viewer had switched from a strong station to a weak one, the received picture might show inadequate contrast. Some loss in synchronization due to the inadequate size of the incoming sync pulses might also manifest itself.

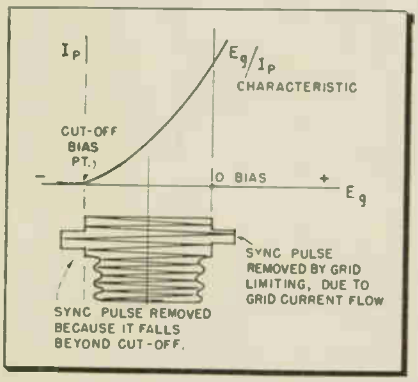


Fig. 1—A large-amplitude IF signal may force the grid bias to swing beyond 0 volts, into the positive region, on positive peaks of the signal, and to exceed cut-off, on negative signal peaks. This condition is most apt to occur in the last video IF amplifier, where the IF signal level is highest. A sharp cut-off tube is assumed.

In either case, resetting of the contrast control would be necessitated—an extra chore that would scarcely draw sighs of pleasure from tired set owners.

By keeping the video detector output substantially constant in spite of large variations in the amplitudes of incoming signals, the need for resetting the contrast control when channels are switched is minimized. Even when the incoming signal increases by a factor of 100, the video detector output will be no more than doubled, in the usual AGC-controlled receiver. When the changes in the strength of the incoming signal are moderate, the output of the video detector will remain substantially constant.

Other undesirable conditions that are avoided by the use of AGC include those due to: 1—changes in signal strength caused by fading 2—changes in the gain of various amplifiers produced by slow variations in supply voltages and 3—changes in the strength of incoming signals because of signal reflections from moving conductors, such as airplanes.

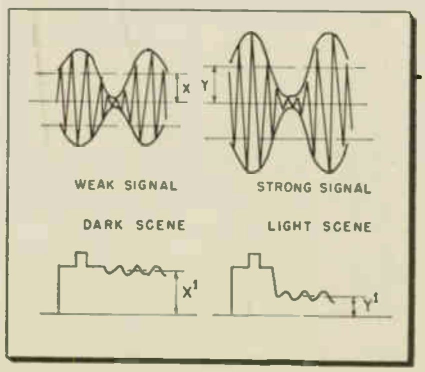
AGC systems may be divided into three basic categories: simple AGC, delayed AGC and keyed AGC. Before we tackle the simple AGC system, a review of AVC action in broadcast AM receivers may prove helpful, because there are several points of similarity between AGC and AVC.

AVC, or automatic volume control, is, as we know, a means of keeping the sound volume constant, in spite of fluctuations in the strength of the incoming RF carrier. A typical AVC circuit is shown in fig. 2. The detector develops a negative DC voltage across R-1 that is proportional to the strength of the incoming signal. This negative voltage is fed back to controlled RF and/or IF stages as a bias. When the carrier tends to increase in strength, a larger voltage is developed across R-1, causing the AVC bias to increase, and the gain of the AVC-controlled stages to decrease proportionately. The signal output of the detector thus remains substantially the same. Similarly, when the incoming RF signal tends to *decrease*, the lowered voltage developed across R-1 causes a lower AVC bias to be fed back to the controlled stages, increasing their amplification. The signal output of the detector again remains substantially constant as a result.

The rate of change of the AVC voltage is determined by R-1 and C-1. The time constant of these components determines how fast the AVC action will be. If the time constant is too long (R-1 or C-1 is too large) the AVC bias may not change as rapidly as fluctuations in the strength of the incoming signal, and proper correction will not be maintained.

If the time constant is too small (R-1 or C-1 is too low in value), C-1 will be appreciably charged by low audic frequencies—i.e., low audio frequencies will develop a voltage across C-1, instead of being filtered out. The AVC bias will, in such a case, fluctuate at an audio rate. A feedback of audio signals among different stages to which C-1 is common may now occur, and degeneration or oscillation is apt to result, depending on the phase of the different signal currents that pass through, and develop voltages across, C-1.

Fig. 3 (top)—The DC bias developed by an AVC circuit is proportional to the average amplitude of the incoming carrier. The average amplitude of the strong carrier, or amplitude Y, is greater than average amplitude X of the weaker signal. Fig. 5 (bottom)—The average level of the TV picture carrier depends on the brightness of the transmitted scene. X_1 is the average amplitude of the video signal carrier between sync pulses in a dark scene; Y_1 is the average amplitude in a light scene.



Circuits in TV Sets

Control System Works; Typical Circuits

Note that the AVC circuit, under normal operating conditions, develops a voltage that is proportional to the average amplitude of the carrier (see fig. 3).

Now, an AGC circuit (fig. 4) must, like an AVC circuit, develop a bias proportional to the strength of the incoming signal. A rectifier is employed that changes the applied IF signal into a pulsating DC voltage proportional to the strength of the incoming signal. The pulsating or video-signal component of this voltage is filtered by R-1 and C-1, and a pure DC voltage is fed back to the controlled stages.

The AGC circuit, unlike the AVC circuit, cannot use the average amplitude of the carrier as a base or reference level. This is true for the following reason: While the average amplitude of the sound carrier in the case of broadcast band signals remains substantially constant if the station is not changed, and fading is not present, *the average amplitude of the TV picture carrier does not.*

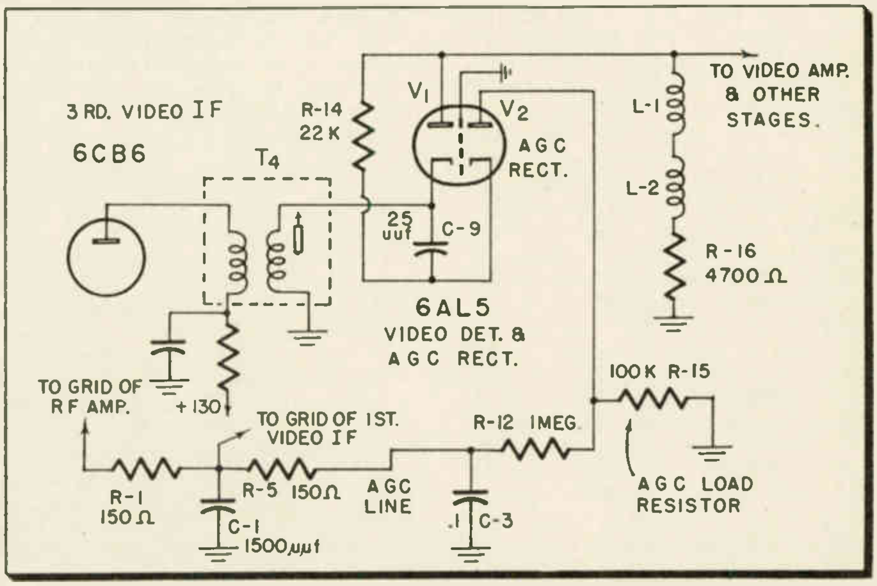


Fig. 6—Commercial form of simple AGC circuit using separate tube for AGC rectifier. Circuit is used in Emerson, Models 662B and 663B. R12 and C3 form the AGC time constant or filter network. R5, C1 and R1 are additional units, used to remove video signals from the AGC voltage.

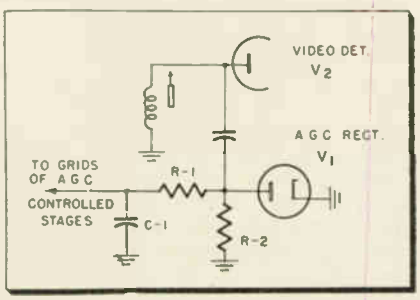


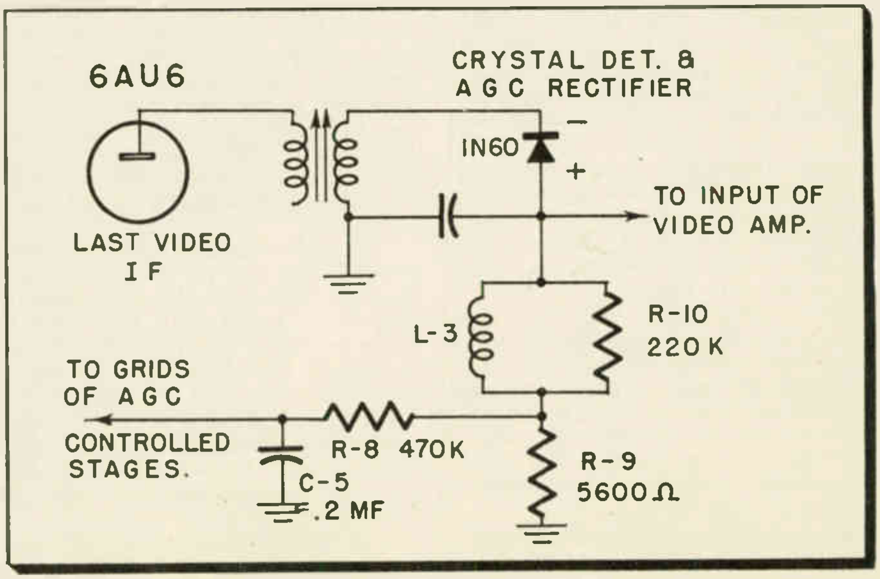
Fig. 4—Simple TV AGC circuit.

This is so because the average amplitude of the TV picture carrier varies with the average brightness of the scene being telecast. The brighter the scene, the lower the average amplitude of the carrier and vice versa (fig. 5). If the AGC system developed and fed back a DC voltage proportional to the average amplitude of the carrier, whenever an increase in brightness caused the carrier average amplitude to decrease, the reduced AGC bias fed back to the controlled stages would increase the amplification of these stages, increasing their output, and bucking the tendency of the carrier to decrease. Similarly, when the average amplitude of the carrier tended to increase, the AGC system would counteract the tendency. The picture's illumination would be incorrectly rendered in consequence.

To avoid such an undesirable condition, the DC voltage output of the AGC rectifier is based on the sync and blanking pulse levels. Since these levels are always of the same amplitude regardless of the brightness of the scene (provided that no fading is present, and the station setting is not changed), the AGC bias developed will be proportional to the incoming signal strength, but will not adversely affect the picture brightness.

Let's see how the simple AGC circuit shown in fig. 4 works. The video IF signal is applied between plate and cathode of the AGC rectifier V-1 and causes current to flow during the positive peaks of the incoming signal. A rectifier voltage is consequently developed across R-2. This voltage is proportional to the strength of the incoming signal, as represented by its sync and blanking levels. If the incoming signal tends to fade, or fall in amplitude, the input to V-1 decreases, and the DC voltage across R-2 falls, reducing the bias of the AGC-controlled stages, and thus raising the input to the video detector to its former level—or rather, preventing the input to the video detector from dropping below its former level. Similar bucking changes oppose any tendency of the signal to momentarily rise in amplitude.

Fig. 7—Circuit used in Bendix TV, Models 2051, 3051, 6001, 6003, and 6100. A 1N60 crystal is employed as a common video detector and AGC rectifier. The + and — signs beside the crystal indicate the cathode (—) and the plate (+) sides of the crystal, not the polarities of the voltages developed by the circuit action.



When the first positive-going signal is applied to V-1's input, V-1's plate becomes positive to its cathode, and the tube conducts. C-1 acquires a charge at this time through R-1. When the incoming signal decreases to the point where V-1's plate is no longer positive to its cathode, the tube stops conducting, and C-1's charge leaks off through R-1 and R-2, developing a negative voltage across these resistors.

After several cycles, the charge acquired during V-1's conduction and the charge lost during V-1's non-conduction become equal, and conditions stabilize. The negative voltage across R-2 has, at this time, become large enough to prevent conduction at any time except the peaks of the incoming signals—i.e., the sync pulses.

The charge built up across C-1 by V-1's conduction is approximately equal to the peak amplitude of the sync pulses. Due to the long time constant of C-1 and R-1 (more precisely, R-1 in series with R-2), compared to the interval between horizontal sync pulses, C-1 does not have enough time to lose much of its charge before the next pulse comes along and replenishes it.

In between horizontal sync pulses, therefore, C-1's charge will not change appreciably. Although video signals are present at the input to the AGC rectifier at this time, they will not appear at the rectifier's output, because the long time-constant of R-1 and C-1 does not permit the output voltage to change at a video rate.

In this way, video signals are filtered out, and the horizontal sync pulse level determines the AGC bias (since AGC condenser C-1 charges up to practically the level of the horizontal sync pulses).

The time constant of R-1 and C-1 is an important feature of the circuit. If this time constant is too short, C-1 will charge up more, since a shorter time constant for a condenser means a faster charging rate, and a larger amplitude of charge acquired in a given interval of time. Now, under normal conditions, when vertical sync pulses are present at the input to the AGC rectifier, C-1's charge will increase from about 75% of the peak amplitude of the input signal, to 88%, approximately, since these pulses have a large amplitude and a long duration. This is an undesirable condition, because it means that the AGC bias will increase when the vertical sync pulses are coming in, reducing the gain of the AGC-controlled stages at this time. The reduction in gain will persist even when the vertical sync pulses are no longer present, because the charge built up across C-1 cannot leak off instantly. The background shading of the picture will be incorrectly rendered as a result of this condition. The resultant distortion is not too noticeable ordinarily, but if the C-1, R-1 time constant decreases considerably, distortion will be apparent.

• The first problem that presents itself with respect to the servicing of a simple AGC circuit is: when to look for trouble in this circuit. If a single diode or crystal is employed as a common video detector and AGC rectifier (see fig. 1), many faults will affect both circuits seriously. When the picture is missing or weak, and other sections of the receiver have been eliminated as possible sources of the trouble, the serviceman will check the video detector, without necessarily thinking of it as an AGC rectifier. When a fault that primarily affects the AGC action, without markedly affecting the video detector's operation occurs, however, a test of the AGC operation is called for.

Only a few such faults suggest themselves in the case of the circuit shown in fig. 1. Changes in the time constant of R-115 and C-110 may be cited as possible defects. If the time constant of this network increases considerably (due to an increase in R-115's value), the ability of the AGC system to counteract changes in the strength of the incoming signal as fast as they occur will be impaired. When channels are switched, in the event of such a fault, improper contrast and/or loss of sync may be noted for a short interval, before the AGC regulation takes hold. Momentary fading that was previously inhibited, may now play tag with the picture from time to time, affecting its contrast and synchronization.

If R-115 or C-110 loses value, reducing the time constant of the network considerably, vertical synchronization and picture shading will tend to be impaired. Let's consider what happens in such a case.

Short Time Constant

The normal time constant of a simple, unsophisticated AGC circuit is around a few tenths of a second. If the time constant is reduced to 1/30 of a second or less, symptoms will probably be noted. C-110 charges faster when its time constant is shorter, and a larger voltage develops across it, particularly when the large-amplitude, long-duration vertical sync pulses are coming in. The AGC bias therefore increases, and the output of the AGC-controlled stages decreases, during vertical sync pulse time. The size of these pulses is therefore reduced with respect to the rest of the composite video signal, reducing the sync pulse input to the vertical oscillator and thus affecting the vertical holding action.

The AGC voltage will, in the case considered, no longer be a relatively pure DC voltage (who is absolutely pure these days?) but will contain a 60-cycle vertical sync pulse ripple in it. This ripple is fed back to the controlled stages, and will tend to modulate the video signal passing through these stages. An undesired low-frequency signal variation that manifest itself in the picture as incorrect background shading may result.

If R-115 decreases to a very low value, C-110 will shunt most of the video information from R-115, weakening or eliminating the picture. The effect on AGC will be as noticeable, in such a case, as a pimple on a broken arm; the serviceman would, of course, be sending out search parties for the lost video, not the missing AGC.

If C-110 decreases very considerably, its filtering action may be reduced to such a point that feedback occurs in the controlled stages, due to the inability of the decoupling networks to remove the excessive ripple that now appears in the AGC line. The result may be oscillation, if the feedback is regenerative in nature; or degeneration (loss of gain), if the feedback is degenerative. Oscillation will tend to manifest itself on the CRT screen as an interference pattern.

Similar results are possible but not likely if one of the decoupling condensers loses considerable capacitance. A far more probable effect of such a loss in capacitance is a loss in set sensitivity. This is to be expected because the decoupling condensers return the tuned grid circuits of the controlled stages to ground. If one of them loses considerable capacitance, or open-circuits—let's say C-101 does so—much more of the grid signal current will have to flow through a decoupling resistor—in the case just assumed, through R-103, then to C-103 to ground. The Q of the tuned circuit affected will therefore be lowered, and reduced set sensitivity, possibly even misalignment, may result.

If the faulty decoupling condenser is in the RF amplifier circuit, more noise can be expected, because a reduction in the Q of the tuned circuit at the RF amplifier grid will reduce the signal-noise ratio, and make noise (snow effect) more prominent on the CRT screen.

If R-115 open-circuited, or C-110 short-circuited, no AGC voltage would be transferred to the controlled stages. Not only would improper contrast and impairment of sync tend to occur when channels were switched; overloading of a controlled—perhaps we should say *decontrolled*—stage might now take place, due to its inadequate bias. Such overloading might manifest itself in the picture as smearing; or it might cause black noise dots in the picture to be followed by white streamers, making the noise effects more conspicuous. In some cases, one or two ambitious amplifiers might be driven into oscillation when strong signals were coming in, possibly producing negative pictures and various unpredictable symptoms.

Open-circuits in decoupling resistors (such as R-103, R-106) and short-circuits in decoupling condensers (such as C-101, C-103) would also remove the AGC bias from the grids of controlled stages, tending to produce the same symptoms.

If any such symptoms are present, and other sections of the receiver seem to have clean bills of health, the AGC circuit action should be checked.

To test the operation of the AGC sys-

in Simple AGC Circuits.

tem, the AGC voltage present across C-110 should be measured, and compared with the corresponding DC voltage cited in the set manufacturer's notes. The conditions under which the voltage is measured should be in accordance with those specified in the manufacturer's notes.

If this data is unavailable, an identical or similar receiver, in good working order, may be used as a reference or standard of comparison. The AGC voltage may be measured in this normal set with a) the antenna connected b) the antenna disconnected, and the antenna input shorted c) the antenna disconnected, and a signal generator attached to the antenna input terminals. The generator is set at some frequency within the range of the channel to which the front end is set, and its output is reduced to a relatively low level for his check.

The receiver under test is then checked under identical conditions, and the voltages obtained compared with those read on the good set.

When the presence of trouble in the AGC circuit is indicated by such checks, conventional DC voltage, resistance and condenser bridging tests should quickly locate the defective unit. It should be noted, incidentally, that improper operation of a stage preceding the AGC rectifier will cause improper AGC voltage readings to be obtained. This is true in all AGC circuits, not merely the one shown in fig. 1.

Testing With a Scope

When a loss in capacitance or open-circuit in the AGC filter condenser (C-110) is suspected, a scope may be used to verify if this is the case. The scope should be set to a low frequency (60-100 cycles), its vertical gain control turned all the way up, and its hot lead attached to the hot side of C-110 (scope ground lead goes to chassis, of course). Normally, very little or no AC voltage should be seen at this point. Just how little is to be expected, can be determined by testing across the AGC condenser of a receiver known to be working properly. If C-110 has lost a good deal of its capacitance, however, its bypassing of video and vertical sync signals will be impaired, and vertical sync pulses may be seen in appreciable amplitude across it.

Suggested DC voltage test points are A, B, C, D, and E. The absence of voltage at any of these points can be readily interpreted. If the AGC voltage, for instance, is present at point C, but not at point D, an open in R-103 or a short in C-101 is indicated.

In the circuit shown in fig. 2, the AGC rectifier is separate from the video detector, and has its own place of business, so to speak. A portion of the IF signal voltage coming from the 4th video IF amplifier and developed across L-102 is fed between cathode and ground of the video detector, detected,

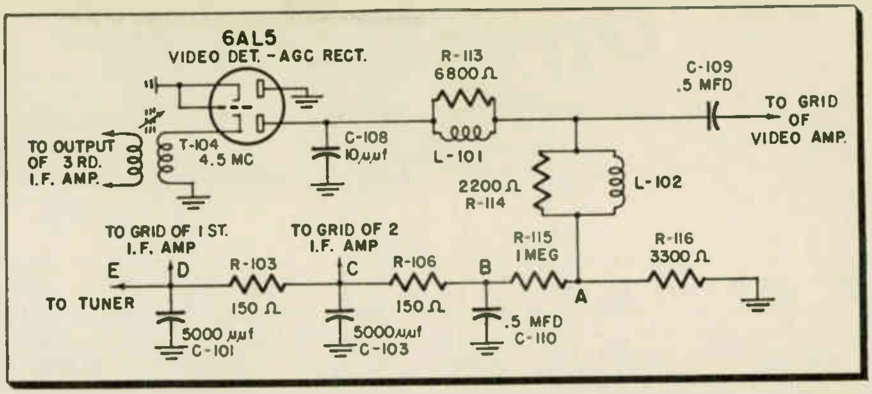


Fig. 1—Simple AGC circuit, in which video detection and AGC rectification are performed by the same diode. Elements of the unused diode are grounded out. The circuit shown is from the schematic of Hallicrafters Models 810A, 815, 822, 870, 871 and 880.

and transferred to the input of the video amplifier. The entire IF signal voltage across L-102 is injected via C-125 between plate and cathode of the AGC rectifier.

R-124 and C-128 form the basic AGC time-constant network. A switch providing for modification of the time constant of this network is incorporated. R-123, R-209, C-127 and C-187 are decoupling units.

The correct setting of this switch is generally made at the time of the receiver's installation. When the set is located in a strong signal area, the three-position switch is placed in position 1, its extreme counter-clockwise setting. The time constant network is now made up only of R-124 and C-128.

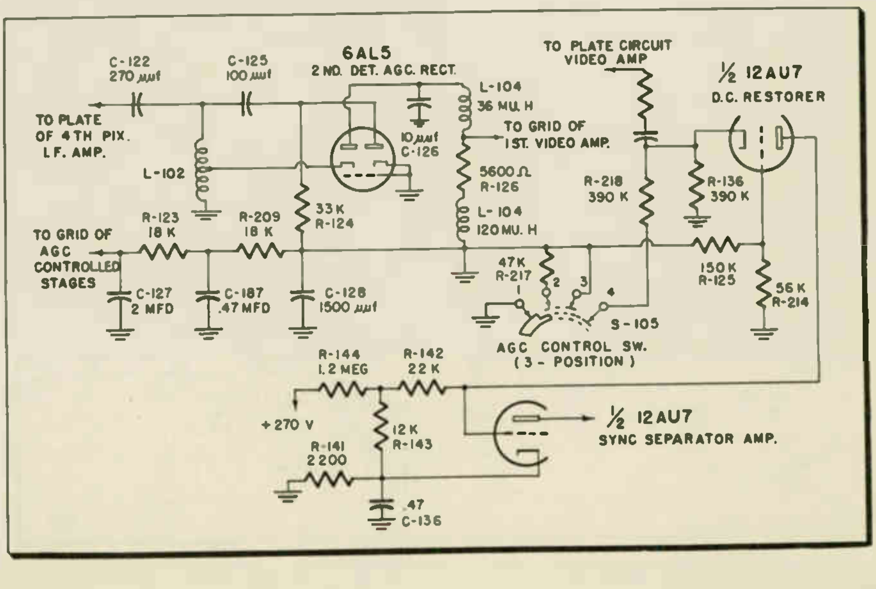
When noise external to the receiver is great enough to interfere with reception, the switch is set to position 2, or its center setting. In this position R-127 shunts series-connected resistors R-125 and R-214, reducing the resistance in the discharge path of C-128. Noise pulses that tend to charge up C-128 will now discharge faster, reducing the false or undesired AGC bias they tend to introduce. This undesired contribution to the AGC voltage lowers the signal gain at a time when optimum signal gain is very much needed.

In position 3—the last position—C-128 is shorted out, and the AGC bias is completely removed. This setting is intended for use when weak signals are being received, and maximum amplification is desired. The receiver will overload if signals in excess of 200 microvolts are received. For signals under 200 microvolts, the set's sensitivity will be optimum, and the sync pulses delivered to the sync stages will be best able to maintain synchronization in the presence of noise.

When the switch is in position 3, contact 4 connects to 1, returning the bottom of R-218 to ground, and shunting R-136 with a resistor of equal value. The signal input to the DC restorer is lowered as a result. Such a lowering of the input to the restorer is necessary because the AGC bias also serves as bias for the triode restorer, and when this bias is removed, the restorer output will tend to become too large. That is, its plate current will increase, and since this current flows through R-142, the grid resistor of the sync separator, and helps determine the latter's bias, the

(*Continued on page* 42)

Fig. 2—AGC circuit used in RCA Models 2T51, 2T60, chassis numbers KCS45 or KCS45A. Only a part of the DC restorer circuit is shown. Separate diode sections of a duodiode tube are used for video detection and AGC rectification.



"Direct Drive" System for

Greater Efficiency Attained with Simpler Circuitry and Components

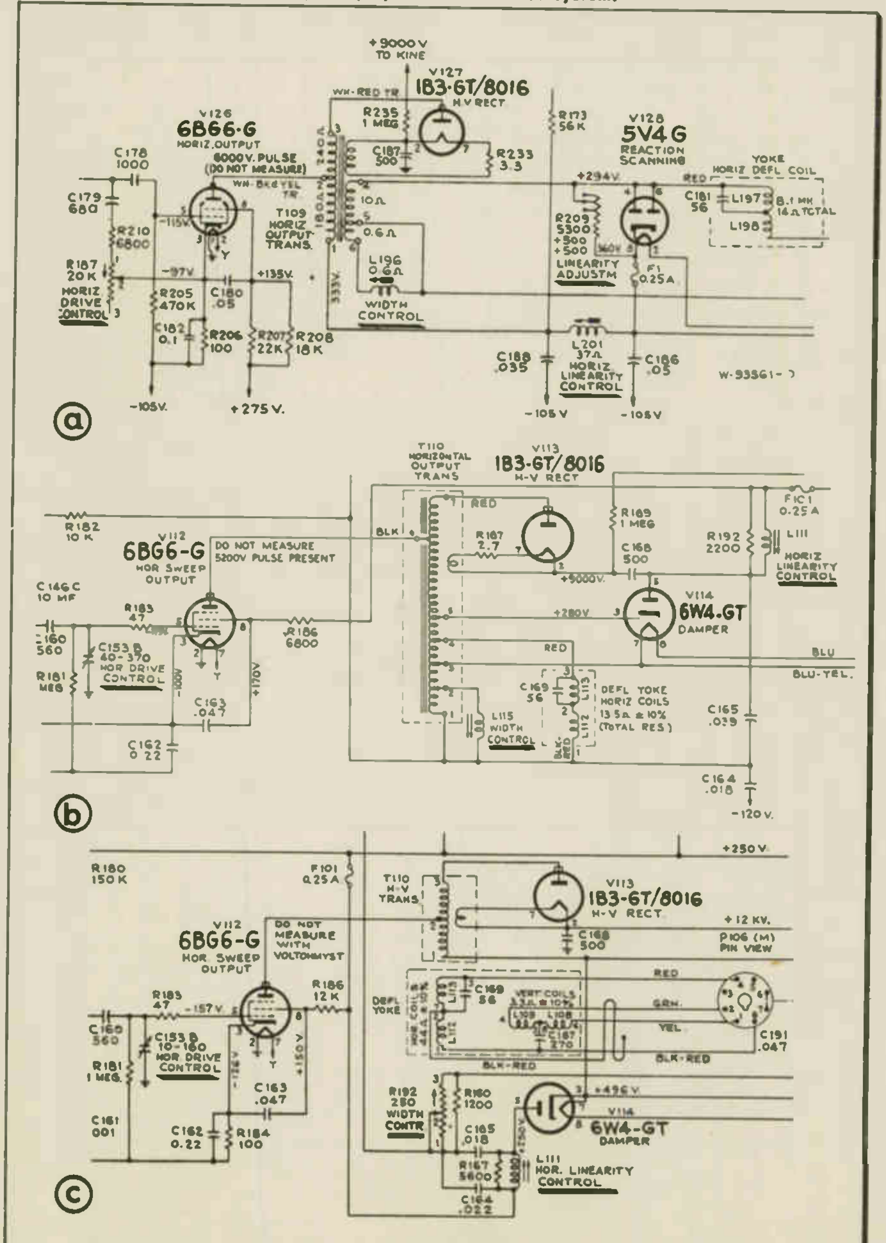
by E. A. Campbell, Technical Editor

• Among the features of the original 630 circuit which have become "classic" to the TV technician is the horizontal deflection-output-high voltage system utilizing the "flyback transformer." For the 9.5 KV-50 degree deflection as needed with the 10BP4, this was a very efficient and ingenious system. But as tubes got larger, and deflection angles increased to 67 degrees and more, the requirements of high voltage and deflection power surpassed the limits of that system.

Voltage doubling with two 8016's was employed to get higher voltages, and paralleling 6BG6's was at times used to increase the drive, but these methods were obviously in the direction of increased cost, and in the latter instance an increased drain on the B supply.

Faced with the paradoxical problems of getting almost twice the deflection power (for 70 degree tubes, as compared with 50 degree deflection) and at the same time meeting the demand for lower priced receivers, the industry came up with ceramic core output transformers and yokes and new output tubes such as the 6AV5 and 6CD6 which would supply more current to the system without additional drain on the B supply.

Fig. 1—Horizontal deflection circuits showing transition from multi-winding output transformers to autotransformer type employed in direct drive system.



The ceramic core material is characterized by almost ten times the permeability found in powdered iron cores used previously, permitting higher voltages to be developed with equivalent amounts of driving current.

The most recent development toward the improvement of efficiency in the horizontal deflection and high voltage system without increasing costs is the "Direct Drive" system introduced in RCA receivers in 1950.

This system dispenses with the output transformer, which was essentially an impedance matching device similar to the audio output transformer, and connects a relatively high impedance yoke directly into the plate circuit of the output tube. This is a logical step, since it to a large degree saves the energy which would otherwise be lost in a transformer due to leakage, heat, etc.

Like Conventional System

Operation of the system is similar in many ways to the conventional systems. The transition from the 630 to the autotransformer type to the direct drive system is shown in figures 1a, 1b and 1c. Briefly reviewing the earlier circuit, we recall that the output tube is driven by the oscillator with a waveform suitable to produce a sawtooth of current in the yoke. The output tube is essentially conducting in brief pulses at a repetition rate of 15,750 cps. When the output tube is cut off by virtue of its grid being driven negative, the magnetic field induced in the yoke by the previous pulse tends to collapse rapidly, generating a back EMF which is high due to the relatively high resonant frequency (71KC—see explanation below). This high voltage was stepped up in going from the secondary to the primary of T109, and is further stepped up by autotransformer action in the primary, placing a positive voltage in the neighborhood of 10KV on the high voltage rectifier.

In the 9T246 circuit (b) shown, an autotransformer is used instead of the conventional output transformer with primary and secondary, but the principle of creating and stepping up the high voltage is essentially the

TV Horizontal Deflection

same. In the T164 circuit (c,) the output transformer section has been dispensed with, and we have only a high voltage transformer (operating still on the same general principle). The yoke (plus this high voltage winding) is the load for the output tube. The increased efficiency of high voltage formers using ceramic core material, as mentioned above, contribute to the capabilities of this circuit.

To discuss the operation of the deflection portion of the circuit, it would perhaps be in order to review the function of the damper tube. The importance of this tube to all the three circuits under consideration is much greater than the word "damper" implies.

We can consider the output tube plate current as having been utilized to drive the trace over to the right side of the screen. Then suddenly that tube is cut off, the field collapses, high voltage is produced and is utilized to supply the 2nd anode voltage. This does not, however, use up much of the energy in the yoke.

Using the Energy

The first use to which we can put this energy is to accomplish retrace. The requirement of our present system is that the beam must get back quickly to the left side of the screen after the trace is completed: approximately 7 microseconds are allowed for retrace as compared with 53.5 M sec. for the visible trace.

When the output tube is abruptly cut off and the high back EMF is produced due to the rapid collapse of the magnetic field, the system is said to be "shocked into oscillation." It has been found useful to design the circuit constants of the output system so that, when this shock excitation occurs, the system will oscillate at approximately 71 KC. Thus in one half cycle of oscillation (7 M sec.) retrace will have been accomplished. A relatively small portion of the energy available is used up in this operation.

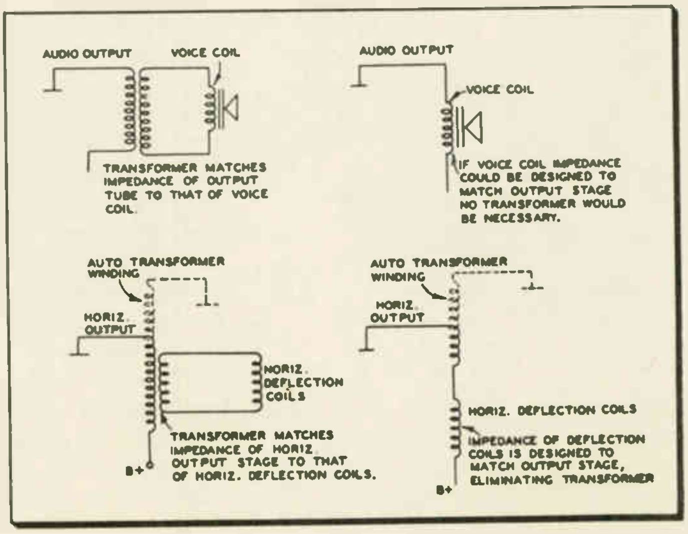
At this point we must stop the oscillation or else the beam will oscillate back and forth at a 71 KC rate until the energy in the yoke is consumed (since a good deal of energy remained after retrace). It would be highly desirable to utilize this energy to satisfy the next demand of the system, which is to start the visible trace across the tube again. To do this, we need to control the oscillation so that the current passes through the yoke at the slower (and at the same time, linear) rate required for the trace. An RC network would accomplish this, but a good deal of energy would be wasted in the resistor in the form of heat.

The damper tube, however, permits this energy to be efficiently utilized. The functioning of the damper tube is already familiar to the TV technician, and is therefore very briefly described as follows: When the output tube is cut off and the high voltage is developed as a result of the collapsing field, this voltage is negative at the damper tube plate and therefore cuts that tube off also. After the retrace is completed, however (or in other words, after a half cycle of oscillation) the plate of the damper is driven positive and the tube conducts. This places a low resistance across the oscillatory circuit and stops oscillations. Due to the resistance of the tube, and the circuit constants associated with it, the energy which had been momentarily stored in the yoke is allowed to decay at a relatively slow and linear rate to start the visible trace on its way. Thus the damper tube in a sense supplies some of the energy to scan the tube—actually, it would be more correct to say that it makes this energy available—and so it was that in the 630 circuit it was called the "reaction scanning" tube.

In the 630, the 5V4 had control of the beam for considerably less than the first third of the trace, possibly no more than 30%. In the direct drive system, however, due to the more efficient transfer of energy to the yoke, almost half the trace is accomplished during the "reaction" part of the scanning cycle (that is, while the 6BG6 is cut off). It can be seen that, by this more efficient utilization of the 6BG6 plate current, more deflection power can be derived without an increase in current.

As the stored energy which is being made available by the damper is almost used up, the field decays at a faster (that is, non-linear) rate. But just before it becomes non-linear, the 6BG6 takes over again. Actually, it had started to conduct a moment before and had by this time gotten to the point where it was conducting in a linear fashion and insufficient magnitude to do the job.

The conduct of the 6BG6 and the 6W4, therefore,



Coupling methods employed to connect loudspeakers to audio output stages as compared to the methods employed to couple the deflection yoke to the horizontal output tube.

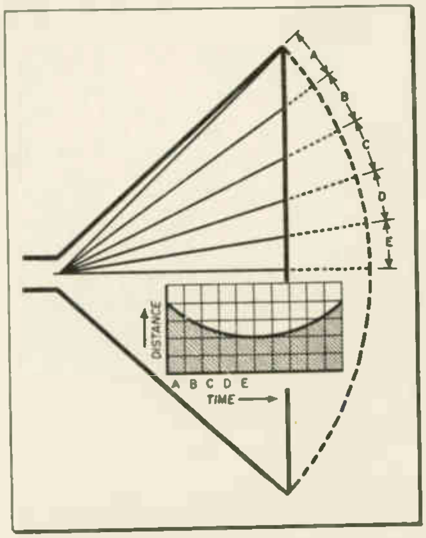


Fig. 2—Comparison of distances traveled in the same time period by the electron beam in curved or flat faced TV picture tubes.

can be likened to a relay race. When runner # 1 (6W4) approaches runner # 2 (6BG), runner # 2 starts moving so that when runner # 1 reaches the point where he will pass the baton, he will be able to pass it smoothly and no speed will be lost. In other words, one runner is standing still while the other is running the major part of his course, but the baton tends to continue around the track at a uniform speed.

The third important function of the damper (the first two were: to dampen the oscillations, and to make the stored energy in the yoke available for the beginning of the trace) is to supply the "boosted B." The manner in which this was done in the 630 is familiar: a pair of condensers in the cathode circuit of the damper were charged up to plus B potential, then when the damper conducted, the "kickback" voltage rectified by the 5V4 was added to this charge, mak-

(*Continued on page* 44)

Reception Characteristics TV Antenna

An Analysis of Some of the Factors Which Must Be Considered in

• It would be a great convenience for the TV installer if one type of antenna were suitable for all locations. It is unfortunately true, however, that every type is designed to do a certain job or achieve a certain result, and the technician cannot oversimplify the situation without costly compromises. It is rather troublesome as well as expensive to try every antenna available in each situation, so it follows that the installer may profit from advance knowledge of the factors to be considered and the results to be expected.

Probably the most exacting requirement to which an antenna system may be subjected is that it must operate over all 12 channels. The gain of the antenna is likely to be different on every channel: the impedance may change, and therefore the power delivered to the set will vary; and the directivity pattern may alter radically throughout the band.

It is axiomatic of some types that the radiation p a t t e r n becomes more sharply directional as the frequency increases. It is probably less obvious that side and back lobes develop on some types at higher frequencies, and in some cases to such an extent that the maximum pickup is no longer in the forward direction.

Before discussing the radiation patterns shown below, however, it would be well to consider what sort of directivity is desirable. In an area where all stations lie in the same general direction, a fairly sharp lobe in one direction which remains constant throughout all the channels covered is desirable. Where the stations lie in the same general direction but are not closely grouped, such an antenna would provide only compromise reception on all stations unless a rotating device were used. Where stations are in different directions (for instance one East and one South), two antennas would be desirable in the absence of a rotator, since utilizing the sidelobes of an antenna which does not have a uniform pattern over the whole

Choose an "all-channel" antenna which is the best compromise between the requirements of the local situation and the characteristics of the different antennas available, on both high and low bands. Some of the factors to be weighed are outlined here, along with the response of some of the popular antenna types. All these diagrams were made by, and are reproduced through the courtesy of the American Phenolic Corp. (Amphenol) of Chicago.

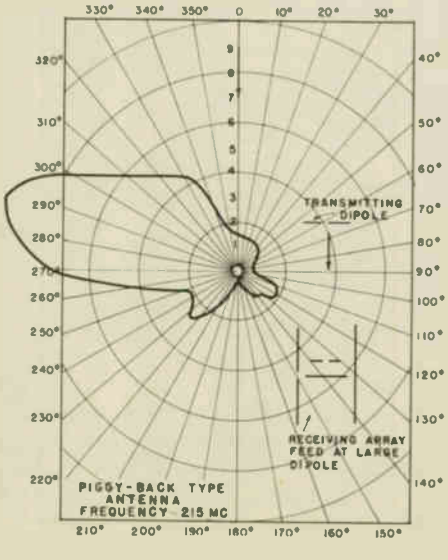


Figure 1-A

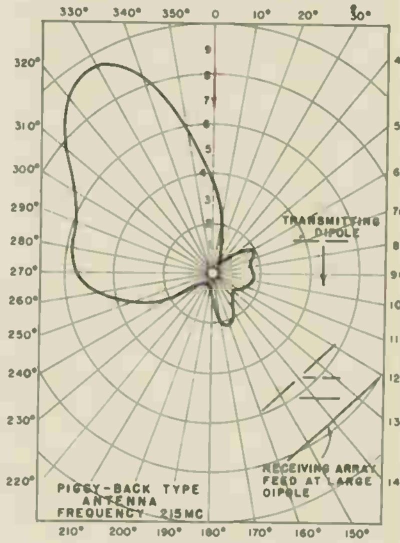


Figure 1-B

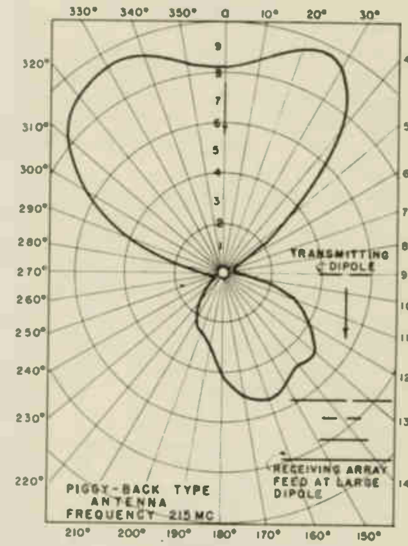
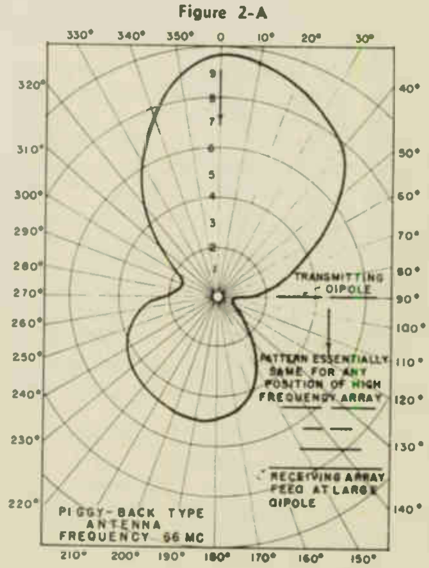


Figure 1-C

Figures 1-A, 1-B and 1-C show a Hi-Lo or Piggy-Back antenna at 215 MC, with the high band antenna always directed at the station, and the low-band unit oriented in different directions. Notice how orientation of the low-band unit changes the pattern of reception even at this (high) frequency. Figures 2-A, 2-B, and 2-C show the same antenna at 66MC, with the low-band unit stationary and the high-band unit oriented. Very little change is noticed in the pattern. Figs. 3-A and 3-B show a Bat-Wing antenna at low and high frequencies. This type develops side-lobes on the high band, but maximum pick-up is still in the "straight ahead" direction. Figs. 4-A and 4-B (next page) show a conical on high and low bands. Like the Bat-Wing, maximum pickup is maintained in the forward direction throughout the 12 channels; the main lobe narrows as the frequency gets higher, and some side-lobes appear. Figures 5 and 6 are explained on page 102.

Figure 2-A



# of Some Popular Types

Choosing the Proper Antenna for a Particular Situation

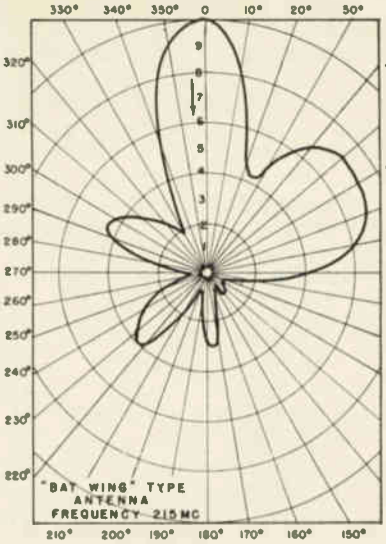


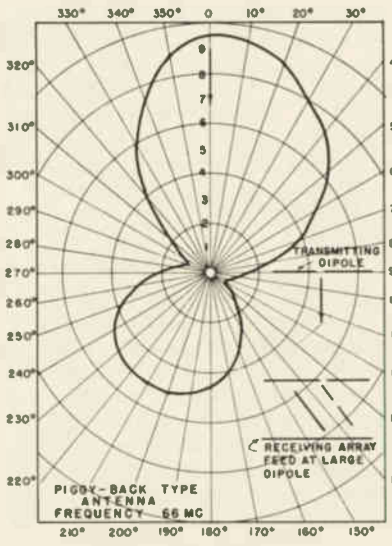
Figure 3-A

band is at best a game of chance. In the first place, the side-lobes rarely provide even half the power of the main lobe. In the second place, such secondary lobes shift in number, in strength and in direction with almost every channel, as can be seen in some of the accompanying diagrams. In the third place, the patterns shown are not a fixed, permanent condition, but rather represent tests made under optimum conditions. The terrain, the height above the terrain, the type of transmission line, and the length and geographical path of the transmission line can change the results obtained at the receiver. The most reliable reception characteristic of an antenna to figure on is the *main* or principal radiation lobe.

Narrow Beam Types

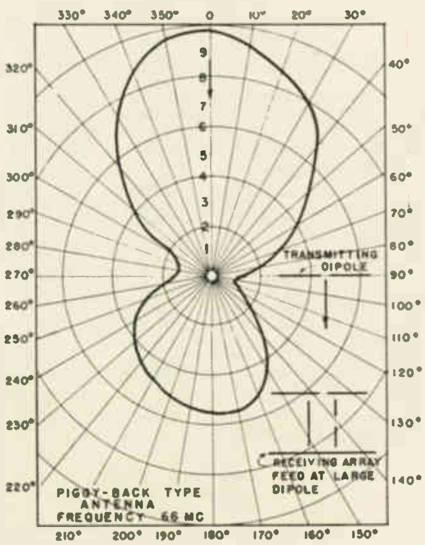
The sharper the directional pattern of the antenna, the more the gain may be considered to be concentrated in the desired direction. A pattern may be too sharp, however, in which case it will be extremely difficult to orient, and especially with a rotator. If too sharp, also, it may be affected by winds and vibration. The actual optimum beam width will vary with the distance from the station and the number of stations desired.

Where high and low band stations are in different directions, the separately orientable "hi-lo" type of antenna suggests itself. No doubt many installers have discovered, however, that one of these two elements cannot always be completely ignored when orienting the other. The accompanying patterns of "piggy-back" antennas show that on the high channels, the low-band antenna still has control over the radiation pattern. On the low-band, the high frequency antenna can distort the pattern a little, although the reception results are still basically that of the larger antenna. Separate lead-ins would be more apt to produce the desired result, and separate masts would be even more of an improvement.



Figu e 2-C

Figure 2-B



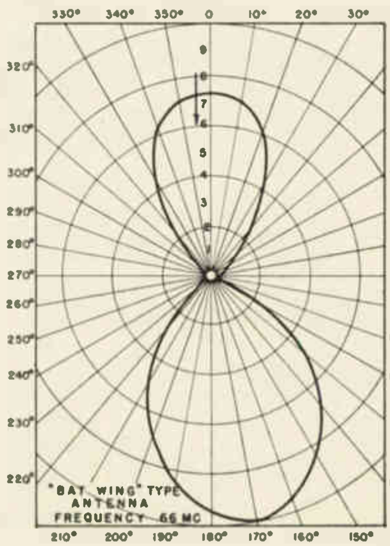
The gain of an antenna is taken to be the relation between the power delivered by that antenna on some frequency and the power delivered by a simple half-wave dipole cut for that frequency. Parasitic elements and stacked arrays are probably the most readily effective means of increasing the gain of an antenna, if it is borne in mind that the impedance is lowered and the frequency-sensitivity increased with these additional elements.

Improving Antenna "Gain"

The gain of an antenna without the use of parasitic elements or stacking, however, depends on its constructional features. A simple straight dipole cannot have any "gain" since the standard against which it is being compared is also a simple straight dipole, cut for the frequency at which measurments are being taken, and properly matched to the load.

Improving the impedance characteristics of an antenna may improve the results obtained with it over a broad

Figure 3-B



number of channels when compared with a similar antenna which does not provide a proper match, but will not result in "gain" over the standard antenna, because the latter is by definition cut especially to each channel, and properly matched. When considering actual practice, however, as opposed to theory, some improvement is possible. For instance, a folded dipole has a theoretical radiation resistance of 300 ohms at its cut frequency, and therefore provides a perfect match for 300-ohm lines and 300-ohm receivers,

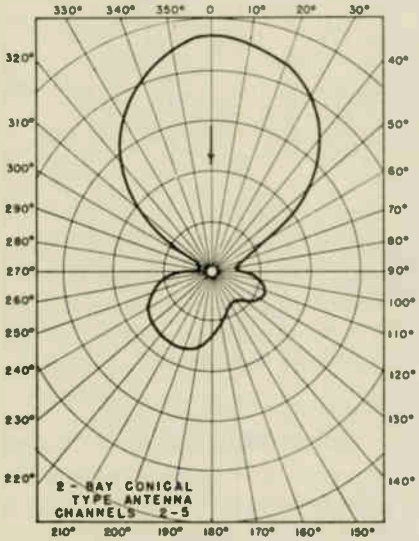


Figure 4-A

both of which are most commonly found in practice. The use of a straight dipole with 300-ohm line in the field, for best results, would require some sort of matching (pad or transformer) in which some losses would inevitably occur. Therefore, the folded dipole could be considered to have provided an improvement. Similarly, any antenna which is designed to provide a better impedance match over the whole band (such as a conical-type) may effect an improved power transfer when compared with some other antenna for which no such provision has been made, although it is does not provide a better impedance match than a "standard reference dipole" which is by definition perfectly matched.

Harmonic Response

Response falls off more sharply below the resonant frequency of an antenna (the frequency for which it is a half-wave in length) than it does above that frequency; and, as a matter of fact, it reaches resonant peaks at odd harmonics. The third harmonic is generally the only usable odd harmonic. For instance, an antenna cut for channel 3 (as many popular low-band antennas are) will have a response peak at channel 9 in the high band. Even-numbered harmonics are relatively poor response points. The principal reason why a channel 3 antenna is usually not good at channel 9 is because the single main forward lobe is replaced by two side lobes about 35 degrees displaced from "straight ahead." However, an antenna which. because of its mechanical design, is able to achieve maximum gain in the forward direction on high as well as low band channels can operate over the whole TV spectrum fairly well provided it is a broad-band design. That is, the Q cannot be too high, for we already know that the higher the Q, the sharper the response and the higher the gain—and also, the narrower the bandwidth.

Weigh All Factors

In selecting an antenna for a situation, the installer must consider how many channels are to be received; whether both high and low band channels must be received; whether (if more than one channel is desired) the stations are in the same or different directions; whether sharp directivity and good front-to-back ratio is desirable for either fringe area high gain or for metropolitan area ghost elimination; whether the noise or weather conditions prevailing necessitate shielded transmission-line (which may suggest special impedance matching considerations in the choice of an antenna); and even physical conditions must be considered: such as whether there is space or sufficient support available for the antenna which is thought to be most desirable. And by no means last and least, the price of the installation must be considered. Where only one low-band station is to be received in a normal signal area presenting no particular problems, the installer cannot justify the extra expense of what may be his "favorite" antenna because it is designed to overcome problems which do not exist in this instance.

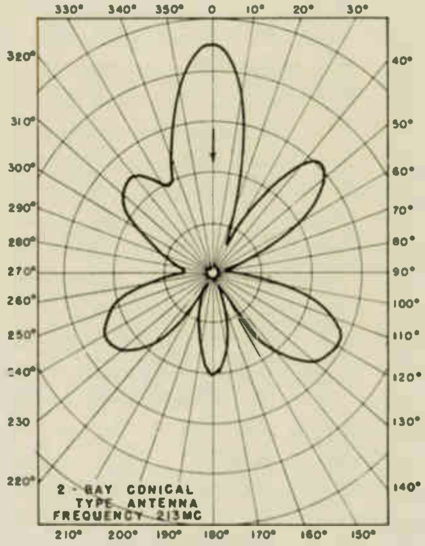


Figure 4-B

The foregoing discussion and the reception patterns reproduced on these pages are designed to facilitate the consideration (or re-consideration) of many of these problems in the selection of an antenna, and to assist in the evaluation of the different types which are available to solve different problems. The ultimate solution will inevitably be a compromise, but let it be the best possible compromise available to insure a satisfied customer, avoid costly call-backs, and stimulate word-of-mouth advertising which brings future business.

Fig. 6: Horizontal radiation patterns of a simple dipole (90" long) and reflector on low and high channels, showing development of side and back lobes on the high band, with change in direction of maximum pickup.

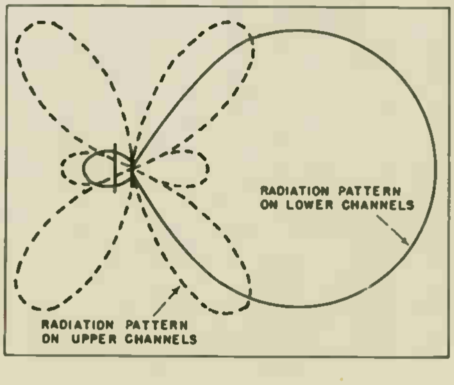
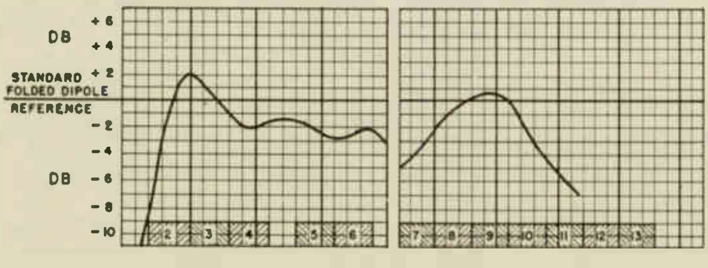


Fig. 5: Gain of a simple dipole and reflector over the 12 channels compared to the "standard" cut for each frequency. The antenna under test was 90" long (approx. Channel 3). Note 3rd hormonic response, as described above.



UHF Reception on VHF Television Receivers

Block Analysis of UHF Converters and Tuners. Important Design Factors. UHF Strip Circuits.

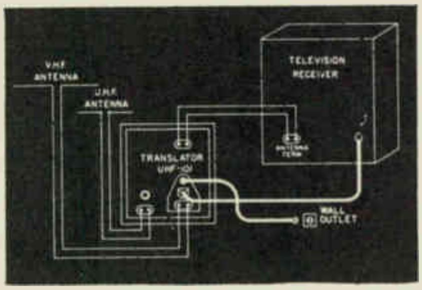


Fig. 1—Connection of the GE UHF Translator to a GE receiver, showing facilities for switching antennas, as well as provision for a single AC power connection controlled at receiver.

● The TV serviceman may be called upon to recommend a good UHF converter or tuner, or possibly he may buy one to install in a customer's set. A knowledge of the factors or points that must be considered in judging a converter or tuner should consequently prove helpful. This knowledge is apt to prove particularly useful in those instances where the serviceman must decide whether poor UHF reception is due to a fault in the antenna system or the VHF receiver, or the converting device. In addition, servicemen will eventually need to repair these units, and should therefore know a good deal about their operation.

The UHF tuning inductances, as well as the symbols used to represent them, may be unfamiliar to many servicemen. A tuning unit is shown in fig. 4, which is a photograph of the UHF converter made by the Kingston Products Corp. Note the symbols for the variable inductances, shown in fig. 3.

The preselector circuit in the UHF converter or tuner must adequately separate UHF and VHF signals. It should help prevent radiation from the UHF oscillator from getting into the antenna. Such radiation may impair the reception of TV receivers in the immediate vicinity—it may, in some rare cases, also interfere with the operation of the converter or tuner producing the radiation.

The mixer used in practically all cases is a crystal. Interestingly enough, no RF amplifier precedes it. One might think that an RF amplifier would improve the signal-noise ratio in the UHF tuner, and help prevent oscillator radiation to the antenna. This is true enough at VHF. At ultra-high frequencies however, the noise factor of an RF amplifier increases with frequency. There is an increase of 6 db when the frequency of operation is raised from 100 to 500 MC; it goes up to 10 db when the frequency is raised to 890 MC. An RF amplifier cannot therefore be counted on to improve the signal-noise ratio at UHF.

Furthermore, an RF amplifier—even a tuned RF amplifier—will not effectively suppress oscillator radiation at UHF. Better, more economical suppression is achieved with a good preselector and crystal mixer circuit (combined with adequate shielding of the converter).

A crystal rather than a tube is used as a mixer because it costs much less than a tube would; it makes a simpler circuit possible (fewer connections, no filament needed, etc.); its noise characteristic is better than that of a tube; and its performance in general is quite satisfactory. The oscillator output can be lower when a crystal mixer is employed—a factor that helps minimize oscillator radiation.

Silicon or germanium crystals are employed. The silicon crystal is regarded as superior to the germanium in that it will generally introduce less noise, and will deliver a higher, more uniform output. The germanium crystal, on the other hand, is far less expensive, will withstand a higher inverse voltage, and has the ability of healing itself after an electrical breakdown.

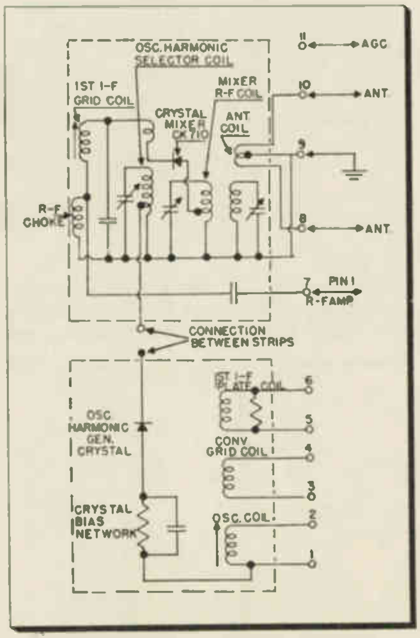


Fig. 2—A UHF strip circuit. (see text)

One of the primary factors in UHF oscillator performance is stability. Since the UHF oscillator is operated at a much higher frequency than a VHF oscillator, the allowable frequency drift, on a percentage basis, must be much smaller.

The stability of the UHF oscillator is much better when the TV receiver to which the converter or tuner is connected is intercarrier in type, than when it employs a split-sound system. When the set is intercarrier, the converter stabilizes during the time the set is warming up (app. 1 minute). In the case of a split-sound receiver, a 3 to 5 minute interval may elapse before oscillator stability occurs. The TV serviceman may have to instruct the converter owner that such an unusually long stabilization period is to be expected of most, probably all converters used with split-sound TV sets.

When the line voltage varies, oscillator drift will be enhanced. If the line voltage should vary between 95 and 125 V, a maximum drift of 70 MC may take place in the UHF oscillator. Constant-voltage transformers may prove necessary adjuncts to converters, in localities where severe fluctuations in line voltage take place.

Resonant suck-outs are a problem in the UHF range. Since the frequency of operation is so high, the tuning inductors present have very small inductive reactances, and can readily resonate at undesired frequencies with the small capacitances introduced by nearby wiring. The resultant suck-out can kill the oscillator output at certain frequencies. Special circuit arrangements are made to avoid such undesired resonances, in the oscillator as well as in other UHF circuits.

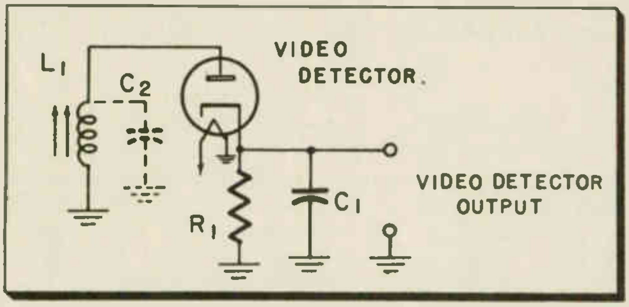
The UHF oscillator is generally operated at a frequency lower than the incoming UHF signal, to present an inversion or reversal of the sound and picture carrier positions on the video IF response curve of the TV receiver.

Oscillator tubes used on the UHF band are apt to be sources of microphonics. The microphonic problem is less severe when the set to which the converter or tuner is attached is inter-

(Continued on page 45)

Servicing Video Detector

Function, Method of Operation and Types of Circuits Used



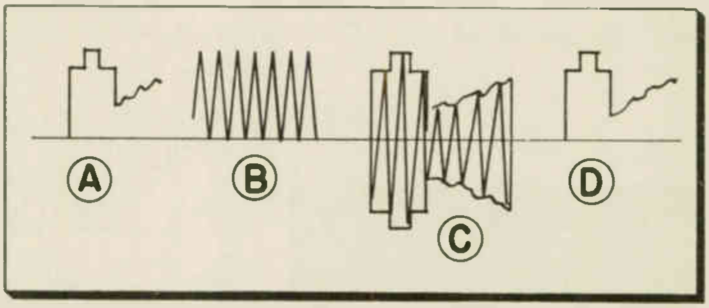


Fig. 1 (above, left): Simple diode detector circuit. L-1 resonates with C-2, the stray capacitance in shunt with it, to form the tuned input circuit. Fig. 2 (above, right): (A) Original video signal. (B) RF carrier with which the video signal is mixed. (C) Resultant modulated RF carrier. Note that this is a bi-directional signal. Note also that when the carrier is mixed with the video signal, its envelope acquires the shape of the video signal. The peaks of the carrier, in other words, vary in accordance with the video signal. At the receiver, the modulated RF carrier is stepped down in frequency, and becomes a modulated IF carrier. (D) In the video detector, the IF carrier is removed, and ½ of the signal is eliminated, restoring the video signal to its original, uni-directional form.

• The function of the video detector in the TV receiver is to remove the video modulation from the incoming IF signal. Diodes are commonly used as detectors, because they are capable of better fidelity than triodes. A simple diode detector circuit is shown in fig. 1.

The modulated video IF signal is applied between plate and ground of the diode. Since the cathode is bypassed to ground for IF by C-1, the signal is effectively applied between plate and cathode. Current flows only when the incoming signal makes the plate positive to cathode. The diode thus acts like a half-wave rectifier. Rectification is necessary because the original video signal is a uni-directional, not a bi-directional one (see fig. 2), and it must be restored to that same form. If the video detector output was bi-directional, the video signal would have a net average amplitude of zero.

Let's see what the diode detector must do, then we can consider how it does it. We want the diode to give output only at the *peaks* of the incoming signal, since these peaks vary in accordance with the video signal (see fig. 2C). In between peaks, the incoming signal is varying at an IF rate. We don't want output from the video detector at these times, because IF signals are undesired in the detector output circuit.

Peak detection in the diode is achieved in this way:

When the positive half-cycle of the modulated IF input signal is coming in, the diode conducts. The upper end of R-1 is made positive to ground, by the flow of conduction current. The voltage across R-1 charges C-1.

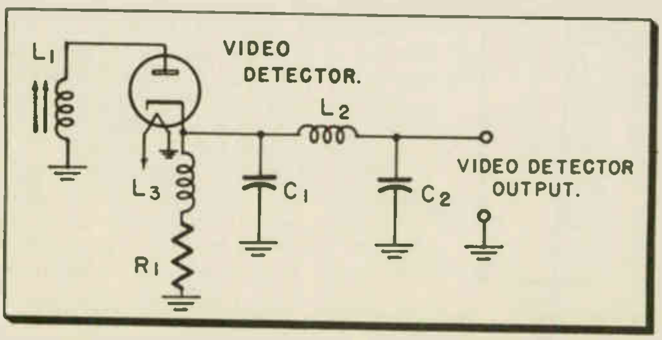
After a few cycles, C-1 becomes charged to the average level of the positive half-cycles of incoming signals. The voltage across C-1 is the diode's cathode-to-ground voltage. This voltage reduces the diode plate-to-cathode voltage. For instance, if the plate-to-ground voltage is +3V and the cathode-to-ground voltage is +2V, the plate-to-cathode voltage is +1V.

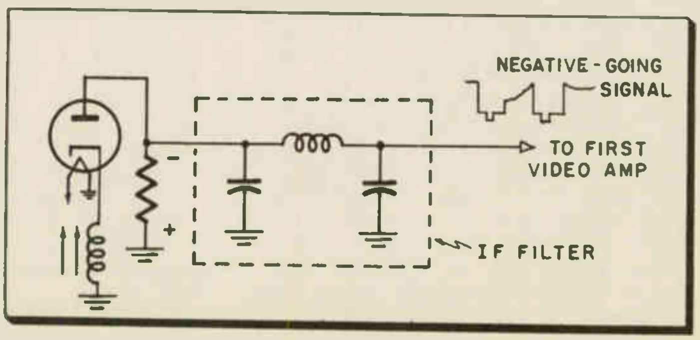
The diode will (after the first few cycles) no longer conduct during the entire positive half-cycle of incoming signal, but only during that portion of the half-cycle when the plate-to-ground voltage exceeds the cathode-to-ground voltage. In other words, the diode will conduct only at the *peaks* of the incoming signal. In between these peaks C-1 discharges through R-1 (since the diode, its source of voltage, does not conduct at these times) keeping the voltage across R-1 substantially constant, in spite of the signal voltage changes taking place at the diode input.

At the peak of the incoming signal, the plate-to-ground voltage of the diode exceeds the cathode voltage, the diode conducts, C-1 charges, and a change in diode output voltage takes place. This change occurs at a video rate, and represents the desired video signal.

Looking at the matter in another way: Because of C-1 R-1's long time-constant, the output voltage cannot follow the rapid IF variations in the incoming modulated IF signal, but only the relatively slow variations in amplitude corresponding to the signal envelope, or the video modulation. The output voltage across R-1 therefore reproduces only the video modulation.

Fig. 3 (Below, left): Video detector with π-type filter. L12, C-1 and C-2 comprise the IF filter. L-3 acts as peaking coil. L-2 generally acts as a peaking coil as well as an IF filter, resonating at about 4 MC with the capacitance in the circuit to boost the HF response in this vicinity. Fig. 4 (Below, right): Diode detector with negative-going video signal output.





Circuits in TV Receivers

to Remove Picture Information from the Composite Video Signal

C-1 thus acts as an IF filter in this simple detector circuit, bypassing IF from the load. In practice, C-1 is not an efficient filter. It is inefficient because the undesired IF (an approximately 26 MC signal) is too close to the highest video frequency to be bypassed (about 4 MC).

If C-1 is used by itself, and is made sufficiently large in capacitance to remove the IF, it will also attenuate high video frequencies as well. If C-1 is made small enough to prevent the attenuation or reduction of high video frequencies, it will be too small to completely remove the IF. A better filter must therefore be used.

The kind employed is a π-type unit or a variation thereof (see fig. 3). This band-pass filter effectively removes the undesired IF, without reducing the detector response at high video frequencies.

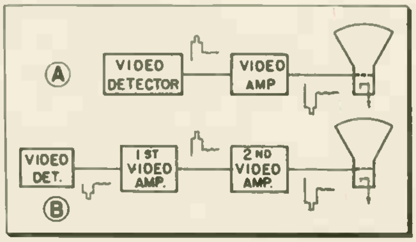


Fig. 5: A negative-going signal is needed at the CRT grid. Such a signal will drive the CRT to cut-off on sync pulses and black signals. (A) If one, or an odd number of amplifiers, is used between the video detector and the CRT, the video detector output will have to be positive-going. (B) If two, or an even number of amplifiers, is employed between the video detector and the CRT grid, the video detector output will have to be negative-going. (It is assumed in both cases that the signal is applied to the CRT grid.)

The output signal of the video detector may be either positive or negative (see fig. 4). Let's see what determines the polarity required.

The video signal applied to the CRT grid must drive the CRT to cut-off on black signals; and must reduce the bias on white signals sufficiently to cause white to be reproduced. In other words, a negative-going signal must be applied to the CRT grid (see fig. 5). (If the video signal is applied to the CRT *cathode*, it must be *positive-going* to achieve the same results.) The polarity of the video detector's output signal must therefore be such that the video signal will be correctly phased at the input to the CRT.

If an *even* number of amplifiers is used after the video detector, and the signal is fed to the grid of the CRT, the video detector output will have to be negative in polarity (see fig. 5B). If an odd number of amplifiers follows the video detector, and the signal is fed to the grid of the CRT, the detector's output will have to be positive-going (fig. 5A). If the video signal is fed to the cathode of the CRT rather than its grid, the polarity of the signal needed at the video detector output in each of the above cases will be reversed.

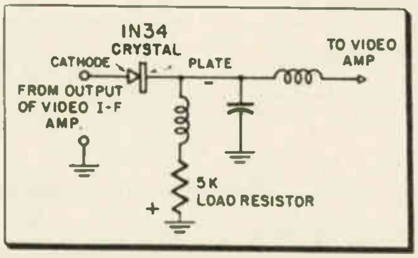


Fig. 6: Crystal detector circuit. A somewhat greater video output is possible with a crystal, due to the fact that 1. its internal resistance is lower than that of a diode and 2. the absence of interelectrode capacitance permits a higher value of load resistance to be used.

R-1, the load resistor (fig. 1) is small compared to the diode load resistors used in broadcast AM detectors. Large values cannot be used because of the shunting capacitance present across R-1. This shunting capacitance, which is composed of the tube inter-electrode capacitance and the stray capacitance present in the circuit, offers a decreasing reactance with increasing frequency. The load impedance therefore tends to be considerably smaller for high video frequencies than for low and middle ones. The larger R-1 is, the greater will be the shunting effect of the capacitance across it at high frequencies, and the larger will be the difference in the low and high frequencies. To avoid such a condition—i.e., the attenuation of high-frequency video signals—R-1 must be kept low. It is generally somewhere between 2000 and 5000 ohms. Use of a low value of load resistance causes the output of the video detector to be reduced in proportion.

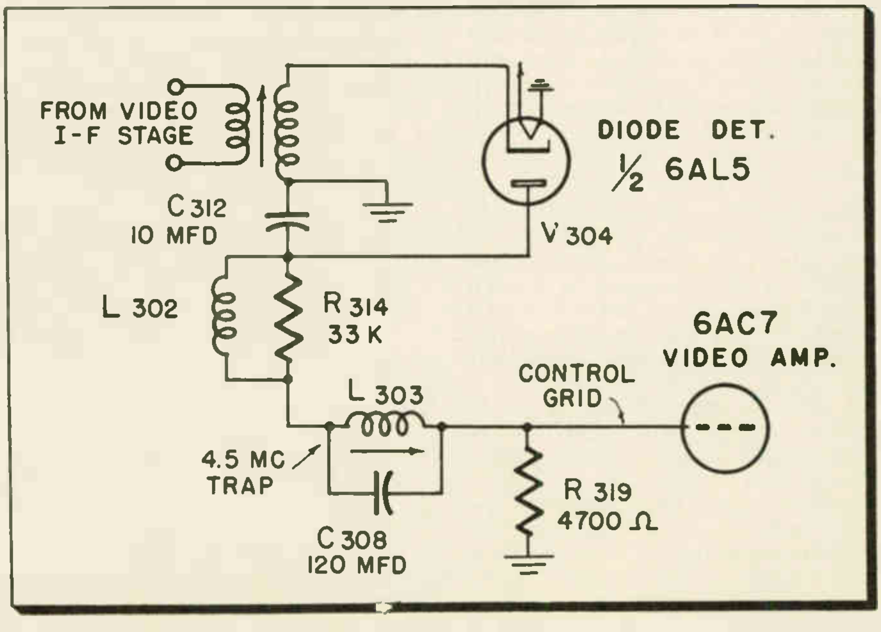
A peaking coil is often inserted in series with the load resistor to improve the high-frequency response (see fig. 3).

Crystals are sometimes used as detectors (see Fig. 6). The crystal functions as a rectifier, and is comparable in its action to a selenium rectifier. Advantages offered by a crystal over a conventional diode detector may be listed as follows: 1—The size of the detector unit is smaller. 2—Less wiring need be used, since only two terminals need connecting into the circuit. 3—No filament heating is necessary. 4—No hum is likely to be introduced into the detector circuit, since the crystal has no filament to act as a source of such hum.

The cost of a crystal was once too high to prevent its widespread use, but currently, relatively low-cost units can be obtained.

Crystals must, of course, be hooked up with the correct polarity, otherwise they will not function correctly. One

Fig. 7: Video detector circuit used in Admiral 20A1, 20B1, and 21A1 sets.



side of the crystal acts as a cathode, the other side as a plate. In other respects, the crystal circuit is similar in its operation to that of a diode tube.

One kind of video detector circuit used in commercial receivers is shown in fig. 7. Let's analyze the circuit, or at least those parts of it which may seem unfamiliar.

The video detector employed is ½ of a duo-diode tube used as a combination video detector and sync limiter.

C-312 is a plate bypass condenser that removes the unwanted IF signal from the detector load resistor R-319. This resistor, incidentally, also acts as the grid resistor of the 6AC7 video amplifier. No capacitative coupling is employed.

L-302 is a peaking coil used to filter out IF, as well as to boost the high-frequency response. R-314, the resistor in shunt with it, is used to dampen, or broaden, the high-frequency response, and prevent excessive peaking at the high-frequency end of the video bandpass.

L-303 and C-308 form a tuned circuit that resonates at 4.5 MC. This circuit is used to trap out a 4.5 MC video signal. Where does this undesired signal come from? Well, the sound traps used in the video IF stages are not always 100% efficient. Some sound IF signal that is left over may therefore get into the video detector. This signal, which is often 21.9 MC, will beat with a video IF signal of 26.4 MC in the detector, and produce a difference frequency or beat-note of 4.5 MC. Such a beating action occurs because the video detector, being a rectifier, not a class A amplifier, offers a non-linear impedance to incoming signals, and whenever two signals meet in a non-linear impedance, they beat against each other as enthusiastically as a drumstick against a drum.

The parallel tuned circuit offers a very high impedance to such a 4.5 MC beat-note. The beat-note will therefore use up most of its energy developing a voltage across this tuned circuit, and very little of it will be left to develop a voltage across R-319, at the input of the video amplifier.

• Slug-tuned L-52, in combination with the stray capacitance in shunt with it (not shown) acts as a tuned circuit common to both the plate of the 4th video IF stage, and the detector cathode circuit. The signal voltage developed across L-52 is the detector input voltage.

R-32, L-53 and C-66 act as an IF filter, preventing an IF signal voltage from being developed across R-29, the detector load resistor.

L-69 isolates to some extent the interelectrode capacitance between grid and cathode of the 1st video amplifier from the detector load resistor (R-29). L-69, in other words, reduces the shunting effect of the 1st video amplifier's input capacitance on R-29, preventing an attenuation of high video frequencies. It thus acts as a peaking coil.

C-67 is a coupling and blocking condenser. It couples the video detector output signal to the 1st video amplifier, but keeps the DC voltage output of the detector from being imposed as a bias on the video amplifier.

Use of Direct Coupling

A fourth video detector circuit is shown in fig. 2. ½ of a 6AL5 is used as the video detector. The other half is employed as a sync limiter.

C-125 is a decoupling condenser, that prevents IF signal voltage from getting into the -125 V DC supply.

L-102, R-119 and C-126 form the IF filter network. L-102 also acts as a peaking coil. R-119 dampens it, preventing excessive response at the frequencies to which L-102, in conjunction with the stray capacitance in shunt with it, resonates. These frequencies are, of course, at the high end of the video bandpass.

L-103 also acts as a peaking coil. Together with R-120, with which it is in series, it acts as the grid load impedance for the first video amplifier.

A voltage of approximately -125 V DC (to ground) is present at both plate and cathode of the video detector in the absence of IF signal input. The direct coupling employed between the video detector and video amplifier necessitates the presence of this high negative voltage.

If the plate of the video detector was returned to ground, instead of to the -125 V source, the grid of the 1st video amplifier would automatically be returned to ground too, making this grid highly positive with respect to the video amplifier's -124 V cathode. When the video detector plate is fed -125 V to prevent it from destroying the harmony of the video amplifier's home life, the video detector cathode must likewise be fed a similar voltage, or conduction between the two couldn't be persuaded to occur. Conduction takes place in the video detector when the incoming IF signal makes the cathode-to-ground voltage slightly more negative than the plate-to-ground voltage.

Troubleshooting the Detector

Symptoms of video detector trouble.— Trouble in the video detector circuit can be responsible for any of the following symptoms: a) Loss of picture. b) Loss of picture and sound (in intercarrier sets). c) Weak picture. d) Weak picture and sound (in intercarrier sets). e) Impaired picture resolution. f) Interference pattern in picture. g) Hum bars in picture.

When to check the video detector.— A check of the video detector seems logical when one of the symptoms cited above is present, and the stages following the detector have been eliminated as possible sources of the trouble.

How to check the video detector.— A quick check of the video detector may be made by tuning in any station, and measuring the DC output voltage developed across the video detector load resistor. A VTVM or high-resistance voltmeter should be used for most accurate results. The voltage measured is compared with the detector output voltage developed for the same channel in a similar set, operated under similar conditions. If the manufacturer lists the voltage that should be present with a TV channel coming in, his figure may be compared with your measurement.

This check will, of course, be conclusive only when the correct voltage is obtained. If the correct DC voltage is *not* measured, one of the stages preceding the detector, as well as the detector itself, may be the source of the trouble. To further localize the defect to the stage at fault, a signal generator and voltmeter may be employed.

Set the signal generator dial to the video IF of the receiver under test, and apply its output between grid and ground to the tube preceding the detector. Then connect the voltmeter across the detector load resistor, and measure the DC voltage developed

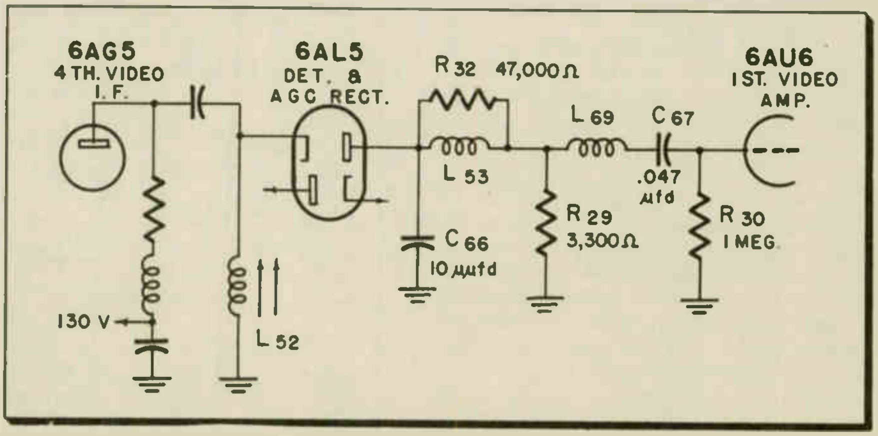


Fig. 1—Video detector circuit used in Philco 50-T1443. Filament circuit is not shown.

there. A comparison of this voltage, and the voltage developed in the detector output circuit of a similar receiver, tested under identical conditions, will reveal if trouble is present.

Defective Components

If the measured DC voltage is considerably below what it should be, trouble in the video detector *or* the stage preceding it, may be present. Simple voltage, tube substitution, resistance and condenser bridging tests should readily localize the fault.

In some cases, an *above-normal* video detector output may be measured. Oscillation in a preceding stage or stages is generally the cause of such a symptom.

Possible troubles in diode detectors, and symptoms they are likely to produce.—The following defects may occur in the basic video detector circuit shown in fig. 3:

Reduction in the value of R-1.—A division of video signal voltage takes place across R-1, Rp and Rx (the DC resistance of L-1). If R-1 loses value, less signal voltage will be developed across it, and more will be dissipated across Rp and Rx. The reduction in

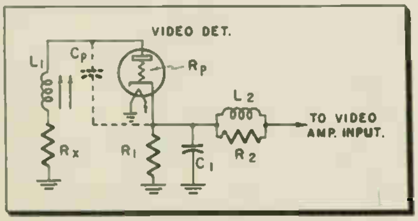


Fig. 3—Basic video detector circuit. Cp is the plate-to-cathode capacitance. Rx is the DC resistance of coil L-1. It is not actually a separate resistor, although it is represented as one.

signal voltage output will decrease picture contrast. (Picture *and* sound will be weakened, if the fault occurs in an intercarrier receiver.

If R-1 loses all, or almost all, of its value, or C-1 short-circuits, no picture (no picture and sound in intercarrier sets) will result.

Increase in value of R-1.—A considerable increase in the value of R-1 will increase the shunting effect of the capacitance in parallel with R-1, impairing the receiver's high-frequency response. Fine detail in the picture will be degraded, and the resolution of the vertical wedges in the test pattern will be impaired, in such a case.

If R-1 increases very greatly in value, the current flowing through the diode may decrease to such a point that a very small signal voltage is developed across R-1, weakening or eliminating the picture (sound too, in intercarrier sets).

Defects in C-1.—If C-1 becomes leaky or short-circuits, the effects will probably be the same as when R-1 loses value.

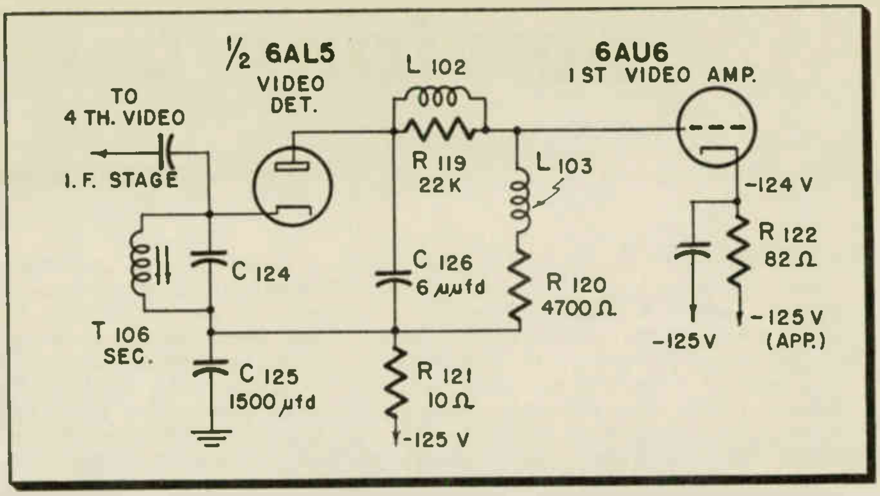


Fig. 2—Video detector circuit used in RCA models 9T270, 9TC272 and 9TC275.

If C-1 loses capacitance, no symptoms may be observed in many cases, because the stray capacitance present in the circuit may be sufficient to effectively bypass the IF signal. In rare cases it is possible that the insufficiently bypassed IF signal may get through to the video amplifier and CRT, causing an interference pattern to be seen on the screen.

A decrease in IF signal input to the detector occurs when C-1 loses capacitance or open-circuits. This is true because the signal voltage applied to the video detector in the circuit of fig. 3 divides between the plate-to-cathode capacitance of the video detector, and the cathode-to-ground capacitance. If C-1 is relatively large—i.e., at least ten times as large as the plate-to-cathode capacitance—very little signal voltage will be wasted across it. When C-1's capacitance has been reduced, however, a substantial percentage of the total signal input is wasted across it, decreasing the input to the detector, and thus reducing the strength of the picture signal (picture and sound signals in intercarrier sets) to some extent.

Sometimes the wrong value of C-1 may be present. In one case known to the author, a factory employee used a 100-mmfd instead of a 10-mmfd condenser for C-1. Picture strength was in consequence poor, and fine detail worse. The condenser was placed under the load resistor, and was not clearly visible. The set passed through quite a few servicemen's hands before the trouble was finally localized. A visual inspection by a serviceman who knew his theory turned up the defect.

Detector Tube Troubles

Defects in L-2.—If L-2 shorts (a most unlikely eventuality) the receiver's high-frequency response may be impaired, and fine detail degraded.

If L-2 opens, the video signal will be transferred through the small capacitance present between L-2's open ends, and the large resistance in shunt with L-2. Weak picture, and poor low-frequency response, manifested in smearing, are possible results.

Defects in R-2.—An open or radical increase in the value of R-2 may result in excessive h-f response. The trouble will be most evident on a test pattern, where small sections of the vertical wedges will be seen to be excessively contrasty.

A short or radical reduction in the value of R-2 may result in impaired h-f response.

Video detector tube troubles.—If the filaments of the video detector open-circuit, no picture will generally be seen. (Sound will be missing also on intercarrier sets.)

If the tube loses emission, the picture's contrast will be reduced. Synchronization may be impaired too, since the sync pulses will be below normal in amplitude. Sound volume may be lowered in intercarrier sets.

In the case of commonly-used duo-diode tubes, aging of one section is apt to be accompanied by aging of the other tube section. More than one symptom will result, depending on the purpose of the other diode.

Cathode-to-heater leakage in the video detector may produce a hum pattern in the picture (several alternate dark and light bars). The hum may be heard in the sound, if the fault occurs in an intercarrier receiver.

Troubles in L-1.—Trouble in L-1's circuit will eliminate or greatly attenuate the IF signal input to the detector, reducing the strength of or eliminating the picture (picture and sound in intercarrier sets).

Trap troubles.—If a 4.5 MC trap in the video detector develops a fault, like a shorted coil or condenser, or open connection between coil and condenser, an interference pattern may be seen on the CRT screen. If the trap is used to transfer an intercarrier sound signal to the sound IF stages, the sound may be lost in such a case.

An open coil in a trap circuit may cause the video detector to become inoperative, since the DC current path is

(Continued on page 42)

Servicing Low Level High

Appearing In Greater Numbers In Home Equipment,

● Since the average radio tuner and crystal phonograph cartridge feed at least one volt to the first stage of an audio amplifier, servicemen handling mostly run-of-the-mill home equipment in former years were not too much concerned with the problems inherent in very low level, high gain input stages. These sensitive critters were usually encountered only in mike preamplifiers found in PA systems, and in broadcast and recording equipment.

The post-war years, however, have brought a good deal of equipment incorporating such features into the home in the form of such things as preamp

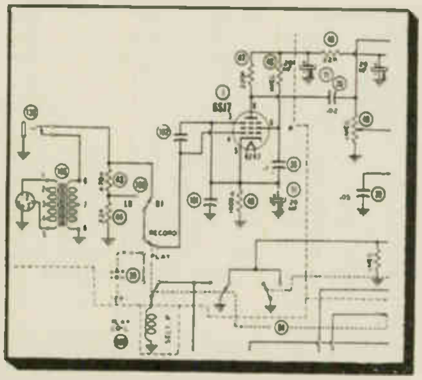


Fig. 1: Mike input stage for Brush Soundmirror BK403 uses a single-ended 6SJ7 (metal) for a gain of at least 40 DB, which is common for such stages. R49 and C11A and B provide isolation and additional filtering especially for this stage. On playback, the playback head feeds directly into this stage without additional compensation.

stages for variable reluctance magnetic pickups and mike input stages in tape and wire recorders.

Troubles in such stages come to the servicer in one of several ways. First, a fault may develop in a unit which originally functioned OK; second, the compact design of some of the less expensive units make good isolation, shielding and lead dress difficult to achieve in their manufacture; and third, some customers become more critical and discerning as they get used to something which at the time of purchase was not carefully evaluated.

Successful troubleshooting of such stages requires a painstaking attention to all small details, for they are susceptible to all sorts of little annoyances which would be negligible in later stages.

Many servicers have found it advisable to develop a pre-arranged check-list covering *every* technique which would possibly cure these troubles, and to go through these checks in order, one by one, on every job. The reason for this is that often a trial and error method may take longer and still overlook some of the less obvious points.

In isolating a trouble to the input stage, the conventional elimination method can be quickly employed, which consists of shorting out grids, preferably through a condenser. When you short out the grid of the second stage, the objectionable hum, noise or microphonics will disappear if the trouble is in the previous, or input stage.

Microphonics of small or large degree probably represent the most common complaint. While the practice of tapping tubes and parts to locate the offending one will sometimes prove helpful, many troublesome jobs come across the bench which do not respond to this technique. That is, microphonics are heard every time *any* part or tube is touched, including the knobs.

Of course the first thing to try is the tube itself. Tubes (even new ones) vary in their inclination to microphonics and it is wise to try several. A time-saving method is as follows: when a new tube immediately and definitely cures the trouble, label this tube "non-microphonic," put it back on your shelf, and find another one to use in the equipment. Then you will have a tube in stock which you can rely on in the future to tell you immediately when a microphonic tube is the trouble. After a while, you will have non-microphonic tubes of all the types usually found in

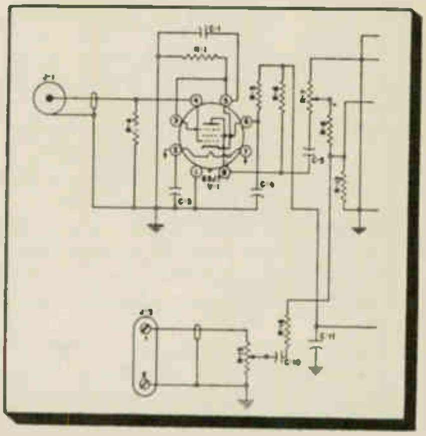
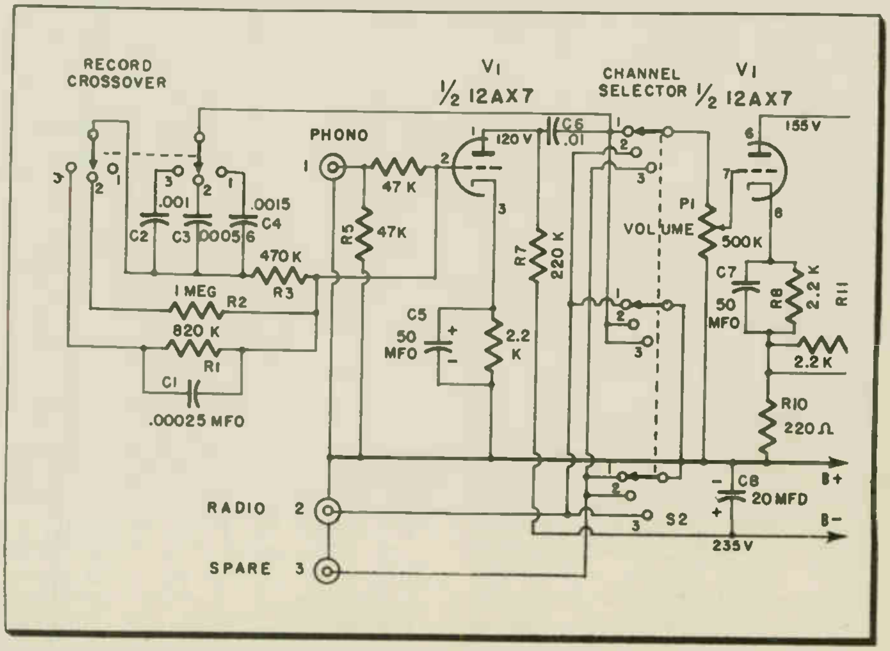


Fig. 2: Stromberg Carlson amplifier AU29 uses a 6SJ7 for mike input (J-1). J-3, the phono input, feeds the second stage. Circuit components are chosen for slightly lower element voltages on the tube and consequently slightly lower gain than the stage in fig. 1, which must handle the extremely low output tape head.

these stages and then the full benefit of such a method can be realized.

Where the tube is not at fault, it may be in a part, a connection, or in the socket itself. See that all leads (including point to point resistors and condensers) are short and preferably tight, so that vibration of the parts and leads is kept at a minimum. With a hot soldering iron, go over every joint in

Fig. 3: Altec Lansing remote-control-preamplifier with very low level input for magnetic pickup and a higher level input for radio tuner and one other piece of equipment. Only the magnetic pickup is fed into the first stage. Use of a miniature twin triode in this stage is typical of current equipment. Feedback is utilized even in the first stage to keep distortion at a very low figure.



Gain Audio Input Stages

Preamplifiers Present Problems of Hum, Noise and Microphonics

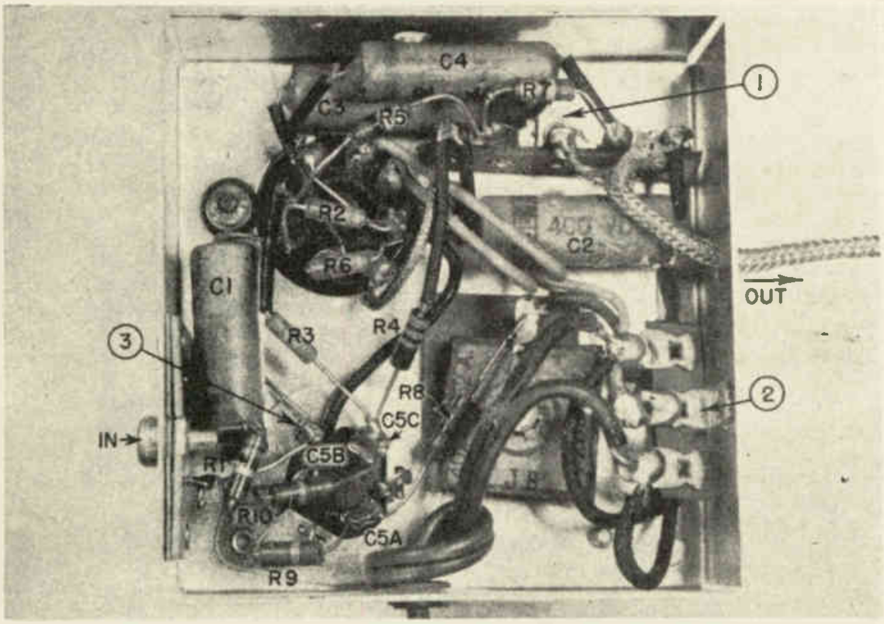


Fig. 4: Chassis view of GE preamp UPX-003, shown as typical of good layout practice in low level input stages. All grounds are connected to chassis ground at point 3 except the output cable shield (point 1) and the transformer center tap (point 2). Unit is completely isolated from the AC line by the power transformer and a good husky filter keeps down the hum. All leads are minimum length, filaments are dressed well away, and the 6SC7 is shock mounted on rubber. Gain of the amplifier is 35DB at 1000 cps, with proper compensation for the LP characteristic. R1 can be varied for HF response.

this stage to make sure that there are no loose or broken solder connections. Give special attention to shields, and particularly if they go through a hole in the chassis or touch it in any way.

Most low level input stages utilize shock-mounted tube sockets. Where the socket is not cushioned, it may be checked and sometimes cured by filing off the top of the rivets and letting it hang by its own leads. This is, of course, assuming that there are enough, and strong enough leads to do this. This is more of a test technique than a repair, since it isn't a good idea to leave the socket in that condition permanently. "Floating" the socket will usually reveal the neccessity for cushioning. To permanently shock-mount the socket, use long screws to bolt it back in place, and put a small rubber grommet over each one.

Microphonic-type noise sometimes results when the leads to the phono cartridge are reversed, or in other words, when the pickup arm (and sometimes the changer chassis, too) are connected to the hot side. This is quickly revealed by tapping the pickup and should not be confused with microphonics in the input stage.

Hum, noise pickup and sometimes detection of AM signals are common in input stages. Tube noise, evident when the gain is wide open, is usually brought about by low gain in the stage or reduced output from the signal source, making it *necessary* to run the gain wide open. That is, every tube has inherent internal noise which will be revealed when a low level, high gain stage is pushed to the limit. Some tubes, however, are noisy even under ordinary conditions and can be checked by substitution. Stage gain checks should reveal the reason for this particular type of noise (which we differentiate from "noise pickup").

Hum can be induced from filament leads and from heater-cathode leakage. Filament leads should, of course, be twisted, and kept away from the grid lead to the tube.

Sensitivity of the grid side is the reason why many of these input stages use grid-cap type tubes such as the 6J7. Where single ended tubes ar used (as they are in most recent designs) lead dress with relation to the grid is much more critical.

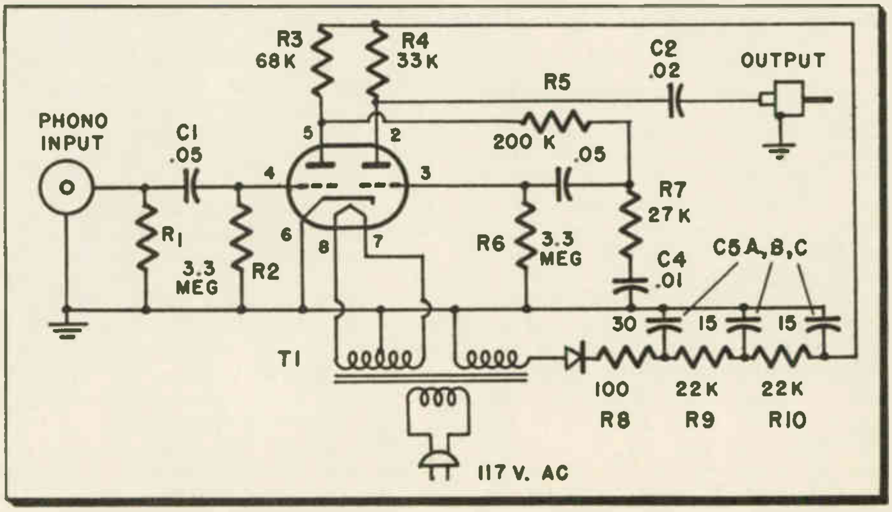
When AC hum is suspected but is difficult to track down, the filament connections can be temporarily lifted off and DC put on the filaments. Either a socket-powered DC power supply or a filament-type radio battery (that is, capable of supplying adequate current) will serve.

It is to avoid just this trouble that some equipment is already provided with a DC source for the filaments in low level stages Such a supply can be added by the servicer if the customer will OK the expense.

In the case of a separate preamp for a GE-type pickup, haphazard placement of the unit may cause hum pickup from a phonograph motor or a power transformer. Relocating the preamp will quickly reveal this trouble. Faulty filtering in the preamp's B-plus power supply (in the case of a self-powered unit) or in the main equipment's power supply will, of course, put hum into the stage. In the latter case, the trouble usually wouldn't be confined to the input stage, and therefore would have been revealed in the grid-shorting test mentioned earlier.

Since this stage is more sensitive, however, B-plus to it should be adequately isolated by an RC filter. If one

Fig. 5: Circuit diagram of GE preamp, shown for better identification of the parts labelled on the photo of fig. 4.



Audio Input

is present, it should be checked, and if there is none, one should be added.

Hum, noise pickup, detection and microphonics can be caused, as mentioned above, by insecure solder joints and connections, and another place to check is at the jacks and plugs used at the input, if any, and at the volume control and/or equalizer, especially if it is on the input side. If the controls *are* on the input side, it would be wise to move them to the next stage, since noise pickup is emphasized otherwise.

Long leads, especially at high impedances, should be avoided, and where they exist, consideration should be given to their possible re-routing. Long shielded leads should preferably be grounded in several places and should be securely anchored for as much of their length as is possible.

Grounding properly is, of course, important as in any other equipment. All grounds at the input stage should preferably be made to one point to avoid ground loops which may, due to the resistance of the chassis, introduce unwanted impedances into a circuit.

Anyone who has experimented with grounds in an attempt to eliminate hum knows that the behavior of such circuits often defies theory and no stone should be left unturned. The writer experienced a case of input hum which was traced to the place where the phono cable was plugged into the amplifier with an RCA-type phono jack. Although the cable shield was well soldered to the plug, and although the plug made good contact with the jack, and the jack was (in this particular case) grounded to the chassis, hum and pickup microphonics could not be eliminated until an *additional* grounding wire was connected between the cable braid and the chassis.

Hum in the input stages of tape recorders can be troublesome due to the fact that these units, which are usually portable, must combine in a relatively compact case one or more motors, an AC operated power supply and an extremely high gain input stage for both mike and recording head.

Hum Balancing Pot

Orientation of the power transformer, shielding and grounding of low level leads, and proper lead dress are of course important in these cases.

Using a pot to balance the AC filament leads may also be helpful in all types of equipment. Where the filaments have one side grounded at each tube socket, it would be necessary to rewire them, and where the center tap of the filament transformer was grounded, it would be necessary to lift this ground and ground the slider of the pot. In order to balance this pot, it is then necessary to run the gain wide open (with no input) in order to have as much hum as possible while listening for a maximum reduction.

Although the redesign of equipment is usually beyond the average serviceman because the customer is not prepared to pay for it, a certain amount of this work can be sold where the customer feels that he must protect his investment in the equipment he bought.

This might include the relocation of tube sockets and components, and the re-routing of leads for better protection and isolation of the stage. In some cases of extremely compact equipment, where the initial design is inadequate for the grade of operation desired by the customer, and where any relocation and rewiring job would be too complicated and unpredictable (due to the small space available), moving the whole preamp stage may be possible.

This can be considered because, although the equipment is by definition portable, it is not often used that way by the particular customer in hand. In this case a new preamp stage is made *external* to the main equipment, where all the proper techniques for handling such stages can be employed.

Long leads external to the amplifier (such as mike and phono leads) are conducive to input hum. While the original design of the equipment is usually such that the leads are not longer than they should be, it often happens that, for convenience purposes, they are extended. High impedance microphones should only be used close to the amplifier, whereas low impedance mikes can be used as much as 1500 feet away with low loss of cable. Sometimes it may be necessary to change the type of mike, where the use to which it is put dictates.

The remote preamplifier control unit, which is growing in popularity due to the convenience and flexibility it offers in multi-unit installations, suggests itself where a phonograph and/or mike are to be used at some distance from the power amplifier. With such a unit, long low-level leads can be avoided and the actual input cable to the main amplifier is operating at a high enough level that critical conditions are usually not encountered.

These units have many other advantages, of course, in that control of many functions can be grouped in one convenient place, and some additional functions may be introduced, such as elaborate equalization networks. It is a good idea to suggest such a unit where practical, and the extra sale will be decidedly advantageous.

An expedient which can be used in a few cases where layout of the input stage seems poor, and space requirements do not lend themselves to improvement, is to rewire the stage on a can-shielded vector socket; or it might be helpful, where the input tube is a pentode, to substitute a 6J7 and get the grid lead up out of the way.

Automatic Gain

(*Continued from page* 29)

separator's bias may become excessive. Lowering the signal input to the restorer when its bias drops tends to maintain the restorer's plate current at its former amplitude.

The servicing procedures used in this circuit are the same as in the preceding one, with some additions.

First, the possibility of the switch being in the wrong position exists.

Second, the presence of a separate AGC rectifier diode brings up the possibility of this section of the duo-diode tube going weak, while the video detector section stays OK. In such a case, the AGC bias would be insufficient, and overloading would tend to occur at all settings of the AGC control switch, when strong signals were coming in.

Video Detectors

(*Continued from page* 39)

interrupted, and the picture (picture and sound in intercarrier sets) is likely to be eliminated.

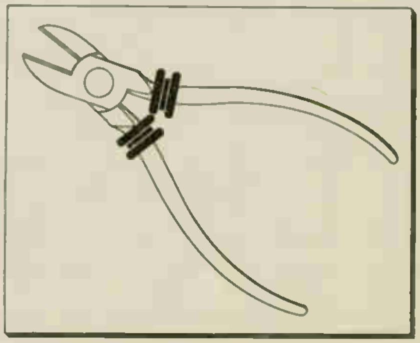
Tube substitution, voltage, resistance and condenser bridging tests should localize all of the troubles discussed.

When a crystal used as a video detector is suspected of being faulty, substitution of an identical unit known to be good will serve as a check.

SHOP HINT

Spring Pliers

Often I have to use snips, long nose pliers or cutters where it is a great disadvantage not to have a spring opening device. I have found the solution shown to be a great help. Just slip a rubber grommet over each handle, up to the very head. This automatically pro-



vides spring tension on the tool. To adjust the amount of spring return, merely slide the grommets up or down as is necessary until the desired amount of tension is achieved.—*Nick Capellini, 639 N. 25th St., Camden 5, N. J.*

PRINTED UNIT ASSEMBLIES

(*Continued from page 10*)

alignment of the staggered circuits could be slightly improved. During development of the RC plates some difficulty was encountered by signal being bypassed by stray capacitances about the 6K input resistor. This situation was corrected by redesign of the layout of the silvered ground area on the reverse side as well as by shortening the printed connections to this resistor.

The combination of etched and silk-screened portions of the assembly into a complete module is shown in Fig. 6.

Assembling of all parts including the tube clips and connections to the coil centers is done by dipping in solder. The coils are protected during dipping by an adhesive paper mask.

The RC card is provided with legs which fit into punched holes in the etched plate, thus dispensing with wire leads. All crossovers have been eliminated from the layout except the necessary connections to the coil centers. For illustration purposes the etched plate is shown reversed with respect to the other parts, the RC card, tube and coil connections going above deck with all protrusions on the etched lower side for convenience in soldering. The brass tuning slug (not shown in Fig. 6) is inserted in the threaded hole in the bifilar i-f transformer. Tuning may be done with the head portion on either upper or lower side of the etched deck.

As a module of construction, the manner of connection to the next stage is of vital importance. A butt joint of the etched plates is affected with a punched dovetail between sections which is supplemented by a single screw and a pronged nut plate fastened through the ground bus. This arrangement holds two adjoining plates quite rigidly in all dimensions so that the abutting conductors may be soldered directly together without wire. This may be done in the same dip-soldering, during which the RC card is attached, so that at least two modules may be assembled and joined simultaneously. While this joint has proven satisfactory to normal handling it is anticipated that improvement may be made by interleaving or dovetailing conductor ends.

Extension of the principles embodied in this i-f stage to the overall unitizing of a receiver is illustrated in Fig. 7. Here, three of the interlocked etched panels, which replace the conventional steel deck, are shown in place in a pair of aluminum channel strips. Such channels are used as a rack into which unit assemblies may be inserted vertically as well as in both planar dimensions.

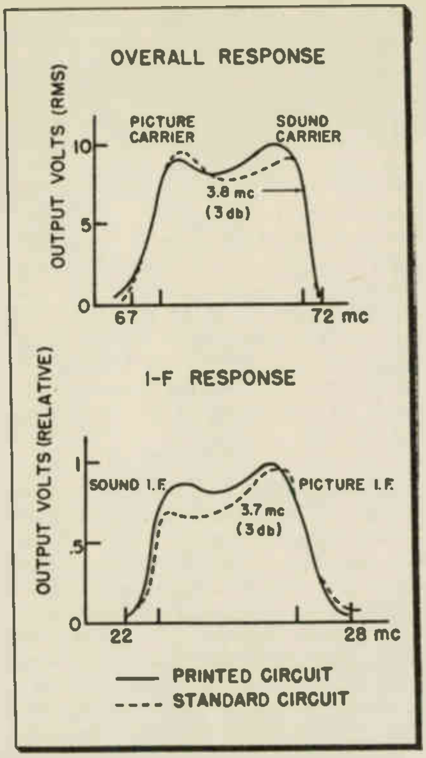


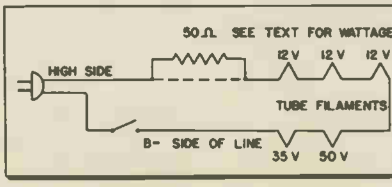
Fig. 9: Comparison of response characteristics of printed and standard 25 mc i-f circuits

It is believed that such a module represents a considerable saving in critical materials as well as offering a method for more close integration of printed components and methods into receiver manufacture.

SHOP HINT

Protect AC-DC Filaments

Many AC-DC radios of past years have had trouble with frequent filament burn-outs. To prevent this, when such a set has come into the shop, I insert in series with the high side of the AC line (in the filament string only, of course) a resistor of about 50 ohms to limit the initial surge of current which normally takes place when the set is first turned on. The

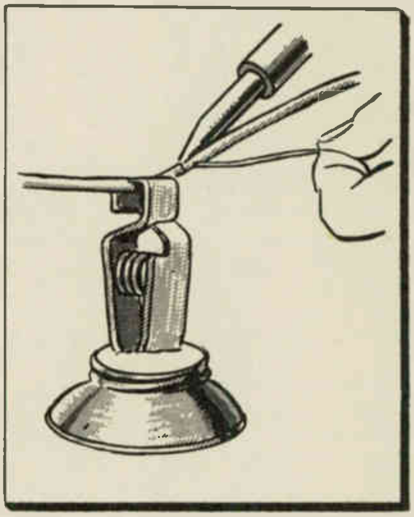


reason this current is so much greater is because the filament resistance when cold is very low, and a great deal of current flows for a few seconds, before warming up, when the resistance rises to its normal fairly high value, limiting the current flow. The resistance during operation totals over 700 ohms, so the extra 50 produces little change in current flow during normal operation, but does serve to limit the initial current and increase the life of the tubes.

The wattage rating of resistors in .150 amp strings (128, 35Z, 50, etc.) is (minimum) 2 watts. Preferable would be 5 watts. In sets using 6 volt tubes, with their 300 ma drain, a 5 watt resistor is minimum, and close. Better use a 10 watter. *A. Westlund, Topeka, Kansas.*

Radioman's Third Hand

A heavy battery clamp which has had the teeth filed down makes a handy small table vise for freeing one hand in doing small soldering jobs, as shown in the drawing. One easy way to mount the clamp is by melting some lead into any metal jar lid, and



letting the lead (or solder) solidify while the end of the battery clamp is held in it. This "third hand" is a good item to carry along in the tool kit for those outside calls, too. *M. Quisenberry, Bucks Radio & Appliance Co., Lexington, Va.*

Repairing GE TV Sets

I have experienced trouble in GE TV sets that could happen in any of the 14C-, 14T-, 16C-, 16T-, 17C- and 17T-models. The characteristics are: no raster, high voltage OK, CRT filament lights, but 1st anode voltage is very low. The remedy is to replace C-311, the .01 coupling condenser feeding the grid of the vertical blanking tube V9A. When shorted, this capacitor can cause a positive voltage to appear on the grid, and the resultant grid current causes the plate voltage to drop. This plate is tied directly to the 1st anode of the CRT, therefore the anode voltage is lowered.—*Melvin Parks, 621 S. Hosmer St., Lansing 12, Mich.*

Direct Drive TV

(*Continued from page* 31)

ing a voltage higher than plus B available. This was used for the 6BG plate, and subsequently at other points in the receiver, such as the vertical oscillator.

In the 630, this boost added about 50 to 75 volts to the plus B. In the direct drive system, due to the relatively high impedance of the yoke, a much larger boost is realized (from 200 to 250 volts). This makes it possible to have available a high plate voltage for the horizontal output tube, the vertical oscillator and the kine G_2 with a lower initial plus B voltage.

As in the 630, a ripple is introduced into the 6BG plate supply by the charging and discharging of the "boost condensers." The linearity coil forms a tuned circuit with these condensers so as to buck out this ripple. Since a certain amount of non-linearity is desired, however (as will be explained in the next paragraph), this circuit is made tunable.

As can be seen in figure 2, the scanning of a (relatively) flatfaced tube results in a situation at the edges of the tube in which the beam travels farther in a given length of time than it would at the center of the tube in the same length of time. This results in non-linearity at the sides of the picture. Actually, the beam is slowed down during its trip across the screen by the resistance of the yoke, so that on a round-faced tube it *wouldn't travel as far* at the right side in a given length of time as it would at the left. These two facts (non-linearity due to flat-faced tubes and non-linearity due to decay of the scanning velocity) tend to buck each other out at the right side of the screen, but are additive at the left.

The linearity control can compensate for this tendency to be non-linear at the left of the picture, by introducing the proper amount of non-linearity by adjustment of the coil slug.

Lest the reader pooh-pooh this contention due to observed results in the field, let us remind him that there are other reasons why the picture may not look at good at the sides as in the middle. Referring again to fig. 2, we can see that if the beam is focussed on the screen in the center, it will focus a little short of the screen at the edges of a flat-faced tube. Furthermore, on a wide-angle tube, there will be some tendency toward an elliptical (rather than round) spot shape at the sides, due to the beam tending to hit the screen a glancing blow. These factors may be and are reported to be corrected in varying degrees by various set manufacturers.

The non-linearity of the picture which was described before as being considerably corrected by the linearity control can also be limited by the use of a so-called "assymetrical" yoke.

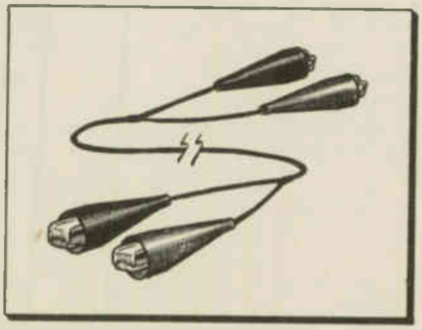
Summing up the advantages of the direct drive system, we find a much more efficient utilization of the energy supplied by the output tube, making it possible to scan large screen, wide angle picture tubes and at the same time supply adequate second anode voltage using the old reliable 6BG6 and *drawing less current* from it than in the 630 (630 plate and screen currents 77 and 11.5 ma., respectively, T164 plate and screen currents 67.9 and 8.1 ma. respectively). At the same time, with a greatly increased B boost due to the efficiency of the circuit, additional conservation in the low voltage power supply is possible.

A footnote to the circuit arrangements of the direct drive system is that, with the yoke connected across the output tube, it is not possible to use DC for centering, as there would be no way to buck it out. Therefore, in order to keep the plate current from decentering the beam, it is blocked out of the yoke with a condenser. Centering is then accomplished mechanically, with the focus magnet.

Tips for Home and Bench Service

Universal Patch Cords

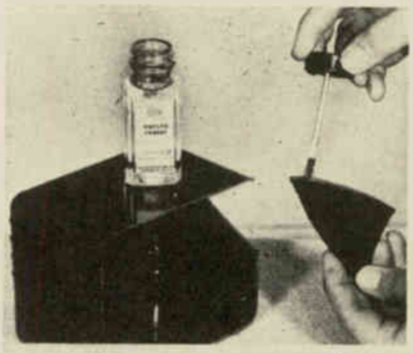
Anyone who has been in the middle of making a test set-up and wanted to connect two units together, and found he had to take time out to make a cable to do the job has wished he had a few patch cords at hand. The properly equipped shop will save several minutes every day always having two or three double patch cords around. These cords require four small battery clamps, four rubber or plastic clamp covers (two black and two red), and about five or six feet of heavy flexible rubber coated wire. The wire is cut into pairs of equal length, taped together every foot or two, and the covers and

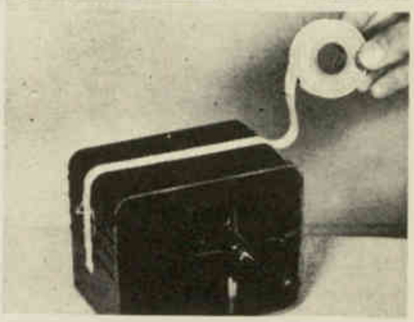


clamps attached at the ends, matching red and black on the same conductors of course so that the patch cords may be used in extending not only AC signals, power, etc., but DC potentials, speaker lines whether grounded on one side or not, etc. *McDonough's TV Service, Rockville Centre, Long Island, New York.*

Cabinet Repairs

Plastic cases of boosters and small radios often become broken. It is possible in many instances to repair these cases to last a considerable time. In the case shown, the broken piece was first coated along the broken edges with Vinylite Cement (made by General

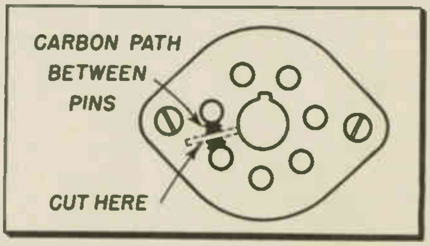




Cement Co.) and then it was firmly placed in original position. Adhesive tape was then used around the entire case to hold the broken piece in place until the cement had set.—*H. Leeper, 1346 Barrett Ct., NW., Canton 3, Ohio.*

Salvage Tube Sockets

More than once I came across octal wafer sockets that broke down between pins. After replacing quite a few over a period of time, I devised the following procedure: Since the breakdown occurs in the form of a carbonization between adjacent pins, an air gap introduced between two pins would be as good an insulator as



can be devised. So I used a key-hole hack saw to cut a slot from the center key of the socket to the space between the pins.

David M. Rice, TV Station WABD,

UHF Converters

(*Continued from page* 35)

carrier in type. TV servicemen should remember this, when they find a converter performing without noticeable microphonics on an intercarrier set, while an identical-type converter attached to a split-sound receiver produces quite audible microphonic effects in picture and sound.

A screwdriver or other adjustment of the oscillator tuned circuit may have to be made in converters or tuners when the UHF oscillator tube is replaced. One series of tests showed that a maximum detuning of 6 MC took place in the oscillator circuit, when a number of identical-make tubes were used to replace the original oscillator. Most of the tubes produced a frequency change of 3 MC or less.

The choice of the first intermediate frequency involves a design compromise. If a high 1st IF is chosen, oscillator radiation through the RF tuned circuit to the antenna will be reduced. Oscillator microphonics will also be cut down. On the other hand, better gain will be realized at a low IF.

The gain of the 1st IF amplifier section is very important, since this is the only part of the UHF tuner or converter which provides a gain. The crystal mixer causes a loss in signal amplitude; so does the preselector circuit. The IF must therefore be low enough to permit adequate gain in the converter or UHF tuner to be attained.

"Gain" is really a misnomer here. If the signal comes out of the converter as strong as it went in, it can pat itself on the back. The converter tends to introduce a signal loss (since the small IF gain may not equal the signal losses in the preceding circuits), and this loss must be minimized.

To keep the noise in the converter as small as possible—a very vital point, since the UHF signal-noise ratio is established in the converter—a cascode (low-noise) IF amplifier is often employed. A 6BK7 is generally found in this section, due to its relatively low cost and favorable noise factor. The dual-triode construction of the 6BK7 makes it possible to economically obtain two stages of IF amplification. Two stages, rather than one, are considered necessary, not only because of the requisite gain they provide, but also because the VHF oscillator is better isolated from the UHF oscillator under these circumstances, preventing undesired interaction between the two.

The bandwidth of the 1st IF amplifier is very broad—approximately 7 MC or more—to allow for mistuning and drift in the UHF oscillator. Designers try to keep the bandwidth as narrow as possible, because higher gain and better attenuation of undesired VHF signals can be obtained with a narrower bandpass. Due to the broad bandpass present, either of the two alternate channels to which the TV receiver may be switched for VHF reception can be selected, without the necessity of retuning the UHF IF circuits.

The IF trimmer or other adjusting device must be reset, however, in cases where it is desired to change the 1st IF. The need for such a change may arise when interference is noted on the VHF channel setting on which converter operation is recommended.

Retuning Converter IF

Let us suppose that the manufacturer has recommended that the converter be operated at Channels 9 or 10. (A choice of two adjacent channels is generally provided because one of these channels is most likely not being used to receive on; the transmission on that channel is very weak in such a case, making the possibility of interference more remote). A VHF station is, let us say, coming in at Channel 9, so 10 is switched in on the VHF receiver. What if interference is present at this setting, as well as at Channel 9 setting?

Channels 8 or 7 may be tried in such a case, provided the 1st IF in the UHF converter or tuner is capable of being suitably retuned to the new frequency range.

Types of interference that can occur when the choice of 1st IF permits them to get through, are worthy of mention. One kind can take place when a harmonic of the VHF oscillator feeds back to the RF circuits. Suppose the desired VHF carrier is 630 MC, and the VHF oscillator is operating at 158 MC. The fourth harmonic of 158 MC is 632 MC. The UHF RF circuits will not reject the interfering signal in such a case, since they are tuned to it.

A similar trouble, called osc-2nd-harmonic image response, can be produced by the beating of the UHF signal against the UHF oscillator signal, *and* the 2nd harmonic of the UHF oscillator signal. Suppose the desired UHF signal is 630 MC, and the oscillator is working at 420 MC, and the 1st IF is 210 MC. The beating of the 630 MC signal with the 420 MC signal will produce the desired 210 MC IF. But the beating of the 630 MC signal against the 2nd harmonic of 420 MC, or 840 MC, will also produce a 210 MC difference frequency. Both the desired and undesired IF signals will be accepted by the 1st IF amplifier, and interference will therefore occur.

The type of interference just described is possible when a channel between 7 and 13 is used for the 1st intermediate frequency.

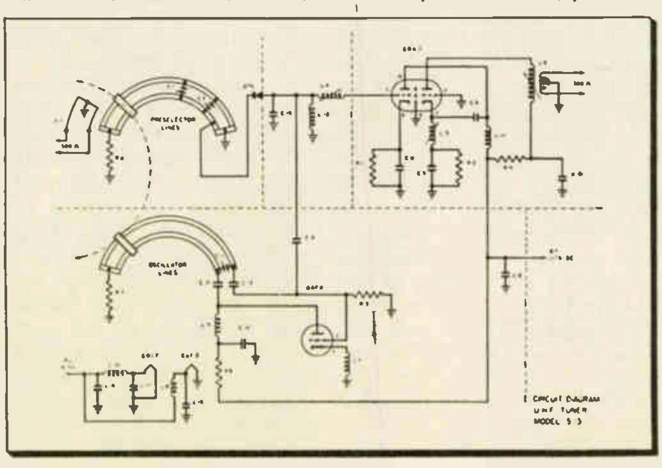
A simple solution that can be tried for the cases of interference cited is the substitution of a different 1st IF. This is done by switching the VHF channel setting, and retuning the IF adjustment on the converter.

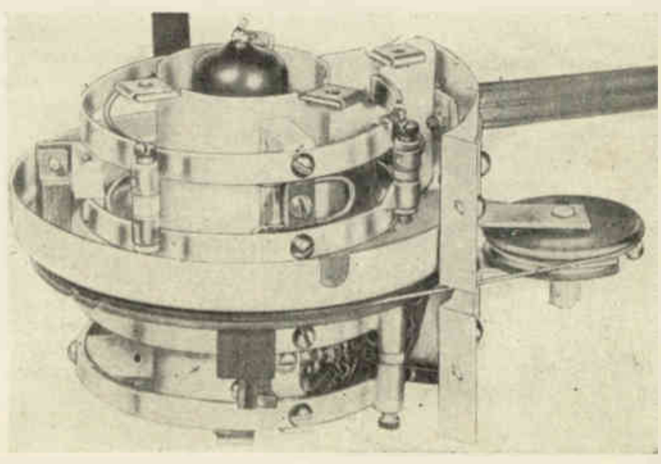
We can now start to consider specific circuits used in UHF conversion devices. The simplest such device is the UHF strip, which is employed in VHF receivers with turret-type tuners.

A strip circuit is shown in fig. 2. It is similar in design to the UHF converter or tuner, except that it omits two stages of IF amplification. The possibility of interference due to the beating of the UHF and VHF oscillator output signals is enhanced by such a design. Radiation of the UHF oscillator is sometimes a problem, due to the absence of sufficient preselection and inadequate shielding of the strips. The signal-noise

(*Continued on page* 48)

Fig. 3—Schematic circuit of the tuner shown in Fig. 4. G7A is the mixer crystal. The 6AF4 is the oscillator. The 6BK7 acts as the IF amplifier. Fig. 4—Top view of UHF Tuner Model 5-3, manufactured by the Kingston Products Corp. The tuner's upper shield has been removed. Note the circulator inductors, the shorting sliders, and the trimmers. The antenna coupling loop is at the rear. The uppermost part of the cascode IF amplifier tube is visible in the center of the tuner. The low noise twin triodes, 6BK7 and 6BQ7, are used in many of the UHF tuners and converters.





How to Interpret AF

Useful Information Can Be Obtained Without Accurate Laboratory Equip-

• It would be a great convenience if we could say that, in making service tests, one would either get the correct result or no result at all. This, unfortunately, is not the case. By making tests the wrong way, or by using the wrong equipment (or defective equipment) it is possible to produce a set of results which bear no resemblance whatsoever to the actual conditions. Or, as they say in the movies, any resemblance to actual persons living or dead is purely coincidental.

In making service tests, extreme accuracy is not so important, but it is important that all the results bear more than a coincidental resemblance to what is going on in the equipment.

Most servicemen learned a long time ago that a meter with 2% accuracy is more than competent to determine the value of a resistor whose accuracy is plus or minus 20% . . . and especially when you're mostly interested in whether it's shorted, open or greatly changed in value. Similarly, when reading DC plate and screen voltages, something near the voltage on the diagram is a pretty good indication that there's no trouble in the circuit.

When reading small DC voltages (such as bias) or AC voltages (AF, RF), a VTVM is indicated, not so much for extreme accuracy as to avoid the loading and detuning effects which are obtained with the usual non-electronic voltmeter, even 20,000 ohms/volt, which like as not will indicate nothing at all on small voltages, especially in high resistance circuits. These effects (loading and detuning) have been amply covered in previous articles, and we won't bother to go into details about it here.

At high frequencies, capacitance becomes important—in the probe, probe leads, probe connections to the circuit, etc.—and special RF probes are indicated. At audio frequencies, however, the writer has found that the common garden variety AC probe associated with the general run of VTVM's is quite adequate.

As a matter of fact, although some RF probes are stated to be usable over such ranges as 20 cps to 200 MC, we have found them to be quite unreliable at audio frequencies. By unreliable, we mean extremely non-linear and non-uniform.

Referring back to our remarks about accuracy, it isn't mandatory that any of your equipment be perfectly linear, but it is important that it produce the same results under the same conditions every time it is used. If it does this, you can then use it with a correction table, much in the same manner that a mariner corrects his compass readings, or a flyer his air-speed indications.

But when the results are extremely non-linear, corrections become cumbersome, and in addition, one is led to suspect that something is wrong with the equipment.

Therefore, naturally, the first thing one should do is to check the equipment which will be used for testing. This means the signal generator, the VTVM and the oscilloscope, if any.

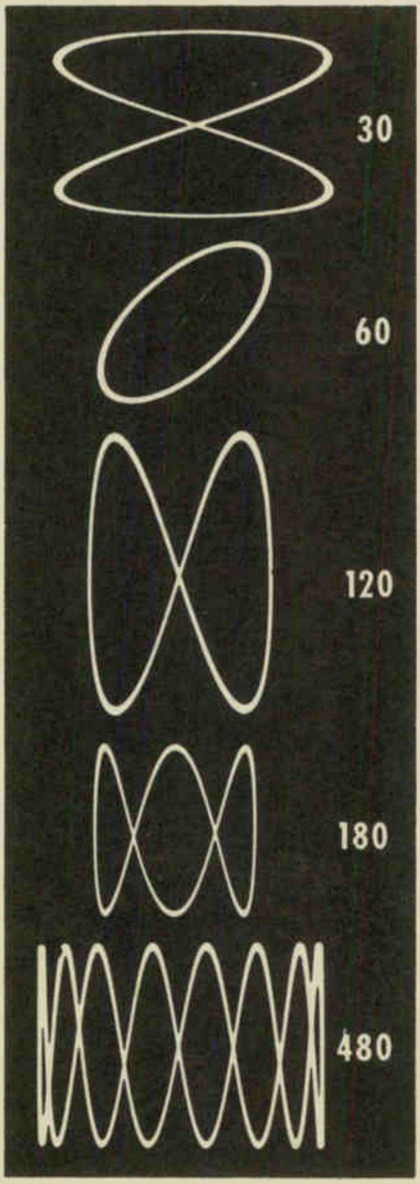
The precise frequency which the generator puts out is not too critical as long as it covers the range you desire, and you use the same check points every time. If you have a fairly good ear for music, you can establish check points by comparing the output of the generator (on earphones) with a known frequency and then marking the harmonics.

Three standards which may be used (and have been used by the writer) are (1) 60 cycle hum, (2) Tuning fork —one can be obtained from a music store for a dollar or less, and (3) the NBS broadcasting station WWV in Washington puts out a 440 cycle tone (A above Middle C), and so do some TV stations with their test patterns.

Once you have the known standard—60 cps, 440 cps, or whatever it may be—you can pick out by ear the octaves of this tone. Each octave above the fundamental is double the frequency of the one preceding it (that is: 60, 120, 240, 480, 960, etc.). These are harmonics, or rather, some of the harmonics. The term "harmonic" means any multiple of the fundamental (that is: 60, 120, 180, 240, 300, 360, etc.).

It is also possible to check frequency by Lissajous figures on an oscilloscope, using 60 cycle AC on the horizontal input and the signal generator on the vertical. Above 480, however, it gets difficult to count the loops. These figures are shown in figure 1.

Fig. 1: Waveforms obtained with 60 cps horizontal input and AF oscillator on vertical, at frequencies indicated.



So much for the frequency, the exact calibration of which, as we said before, is not too important. In making amplitude-vs-frequency measurements with your generator, there are three things which you must consider: (1) the setting of the gain control, (2) the setting of the attenuator, and (3) the resistive termination across which the measurements are taken.

Frequency response and purity of the sine wave output may be affected by the setting of the gain control. On high quality equipment this need not be so, but it's a good idea not to take it for granted without checking. The same thing may be true of the attenuator setting, and the resistive termination.

The latter is the first thing which must be attended to before making any tests. Every generator works most efficiently and effectively when properly terminated in a load equivalent to its internal impedance. The output voltage will, of course, increase with increased load resistance up to a certain point. The open circuit voltage of a generator (or an amplifier) *may* not correlate at all with the output across the proper load with respect to amplitude, linearity and distortion, so this must always be attended to. When testing a power amplifier, the load resistor which is substituted for a voice coil must also be of

Response Measurements

ment But Care Must Be Exercised in Making Tests and Analyzing Results

AUDIO RESPONSE CHECK POINTS

Signal Generator: Is it properly terminated; is it linear at all settings of gain control; is it linear at all settings of attenuator; is it properly matched to the unit under test; is there hum or harmonics in output?

VTVM: Is the response of the voltmeter and its probe linear over the audio range?

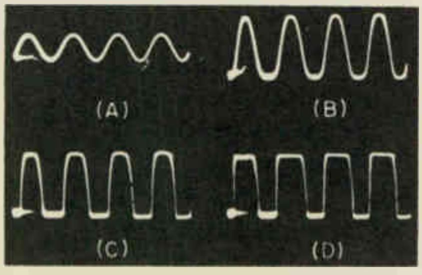
Amplifier: Is proper input being applied to it (no overloading); is it properly loaded on the output side; is there hum or harmonics in output?

adequate wattage to accommodate the output of the amplifier.

If the signal generator does not have an output attenuator (and many of the less expensive ones do not), the technician would do well to install one if he intends to make useful employment of the unit. The reason for this is one of the cardinal points of testing of this type, namely that the input voltage to the unit under test should be proper for its design. If the unit under test is overloaded, the results may be absolutely meaningless.

An example of this is a preamp for a magnetic pickup—or for that matter, any low level input stage. The output of a GE magnetic pickup is about 10 millivolts and the input to the preamp is therefore of that order. Where the output of the signal generator may be anywhere from a volt to 10 volts, the preamp is obviously extremely overloaded. That is to say, with the bias set for small input voltages, the tube will in effect operate with insufficient bias, and saturation, clipping and distortion (production of harmonics, among other things) will occur. You can easily observe this by observing the output of such a stage on a scope. With excessively high input voltages, the output waveform becomes an almost perfect square wave (see fig. 2).

Fig. 2: B, C, D show distortion of sine wave input (A) with too large an input signal. In the extreme (D), squaring of the wave results.—Illustrations from "Encyclopedia on Cathode Ray Oscilloscopes and Their Uses," published by John F. Rider.



Which fact brings us to the generator's gain control setting. In the first place, it may not be possible to reduce the gain sufficiently with the gain control (in the absence of an attenuator, that is). In the second place, the generator may not operate satisfactorily at very low settings of the control.

As an example, the writer one time made a frequency run on an amplifier with a very low gain control setting of the generator. The results obtained were so linear that they were suspect, since the amplifier had compensation circuits which would have precluded such results. The tests were then repeated with an oscilloscope and it was discovered that all the signal generator was putting out at this setting was 60 cycle hum, and therefore the entire "frequency run" was actually done at a single frequency.

The output attenuator, of course, must also be checked at different settings, as mentioned earlier, since such devices are usually frequency sensitive. This is especially true if the attenuator is only a "volume control" type unit. Such a unit reflects different impedances at different settings, and also varying distributed capacitance due to the wiring. A constant impedance T-pad is a better solution.

Not only should the generator be properly terminated, but also the input impedance of the device under test should be properly matched. To connect a low impedance device across a high impedance generator will seriously affect the operation of the generator. To merely mismatch the output of the generator will, of course, affect its output voltage.

Several frequency runs on the generator itself, at different gain settings and different attenuator settings, while tedious, will clear the atmosphere for all future work. The technician will either find that the output of the generator is linear to a useful degree over the main part of its ranges, or else he will find out what allowances must be made for non-linearities in future tests.

There is yet one big "except" to the foregoing statement, which is that the results depend on the reliability of the VTVM. It is highly desirable that some comparative tests be made in order to establish the validity of the VTVM readings. For instance, the same tests can be made with some other meter; or the meter can be tested on some other generator; or the observed readings on the VTVM can be compared with visual results on a scope. Any two sets of readings which were close to being the same would put the technician's mind at rest on this score.

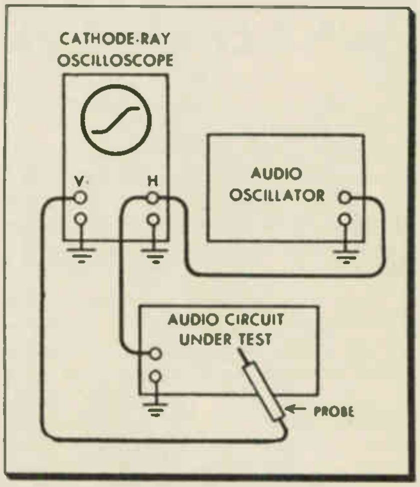


Fig. 3: Arrangement for estimating both frequency and amplitude distortion at a glance, making it easy to monitor oscillator output for uniform input to the device under test.

The usefulness of an oscilloscope for audio testing cannot be overemphasized, for the scope reveals distortion and amplitude at the same moment. As mentioned before, it is practically impossible to tell whether (for instance) the voltage on a meter contains a lot of 60 cycle hum, or whether it contains harmonics, etc. In this respect, the writer recalls a frequency run on a 3 or 4-year-old tape recorder. Fairly good (voltage) output was observed to 10,000 cycles, but when the results were observed by listening to the tape, it was found that above 6000 there was nothing but a wild jumble of whistles and birdies which resulted from intermodulation between the signal input and the bias, which was in that case 20 KC. In

(Continued on page 48)

Audio Response

(*Continued from page 47*)

addition, there was some hum.

The oscilloscope has a very critical eye for such details, on the other hand. When reading amplitude of the trace, it should be remembered, of course, that the trace is a peak-to-peak indication which is 2.83 times RMS readings obtained on the VTVM. It should also be borne in mind that the average VTVM does not respond accurately to non-sinusoidal waveforms, whereas the scope gives a complete picture (depending of course, on its own accuracy) of whatever is put into it. The scope will thus detect distortion in the output of the signal generator as well as distortion introduced by the amplifier under test.

The scope can also be used for square-wave testing, of course, which is a terrific shortcut in audio amplifier checking, since it covers amplitude, frequency and phase all at one time over a fairly wide range.

UHF Converters

(*Continued from page 45*)

ratio for incoming UHF signals may be much poorer (than in UHF converters or tuners). UHF oscillator frequency drift has been observed to be greater, due to lack of suitable drift-compensating units.

There are two strip sections in each UHF strip. One section is made up of the antenna input circuit, a crystal mixer with its tuned circuit, and a 1st IF grid coil. The other strip section contains coils for the 1st IF plate, converter grid and oscillator. (The stages referred to are the VHF receiver's RF amplifier, converter and oscillator, respectively.) An oscillator harmonic generator crystal and its accompanying bias network is also present.

The oscillator crystal generates a fundamental frequency, a harmonic of which is used as the oscillator signal. The UHF signal is fed into the balanced antenna input coil and transformer-coupled into the mixer tuned circuit, where it is mixed with the oscillator signal, causing an IF signal to be produced. This 1st IF signal falls into the section of the spectrum that lies between the low and high VHF bands.

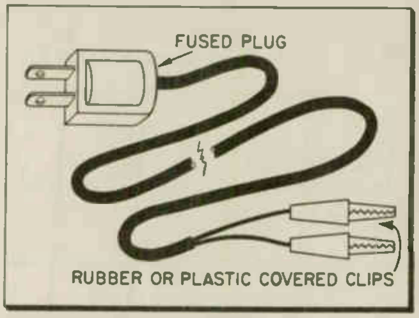
The 1st IF is coupled to the VHF receiver's RF amplifier, and then processed like a conventional VHF signal.

UHF strip circuits have been considerably improved of late, but the circuits employed are, at the time of writing, not available. One strip manufacturer dispenses with a dual conversion system, and converts the UHF signal directly into a 40 MC video IF signal. By switching in suitable tuned circuits, he is enabled to use the VHF oscillator and mixer to amplify the UHF signals.

Shop Shortcuts

Universal Test Cord

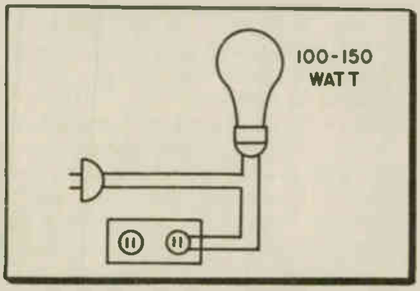
One of the most useful tools around any repair shop is a test cord for the AC supply line. This test cord has fused plug on one end which carries two tubular fuses of 2 to 6 amp. capacity, depending on the equipment to be under test. On the other end it has small alligator clips almost completely covered by rubber



grips to protect the technician from shock and to keep the clips separated when they are used on terminals which are close to each other. This sort of cord can be used as a universal test cord for TV sets, particularly in the case of older sets such as GE, Philco, Emerson, which for some years had an AC interlock receptacle differing from what has now become standard for the industry.—*Arthur Bertram, 247 West 13th St., New York, N. Y.*

Test Lamp Setup

Useful in testing for shorts in radios and other devices, but particularly needed when checking for shorted



power-supply components, this fuse protector lights up brightly on shorts, dully if device is OK. *J. L. Brody, Ab's Radio, Chapel Hill, N. C.*

Tool Keeper

Although you may have "a place for everything" in the way of tools at your service bench, it is very seldom that you keep "everything in its place" when you're busy turning out the work. The result is that when you want a particular tool, you have to stop and turn everything over in an attempt to find it. I have solved this problem by putting the most-often-used ones in a pan or tray where I have them handy for every job. I use a wide bread pan, which works out very nicely. For the contents, I suggest: long nose pliers, cutters, solder, soldering tool, dual blade screwdriver (Philips & Standard), small set-screw driver, ¼" socket, ⅜" socket and flashlight.—*Ralph E. Hahn, 2450 Waukegan Rd., Glenview, Ill.*

Dial Stringing

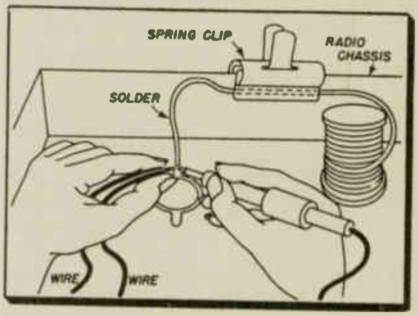
I use an old shoe-button hook to pick up cable and slide it onto reels. For string, I use 24 lb. hard braided nylon fishing line, which I find most satisfactory. Some wax on a large pulley will help hold two cables in place while stringing. To get a good fit, I first string the cable on the shafts of the slide pulleys (will stay in place there better, too) and when I'm finished, I slip it over the pulleys themselves. This makes the cable tight and eliminates "push-pull" dialing. Rubber bands on knob shafts keep string from slipping.—*Beryl Bass, Bass Radio, Lamoni, Iowa.*

Intermittent Noises

Don't bother to examine the TV set or radio in cases where the customer says that walking across the floor causes noise in the receiver. The trouble is in the house wiring, and may be due to grounded electrical feed wires, or lack of a ground for the entire lighting circuit. In some cases it is possible to eliminate the "noise" condition by moving the receiver to another location.

Servicers "Third Hand"

Often on midget radios, it is impossible to make the usual mechanical joint first, before soldering, due to short leads or very tight quarters.



The drawing shows how I use a spring clip as a third hand to hold the solder in exactly the right position.—*J. Amorose, Amorose Radio, Route 4, Hungary Rd., Richmond, Va.*

Phono Groove-Skipping

Before making any adjustments on a phono record changer where the complaint concerns the arm "sliding" across the microgroove record, use a small pocket level to determine whether or not the turntable is tilted. Sometimes it is necessary to raise the rear of the turntable slightly to eliminate "sliding," though, theoretically, it should be perfectly level.—*Ed. Note: Obviously you should do this before removing the changer from console or table cabinet, in the customer's home.*

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TV Receiver Manufacturers Ready

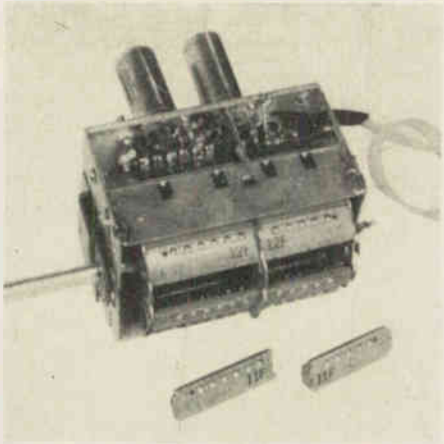
Set makers show FCC and industry engineers various means for adapting

WHILE at Washington the engineers of the FCC and the broadcast stations work to set up a UHF TV allocation (see large chart accompanying this issue of TELE-TECH), the manufacturers of TV sets also have been busy designing conversion devices which will permit present VHF standard TV sets to receive stations in the UHF band.

And although a year or two may elapse before UHF-TV becomes a matter of actual general operation in the United States, the manufacturers well recognize that TV sets going on the market this Fall will be expected to serve their owners for a number of years and so must be simply convertible to receive UHF signals when these do come on the air in 1952, '53 or '54!

Bridgeport Tests

Progress in UHF conversion of standard TV receivers of many makes was high-lighted several weeks ago when the RTMA invited the FCC members and engineers to a demonstration of UHF adapters, held at Bridgeport, Conn., where NBC has an experimental UHF transmitting station in regular operation.



CAPEHART-FARNSWORTH—Using a regular Capehart CX-33 receiver chassis, four miles from the Bridgeport transmitter ultra-high-frequency conversion was accomplished by inserting UHF channel strips in Standard Coil tuner already a part of instrument. Complete Capehart line uses same chassis.

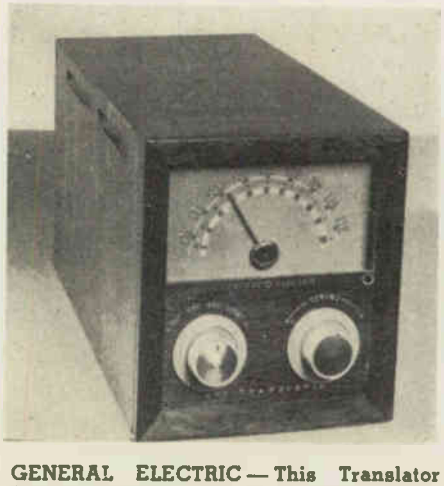
The TV receiver makers had set up their conversion devices in the bedrooms of Bridgeport hotels, about 4 miles from the transmitter, and the Washington officials trooped from room to room, watching the clear, bright UHF pictures received on 529-535 megacycles at 4 miles distance, and comparing these with the same program—snowy and diathermy-ridden—received on VHF channel 4 from New York, 56 miles away.

In this respect, the Bridgeport demonstrations proved almost too convincingly that UHF gives superior results without reception difficulties. For as the manufacturers' experimental engineers vied with each other to bring in perfect UHF reception in the lofty hotel rooms, the non-technical observers did not always stop to think what corresponding quality of UHF reception would be possible in the homes of an average city or town with hills and building obstructions.

Downlead Problems

Difficulties of carrying UHF signals many feet from antenna to chassis were also apparent. One maker had installed a roof-top antenna 25 ft. away but experienced such losses in the down-lead, that a built-in antenna in his converter box gave practically the same effective signal! The tiny UHF antennas of pencil length, however, showed the simplicity of the UHF pick-up problem for direct-view locations. Some UHF antennas were simply stuck up on the wall with adhesive.

CROSLEY—"Ultra tuner" measures 7 x 7 x 9½ in.; attached by screwdriver to receiver. Works with any continuous-tuning TV receiver. One model Ultratuner with self-contained UHF antenna. Installation requires no work on receiver. Covers 122 to 132 megacycle frequency range. Retail price, about $40.



GENERAL ELECTRIC — This Translator (Model UHF-101) has been tested for 18 months in the Bridgeport area and is now in limited production. Below the megacycle numerals there is a logging scale for added convenience in tuning. A travelling dial light spot-illuminates each numeral.

HALLICRAFTERS' new ultra-high-frequency converter operates over a 450- to 900-megacycle range. The output frequency feeds into either Channel 3 or 4 of any present-day television receiver. The Hallicrafters Company also has UHF coil strips available for its turret-type "Dynamic Tuners."

with UHF Conversion Devices

present standard VHF sets to receive programs from future UHF stations.

STROMBERG-CARLSON'S converter, styled in green leatherette and measuring only 8 x 4 x 6 in., uses a 6F4 as a local oscillator, a 6BQ7 as a cascode r-f preamplifier, and a 1N72 germanium crystal mixer. Unit has a 12MC bandwidth and balanced output feeds VHF-TV channels 5 or 6.

To the lay Commissioners, the novel converter container shown by Stromberg-Carlson in the form of a handsome tooled-leather cigar box, attracted special attention, and pointed a possible trend of decorative camouflaging which purchasers may demand, if UHF converters are to be kept on top of their present TV receivers in their living rooms.

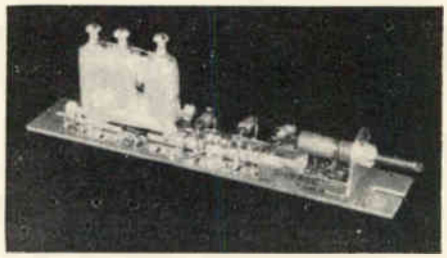
Pictured herewith are a number of UHF converters or translators which have been developed by TV manufacturers for their own receivers or for general use with all or most receivers. Included also are several designs which were not demonstrated at the RTMA-FCC Bridgeport session.

Other Exhibits

In the case of certain converting devices exhibited at Bridgeport, photographs were not released but information as follows was made public at the individual session:

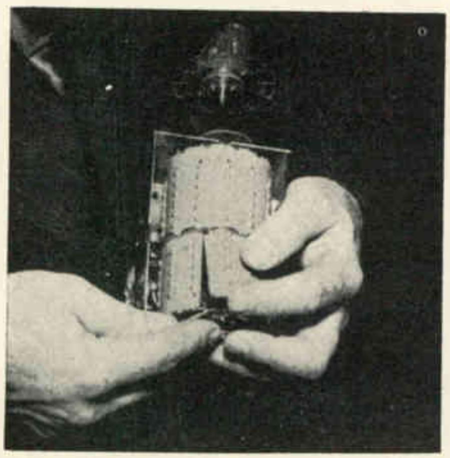
PHILCO—While this company has been experimenting with several types of UHF conversions, it demonstrated at Bridgeport only an external converter with continuous tuning which may be attached to any Philco TV set. This covers the full range of proposed UHF channels and is easily attached. Philco also has its tiny "match-box" single-channel converters which may be made available later, for use under appropriate conditions.

RCA VICTOR—Designed to bring in all UHF channels and suitable for attachment to any television receiver, the RCA converter was shown to give pictures that compare favorably in every respect with VHF reception. On the face of the attractively designed converter are two knobs and an easily read dial. Installation of the converter is sufficiently simple to be performed from an instruction sheet by the average set owner. Retail price, about $50.



ZENITH—During the FCC Bridgeport demonstrations, Zenith engineers showed how a UHF strip (like that pictured) could be slipped into the Zenith tuner in a very few minutes, enabling the standard receiver to operate on UHF without any change in the set itself

MALLORY—Means for converting standard television receivers were demonstrated at the Stratfield Hotel, Bridgeport, and inspected by the FCC party, but photographs and technical details requested by TELE-TECH were not available at press-time.



STANDARD COIL—Simple transfer of strips in tuner, readies any set so equipped, for reception of uhf signals within a few minutes. The two-section strips in effect turn TV set into a double conversion circuit. CK 710 diode is used as converter. Fingers shown belong to Edwin Thias, engineering VP.

TARZIAN—Full-band UT-1 tuning unit for ultra-high-frequency telecasts is adaptable to any set now in use; does not interfere with VHF channels. Self-contained power supply. No electrical changes are necessary in present television sets. Unit may be placed on top of the set or installed inside.

WESTINGHOUSE—With this new UHF converter, the set is capable of receiving all uhf channels, in addition to standard telecasts in the very-high-frequency range. The converter, housed in a mahogany finished wood cabinet, can be easily connected to all Westinghouse television receivers now in use.

Receiving Antennas

Three-year field tests near Washington, D. C. for UHF operation on basis of electrical

By E. O. JOHNSON and J. D. CALLAGHAN

Radio Corporation of America, Camden, N. J.

REQUIREMENTS for the reception of television signals on the UHF band (470 - 890 MC) are much the same in many respects as on the existing VHF band (54 - 216 MC). For the more difficult fringe areas, or locations where reflections are severe, special types of antennas will be needed, just as they are in VHF.

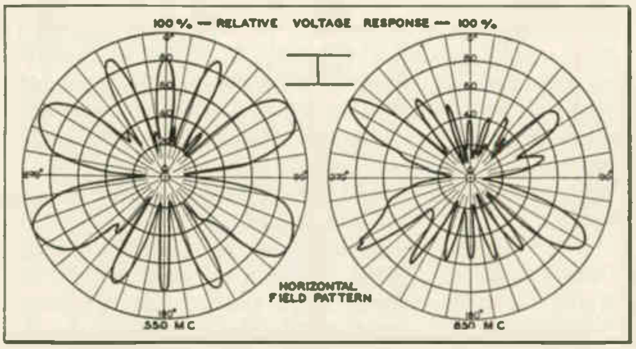
Of the wide variety of special UHF antennas designed and tested during field tests in Washington and Stratford, near Bridgeport, Conn., from 1948 to the present, several types have proved so outstanding in their simplicity, economy, and performance, that it is felt they will find additional widespread use where maximum performance and reliability are primary considerations.

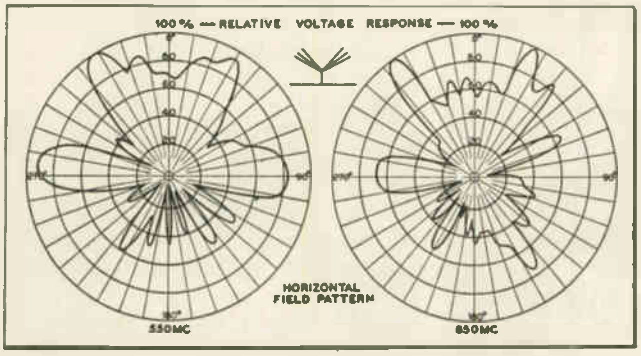
Each of these special types possesses properties peculiar to its individual design, and these types should provide a choice that will meet the requirements of even the most difficult locations.

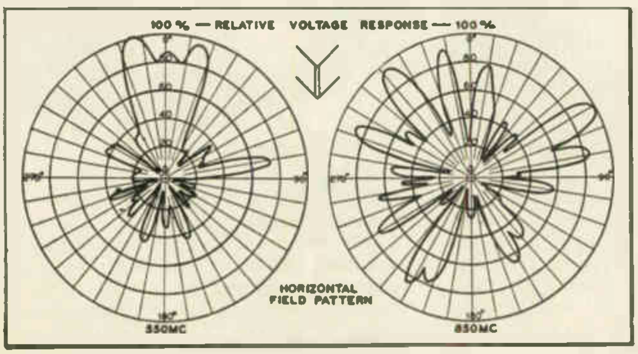
While the factors of performance, size, ease of installation, appearance, strength, cost, and availability of materials must all be considered in UHF antenna design, this discussion will be limited to performance, as determined by the electrical characteristics.

Antenna characteristics are classified here according to gain, directivity, and bandwidth, as follows:

Gain—Antennas may be roughly classed as "low gain" or "high gain," depending on their design for use in strong signal areas or weak signal areas. It should be noted that in all







Figs. 1-3: (Left) Diagrams showing (above) horizontal field patterns for Channel 2 dipole and reflector, (center) VHF fan-type dipole and reflector, (bottom) VHF double V antenna

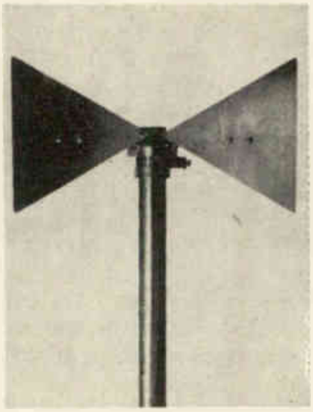


Fig. 4: Fan dipole

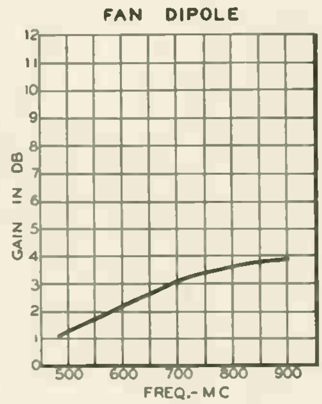
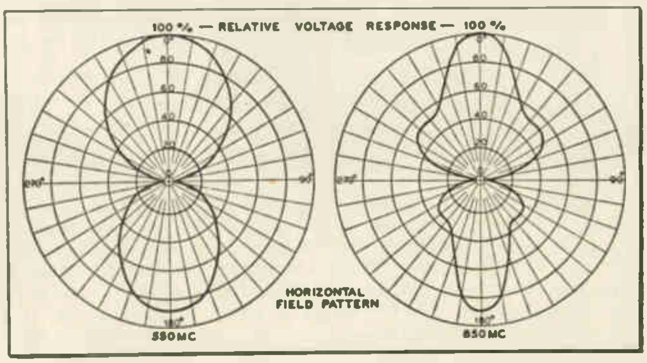


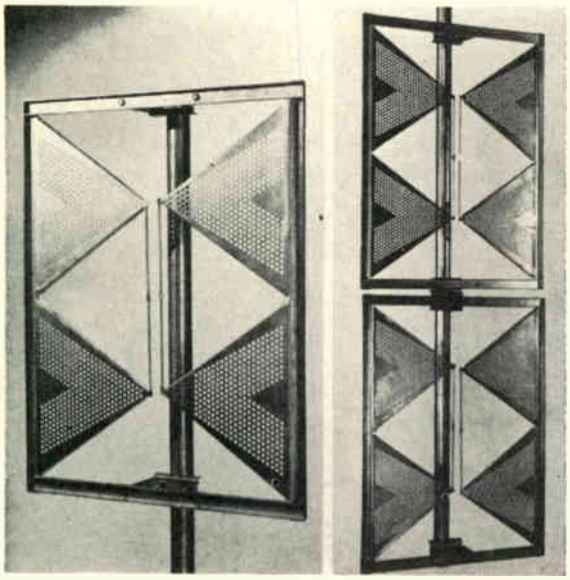
Fig. 5: Fan dipole gain

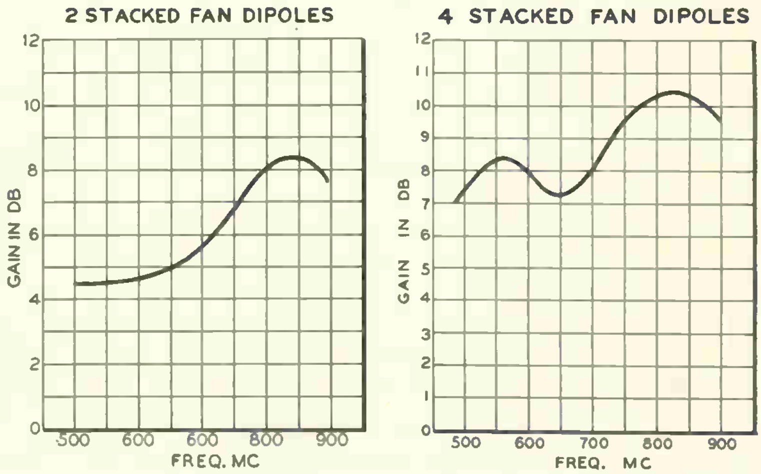
Fig. 6: Horizontal field pattern showing directivity of fan dipole



for UHF Television

and Bridgeport, Conn. reveal antenna types best suited performance, mechanical simplicity, and cost economy





Figs. 7-10: (Left) Physical appearance of two-stacked (left) and four stacked fan dipoles. (Above) Gain vs frequency for the two types

the gain curves shown, the O db reference line is the gain of a thin half-wave dipole adjusted to resonance at each individual frequency. Thus, any given point on the gain curve references the antenna under discussion back to a half-wave-length dipole resonated for that particular frequency. The antennas shown have been designed to work into a balanced 300-ohm line, the gain curves were obtained by using a 300-ohm load at the antenna, and the reference dipole was also matched into 300 ohms.

Directivity—This can vary from the low-gain omni-directional antenna, which receives from all directions, to the highly specialized uni-directional antenna, which has a very narrow angle of reception from one direction only, thus discriminating against unwanted signals. Directivity can be further broken down into horizontal and vertical planes. Horizontal directivity can often be used to great advantage in reducing reflections and multi-path cancellation of signal from objects in directions other than that of the transmitting station. Vertical directivity is often very useful in removing the effects of signal cancellation due to reflection from the earth or other objects either above or below the path between the receiving antenna and the transmitter. This also makes the placement of the antenna less critical. Flutter of signal caused by airplanes is often substantially reduced by an antenna with high vertical directivity. Since high directivity and high gain usually go hand in hand, the so-called "fringe area" type of antenna is very useful in metropolitan areas to eliminate reflections or multi-path conditions.

Bandwidth—Antennas may also be classified as to their bandwidth, i.e., their ability to receive signals efficiently over a wide range of frequencies. Since the UHF spectrum covers 70 television channels, the design of these antennas sometimes seems unconventional when compared to the usual type of antenna designed for single-channel operation.

VHF Antennas at UHF

Most VHF antennas are not very satisfactory at UHF, except in medium and high signal strength areas which are free from reflection problems. Their general UHF characteristics are:

Gain—Low, varying from approximately 10 db below a resonant dipole to 3 db above that of a resonant dipole when they are oriented for maximum response.

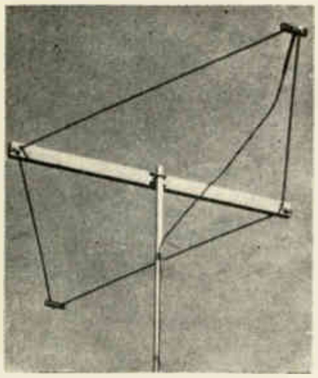
Directivity—Poor in both the horizontal and vertical planes. This is due to the many lobes present and the fact that the major lobe does not usually fall on the axis of the antenna. Figs. 1, 2, and 3 show the horizontal polar patterns of three widely used types of VHF antennas at 550 and 850 MC.

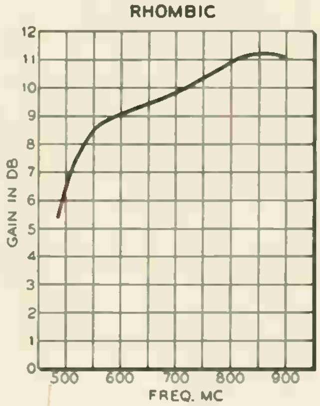
These, as well as other polar patterns in this article, are shown in terms of relative voltage with the maximum lobe being equal to 100%. Because the television receiver is essentially a voltage-sensitive device, signals picked up by any of the minor lobes will appear on the receiver in the same relation as shown on the chart. Polar patterns are sometimes shown in terms of power, which will make the same antenna appear to be more directive. Thus, a minor lobe showing only 10% response in a power plot, will actually be 31.6% in voltage.

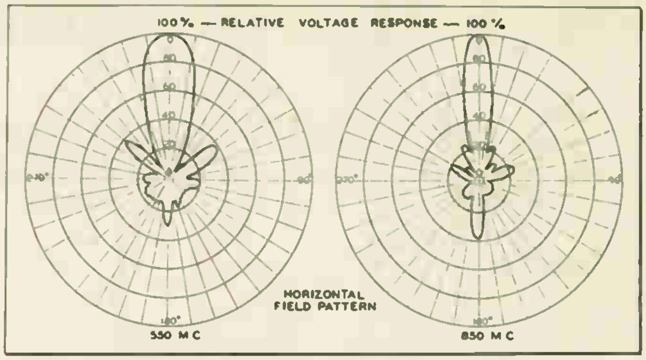
Bandwidth—This is generally adequate, with the gain falling off somewhat toward the high end of the band. A major disadvantage is that the main lobes shift direction with frequency, requiring separate orientation for stations operating on widely separated channels.

Fan Dipole

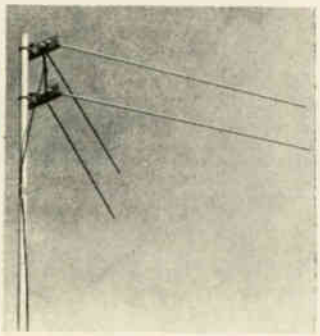
This dipole, shown in Fig. 4, is one of the simplest of all UHF antennas. The antenna is constructed of two triangles of metal, supported

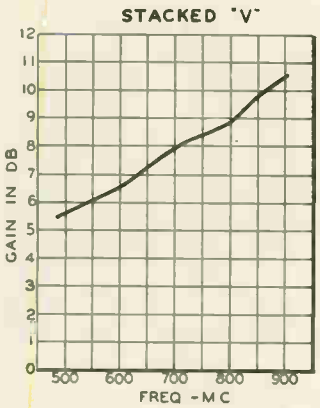


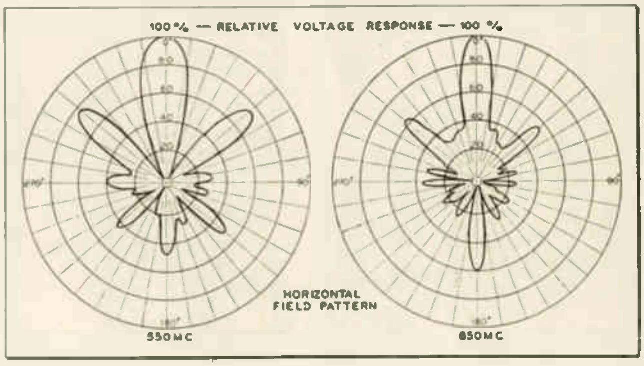




Figs. 11-13: Physical appearance, gain vs frequency curve, and horizontal field pattern directivity for rhombic antenna







Figs. 14-16: Physical appearance, gain vs frequency curve, and horizontal field pattern directivity for stacked "V" antenna

by a suitable insulator. Both triangles lie in the same plane, and the transmission line is attached to each apex. Its characteristics are as follows:

Gain—The gain is shown in Fig. 5. It will be noted that this antenna shows some gain over a half-wave dipole because of its unique construction.

Directivity — Typical directivity patterns are shown in Fig. 6. While a slight front-to-back ratio seems unusual for a dipole antenna, the reduction in response in one direction is caused by the metal mast and mounting support.

Bandwidth—As can be seen from Fig. 5, the bandwidth of the triangular shaped dipoles is excellent.

Stacked Fan Dipoles

The simple fan dipole can be stacked vertically, as shown in Figs. 7 and 8. When properly phased, the gain of the two-stack fan dipole is that shown in Fig. 9, and that of the four-stack fan dipole is that shown in Fig. 10.

This stacking will result in an increase of vetrical directivity, although the horizontal directivity will remain as shown in Fig. 6.

It will be noted that the bandwidth, while still good, is not quite as uniform as that of the single fan dipole. This is mainly due to some frequency selectivity in the individual transmission lines used for phasing the dipoles.

Rhombic Antenna

Rhombic antennas have been built and used very successfully during all the UHF field tests. One of these is illustrated in Fig. 11. These rhombics have been adjusted for unidirectional operation and are usually terminated at the far end with a suitable resistor. The general characteristics are as follows:

Gain—High, as shown in Fig. 12, making this antenna very well suited for fringe area operation.

Directivity—This is also very good, as shown in Fig. 13. It will be noted that the major forward lobe is quite narrow in the horizontal direction, decreasing in width with increasing frequency. While some minor side and back lobes are present, these should give no trouble except in very severe cases of reflections or multipath reception. Although the vertical directivity pattern is not shown, the major lobe in the vertical direction is approximately three times as broad as that shown for the horizontal.

Bandwidth—This is a broad-band type of antenna, showing a rising gain characteristic toward the high-frequency end of the band, which is very desirable.

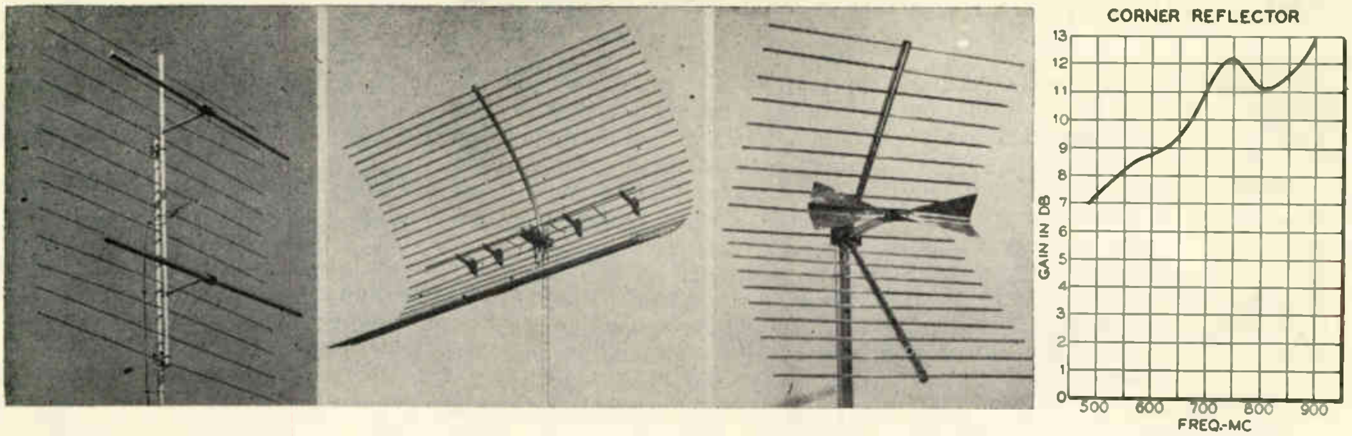
Stacked Rhombics

Two or more of these rhombics can be stacked vertically, one above the other. When two of these antennas are stacked 12 inches apart, the result is an increase in gain of about 2 db across the entire band.

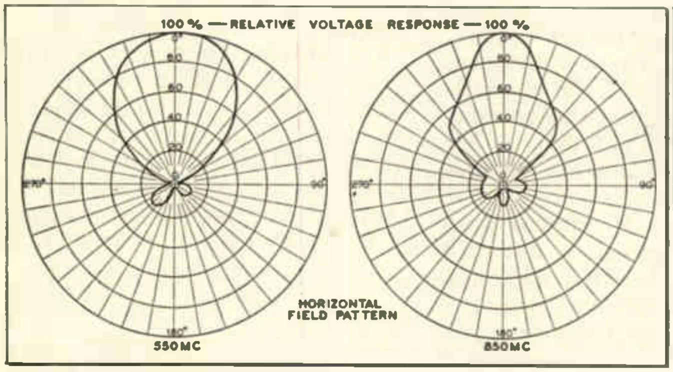
This stacking also increases the vertical directivity, although the horizontal directivity will remain approximately as shown in Fig. 13.

Stacked "V"

Two "V" type antennas stacked one above the other are illustrated in Fig. 14. This combination uses the same rods as a standard dipole made for Channel 2, and thus contains about the same amount of metal as a simple VHF dipole and reflector. It is a very efficient antenna, considering its simplicity of



Figs. 17-20: Sheet reflector-type antennas (l. to r.) Flat sheet, parabolic reflector, and corner reflector with gain vs. frequency curve



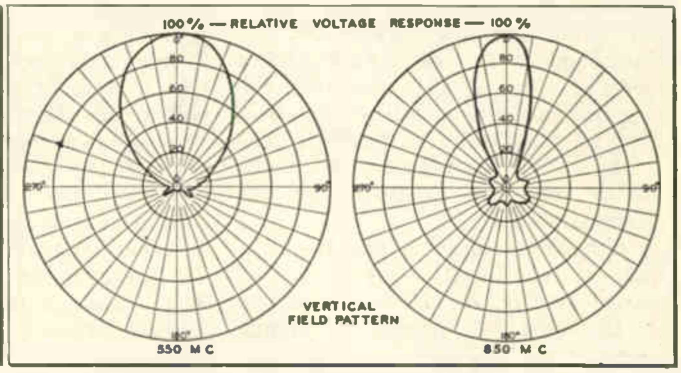


Fig. 21: (Left) Horizontal directivity field pattern for corner reflector. Fig. 22: Vertical directivity field pattern for corner reflector

construction, and is relatively easy to mount on existing masts. It shows the following characteristics:

Gain—This is a relatively high-gain antenna (as shown in Fig. 15) for use in medium and weak signal areas. It also shows an increasing gain characteristic with frequency, which is highly desirable to overcome both propagation and transmission line losses which increase with frequency.

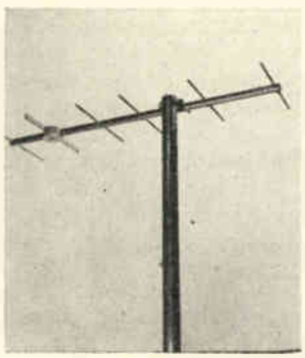
Directivity—The directivity pattern, as shown in Fig. 16, indicates one narrow major lobe, plus multiple secondary lobes. This should be adequate in most areas that are reasonably free of reflections.

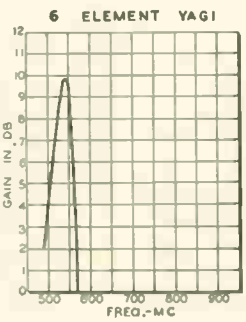
Bandwidth—The bandwidth of this antenna is excellent, covering more than the required frequency spectrum.

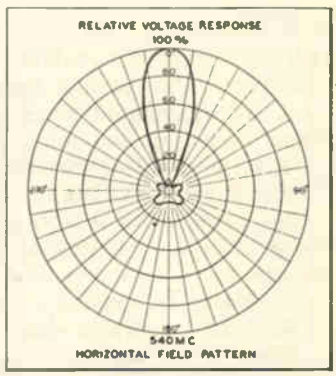
Sheet Reflector Types

Sheet reflector-type antennas, wherein one or more dipoles are arranged in front of a large metallic sheet, have been in use for some time in such applications as radar and micro-wave transmission.

Although they can take many forms, three experimental types are shown here, Fig. 17 showing dipoles arranged ahead of a flat sheet; Fig.

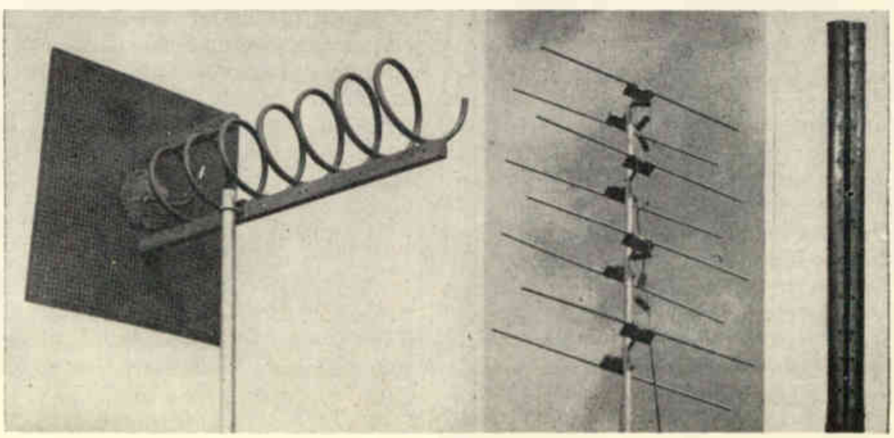






Figs. 23-25: (Left) UHF Yagi, (center) gain vs frequency for 6 element Yagi, (right) horizontal field pattern for latter

Fig. 26: (Left) Helical antenna. Fig. 27 (Center) Stacked dipoles and reflectors
Fig. 28: (Right) Slot type antennas may be used extensively on UHF-TV



18 showing five co-linear dipoles at the focus of a parabolic sheet; and Fig. 19 showing a modified fan dipole of a corner reflector.

While the ideal reflector is a solid sheet of metal, a multiple number of rods or a wire mesh is generally used to reduce wind resistance, ice loading, and weight. This is perfectly satisfactory from an electrical standpoint, provided that the openings in the metal are only a small fraction of a wave length.

Being one of the most compact and highly efficient of the sheet reflector types, the corner reflector has been selected for discussion here. This particular antenna uses a 90° included angle in the corner and a modified type of fan dipole as the antenna element. It will be noted in Fig. 19 that the fan dipole is also folded at 90° to conform to the shape of the reflector. Following are its characteristics:

Gain—This antenna has the ultimate in gain for its compact size, as shown by Fig. 20. It should be one of the best performers in fringe areas.

Directivity—This antenna is also an outstanding performer in directivity, being truly uni-directional. The directivity in the horizontal plane is shown in Fig. 21, and the directivity in the vertical plane in Fig. 22. The almost complete absence of unwanted lobes should reduce reflection and multi-path troubles to an absolute minimum.

Bandwidth—Although the corner reflector antenna is normally considered to be a relatively narrow-bandwidth antenna, the combination of a proper-size reflector and the unique design of the dipole element has resulted in a compact, high-gain antenna which covers the entire UHF spectrum.

Yagi Antennas

The Yagi is a familiar type of high-gain, narrow-bandwidth array which can be equally as useful at UHF as at other frequencies. It produces more gain for its size and weight than any other types of antenna. The mechanical construction of a yagi to operate at these frequencies is very critical, and close dimensional tolerances must be held if its high gain is to be realized. The one illustrated here (Fig. 23) is a six-element, wide-spaced type. At UHF, advantage can be taken of the increased gain afforded by wide spacing without a structure which is prohibitive in size. The antenna shown here has an over-all length of only 28 inches.

Gain—The gain curve is shown in Fig. 24. While this should be adequate for most weak signal installations, still higher gains may be obtained by stacking two or more of these antennas in the conventional manner.

Directivity—The horizontal directivity pattern of this antenna is shown at its resonant frequency in Fig. 25. This is also a very excellent pattern for the elimination of reflections and unwanted signals. The vertical directivity pattern shows only a slightly greater lobe width than the horizontal pattern.

Bandwidth—This is a very narrow bandwidth antenna, showing its peak gain only on the channel for which it is made. It may be noted, however, that a total of seven UHF channels fall within the range of this antenna if a sacrifice in gain of 3 db at either end of the pass band can be tolerated.

Almost any type of antenna used at other frequencies can be designed for operation on the UHF television band. Simple types, such ordinary dipoles, dipoles and reflectors, and combinations of these can be used effectively, although they will not show the broad bandwidth characteristics of the previously described special types. One such array of dipoles and reflectors is shown in Fig. 27.

Also worthy of mentioning are several experimental types which are too cumbersome to use at lower frequencies, but adapt themselves very readily in this portion of the spectrum. They are the helical-type antenna, shown in Fig. 26, and the slot-type antenna, shown in Fig. 28.

Transmission lines are an important part of the receiving antenna system, and many types of lines have been evaluated during the field tests. The best antenna performance can be obtained only by the proper choice and installation of the transmission line. Because of the much greater loss in the flat ribbon types of transmission line under adverse weather conditions, those used with the most success in experimental UHF installation have been Types 2, 3, and 4, in the list below. The 300-ohm tubular line, while better than the flat line under conditions of soot, grime, and moisture, still shows an appreciable increase in loss. The coaxial types are not affected, but naturally have greater initial attenuation. The proper choice of transmission line and its proper installation will provide the same trouble-free service as that obtained on present VHF channels.

	Loss — DB/100 Feet					
	100 MC		500 MC		1,000 MC	
Type	Dry	Wet	Dry	Wet	Dry	Wet
1 Standard 300-Ohm Flat Line	1.2	7.3	3.2	20.0	5.0	30.0
2 Tubular 300-Ohm Line	1.1	2.5	3.0	6.8	4.6	10.0
3 RG 59/U Coax	3.7	—	9.6	—	14.5	—
4 RG 11/U Coax	1.9	—	5.2	—	7.8	—

The antennas discussed above are all of the balanced 300-ohm type. Where it is found desirable to use an unbalanced 75-ohm coaxial transmission line, or where the receiver is designed for 75-ohm unbalanced input, an impedance transformer and balancing network are necessary to couple these two unlike items together. This balancing network is referred to as a balun, and the impedance transformer can be conveniently incorporated in the same structure.

A lightning arrestor is often necessary on UHF as well as on VHF. Lightning arrestors designed for VHF use have proven unsatisfactory at UHF, due to their electrical mismatch and signal loss. The balun incorporates positive lightning protection in its design, without the losses of standard lightning arrestors, provided its case is adequately grounded.

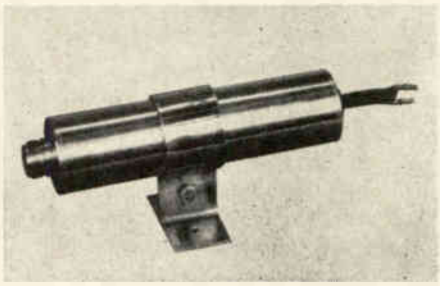


Fig. 29: Balun for matching balanced 300-ohm line to unbalanced 75-ohm coaxial

Typical installation procedure when using 300-ohm line is to install the balun (shown in Fig. 29) on the outside of the building near the entrance point of the transmission line, and to attach a lightning ground to its case. Coaxial line is then run to the 75-ohm input of the receiver.

If coaxial line is used throughout, the balun is installed at the antenna and the shield of the coaxial cable is properly grounded at the entrance to the building.

Naturally, it will be to everyone's advantage to make UHF installations as simple and economical as possible. The approach in adding UHF to present VHF may be to utilize one of the following procedures:

a. Investigate the possibility of using the existing VHF antenna and transmission line—compromising antenna orientation where necessary.

(*Continued on page* 41)

JTAC COLOR TELEVISION SYSTEM COMPARISON TABLE

Tabulation of color TV characteristics and standards, prepared by Joint Technical Advisory Committee for FCC, presents details of competing systems

System	Horiz. Resolution Dots Per Line (5) (6)	Vert. Resolution Number Lines (6)	Product of H and V Resolutions	Frame Flicker		Interline or Interdot Flicker and Crawl (7)		Smoothness of Motion		Color Break-Up (8)	Receiver Changes Needed for Compatibility (12)		
				M	C	M	C	M	C		M (9)	C (10)	Comparison (11)
A1—6-MC Monochrome. 30 Frames. 60 Fields. Present Commercial System.	507	525	266 x 10³	Equal	—	Equal	—	Equal	—	—	—	—	Equal
B1—12-MC Simultaneous Color. 30 Color Pictures. 60 Fields. (1) G = 4MC; R = 1.8 MC; B = 1.4 MC. Like system demonstrated by RCA in 1947. "Mixed Highs" employed.	G 507 B 507 R 507 M 507 (25)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal	Equal	Equal	Equal	No	None	N. F.	Equal (13)
C1—12-MC Field Sequential Color. 24 Color Pictures. 144 Fields. Like system demonstrated by CBS in 1947.	C 528 M 528	C 525 M 525	C 277 M 277	Inf.	Inf.	Equal	Equal	Sup.	Inf.	Yes	N. F.	N. F.	N. A.
C2—6-MC Field Sequential Color. 24 Color Pictures. 144 Fields. Like system demonstrated by CBS in 1949-50	C 275 M 275	C 405 M 405	C 111 M 111	Inf.	Inf.	Equal	Equal	Sup.	Inf.	Yes	a–d	a–c and f–h	Inf. (14)
C2A—6-MC Field Sequental Color. Dot and Line Interlaced. 12 Color Pictures. 144 Fields. Like system demonstrated by CBS to FCC on April 26, 1950.	C 550 M 550(15)(26)	C 405 M 405	C 222 M 222 (15)	Inf.	Inf. (16)	Equal (17)	Equal (17)	Sup.	(18)	(19)	a–d (20)	a–c and f–h	Inf.
C3—6-MC Field Sequential Color. 20 Color Pictures. 240 Fields. (2) Dot and Line Interlaced.	C 420 M 420	C 315 M 315	C 132 M 132	Sup.	Sup.	Equal	Equal	Sup.	Equal	Yes	a–e	a–c and f–h	Inf.
D1—6-MC Line Sequential Color. 30 Color Pictures. 60 Fields. Simple Interlace. Alternate odd lines R, G, B, then alternate even lines R, G, B.	G 507 B 507 R 507 M 507	G 175 B 175 R 175 M 175-525	G 89 B 89 R 89 M 89-266	Equal	Equal	Inf.	Inf.	Equal	Equal	No	None	i	Inf.
D2—6-MC Line Sequential Color. 30 Color Pictures. 60 Fields. Non-interlaced. (3) First Field G, R, G, R, then Second Field G, B, G, B.	C 504 M 504	G 264 R 132 B 132 M 264	G 133 R 67 B 67 M 133	Equal	Inf.	Equal	Inf.	Equal	Inf.	No	None	i	Inf.
D3—6-MC Line Sequential Color. 10 Color Pictures. 60 Fields. Simple Interlace Plus Color Line Commutation. Under development by Color Television, Inc. in 1949-50.	C 507 M 507	C 525 M 525	C 266 M 266	Equal	Equal	Inf.	Inf.	Inf.	Inf.	No	None	i	Inf.
D3A—6-MC Line Sequential Color Line Interlaced with Color Commutation. 10 Color Pictures. 60 Fields. Like system demonstrated by CTI to FCC on May 17, 1950.	C 507 M 507	C 525 M 525	C 266 M 266	Equal	Equal	Inf.	Inf.	Inf.	Inf.	No	None	i	Inf.
E1—6-MC Dot Sequential Color. 15 Color Pictures. 60 Fields. (4) Dot and Line Interlaced. (3) Line Sequence G, R, G, B.	G 254 R 254 B 254 M 254-507 (26)	G 525 R 262 B 262 M 262-525	G 133 R 67 B 67 M 67-266	Equal	Equal	Equal	Inf.	Equal	Equal	No	None	i	Inf.
E2—6-MC Dot Sequential Color. Dot and Line Interlaced. 15 Color Pictures. 60 Fields. "Mixed Highs" like system demonstrated by RCA in 1949-50.	G 507 B 507 R 507 M 507(25)(26)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal (17)	Equal (17)	Equal	Equal	No	None	(21)	(22)
F1—6-MC Frequency-Interlace Color. 30 Color Pictures. 60 Fields. Standard Line Interlace "Mixed Highs" under development by G.E. Co.	G 507 B 507 R 507 M 507(25)(26)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal	Equal	Equal	Equal	No	None	(23)	(24)

LEGEND: M—MONOCHROME (BLACK & WHITE)

C—COLOR	INF.—INFERIOR
G—GREEN	SUP.—SUPERIOR
B—BLUE	N. F.—NOT FEASIBLE
R—RED	N. A.—NOT APPLICABLE

(1) Committee agrees that optimum performance requires less bandwidth for blue and red channel than for green channel. The numbers shown were suggested by RCA.

(2) Interlaced in both directions. Vertically in the usual fashion, horizontally by pulsing the video signal with an 8-mc dot carrier.

(3) Suitable correction is applied for the excess of green.

(4) The video signal is pulsed with an 8-mc dot carrier and the colors are changed at both line and dotting frequencies.

(5) A picture dot is a half cycle of the top frequency of the nominal video band. For example, in present commercial transmission, with a nominal video band of 4 megacycles a picture dot lasts ⅛ microsecond. A scanning line lasts 63.4 microseconds. Hence, the number of picture dots per line is 507.

(6) Blanking times are ignored throughout, because figures are not available for some of the systems.

(7) It is assumed that brightness and viewing distance are such that there is no frame flicker and the scanning lines are just not resolved. It was agreed that for the systems considered, susceptibility to flicker and crawl are not appreciably different. In some different systems, susceptibility to small-area flicker may be different from that to interline crawl. For system D1, there will be an increased tendency for interline flicker because of the assignment of a specific line to a specific color.

(8) In systems C1, C2 and C3, longer persistence phosphors, as used in the all-electronic receiver, have almost eliminated color break-up.

(9) To allow present receivers to receive color transmissions in monochrome.

(Continued on page 48)

Recent Developments

A review of the semi-conductor junction types feature small

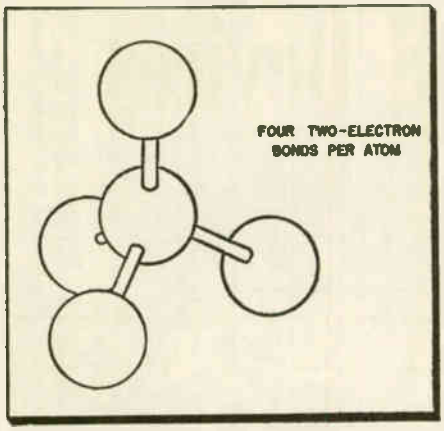


Fig. 1: In a perfect insulator electrons are tied up in interatomic bonds and cannot participate in conduction

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Power Transistors Soon?

Important new developments in germanium diode manufacturing techniques have resulted in a design suitable for ac power rectification purposes. These new diodes are reported to have ratings of approximately 350 ma at 130 volts r.m.s., and as such, as capable of providing dc power requirements of the average television receiver, (General Electric type G-10).

Research in this field, accentuated by shortages of selenium, is speedily going forward with a view towards the ultimate development of types capable of handling 2-10 amperes of current. If this can be achieved, new forward steps might well lead to the development of power transistors. In turn, the availability of power transistor types would truly make germanium semi-conductors a direct substitute for vacuum tubes. With the added features of simplicity, long-life, ruggedness, and greater power conversion efficiency, their extensive application in future designs of both receivers and transmitters becomes a certainty.—*Editors.*

THE art of making semiconductor devices is slowly becoming a science. Fundamental studies of the origin, nature, and behaviour of p-n junctions in semiconducting materials have charted paths for this transition. This article may be regarded as a progress report along one of the paths of this development from art to science.

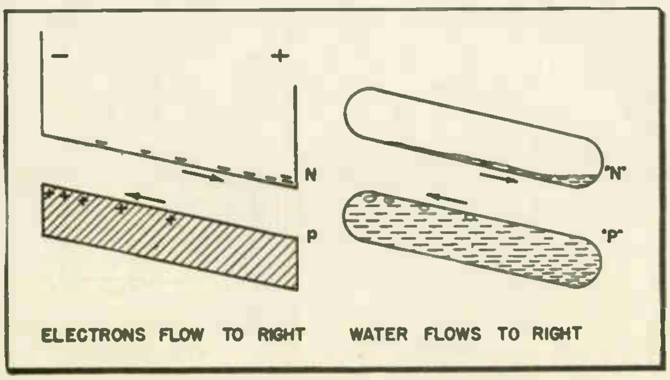
One of the first fruits of the scientific approach to semiconductor work has been the development of the transistor. Let us compare the new p-n junction transistors to the earlier types, and make some guesses as to the extent of future applications. In order to make educated guesses, a physical picture of some of the electronic processes which take place within semiconductors and which determine their properties, will be briefly outlined.

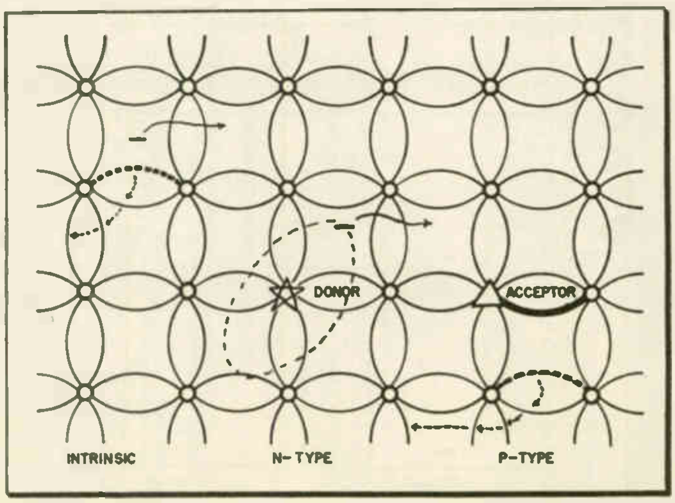
This picture will not be complete or fully accurate as to detail, but will give an essentially correct concept of why these devices work.

A semiconductor has certain electronic properties intermediate between those of metals and insulators. In defining these it is to be noted that metal contains a number of so-called "free" electrons, whereas a perfect insulator has none. All of the electrons in a perfect insulator are tied up in interatomic bonds and cannot participate in conduction (Fig. 1). Conduction is possible, however, at high temperatures when a few electrons are thermally excited. At these temperatures the elec-

Fig. 2: Two conduction processes

Fig. 3: (right) Conduction centers





in Transistors and Related Devices

characteristics and their applications in transistors. New p-n-p size, high gain, low noise, high efficiency and improved stability

trons are torn loose from their bonds and can move about and conduct electricity. The heated insulator has now become what is termed an intrinsic semiconductor. There is no sharp distinction between insulators and intrinsic semiconductors. If the electronic bonds are easily broken, then a noticeable amount of conduction will take place even at room temperature, and the material is called a semiconductor.

Two Conductivity Processes

In reality, two conductivity processes take place simultaneously in an intrinsic semiconductor as shown in Fig. 2. If an electric field is impressed on the semiconductor, electrons will flow from left-to-right in the conduction band, just as the liquid will flow along the bottom of the nearly empty tube when tilted. This type of conduction is called n-type conduction.

Neighboring electrons in the filled band, however, also can jump into the vacancy left by a flowing electron thus leaving new vacancies elsewhere. As the electrons fill up vacancies they drift from left-to-right, the holes move right-to-left, just as the bubbles in the nearly filled tube move right to left when liquid is really flowing left to right. Since the holes move in the opposite direction to that of the electron in an electric field, they can be regarded for some purposes as + charges. This is called p-type conduction.

Another source of holes and electrons are impurity atoms. Atoms with 5 valence electrons, i.e., with one extra valence electron (these atoms are called donors) may enter the lattice substitutionally and contribute to n-type conduction as shown in Fig. 3. Correspondingly, lattice defects or impurity atoms (called acceptors) with only 3 valence electrons instead of Germanium's four can trap electrons, leaving unsatisfied bonds, or "holes", nearby which can contribute to p-type conduction. All these conduction processes are important in germanium. When conduction is principally by conduction-band electrons, a semiconductor is called n-type; when it is principally by holes, it is called p-type. When n- and p-type regions occur in the same crystal, the boundary between the p-type and n-type materials is called a p-n junction.

A p-n junction itself comprises a rectifier which operates roughly as sketched in Fig. 4, where for simplicity the only charges shown are those contributing to conduction: If the p-region is made positive, the holes move right-to-left, electrons move left-to-right. They move toward each other and recombine. The forward voltage need only be enough to keep this current going. If p-region is made negative and the n-region positive, then holes and electrons move away from each other. The region between has its movable charges removed and thereby becomes an insulator.

The back current should be composed mainly of hole-electron pairs

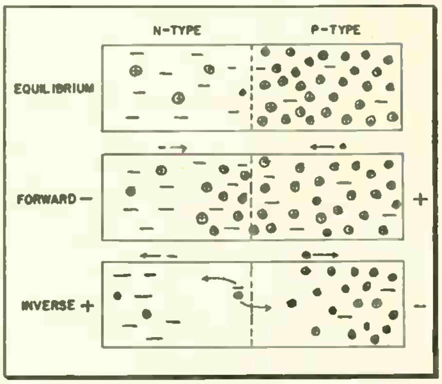


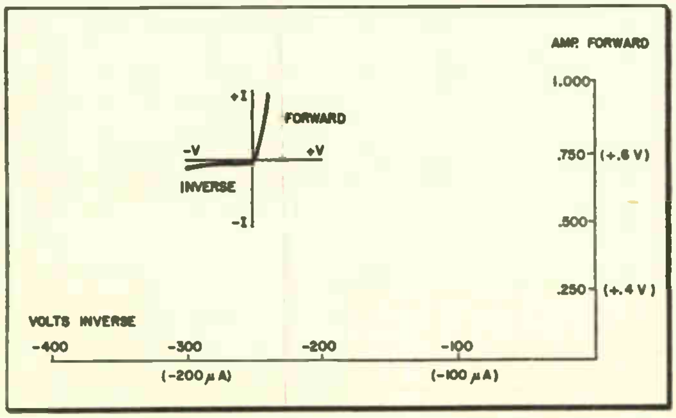
Fig. 4: Rectification by a P-N Junction

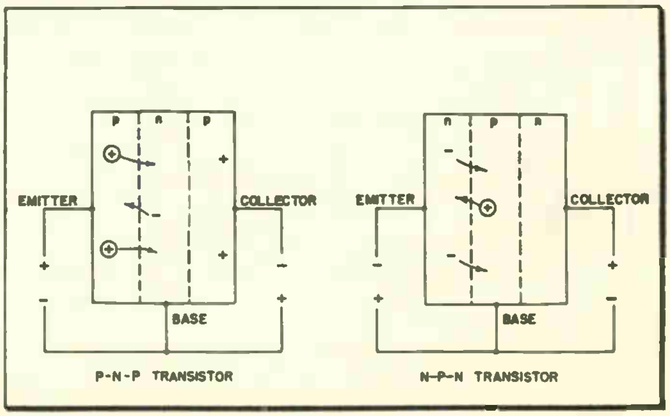
created thermally in this region and should be expected to increase rapidly with temperature.

Diffusing Impurities

At GE a process for diffusing donor and acceptor impurities into germanium so that n-p junctions can be produced at will has been developed. This process is described by Hall and Dunlap of the General Electric Research Laboratory ("Physical Review", Nov. 1, 1950). Characteristics for a typical rectifier made in this way appear in Fig. 5. Similar units have been made which will withstand inverse potentials greater than 700 volts, drawing less than two milliamperes leakage current. These units can be broken down repeatedly by high inverse voltage without permanent damage. The peak current densities in the forward direction are of the order of

Fig. 5: (left) E-I characteristics in diffused P-N junction germanium rectifier. Fig. 6: (right) P-N junction transistors





DEVELOPMENTS IN TRANSISTORS

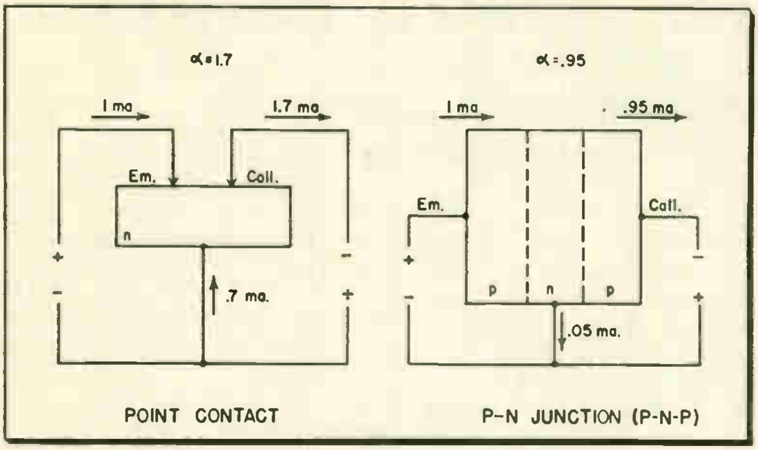


Fig. 7: Comparison of transistors

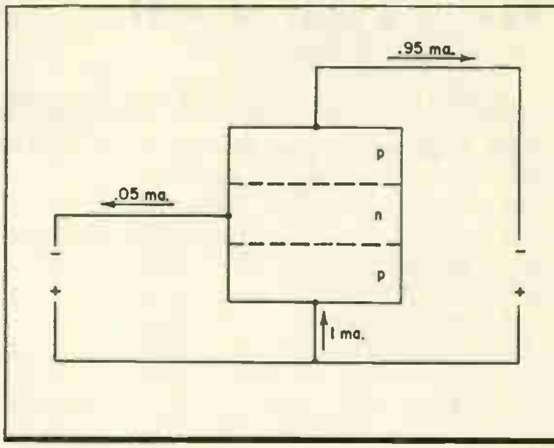


Fig. 8: Circuit current gain $\alpha/(1\text{-}\alpha)$

hundreds of amperes per square cm. and the efficiency of these diffused rectifiers is better than 99%. This compares to efficiencies in the 80's for tubes, in the 70's for selenium rectifiers.

Barrier Layer

The p-n junction transistor is a logical consequence of the single p-n junction rectifier. Returning to Fig. 4, note that a p-n junction rectifies by the virtue of a barrier layer which is non-conducting only because there are no carriers in it. If the barrier is thought of as a hindrance to current flow, this hindrance is more analogous to a desert than to a mountain. When carriers are introduced into the barrier region, conduction does take place. One way to introduce carriers is to heat up the device. This however, is not an easily controllable method. Another way is to shine light upon the junction. This can photo-electrically excite hole-electron pairs. A family of photo diodes or photo transistors using this mechanism has come into being. The control method most applicable to electronic circuits, however, is injection of carriers by conduction through a p-n junction.

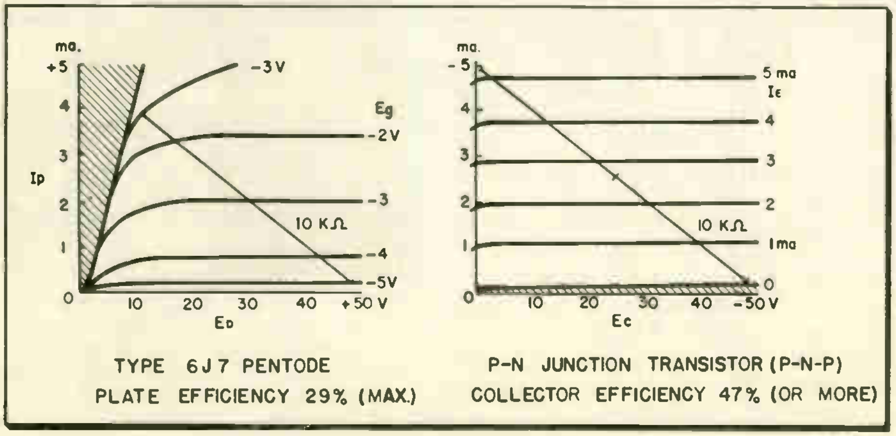
By a process developed in the Electronics Laboratory of General Electric, based on the diffusion process mentioned above, two p-n junctions are arranged back to back in a single crystal of G_e as shown in Fig. 6. This particular transistor consists of a sandwich of two p-type regions separated by an n-type region. Separate electrical contacts are made to each region. Two diodes are thus formed, back to back. The right-hand diode will be operated in the inverse direction. The left one will be operated in the forward direction, in which hole and electrons flow toward each other. Some of the current flowing across the left p-n junction is in the form of electron flow to the left, some consists of holes moving to the right. In particular, if there is a greater density of holes in the p-type region than of conduction electrons in the n-type region, most of the current crossing the barrier will be in the form of holes. The p-n junction is not a barrier for holes moving from left to right, and most of these injected holes can reach the collector and appear as current in the collector circuit. To put it very simply, the leakage current through the right hand junction has been increased by hole injection through the left hand junction. The ratio of changes in collector current to the changes in emitter current is called alpha. If the collector current were injected 100% as holes, and if none of these recombined with electrons before reaching the collector, alpha would be unity. In practice, however, alpha is never quite unity.

The n-p-n junction transistors operate in a corresponding way shown on the other sketch in Fig. 6. In this case, the emitter injects electrons into the p-type base material, and these electrons are collected by the positively biased collector.

Operating Principles

At this point, a comparison in operating principles with the older point contact transistors is in order. Fig. 7 shows them side by side. In the point contact transistor, as in the new p-n-p types, the emitter injects holes into n-type germanium, and these holes appear in the barrier region of an inverse biased rectifier. In the case of the point contact transistor, however, there is a physical multiplying effect, resulting in more current being collected than was originally emitted, 1.7 times as much for a typical unit, (i.e., alpha = 1.7). Herein lies the fundamental distinction between the two types. The new p-n-p or n-p-n junction transistors have alpha less than unity. When alpha is greater than unity as in the point contact transistors, the base current may reverse

Fig. 9: Curves of Class A efficiency,—tubes vs transistors



direction, and circuit impedances can become negative, leading to short circuit instability. But the new units with alpha less than unity are completely free of this short circuit instability.

It would seem, at first thought, that high alpha would be an advantage, but high current gain in a circuit can be achieved with alpha less than unity. For example, the base current is small in the new transistors so that we may connect the transistor as shown in Fig. 8 with the signal applied to the base electrode. In this case the output signal current change is about 19 times the input original current change. The value .95 is not to be taken as an upper limit. Higher alpha p-n-p transistors have been made. Circuit current gain increases rapidly as alpha approaches unity and, for example, if alpha equals .99 the circuit current gain is 99.

The above remarks are hypothetical and predict certain general characteristics. Next, the actual physical realization of units with these highly desirable characteristics will be described.

Acceptor impurities are diffused into corresponding regions on opposite sides of a thin wafer of n-type germanium, forming a p-n-p sandwich as described above. A number of n-p-n transistors have also been made by diffusing donor impurities into p-type germanium, but all the results given here apply to the p-n-p units with which there is more experience.

At this point, it would be well to outline a summary of the salient features of these new transistors for comparison with the point contact transistors and with vacuum tubes.

1. SIZE: The new transistors can be completely enclosed in a plastic bead less than ¼ inch in diameter. They are much smaller than the tiniest subminiature vacuum tube. How much smaller they can be made depends largely on assembly techniques. There seems to be no fundamental limit in size.

2. POWER ECONOMY: Like the older transistors, the new p-n junction transistors require no filament power at all. They respond instantly when switched on and require no standby power to keep them warmed up.

The efficiency may be compared with the vacuum tubes by reference to Fig. 9, where the shadded areas may be regarded as inaccessible to voltage swings. To obtain the maximum theoretically possible Class A efficiency of 50% in a tube, it would be necessary to be able to operate the tube down to zero plate voltage, and to be able to swing the grid to complete cutoff. For the type 6J7 pentode, with the plate supply voltage and load resistance shown, the maximum efficiency is 29%. The new transistors can operate down below one volt on the collector without serious distortion, and can approach close to the theoretical maximum Class A efficiency of 50%.

3. HIGH GAIN: Power gains on the order of 40 db stage have been measured using matched impedances. Direct coupling of stages is possible with good gain. Maximum utilization of these devices requires a reexamination of circuit theory from a new point of view. The gain depends, in any case, upon the equivalent circuit parameters, and further development of desirable parameters assures even higher gains as development proceeds.

4. STABILITY: Since alpha is always less than unity, p-n junction transistors are entirely free of the short circuit instability which plagued the point contact transistor.

5. LOW NOISE: Quantitative studies of large numbers of units remain to be made, but preliminary data indicate these units are several orders of magnitude quieter than point contact transistors.

6. WIDE POWER RANGE: These units are efficiently usable in the microwatt power dissipation range. Units provided with more area for heat dissipation have been operated continuously above 1 watt. The upper limit of power dissipation on these units has not yet been established.

7. RUGGEDNESS: When properly encased in a plastic bead, these units are mechanically very sturdy.

8. FREQUENCY RESPONSE: P-N Junction transistors have full gain at audio frequencies. They have a usable amount of gain at radio frequencies, depending upon the circuitry used. The upper limit of high frequency response is a complicated function of collector capacitance, transit time, and other effects. Since each upward extension of the frequency range can open new fields of application, high frequency studies will naturally be an important phase of future developments.

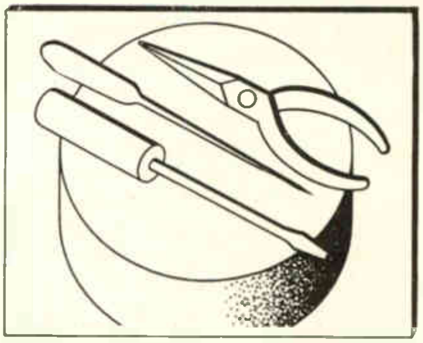
9. SIMPLICITY: An outstanding feature of the new transistor is the simplicity of construction. There is no heater to burn out, no cathode to deteriorate, no wire grids to vibrate microphonically. There is nothing to wear out. The heart of the transistor is simply a piece of Germanium with three wires firmly attached.

To what extent it will be possible to replace vacuum tubes by transistors remains to be seen. For one thing, it is not a mere matter of replacement in existing vacuum tube circuits. Circuits must be redesigned to take advantage of the characteristics of p-n junction transistors. But wherever space, power dissipation, and ruggedness are important, transistors will be called upon to serve. Their development is still in its infancy, but the results already obtained are very encouraging. As the making of semiconductor devices becomes less and less of an art, and more and more of a science, continuous improvements may confidently be expected.

SHOP HINTS

Small Tool Holder

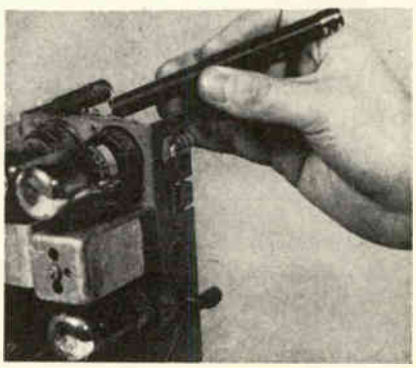
Take a magnet from an old PM speaker (or a couple of them), put it on the front of a test instrument or steel drawer, and park your small tools thereon: those miniature phono needle screwdrivers, scribers, etc. They'll be



out in plain sight, easy to grab, and not buried down in the bottom of a tool drawer or box.—*F. C. Hoffman, Radio Doctor, 309 Harrison St., Kewaunee, Wisconsin.*

Checking Condensers

Tubular condensers which intermittently open or short are often located by pulling or twisting the condenser leads. Such checking is more easily and safely done by use of a fiber align-



ing tool having a slot in one end. The slotted end may be slipped over the bare condenser wire and twisted without danger of shock.—*H. Leeper, 1346 Barrett Ct., N.W., Canton 3, Ohio.*

Heater-Induced Hum

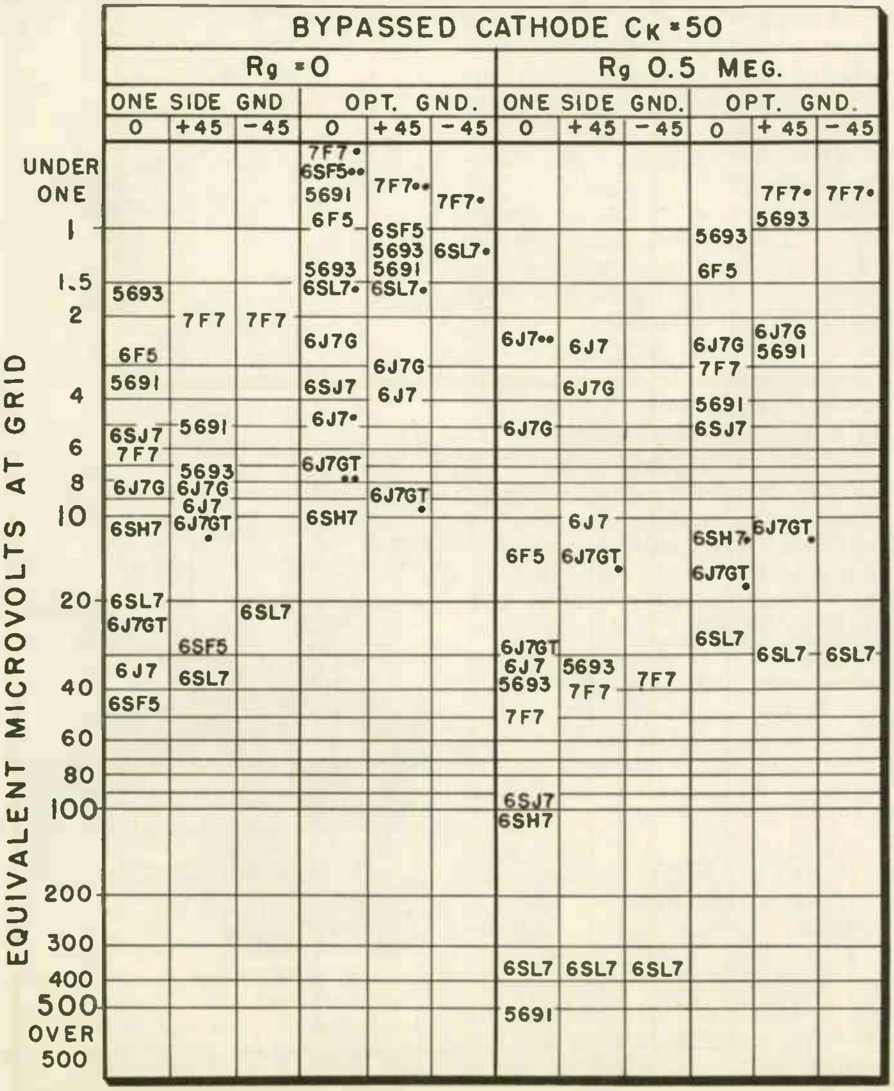
60-cycle hum in eleven different tube types are catalogued for bypassed and unbypassed cathode conditions

BY suitable choices of tubes and circuitry, heater induced 60-cycle hum in ac operated low-level amplifiers can be reduced to less than 1 microvolt. Less fortunate tube and circuit combinations may give heater-hum levels of more than 500 microvolts.

These are conclusions of a limited investigation of heater hum recently made at the National Bureau of Standards and the study has yielded useful practical data for designing such amplifiers. Emphasis was on cataloguing heater hum characteristics of various tubes and circuit arrangements, rather than on investigating the causes of the hum.

Eleven tube types, in various circuit arrangements, have been studied so far. Included were single triodes 6F5 and 6SF5; dual triodes 6SL7, 7F7, and 5691; and pentodes 6J7, 6J7G, 6J7GT, 6SJ7, 5693, and 6SH7. In general, only 4 to 6 tubes of each type were checked, although tubes of several manufacturers were included wherever possible. Data were discarded for occasional individual tubes which, in showing wide deviations from the mean, were not believed representative.

Fig. 1: Levels of heater-induced hum in eleven tube types with bypassed cathodes in various amplifier arrangements. Vertical position of the tube on the chart indicates 60 cycle hum in equivalent microvolts at grid for several circuit variations



Circuits were varied with respect to cathode bypass capacitance, heater return tie point, heater return potential, and grid circuit resistance. The cathode resistor was either bypassed with a 50 μf capacitor or left unbypassed. Input grid resistance was either zero or 0.5 megohm. The heater return was either to one side of the heater, or through the adjustable arm of a 100-ohm potentiometer placed across the heater supply and adjusted for minimum 60-cycle output. Heater return potential was either to ground, to 45 volts positive, or to 45 volts negative. Hum measurements were made with various combinations of these circuit variations.

In the test set-up, the 60-, 120-, and 180-cycle hum components of the output of the amplifier under study were measured on a vacuum-tube volt-meter, using appropriate amplification and filtering. At the same time, wave form was observed on a cathode-ray oscilloscope. Gain was measured by applying a known signal to the grid of the test amplifier; hum level could then be expressed in terms of equivalent microvolts at the grid. Provision was made for switching from ac to dc heater supply for calibration and comparison.

To obtain the desired measurements of heater-induced hum, external ac hum was reduced to a negligible value, using recognized shielding precautions; heater leads were twisted and shielded and kept away from the grid circuit, which was also shielded.

Circuit components were based on median values given in manufacturer's manuals. Preliminary checks indicated that hum is not significantly affected by the usual variations in components—plate, screen, and cathode resistors, and cathode and screen bypass capacitors—required to match different load impedances.

The most hum-free amplifiers investigated so far at NBS used either of several triodes (6F5, 6SF5, 7F7, or 5691) or a pentode (5693), in a circuit including bypassed cathode, heater grounded through an adjustable potentiometer, and low grid impedance. Wide hum differences were found for different tube types, as well as for different circuit arrange-

in Audio Amplifiers

ments. Apparently, however, the 60-cycle equivalent input hum of almost any tube type tested, whether triode or pentode, can be reduced to 10 microvolts by suitable circuitry; and all of the triodes tested could be brought below 2 microvolts.

The NBS figures are for the 60-cycle components alone and are therefore not fully comparable with figures given in the literature, which generally include harmonics. The 60-cycle components were measured because of their importance in low-level power-frequency amplifiers, often required in instrumentation applications. Some of the low 60-cycle values measured at NBS were accompanied by harmonics no greater or even substantially less than the 60-cycle figure; in other instances the harmonics were many times greater than the 60-cycle component.

The general effects of the circuit variations were not unexpected. Without the cathode bypass condenser, hum was of course much greater; a sufficiently large bypass capacitor is obviously desirable for all low-hum applications. Return of the heater circuit through an adjustable potentiometer connected across the heater supply, when adjustment was optimum, reduced the hum to as little as 1/20 or even 1/50 of the initial value. Returning the heater circuit through 45 volts, either positive or negative but preferably positive, reduced hum somewhat in most cases. Increased grid circuit resistance tended to give greater hum in triodes, while in pentodes hum in general either showed no change or else decreased with increased resistance.

1. "Low Noise Miniature Pentode for Audio Amplifier Service", D. P. Heacock and R. A. Wissolik. TELE-TECH, Vol. 10, No. 2, Feb. 1951.
2. "Controlling Hum in Audio Amplifiers", L. T. Fleming (NBS). Radio and Television News, Nov. 1950, p. 55.

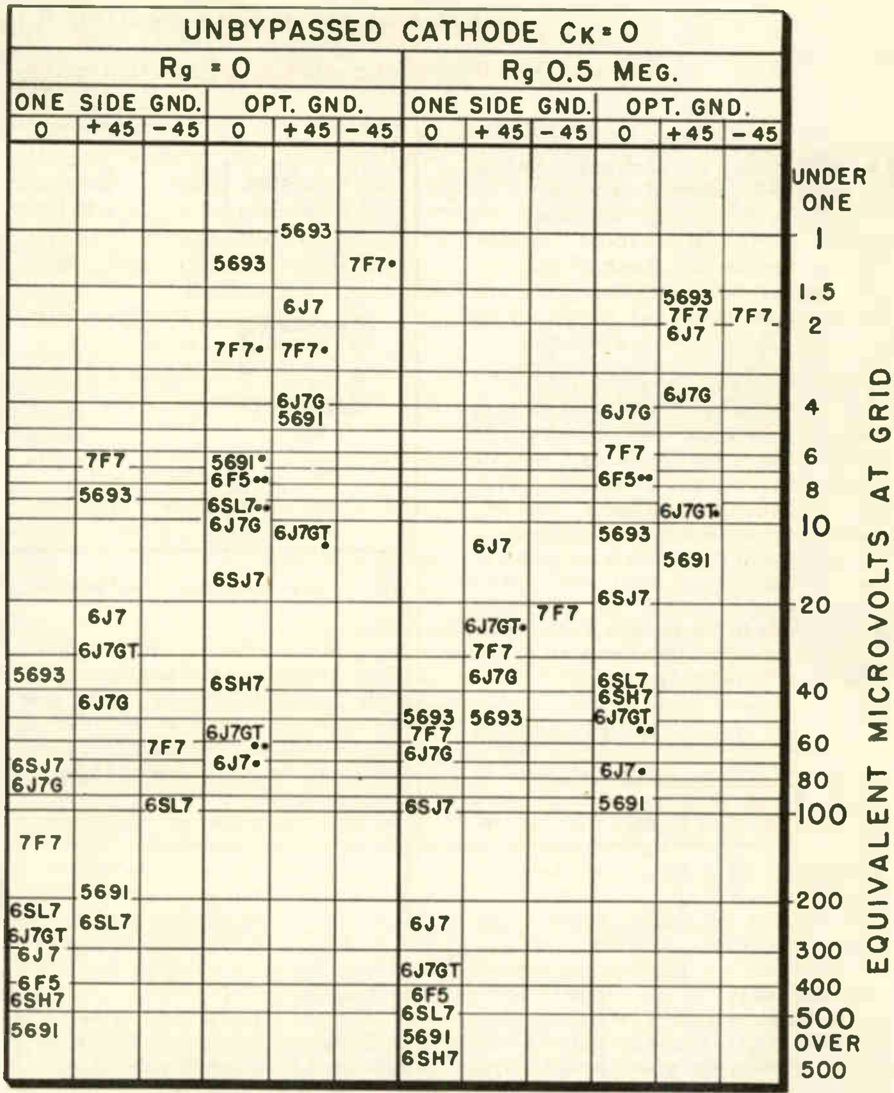
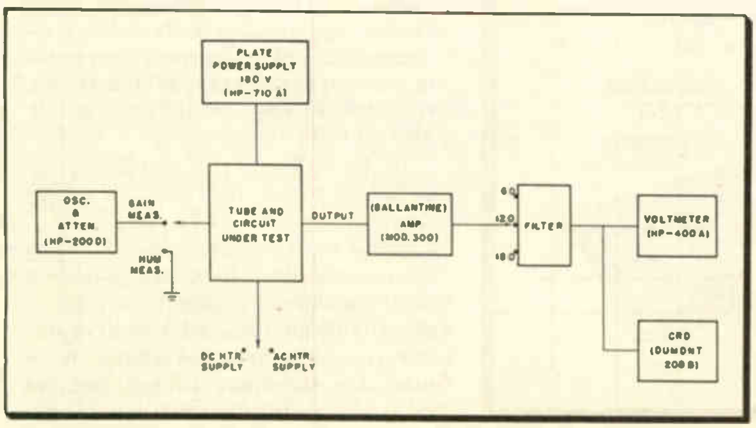
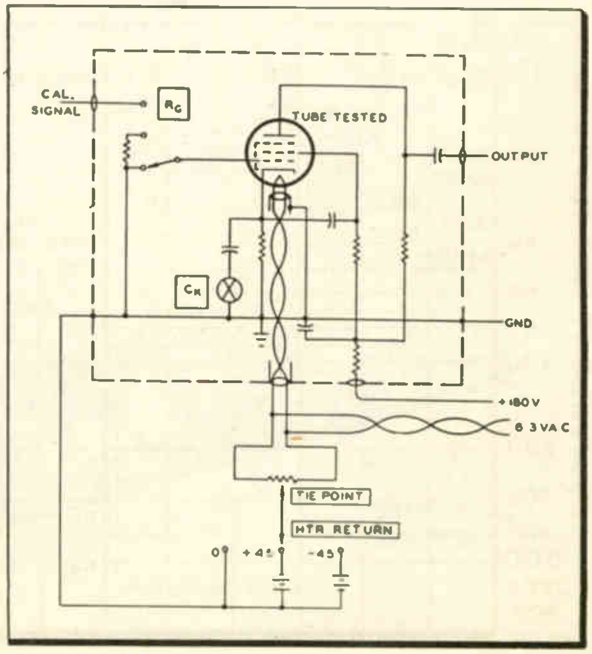


Fig. 2: (above) Chart similar to that shown in Fig. 1 except that cathode circuits are in unbypassed condition
Fig. 3: (lower left) Block diagram of complete arrangement for measuring hum level
Fig. 4: (right) Typical low-level amplifier circuit used in these measurements





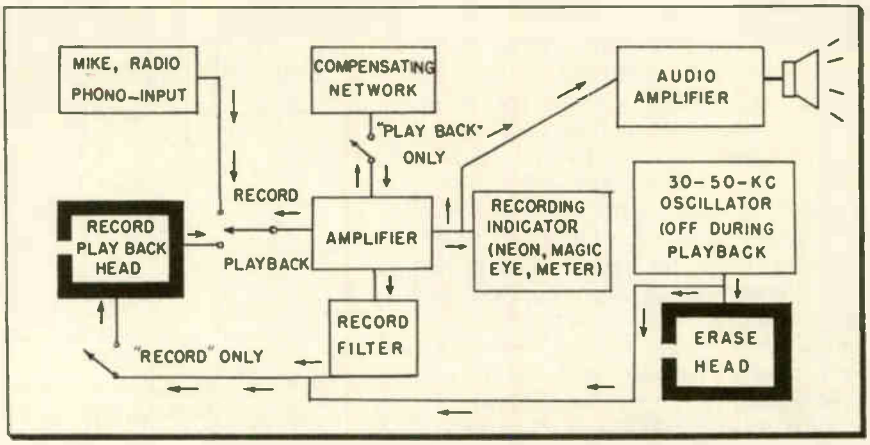
The Servicing and Maintenance

Part I of an Article Dealing With Principles and Problems of

By Charles Graham, Technical Editor

• Today tape recorders are becoming more widely adopted than wire recorders, even though a substantial number of the latter are still in use. The electronics for the two mediums are almost identical, and only the mechanisms show much dissimilarity. We will therefore consider tape recorders primarily, noting exceptions in some cases which apply to wire.

A magnetic recording consists of a medium which has been magnetized in accordance with electrical signals whose frequency and amplitude change to reproduce the intelligence (usually sound) it is wished to record. The best magnetic mediums have been found to be a certain type of steel wire (normally .004 inch diam.) and paper or plastic tape which carries a thin coating of ferrous oxides. The tape is ¼" wide and about .002 inch thick.



FI2. 2. Block diagram of typical recorder. Some models incorporate erase in the other head.

Heads Do Three Jobs

There are three magnetic processes involved: recording, playback, and erasing. In most home and office recorders the playback and recording are accomplished by use of the same magnetic head.

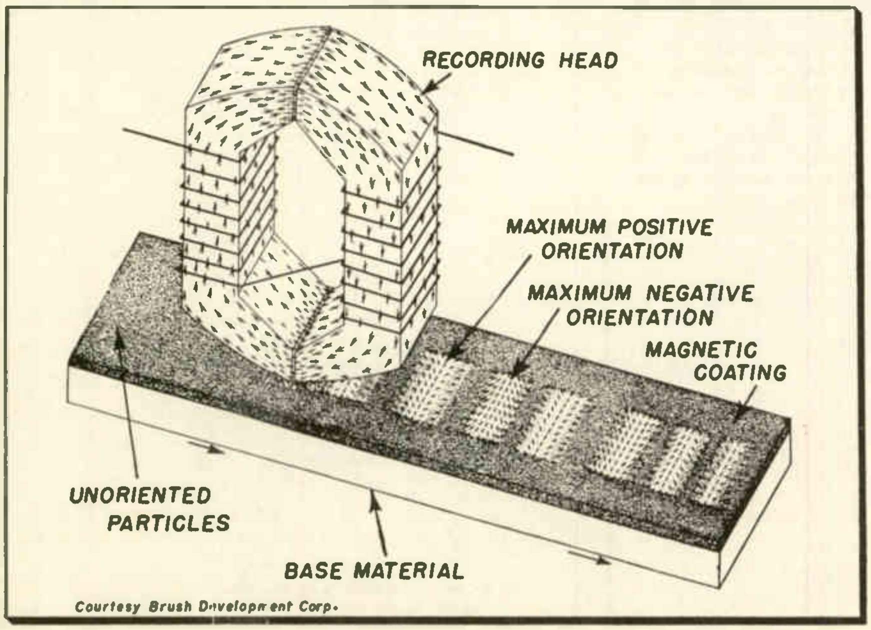
It is also necessary to move the magnetic medium, whether it is tape or wire, past the playback or recording head at a fairly constant speed. As the tape passes the recording head, currents from the amplifier induce varying magnetic poles in the tape. These magnetic poles are spaced closely together for sounds of high frequency and farther apart for sounds of low frequency. In additon, if the sounds being recorded are weak, then there are only a few particles of oxide magnetized, whereas, the areas of magnetic orientation are larger for stronger sounds.

When these areas of magnetically oriented oxides are pulled past the playback head they induce small voltages in the windings of the playback head, and these voltages are amplified and used to drive a loudspeaker, creating the sounds which made the original recording.

Erasing is accomplished by subjecting the recorded tape to a very strong magnetic field which wipes out previously recorded signals, or saturates the tape. This can be done either with a magnet, called a DC erase, or with an erase head similar to the record-playback head, with an AC current producing the AC erase. This leaves the tape quieter, and is most often employed.

There is one recorder which uses a permanent magnet to produce a sort of AC erase by arranging several poles of a magnet to give the effect of reversing the poles rapidly. In a few recorders, the erase and playback-record heads are combined into one head, with an E shaped lamination which has separate erase and playback-record windings wound on it. This type of head has two gaps in it, the wider, around .01" is the erase gap. These gaps are filled with soft, non-magnetic metal to insure that the tape does not catch in the gap. The smaller gap is about .0005" wide, and is for playback and recording. The AC current used to supply AC erase is usually about 30 to 50 KC, and is supplied by a beam output tube such as a 6V6 or 6K6, or in some recorders by a twin-triode like the 6SN7, in a pushpull circuit.

In recording, as the tape is pulled past the recording head, the particles of ferrous oxide, which have been unoriented, are magnetically arranged in place to form many small magnets, as shown in the drawing on the left. This is caused by the magnetic lines of force which are set up across the recording gap in the recording head. These magnetic lines of force are the result of the current in the recording head laminations, which current is in turn created by the recording amplifier. The currents required are fairly small, and a triode tube will supply the recording current easily. It is necessary to supply a small amount of AC bias to the recording head



Courtesy Brush Development Corp.

# of Magnetic Recorders

Tape; Non-Mechanical Service Procedures Are Discussed

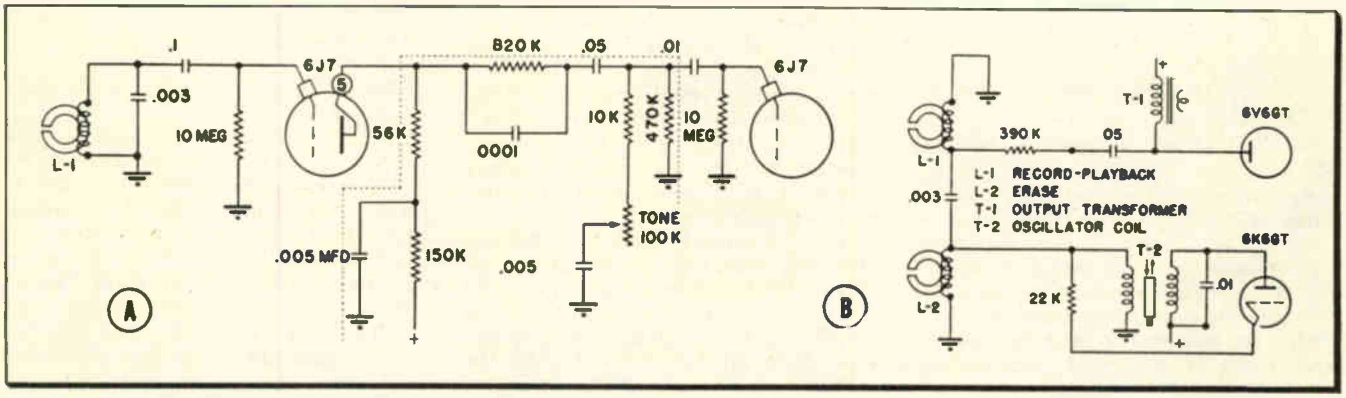


Fig. 3. Simplified playback circuit (A) and record-erase arrangement (B) taken from Revere model TR-200 tape recorder.

along with the recording current. This AC bias is usually a small portion of 30-50 KC alternating current, taken from the conveniently at hand erase circuit. The reasons for the AC bias are highly theoretical. However, it is easily demonstrable that without this so-called AC bias the recording will be so distorted that it will be hardly recognizable. The amount of AC bias used varies from one recording head to another, and from one tape to another. It usually is from 2 to 4 ma., and its adjustment is rather critical in getting good results from the recorder. Later we will consider means of checking the AC bias, and ways of varying it, where necessary.

Equalizing Networks

Due to the fact that magnetic tapes do not have a linear frequency response characteristic it is necessary to apply equalization at several points. The first equalization is done in the recording. The recording current is usually taken from the plate of a tube, so there is a recording filter network, consisting in most cases of one condenser and one resistor, connected between the plate of the recording amplifier output tube and the record head.

In playblack the tape is pulled past the reproduce, or playback head, which is now connected to the grid of a very high gain amplifier. Again equalization is applied. This time it is in the form of a condenser (usually around .002 to .004) which is intended to resonate with the inductance of the playback head to provide boost at around 5000 cycles. After amplification in one or two stages there is bass boosting also, to compensate for the loss of lows.

These equalizations are in addition to and separate from any form of manual tone control. Most recorders have tone control of the well-known high roll-off variety. This is never incorporated in the record circuit, but only in the monitor and playback circuits.

In figure 2 is shown a block diagram of a conventional home-type tape recorder. The audio amplifier is usually automatically disabled during mike recording so that undesirable acoustic feedback will not occur.

There are a large number of troubles which can occasionally arise in any piece of electronic equipment. The largest number of these are sufficiently similar to regular radio or audio amplifier troubles so as not to call for special comment. Therefore detailed trouble-shooting procedures which are identical with radio procedures will not be repeated here. However, the use of the supersonic (30-50 KC) AC bias and erase currents introduces a new element. As before stated, the amount of bias employed is not only rather critical if good re-

Troubleshooting Common Electronic Faults in Magnetic Recorders

Trouble	Symptoms	Remedy
I Records distorted and/or weak	No AC bias (30-50 KC) (measure bias E or I as outlined in text)	1. Substitute new tube in supersonic bias-and-erase circuit. 2. Measure DC volts (neg.) at grid of same tube.
II Records distorted (previous recording remaining on wire or tape)	No erase—or weak (only if AC erase is used. If magnet erases, omit II.)	1. Follow procedure for Trouble I, except insert 2, below, after 1, in I. 2. Check erase head for open, or short. Should read at least .1 ohm or more.
III Records, but slight sound remains from previous recording(s)	Insufficient bias or erase 3. Check for shorted turns by comparing R of heads with known good heads (of same model—head design often varies from one production run to next.	1. If permanent magnet is used for erase, add AC erace circuit and head—manufacturer's data. 2. If AC erase, check for proper magnitude of both erase and record bias. Check waveform with 'scope. 4. Check with previously recorded tapes known not to be overrecorded (saturated)—or tapes from another machine. Also try another type or brand of tape.
IV Excessive hum	Determine whether hum is in circuit or is recorded on tape 3. Add hum removal circuit to filaments. See text—also RTR, page 75, Aug., '51.	If on tape, check power supply for humless B plus. If not in recording, check 1st stage— 1. Try 2 to 4 new tubes in 1st stage. 2. Check lead dress of 1st grid, and of play head lead.

sults are to be obtained, but that amount varies with different recorders and different makes of recording tape.

Badly distorted recordings can arise from the following causes associated with the supersonic alternating current.

1. Weak bias—tube not oscillating strongly enough.

2. No bias at all—tube or components bad.

3. No bias—or erase head burned out.

4. Too much bias—or poor waveform—often happen together.

The best place to test for proper AC bias is at the recording head itself. If the shop is equipped for TV work, an oscilloscope will be handy, and it can be connected right across the recording head. The advantage of using a 'scope, if the recording is distorted, is that the scope will not only measure the amplitude of the AC bias, but will show whether or not there is a good sine-wave shape at the recording head. *No shape other than a sine-wave is acceptable in the AC bias.* If the scope is used for TV work, the voltage calibrator should always be hooked to its terminal, so the shielded input lead of the calibrator, which is usually connected into the TV set to measure waveforms, is here connected across the recording head. The recorder is put in record position with no signal going to its input. The only signal then appearing across the recording head will be the supersonic bias. If there is no bias at all, check the supersonic oscillator tube and circuit to ensure that it is oscillating. In some cases it will be found that there is enough bias but that it is of the wrong frequency. Particularly if the frequency is too low, say in the audio range, annoying chirps, whistles, and distortion may arise. To check the approximate frequency of the AC bias, bridge the 'scope across the recording head and inject a high audio frequency into the input of the recorder. If 15 to 20 KC is used, it will be possible to compare this signal directly on the 'scope screen with the unknown bias signal. The amplitude of the 15 KC input would have to be kept low, of course, to permit observation on the screen of similar amplitudes of the two signals. Use the highest audio signal for comparison purposes which is available, and which is a convenient sub-multiple of the desired bias frequency.

If the frequency is radically off, almost always the waveshape will be poor also. This will be found to be due to a failure of some oscillator circuit component.

If the waveform is OK but the amplitude is less than the manufacturer recommends, a new tube is often the answer to the problem. In the trouble-shooting chart shown it will be noticed that the first step in checking for distorted and weak recordings is trial of a new bias and erase oscillator tube.

Another way to measure the AC bias, if a scope and calibrator are not at hand, is to insert a 10 ohm resistor in series with the record head, put the recorder in record position, and measure the AC voltage across the resistor. If the proper bias current at the head is 4 ma., then the voltmeter should read .04 volt. In some cases the manufacturer does not specify the bias *current* in the service literature, but instead gives the proper value of AC voltage at the plate of the oscillator tube or at the recording and erase heads. In such case, direct measurement can be made.

Often recorders come into the repair shop with a complaint of "hum". When this is a *correct* description of the trouble it is often found that it is merely a small amount of hum which was there all the time, due to the extremely high gain of the amplifier, but has only lately been noticed. This hum can usually be lessened by one or more of the following steps.

First the recorder is put in play position, with the volume control at maximum, with no tape. Let the motor run, and after removing the mounting screws from the power transformer, try changing its orientation slightly for minimum hum. (Some recorders have the power transformer mounted so that it can be rotated by simply loosening the screws.) If the power transformer is already mounted at an oblique angle, as in some late models, it can be assumed that it has already been oriented properly at the factory.

Examine the lead from the playback head to the first grid. In many cases this lead is protected with cotton or plastic and is grounded only at the grid return of the first amplifier tube. If the shield of this lead touches ground accidentally elsewhere it will often create bad hum. Also watch the dress of this lead. Its placement near filament, 110 V and other leads can often cause hum. Simple experimentation with redressing it may correct the trouble.

A first amplifier tube can often develop a slight amount of heater-to-cathode leakage. Though not nearly enough to show on a tube tester, in a high gain amplifier of this sort it can cause a lot of hum. Therefore the first check is to try at least two, and preferably four, new tubes in the first voltage amplifier, meanwhile leaving the volume turned up full, recorder in play position, with no tape.

Finally, hum in the first tube can be cut to an absolute minimum by installing a 100 ohm pot across the filaments, removing the filament winding centertap (if any) from ground, and grounding the arm of the pot. Adjustment of the arm is then made for minimum hum. Or alternately, a small B voltage is applied to the first filament by using a voltage divider network across the B supply. Two ¼ watt resistors of 20 to 30 and 200 to 300 K will do.

Part II

• The radioman of today, it is often said, has to be an accomplished plumber, steeplejack, tinsmith, and cabinetmaker, in addition to his abilities in electricity and electronics. Certainly in the repair of recording machines his skill as a mechanic is called for as often as is his knowledge of the electron art.

Most recording machines are complicated electro-mechanical devices. So a brief examination of the mechanical operations which magnetic recorders must perform is in order, before we go after the faults which can arise in the performance of these operations.

The tape must be *transported* evenly past the recording, playback, and erase heads. The tape must be wound fairly closely on the *take-up* reel, and must unwind easily from the *supply* reel, without *spilling.* In addition, it must be possible to stop all three of these operations at once, smoothly and quickly, without breaking or tearing the tape (which is made to withstand a pull of from five to eight pounds). Finally, it must be possible to start these three movements quickly and smoothly, either in the normal, forward direction, or in reverse.

At the same time that the tape is being moved forward, stopped, or run in reverse, the heads (most often *two*: record-playback, and erase, but sometimes *all-in-one*, and in a few recorders, *three* separate) have to be in close, but not binding, contact with the tape, and they must in some machines even shift vertical position.

It is difficult to design a machine which will go through these various motions, and still make the machine foolproof, easy-to-operate, and cheap to produce. Design engineers have shown a great deal of inventiveness in producing transport mechanisms to do these jobs. But nevertheless these machines must sometimes come into the shop for repair or overhaul due to their necessary complexity.

The tape is pulled past the recording (or playback) head at a very steady even speed. Usually this is 7.5 *inches-per-second,* though many home machines have a speed of 3.75 *ips,* or allow a choice of either speed (professional machines are usually 7.5 and 15 ips, or 15 and 30 ips, for extreme high-frequency response and optimum signal-to-noise ratio). The tape is pulled by a metal or cork-covered capstan which is attached to a fairly heavy flywheel. The flywheel is used to smooth out small rapid periodic variations in the speed of the capstan. When these variations are present, they cause *flutter.* The flywheel is driven by an electric motor,

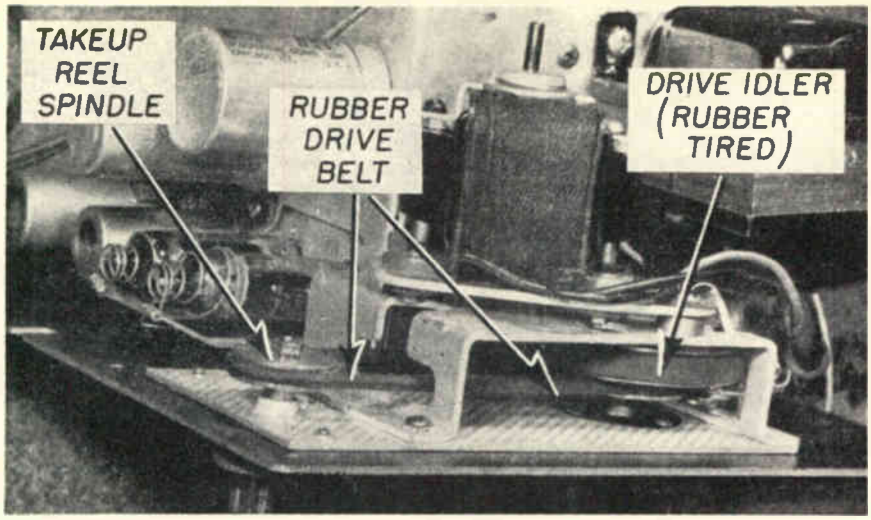


Fig. 1. Below is bottom mechanical assembly of Ampro machine. Motor is atop drive housing.

either coupled to its shaft through a pulley-and-idler combination, or by means of a rubber belt.

Since the tape moves at a constant speed, the *take-up* reel must take up a constant linear amount of tape, but it must take it up with a constantly increasing diameter which means a constantly decreasing rate of turning. Meanwhile, the *supply* reel must pay out the tape at a constant speed, but from a constantly decreasing diameter, which requires that *it* turn at a constantly increasing speed. And when the transport goes in the reverse direction, the roles of the two reels (!) are reversed.

The only way which has been found to accomplish this variety of functions is to keep the tape moving steadily, and let whichever reel is taking-up at the moment *slip*, while the reel presently pulling *drags*. The tensile strength of the tape is therefore seen to be a limiting factor in determining how much slipping or dragging pressure there is between each reel and the capstan. The most expensive recorders use separate electric motors for the capstan drive, take-up reel, and supply reel. A slight DC is applied to the field of the supply motor, and this provides light but constant braking, or drag. For smooth quick stopping, a stronger DC is applied to the fields of all motors. Unfortunately this is an extremely expensive way of doing the job. Mechanical clutches are used on most home recorders, and if not allowed to go too long without adjustment, and if not mis-adjusted, they function well.

These mechanical clutches are usually felt clutch plates, or cloth or rubber (slipping) drive belts. The felts must occasionally be cleaned or replaced, and the belts become smooth or stretched after protracted use, and so require replacement.

The record-playback head and the erase head often get dirty, due to the collection of oxide (recording material) from the tape. Cleaning of the heads is the first of all standard maintenance procedures.

Alcohol* and a brush (or drugstore "Q Tips") are required for cleaning the heads and other parts. The drive capstan should be cleaned, although it will not require attention as often as the heads. Care must be exercised not to injure the capstan with excessive cleaning. Early recorders had capstans covered with cork, and special care must be taken with these. Today most machines use idlers having neoprene rubber surfaces, and capstans are precision ground.

Most important maintenance is keeping the mechanism clean. Many of the mechanical motions are transferred by neoprene idlers and pulleys, which does produce a certain amount of rubber particles and dust. This can get into bearings and cause wow, flutter, and in some cases even stalling, if not cleaned out after excessive periods of use.

The diameters of the various pulleys, idlers, flywheel (if it is a bearing surface) capstan, and drive shafts, are all critical. They are generally ground or turned down in production (not simply *cast*, as are similar parts on many phonographs, which are an entirely different class of mechanism) to tolerances of one or two thousandths of an inch. This means that sandpaper, files, or other abrasives are strictly forbidden from touching any bearing or driving surfaces. There is no reason for the serviceman to treat these surfaces at all, except to clean them of grease or dirt.

Where a belt is used to transfer power from motor shaft to take-up reel, the belt may after a time become dirty and allow too much slippage, or it may bind. Chemical cleaning of the belt may be attempted, but replacement is recommended. When such items are ordered from the manufacturer, it is wise maintenance procedure to order two belts even though only one may be needed at the moment. (Manufacturers' charges for these parts are nominal, ordinarily.) Thus one is prepared the next time the same difficulty crops up.

If a recorder has not been dropped or otherwise mishandled, there is little likelihood that any mechanical work other than cleaning or replacement of idlers or belts will be required. When real damage has been done, such as the warping of the main motor board, bending of drive shaft, injuring of idler or pulley bearing surfaces, then it is best to return the mechanism to the manufacturer or his authorized factory maintenance center for rebuilding.

Manufacturer's service notes are very detailed concerning any mechanical repairs which the maker deems OK for the serviceman. In the absence of specific instructions, no mechanical work should be done on tape recorders other than cleaning and replacement of worn idlers, belts, felt brakes, or clutch faces.

Felt brakes are used in most recorders to stop or to slow down the take-up and supply reels. When it is necessary to replace these, they may be removed with cement solvent and new ones reglued in their place. On some machines felt clutches are used which consist of large felt pads glued to metal plates. These fit against other, matching, metal plates. The pressure of the felt pads against the plates is varied, depending on whether slipping or stopping action is desired.

The accompanying chart of common mechanical difficulties will serve as a guide in the absence of manufacturer's service data on the specific recorder involved. In all cases, the

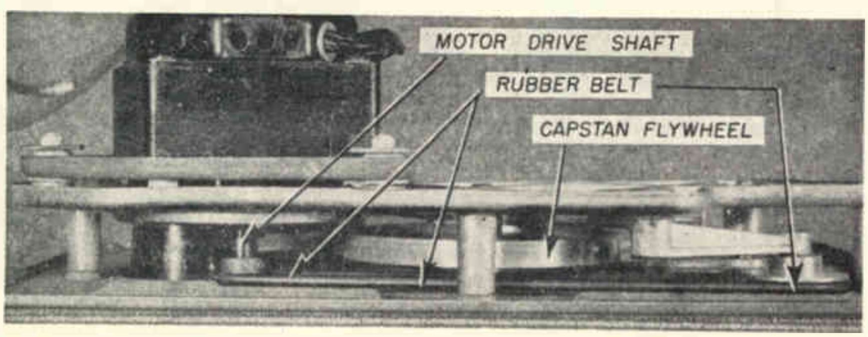


Fig. 2. In the Eicor mechanism above is shown the rubber belt which transmits motor force to takeup reel and capstan. Maintenance of proper belt tension and friction is important.

*Carbon tet is OK for cleaning heads. Some types of rubber are affected by carbon tet, however, so alcohol is recommended.

Tape Recorders

recommendations of the manufacturer should be followed carefully.

A few tape machines have unfortunately been put on the market in which some of the parts were not within the designer's tolerances, with the result that a small percentage of machines in use have flutter troubles which no amount of cleaning and adjusting can correct. In such cases, the makers are usually glad to receive information on the difficulties and will cooperate in taking care of the trouble by fixing the mechanisms at the factory. A word of caution, however: never send a machine back to the maker without first writing to request authorization, disassembly instructions (in some cases they will want only the mechanism, while in others the entire machine must be shipped), and packing instructions.

There are two ways of winding tape on the reels, and so there are two methods of threading the tape onto the mechanisms. Most machines today use the "A" wind, in which the oxide coating faces in *towards* the center of the reel, but a few still use the "B" wind. In the "B" wind the magnetic oxide coating (the duller side) faces *away* from the hub.

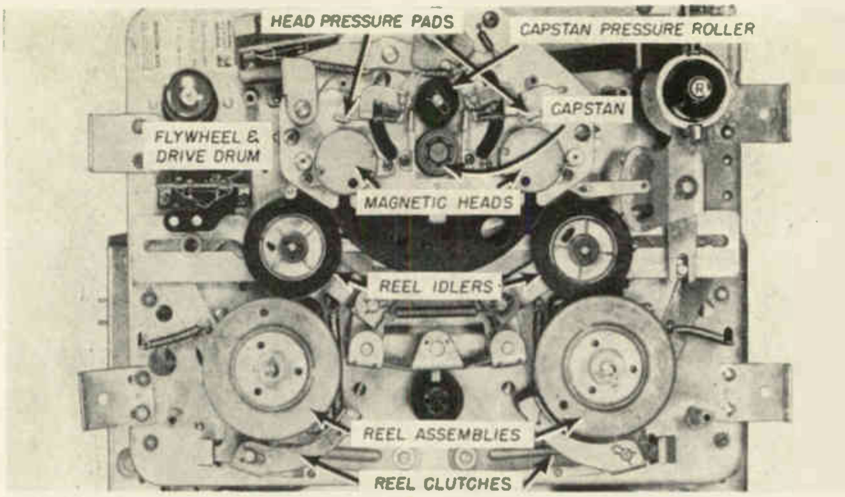


Fig. 3. Instantaneous dual track design of Webcor recorder uses symmetrical setup of reel assemblies, drive idlers and heads, which function both in play-record and erase.

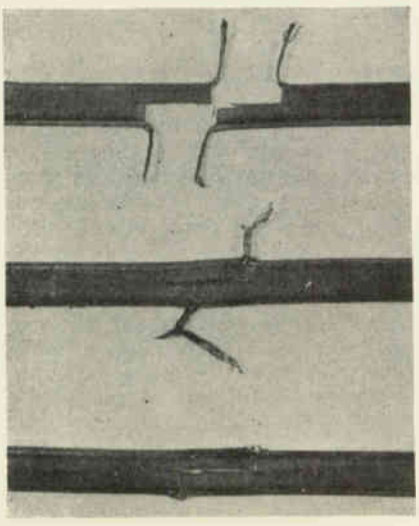
Troubleshooting Common Mechanical Faults in Magnetic Recorders

Trouble	Cause or Symptoms	Checks and Remedies
I. Distorted playback	Sounds "slow" or "sick" Sounds weak or uneven in volume	Check with tape made previously, known to sound OK. "Flutter"—clean all bearing and driving surfaces as mentioned in text. Ensure no parts are worn or binding. Dirty play-record head—clean. Tape not making good contact—guide pins or rollers bent—pressure pads worn, bent, or loose.
II. Distorted recording	Previously recorded tapes play OK, present ones sound distorted	See other chart, page 79, Oct. RADIO & TELEVISION RETAILING—II—bias weak or absent. Tape needs pre-run—sticks on reel, failing to unreel smoothly.
III. Insufficient erase	Previous material stays partly or wholly on	See other chart—part III—Dirty erase head (if magnet, old, weak). Erase head not making good contact with head.
IV. Poor response	High frequencies weak or uneven but speed OK	Play head dirty—picking up dirt, grease, dust, from tape. Or play head worn badly. See part III, 2 other chart—check for excessive erase current.
V. Tape moving too slowly "Wow" or "Flutter" Tape breaks at capstan Tape fails to move, or fails to takeup properly	Check with previous—OK recording "Wow is periodic speed variations a few times/sec. "Flutter" is same, but many times/sec. Power on, motor running	Too much or insufficient pressure of pads or pinch rollers or wheels against tape. Takeup reel dragging—check clutch pressure and/or surface.. Capstan worn or binding. Motor shaft binding. Also check No. 1, above. Supply reel sticking, takeup reel or clutch worn or oiled; drive belt or pulley oiled or badly worn.

SHOP HINTS

Twin-Lead Splices

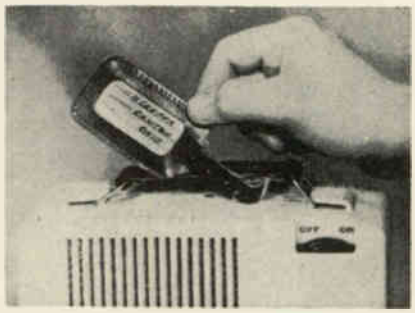
From Arthur Davis, New York City: The best rule for splices in TV lead-ins is not to make any as they invariably result in a trouble point, due either to a poor impedance match (causing line reflections) or a rusted, intermittent or open connection (resulting in signal losses, noise and flashes, or lack of signal). If you must make them, however, try to preserve the wire spacing (so as to maintain the impedance) and make a good, clean, secure connection. I use a staggered splice to achieve this result, as shown in the picture. The stagger is cut into one end, and then matched (in reverse) on the other piece.



Then the leads are twisted together. At this point, the twin-lead is back in its original shape again. I then trim off the excess. As shown in the third view, the twisted leads were soldered, and the hot iron used on the plastic to melt it over the exposed leads. If you don't have the time or facilities to use an iron (as for instance, outdoors), you can spray the connections with a plastic spray such as Krylon, or tape with one of the plastic electrical tapes. When I use tape, I try to keep it down to a minimum, as I believe too much tape affects the signal.

Goodwill on Portables

Whenever a portable radio is repaired, or batteries installed, a luggage name tag holder is attached to the handle of the portable, with the owner's name and address written in. In this way the customer gets a permanent identification tag which is at the same time a servicing re-



minder, for the dealer's name is also imprinted on the tag, along with his telephone number and address. *H. Leeper, Canton, Ohio*.

How to Install TV Towers in Fringe Areas

Step-by-Step Explanation of How to Get Them Up So They'll Stay Up

This detailed explanation covers proper mounting of the base; number, size and installation of guy wires, raising the tower, securing and plumbing the tower, mounting of rotators where used, proper grounding & other installation techniques.

• After the antenna has been selected, the most important problems in a fringe area television installation are those of getting the antenna as high in the air as possible—and making it stay there! Inexpensive masts made of thin-wall conduit or dural tubing are widely used for antenna supports in areas where heights of thirty feet and less give satisfactory reception, but their flexibility makes the erection of longer lengths difficult. Rigid towers of uniform triangular cross section, although more expensive, are more easily handled during erection and most types are strong enough to be climbed if antenna repairs become necessary. Self-supporting towers of the windmill variety are often used in locations where limited lot space does not permit use of guy wires. This article takes up the installation of guyed towers.

Mounting the Base

To insure that the guyed tower or mast will withstand winter winds and icing, a properly-designed base support and system of guys must be provided. In resisting the force of the wind, tension is developed in one or more guy wires, resulting in a downward force against the base of the tower which adds to the dead weight of the tower itself. Other things being equal, the amount of tension in the guy wires depends upon their placement with respect to the tower, and as shown in Fig. 1, may be minimized by attaching them at equal angles around the tower and as far from its base as possible. Care should be taken in choosing locations for guy wire anchors. Where screw hooks set in an ordinary roof are to be used as anchors, it is essential that they be set in rafters, as sheathing has very little holding strength. If the rafters cannot be located by measurements or by sounding, it is best to obtain the owner's permission to drill small test holes, which are immediately patched with roofing compound. If more than one set of guys is to be anchored in this manner, it is well to provide a separate screw hook for each guy wire, allowing sufficient separation between screw hooks to avoid splitting the rafter. If the guy wires have been properly located, most towers may be supported safely under almost any weather condition by one set of 6-20 or 6-18 steel guy wires for each twenty to thirty feet of tower height. Smaller guys at more frequent intervals are recommended for pipe masts, to avoid buckling. Construction of the base on which the tower or mast is to be mounted varies greatly from one installation to another. In all cases, however, the base should be capable of supporting several times the weight of the tower and antenna.

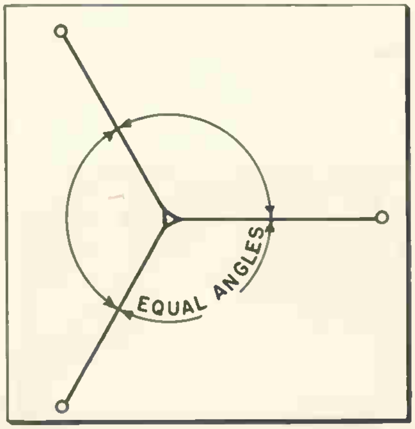


Fig. 1: Guy wires shown looking down at the top of the mast. If angles shown are unequal, wind blowing into the greatest angle will produce the highest stress in the guy wires. The distance from the guy wire anchor to the base of the tower should be about ¾ of the height of the tower at the point where the guy wire is attached. If this distance is less than ½ the height, use stronger guy wire and anchors. For recommended sizes of guy wire, see text.

Except in severely crowded locations, moderately high towers are most easily assembled complete on the ground, then erected with the aid of a hinged base and a boom, as shown in Fig. 3. After all sections have been bolted together and inspected for loose rivets, poor welds, and other defects, the completed tower should be bolted to a hinged base which is fastened securely to the roof or foundation on which the tower is to be erected. Support the free end of the tower on a sawhorse or box while the antenna, lead-in, guy wires, and stand-off insulators are assembled to it. If a motor is to be used to rotate the antenna, it should be tested before being attached to the tower to avoid the complications which arise from finding it improperly wired or defective after the tower has been raised. After testing, the motor should be left in its extreme counter-clockwise position and the antenna attached in such a manner that it will be pointing north after the tower has been erected. If the motor is geared to turn the antenna at one r.p.m. (most antenna rotators are), the second hand of a watch may be used as a direction indicator after the tower has been erected by starting clockwise rotation of the antenna from the

Fig. 2: When towers of up to 30 feet in height are installed next to a building, a single bracket attached to the gable or wall at a height of fifteen feet or more will take the place of all guy wires.

counter-clockwise stop at the instant the second hand passes zero.

It is important to determine in advance the length of the back guy wire in the top set. If this guy is cut to length and attached to the tower and to its anchor before the tower is raised, it will become taut and stop the tower as soon as the tower has been pulled into an upright position. The length of the guy wire may be calculated by any one of several methods, one of the easiest being by the use of a table of squares and square roots. (See Table I) The remaining two top guys should be pulled tight and fastened to temporary anchors on either side of the tower in line with the hinge pin in the tower base. These two guys act to steady the tower and prevent it from falling sideways during erection. Lower sets of guys, if used, should be cut to length and attached to the tower at the proper heights, then coiled and tied temporarily to the tower at a height which will be accessible from the ground after the tower has been raised.

The actual erection of the assembled and rigged tower is begun by attaching a boom at a ninety-degree angle to the base of the tower and guying the boom if necessary to prevent it from being pulled sideways. A sturdy ladder may be used without side guys as a boom for the erection of small towers. A rope is tied to the boom and then to the tower at a distance from the tower base approximately equal to the height of the boom. To avoid climbing the tower later to retrieve this rope, a slip knot may be tied in such a manner that after the tower has been raised, the free end of the rope will be within reach of a man standing on the ground. Two men, one to push the tower up as far as possible by hand, then steady it as it goes up, and another to pull on the rope, can raise light-weight towers of at least forty feet in height. A block and tackle is helpful for raising heavier or higher towers. After the tower has been pulled upright, the man holding the rope can steady it against the pull of

Fig. 4: Helpers adjust guy wires as tower is plumbed with a hand level.

the back guy wire while his helper carefully moves the other two guy wires one at a time to their permanent anchors. The free ends of the lower sets of guy wires, which were temporarily fastened near the base of the tower, may now be attached to their anchors. To prevent kinking of the back guy wire while the tower is being raised, carry the mid-point of the wire as far as possible from the tower and attach a sliding weight to it. As the tower is raised, the weight will be dragged along, maintaining enough tension to prevent kinking the wire. When the tower is pulled erect, the weight will slide down the wire to the anchor, where it may be easily removed. The tower should be plumbed by adjusting the guy wires, taking care that the final guy wire tension is no more than that necessary to prevent swaying.

Certain makes of conical antennas have been found to lose elements due to fatigue cracks developing near the clamp as the result of vibration and strumming in the wind. It is well to

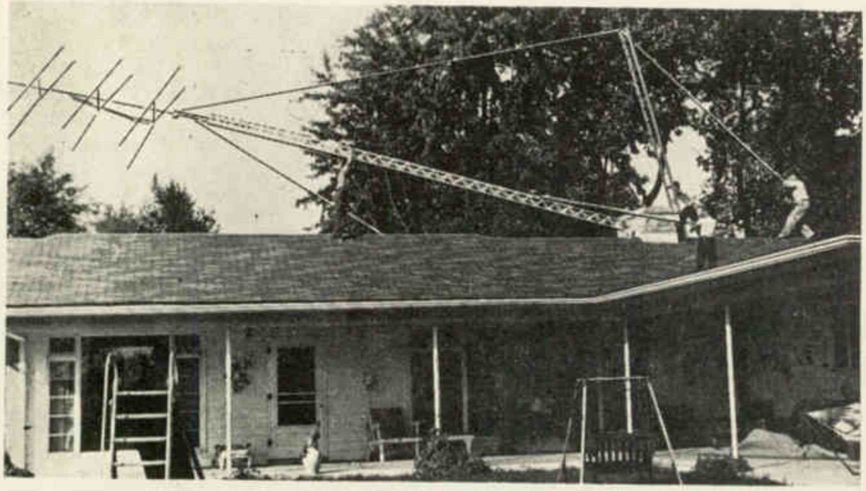


Fig. 3: The tower ready for raising. Below, the drawing shows the tower supported on a sawhorse as described in the text, where the other notes on the drawing are also more fully explained. The photo above shows the same situation a few minutes later, with the tower on the way up. Helpers are holding guy wires to keep the tower from falling sideways as it is raised. In the photo, a ladder is being used as a boom pole, and a direct pull is being exerted by the installer instead of a block and tackle as shown in the drawing.

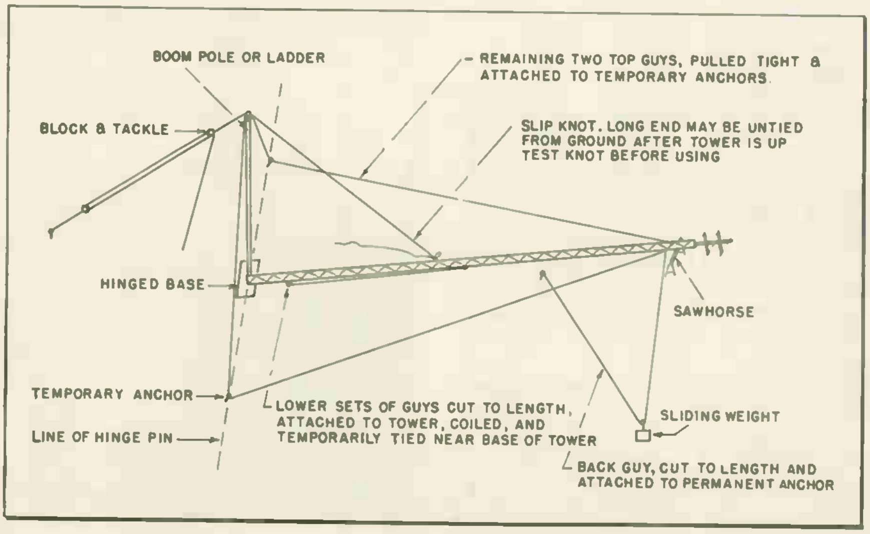
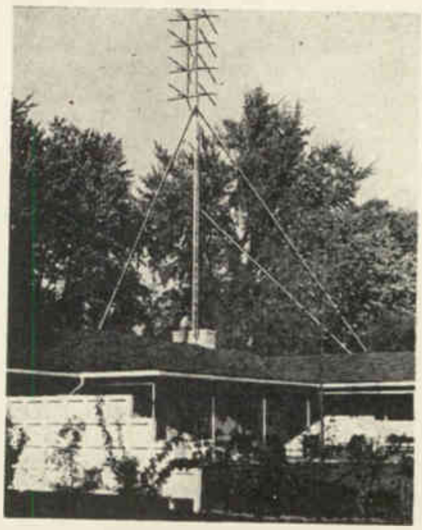


Fig. 5: The complete installation. A separate conductor should be run to a good ground for lightning protection. Grounding a guy wire endangers the mast, should that guy wire be damaged by lightning.



mount such antennas six or eight feet above the highest set of guy wires to permit a small amount of unrestrained motion. Many types of antennas make a roaring noise like that of an airplane under certain wind conditions. To avoid service callbacks, be sure to plug the top of the antenna mast with a large cork, and either place corks in the ends of the antenna elements or flatten them with pliers.

Towers and masts which rise more than a few feet above the rooftop should be protected against lightning damage. In most locations, a suitable grounding system may consist of one continuous length of #4 copper wire fastened to the base of the tower and brought down to a cold water pipe or an eight-foot ground rod. Electrical codes prohibit the use of soldered joints at any point in a grounding system: use clamps instead. A useful tool for driving ground rods may be made from a short length of one-inch pipe by fitting a pipe cap on one end. Under no circumstances should the #4 copper ground conductor be omitted and the guy wires grounded instead—a lightning stroke might damage one or more guys, leaving the tower unsupported.

Men working on rooftop installations should wear sneakers or crepe-soled shoes, both to insure safe footing and to prevent damage to the roof. One of the surest ways to incur customer ill-will is to leave his roof in a leaky condition. Much trouble from this cause will be avoided if a thorough inspection of the roof covering is made just before leaving the roof, and all damage carefully repaired. It is well to call existing leaks to the customer's attention, both as a service to him and as a protection to one's self.

The installation pictured on these pages was made in Kokomo, Indiana. WFBM-TV, Indianapolis, is about 50 miles distant, while other stations received here are located in Chicago, Cincinnati, Dayton and Milwaukee. All of these cities are over 120 miles distant. "Economy-minded" customers who do not care to "fish" for distant stations, are usually given a channel 6 Yagi or a 4-element conical antenna permanently oriented for WFBM-TV. For those customers who desire more programs to choose from, it has been found fairly successful to install an 8 element (4-stack) conical antenna and a rotator atop thirty to sixty feet of tower. Insofar as the location in Kokomo is about equidistant from and on a line connecting Chicago and Cincinnati, co-channel interference is a limiting factor on long range reception, the installers say.

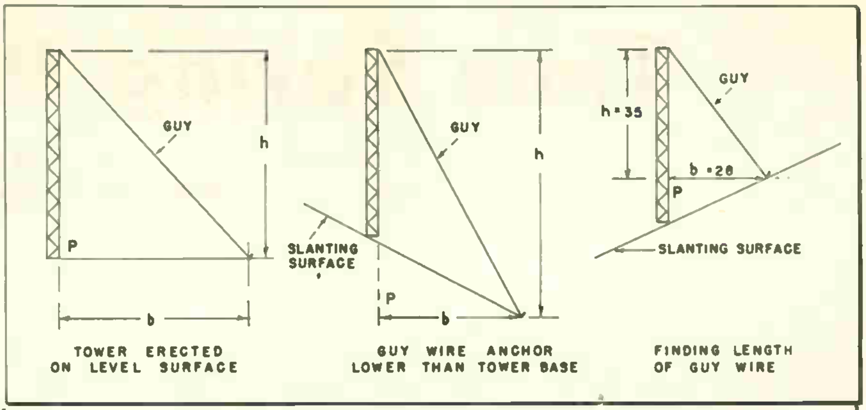


Table I

CALCULATING LENGTH OF A GUY WIRE

A guy wire is to be attached to a tower as shown. To find its length, measure the distance from the anchor to point p, which is level with the anchor and on the tower (or directly below it, if the anchor is lower than the base of the tower). Call this distance b. Choose the point at which the guy wire is to be attached to the tower and find the distance h between it and point p.

The length of the guy wire is equal to $\sqrt{b^2 + h^2}$. In this example, find $b = 28$ in the "No." column of the table and opposite it read $b^2 = 784$. Similarly, find $h^2 = 1225$. Adding, $b^2 + h^2 = 784 + 1225 = 2009$. In the "Square" column of the table, locate the number nearest 2009, which is 2025. Opposite 2025, read 45, the length of the guy wire. Be sure to allow additional wire for splices at the ends.

TABLE OF SQUARES

No.	Square	No.	Square	No.	Square	No.	Square	No.	Square
10	100	21	441	32	1024	43	1849	54	2916
11	121	22	484	33	1089	44	1936	55	3025
12	144	23	529	34	1156	45	2025	56	3136
13	169	24	576	35	1225	46	2116	57	3249
14	196	25	625	36	1296	47	2209	58	3364
15	225	26	676	37	1369	48	2304	59	3481
16	256	27	729	38	1444	49	2401	60	3600
17	289	28	784	39	1521	50	2500	61	3721
18	324	29	841	40	1600	51	2601	62	3844
19	361	30	900	41	1681	52	2704	63	3969
20	400	31	961	42	1764	53	2809	64	4096
								65	4225

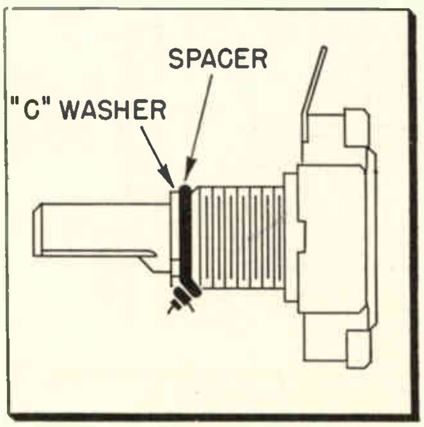
Tips for Home and Bench Service

Noisy Volume Controls

Noisy controls can many times be temporarily repaired and freed from the "scratch" by applying more pressure from wiping arm to carbon ring. This may be accomplished by placing a spacer between the "C" washer and the body of the control. A good spacer can be one strand of AC linecord wound once around the shaft and then the ends twisted. A slight pull on the shaft of the control will reveal sufficient space for this repair operation.—*David Allen, Allen's TV, Radio & Appliance Co., 11034 So. Vermont Ave., Los Angeles, Calif.*

TV Loudspeakers

A job that can make the customer happy and the serviceman prosperous is to put a better speaker on the TV set. Usually the set has a small one, and often poorly placed.



A great improvement can be effected by installing a large, good quality speaker in an appropriate baffle. Many TV sets, however, have a field coil speaker. The best thing to do is to leave this speaker on the chassis (which saves you the trouble of redesigning the power supply) and install a switch in the voice coil leads so that either speaker can be used. Putting in a plug for the new speaker completes the job. The beauty of this arrangement is that, when servicing is required, the big speaker can be left in its cabinet, and the little speaker can be used during repairs.

Time Saving Pointers on

How to Diagnose and Repair Intermittent,

By Solomon Heller

• For many servicemen, the oscillator section of the broadcast receiver has always been the most difficult to understand and troubleshoot. The reason may lie in the apparent complexity of oscillator circuits, particularly when multi-point band-switches are present. Many servicemen who have read and grasped discussions of simplified oscillator circuits are apt to get lost in the underbrush of an unfamiliar, unsimplified oscillator diagram (see Fig. 1).

This article will not pretend to remove completely the thick blanket of fog from the subject. We will, however, attempt to punch enough holes in it to make oscillator servicing somewhat simpler.

Oscillator Fundamentals

We base our article on the premise that an oscillator stage may frequently be serviced, even when the exact details regarding its operation are unknown. It is often enough to understand that: 1—All oscillators used in broadcast receivers generate a signal which, when mixed with the incoming RF signal, produces the intermediate frequency. 2—Feedback of a correctly-phased signal voltage from the output to the input circuit of the oscillator is necessary. When transformers are used for feedback, their leads must be correctly connected, so that the signal fed back is in the proper phase to sustain oscillation. (Reversed leads will cause oscillation to cease.) 3—A tuned circuit is generally present in the oscillator grid. 4—A grid-leak bias of the correct amplitude is present at the oscillator grid when the stage is functioning normally. 5—The plate voltage on the oscillator tube must be adequate to sustain oscillation. With this basic information, a fairly intelligent attack on almost any oscillator may be made.

Standard Checks

The first problem that must be faced is: When should trouble in the oscillator be suspected? The presence of any of the following common symptoms should focus suspicion on the oscillator:

1—Inoperation, accompanied by high sensitivity in the set. Background noises, crackling sounds and hisses are noticeably present.

2—Reception of only one station at the low end of the broadcast band. Reception of this station is not eliminated when the stator of the oscillator tuning condenser is shorted to the rotor.

3—Reception of stations at the high end of the broadcast band, but not at the low.

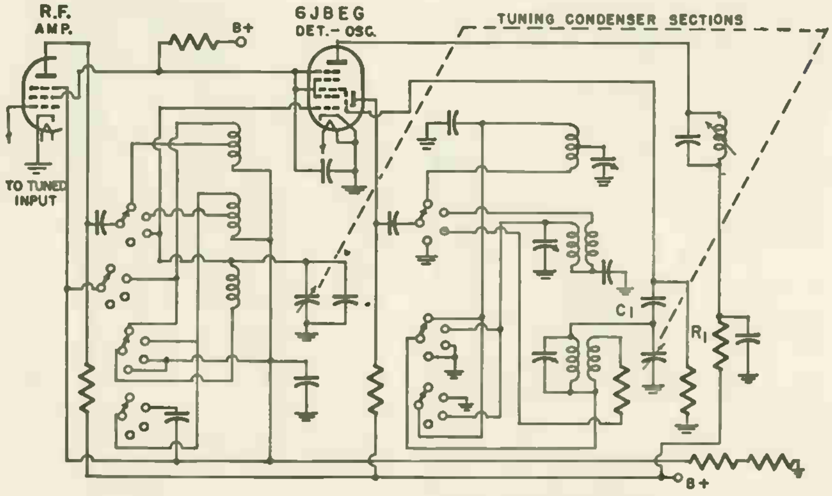
4—Intermittent appearance of any of the above symptoms.

5—Set's ganged tuning condenser needs frequent resetting.

6—No station, or one station, is received; a modulated i-f signal applied to the antenna input of the receiver is heard in the speaker.

The next problem is, how should the oscillator be checked? One or more of the following methods may be employed, depending on the symptoms: a) voltage tests, b) resistance tests, c) frequency or alignment check, d) component substitution checks.

Fig. 1—An oscillator circuit of the simpler sort. For more intricate-looking circuits exist. Part of the RF amplifier and the mixer is shown in this diagram. Set model number is Philco Model 41-758.



When no station, or only one station is received, a grid-leak voltage check of the oscillator will quickly reveal whether this stage is the source of the trouble. If the correct grid-leak bias is present, the oscillator is functioning normally. This test, it should be noted, tells us nothing about the frequency at which the oscillator is operating. A simple alignment check will, however, clear up the latter point.

Several pointers regarding the grid-voltage check just referred to are worthy of mention. First, only a vacuum tube voltmeter using an isolated DC probe will give an accurate oscillator grid voltage reading. Since servicemen sometimes use other types of voltmeters for this purpose, it may be helpful to consider the matter in detail.

Measuring Bias

If a 1000-ohm-per-volt meter, or a 20,000-ohm-per-volt meter, were employed, two undesirable effects would occur when the voltmeter leads were applied between the oscillator grid and ground: 1—The relatively low input resistance of the voltmeter would reduce the impedance between grid and ground of the oscillator (see Fig. 2). The resultant loading of the oscillator tuned circuit would lower the "Q" of the latter, cutting down the amplitude of the oscillator signal or even eliminating oscillation completely. 2—The leads employed would introduce a certain capacitance (represented by C_L in Fig. 2) in shunt with the oscillator tuned circuit. Detuning of the latter would result.

To prevent effect No. 1, a VTVM is employed. The input resistance of a VTVM is generally in the neighborhood of 10 megohms. 10 megohms will not appreciably decrease the relatively low grid resistance—20K to 100K—with which it is placed in shunt.

To prevent effect No. 2, a 1-meg isolating resistor is inserted in series with the DC probe of the VTVM (see Fig. 3). In many cases, the resistor is already present in the probe, and need not be added by the serviceman. The shunt capacitance of the "hot" meter lead is isolated from the oscillator tank circuit by the 1-meg resistor, and is thus prevented from detuning this circuit.

Servicing Oscillator Stages

Inoperative and Drifting AM RF Oscillators

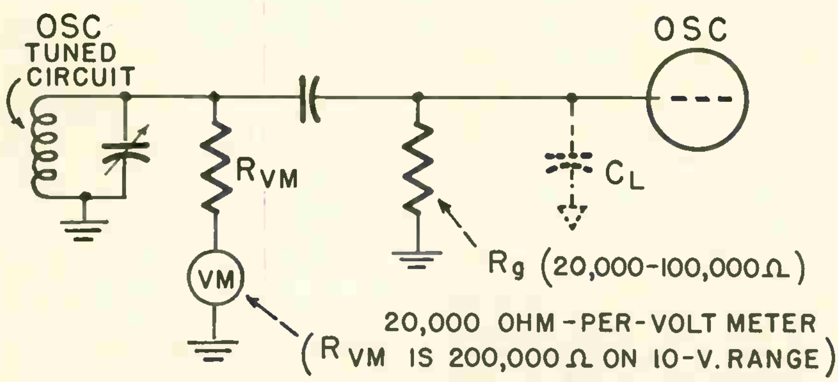


Fig. 2—Using a voltmeter with a relatively low input resistance will load down the tank circuit. If Rg is 100,000, and Rvm, the internal resistance of the meter, is 200,000, the effective value of Rg becomes about 67,000 ohms.

When no VTVM is available, the oscillator grid voltage may be indirectly checked by inserting a milliameter in series with the grid-leak resistor, as shown in Fig. 4. By measuring the current (in amperes) and multiplying it by the grid resistance (in ohms), the oscillator grid voltage may be obtained.

A negative voltage reading somewhere between 5 and 25 volts should be present between the grid of the oscillator and ground. The average voltage for an AC superhet is roughly 15; for an AC-DC receiver, about 10; for portables, 7-10. The reading will vary as the oscillator tuning condenser is rotated throughout its range; this is normal. The highest oscillator voltage will generally be measured at the high-frequency end of the band. There should be no point, throughout the range of the tuning condenser, at which the grid voltage drops to a very low value, or zero, if the circuit operation is normal.

If no grid-leak voltage is measured, the following tests (among others) should be made: 1—Substitute an oscillator tube known to be good for the one present in the set. 2—Check plate and filament voltages of the oscillator stage. 3—Check for open or short in tuned circuits. Tuning condenser, padders, trimmers, coils and band-switch may all be part of a tuned circuit. 4—Check for an open in the cathode circuit. 5—Check the resistance of the oscillator grid resistor (R_1 in Fig. 1). 6—Replace the oscillator grid-leak condenser (C_1 in Fig. 1) with an equivalent unit. 7—Substitute a new plate by-pass condenser, if any is used.

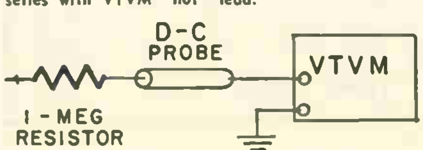
When only a few stations at the high end of the band are received, the oscillator may only be partially operative. The serviceman should, in such a case, check for inadequate plate and filament voltages; excessive cathode voltage (if the oscillator is cathode-biased); reduced capacitance in the grid-leak condenser; reduced value of grid-leak resistor; bad tube; defective oscillator coil.

Tube Variations

The question is sometimes raised, why do oscillators work for a while in certain receivers, then go dead? An allied query is, why will a new tube oscillate in one circuit, while it won't in another, similar or identical to the first? Basically, the same answer may be given to both questions. Let's develop this answer a bit.

When the transfer of energy in an oscillator is not adequate to sustain stable oscillation, the oscillator is apt to function until a sudden decrease in the line voltage reduces feedback below the critical level, causing oscillation to cease. The trouble is not, in such a case, due to the decrease in line voltage; it is caused by the inadequate transfer of energy in the oscillator. A sudden increase in the line voltage may cause the oscillator to start functioning once more, puzzling some servicemen no end. Possible

Fig. 3—Inserting a 1-meg isolating resistor in series with VTVM "hot" lead.



sources of the trouble are the same as those cited for a partially-operative oscillator. The grid-leak voltage, incidentally, will be below normal when the condition just described exists.

Now, the replacement of the original oscillator tube with another one may remedy the condition, causing the serviceman to regard the job as finished. This may not, however, be the case.

Oscillator tubes vary in their transconductance. If a tube with an average or lower than average transconductance is used in the case we have been discussing, the unstable oscillations are apt to continue. (It should be noted that the same tube may perform perfectly well in an identical circuit where no decrease in the oscil-

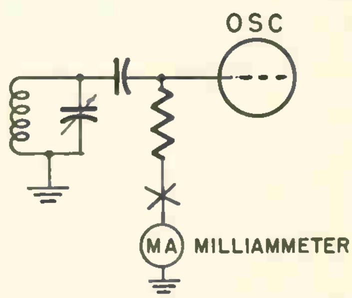


Fig. 4—Measuring grid voltage of oscillator with milliammeter. The circuit is opened at the ground side of the resistor (X), and the meter inserted as shown.

lator's transfer of energy has occurred.) If, on the other hand, a tube with a higher than average transconductance is substituted, the efficiency of the oscillator may be boosted far enough beyond the critical point to result in fairly stable operation—for a while. When the initially high transconductance of the tube decreases somewhat after several months of use, however, the original instability of the oscillator is apt to reappear.

Oscillator drift—the last symptom on our agenda—is frequently due to a defective oscillator coil. Moisture absorbed by the coil when its moisture-proofing covering has broken down causes a varying leakage between turns, or a corrosion of some turn section, producing a drift. If replacing the oscillator tube does not eliminate the drift, a new coil should be substituted. When no exact replacement is available, the old coil may be dried out in an oven. It can then be covered with wax melted from a condenser, and rewired into the set, where it will often (not always) perform satisfactorily.

Servicing Vertical Sweep

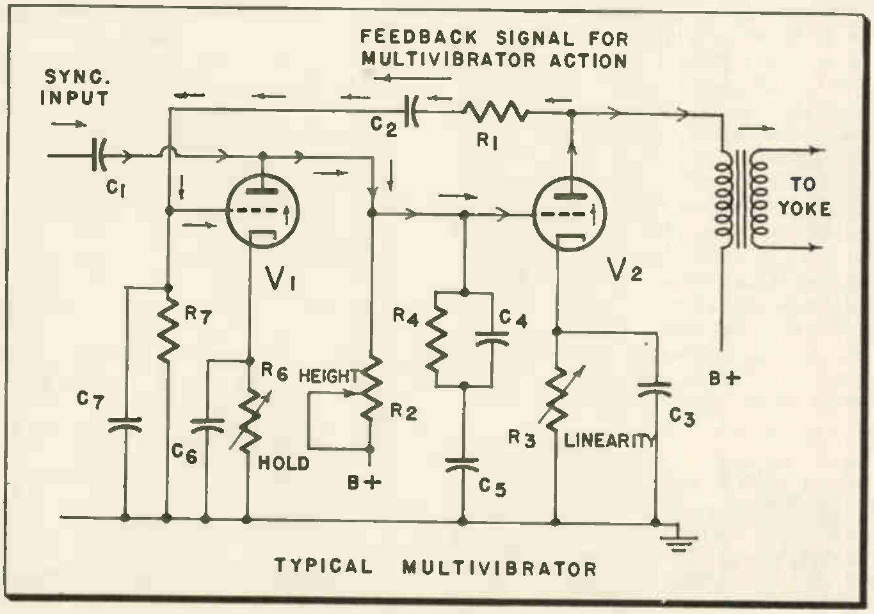
Use of Scope and Calibrator Speed Troubleshooting.

• The vertical section has been selected because although it is somewhat simpler than the horizontal section, in each case the methods for troubleshooting are closely parallel. There have been two main trends in the design of the vertical oscillators employed in modern receivers. The first to be widely used was the blocking oscillator type, which employed a transformer for the dual function of getting feedback from the output of the oscillator back to the input (to sustain oscillations) and for injecting the sync signal into the grid and mixing it with the feedback signal. The other commonly used method is the familiar multivibrator circuit, in which the feedback is from a second tube or tube section back to the first section through an R-C network. This type is coming into much wider acceptance as sets become simpler and smaller. The circuit of Fig. 1 is that of the GE 12T3, very slightly simplified, and is typical of present practice. A quick review of its operation is in order.

Integrating Network

After the composite sync pulses are amplified, they must be separated —the vertical pulse, being 60 cps is a low audio frequency, and can be separated from the relatively high frequency of the horizontal pulses by using a filter with a fairly long time constant. This long time constant merely smooths out the fast pulses (horizontal—15,750 cps) and does not greatly change the slow, or low frequency, vertical pulses. This filter network is called the integrating network, and its configuration is quite standard in most sets. It is shown in figure 2A. The values may change from set to set, but they are always similar in size. From the integrating network the snyc pulses are fed to the vertical oscillator. (Also called the vertical multivibrator, blocking and discharge tube, etc.) The pulses are used to trigger, or set off the vertical oscillations. They maintain the vertical sweep in exact *syncronism* with the vertical sweep at the transmitter.

After being shaped by the integrating network, the vertical sync pulse is passed to V2, the vertical deflection output tube, where it is amplified. Part of this amplified pulse is now sent back to the grid of the first generator tube, V1 through R1 and C1. The values of these two parts are chosen so as to rule out amplification by V1 of any little bit of the horizontal pulse that may be left in the composite sync signal even after it leaves the integrating network. V1 amplifies the vertical pulse fed to it from V2, and from VI plate it goes, along with the incoming sync pulse from C_1 on back over to the grid of V2. Thus a continuous oscillation is maintained, with the sync pulses coming in from the sync amplifying section through the integrating network to keep the multivibrator working at the right speed. The vertical hold R_6 is set so that V1-V2 would be a little bit slower than 60 cps if the sync pulse didn't come in, so that the sync pulse may furnish the actual triggering of the sweep.



Now that the grid of V2 is working properly the plate circuit, consisting of the plate of V2, the primary of T2, the vertical output transformer, and the B supply, is receiving its pulses of current at a rate of 60 cps., and the transformer T2 supplies these pulses of power to the vertical deflection yoke as the vertical sweep.

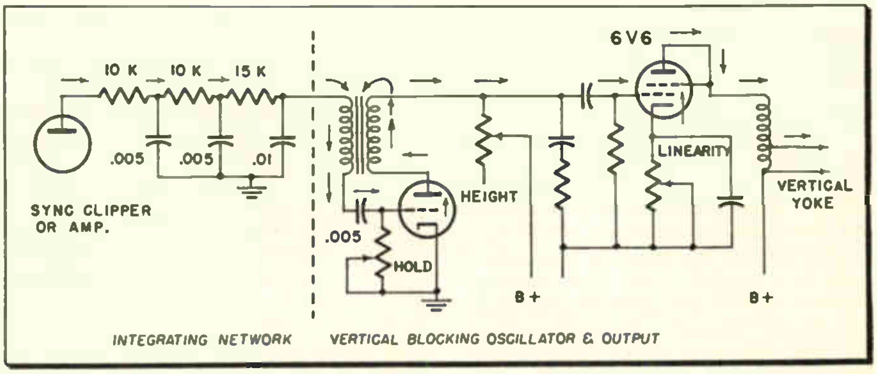
Signal Trace With Scope

Many technicians prefer to use a scope for signal tracing in vertical or horizontal circuits, and we incline to that view too. If the signal gets lost even though most voltage readings are right it's easy and fast to touch the scope lead progressively to the integrating network, oscillator grid, plate, output grid, and finally plate, and then to the secondary of the vertical output transformer. Remember here that you've got plenty of B plus to worry about, so use the rule of one hand behind you, or one hand in your pocket, while chasing the scope input lead through the set. This signal tracing with an oscilloscope will be found to be easier than the method of using a VTVM once you are accustomed to knowing what to look for at the usual check points because if a VTVM were used first, and failed to reveal the defect by improper electrode voltages, you would still have to use the scope. This way, the first step is eliminated. In connection with 'scope signal tracing it is wise to make full use of manufacturers or other service literature. These usually show photographs or simple outline drawings of the wave shapes to be expected in normal operation at each check point. Notice one thing in looking for these wave shapes; they may be drawn as they really are—not as they'll show up on a 'scope which has a fairly limited high frequency response. With a little practice you'll have no trouble in knowing what differences to expect in the published wave shapes and what you get on your scope. (All radio servicemen who use a 20,000 ohm per volt meter are easily able to mentally compensate for the difference between what their meter reads and what it really means in circuits of high or relatively high impedance.)

Circuits in TV Sets

Present Day Circuits Are Getting Simpler

A voltage calibrator is standard equipment in the best shops, being hooked right onto the scope input at all times so that input voltages can be instantly measured and compared with the values given in the service notes. The calibrator has a switch which, in the "Off" position allows connection directly to the scope, as though the voltage calibrator were not there. It also functions as a variable control of the input voltage to the scope. In this way it provides a method of finding out quickly where the vertical signal is being lost or attenuated. There are several excellent voltage calibrators now on the market. This tool has long been used as an aid in the laboratory, where the scope also was employed for years before it found such widespread use in TV servicing. Now top technicians are finding that leaving the voltage calibrator permanently attached to the input of the scope saves motion and time.



Common Troubles

Troubles in the vertical section of the set are among the most straightforward to handle. As with all types of TV failures, they will, a great deal of the time, be nothing but tube failure. So naturally we will pull and try new tubes first in the oscillator, then in the vertical output socket. If the set has a vertical buffer, or a vertical discharge tube, these are tried also. There is one vertical trouble which cannot be cured by working in the oscillator or output stages, however. It is called the keystoning effect. When the *raster* has a trapezoidal shape, when one side is longer up and down than the other, it is caused by trouble in the vertical deflection coil. The most usual cure for this is to replace the deflection yoke.

More common troubles are caused by failures or changes in the circuit components. The commonest trouble is the one which causes the customer to say, "I get only a thin white line." This is well known and indicates, of course, a complete lack of vertical deflection. After trying tubes, which we will from here on assume are the first thing attempted in all normal repair procedures, we check for B voltage on the plates. If that is found to be present, we go next to the cathodes, and if we get 2 to 13 volts there we're usually safe in assuming that the tube is drawing current. In some circuits, especially the oscillators, it is okay to have 100 to 150 volts positive on the cathode. Just jump over to the grid to be sure it has a comparable voltage, ten or so volts lower than the cathode. If you have this grid bias developed, the oscillator is almost always working, and the trouble lies beyond it. If no oscillations are present, then the ohmmeter is the tool for finding out why. At this point, the service notes are the best reference, and sometimes it's a little tricky to find a leaky condenser or an open in an oscillator circuit, so read that meter carefully, and use the right scale.

Less common than the "thin white line", but not unusual, is the folded-up, or "curtain-raising" effect. In this the vertical height is insufficient, and the bottom edge of the picture is bent back up over itself. This is due to a defect in the input of the oscillator, and in the circuit of fig. 1 would be caused either by a leaky condenser, C7, or a change in the resistance of R7, or R6. A shorted condenser C6 might produce a similar result, due to shifting the operation of the tube onto the wrong part of the amplification curve.

Improper Height

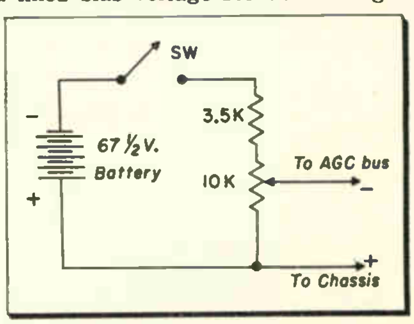
Inadequate picture height could be caused by a number of changes in the circuit constants. A frequent cause of this is a rise in the value of the plate charging resistance. Another cause would be shorted turns in the sweep output transformer or a cathode condenser C3 being too small, or becoming open. These would produce poor linearity, and possibly inadequate height also, depending on the exact circuit values involved. Almost any improper potential on the elements of the output tube might result in insufficient height, and certainly low emission of the tube would be a fault to watch out for. This would ordinarily have been taken care of, had good troubleshooting procedures been followed, as the first step in the initial examination of the set in the customer's home.

Inadequate height *combined with* a complete absence of vertical synchronization usually indicates a short in the cathode circuit of the sweep generator tube. In this circuit, a short in either the hold control or the condenser parallel with it would be the guilty components. Finally there is a whole raft of faults tied up with too much height, poor vertical linearity and the inability to control either properly. In this case the use of the voltage calibrator to check on the size of the input signal, and comparison of this with the value given in the service data would reveal the defect at once. It is a smart idea to have good equipment in the service department, in this case, scope and voltage calibrator. But the only thing that will service sets well is the right use of the tools.

SHOP HINT

TV Bias Source

A convenient method of obtaining a fixed bias voltage for use in align-



(*Continued on page* 48)

How New Automatic Focus

One Design Replaces Both Electrostatic-Focus and Magnetic-Focus Types.

By Charles Graham, Technical Editor

• After changes in the design of cathode-ray picture tubes which have involved TV sets (and consequently servicemen) with *five* different beam focus-and-deflection systems, a means has at last been devised which provides a simpler way of focusing the electron beam than have any of the previous five. In addition, there are a number of advantages attendant upon this design which will further simplify the task of the technician who finds himself confronted with the job of replacing a weak or burned-out picture tube, or converting a small screen set to a larger size.

Procedure For Installing Automatic-focus Tubes

1. Remove focus coil from neck assembly.
2. Install centering device only when no variable DC centering is available through the yoke.
3. Plug new type CRT in and start operation.
4. Change ion trap if necessary. Correct type stated by tube mfr., and depends on amount of second anode voltage. Trap is adjusted for max brightness only.

History of Developments

When non-mechanical TV was in its infancy there were two electron guns used. One was in CRT's like the present 5 and 7 inch oscilloscope tubes, and both beam deflection and beam focus were accomplished electrostatically. The other was a combination of magnetic deflection and electrostatic focus. This design was used in tubes as large as the 12 inch size. Unfortunately, when the circuit constants, line voltage, etc., varied, often the degree of focus did also.

The difficulty of manufacturing these guns resulted in higher priced tubes, and with the advent of tubes with wide deflection angles, the guns were unable to produce pictures of sufficient quality.

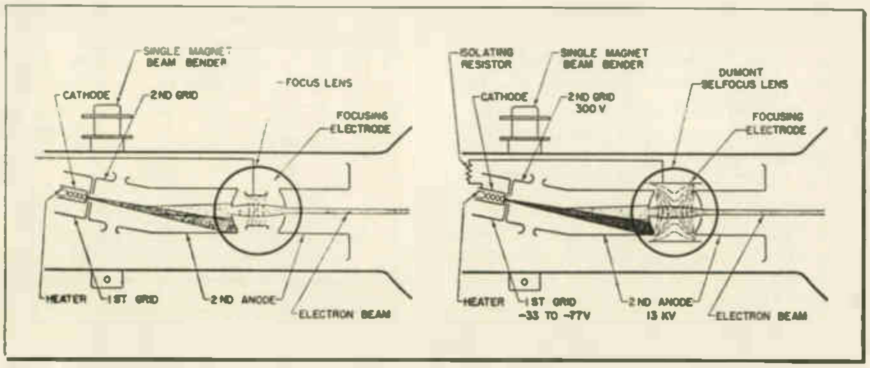
Meanwhile set designers switched over to the system of magnetic deflection and magnetic focus which is now familiar, and which is still the most widely employed system. When shortages were threatened last year, and it became clear that sooner or later set designs would have to be pared of excess metals, tube engineers went to work to try eliminating focus coil and focus magnet. Improvements in quality control of electron-gun production, and advances in research allowed them to come up with a system of electromagnetic deflection and electrostatic focus which was better than that obtainable before magnetic focus had become universal. Too, this time they were able to apply electrostatic focus to tubes of even a 20-inch diagonal (a size which was regarded so huge two years before that the tube had to be *specially* ordered, and it sold in the trade for over $200!).

A large number of these tubes, called electrostatically-focused, or simply "electrostatics", are today being used in TV sets. But although the use of electrostatics does save copper and cobalt (in focus coils and permanent magnets), it requires a focus voltage rectifier tube, a potentiometer, and at least three other small parts.

Low-voltage Focus

A partial solution to *this* problem (the requirement for the parts which make up the focus anode supply) was found soon after when some companies started engineering and producing *low-voltage* electrostatics. These picture tubes required, instead of one-quarter the second anode voltage, or about 2500-3000 V., only a few hundred volts. This eliminated need for the focus rectifier tube and some other parts, but it still called for a focus potentiometer across the B+ supply.

Fig. 1. On the left is shown a diagram of the electron gun for the older type of electrostatic focus. At the right may be seen the new automatic-focus electron gun.



Now on the market, both for replacement tubes and as initial equipment in new TV receivers, are automatic-focus tubes. This means that whereas in all previous models there has been some sort of adjustment (either a manual one, as with permanent-magnet focus devices, or an electrical control to vary the focus current or potential) now the serviceman will be required to make no manual adjustment of beam focus at all.

Zero Voltage Focus

In sets which use electrostatically focused tubes the new type tube can be substituted directly. No changes are necessary. Of course the focus control ceases to have any function.

As will be observed in the accompanying drawing, the electron gun of the new picture tube is similar in construction to the previous electrostatic type. The main difference is in the shape and placement of the focus anode. This electrode, together with the other grids and the second anode, forms an *electrostatic lens*. The purpose of the lens is to keep the electron beam sharp, of constant size, and as nearly circular in shape as is possible, throughout its trip down and across the face of the tube.

The resistor shown in the circuit between the focus anode and the cathode provides isolation for the focus anode for two reasons: 1. It reduces the input capacity of the tube in the case of cathode video drive. 2. Some manufacturers use little filtering of the second anode supply. Thus anode supply pulses might be coupled to the tube through the interelectrode capacity of the focus electrode were it not for the isolating resistor.

It was found that by increasing the

Picture Tube Operates

Requires Neither Focusing Coil Nor Electrode Supply

diameter of the focus electrode and having it overlap rather than fit between the two adjacent elements, it was possible to make many of the gun dimensions less critical. It also allowed more substantial physical mounting for this electrode, as can be seen in the photograph of the electron gun, fig. 2.

In sets which have electromagnetically-focused tubes as original equipment, the focus coil can simply be dismounted from the neck assembly and taped down on the side of the chassis out of the way. Or the focus coil may be removed completely and resistor of the proper size installed to take the place of the focus coil. (In the case of permanent focus magnets, naturally there is no need to keep the magnet once the new tube is installed.)

Focus Regulation

When the focus potential is a sizable percentage of the second anode voltage, as in the case of electrostatic-focused tubes, variations in the focus potential, or in the second anode voltage can cause a change in the degree of focus attained unless these voltages vary in direct proportion. This is one problem partially eliminated in the development of the low-voltage electrostatistics. By reducing the percentage of the second anode voltage which the focus potential represented, better regulation of the beam focus in relation to potential variations was accomplished. But it was still only a relative degree of regulation.*

In developing this newest electron gun, for automatic-focus tubes, DuMont engineers found that they had achieved almost perfect regulation of beam focus. That is, through the design of the electrostatic lens system in the electron gun, they had made the degree of focus sharpness almost entirely independent of reasonable variations in the second anode voltage. (Naturally, lowering of anode voltage will still produce dimmer pictures.) In addition, variations in beam current which previously caused changes in the size of the spot and focus were lessened in the new gun.

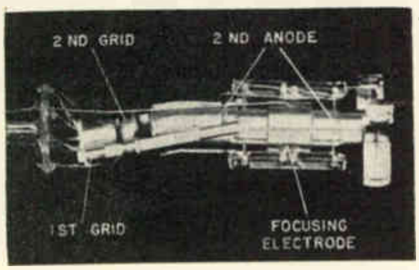
Finally, the new design increased the amount of the normal focus independence of line voltage variations and set warm-up. In the earlier sets, it was often necessary to readjust the focus control due to the warm-up.

Customer neglect of focus adjustment has much of the time resulted in an inferior picture which was not the fault of the set or installation. This tube removes the necessity for that adjustment.

Because of the shape of the new electrostatic lens system, there appears to be slightly better resolution of the beam at the edges of the pictures. This too has been a problem with some other tubes.

* A high degree of regulation, or *good* regulation is attained when the ratio of variation in the output or product is small compared to changes in the supply or the size of the load. Thus a power supply would be described as having *poor* regulation if doubling its load from normal cut the voltage supplied in half.

Fig. 2. Photograph shows DuMont electron gun for no-focus voltage picture tube.



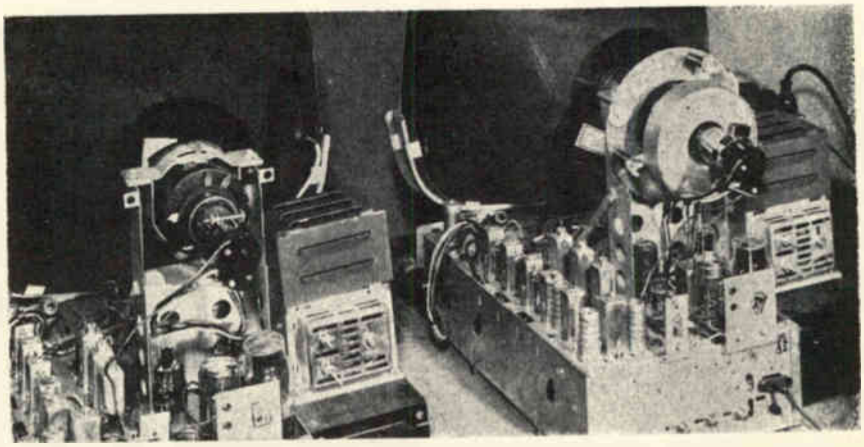


Fig. 3. DuMont set on left has simpler neck assembly due to new style picture tube. Small centering magnet at rear of yoke is required only on with sets having no DC centering.

Conversion Steps

In converting sets the advantage of using this type of tube may be easily seen. In conversions *previously* it was necessary to go through three separate steps:

1. *Cabinet work.*
2. *Deflection circuit changes* —
   (a) usually changing horizontal output stage for more sweep and higher second supply.
   (b) changing yoke from 50 to 70 degrees.
3. *Focus changes* due to higher anode voltage, (and sometimes due to the requirements of the tube itself.)
   (a) More focus current was usually required.
   (b) Frequently a different focus coil was required.
   (c) The range of the focus control often had to be changed.

In converting to larger tube sizes with the automatic-focus type the third set of conversion requirements is eliminated. As a sales point, too, the customer can be honestly assured that this tube is the "latest" engineering development in cathode-ray tubes.

Cuts Inventory

The advantage of using this type of picture tube for all replacements is obvious when one considers that instead of having to keep on hand a 17-inch electrostatic-focus tube and a 17-inch magnetic focus tube, the serviceman or dealer can take care of either type with only one 17-inch replacement. The same applies to the 20-inch replacement stock problem. In this way the inventory of replacement picture tubes for smaller shops may safely be halved.

The cost of the automatic focus tubes is at present set the same as the price of the equal size rectangular tubes of other focus systems. DuMont is producing the 21KP4A, the 17KP4 and the 20JP4. Thomas Electronics is producing some of these tubes, and GE has announced the 17RP4. At presstime other manufacturers had indicated that they would soon produce these tubes, but could not yet make official announcements.

Printed Circuits Widely

New Units Gain Acceptance Because of Saving of Labor and Space

• When Grandad made his first superregenerative receiver from plans in the daily paper, he was told to use a lead pencil mark between "A" and "B", to make a resistor.

This *simple* resistor was one of the first clues to present-day printed-circuit techniques, and as a starter it lay almost absolutely still for about twenty years. Present-day printed-circuits have several advantages, yet the keynote to them all is *simplicity*. The pencil mark represents about the simplest component we could hope for, and our modern printed circuits aren't that simple. But they *are* made by mass-production methods, which is something Grandad wasn't able to accomplish. Today there are over 15 million printed circuit components in civilian sets. (Figures on military sets are still secret, but it is known that previous to civilian use the military necessity for compact parts and assemblies required large quantities of such components.)

Because they are showing up increasingly in television receivers and other common electronic devices, a brief discussion of the construction, applications, and advantages of printed circuits is in order.

Just as miniature tubes were developed during the last war, and have now come into general use, so it is likely that a great many other miniaturizations, including printed circuits, will soon be used in everyday sets even more than they are now, due to defense research.

When "printed circuits" are mentioned, many technicians tend to think of the stamped metal antennas which have been widely employed in AC-DC sets. Or they recall the turret tuner which has its coils photo-etched in thin copper. But the type of printed circuit most widely employed today is neither of these. Printed circuits as they are used at present in TV and radio receivers are flat rectangular plates, generally between ¾" and 1½" long, about an inch or less high, and ⅛" thick. They are ceramic plates onto which have been bonded metallic paints and compounds to form resistances and small condensers in circuits where these parts are commonly used in the various sets with the same values frequently chosen. The vertical integrator plate, for example (See Fig. 2) is a combination of several condensers and several resistors in a circuit which is pretty standardized throughout the industry. Since the same circuit values can be used for this circuit (the vertical integrating

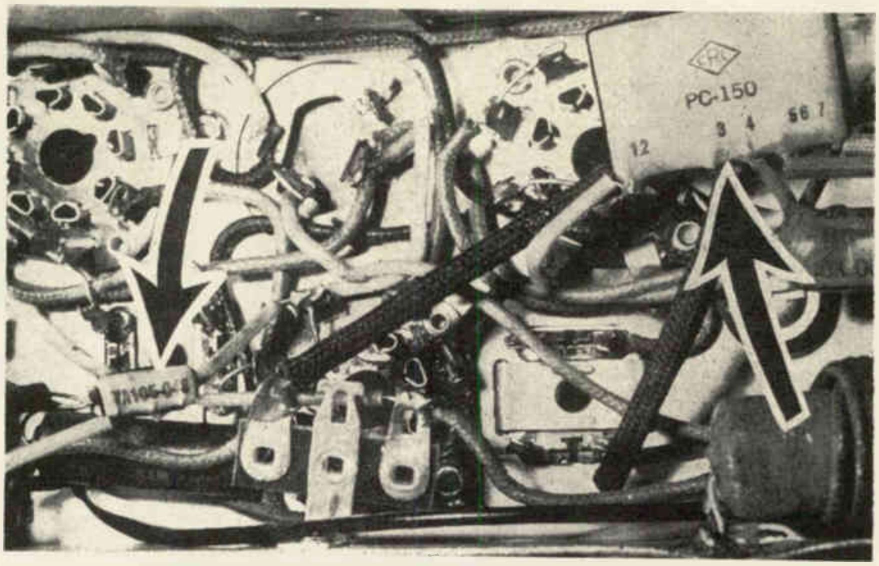


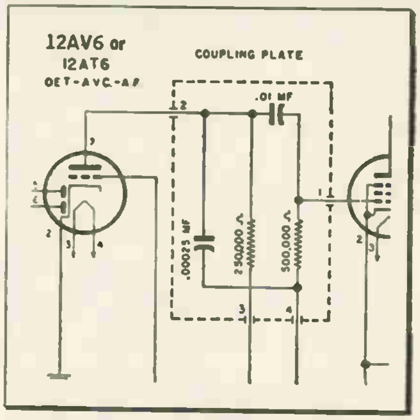
Fig. 1. Olympic AC-DC radio set shown above employs a printed circuit triode coupling plate (upper right). The smaller printed circuit plate directly above is a diode load network. At right here is reproduced part of schematic from Sentinel service notes showing triode coupling plate.

network) in most TV sets, the circuit lends itself admirably to the use of a printed circuit plate. Another place where standardization of circuitry has progressed in the industry to a comparable point is in the coupling network between the output of the det-AVC-first audio stage and the power amplifier stage of small radios. Consequently, a large number of sets now employ printed circuit plates in this part of their circuit.

These components are most widely used in TV sets. Most hearing aids use printed circuits, naturally, because of the extreme small size available, and many portable and AC-DC table sets are including them.

Both resistors and condensers may be made by the printed circuit technique, and when both are fabricated in various combinations, they save not only space, but a great deal of time and work in the manufacture of the circuits they are part of. This is because they incorporate so many circuit components into one piece, with the common, internal connections already made, and hidden in the body of the piece.

See Fig. 1 for diagrams which compare the number of soldering and wiring connections normally required in the construction of a plate coupling network with the number needed with the use of a printed circuit unit. In this audio coupling network between a pentode voltage amplifier and the



next stage, it will be seen that ordinarily *eleven* various points and *five* components would have to be connected together with *eight* or more soldering and twisting operations. With the printed circuit unit this is reduced to five solderng points, and *one* component.

The best example of this sort of saving is in the vertical integrator plate, however. Here *eight* parts become *one*, and *twelve* or more interconnections become *three* soldering operations!

There are over twenty different printed circuit components being produced today. Of these, the vertical integrator network (See drawing, Fig. 2 is the most widely employed, being used at present in over three million TV receivers. Running a close second is the printed circuit coupling plate*, with over 2,750,000 in portable and table radios. There are also over a million small filter networks* already sold to set manufacturers and almost as many printed output

Used in Current Sets

in the Manufacture and Servicing of Radio TV and Equipment

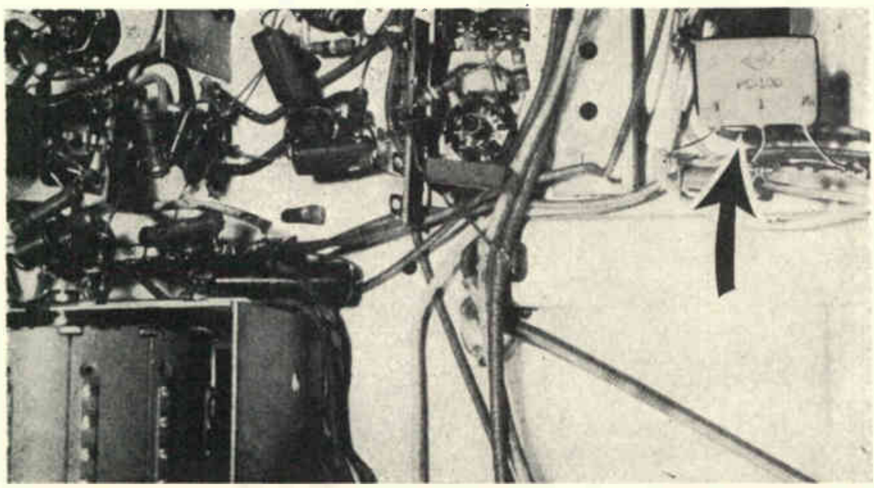
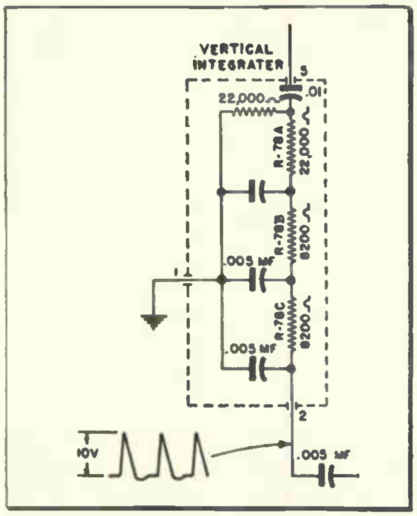


Fig. 2. Photograph above shows most common printed circuit component in use today. It is the vertical integrator plate. Typical manufacturer's service diagram is partially reproduced at left to show (inside dotted lines) the *eight* parts which are included in single printed circuit part. Only *three* external soldering connections are made.



stages*. Fifty or so manufacturers have already used these components in one or more sets each.

From the above statistics, it may be seen that printed circuits, though comparatively new, are rapidly spreading in use. With the speed-up of research and development which the present defense electronics program is bringing about we may reasonably look forward in the near future to even more widespread employment of these parts.

The National Bureau of Standards has already conducted a large program aimed at producing improvements in printed circuit design for manufacturers to the armed forces. This program has developed some important advances in design which are undoubtedly incorporated in military equipment, but are still for security reasons not in civilian use. When they can be released for public benefit, they will change the appearance of home receivers even more than did the advances made during the last war.

In another type of printed circuit metallic paints are sprayed or painted onto insulating surfaces to form the "wire" connections between various circuit components. A different composition of paint is subsequently applied at the proper points to serve as resistor. This sort of printed circuit is used in many hearing aids.

Naturally, such resistors cannot be employed in parts of the circuit which carry substantial current. They are, generally speaking, good in circuits where up to 1 or 2 watt values are usually specified, but not in power output or supply sections.

If part of a printed circuit were to be replaced, as for example, in a hearing aid, the simplest solution would be replacement of the entire printed unit. Failing that, in many cases, it is possible to replace just the faulty condenser or resistor. If this cannot be done, as for example, when several resistors and condensers are contained physically in the same unit, then it is necessary to replace the entire printed unit.

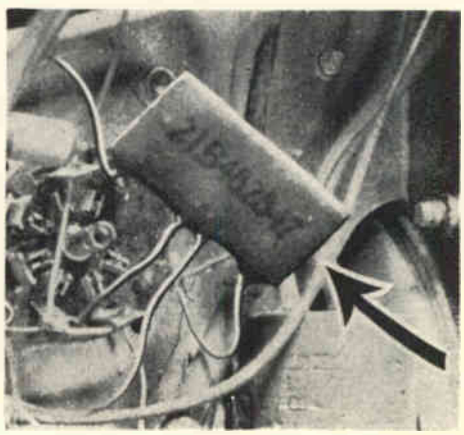
In some cases it is possible to replace just the faulty part, with paint from kits which are now commercially available for the purpose. If a resistor were to be replaced, metallic paint of the appropriate kind would be applied, the resulting resistance measured with a voltohmeter, and more paint added, or some scraped away, until the proper resistance value was obtained.

Regular condensers (or even resistors) can be soldered into printed circuit, as parts replacements, if care is observed not to damage the insulating plates and other circuit parts. Solder which has some silver content is needed for this sort of soldering, however. One caution is in order. When a printed circuit plate is to be replaced in a receiver, often the numbers which identify the leads projecting from the plate are numbered in a different order from the lead numbers which are on the original part. In such cases, the new part should have its leads soldered in the same order, counting from left to right, into the circuit, without regard for the numbers shown. A physical comparison is used—not the numbers.

The advantages which the manufacturer obtains from the use of printed circuit components in his sets may be summarized as follows: (1) Several parts may be replaced by one part. (2) Installation time on the production line is saved through fewer connections to be wired and soldered. (3) Since there are fewer connections to be made by the assemblers, there is lower probability of mistakes. (4) Space is saved — allowing smaller chassis, or more room for other, outsized, or non-standard parts.

These advantages are leading more and more manufacturers to the use of printed circuit components, so we will continue to find more and more of them in the radio and TV sets of today and tomorrow.

Motorola table set shown below uses connections with a P.C. plate.



***Centralab's trademarked names for these components are *Couplate, Filpec,* and *Audet,* respectively.**

Servicing and Maintaining

Key to Profitable Phonograph Maintenance Is

• The step-child of many service departments is the handling of record-changer repairs, and allied phonograph problems. Yet today there is renewed interest in phonograph records as an entertainment medium, due at least in part to the advent of microgroove. With the upsurge in sales of records has come a stepup in the number of phonograph service calls. In addition, the use of fine-groove records has made the listener more readily aware of minor flaws in the operation of the changing mechanism. This is because here the output of the needle is smaller in relation to machine-noise than it is in the case of regular groove records. A further complication is the introduction of better quality sound into present-day combinations, resulting also in "better" reproduction of rumble, scratch and distortion.

In the past, many shops have regarded changer service as such an unimportant part of the work that they have not even had a rack to mount the changer on when it came in. A recent informal survey by the writer found racks in less than one out of four radio repair departments. Yet all the shops stated that they did changer repairs and further, that such repairs were increasing in volume.

Most phonograph repair jobs start with an outside service call. It is important that the outside technician know his own limitations; that he be able to correctly and quickly recognize when a changer repair is not the kind to be done in the home. Many jobs that should have been done in the shop have become needlessly complicated by having been first attempted in the customer's house without proper equipment.

Take the case of Jim Doakes, serviceman. After putting a new needle in Mrs. Jones' changer (an old single-speed one which had a lot of cast white metal parts) he showed her how well the new needle sounded. Jim was about to leave when Mrs. Jones asked him if there was anything he could do about the fact that sometimes the arm did not drop just right. He figured it couldn't be very difficult, even though he was unfamiliar with the adjustments on this model changer. After looking in vain for a positioning adjustment he lifted up the changer and, seeing what he thought was a small nut on the arm spindle, tried to loosen it with a spintite. Of course it wasn't a nut, but just a piece of casting and it broke off, disabling the machine. Jim tried to fix it, but with no success. (It happened there was no such adjustment at all on this early-type machine.) Finally, he had to leave a very irate Mrs. Jones and promise to come back the next day with a new part. It took three weeks to get a replacement part for this old model changer, and even then the changer had to be picked up and brought into the shop for the replacement. The dealer lost a lot of good-will and money in this case because (a) the technician was so anxious to please that he attempted a job he was unfamiliar with, and (b) he attempted a job in the home which should have been done in the shop.

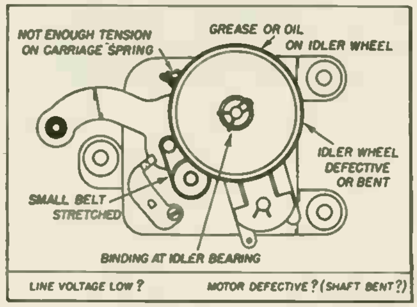
The outside man must be able to tell when the job cannot properly be accomplished in the home, and he must be sufficiently self-assured to tell the customer, firmly where necessary, that the job cannot be done correctly on the spot.

He must not use this means to cover up a lack of proper equipment being carried on the outside call. This equipment should be contained in a kit kept separately for just the times when needed and should include at least the following:

A stroboscopic disc, for use under an AC light source — for checking speed of turntable.

A phono test cartridge, with shielded lead 3 ft. to 4 ft. long and clips at its end. (Removable-needle type).

Carbon tet and/or alcohol, and cloth.



Above: Mechanism is part of V-M changer, used in many combinations today.

Pressure gauge for measuring weight of needle on groove.

Lubricating grease and *light machine oil.*

Small *kit* of *replacement needles*, both sapphire and metal.

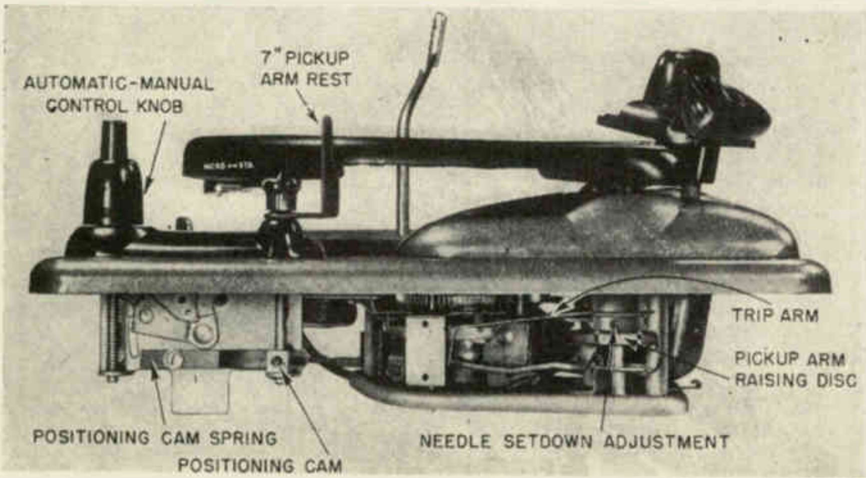
With the kit of phonograph adjustment equipment listed above, the serviceman should be able to correct most minor troubles and make most adjustments. It is assumed that in addition he will have the usual complete radioman's set of tools with him.

Repair jobs which cannot be handled outside will also require, beyond the things listed for the outside phono kit, *manufacturer's factory data, universal AC (fused) test leads* for checking motors, *rack* for mounting the changer and turning it upside down when necessary.

For testing the operation of mechanisms after they have been completely repaired and adjusted, a stack of records, both 10" and 12", some 12" 33 RPM, and a few 45 RPM discs should be kept in the service department.

There are also available *test records* which will rapidly *check* the *changing cycle* of record changers. These records have only about one groove per inch, so that they run in to the center in four or five revolutions.

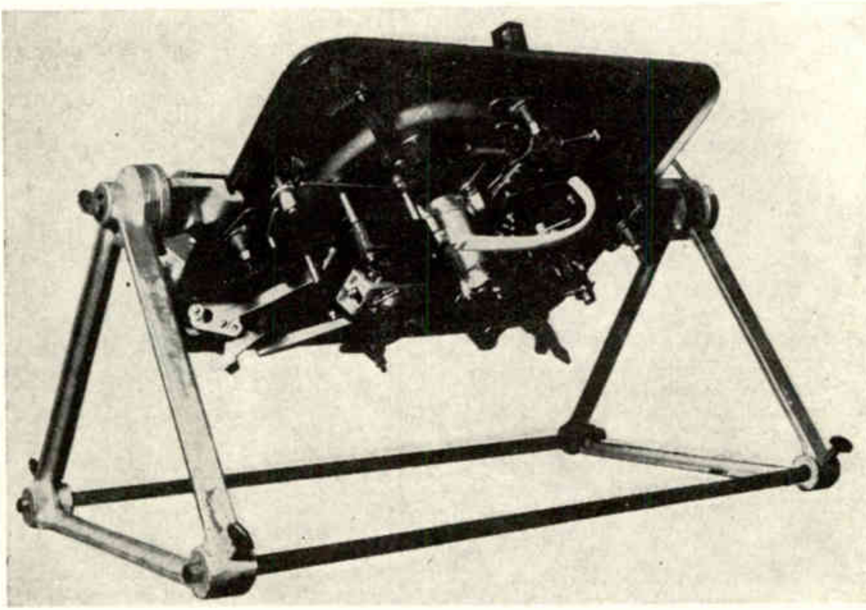
Below, in a typical factory service photo is shown a side view of Webster-Chicago's model 106.



Phono Record Changers

Use of Proper Equipment, Including Manufacturers' Data

In shops where high-quality machines are sold or repaired, a *test record* for checking the *frequency response* of the entire system will prove helpful. These records are made by major record companies, and carry grooves modulated with frequencies from 50 cycles to 10,000 cycles, thus providing a check not only of the needle and cartridge, but of the amplifier and speaker also. In cases where rumble is the complaint, it is helpful to have an amplifier and speaker with very good bass response available for checking this point.



Mounted on adjustable changer rack for easier, faster repair is a Garrard 3 speed changer.

Do It in the Shop

Whenever the trouble is not merely an adjustment which could have been made with a screwdriver, or by replacing the cartridge or needle, the changer should be brought into the shop. The technician who attempts to repair Mrs. Jones' changer in her home beyond the aforementioned repairs is asking for trouble. Involved changer repairs cannot and should not be attempted without a proper rack and the benefit either of manufacturer's diagrams, or years of experience.

Caution! See that no one in your shop ever puts a changer, regardless of make, directly on the floor. It takes only a very slight bump to bend or break the parts of many changers. See that pieces of cardboard are available at all times where changers may be set down.

After the changer is in the shop, it should be set in the rack and, if in operating condition at all, started running. Put one or more records on it and observe its action and see what it fails to do.

If the complaint is "rumble", "squeaking", "thumping", etc., that is, if it is mechanical trouble, but not a failure, then the section of this article dealing with *Maintenance* should be referred to.

If the trouble is a failure to properly accomplish some part of its dropping, changing, or playing cycle, usually the manufacturer's service information will list the common failures and the points to check for eliminating them.

To check mechanical operations, move the turntable by hand on the rack. Move it in the reverse direction if it is jammed. But be careful. A light hand and several years of experience are helpful here. Be certain what you're doing, particularly if it involves *bending* or *twisting* any part of a mechanism. There are almost no repairs that call for this, so stay away from it unless the manufacturer's literature specifically recommends it.

Bridging the test cartridge across the leads of the old head will show at once whether the trouble is in the cartridge or in the set. Most crystals will read high resistance if weak, distorted or dead, and will therefore not materially affect the input impedance of the test head. (Normal resistance of crystal heads is about 2, 3, or up to 10 megs. Variable reluctance heads read much lower—200 to 500 ohms being typical.)

Bad tone which affects only the high notes will usually be caused by a worn or chipped needle, if the fault is present only on phono (not on radio). Particularly with microgroove records the problem of worn needles will be more prevalent than it was with 78s. This is true because (a) the wearing pressure is much greater on the tip of the needle than with 78, despite much lighter total weight, (b) "Permanent" needles are in much greater demand and wider usage than ever before. (c) Present day equipment is capable of much better fidelity and high frequency response, showing up needle wear much more readily than did earlier, poorer equipment.

If the distortion is severe, *and is accompanied by a loss in volume*, the crystal should be suspected. A quick easy check for crystal failure of this sort is to press the crystal lightly to one side of the groove. If this restores most of the proper tone, then one of the two elements of the crystal is dead. Replacement of the unit is the only remedy.

When the motor fails to turn and the servicer has determined that there is no simple failure of contact in one of the interconnecting cables or plugs between the main AC line and the motor, then it is reasonable to suspect the motor itself. Most phono motors for 110 V, 60 cycles, read about 10-20 ohms, a reading much lower than this or considerably higher will indicate shorted turns, or if high resistance, an open in the motor. It usually does not pay to rewind such motors, so a replacement motor must be installed.

More and more changers, particularly in the three-speed category, and in the expensive sets with extended frequency response, will give rumble troubles or speed variation troubles. There are three speed variation difficulties which can occur.

The most common, and easiest to recognize, is "wow." So-called, because of the sound of the word, it is caused by periodic changes in the speed at which the turntable goes around. These changes are very slow (from about ½ change per second on 33 RPM, at the slowest, to a few per second). They are usually due to defects or foreign material in turntable, turntable bearing, main idler, or some other fairly slow

(*Continued on page* 41)

Crystal Diodes Replace

Use of Germanium Units Found Increasing in 1951 Models; Simplification of

• First used in military electronic equipment during World War II, germanium crystal diodes have recently been proving their worth in consumer products, particularly television sets. They are now available for replacement purposes, as well as in original equipment.

Briefly, these units are basically the same as the crystals we knew in early crystal receivers: that is, they are rectifiers. It is mainly the characteristics and constructional features of the new crystals which make them different from early crystals. The latter usually used crystals of the mineral Galena; a "cats whisker" or fine wire was used to find a "hot spot" on the crystal; and the characteristic of the unit was that it conducted better in one direction than the other. The 1N23's that were used in radar employed crystals of silicon, and the units that are being used now in TV (1N34, etc.) utilize crystals of germanium.

Many Advantages Seen

One characteristic of the silicon and germanium crystal diodes is that it isn't necessary to search for a hot spot with the catswhisker, and therefore the latter can be permanently fixed. This means that the crystal diode can be sealed up in a cartridge, which greatly increased its utility. Other characteristics of these diodes are: Relatively flat response at Very High Frequencies over a relatively wide dynamic range of signal levels: low forward resistance, which contributes to good rectification efficiency at low signal levels; transit time, interelectrode capacitance and internal noise, which are limiting factors in the use of vacuum tubes at VHF and UHF, are relatively negligible in the germanium diodes; and finally, of course, when compared with a tube, the germanium diode with pigtails can be soldered in like a resistor—takes little space, needs no filament wiring or other voltages, and no tube socket.

Reverse Current Passed

On the negative side, it should be mentioned that germanium crystal diodes will not withstand as high inverse voltages nor as high ambient temperatures as will equivalent vacuum tubes, such as the 6AL5. Also, it is well to note that while the back resistance is much higher than the forward resistance (the ratio is about 100:1 for germaniums) it is nevertheless a finite resistance (roughly about 100,000 ohms), and current will flow in the inverse direction. A vacuum tube diode, on the other hand, would pass no current if its anode were made negative.

However,—and this should really have been listed under the advantages —the life of a germanium diode (estimated at 10,000 hours) greatly exceeds that of a vacuum tube when operated properly, observing the peak inverse voltage and operating temperature. Table 1 shows some of the pertinent features of the more popular types of germanium crystal diodes used in TV receivers.

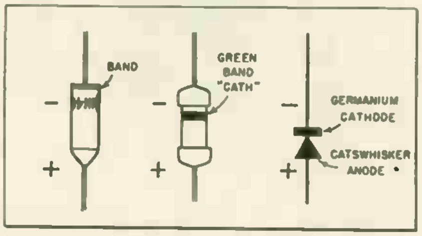


Fig. 3: Proper polarity indications for germanium diodes.

For circuit connection purposes, the characteristics of the crystal diodes are shown in figure 3. Considering the interior of the crystal, the catswhisker is comparable to the anode of a rectifier and the germanium crystal is the cathode. As would be expected, the plate is considered to be the positive end and the cathode the negative. As in a tube rectifier circuit, however, the output is taken from the cathode. This

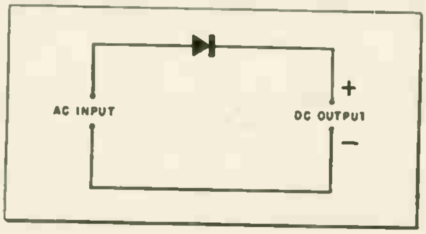


Fig. 4: Output taken from cathode (minus) end of diode.

is shown in the simplified schematic of figure 4. On the Sylvania (1N34, 1N60) crystals, the cathode end is marked with a green band. On the General Electric (1N64, 1N65) crystals, the cathode end is the larger end (opposite to the tapered end). Earlier Sylvania diodes had a "plus" and "minus" sign instead of the green band. The newer GE crystals also have a band on the cathode end. The "minus" end corresponds to the cathode end and should be placed in the circuit so that it faces the "plus DC" output end of the circuit. This is important due to the relatively low inverse rating of the units and the fact that they *will* pass current in the wrong direction.

Several Uses In TV Sets

A typical video detector circuit using a germanium crystal diode is

Table 1

	IN34	IN60	IN64	IN65	6AL5
Peak Inverse Volts	75	70	20.	85	330
Inverse current @ —50V	.8ma	(not known)		.2ma	0

Ambient Temp. Range*—50° to + 75°C for all types —
* Fahrenheit = 9/5 (C + 32)

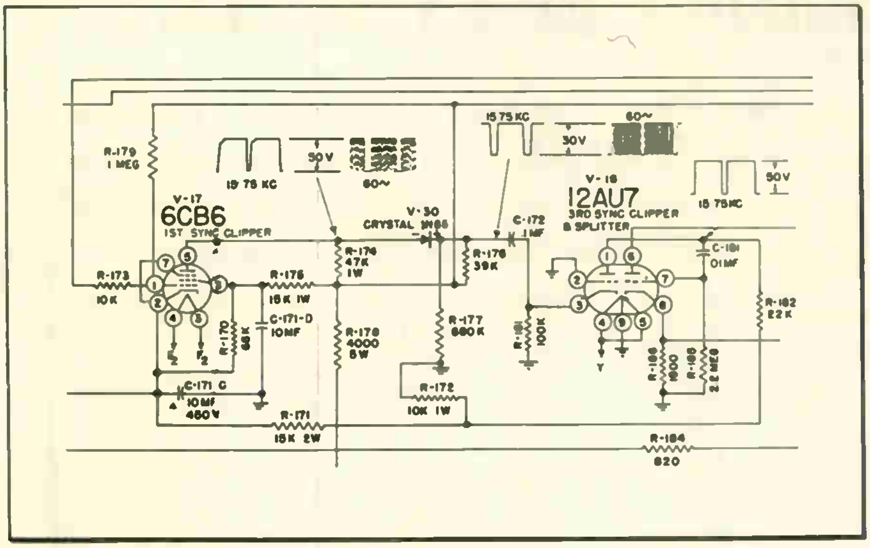
Table II

Current TV models using a germanium crystal diode as video detector

Make	Models	Crystal
Andrea	Normandy	IN34
Arvin	2121TM, 2123TM, 2120CM, 2126CM, 2124CCM, 3080T, 2161TM, 2160CM, 2164CM, 2162CCM	IN64
Brunswick	616, 6161, 1116	IN34
Emerson	673, 660, 665, 664	IN60
Freed	54, 55, 56, 68, 101, 103, 104	IN64
GE	All current models	IN64
Hallicrafters	805, 806, 809, 810	IN60
Hoffman	All current models	IN60
I.T.I.	248, 348	IN34
Magnavox	Cosmopolitan	IN36
	French Provincial	IN60
Majestic	All current models	IN64
Mercury	6111, 6114, 9114	IN34
North Amer. Philips	1200, 588	IN34
Pilot	127, 163, 166	IN60
Setchell-Carlson	150, 1500, 1500LP	IN34
SMA Co.	111, 114, 117	IN34
Stewart-Warner	9200A	IN64
Tele-Tone	All except Imperial models	IN64
Trad	All current models	IN34
Zenith	All current models	IN64

Tubes in New TV Sets

Manufacture and Servicing as Well as Improved Performance Noted



Many Other Types and Uses for Germaniums

The use of germanium crystal diodes in a wide variety of equipment [close to 3 million will have been sold by the end of this year] can be considered still in its infancy; and the use of these units in home TV receivers, covered in this article, represents but one of the many growing markets for them. At present approximately half a dozen out of more than 35 available types are being employed in TV sets. In addition to this use, many are finding their way into radios (particularly FM), test and measuring equipment, commercial and government communications equipment, research equipment, etc., and new uses for them are being uncovered daily.

shown in figure 5. The receiver is General Electric 16T3, 16T4, 16C113 and 16C116.

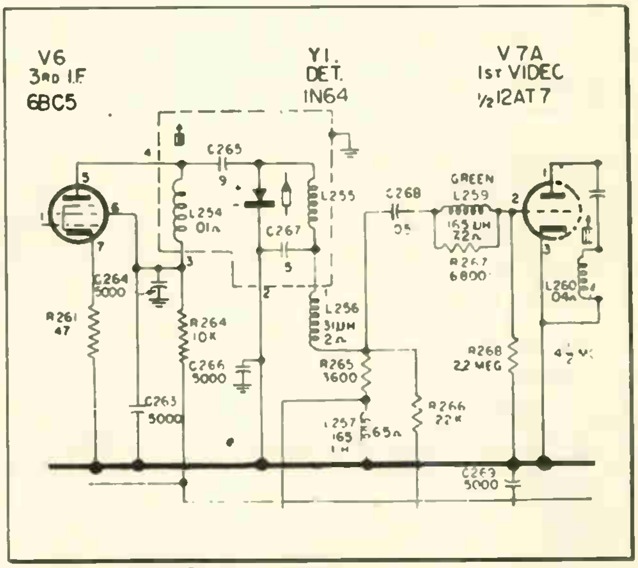
Still another application of the germanium crystal is shown in figure 6, in which is shown a portion of the schematic of the Stromberg Carlson 119 series receivers (Empire, Georgian, 18th Century and Chinese Classic). V-30, a 1N65, is used as the 2nd Sync Clipper. This operates in conjunction with V-17 (1st Sync Clipper) and V-18 (3rd Sync Clipper and Splitter) to remove large noise pulses, to maintain the proper blanking level and to separate the sync signals from the video.

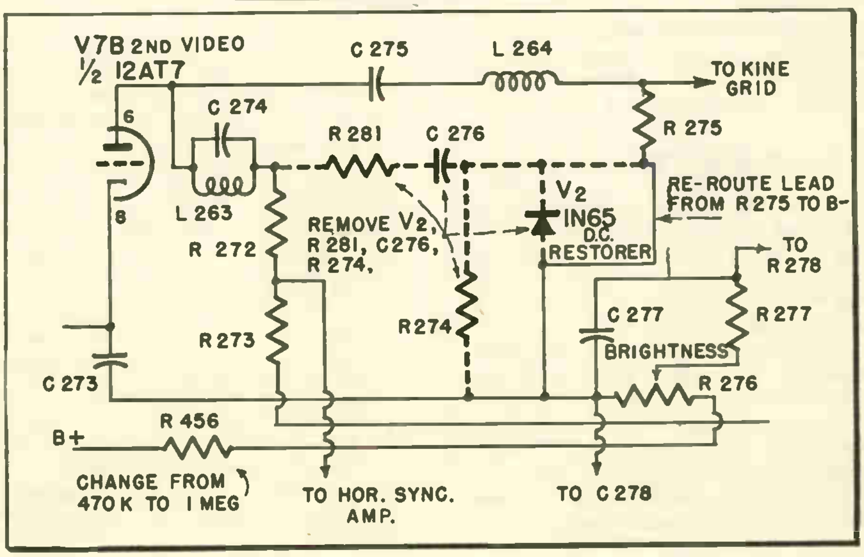
Used For DC Restorer

Germanium diodes may also be used for DC restorers. Substitution of a 1N65 for a 6AL5 DC restorer in the GE models 12T3 and 12T4 is shown in figure 7. Many of the late model sets, however, eliminate the necessity for DC reinsertion by using direct coupling from the video amplifier to the grid of the kinescope.

Of course, the uses for germanium diodes outlined in this article are but a few of the many possible uses. The purpose of this article was only to show uses found in current model TV receivers. Nor are all the many types of diodes which are available described here, but only those found in the aforementioned TV sets. There are some types which accommodate back voltages up to 200 volts, and there are some (silicon types) which are useful at frequencies up to 10,000 MC.

Fig. 5 (at right) a portion of the schematic for GE TV sets 16T3, 16T4, 16C113 and 16C-116. The symbol beside the diode is the physical appearance of the unit as shown in fig. 3. Fig. 6 (Above) Stromberg Carlson 119 series. Due to an error in the original diagram, the symbol for V-30, the 1N65, should be reversed from that shown, so that the bar designation (the cathode) connects to the plate circuit of V-17. Receivers are wired correctly in this respect. Fig. 7 (below) GE model 12T3, showing how a crystal diode can be substituted for V2, 6AL5, the DC restorer.





Suppressing Local Oscillator Radiation in TV Receivers

Proper shielding, grounding, and orientation of oscillator components; adequate rejection in coupling and power supply networks reduces chassis radiation

By *JOHN P. VAN DUYNE*
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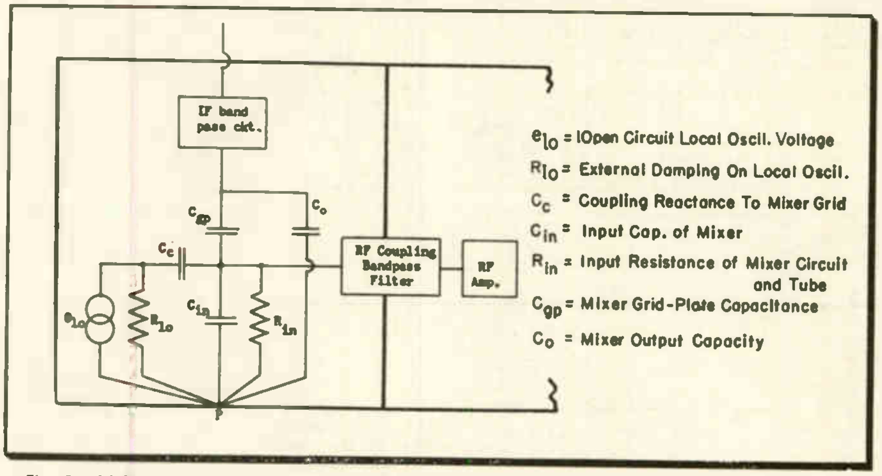


Fig. 1: Shielded local oscillator equivalent circuit. R-F and i-f bandpass filters introduce sufficient attenuation at local oscillator frequencies to make their ground returns relatively unimportant

DURING the last three years, there has been a mounting engineering interest in the suppression of incidental radiation capable of interfering with radio broadcasting and communication services. This interest stems from an engineering conference on oscillator radiation held by the FCC on Nov. 1, 1949. At this conference, attention was drawn by the FCC to the fact that during the period July 1, 1948 to June 30, 1949, 1,730 complaints of interference to broadcasting services were received.[1]

These complaints covered many sources of interference, but the most rapidly growing source was that from the LO (local oscillator) of TV receivers. As a result of this conference, the RTMA Committee on radio interference was reorganized and an active compaign was begun on Jan. 11, 1950 in New York City. At this time, the R15 Committee of RTMA was made aware of the magnitude of the problem and the FCC desire for an early solution.

The work of this committee and that of the IRE Committee on radio receiver test methods culminated in the adoption of two standards: (1) a standard of allowable radiation limits for TV and FM receivers by the RTMA, and (2) a standard on "Method of Measurement of Spurious Radiation of Frequency Modulation and Television Receivers" (50 IRE17 PSI) by the IRE Committee. Once the TV design engineer had a specific limit and method of measuring performance against that limit, it was possible for him to design economical TV receivers to meet the specified radiation limits with a reasonable safety factor.

There are several sources of incidental radiation in a TV receiver. These are, in order of importance: high frequency LO, horizontal deflection system and associated high voltage generator, video i-f amplifier, sound i-f amplifier, and video amplifier. By far the most serious of these has been the high frequency LO radiation. The remainder of this article will deal with methods and techniques useful in the design of a TV receiver and particularly its r-f tuner to meet the new RTMA radiation limits on LO radiation. Space does not permit a discussion of the other forms of interference here.

The LO radiation problem may again be subdivided into "antenna radiation" and "chassis and/or power line" radiation. The power line radiation situation will be considered a special case of so-called chassis radiation. This is due to the fact that excitation of the power line is a result of the same leakage of LO energy from the r-f tuner that excites the whole chassis. By antenna radiation, we mean that component of radiated interference which may be eliminated by the removal of the transmission line from the receiver and the substitution of a matched dummy load resistor. The remaining interfering radiation will be referred to as "chassis radiation."

Experience to date has indicated that when starting with an existing receiver design, by far the most serious component of radiation is the chassis radiation. See Table 1 for supporting data. This is not necessarily true once the design has been altered to minimize chassis radiation. The progress of a radiation reduction investigation is analogous to the problem of the archeologist. When

TABLE I: Radiation Data on Typical Untreated TV Receiver

Channel	Antenna Plus Chassis Field Strength µV/Meter*	Chassis Alone Field Strength µV/Meter*
4	52	34
5	100	90
6	168	113
7	426	464
8	450	487
9	474	592
10	900	972
11	1478	1296
12	1850	1924
13	1865	1872

* Measurements by standard IRE method. RTMA limits: low VHF band 50 µv/meter; high VHF band 150 µv/meter;

he uncovers one layer of interesting relics, has carefully dusted off and restored each one of his important finds, and is about to sit back and enjoy a well earned rest, he discovers that there is yet another layer peering through the dust to mock him. This results in a certain amount of jockeying to and fro from chassis to antenna radiation and the need for constant field testing of "improvements."

Unfortunately, as the engineer begins to peruse the available literature on these problems of radiation reduction, he soon finds that the bulk of the literature is concerned with antenna radiation and mentions little of the problems of chassis radiation. This is natural in view of the fact that prior to the wide sale of TV and FM receivers which operate in the VHF region, most receivers, both home and communication, operated in a frequency range such that the chassis was very small compared to a half wavelength, hence minimizing the importance of chassis radiation.

However, in the case of TV receivers, the chassis usually is big enough to approach half-wave resonance in the 174 to 216 MC TV band and therefore is an efficient radiator. Once this situation is realized, the next step is usually to pull the dust cover off the nearest available VHF standard signal generator and view, in awe, the elegant shielding employed by the manufacturer of the instrument. It would be nice if it were practical for the TV designer to construct the LO of his TV receiver in a manner similar to the signal generator. Unfortunately, however, the economics of the situation prevent this course of action. The buying public would not be favorably impressed with an increase in list price consistent with employment of signal generator techniques.

Signal Generator Techniques

However, it is possible for the TV design engineer to profit immensely by careful consideration of the techniques employed by the signal generator manufacturer. The principles exemplified by this construction may be applied in a much less expensive manner to a TV tuner. Following a further discussion of the basic problem, we shall discuss such techniques as applied to a TV receiver.

Reference to an elementary text on radiation discloses that we get a radiation component whenever an electromagnetic field is accelerated in a medium of finite velocity of propagation. If this radiated energy is not totally reflected, the original electromagnetic field experiences an energy loss. It is the job of the designer to provide either for the reflection or the absorption of this energy which would normally be lost to the LO and gained by the receiver in the next apartment.

In order to prevent the radiation of energy by the receiver chassis, it is obvious that we must prevent the excitation of that chassis by the LO energy or totally reflect the energy radiated by the chassis. Since it is wasteful of material to attempt to confine a field within such a large volume, the most economical approach is that of preventing the excitation of the chassis.

Thus we may state that the basic problem confronting us as design

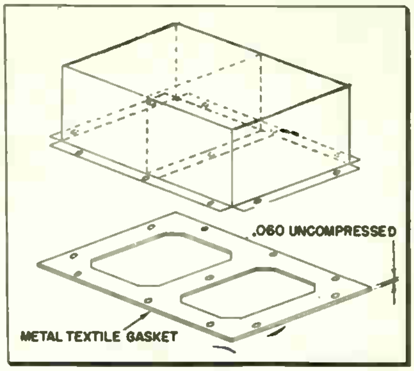


Fig. 2: Typical shield construction

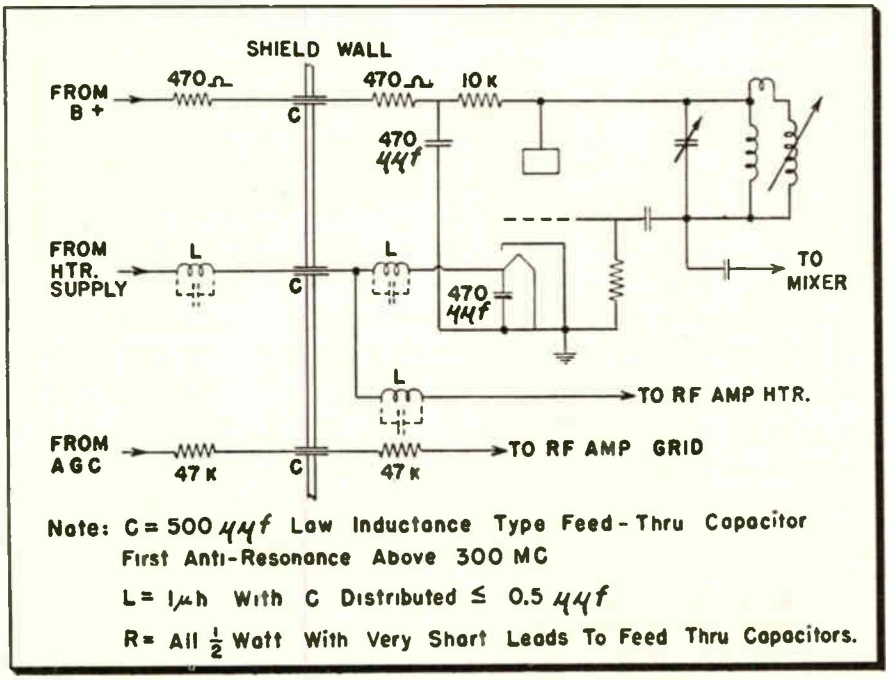
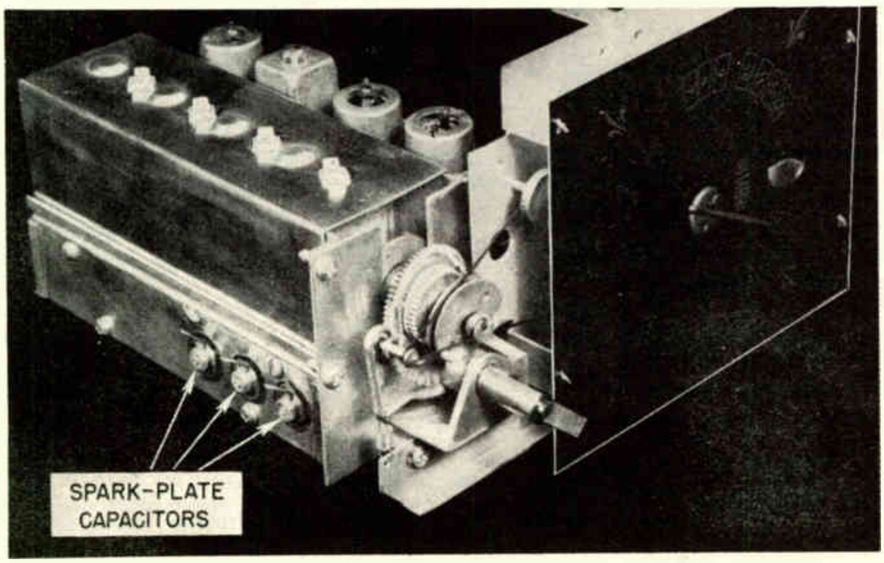
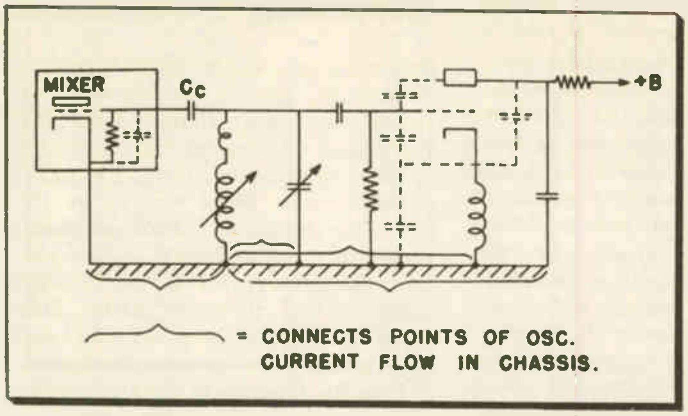


Fig. 3: Filter arrangement designed to prevent spurious resonances within oscillator tuning range

Fig. 4: Spark-plate capacitors employed to filter B+; heater and AGC leads passing through shield wall





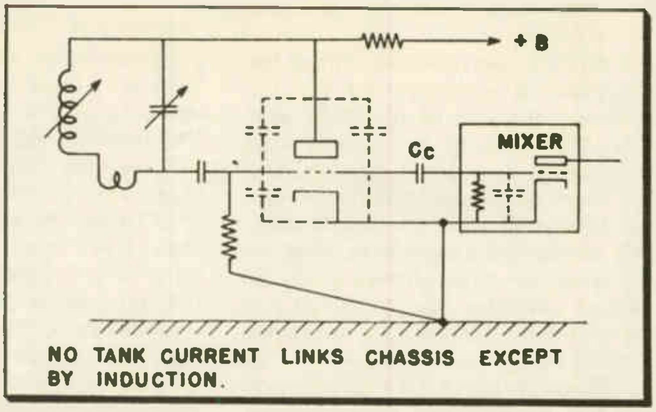


Fig. 5A: (L) Poor oscillator design causes conduction currents in chassis. Fig. 5B: (R) Good oscillator design reduces chassis currents

engineers is to confine the electromagnetic fields due to the LO to the immediate vicinity of the LO. The degree of this confinement is, of course, established by the limits that one is trying to reach. The RTMA limits on radiation have been established with the intent of protecting the maximum amount of service area without imposing an impossible economic burden on the buying public.

There are several characteristics peculiar to TV receivers which aid the program of LO radiation reduction. These are:

a. The oscillator is operated on the high frequency side of the desired signal, separated from the sound carrier by 21 or 41 MC in modern receivers. This separation permits relatively simple and inexpensive selective circuits greatly to attenuate the oscillator signal before it reaches the r-f amplifier plate circuit.

b. The i-f is removed by at least one octave from the oscillator frequency. This permits i-f band pass circuits of proper design to discriminate greatly against the oscillator signal.

c. A higher degree of r-f circuit shielding is required by a TV receiver for many reasons other than oscillator radiation suppression. It only remains to extend this shielding to include the problem of oscillator radiation.

There are also some problems in the TV receiver which complicate a low radiation design. These are:

a. The need for a high degree of economy and reproducibility in the design.

b. The circuits located within the shielded compartments must be available for quick servicing.

c. The chassis used in TV receivers are large enough to be rather efficient radiators, especially in the 174 to 216 MC band.

d. The use of metal cabinets may, under some circumstances, in-

TABLE II: Local Oscillator Radiation Reduction Results

	Antenna Plus Chassis Radiation		Chassis Radiation Alone	
TV Channel	Before µV/Meter*	After µV/Meter*	Before µV/Meter*	After µV/Meter*
4	52	11	34	Less than five
5	100	11	90	Less than five
6	168	7.3	113	Less than five
7	426	32	464	7.2
8	450	28	487	7.0
9	474	52	592	7.2
10	900	27	972	5.6
11	1478	26	1296	6.2
12	1850	41	1924	13.
13	1865	29	1872	25.

* IRE Standard Method

RTMA Limits: low UHF Band 50 uv/meter; high VHF Band 150 uv/meter

Fig. 7: Grid-separation amplifier and equivalent circuit. Plate current in input has LO component

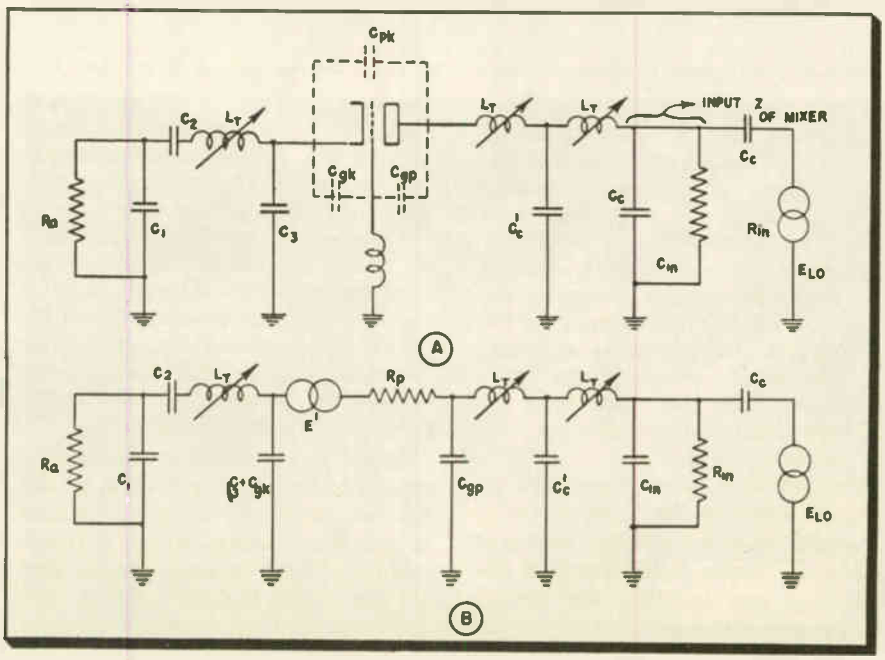
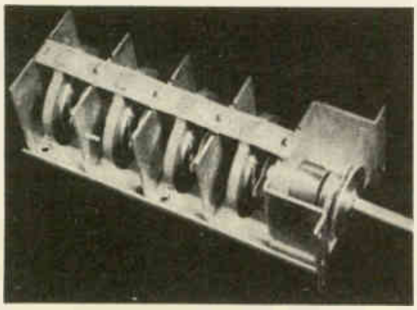


Fig. 6: Continuous inductance tuning unit



crease the effective radiation surface.

e. Our present defense effort has made it necessary for the designer of civilian goods to conserve metals, especially the highly conductive ones which are most desirable for r-f shielding.

With the preceding facts in mind, the designer then proceeds to the task of selecting circuits and physical layouts to accomplish his ends. The following rather obvious points are listed so that it may be easier to follow a detailed discussion of each point. These are the general means for restricting the electromagnetic fields of the oscillator to the vicinity of the LO. Fig. 1 illustrates some of the following points:

a. The oscillator and mixer circuits must be enclosed in a conducting shield as completely as possible. Shield joints must be designed in accordance with the principle of minimum leakage consistent with ease of shield removal and economy of manufacture. The shield should be fastened to the next larger support member at points of as near equal potential as possible to minimize excitation of the larger surfaces.

b. All power supply leads entering the above mentioned compartment must be filtered for r-f.

c. The oscillator must be so designed that it produces a minimum of current in the surrounding metal. This may be accomplished by the following general methods:

   1. Single point grounding must be used for the entire oscillator circuit.
   2. The oscillator inductor must be oriented so that its field induces minimum currents in the surrounding metal.
   3. The oscillator inductor field may have to be restricted by such means as a complete coil shield or vestigial shielding such as a shorted turn surrounding that coil.

d. Since the mixer or frequency converter tube is driven by the LO, usually via control grid injection, it is necessary to design the band pass networks associated with the mixer tube for minimum transmission at oscillator frequencies.

The obvious, but uneconomical, way to design oscillator shielding is to enclose the oscillator by means of soldered, "water-tight" joints in the shielding and possibly the use of double shielding. This is obviously not a reasonable approach to high production. The approach should be that since the shield must be inexpensive and readily removable, extreme emphasis should be placed on minimizing the magnitude of currents induced in the shielding by the LO. It is of even greater importance to prevent the actual conduction of oscillator current by the chassis and/or shielding. Once the oscillator currents in the shielding have been reduced to a sufficiently low value, the need for precious metals in the shield compartments and the need for multitudinous grounding fingers or mounting screws is minimized. Almost any crude metal box of rather low conductivity material, such as thinly plated steel, will adequately confine the electrostatic field, providing that there are no holes or slots in the shield across which a potential difference can exist. This can usually be accomplished, for the electrostatic field, by proper orientation of holes and slots. However, such is not the case for the electromagnetic field.

The presence of any holes will permit magnetic lines of force to "bulge" through the opening, thus permitting the excitation of currents upon the exterior of the compartment shield. These currents then excite the main chassis which is a fairly efficient radiator and the damage is done. From that point on, additional filtering of leads or careful placing of components within the oscillator compartment will be to no avail. Thus holes must be avoided at all costs. This means that supply leads must leave the compartment in a manner that prevents magnetic lines of force from accompanying the wire. The means of accomplishing this with a filter will be discussed later. One hole that is very difficult to avoid is that for the tuning shaft. It is possible to minimize leakage of this nature by use of either an insulated shaft in an elongated bushing (waveguide below cut-off attenuator) or by careful grounding of a metallic shaft together with care in minimizing excitation of the shaft by oscillator currents inside of the compartment. This latter approach is by far the most practical in a TV tuner. It admittedly does not allow the same degree of attenuation as the former method, but experience has proven it to be adequate.

Shield joints, whether fastened by screws or by spring pressure, should have as large an overlap as possible to minimize leakage which is inevitable in joints between metals that are not of the highest possible conductivity and so carefully formed that they provide an almost water-tight joint. This is the big point of departure from signal generator technique. Grounding fingers are no doubt desirable, but they are equally uneconomical. Since shields in TV receivers must be made of sheet metal in great quantity and at low cost, the tolerances that may be specified are of necessity loose. This means that the designer must be very cautious, especially when designing the joints, to provide for the necessary allowances and at the same time accomplish contact over as great an area as possible. A practical means for accomplishing this (see Fig. 2) lies in the use of a gasket of a metal textile to provide good contact between mating non-planar surfaces.

A further point of departure from signal generator technique lies in the choice of metals for the shield. Brass, copper, and silver are entirely uneconomical as base metals and are further unthinkable in view of the requirements of the defense program. On the other hand, high conductivity metals are desirable, in that smaller thicknesses are necessary for a given attenuation of a confined field and that good joints are more readily obtained. A metal thickness of about 10 times the "skin depth" is necessary to produce an attenuation of approximately 86 db in the field intensity. This would require approximately .003" of copper if the minimum frequency were 80 MC. This amount can be most economically produced by "overlay" techniques.

If overlays of copper are used, the shields should be formed with the copper on the inside. However, experience has shown that cold rolled steel will provide adequate attenuation in thicknesses of 0.030" or more, if the joints are plated with at least 0.0005" of copper. This latter shield, together with the previously discussed care in minimizing current density in the shielding will produce very satisfactory results. The main enemy of the effectiveness of such shielding is corrosion and care must be taken in handling and fabrication to minimize such tendencies.

The necessity for adequate low-pass filtering in the power supply leads is obvious. In the case of high voltage and automatic gain control lines, it is possible to use series resistor, shunt capacity filters. It is important that the capacitors not experience any anti-resonant effects within the tuning range of the oscillator. The use of series resistors of a few few hundred ohms on both the input and output of this filter usually prevents resonance in the supply leads exterior to the tuner. It is usually necessary to use LC filters in the filament leads to avoid excessive voltage drop. These filters must be designed to prevent any spurious resonances in the tuning range of the oscillator. See Fig. 3 for typical filters. Several types of capacitors are suitable for use in these filters. One type has been used by automobile radio manufacturers for years under the name of "spark-plate" capacitors. Fig. 4 illustrates such capacitors. This technique is applicable to the TV receiver if material of adequate insulation resistance and dielectric strength is used. Another alternative is the use of either disk or cylinder "feed-through" types of ceramic capacitors.

As mentioned earlier, it is of extreme importance to minimize the flow of oscillator tank currents in the chassis or shields of the tuner. Fig. 5 A shows an oscillator circuit that is very bad from the standpoint of causing conduction currents to flow in the chassis. A change to the circuit of Fig. 5 B will eliminate this portion of the difficulty.

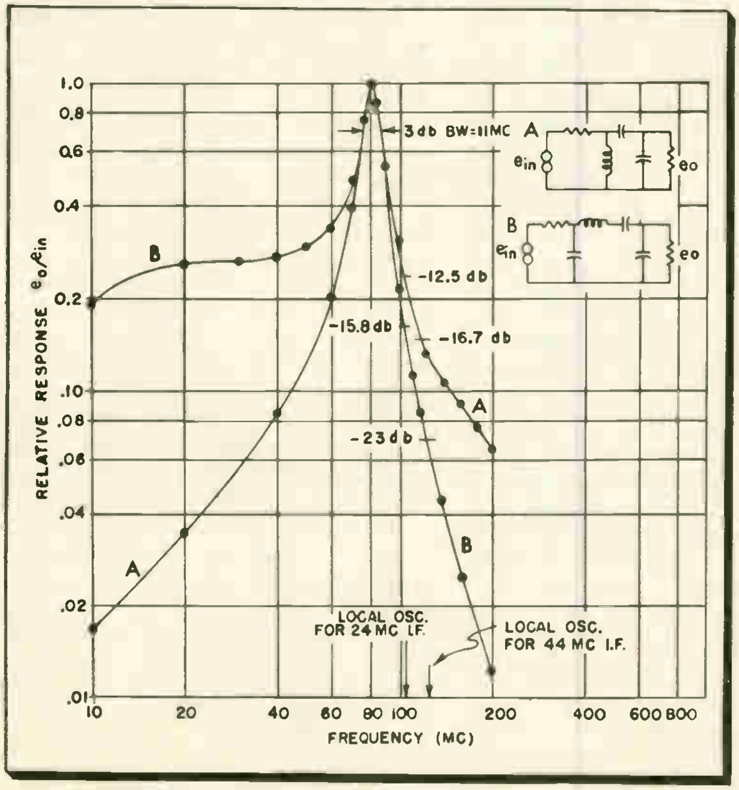
It still remains to locate the oscillator inductor so that its magnetic field links the chassis and shielding as little as possible. In switch, turret, or permeability tuners, this can be readily accomplished by winding a coil with a fairly high ratio of length to diameter and the use of high permeability core material to confine the magnetic field, plus spacing from the chassis of at least two coil diameters. Most pure permeability tuners suffer from a rapid increase in chassis radiation at the high end of the tuning range. This may be due to the increased extent of the field about the oscillator coil when the core is fully removed from the coil. Hence, the use of combined permeability and eddy current shielding tuning is indicated. Naturally, the conducting shield used for eddy current shielding inductance variation must surround the inductor if the desired confinement of the field is to be obtained.

Some forms of continuous inductance tuning devices such as shown in Fig. 6, have a naturally extensive magnetic field. Since, for minimum back-lash, the oscillator inductor must be close to the tuning shaft, it is somewhat difficult to minimize excitation of the shaft. A partial solution to this problem has been the use of a conducting ring in close proximity to the oscillator coil field. This ring can also be used as an aid to tracking, due to its effect on the oscillator coil inductance. In the high VHF band, the effect of the ring is small, due to its looser coupling to the coil. Fortunately the shaft excitation has been found to be a major problem only in the 90 to 110 MC region where the shielding of the oscillator coil field is relatively great.

The problem of confining the local oscillator energy which is conducted from the shielded compartment by the antenna and i-f output leads is one which is readily susceptible to quantitative analysis. However, the results of analyses of this nature must be viewed in the light of maximum attainable figures, rather than the preordained result of following the schematic diagram that was analysed. This departure of results from theory can be minimized if care is taken in the analysis to include all the significant reactances.

The usual approach is to assume that for reverse transmission, the r-f amplifier tube is a passive network composed of the interelectrode capacitances and lead inductances. This is not true in general, but only in special cases. Pentode r-f amplifiers, in which there are a minimum of common impedances in the cathode circuit may be successfully analysed as a passive network. Cathode separation triode r-f amplifiers usually follow this theory also. However, the grid-plate capacity is not the only coupling. Above 200 MC, the cathode lead inductance may allow direct conduction of oscillator energy into the grid circuit, even with C_{pg} perfectly neutralized.

A somewhat different condition occurs with grid-separation amplifiers, since the plate current flows in the input (cathode) circuit. The



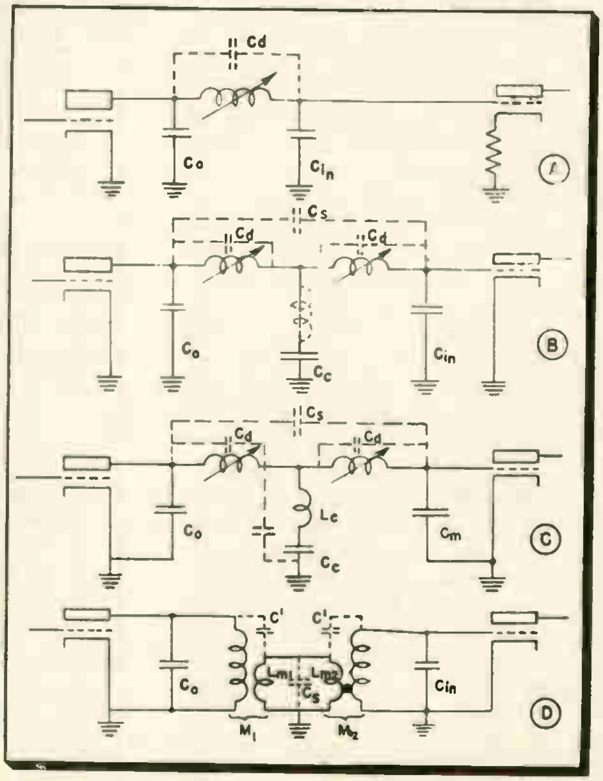


Fig. 8: (L) Comparison of selectivity of anti-resonant circuit (A) with high selectivity input (B) shows greater attenuation of (B) prevents reverse transmission of LO frequencies through r-f stage. Fig. 9: Mixer bandpass couplings circuits, stray reactances dotted.

plate current contains a component of LO signal due to the rather low plate resistance of the triode and this component appears across the transformed antenna impedance. See Fig. 7 for details. Normally, one would expect that the antenna component of LO signal due to a finite R_p would only be noticeable at frequencies so low that X_{cpk} was equal to or greater than R_p. This occurs about 65 MC for $C_{pk} = 0.5$ uuf. Sometimes an effect occurs above 200 MC in which the antenna radiation varies with g_m of the tube. This has been traced to regeneration in the r-f amplifier at frequencies well above the signal frequency, but close to the oscillator frequency. This is usually a result of the grid circuit impedance increasing due to L_g (see Fig. 7). Thus, it is essential to provide a high degree of antenna circuit selectivity at oscillator frequency if a grid-separation triode r-f amplifier is used. Such an input circuit and its selectivity curve compared with a simple anti-resonant circuit of equal Q is shown in Fig. 8. The popular "cascode" or driven grounded grid circuit affords another means of achieving high antenna circuit selectivity together with the passive isolation of the cathode separation input triode.

Much more can be said about proper design of interstage coupling circuits for LO energy suppression, but would be a subject for a paper in itself. Suffice it to say that r-f band-pass circuits between the antenna and mixer grid should have maximum "above band" rejection and those between mixer plate and r-f grid should have similar abilities. It is also essential that the stray reactances associated with practical components should be negligible all through the LO tuning range. Fig. 9 illustrates some of these circuits, together with the dangerous stray reactances which are shown dotted.

The degree of improvement in radiation reduction that can be achieved by the application of some of the previously discussed techniques is shown in Table II. The figures shown are results of measurement of a complete receiver, before and after radiation proofing, by the IRE field method.

In conclusion, a note of caution should be sounded. It is possible, by careful circuit "tailoring" to produce substantial reductions in antenna radiation due to presence of two or more sources of leakage of opposite phase. In TV receivers, the frequency range is so great that such "bucking" is unlikely to hold over the frequency range and is certain to be impossible of attainment in mass production. It is necessary, if uniform results are to be achieved, studiously to avoid such cancellation phenomena. It is far more economical, in the long run, to put a few more cents into a good sheet metal design that is subject to simple inspection techniques, than to rely on "tricks" which will pile up rejects, or worse still, place radiating receivers in customers' hands.

Thanks are extended to Mr. E. G. Mannerberg without whose cooperation this paper could not have been completed.

1. K. A. Chittick, "Report of Engineering Conference on Oscillator Radiation of the F.C.C. on Nov. 1, 1949."

UHF ANTENNAS

(*Continued from page* 8)

b. Utilize built-in or cabinet-top antennas—principally in strong signal areas.
c. Install a separate UHF antenna on the existing mast, feeding both UHF and VHF antennas into a common transmission line by using a special coupling network.
d. Make an entirely separate UHF installation if the location of the VHF antenna is not satisfactory, or move the existing VHF mast to a position suitable for both services.

Record Changers

(*Continued from page* 33)

turning part.

The second common variation in the speed at which the turntable revolves is "flutter." This is a more rapid periodic change in the speed of rotation. It may be roughly said to go from about 15 times a second up to the point where it is no longer noticeable. Most people will react to flutter by saying, "the phonograph is going too slow", or "it sounds slow, or sick." This is, of course, partly true since variations of this sort will usually be accompanied by some slowing down. But the slowing down is not what they hear. Contrary to the opinion of most people, they cannot tell when a record is going very slightly slow or very slightly fast unless they are extremely familiar with the particular record. When they say it's going slow, the odds are ten to one it has flutter.

The third trouble is actual slowing down of the turntable. On governor-controlled phonographs, which are almost out of existence as new equipment, the cause is usually a lack of lubrication, or an accumulation of dirt and grease in the governor. In synchronous motors, which most phonographs today have, the trouble may be too heavy a pickup arm, a broken needle point, cold motor (grease thick—gets back to normal after warmup), dirt on any moving part, or lubricant dried up. The rubber idlers or belts should also be checked.

Maintenance on record changers consists of checking for proper operation, cleaning, and lubricating. The proper cleaning agents are carbon tetrachloride (alcohol is *usually* OK, but be careful of the material it is used on) and a cloth, with a small brush for getting into tight places. All surfaces such as the working surfaces of the motor pulleys, idler pulleys, idler wheels, inside turntable wheels, and friction surfaces in governors, should be carefully cleaned, allowed to dry, and then run for a while. At the same time, before test-running, the bearing surfaces (or inside), of these parts should be cleaned of oil and dirt, and then covered very lightly with a light grade of machine oil. (It cannot be said too often that much of the trouble in new or recently-repaired changers comes from over-generous lubrication. What may not seem like excess oil when the parts are at rest quickly gets distributed to other parts of the machine as soon as the changer starts operating.) Be careful not to lubricate brake surfaces or certain parts of governors. Manufacturers' literature always shows a pictorial diagram of the places for lubrication. In addition to these places, many changers require a couple of drops at each end of the motor every few months. In a large percentage of these motors, there are small pieces of felt near the bearing ends of the motor axle which are intended to hold the lubricating oil. (Do not saturate these — use just two drops in most cases.

Often a flat on the main idler wheel can be eliminated by taking the rubber wheel off and reversing it; that is, turning it inside out.

After the repair has been made, a stock of records should be placed on the changer and allowed to play through two or three times before the changer is marked "ready" and put aside for delivery.

New York TV Stations Utilize

ERP comparisons for transmitters at the same location but on different frequencies first time. FCC's permission to increase powers adds approximately 10,000 square miles

By *JOHN H. BATTISON*
Consulting Editor

LATE in 1949 when the announcement was made that WJZ-TV would share the top or the Empire State Building with WNBT, considerable interest in the project was engendered by the television engineering fraternity. Here was a challenge to the ingenuity and resourcefullness of engineers in applying previously known principles of diplexing to *four* carriers from adjacent radiators.

Later, in rapid succession it was announced that WCBS-TV, WABD, and WPIX would also erect antennas on the same tower and plans for a multiple unit transmitting antenna were drawn up. Then in July of this year it was announced that WATV would probably join the other five telecasters on the top of the highest building in the world. Final authority has been received from the FCC for modification of WATV's construction permit to make this change in location.

As a first step in the ending of the freeze, the FCC recently removed its restriction on the use of maximum power by the existing 107 TV stations. One result of removing the power limitations is that most existing stations can increase the output of their transmitters to the full rated output which is 5 kw for all except community stations.

The removal of the power limitation means that WNBT is now operating from the Empire State Building with 14.5 kw, WJZ-TV is using 17.0 kw from the same location and WPIX is radiating 21.7 also from the new antenna. WABD and WCBS-TV are radiating 14.25 kw and 20.1 kw respectively from their original installations, and WOR-TV is radiating 22 kw.

The factor of greatest interest to both engineers and telecasters in all these power increases is what happens to the service areas of stations when the power is raised. In all cases referred to above the *effective radiated power* (ERP) is used since this is a factor which influences coverage assuming height and frequency are similar. For the first time in television history it is possible to compare the effective coverage of television stations operating with similar high powers and from the same antenna height—within a few score feet, which is negligible at 1400 ft. above sea level.

So far in these tests it has not been possible to obtain comparative coverage maps due to the short time which has elapsed and the fact that there are various methods of expressing service area currently in use. For instance, NBC and CBS use the 0.1 MV/M contour as the limit of service while some other stations use the earlier 0.5 MV/M contour as the measure of service. The FCC has instituted a new grade of service area connotation by labelling the areas grade "A", and grade "B". Also at this time the three stations using the Empire State facilities have not completed full measurements. Probably it will not be until WCBS and WABD join the other stations that a really comprehensive and comparative survey will be made. After all, one field trip would suffice to measure all five, or six, transmitter strengths, and it would result in economy in manpower and effort.

As far as WNBT is concerned, an increase in service area of about 9 miles radius has been obtained with the increase of power to 14.5 kw ERP. This results in adding about 10,000 square miles to the total service area. The antenna was rephased slightly to increase the signal to the nearby areas, but this did not affect the service contour.

The major effect of these power increases has been to extend the service area in all directions and provide a usable signal in areas that before were considered "fringe." In addition, while improving the signal strength more or less uniformly, it has the advantage that at the points where previously there was interference between co-channel stations the signal strength at these points has increased so that even if the interference contour has not moved further away the signal strength, and hence the signal to noise ratio has improved.

Same Coverage Increase

In the case of WJZ-TV with a power increase to 17 kw the 0.5 MV/M contour has moved out to 57 miles and the 0.1 MV/M contour to approximately 75 miles. Probably all the stations on the new tower will experience about the same relative increase in signal strength coverage. In many cases the FCC authorization merely specified that power might be increased to the maximum 5 kw rated output of the transmitter, rather than a definite ERP.

It is quite possible that WNBT experienced the greatest improvement in signal with the power increase since it previously had a very low ERP due to its high antenna and consequent severe limitation to keep

ERP COMPARISON FOR TV STATIONS IN NEW YORK AREA

1. Station	2. Old Power Transmitter	Old Power ERP	3. Old Transmitter Locations Power under Order 5 Transmitter	ERP	4. Power under Order 5 Empire State Transmitter	ERP
WABD	4.0 KW-V 2.5 KW-A	14.25 KW-V 9.45 KW-A	same as 2 4 KW Transmitter		5 KW-V 2.5 KW-A	16.7 KW-V 8.4 KW-A
WCBS-TV	3.0 KW-V 2.5 KW-A	13.7 KW-V 10.2 KW-A	5 KW-V 2.5 KW-A	20.1 KW-V 10.2 KW-A	5 KW-V 2.5 KW-A	20 KW-V 10 KW-A
WJZ-TV	0.815 KW-V 0.800 KW-A	3 KW-V 3 KW-A	5 KW-V 2.5 KW-A	17.0 KW-V 9.0 KW-A	same as	(3)
WNBT	1.42 KW-V 1.15 KW-A	5.2 KW-V 4.2 KW-A	5 KW-V 2.5 KW-A	18.3 KW-V 9.2 KW-A	same as	(3)
WOR-TV	2.04 KW-V 2.5 KW-A	9.0 KW-V 11.0 KW-A	5 KW-V 2.5 KW-A	22 KW-V 11 KW-A	....	....
WPIX	3.5 KW-V 1.75 KW-A	16.3 KW-V 8.17 KW-A	5 KW-V 2.5 KW-A	26.3 KW-V 13.2 KW-A	5 KW-V 2.5 KW-A	20.8 KW-V 10.6 KW-A
WATV	5 KW-V 2.5 KW-A	30.5 KW-V 15.3 KW-A	same as	(2)	5 KW-V 2.5 KW-A	22.5 KW-V 11.8 KW-A

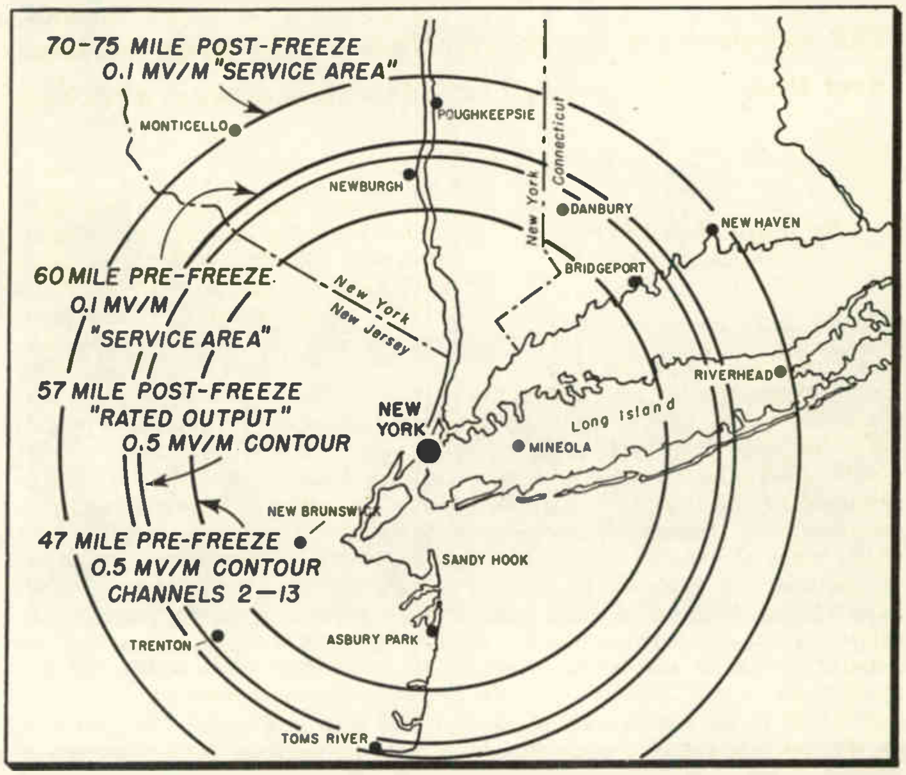
Unique Antenna Installation

now possible for to service area

within the FCC's 50 kw at 500 ft. figure. As reports are received from other stations and final measurements are made it will be interesting to compare the effect of raising the powers of other low power artificially limited stations.

When WATV commences operation from the Empire State Building, it is expected to use a series of dipoles mounted around the base of the tower in much the same manner as WCBS-TV is using at present. Perhaps the results of using channel 13 at this height and with high power will present some extremely interesting phenomena in the field of long distance reception.

The comparison between the Empire State transmissions and those from WOR-TV's antenna in North Bergen may point up the effect of an increase in height, i.e. the difference between the WOR tower and the Empire State Building. However, the effect of frequency will be eliminated since the Empire State Building transmissions occur on frequencies which bracket that of WOR-TV.



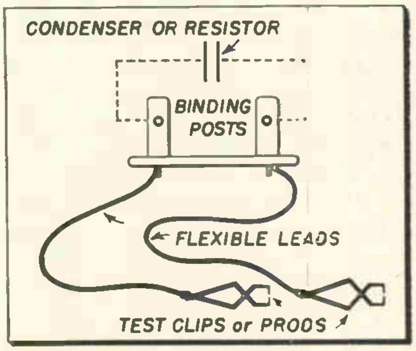
Expanding service area as seen by TV stations in New York City during last 3 years

The only revised coverage map thus far available is from WOR-TV and is based on the increase in power and was compiled by means of increased mail response after the event. As soon as WCBS-TV and WABD join the tower it is expected that revised coverage maps will be available.

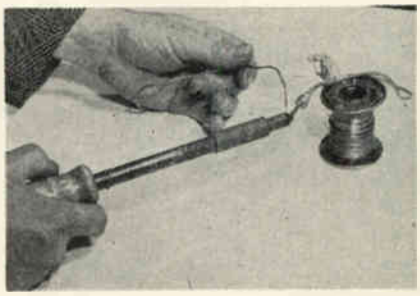
Service Shortcuts

Substitute Condensers

Everyone at some time has found it necessary to substitute a condenser



or resistor in a circuit momentarily to test the part in question. The usual method is to hold the substitute in your hand, or tack it in with a soldering iron. The test fixture shown enables the servicer to insert a condenser or resistor between two binding posts, and with the aid of two flexible leads and clips, to make positive contact. This eliminates the need for soldering, or the hazard of holding the part. Should it be necessary to make contact at a difficult location, the clips can be clipped on long insulated screwdrivers or regular test prods.—*Grant Nonnamaker, Grant's Radio, 6548 Torresdale Ave., Philadelphia 35, Penna.*



Soldering Tip

From R. Whitman, Greenwich, Conn.: When soldering leads on RCA phono jacks, speaker plugs, Amphenol plugs and the like, most people hold the tip upside down and try to melt solder down into it. This gets a lot of solder on the outside of the pin, but very little inside where it is needed. I have found the following method very easy, secure and neat: Put the tip *down* on the iron and heat it a bit. Then tip it slightly so that the opening in the bottom is slightly exposed, and put the solder on the iron at this point. The hot tip will draw the solder *up*, with none on the outside. The jig I use to do this (as shown in the photo) is simply an alligator clip to hold the lead down in place. You can also set the iron in a stand and hold the lead down on it (hold it with a long nose unless your hands are pretty tough).

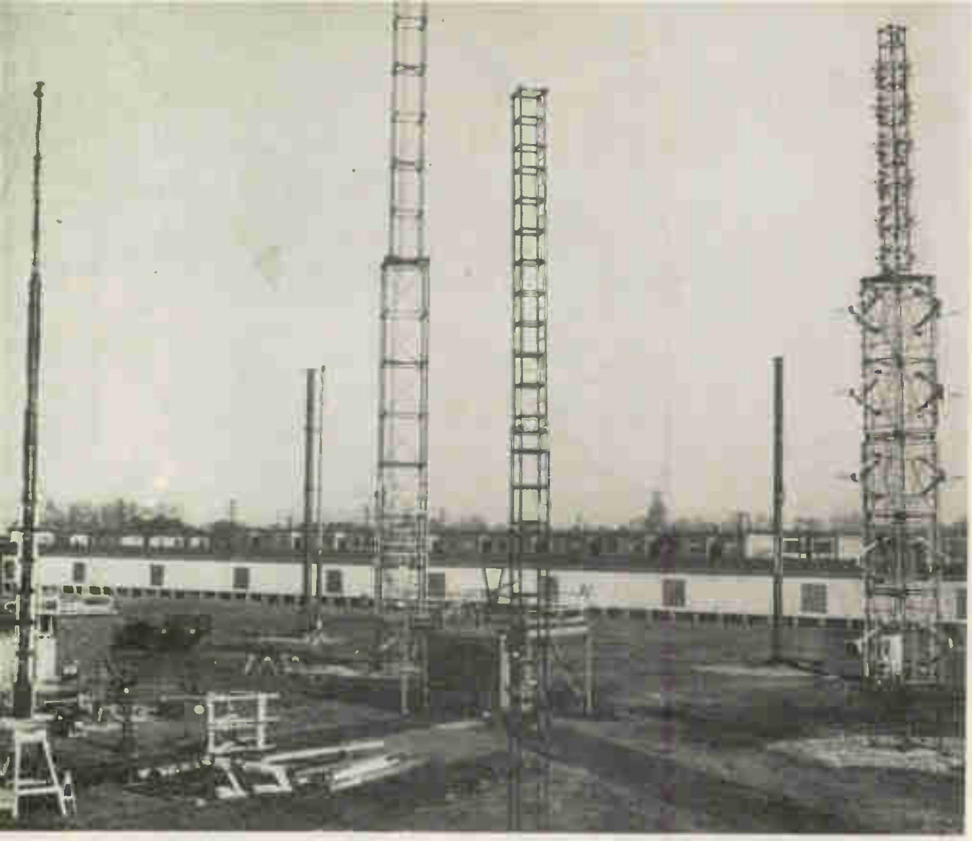
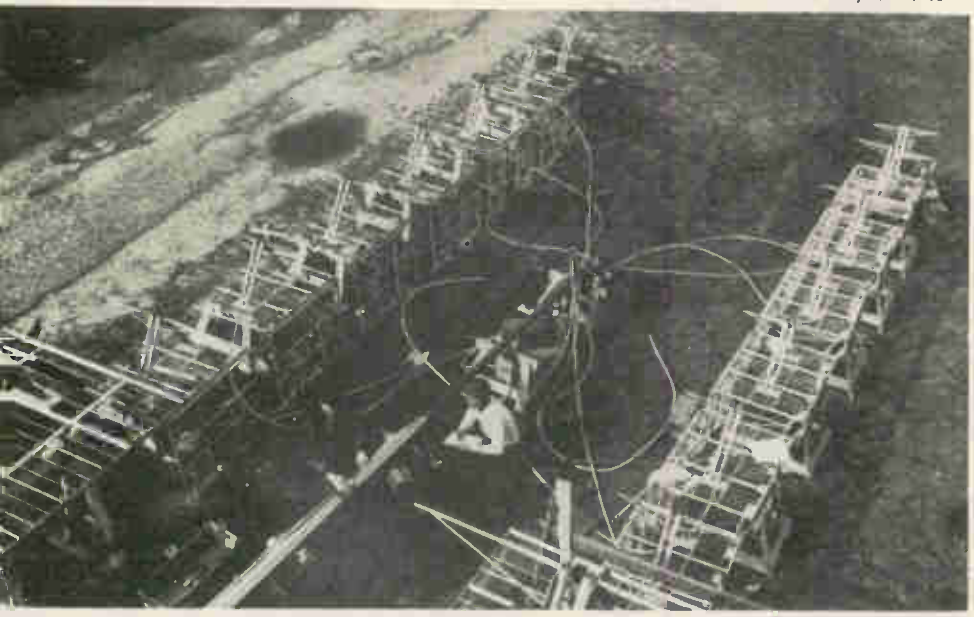


Fig. 1: Test towers at RCA, Camden. Foreground tower will support antennas for channels 7 and 11; left to right are antennas for channels 11-4, 2-5, and 5-7.

Fig. 2: SWR. measurements made on ch. 7 radiator with ch. 5 antenna adjacent to it.



Designing

By JOHN H. BATTISON
Consulting Editor

WHEN the decision to install more than one television station on the Empire State Building was made, the primary consideration was interaction between stations. The first expectation was that four telecasters would share the new tower; however, later this figure was increased to five. In the antenna design only interaction between antennas can be considered. To date some preliminary tests have been made on the coupling between adjacent antennas which indicate that a decoupling of the order of 26 db can be achieved. This figure was obtained on the basis of previous experience.

Probably the only good feature of the late November and early December hurricanes experienced in the east was the very thorough workout and lifetest it gave the test antennas at the Camden plant of the Radio Corporation of America. Fig. 1 shows a general view of the test ground with the antennas mounted on towers to simulate the actual proximities to be encountered in practice. Rain, snow, heat and cold as well as fumes and corrosive air about as bad as that encountered in New York have impinged on these radiators but they have withstood all that the elements can do. In New York City, also, the steelwork received a workout when the hurricane hit town, but from all reports no trouble was encountered.

The location of the antennas has already been discussed in the November issue of TELE-TECH (cover), it is their close proximity which was expected to present many difficulties in connection with isolating the antennas. Many tests have been carried out to determine the amount of interaction between the adjacent antennas.

In order to simulate actual conditions on top of the Empire State Building as nearly as possible, four test towers were built on which each pair of adjacent antennas will be mounted. This test will yield impedance data over the channel as well as the amount of interaction. It also simulates assembly problems on top of the building. Four towers

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Fig. 3: 20 Kw diplexer and equalizer unit for the lower channel radiating system.

World's Highest TV Antennas

Many problems concerning interaction between adjacent antennas are solved in the TV-FM transmitter installation on Empire State Building

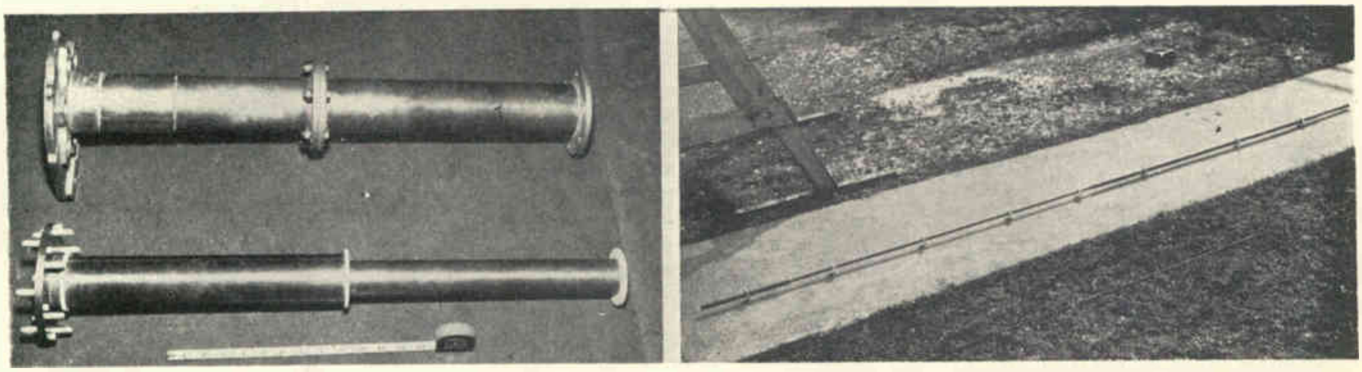


Fig. 4: Left, closeup of a feed line transformer and junction box. Right, triplexing transformer for channel 4 radiator.

are needed for Channels 2 and 5, 5 and 7, 7 and 11, and 11 and 4.

In each test operation signals at the visual and aural frequencies were fed into the deplexer and passed through the power equalizer (if required) and then to the antenna. In the antennas tested both antennas are assembled completely. An Oscillator is fed into one antenna and a field intensity meter is connected to the other to determine the amount of coupling. When the proper frequency is applied to the transmitting antenna the amount of power pickup by the adjacent antenna is measured. A figure of 26 db down is considered satisfactory.

Types of Antennas

The antennas used are of two types; channels two, five, seven and eleven use the RCA U Super gain antenna while channel 4 uses the RCA Super Turnstile antenna. For stations WCBS-TV and WABD special emergency antenna switching arrangements are used so that the antennas can be operated as either 2, 3, or 5 bay radiators. The reason is presumably to allow emergency operation in the event that trouble occurs in the whole system. The antennas are split and separate transmission lines, diplexers, and power equalizers, are used for each section. In normal operation the power is divided as shown in Fig. 5 and all sections are used, but if trouble develops in either section it can be cut out and the transmitter operated into the good unit. Switching is manual and carried out simply. It is understood that the other stations have different emergency facilities so that this feature will not be used.

Stations using the Super Gain antenna were given their choice of single-line or double-line feed. The low band stations chose single-line feed while the high band chose double-line feed. Low-band stations will use a bridge-type power equalizer which tends to broad-band the antennas. Broad banding problems are more severe on the low bands since Channel 2, for instance, occupies a 10% band width compared to 3% for Channel 11.

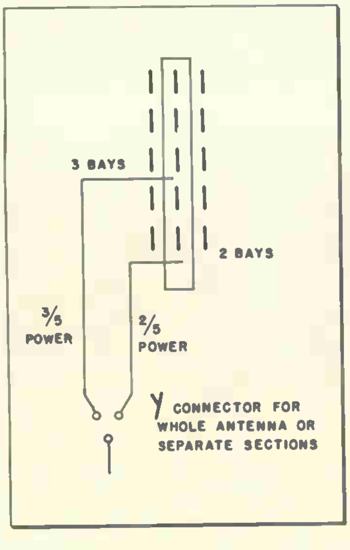
For most of the antennas the feeders running from the junction boxes illustrated in Fig. 7 are RG 35/U with the metal armour removed. However in some of the illustrations RG 35/U with the braid still on it is shown. The impedance is 75 ohms.

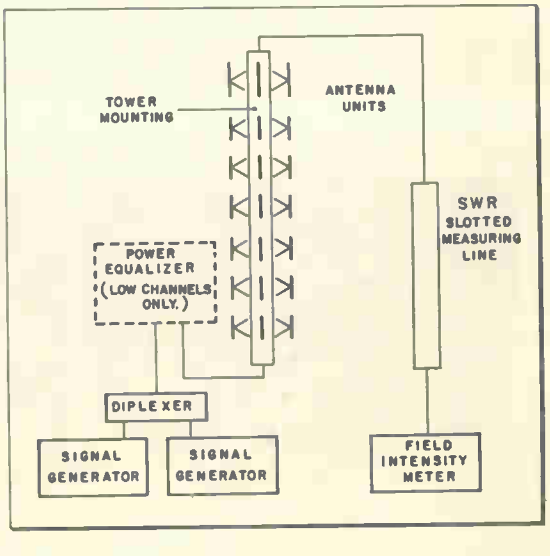
Few of the mechanical details of tower construction appear to have interfered with the electrical design of the antennas, in fact that the only one which has been discussed was the need to reduce the width of the channel 11 reflectors due to the small size of the latter, and the large (about 8 inch) steel angle which comprises the sides of the tower at this point. Thus it became necessary to simulate these solid reflectors by the use of sheet metal during the tests.

The pole for mounting the channel 4 Super Turnstile presented a problem inasmuch as it had to be cut into ten foot lengths to get it in the elevators and up to the top of the Empire State Building. The connections to the Super Turnstile Antenna are unusual in that flexible RG 35/U is used rather than the normally used rigid copper transmission lines. The turnstile type of antenna had

(*Continued on page* 48)

Fig. 5: (Left) Switching system provides whole or partial operation of low band antennas. Fig. 6 (Right) Set-up to measure degree of interaction between antennas.





UHF-Converter Design Features

More recent manufacturer's data provides additional details on technical characteristics of TV tuners.

Mallory Converter

Utilizing a recently developed type tuner, this converter, designed by P. R. Mallory & Co. Inc., Indianapolis 6, Ind., covers the r-f range of 470 to 890 MC. The tuner used in this converter is of the three section type. It consists basically of two r-f circuits overcoupled to provide a relatively constant band width, and the third section being used for the local oscillator which tunes 82 MC below the r-f band. The output of the oscillator is connected to a crystal diode as well as the incoming r-f signal. The output of the crystal goes to a low noise triode r-f amplifier which has a single broad tuned circuit in the input and a double tuned circuit in the output. The band width of the output circuit is approximately 12 MC wide so that it will cover the adjacent channels of 5 and 6. The choice of channels 5 and 6 was made because it was felt that a better noise figure could be obtained on the low TV bands, and also that the switch problem would be slightly easier. The output of the converter being at an r-f frequency of 5 and 6 enables it to be connected to any present day TV receiver.

The power supply is of the transformer type using a tube rectifier and is strictly conventional. The on-off switch serves a dual function in that it switches the VHF antenna straight through the converter to the receiver antenna terminals when in the off position. When the converter is turned on the output of the converter is connected to the VHF receiver. The UHF antenna is not switched, but is connected to the first tuned circuit at all times. A 110 volt receptacle is provided on the back of the converter so that the television receiver may be plugged in and thus turned on and off with the converter. Installation of this converter is comparable to that of installing a booster on a present day TV receiver.

Stromberg-Carlson Converter

The new UHF television converter developed by Stromberg-Carlson is designed to operate on all Stromberg-Carlson receivers as well as those of other manufacturers and to tune all of the 70 channels in the UHF band. It can be installed on existing television receivers without modification in a few minutes.

The cabinet, shown in Fig. 2, is styled in green leatherette and proportioned to harmonize with the television receiver. The outside dimensions are approximately 8 in. wide, 4 in. high and 6 in. deep. The unit weighs 5½ pounds and has a power consumption of about 10 watts. Channel indicator, vernier tuning knob and function switch are all located on the right side of the unit.

Top and bottom views of the chassis are shown in Fig. 3 and Fig. 4. The converter is designed for connection between the antenna lead-in and the television receiver. Receiver power is obtained from a socket in the rear of the converter chassis which in turn is plugged directly into the ac line. A single three-position function switch provides the following combinations: 1. Off—Both

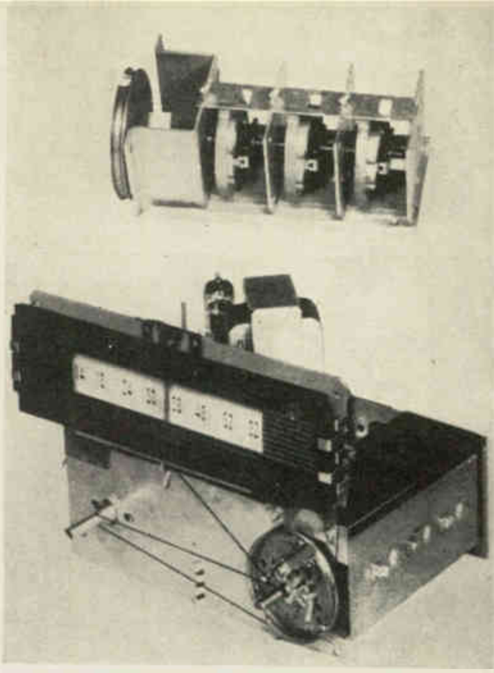
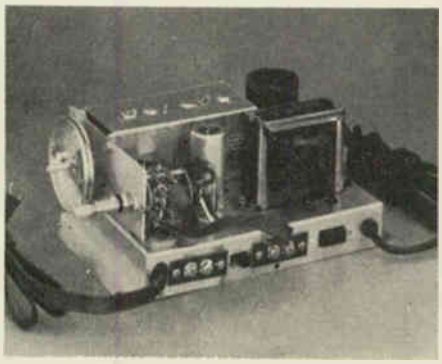


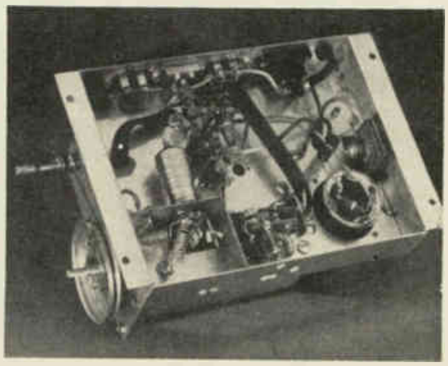
Fig. 1: (Above) Three section tuner used in P.R. Mallory's UHF-Converter (Below)

converter and television receiver; 2. VHF—a-c power to television receiver on, VHF antenna directly connected to television input. Converter heaters on. 3. UHF—a-c power to both units and choice of separate UHF antenna, VHF antenna or built-in cabinet antenna depending upon signal conditions.

The converter can be operated by tuning the receiver to either of two channels (#5 or 6) which is not occupied by a local station. This choice is made during installation by a switch in the rear of the converter chassis, which shifts the first IF tuning 6 MC. The bandswitch of the UHF pre-selector circuits is 12 MC., allowing this shift without loss of tracking. Selection of this IF is a compromise providing a mean between the extremes of the high noise factor in the high channels and the undesirable spurious responses of the very low frequency channels. The rapid attenuation with increasing distance of UHF signals which might cause spurious interference

Figs. 2-4: (Left) Overall view of the Stromberg-Carlson UHF converter. (Center) Top and (Right) bottom view of chassis





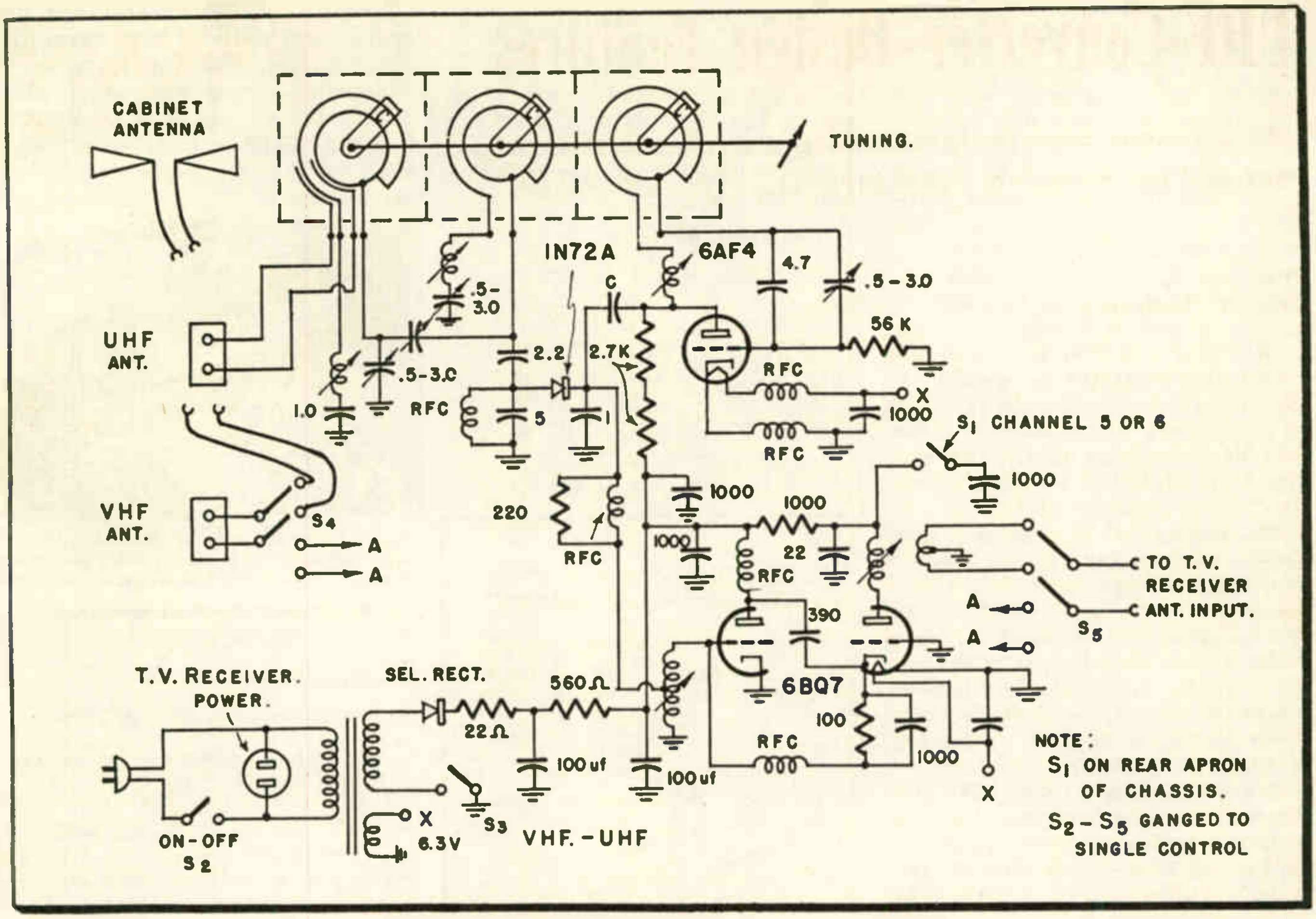


Fig. 5: Schematic diagram of the Stromberg-Carlson UHF-Converter

appears to make it practical to use a lower IF than would otherwise be possible.

Mixer Circuits

In both the antenna and mixer circuits, the tuning elements are inductively padded in order to secure the proper tuning range. This is accomplished by extending both conductors of the antenna section and one of the conductors of the mixer section about ⅞ in. external to the tuning unit. The balanced 300-ohm antenna is coupled into the extended section of the tuning unit with the aid of an ungrounded loop.

A combination of high-side capacitive and inductive coupling is used between the antenna and mixer tuned circuits in order to provide a bandwidth of 12 MC. throughout the UHF band. The 1N72 crystal mixer is coupled capacitively to the mixer tuned circuit, and an RF choke provides a d-c return path for this circuit. (See Fig. 5)

Grounding of the low frequency ends of the antenna and mixer lines and the grounding of the rotor of the antenna section eliminate spurious suck-outs within the band.

The oscillator design utilizes a miniaturized version of the 6F4. A series trimmer condenser effectively sets the low frequency end of the tuning range, and a series trimmer inductance consisting of the grid and plate leads control the total range and the high frequency limit. This adjustment consists of varying the separation between these leads. "Holes" in the frequency range are avoided by using resistors rather than chokes in the plate and grid return circuits and by using dissimilar chokes in the cathode and ungrounded heater leads. A special UHF low-capacity tube socket is used to prevent bypassing the tuned circuit by the grid-plate socket capacity.

Tube "warm-up" drift, although somewhat a function of individual tubes, is nearly complete within one minute after application of plate voltage, with heaters previously warmed up. This initial drift is minimized by using the lowest plate power which will give reliable performance.

Complete shielding of the oscillator tube, circuit, and tuner section together with low oscillator plate voltage reduces oscillator radiation.

The conversion loss of the crystal mixer is overcome by the addition of a low noise amplifier. A "cascode" circuit using a 6BQ7 tube was selected because of its inherently good noise factor. This circuit consists of a neutralized grounded cathode input section followed by a grounded grid stage.

Both the input grid and the interstage circuit of the cascode are adjusted to have bandwidths of about 12 MC., i.e., to include both Channels #5 and 6. The plate of the output triode, however, is adjusted for a 6 MC. bandwidth and a switch is provided on the rear of the chassis to select the desired channel. Economy is achieved by the use of a simple slide switch as a channel selector which varies the value of capacity in series with the plus B end of the plate tuning coil. Balanced output is used in order to eliminate interference pickup on the lead coupling the converter to the VHF receiver.

Since most television receivers have no provision for supplying power to an external converter, this converter is self-powered. Both chassis height limitations and power economy dictated the use of a selenium rectifier in preference to a vacuum tube, but a power transformer is used to eliminate hum interference between converter and television receiver.

AC power for the television receiver can be secured from the rear of the chassis, and a switch on the converter energizes both units and selects either VHF or UHF reception.

The heaters of the converter tubes remain on for both types of reception with a plus B switch being provided in the ground return of the power transformer secondary. Switching in this manner allows instantaneous change from VHF to UHF and also removes the voltage from the converter filter condensers during VHF operation.

Input terminals for both VHF and UHF antennas are provided on the rear of the chassis. When receiving signals on Channels #2 to 13, the VHF antenna is directly connected to the television receiver input. For reception on Channels #14 to 84, a separate UHF antenna may be used, or if signal conditions allow, either the VHF antenna or a built-in cabinet antenna may be selected.

Tallest TV Antennas

(*Continued from page* 45)

to be used here since the physical size of the elements of a channel 4 Super Gain Antenna would be entirely too heavy for the tower to support at this height.

FM Operations

In addition to the television stations there will also be three FM transmitters located on the top floors of the building. WCBS-FM, WNBC-FM, and WJZ-FM will all mount their FM antennas on the tower which supports the TV antennas. NBC will use a triplexer operation taking advantage of the closeness of the TV frequency to the FM channel, and the board band width of the superturnstile antenna. WCBS-FM and WJZ-FM may use modifications of super gain antennas, but it is understood that final decisions have not yet been made and the matter is undergoing further study.

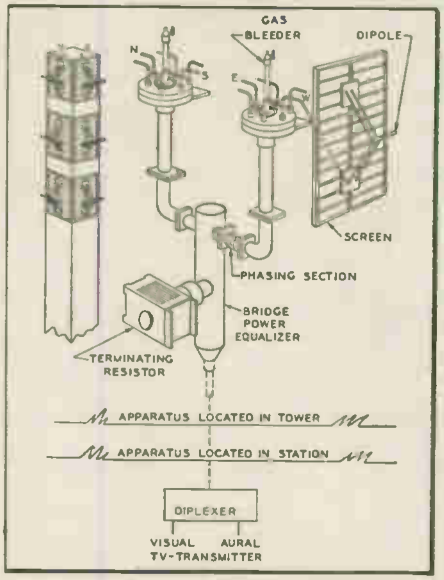


Fig. 8: Diagram of connections and arrangements of parts for phasing and exciting super gain antennas on low band channels.

Fig. 7: Junction boxes on channel 4 center pole. Later, outer braid was stripped from the RG/U coaxial cable transmission line

SHOP HINT

TV Bias Source

(*Continued from page* 27)

ing TV sets is shown. It makes use of a dual control of the type used in TV sets, one section 10K ohms and the other 3500 ohms. The two sections are connected in series and provide a coarse and a vernier adjustment for accurate control of the voltage. The control I used is an RCA replacement which also has a switch. I use this to break the negative lead of the battery, thus removing the load from the battery when not in use.—*Robert Seymour, 567 Elm Grove Drive, Elgin, Illinois.*

COLOR-TV TABLE

(*Continued from page* 9)

(10) To allow present receivers to receive color transmissions in color.

(11) Quality comparison of monochrome picture from color transmission with monochrome picture from monochrome transmission.

(12) These changes do not consider the use of single trichromatic cathode ray tubes. In columns 108M and 108C letters a to i mean the following:

a. Change H and V sync components.
b. Change H and V deflection components.
c. Make power supply adequate, including hum protection. Subcommittee members disagreed on the necessity for this, without further tests.
d. New high-voltage circuits.
e. Add dot modulator with its power supply.
f. Add color phaser. This is optional, since phasing may be accomplished manually.
g. Add color disk and drive and synchronizer.
h. Add magnifier (optional).
i. Add video projection unit, including color switching circuits and associated power supply.

The above list of modifications presumes a picture of minimal brightness and 10-inch size with a magnifier.

(13) The performance is substantially equal to that of system A1. There may be slight degradation on strongly colored objects.

(14) Mr. Smith reports that the receiver noise becomes more visible in fringe areas. Also that the resolution becomes poorer. Mr. Goldmark does not concur with this, but proposes further tests to clarify the question.

(15) This assumes that the receiver takes advantage of dot interlacing.

(16) This applies when using single tube and color disk. Flicker may be roughly equal to standard black and white when using three long persistence phosphors and projection type receiver as in CBS demonstration of April 26, 1950.

(17) This applies to interline flicker and crawl. Present information is insufficient to evaluate inter dot flicker and crawl.

(18) Superior for most objects. In areas of pure primaries (red, blue or green) inferior by a ratio of 48 to 60.

(19) Same as system C2 when using receiver with single tube and color disk. Absent when using three long persistence phosphors and projection type receiver as in CBS demonstration of April 26, 1950.

(20) Present monochrome receivers will receive transmissions with detail equal to that of system C2. It may not be practicable to add equipment for dot interlace reception to receivers now in the hands of the public.

(21) The receiver will need the following additional equipment: Inverse sampler; picture translator; power supply.

(22) Present information is insufficient to evaluate effects of inter-dot flicker and crawl and of dot structure in picture. Otherwise the answer is "equal."

(23) Receiver will need following additional equipment: Three-channel video amplifier, picture translator, power supply.

(24) Present information is insufficient to evaluate effects of fine grain pattern in picture. Otherwise the answer is "equal."

(25) These figures apply to normal subject material. With certain special test patterns the resolution may be less. With a standard test chart printed in black on a background of one of the primary colors, the color of the background in the vertical wedge will desaturate progressively toward the fine end of the wedge. The same test chart printed in one primary color on a background of another primary color will show decrease of detail in the range corresponding to "mixed highs."

(26) Due to the effect of crosstalk and spurious components, generated in this sampling process, the horizontal resolution obtainable in the individual primary color images may be somewhat less than in monochrome.