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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, how-

ever, 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.
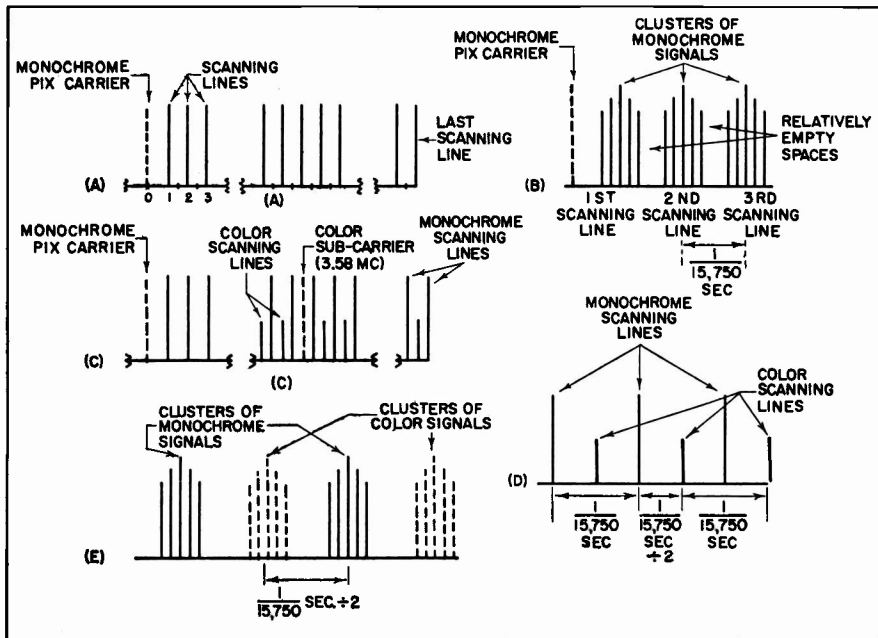
the New TV Color System

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 scan-

ning rate $(15,750 \times 455 = \frac{3.58 \text{ MC}}{2}$, 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.
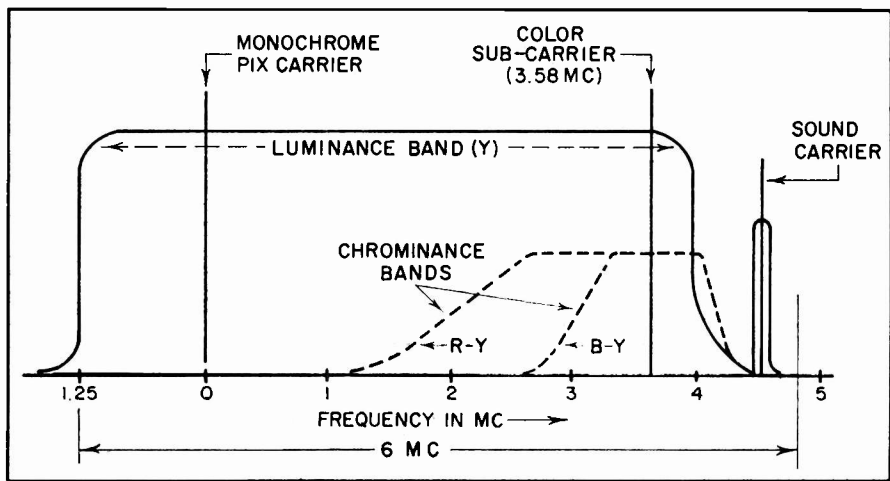
human eye can readily perceive. The eye distinguishes between three separate, distinct visual sensations; 1—Brightness (relative intensity of light, or *luminance*). 2—Hue (the color or colors present—red, green and/or blue). 3—Saturation (purity of color present. A very deep red would represent a high 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.
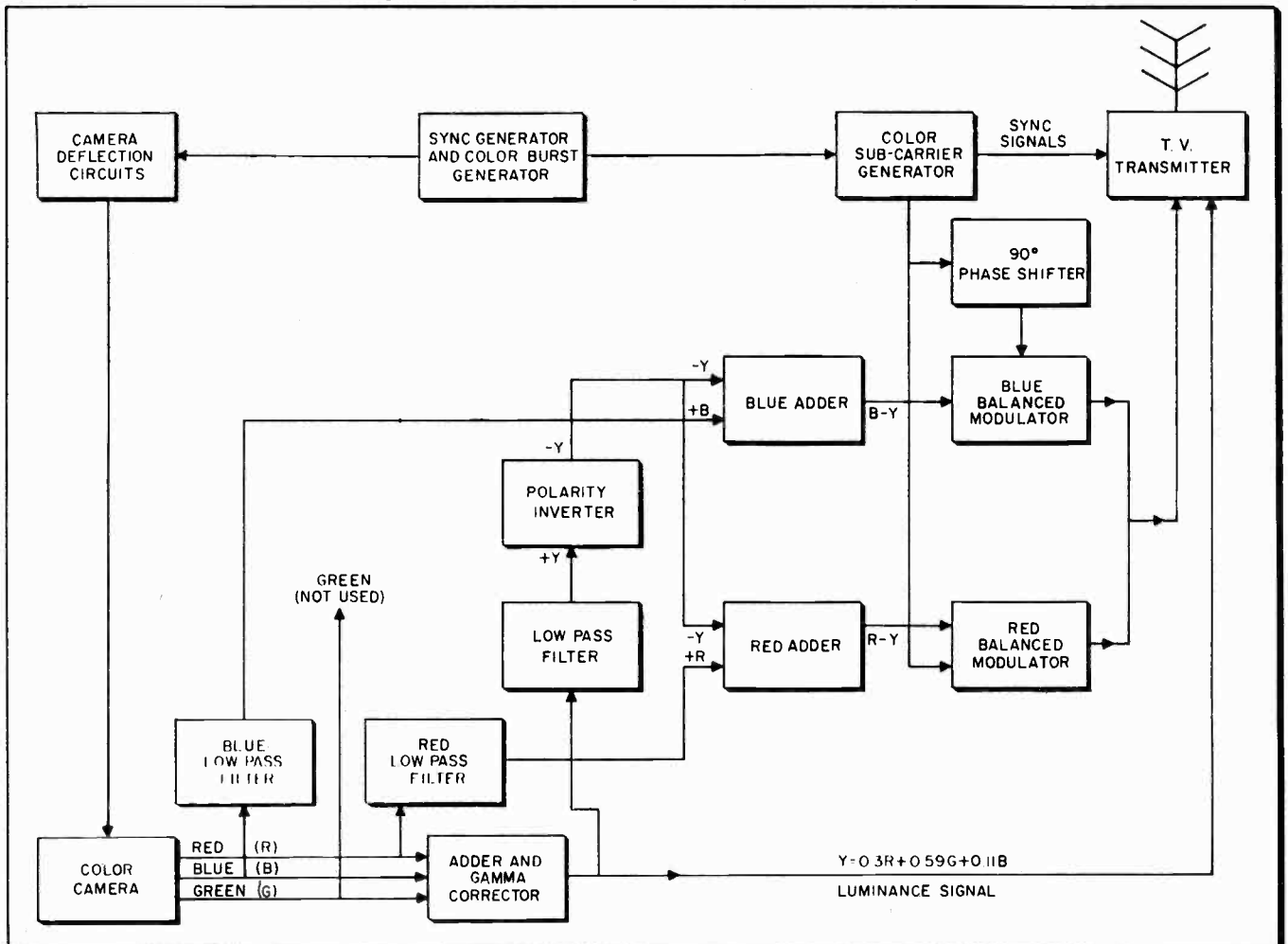
System

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 assignments 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
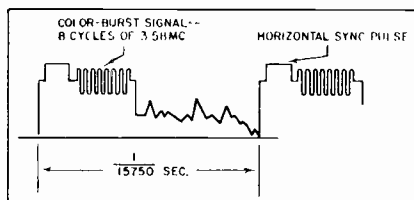

Fig. 4—Color-burst signal used to provide synchronization of chrominance signals at the color receiver.

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 car-

ries 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-

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.
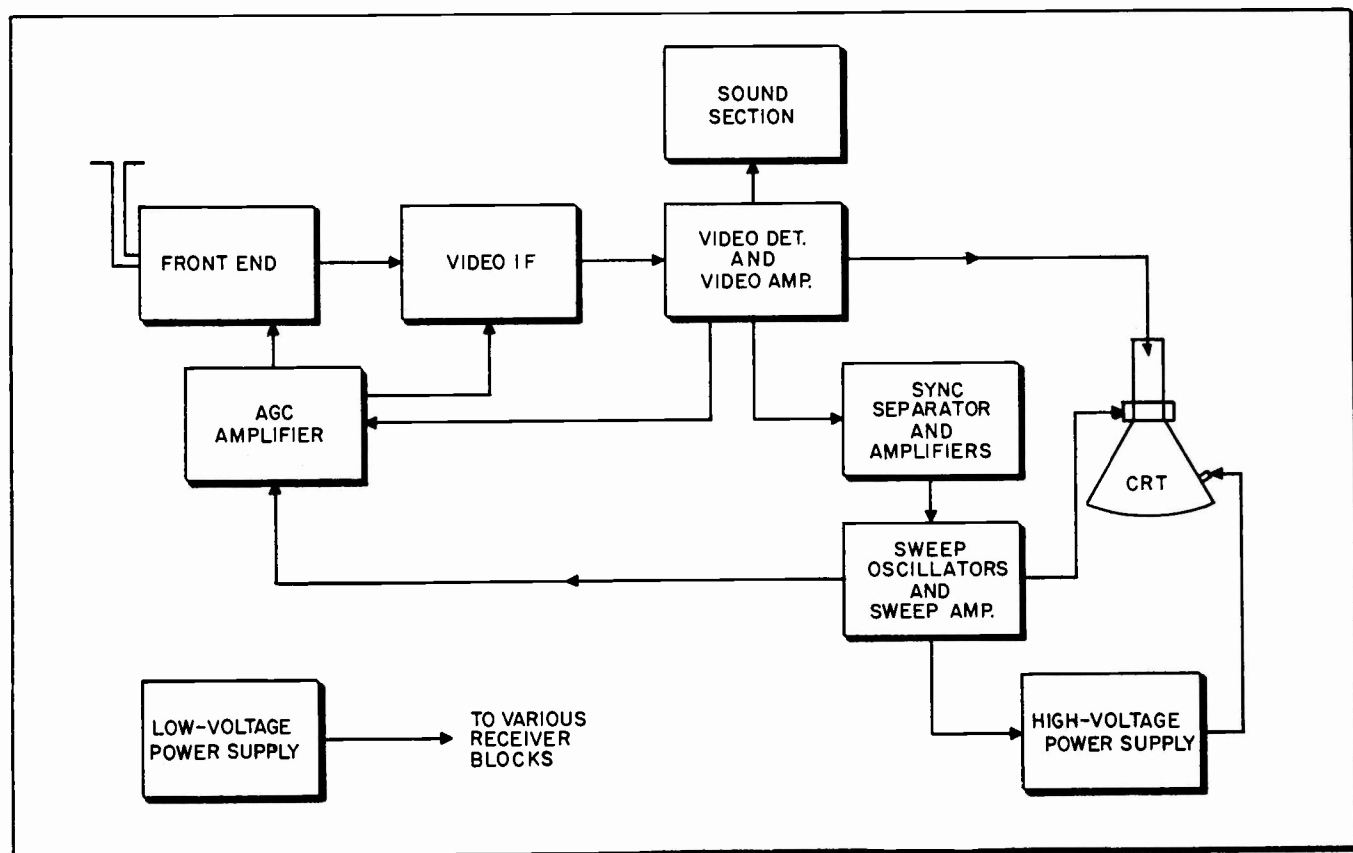
TV Receiver Circuits

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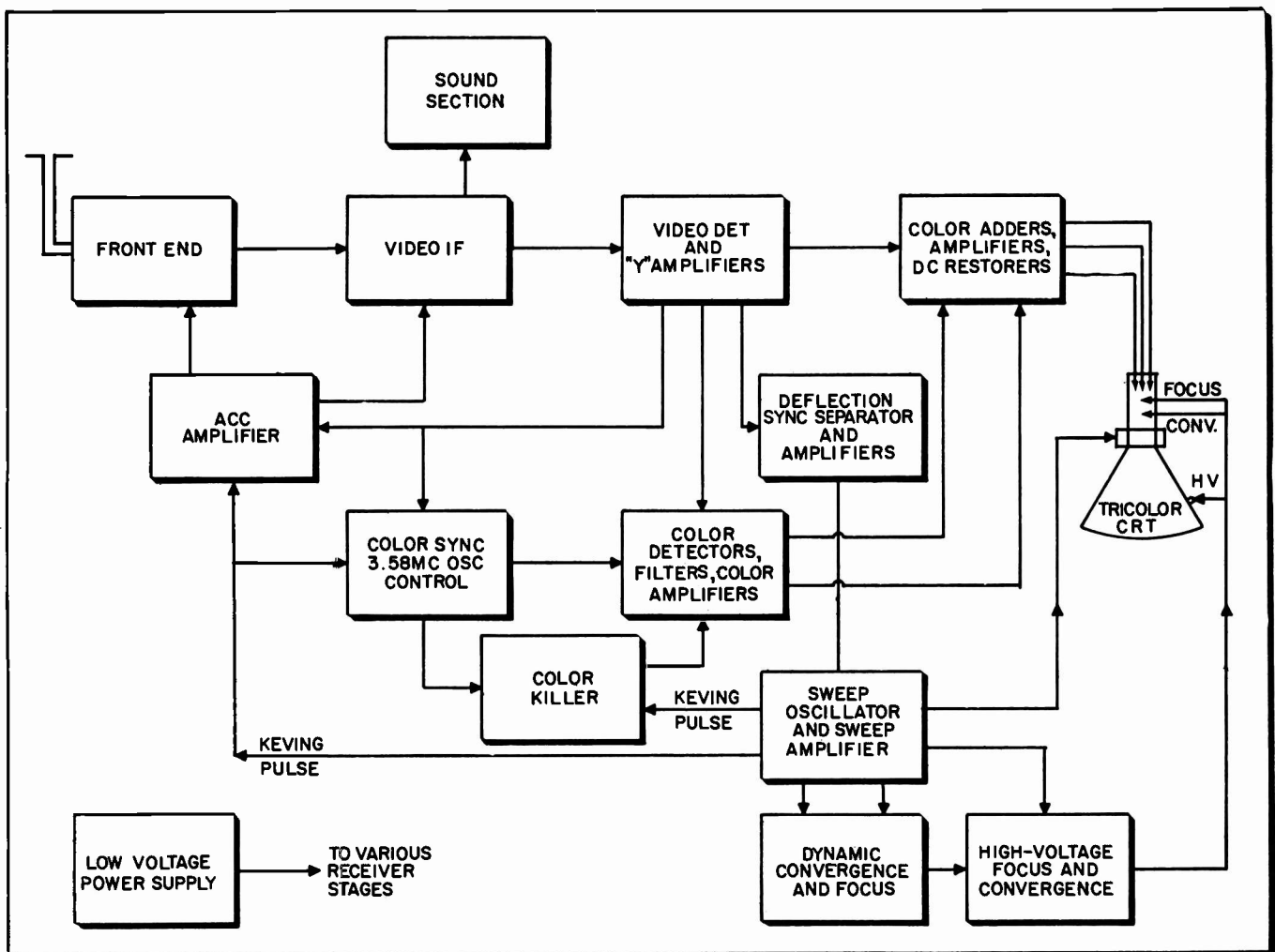
"Y" signal is the luminance information of the color signal—that is, it contains information regarding the brightness of each pictorial unit. This "Y" signal is, incidentally, the only one of the several video signals present in the color transmission that a monochrome set will also respond to, and is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

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

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.
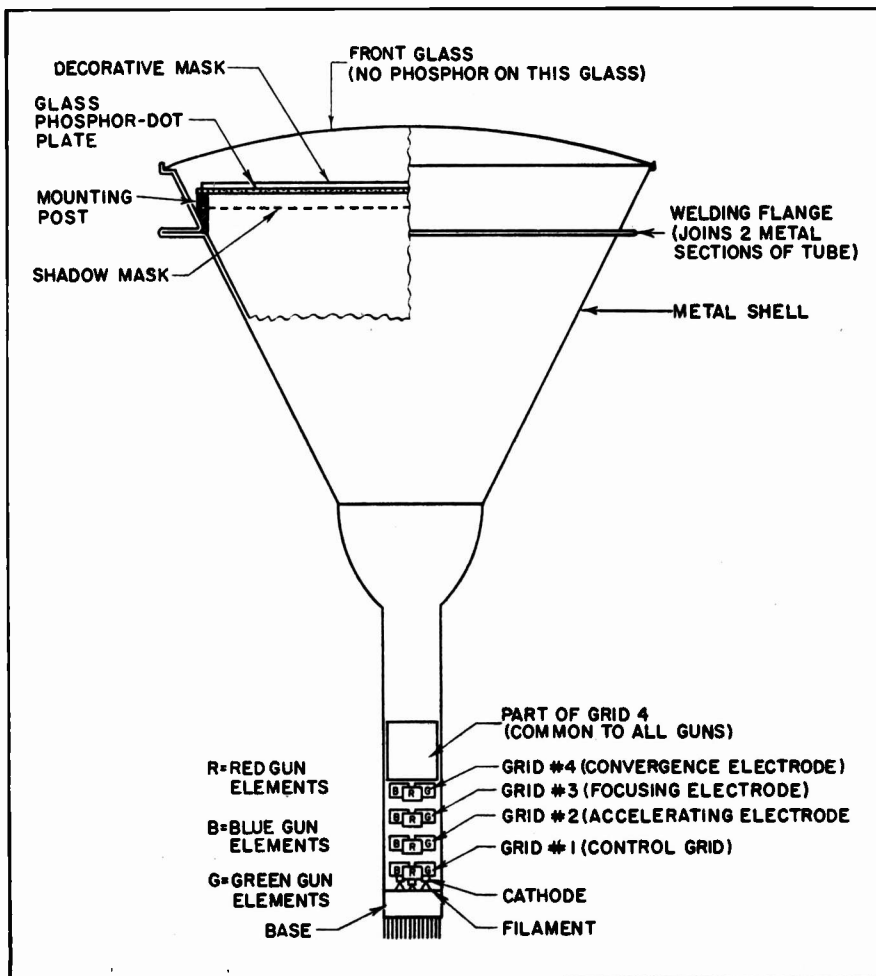
the HVPS), causing the picture to shrink. The reverse happens when the brightness goes up. While such effects are hardly noticeable in a monochrome set, they affect a color picture very seriously. This is so because the correct rendition in color of one pictorial unit depends on the impingement on the 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

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.
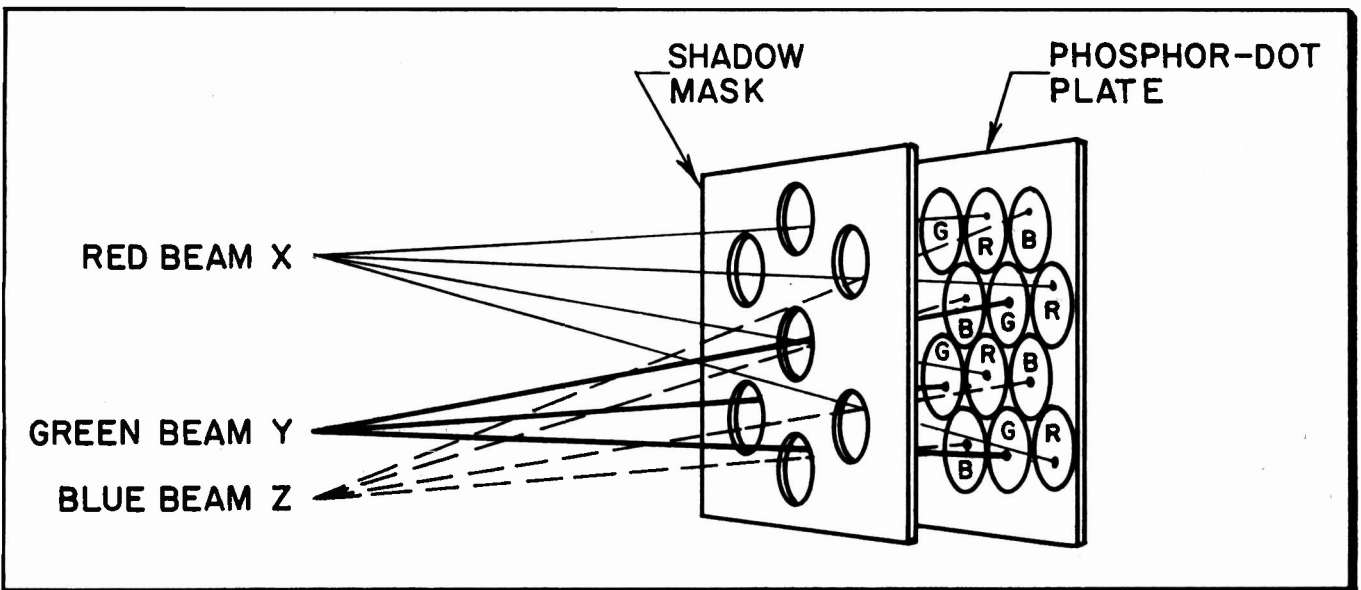
Picture Tubes for

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.
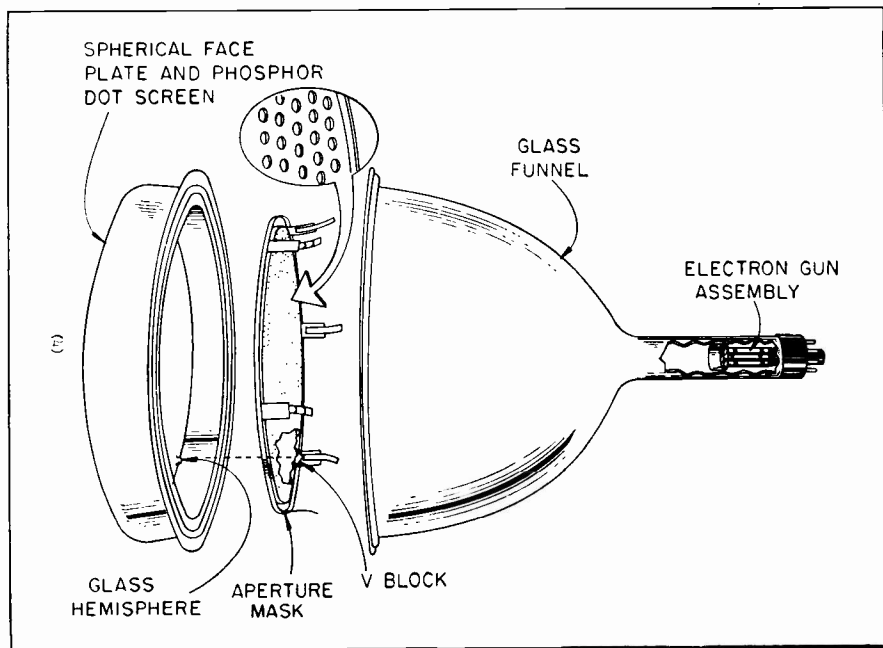
Convergence of Beams

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

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.

SPHERICAL FACE PLATE AND PHOSPHOR DOT SCREEN

GLASS FUNNEL

ELECTRON GUN ASSEMBLY

GLASS HEMISPHERE

APERTURE MASK

V BLOCK

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.

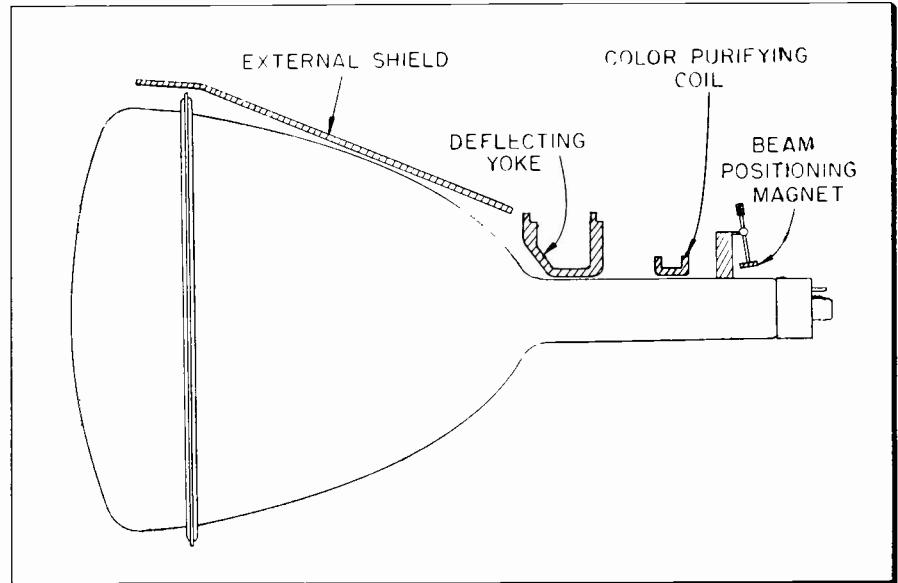The electron beams travel in straight line paths from the deflec-

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.

tion 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.

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.
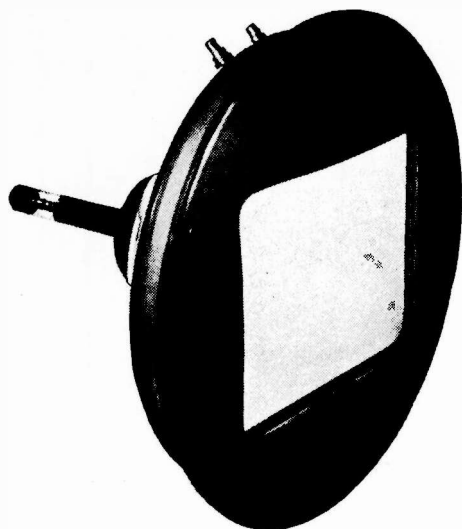
Installation and Adjustment Procedure

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

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.

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

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.
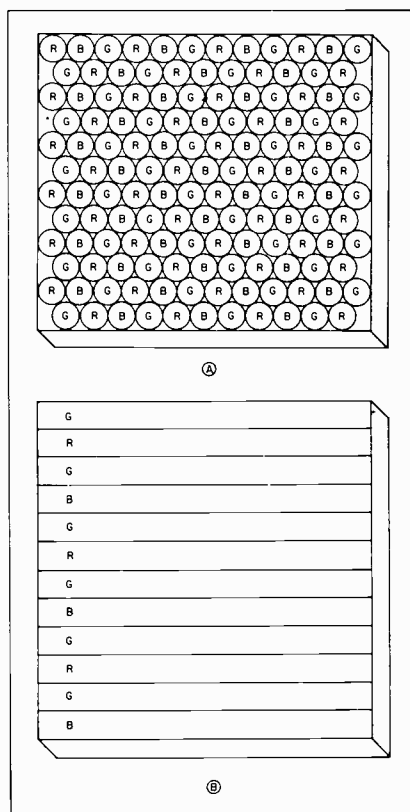
A Single-Gun Color Tube

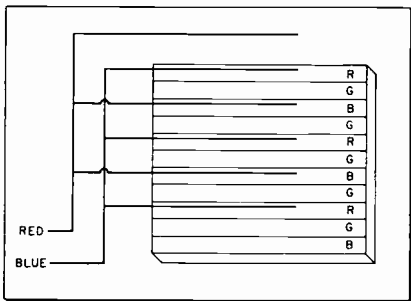## with 3-Gun Types. Associated Receiver Considerations

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.
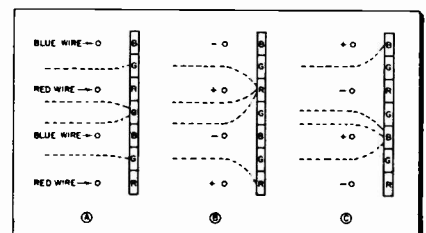
Tracking Down TVI to

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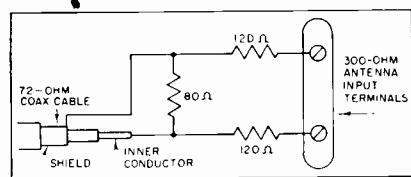
Fig. 1—Suggested matching network for connecting probe to receiver's antenna input.

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

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

Its Source

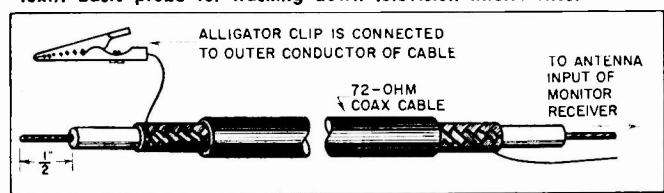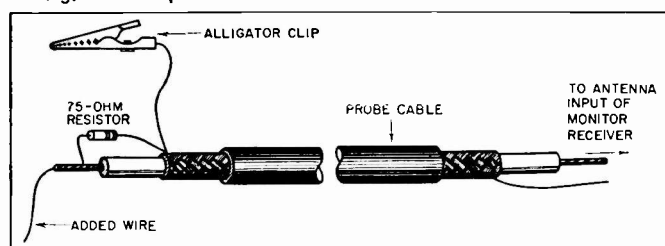## Using a Probe and a TV Receiver.

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 ($\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, 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. Capacitive 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.

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.
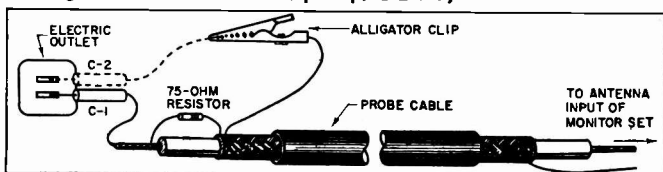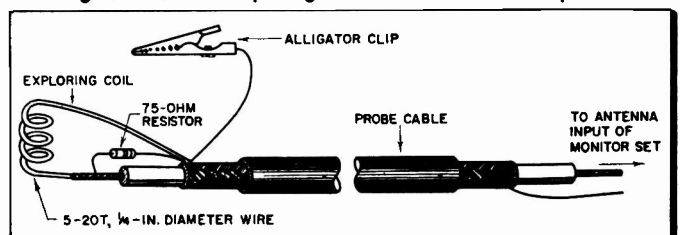

Fig. 5—How an exploring coil is connected to the probe.

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.

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-
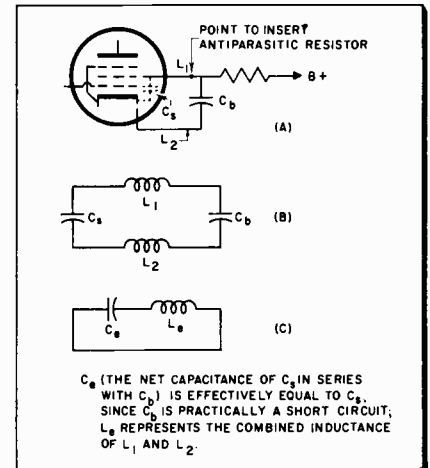

Fig. 2A—Partial schematic of a stage, showing location of bypass (C_b) and interelectrode (C_s) capacitances; also stray inductances (L_1 and L_2). B—Parasitic elements of circuit shown in (A). C—Simplification of circuit shown in (B). C_e and L_e are the effective net capacitance and inductance, respectively.

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
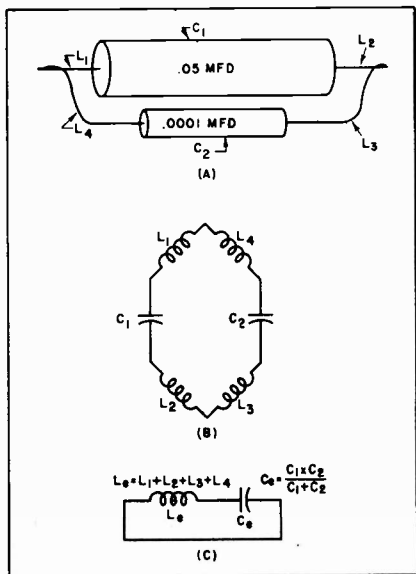

Fig. 1A—Capacitors in parallel, together with their lead inductance, may make up a parasitic resonant circuit. B—Elements of the parasitic circuit, schematically shown. C—Simplified, equivalent L-C series resonant circuit. Effective inductance is represented by L_e; effective capacitance is represented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

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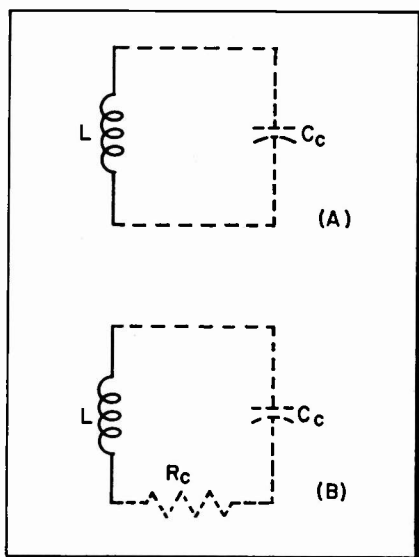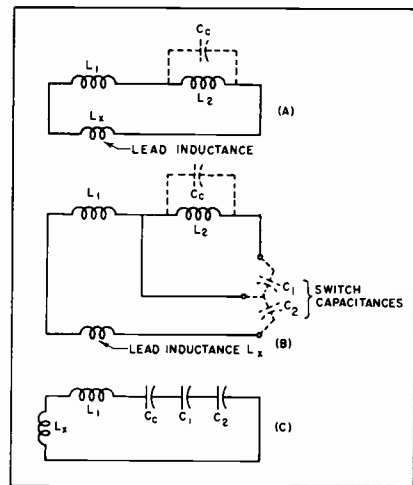
Fig. 3A—Capacitance (C_c) present between the turns of a coil forms a resonant circuit with the coil's inductance. B—Circuit of (A) with parasitic resistance of coil (R_c) added.

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

Eliminating Television

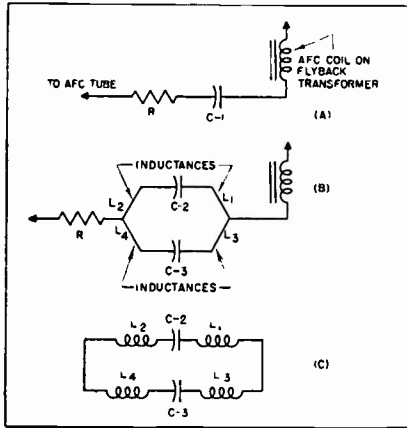## Practical Methods of Attack on Spurious Oscillation

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.
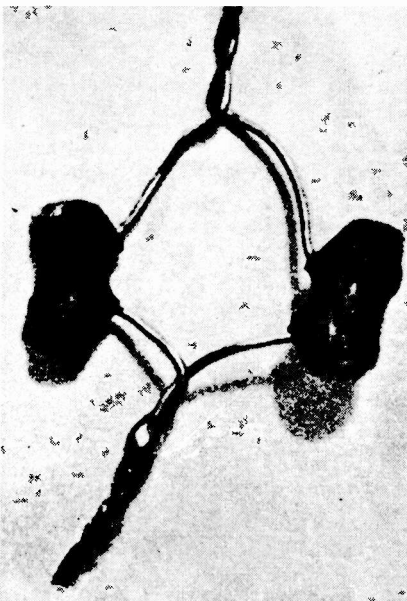

Fig. 2—Photo of two ceramic capacitors used to replace C-1 (schematically shown in 1A).

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
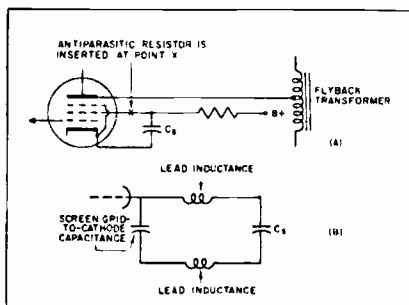
Interference Due to Parasitics

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
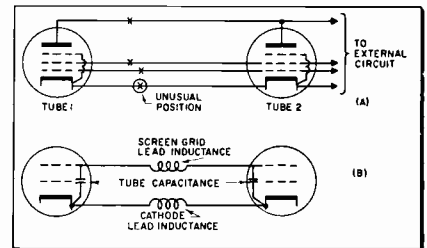

Fig. 4A—Simplified circuit of two tubes in parallel. Antiparasitic resistors are inserted at points indicated by X. B—Circuit of (A) re-drawn to show parasitic network present.
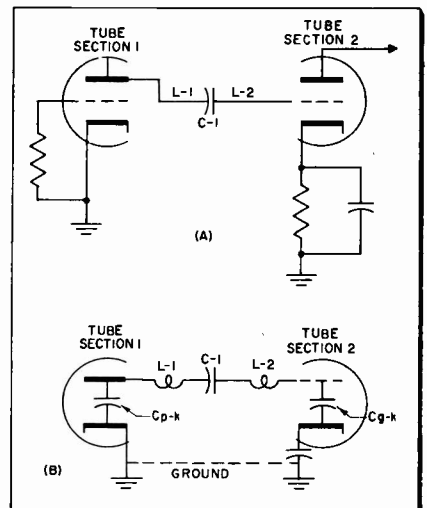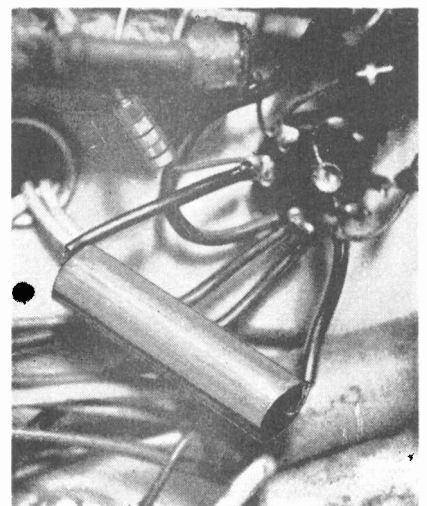

Fig. 5A—Section of sync circuit. B—Parasitic circuit of (A). Cp-k and Cg-k are the plate-cathode and grid-cathode capacitances.

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

Eliminating TVI

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 fre-

quency 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 re-

sistance 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,
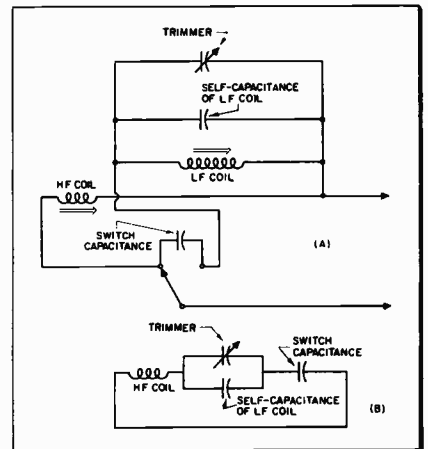

Fig. 8A—Schematic of section of tuner circuit.
B—Parasitic circuit of tuner shown in (A).

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.
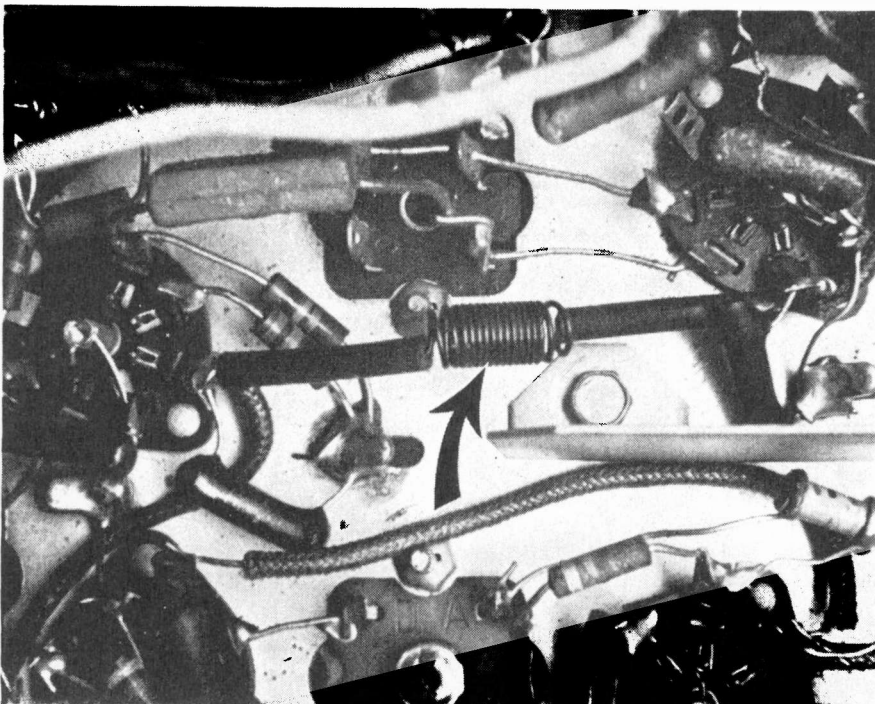
Ringing Problems in TV Sets

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
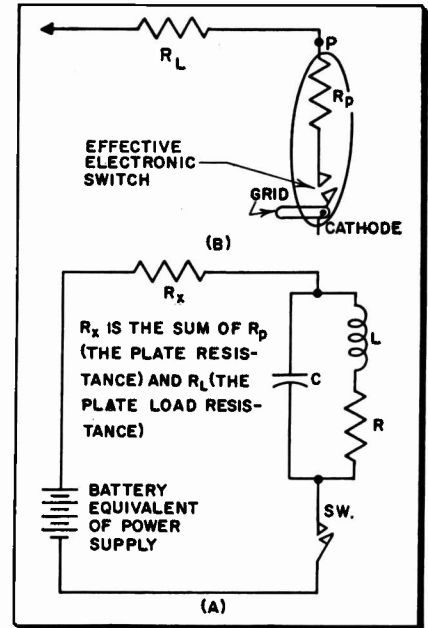

Fig. 2A—Simple ringing network (L, C, R) and associated circuit. R is made up chiefly of the resistance of the coil winding. B—Equivalent circuit of triode-switch tube. Grid-cathode voltage acts like a mechanical switching arm that opens or closes the switch.

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. 1—Section of horizontal multivibrator circuit. L and C-1 make up the ringing circuit.
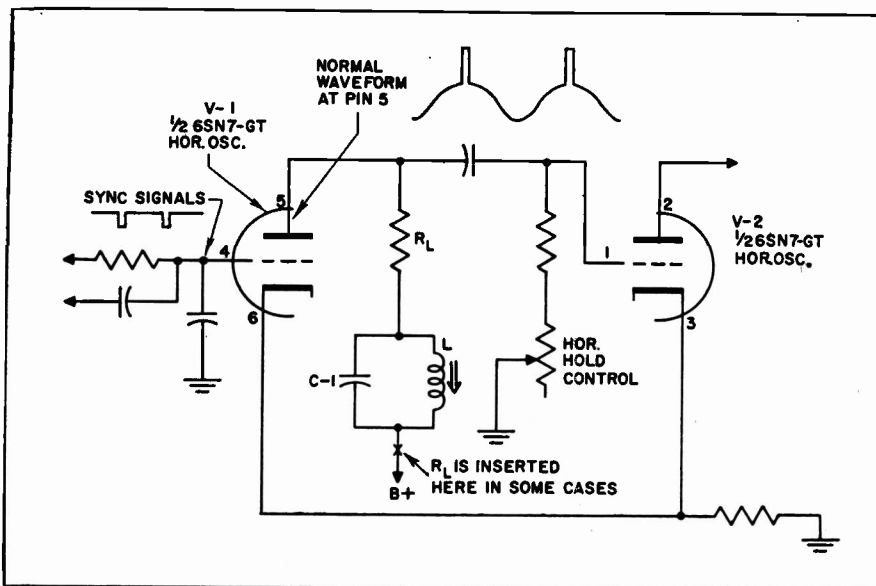
(such as the lightly-damped networks associated with quartz crystals that are used to "ring" in some radar applications).

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).
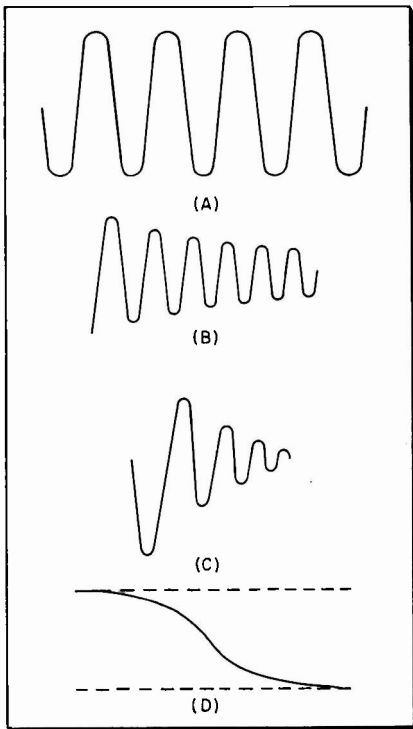

Fig. 3—Waveform of a ringing circuit when the latter is (A) undamped, (B) slightly damped, (C) heavily damped, (D) over-damped.

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 "overdamping," 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
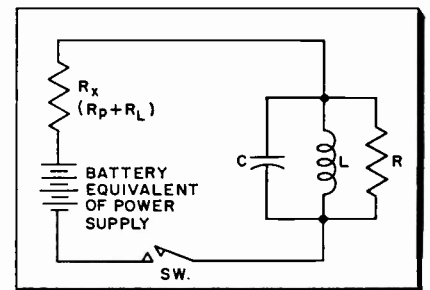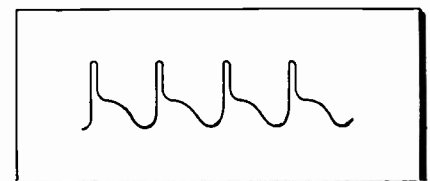

Fig. 4—Ringing circuit with shunt resistance.

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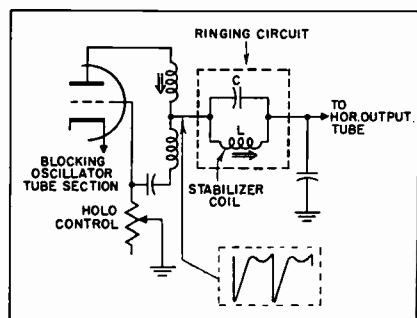
Localization of, and remedies for, this type of fault have been considered in a previous article. Barkhausen-Kurtz oscillations may also produce similar symptoms. A magnet moved about the horizontal output tube will eliminate, and thus serve as a check for, this source of trouble.

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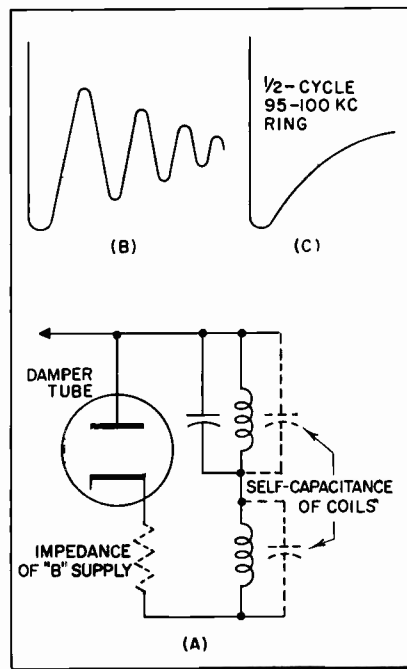
Fig. 7A—Section of damper circuit. B—Ringing waveform if damper tube were not used. C—Ringing waveform with damper present.

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 appear-

ance 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

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 elim-

inated 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

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.
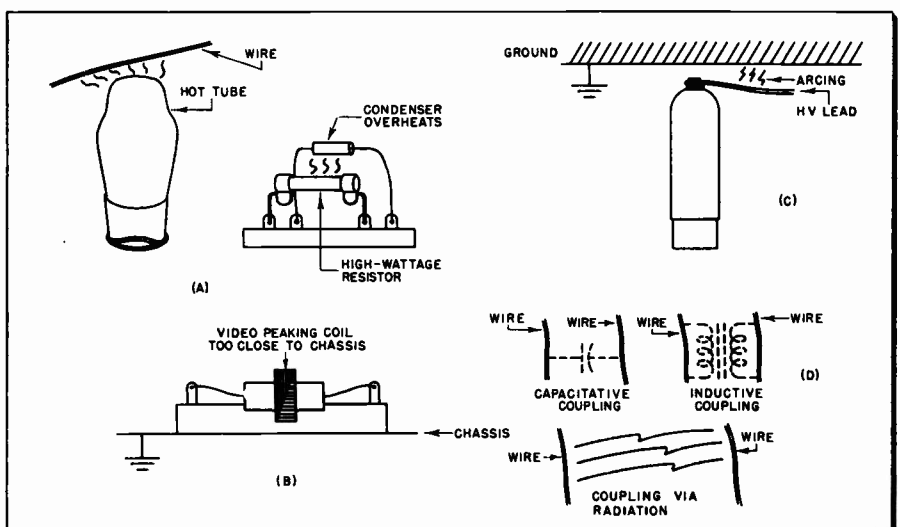
Eliminating Tweet Interference

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.
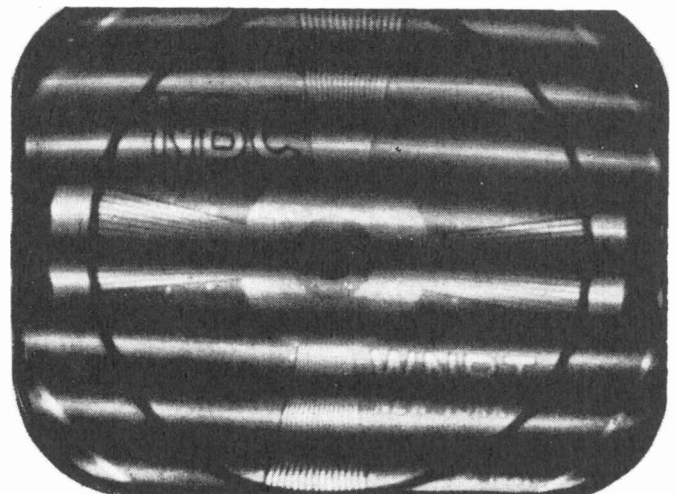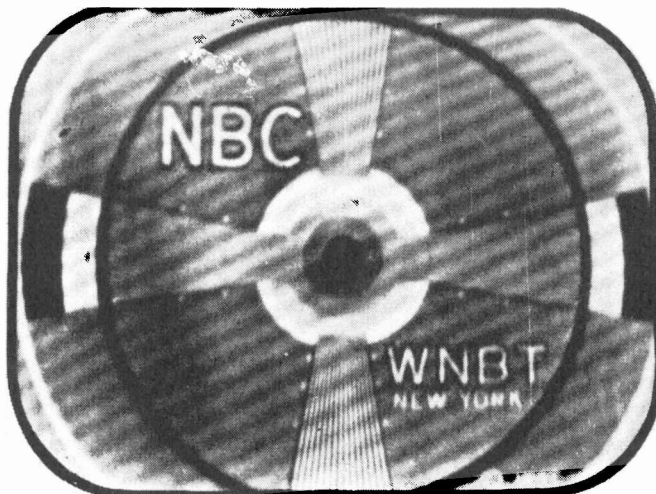
Switch Tuned UHF-VHF Antenna

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.

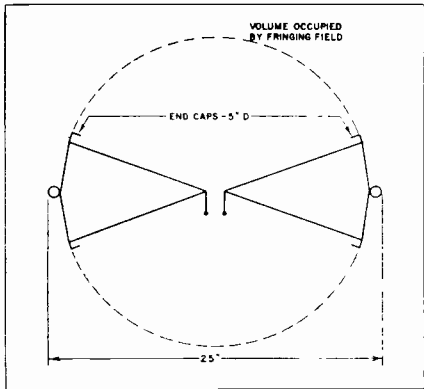Regardless of the particular design of the small antenna there is at least one fundamental limitation to which

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 bandwidths 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

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.

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-

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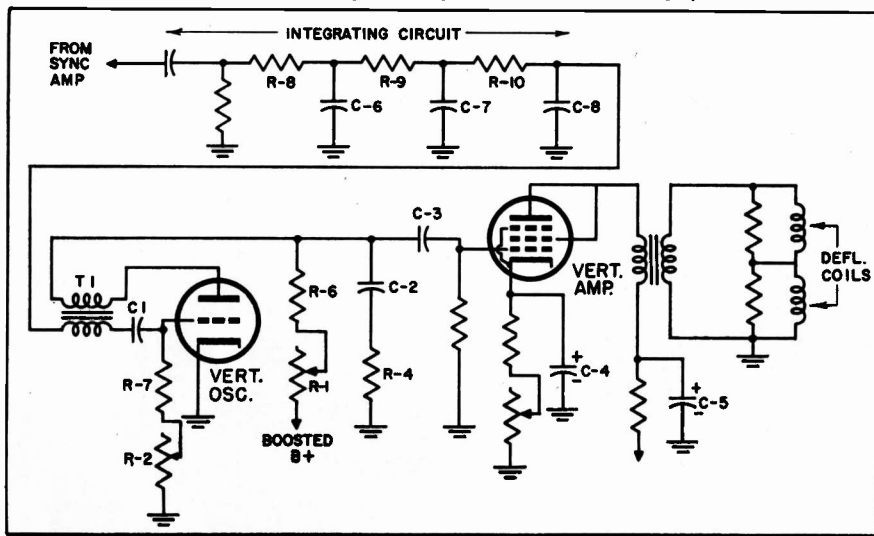
Deflection Circuits

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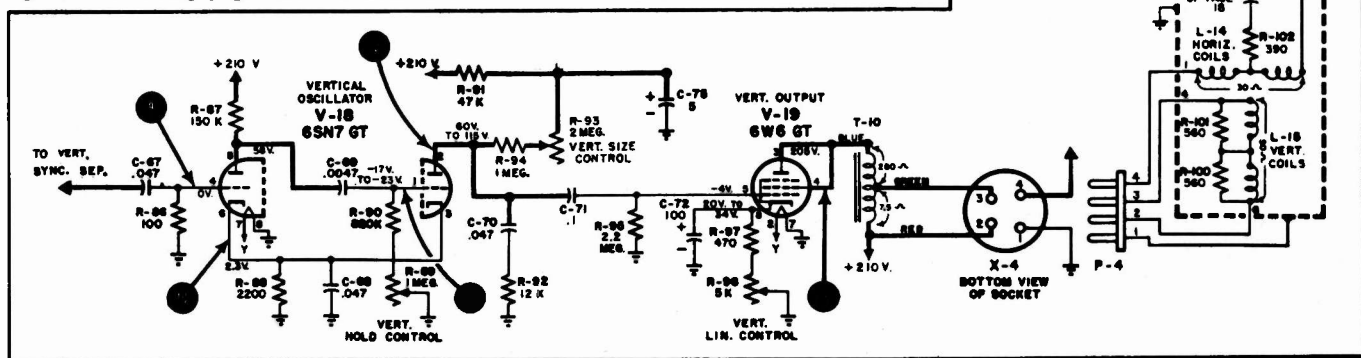
in size from the other, look no further; replace the yoke. (It would seem wise to check components in parallel with yoke windings, before condemning the yoke—Ed.)

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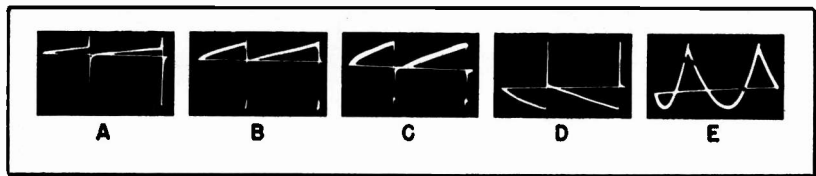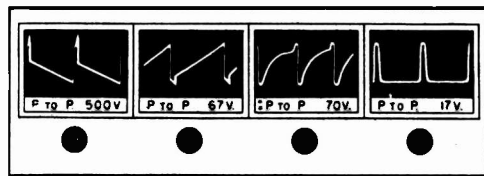
Fig. 4—Waveforms and their amplitudes in the circuit of Fig. 2 (preceding page). Numbers under the waveforms refer to the circuit points in Fig. 2 at which the waveforms were obtained.

Vertical Circuit Troubles

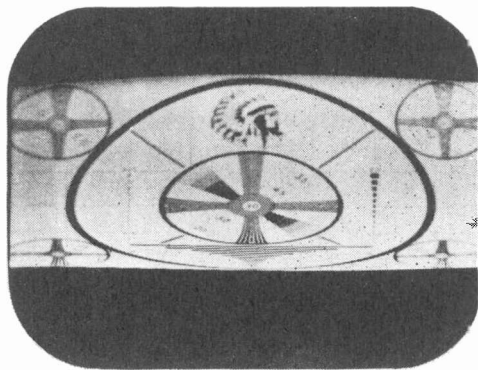## Common Defects, and How They Affect the Test Pattern

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.
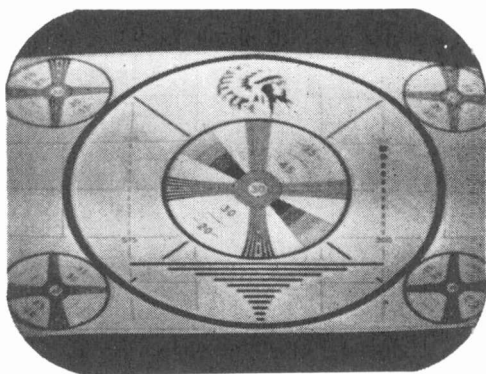

Fig. 2—Insufficient picture height, vertical linearity approximately normal. Possible sources of trouble: Loss of emission in the vertical oscillator or sweep amplifier; increase in value of oscillator (multivibrator) plate resistor; defective vertical output transformer; improper plate or grid voltages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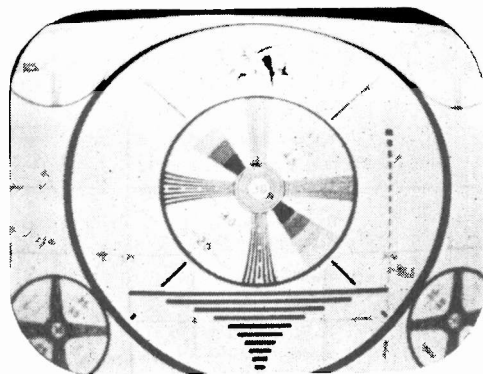

Fig. 3—Poor vertical linearity; height can be adjusted satisfactorily. Possible sources of trouble: Improper setting or defect in linearity control potentiometer or other linearity circuit components; vertical amplifier tube may require replacement; loss of capacitance or leakage in the cathode bypass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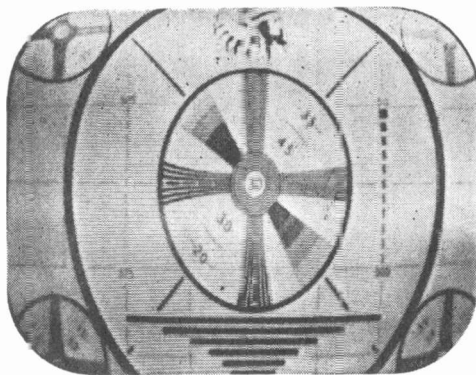

Fig. 4—Excessive height. Usually caused by excessive "drive" at grid of vertical amplifier. Check for decrease in value of charge resistor in plate circuit of vertical oscillator, reduced capacitance in charging capacitor; defective height control.
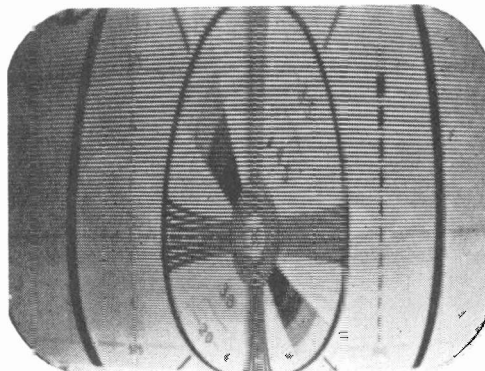

Fig. 5—Excessive height, vertical linearity poor, foldover at bottom of raster. Possible sources of trouble include: Leakage in the coupling capacitor between the vertical oscillator plate and amplifier grid; loss of capacitance in the oscillator's charging capacitor.
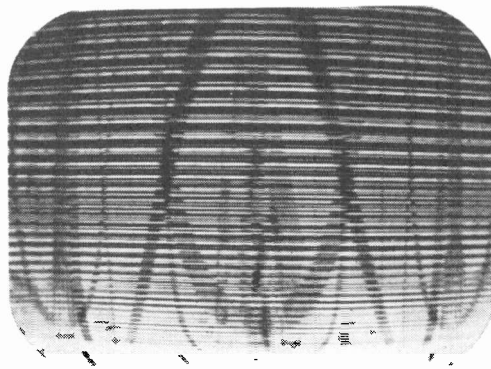

Fig. 6—Excessive height. Sweep is so great that the horizontal scanning lines are pulled apart. Severe leakage in the coupling condenser between vertical oscillator and amplifier may cause this.
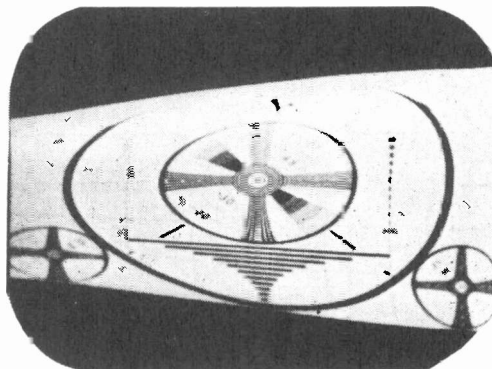

Fig. 7—Vertical keystone effect. Possible trouble sources: Change in value of a shunt resistor across one of the vertical yoke coils; shorted turns in vertical yoke. (Photos on this page courtesy GE; captions based on GE text.)

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).

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-

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.
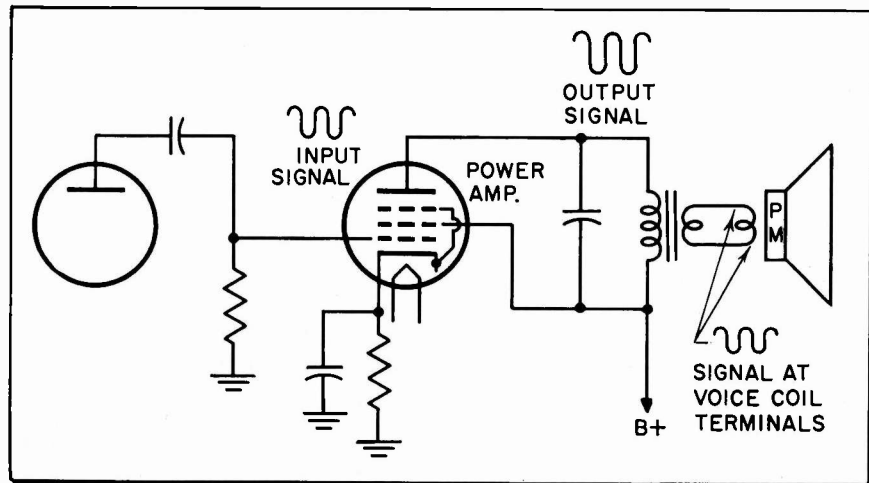
by Dynamic Signal Monitoring

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 at-

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

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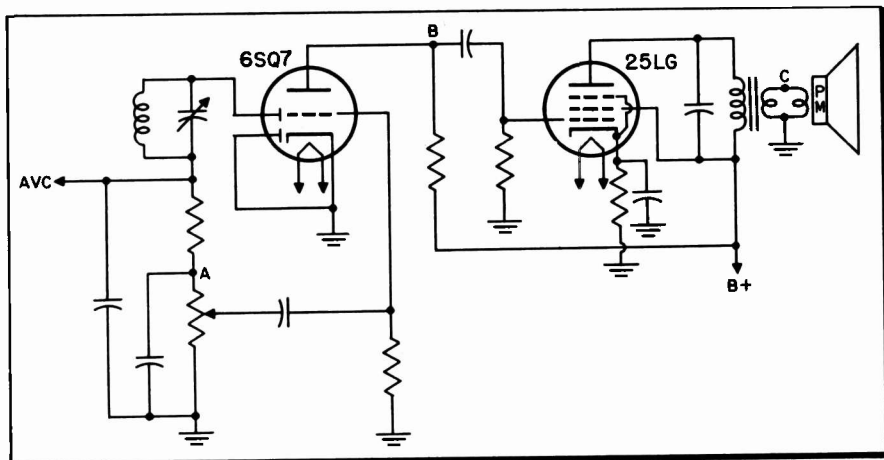
Fig. 2—Initial monitoring setup for intermittent AC-DC broadcast radio receiver. Suggested monitor points are: A and ground; B and ground; C and ground.

tention 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

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

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

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.
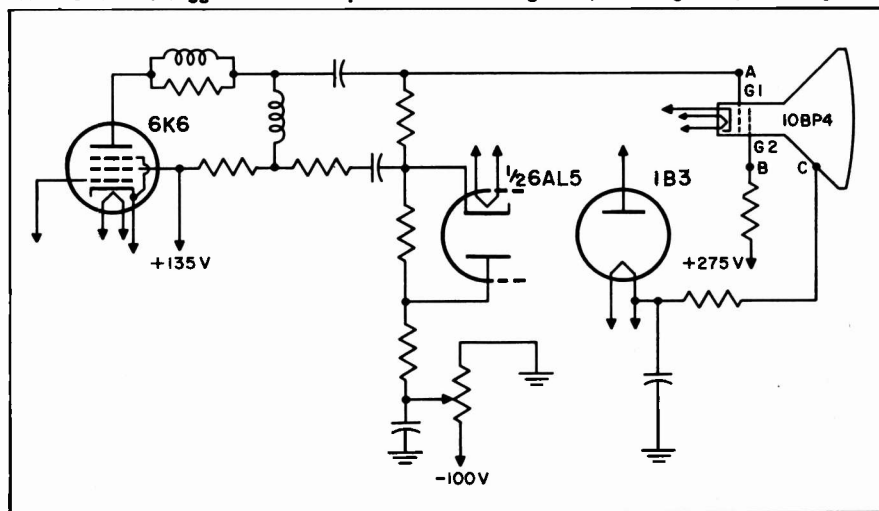
The ABC of Transistors

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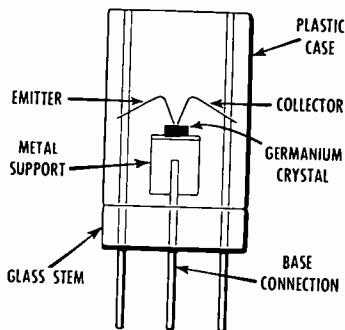
Fig. 1—Enlarged point-contact transistor. The base connection is made to a large-surface crystal area. The emitter and collector wires touch the other large-surface area.

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.
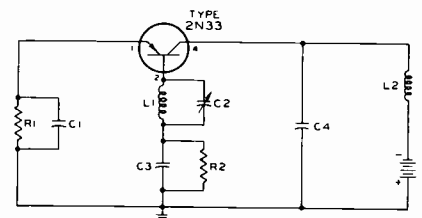
A transistor of the point-contact

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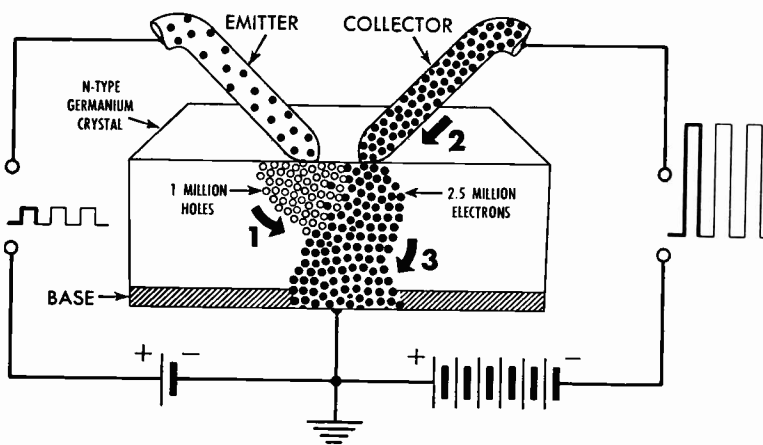
Fig. 2—Enlarged point-contact transistor: If a signal injects 1 million holes at emitter, they will be attracted towards collector (1). Near collector, holes reduce barrier to electron flow (2) allowing some 2.5 million electrons to pass into crystal. Of these, 1 million neutralize the holes ;the others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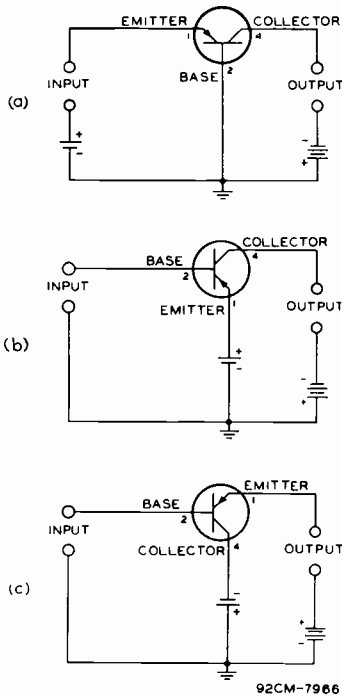
(a)

(b)

(c)

92CM-7966

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

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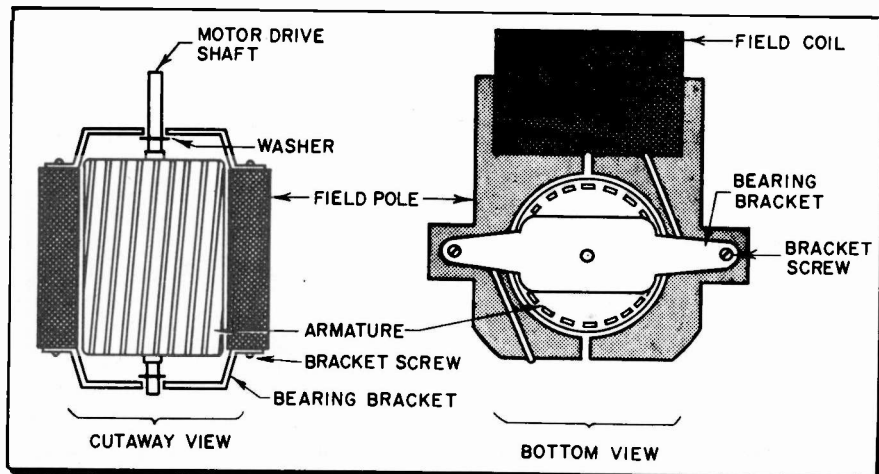
The phono motor may develop a high resistance in its windings, or a low magnetic field, causing it to slow down. The only remedy for such a condition is to replace the motor. Use only a direct factory replacement. This is necessary because the diameter of the motor drive shaft helps determine the speed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

MOTOR DRIVE SHAFT
WASHER
FIELD POLE
ARMATURE
BRACKET SCREW
BEARING BRACKET
CUTAWAY VIEW

FIELD COIL
BEARING BRACKET
BRACKET SCREW
BOTTOM VIEW

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 prop-

erly seated in a vertical position. A simple bend-adjustment can easily remedy the condition.

The turntable center-hole can become enlarged due to wear, caus-

ing 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

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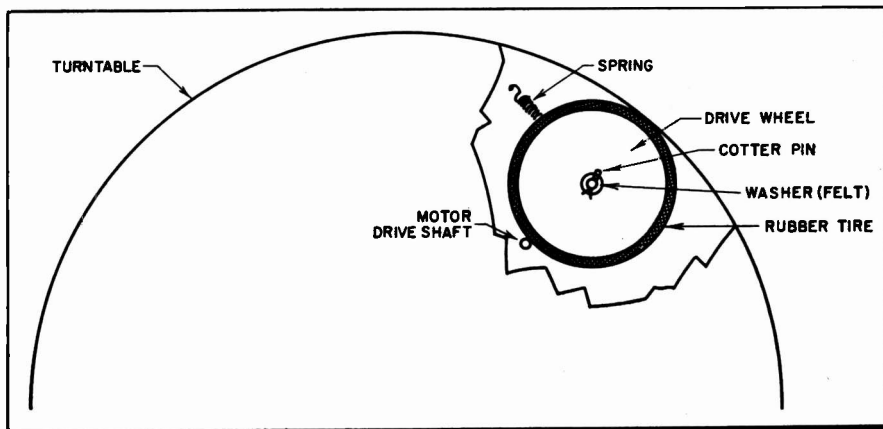

Fig. 3A—Flat and indentation on drive-wheel tire. B—Removing tire from drive wheel.
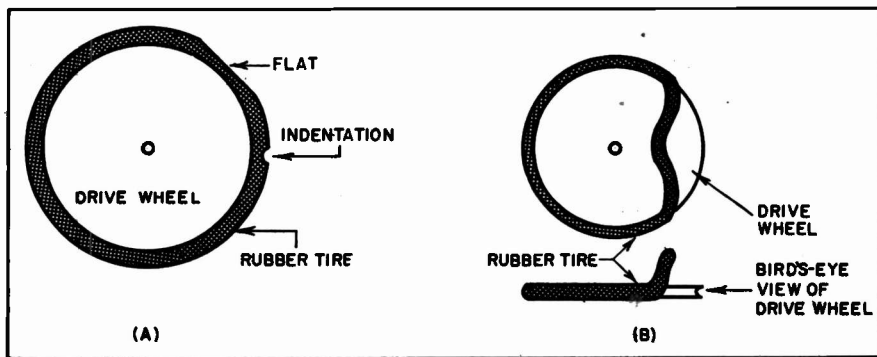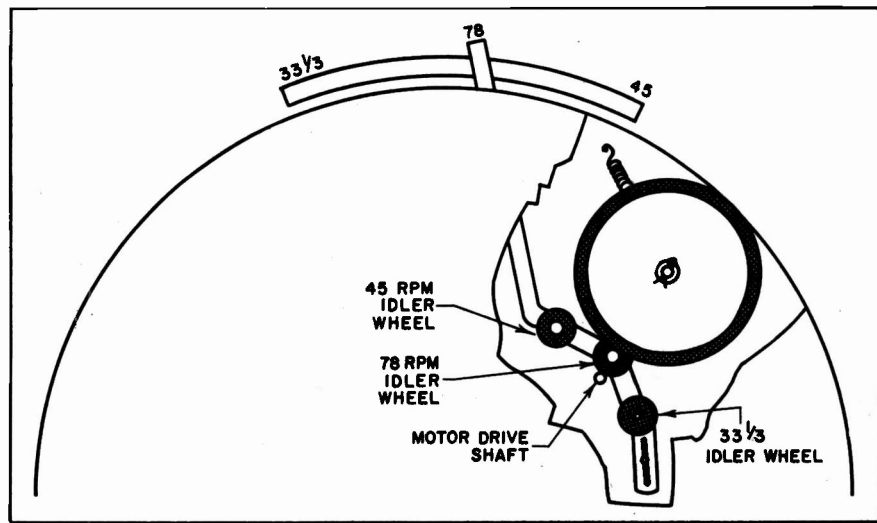

Fig. 4—Three-speed drive assembly showing separate idlers mounted on selector lever.

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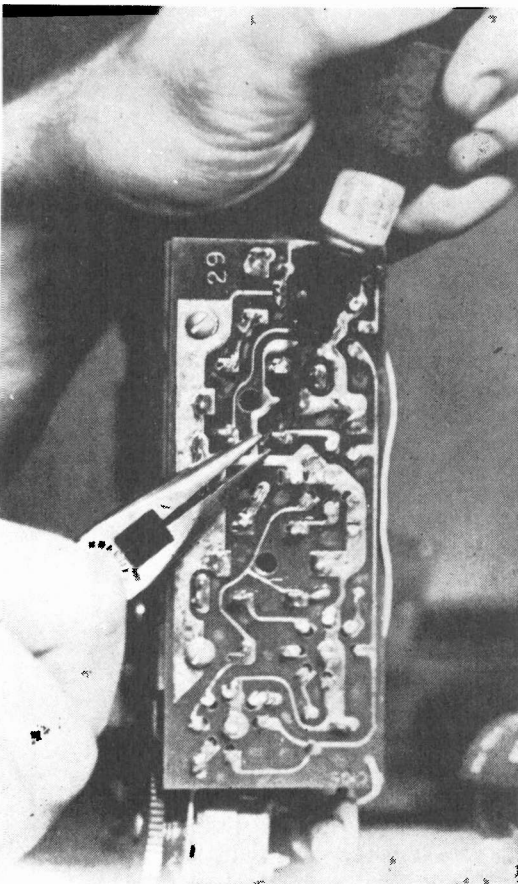
Several types of etched-metal, embossed-circuit and printed-circuit sets exist. In the true printed-circuit receiver, the wiring is electroplated on a layer of conductive (metallized) ink, printed on a sheet of phenolic plastic material, and deposited by a printing or silk-screening process. The bond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

NOTE REDUCED 12SA7 FILAMENT VOLTAGE THE SMALL INCREASE IN CURRENT IS INSUFFICIENT TO MAKE UP FOR 30% DECREASE IN THE 12SA7 HEATER RESISTANCE
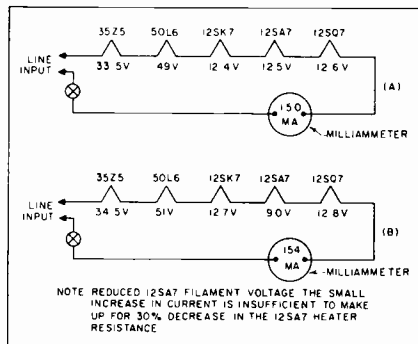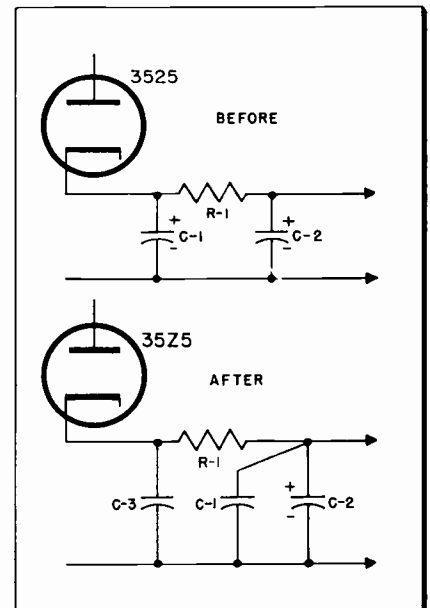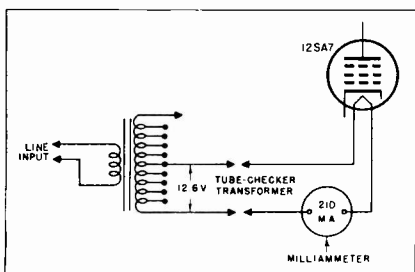
Fig. 1A—Normal heater voltage readings. B—Readings with defective 12SA7 in set.

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)

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 ⅛th 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).

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.
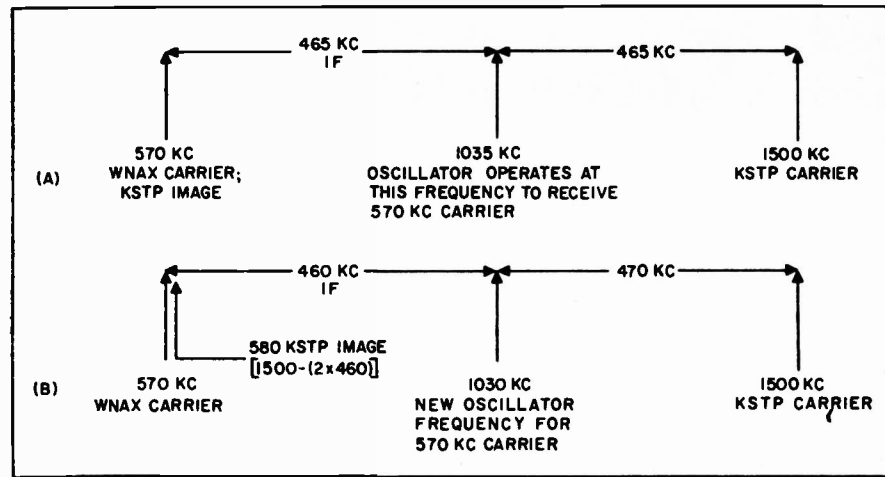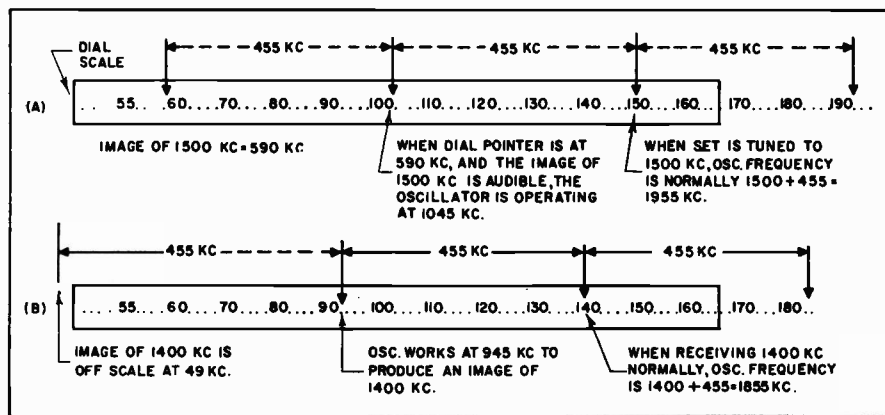

Fig. 2A—How the image of a 1500 kc transmission heterodynes with a 570 kc station to create beat interference. B—How shift to a new i-f eliminates image of undesired station.

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.

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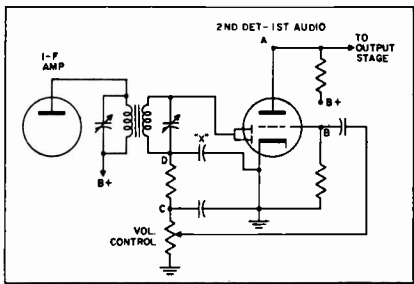
Fig. 1—I-f and second-detector circuit of 5-tube ac-dc receiver. Intermittent open-circuiting of condenser "X" resulted in fading.

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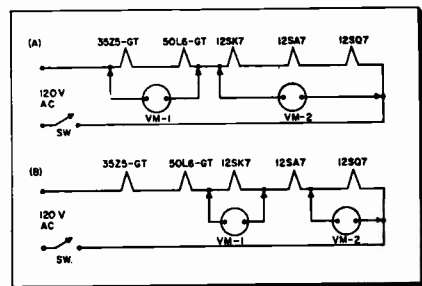
Fig. 2A—Connection of 2 ac voltmeters across tube filaments for first fading check. B—Voltmeter connections for the second fading check.

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).
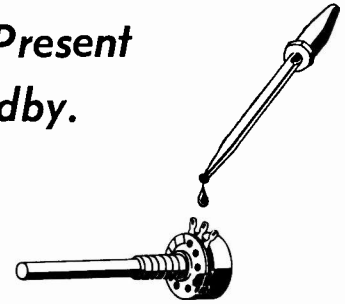
An efficient product should contain ingredients to perform all of the above functions in an expedient manner for the serviceman. The product should be supplied with a dropper attachment, and the serviceman should be equipped with a small brush, a cloth, a pipe cleaner, and a toothbrush, so that all types 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.
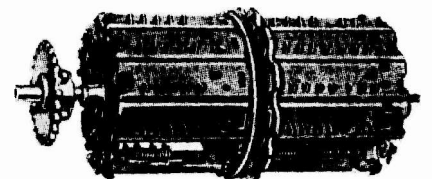
Color vs Black & White

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 meaning-less, 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

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.
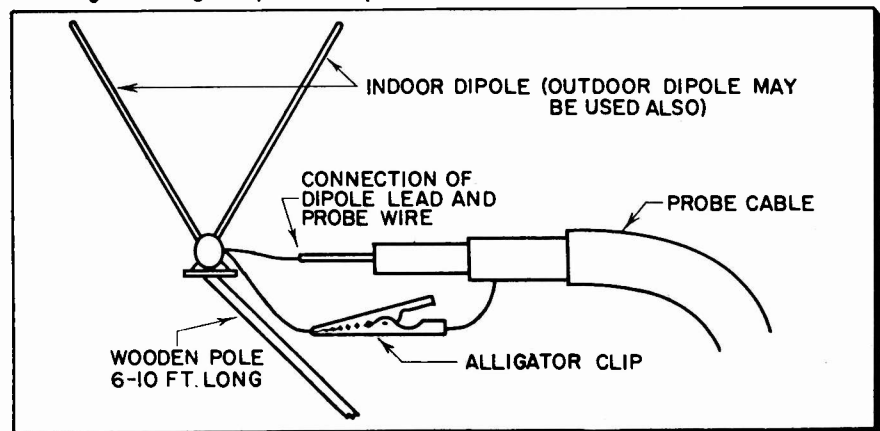
Localizing TVI

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.

INDOOR DIPOLE (OUTDOOR DIPOLE MAY BE USED ALSO)

CONNECTION OF DIPOLE LEAD AND PROBE WIRE

PROBE CABLE

WOODEN POLE 6-10 FT. LONG

ALLIGATOR CLIP

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

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.

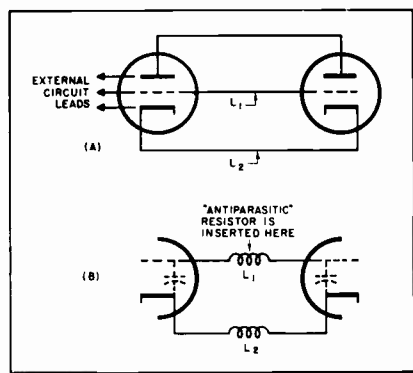When attempting to effect a shift in the TVI frequency, care must be exercised that the new frequency

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

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

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
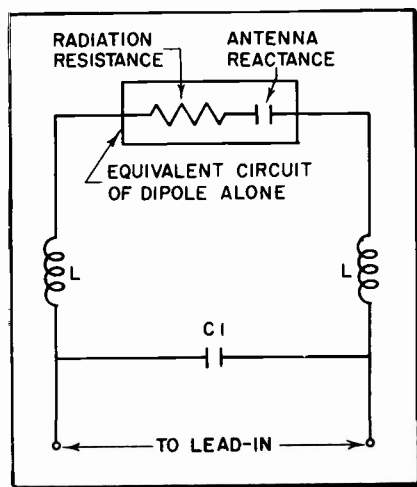
Fig. 3: Simplified circuit of matching network

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.
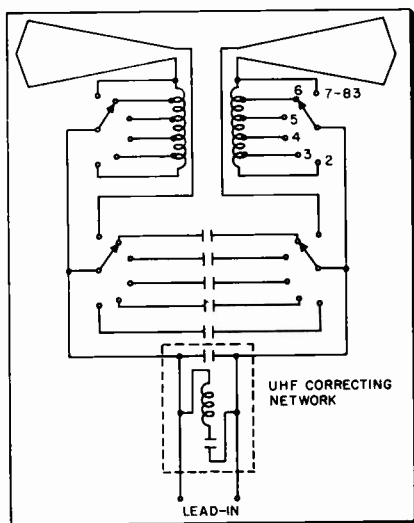
The complete circuit of the antenna

Fig. 4: Double-wafer four-pole selecto 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
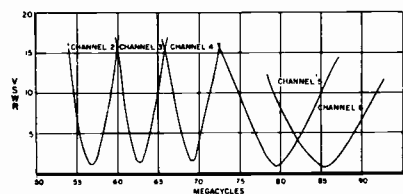

Fig. 5: SWR for low VHF band positions

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-
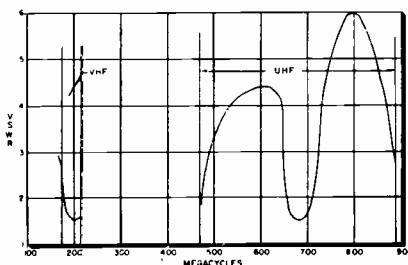

Fig. 6: SWR for high band VHF and UHF

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 out-

put 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.
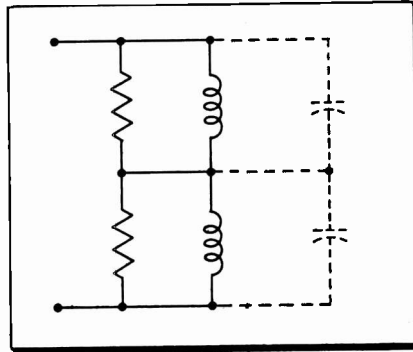
Ringing Problems

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

Fig. 9A—Sketch showing resistance and capacitance associated with peaking coil circuit. B—Increasing resistance in shunt with coil.
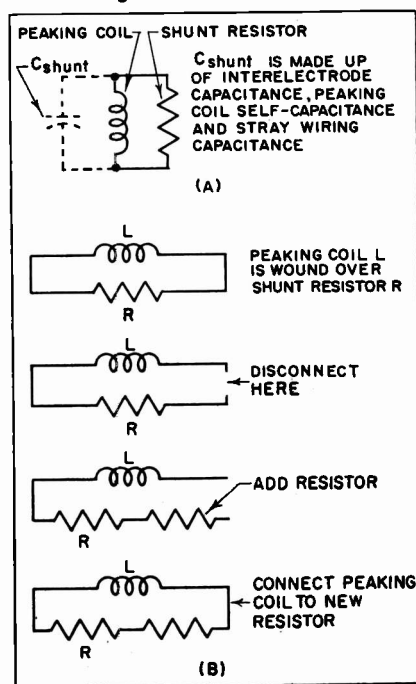
value—do not excessively overdamp one coil circuit alone, in order to get by with only one resistor.

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.
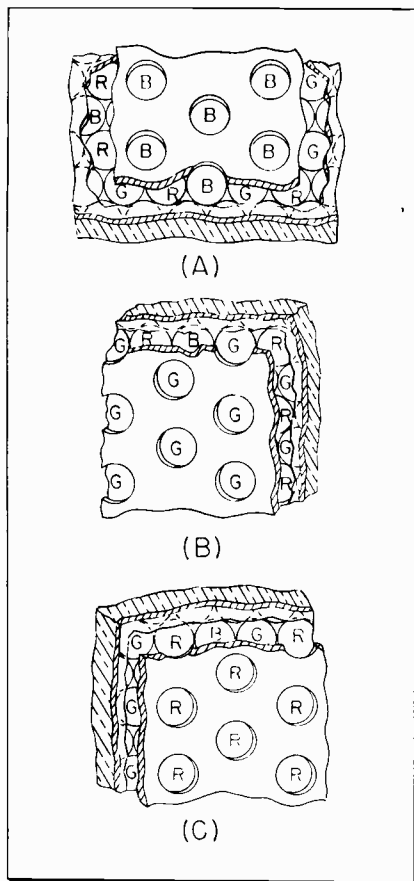
Color Picture Tubes

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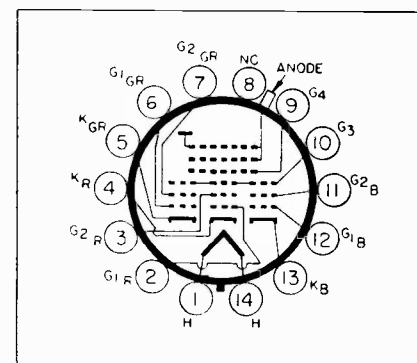
Pin 1: Heater
Pin 2: Grid No. 1 of red gun
Pin 3: Grid No. 2 of red gun
Pin 4: Cathode of red gun
Pin 5: Cathode of green gun
Pin 6: Grid No. 1 of green gun
Pin 7: Grid No. 2 of green gun
Pin 8: No connection
Pin 9: Grid No. 4
Pin 10: Grids No. 3
Pin 11: Grid No. 2 of blue gun
Pin 12: Grid No. 1 of blue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