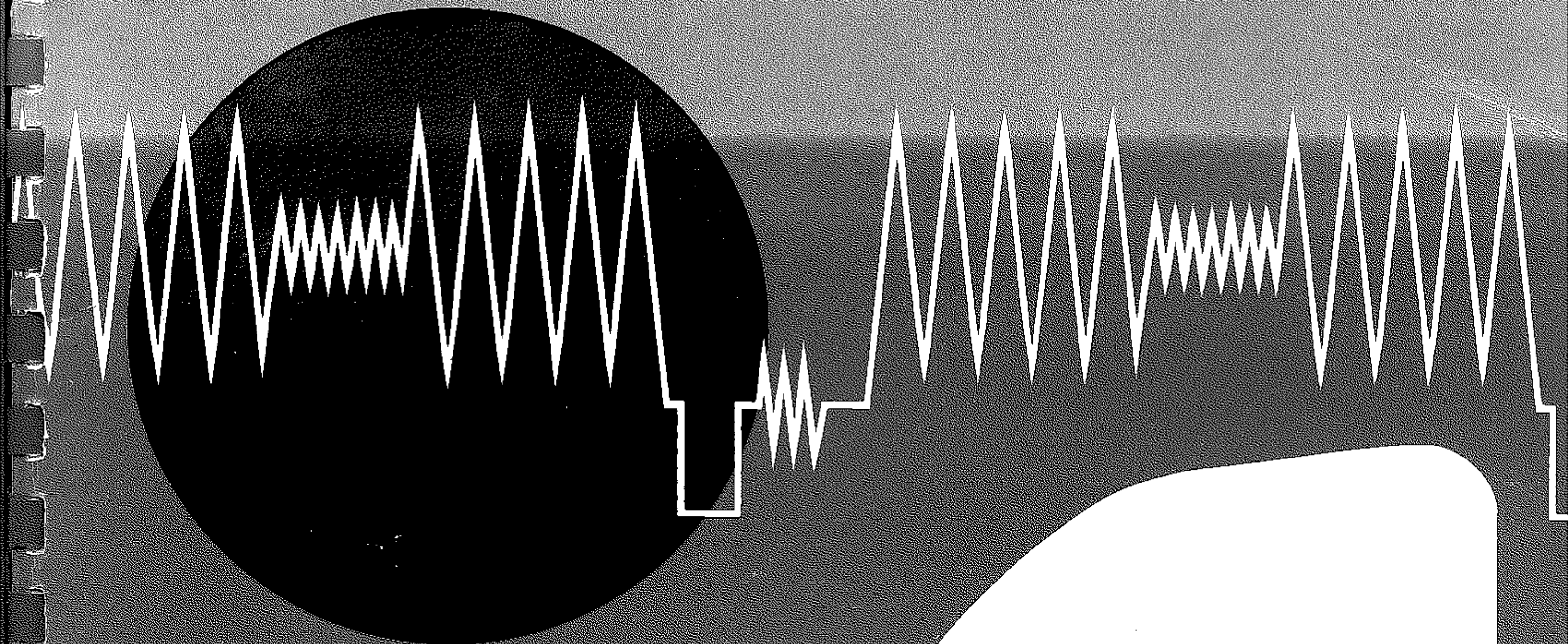
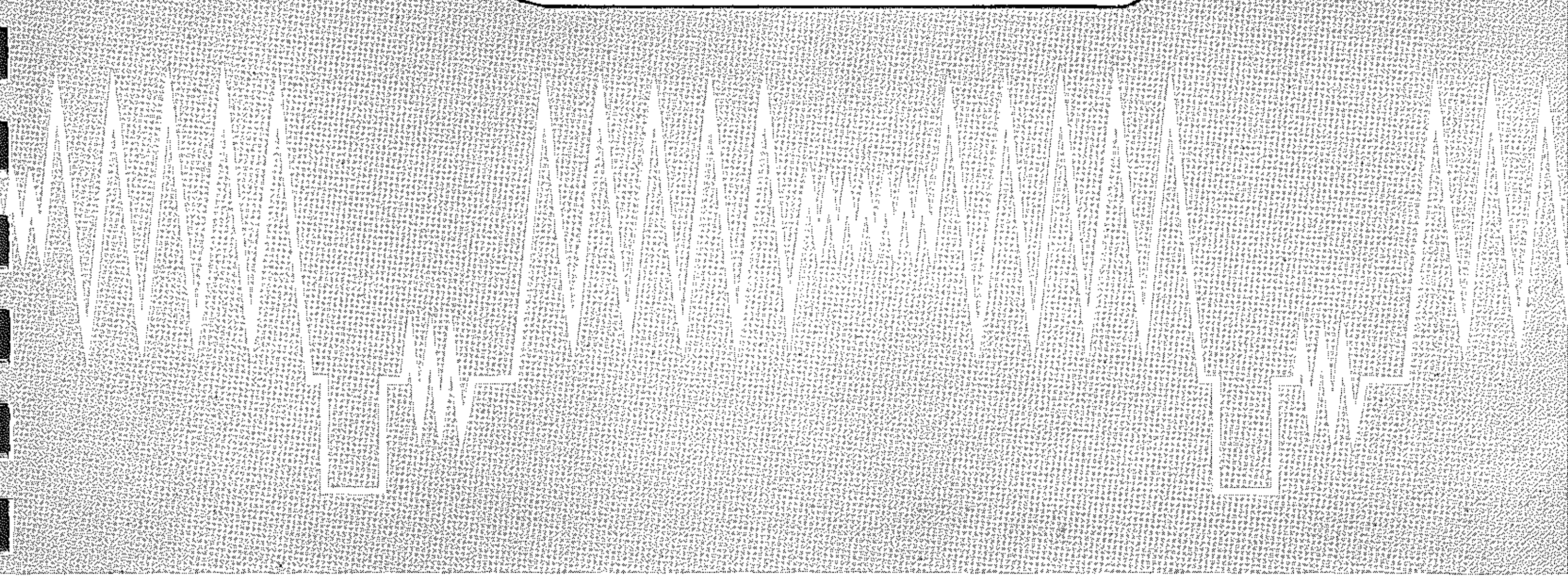


Television Signal Analysis

Second Edition

TELEVISION SIGNAL ANALYSIS

Second Edition



Revised by
Network Transmission Committee
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Video Transmission Engineering Advisory Committee

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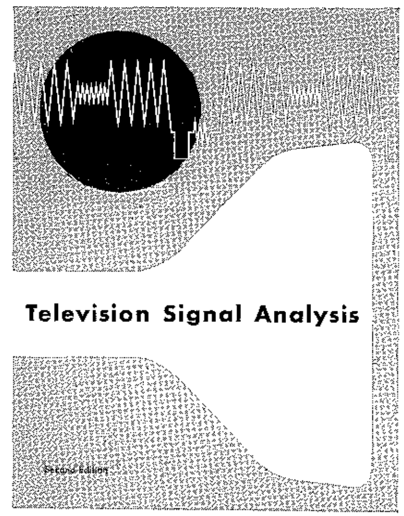

Introduction

This booklet has been prepared as a general reference for technical employees who are concerned with the analysis of television signals. Such analysis has as its purpose a determination of the quality of the signal as received at various points along its transmission path; and, if signal impairment appears, a diagnosis of its probable cause. This would naturally lead to the taking of corrective measures as may be indicated.

It is clear that, to have any significance, the observation of signals requires the use of monitoring devices that are always capable of giving a faithful representation of the actual signal on the line. Correct adjustment and proper maintenance of these devices must, therefore, be assumed. Granting this, any observed deficiency in the signal must either be present in the output of the camera equipment or be the result of failure of the transmission system to carry the signal without distortion from its point of origin to a distant monitoring point.

To properly discharge his responsibilities, the technician must know how the signal delivered by the camera looks in comparison with the signal which he is receiving. If this comparison indicates that undue distortion is being introduced by the transmission system, he may wish to compare his received signal with the signals received by other monitors back along the line in order to isolate the section of the transmission system that is at fault.

A single observer, of course, cannot make simultaneous observations of a signal at a number of different points. Comparisons, therefore, depend upon telephone communication between observers who may be located at widely separated points and who may be associated with entirely different communications or broadcasting organizations.

For such communication to be fully effective, it is necessary that the observing devices employed at all points be sufficiently alike to produce signal presentations that are directly comparable in kind. It is also necessary that all observers have a common understanding of what constitutes the normal signal presentation. Each observer should be able to recognize the appearance of the more usual types of signal impairments that may occur from time to time. In addition, skill in diagnosing the probable general cause of any observed impairment is highly desirable as a first step in facilitating the location and correction of the fault responsible.

It is obvious that effective communication between observers requires that each use a language that is readily understood by the others. The growing television vocabulary has tended to develop some confusion, with several different words or phrases being used for the same thing in many cases. In this booklet, an attempt has been made to select the particular words or designations that seem to have gained the widest acceptance.

Since the primary objective of this report is to promote common understanding of signal forms and their nomenclature, the following pages first discuss and illustrate satisfactory monochrome and color television signals as they appear in standard picture monitor and oscilloscope presentations. Various types of test signals and their uses are discussed, followed by the major video signal impairments. Each impairment is considered separately, with emphasis placed on significant features which are apparent when viewed on picture monitors and oscilloscopes. Finally a glossary of the more commonly used video terms is presented.

The information contained in this book is based on technical standards used in the United States. Much of it is also applicable to TV signals based on other standards.

Much of the photographic and descriptive material included has been prepared with the help of the Engineering groups of the American Broadcasting Company, the Columbia Broadcasting System, and the National Broadcasting Company, all of whom have been extremely cooperative. This booklet, then, endeavors to represent the viewpoints of both the broadcasting and telephone industries.

The Television Signal

A picture monitor in a broadcaster's studio or in a telephone company television operating center might depict a test pattern as shown in Fig. 1. This picture is free of discernible defects as evidenced by straight lines, undistorted circles and a complete range of grays.

The complete analysis of the picture signal, however, cannot be determined by the picture monitor alone. In the operation and maintenance of network television transmission, it is also necessary to analyze the signal using a cathode ray oscilloscope (A-scope). The A-scope permits the display of the voltage-time characteristics at the horizontal and vertical scanning rates.

1. Horizontal Scanning Interval

Fig. 2 is the horizontal video signal presentation of the monochrome test pattern of Fig. 1 as seen on the A-scope with a sweep rate of about 7,875 cycles per second (one-half the 15,750-cycle line rate). As shown, polarity of the signal generally displayed on A-scopes used in broadcasters' control rooms and telephone company television operating centers is "Black Negative."

The complete video signal for one scanning line (h), included between E and G, requires a time interval of 1/15,750 second or 63.5 microseconds. The horizontal blanking interval occupies nominally 11.11 microseconds of this time and the picture information, the balance of the time, or 52.39 microseconds.

The horizontal and vertical sync pulses, which synchronize the sweep circuits in the receiver with those of the camera, determine the timing of the scanning lines, thus accurately placing each element being scanned. The horizontal sync pulse is shown during the horizontal blanking interval, with a voltage level corresponding to D.

The picture brightness information varies between A and B, with the peak white amplitude of the picture at A and the peak black amplitude of the picture at B. In the case of test pattern signals, these peaks correspond to reference white and reference black levels, in which range it is expected that normal program picture information will fall. Any video voltage less than A will produce decreasing brightness until black is reached at B. Thus the region between A and B represents the picture brightness information. In terms of voltage, the instantaneous level corresponds to the brightness of the televised scene at that particular instant.

The "Setup" of the picture is the difference in voltage between the blanking and reference black levels, as indicated between C and B in Fig. 2. On the IRE scale, which has been adopted for industry-wide use, the setup value for network transmission is normally 7.5 IRE units.

It may be seen that if a picture has no black information, but only goes from white to gray, the black peaks will not approach black level as closely as they would if the picture contained full blacks. This picture would appear to have a high setup. On the other hand, black peaks should not extend below the reference black level. Broadcasters attempt to maintain a reference black in the picture during all transmissions to produce the most pleasing effect. FCC technical standards [FCC Rules & Regulations, Section 3.682 (a) 17] require that setup remain between 5 and 10 IRE scale divisions during broadcast periods. Many studios are now equipped with electronic devices to maintain minimum setup leaving the studio.

Typical proportions for a one-volt peak-to-peak composite signal as displayed on an oscilloscope with an

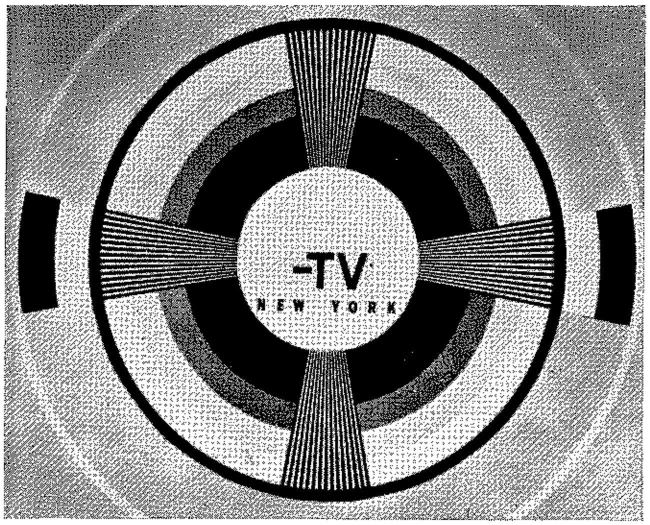

FIG. 1 — NORMAL VIDEO SIGNAL —
PICTURE MONITOR PRESENTATION

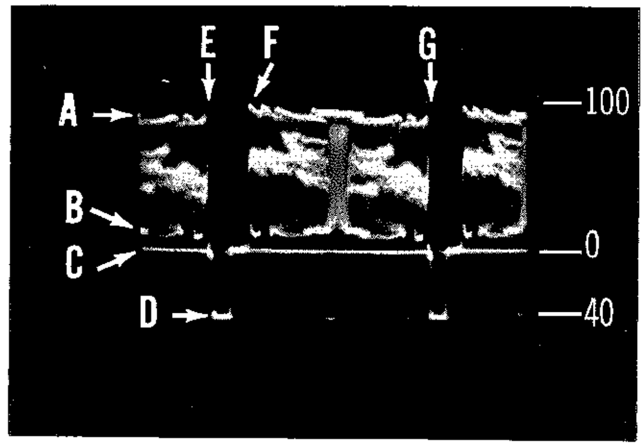

FIG. 2 — NORMAL VIDEO SIGNAL —
A-SCOPE HORIZONTAL PRESENTATION

A. White Peak
B. Black Peak
C. Blanking Level
D. Synchronizing Level
E-G — Complete Horizontal Interval = 63.5 microseconds (μs)
E-F — Horizontal Blanking Interval = 11.11 microseconds (μs)
F-G — Picture Signal = 52.39 microseconds (μs)

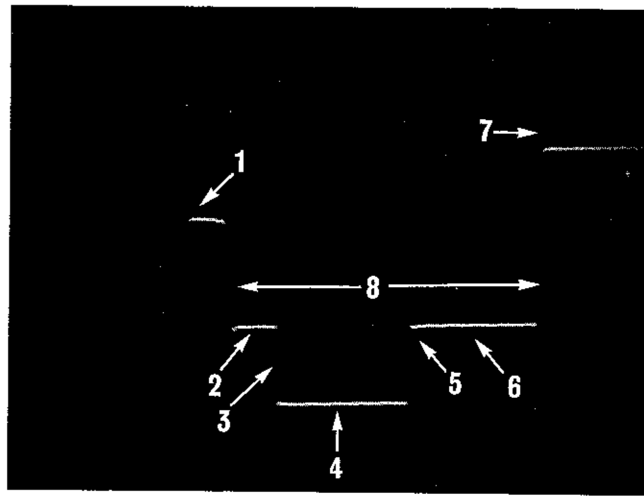

FIG. 3 — NORMAL VIDEO SIGNAL —
A-SCOPE EXPANDED HORIZONTAL PRESENTATION

1. Video Voltages at Right Side of Picture
2. Front Porch = 1.59 μs or 2.5% Horizontal Interval (h)
3. Leading Edge of Sync
4. Tip of Sync = 4.76 μs or 7.5% h
5. Trailing Edge of Sync
6. Back Porch = 4.76μs or 7.5% h
7. Video Voltages at Left Side of Picture
8. Horizontal Blanking Interval = 11.11 μs or 17.5% h

IRE scale are 40 divisions of sync, 7.5 divisions of setup and 92.5 divisions of picture information, as shown in Fig. 2.

Fig. 3 is an expanded view of the horizontal blanking interval with component parts, including the horizontal synchronizing pulse and adjacent signals identified. The nomenclature tabulated here, if universally used, will minimize confusion when tracing a signal impairment to its source.

The front porch isolates the synchronizing pulse from transients or overshoots in the video signal at the end of the scanning line. This is done in order that the synchronizing circuits in receivers or customer processing or stabilizing amplifiers will not be triggered prematurely, thus producing a picture with successive horizontal lines displaced in a sporadic manner causing jitter or possible tearing.

The leading edge of the sync pulse is used to synchronize the horizontal sweep oscillators in most monitors and receivers, and to trigger some clamping circuits. Excessive slope or curvature of the leading edge of the sync pulse, if sufficiently serious, may cause erratic or even complete failure of synchronization in monitors or receivers. It may also cause clamping failure in transmission equipment.

The tip of the sync pulse is used as the reference point in the d-c restorers of monitors and some oscilloscopes, and in the d-c restoration or clamping stages of telephone company equipment.

A pulse derived from the trailing edge of the sync pulse is used to trigger the clamping circuits in most types of stabilizing amplifiers used by broadcasters. Serious slope or curvature of the trailing edge of the sync pulse will cause improper operation of these stabilizing amplifiers, causing tearing and rolling in the reproduced picture.

The back porch completes the horizontal blanking interval. If the operation of the sweep circuits of a monitor or receiver is considered, it will be apparent that when the electron beam has traversed the picture tube from left to right, it cannot return to the left side of the tube (retrace) instantaneously, but requires a small amount of time to do so. If picture voltages were allowed to begin immediately after the horizontal sync pulse, the picture components they represent would be visible during retrace. The duration of the back porch interval provides enough time for the sweep circuits to retrace completely, prior to the occurrence of the next line of picture information.

While the customers' processing or stabilizing amplifiers are triggered by the trailing edge of the sync pulse, they actually clamp during the back porch interval. This type of clamper-amplifier employs a time delay RC circuit which is generally adjusted to delay the start of the clamping action until sometime during the first quarter of the back porch interval. The clamping or reference level is usually an average of the voltage level during the first microsecond (one quarter) of the back porch interval. Therefore, if the back porch is seriously deformed or contains a large amount of noise, these amplifiers will clamp improperly, resulting in an impaired or useless picture to the customer although the picture may appear usable at the serving telephone office.

2. Vertical Scanning Interval

Fig. 4 is the video signal presentation of Fig. 1 as seen on the A-scope at the vertical scanning rate, approximately 30 cycles per second.

The levels of white peaks, black peaks, blanking and tip of sync indicated in Fig. 4 are of the same value on the IRE scale as shown for Fig. 2. The vertical synchronizing pulse, with the associated equalizing and blanking pulses, may be seen in the center of the picture. This presentation can reveal many of the common types of low-frequency trouble, such as clamping failures, 60- or 120-cycle interference or other serious signal distortions.

Fig. 5 is an expanded view of the vertical blanking interval with the component parts identified. Certain signal distortions that cannot be detected in the normal presentation may be seen in the expanded view.

The requirements imposed by interlaced scanning create the need for the equalizing pulses. The odd and even fields occur alternately at the rate of 60 fields per second. The first line of an odd field starts at the top left corner of the raster and the last line ends at the bottom center of the raster, while the first line of an even field starts at the top center of the raster and the last line ends at the bottom right corner of the raster. Therefore, it may be seen that if the vertical synchronizing pulse occurred immediately following the last horizontal scan, the vertical pulse integrator capacitor in a receiver would have a different residual charge depending upon whether the vertical sync pulse followed an even or odd field. The fact that the vertical synchronizing pulse occurs one-half line nearer a horizontal sync pulse following an odd

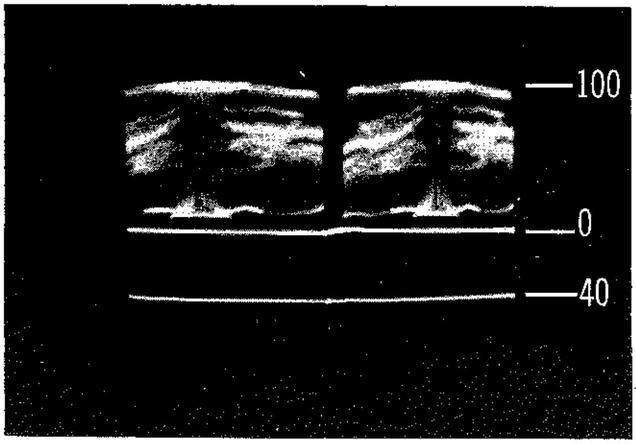

Fig. 4 — NORMAL VIDEO SIGNAL — A-SCOPE VERTICAL PRESENTATION

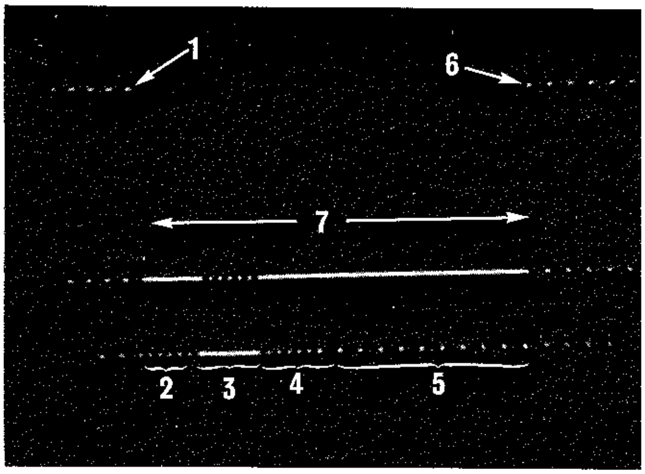

FIG. 5 — NORMAL VIDEO SIGNAL — A-SCOPE EXPANDED VERTICAL PRESENTATION

1. Picture Voltages, Bottom of Picture
2. First Group of 6 Equalizing Pulses
3. Serrated Vertical Sync Pulse
4. Second Group of 6 Equalizing Pulses
5. Horizontal Sync Pulses
6. Picture Voltages, Top of Picture
7. Vertical Blanking Interval

FIG. 6 — VERTICAL BLANKING — PICTURE

field than when following an even field would result in imperfect interlacing if the first group of six equalizing pulses were not provided. These equalizing pulses preceding every vertical synchronizing pulse assure that the vertical pulse integrator capacitor in a receiver will have the same residual charge at the beginning of the vertical sync pulse, regardless of whether it follows an odd or even field. These six equalizing pulses each occur at one-half horizontal line intervals, which is twice the line frequency, or approximately 31,500 pulses per second.

The serrated vertical pulse has a duration of approximately three full lines. The serrations occur at the same rate as the equalizing pulses and keep the horizontal sweep oscillators in receivers and monitors synchronized and running smoothly during the vertical synchronizing pulse. Alternate serrations function as horizontal sync pulses.

The second equalizing pulse group follows the serrated vertical sync pulse. These equalizing pulses also occur at twice the line frequency. The first and second set of equalizing pulses, along with serrations of the vertical sync pulse, permit stable operation of the horizontal sweep oscillator for the two different horizontal line conditions between the odd and even, and between the even and odd fields.

The portion of the vertical blanking interval between the end of the second set of equalizing pulses and the first video information of the new field (5 of Fig. 5) is provided to allow time for the vertical sweep circuits in receivers to return the electron beam completely to the top of the raster before the video information of the new field starts. By adjusting the vertical hold control of the picture monitor and increasing the brightness, a presentation similar to Fig. 6 can be obtained. This shows the vertical blanking interval as a wide dark bar. The black bars within the vertical interval represent equalizing and vertical sync pulses.

3. NTSC Color

Fig. 7 presents the horizontal display of an NTSC color signal on a wide-band A-scope. As shown, the A-scope presentation is similar in appearance to that of a monochrome signal insofar as horizontal blanking, sync and picture information are concerned. The burst of high-frequency during the back porch interval represents the most distinguishing feature of the A-scope presentation of the color signal. This is the color sync burst, comprising 8 or 9 cycles of a sine wave signal of approximately 3.6 (3.579545) mc. The peak-to-peak amplitude of the color burst should be the same as the amplitude of the horizontal sync pulse, i.e., 40 divisions on the IRE scale. The color burst is centered at blanking level, and with respect to time starts about one-tenth of the total back porch interval from the trailing edge of the sync pulse. Another distinguishing feature is the presence of video information below black level, which varies with the hue and saturation of the colors being televised.

For color transmission the horizontal scanning frequency is 15,734.264 $\pm$ 0.044 cycles per second rather

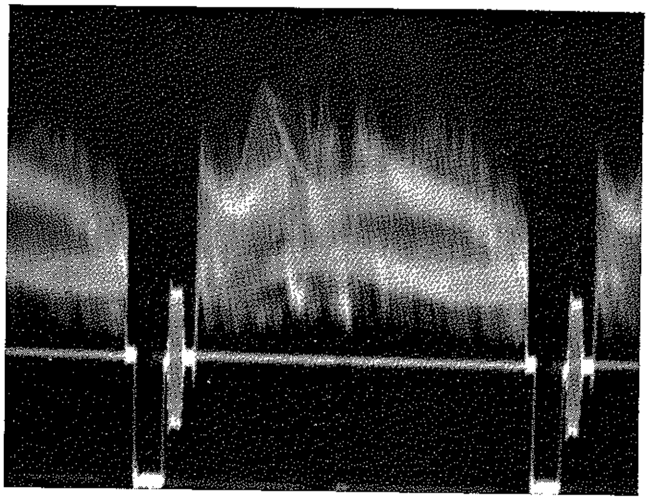

FIG. 7 — COLOR SIGNAL — HORIZONTAL — WIDEBAND

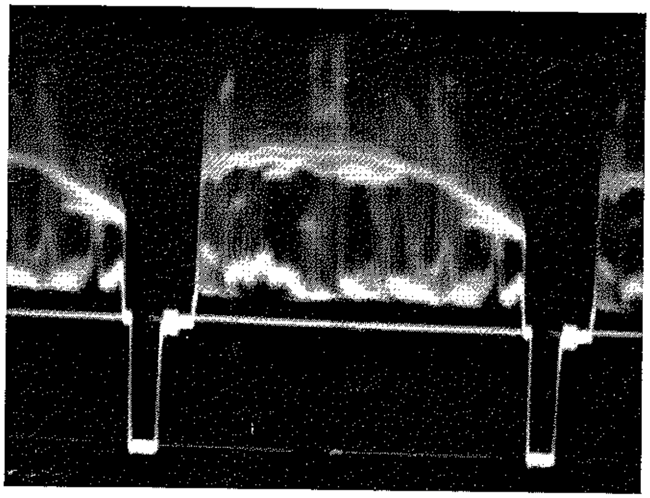

FIG. 8—COLOR SIGNAL—HORIZONTAL—IRE ROLL-OFF

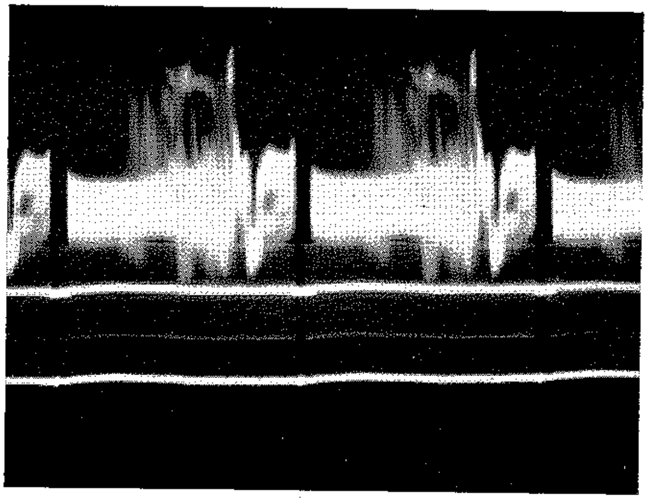

FIG. 9 — COLOR SIGNAL — VERTICAL — WIDEBAND

than the nominal value of 15,750 cycles per second. The vertical scanning frequency is 59.94 cycles per second rather than the nominal value of 60 cycles per second. The complete video signal for one scanning line requires a time interval of 1/15,734, or approximately 63.6 microseconds. The horizontal blanking interval requires approximately 11.1 microseconds of this time with the picture information utilizing the balance of the time, or 52.5 microseconds. This compares closely with the nominal intervals shown in Fig. 2 for the monochrome signal.

If an A-scope presentation of a color signal were expanded, the color information would be seen varying in amplitude according to the saturation of the colors being transmitted. By operating the A-scope with the IRE roll-off characteristic, the color signal appears as in Fig. 8, with practically all of the color information removed. The scope presentation shows mainly the luminance, or monochrome portion of the signal.

A-scope presentations of color signals at the vertical sweep rate, using either the wide-band or IRE roll-off characteristic, do not differ from the monochrome signal presentations except for the presence of the high-frequency color information. Such a presentation is shown in Fig. 9, with the A-scope in the wide-band position.

Television Test Signals

This section describes some of the test signals used in line-up and maintenance of television channels.

1. Sine Waves

Sine wave measurements are frequently used to determine gain-frequency characteristics of transmission channels. These signals are generally obtained from the 61B or 61C signal generator. The 70A or 70B power meter, a thermocouple instrument, is used for making the measurements. To provide accurate measurements at frequencies below 10 kc, clamping circuits along the transmission path must be disabled. Simple sine wave measurements cannot be made where gating circuits are used, as in certain types of radio relay systems, to set the carrier rest frequency at the time of the horizontal sync pulse. In such cases, synchronizing pulses must be present for faithful reproduction of transmission conditions.

2. Monoburst

The name "monoburst" has been applied to the resulting composite signal which is illustrated in Fig. 10. The complete monoburst signal consists of single frequency sine waves plus sync pulses at the line rate, a blanking interval, and a means for varying the setup and the amplitude of the sine waves. The presence of sync enables the gating and clamper circuits to operate in their normal fashion. Monoburst signals are measured and interpreted by using a calibrated oscilloscope.

3. Window Signal

The window signal is a large square or rectangular white area with a black background. Fig. 11 is a typical broadcasters' window signal (with sine-squared pulse) viewed on a picture monitor. Figs. 12 and 13 show the

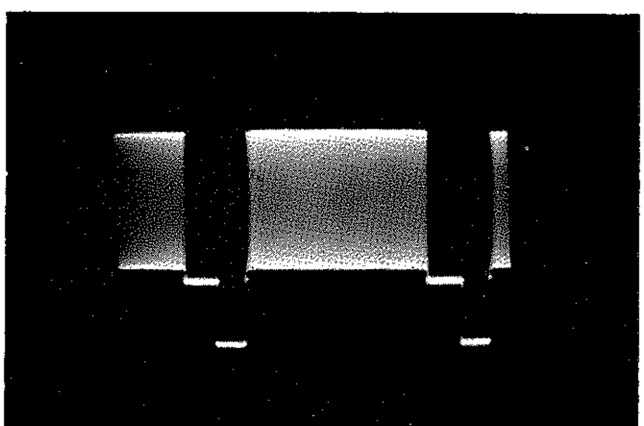

FIG. 10 — MONOBURST SIGNAL — HORIZONTAL

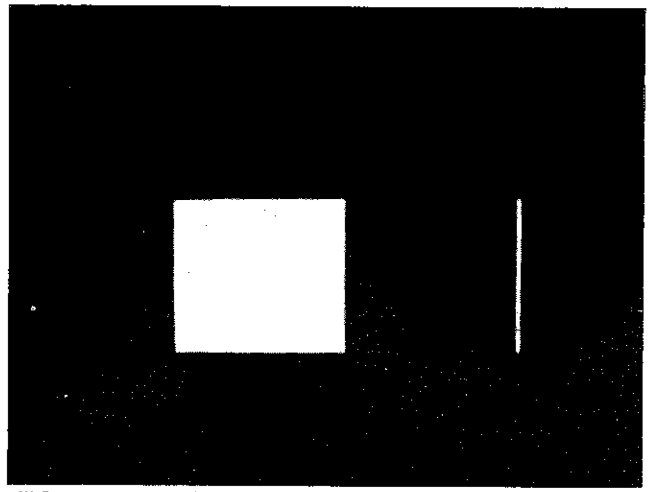

FIG. 11 — BROADCASTER'S SINE-SQUARED WINDOW AND PULSE — PICTURE

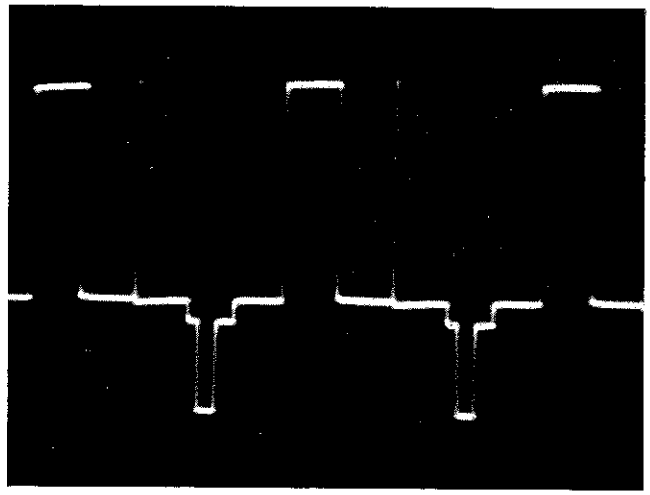

FIG. 12 — BROADCASTER'S SINE-SQUARED WINDOW AND PULSE — HORIZONTAL

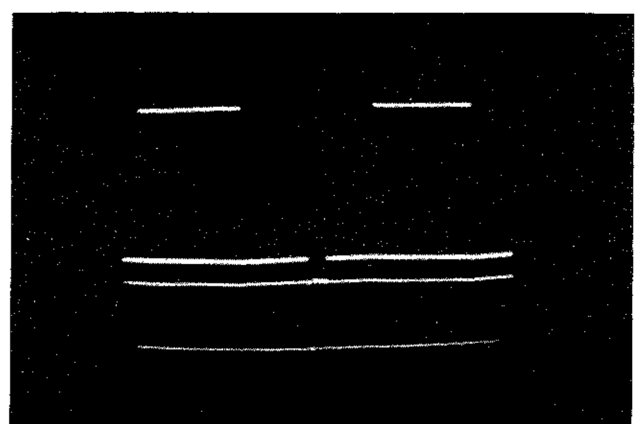

FIG. 13 — BROADCASTER'S SINE-SQUARED WINDOW AND PULSE — VERTICAL

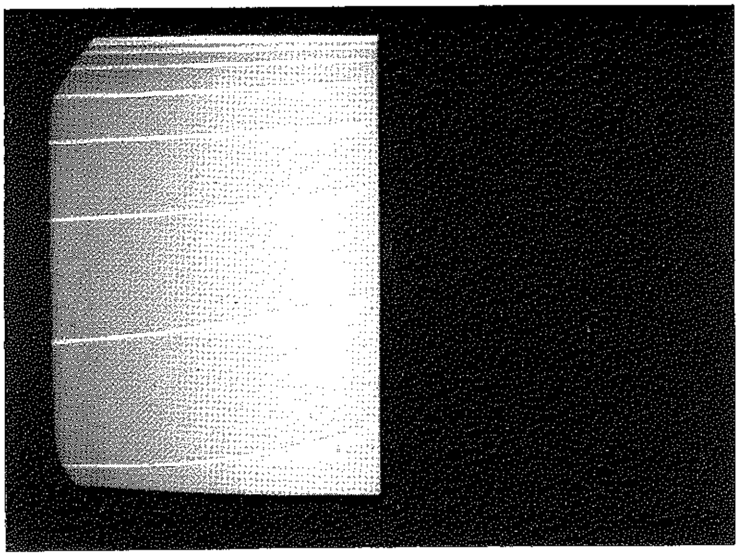

FIG. 14 — 61C WINDOW SIGNAL — UNMODULATED — PICTURE

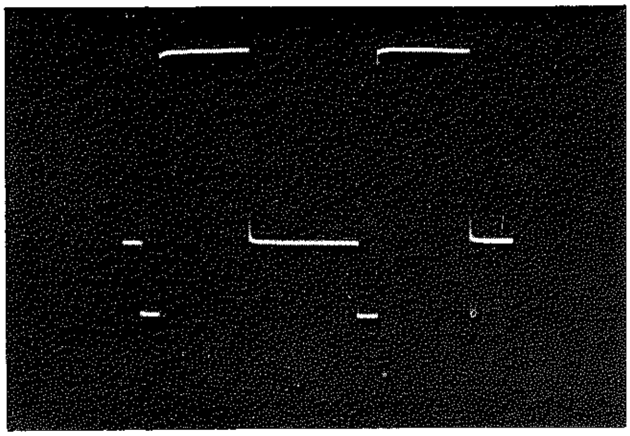

FIG. 15 — 61C WINDOW SIGNAL — UNMODULATED — HORIZONTAL

horizontal and vertical presentations on an A-scope. The picture signal has two normal levels, reference black and white. The white level can be adjusted, but is usually set at reference white. In order to locate the maximum energy content of the signal in the lower portion of the total frequency band, the white area is adjusted to cover ¼ to ½ total picture width and ¼ to ½ total picture height.

The window signal is useful for a number of checks and tests when observed on picture monitors or A-scopes, including:

1. Level or continuity check — Using a window of known white level, the peak-to-peak voltage of the signal may be read easily on a calibrated oscilloscope, using the IRE roll-off characteristic.
2. Measurement of sync compression or expansion — Comparison of the locally received window signal with that of the office transmitting the signal with respect to horizontal sync and white levels on calibrated scopes using IRE roll-off, permits accurate evaluation of these linearity characteristics at the receiving point, in order that necessary correction can be made.
3. Minimizing streaking — Observation of the test sig-

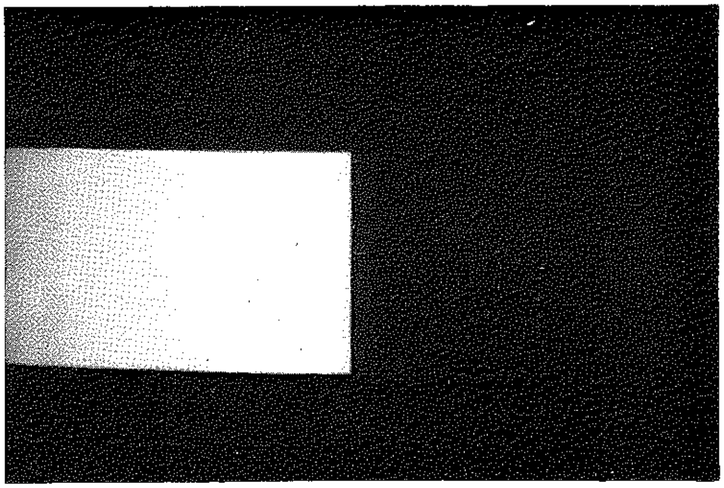

FIG. 16—61C WINDOW SIGNAL—MODULATED—PICTURE

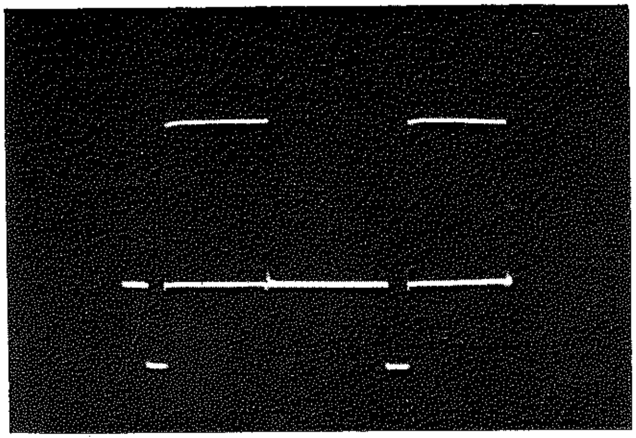

FIG. 17 — 61C WINDOW SIGNAL — MODULATED — HORIZONTAL

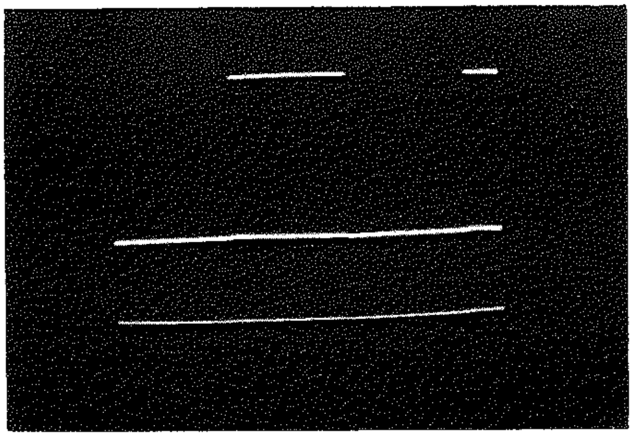

FIG. 18 — 61C WINDOW SIGNAL — MODULATED — VERTICAL

nal on scopes using the IRE roll-off characteristic at both vertical and horizontal rates, enables evaluation of streaking so that adjustments can be made on clamper-amplifiers and low-frequency equalizers to minimize the impairment. When using a picture monitor for observation of streaking, it is essential to make sure that it is properly adjusted and free from internal defects which might give false indications.

4. Observation of ringing — The presence of ringing may be detected by using properly calibrated wide-band scopes and expanding the horizontal presentation to a convenient scale. Ringing amplitude may be measured directly. Its frequency may be calculated by adjusting the horizontal gain of the oscilloscope until the width of sync (about 5 μs) covers 5 scale divisions. Then, by placing the ringing of the window on the horizontal scale with the centering controls, the approximate frequency (in mc) can be determined by dividing the number of complete cycles by the number of divisions over which they extend. Ringing also may be seen on picture monitors.

The window signal generally used by the broadcasters contains both horizontal and vertical sync as in Figs. 11, 12 and 13. In this type of signal, the white window is adjustable in size both horizontally and vertically, and also is adjustable in position anywhere on the black background.

The window signal provided by most telephone company generators, such as the 61C signal generator, produces a white area adjustable in width from the left edge of the raster, with a black area in the remaining portion as shown in Figs. 14 and 15. Sync pulses are provided at the horizontal rate (15,750 per second). The window signal produced by the earlier model signal generator (61B) is similar (but not as suitable) to the 61C for streaking tests because the black and white areas are reversed. There is no adjustment of picture height for either the 61B or 61C white window, but by modulating these signals at a 60-cycle rate, by means available within the set, a window of approximately ½ the picture height can be obtained, as shown in Fig. 16. Horizontal and vertical A-scope presentations are shown in Figs. 17 and 18. Since none of these signals has vertical sync information, the vertical retrace of the monitor is not blanked, and the retrace lines are visible. This does not, however, interfere with observation of the waveform.

4. Sine-Squared Test Signal

Another test signal which has proved very useful is the sine-squared signal shown in Fig. 19. Use of this pulse permits an evaluation of amplitude vs. frequency response, transient response, envelope delay and phase. An indication of the high-frequency amplitude characteristic can be determined by the pulse height and width, and the phase characteristic by the relative symmetry about the pulse axis. The principal application of this pulse, however, is for checking transient response and phase delay. When the phase delay is not uniform with frequency, undesired overshoot or ringing may occur. The sine-squared pulse provides a sensitive check for this condition. Although the square wave signal has been used for this application in the past, it has serious shortcomings not found in the sine-squared signal. A square wave, having an almost infinite harmonic content, can indicate the presence of overshoot or ringing at frequencies so far beyond the transmission system bandwidth that they have no effect on picture quality.

The sine-squared signal by contrast, has a limited harmonic content and, when applied to a limited bandwidth system, will yield no irrelevant information. In addition, this pulse has the added advantage of closely resembling in wave form the output of a camera, since the electron beam has a density distribution which varies as a sine-squared function. The pulse used for checking television systems should have a repetition rate equal to the line frequency, and a duration, at half-amplitude, equal to one-half of the period of the nominal upper

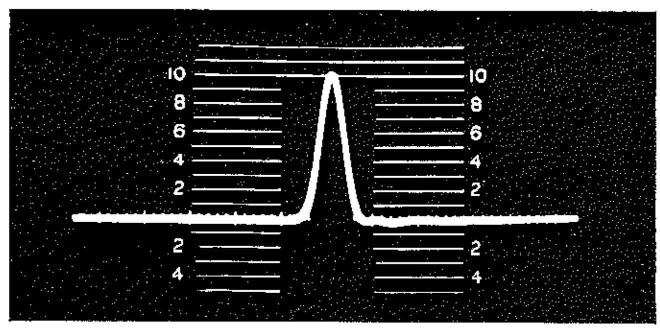

FIG. 19 — SINE-SQUARED PULSE SIGNAL

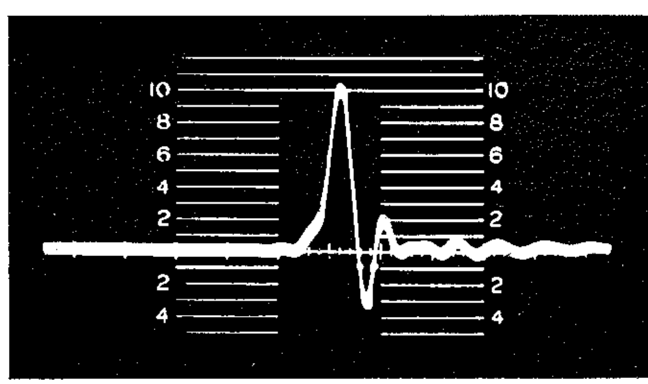

FIG. 20 — SINE-SQUARED PULSE SIGNAL — SIGNAL IMPAIRED WITH SEVERE PHASE DELAY

cutoff frequency of the system. Thus, for a 4 mc bandwidth the half amplitude width becomes 0.125 microseconds. The resulting spectrum distribution is then almost flat to 2 mc, 6 db down at 4 mc and virtually zero beyond 8 mc.

When this pulse is passed through a television system having gradual roll-off at the upper end of the pass band and constant delay with frequency, the pulse is transmitted with negligible distortion. If, however, there is increasing delay with increasing frequency, one or more overshoots will appear following the main pulse, as shown in Fig. 20. Conversely, decreasing delay with increasing frequency shows as overshoots or ripples preceding the main pulse. Under conditions of constant delay, but too rapid cutoff, overshoots will appear both preceding and following the main pulse.

It has been found that there is a very close relationship between the magnitude and number of cycles of ringing as observed on a picture monitor, and the amplitude and shape of the overshoots observed with the sine-squared pulse on a waveform monitor. It has become common practice to include the previously described window signal along with the sine-squared signal, on the same scanning line as shown in Figs. 11 and 12. When this is done the transitions of the window signal are processed through the same shaping network that produces the sine-squared pulses. This arrangement does not introduce any additional high-frequency components.

5. Multiburst

A multiburst signal is used for a quick check of gain at a few predetermined frequencies.

One form of multiburst signal, illustrated in Figs. 21 and 22, consists of a burst of peak white (white flag) followed by bursts of six sine wave frequencies from 0.5 mc to 4.0 mc, plus a horizontal sync pulse, all transmitted during one line interval. The white flag provides white level reference. Fig. 24 indicates the burst frequencies normally used by the telephone company. Most broadcasters use frequencies of 3.0 and 4.2 mc instead of 2.9 and 4.0 mc. However, all the frequencies may be varied. Vertical sync information is usually provided in multiburst generators.

Some of the earlier models of multiburst generators do not include the white flag; that is, six sine wave bursts occupy the entire interval between sync pulses.

At the receiving point the signal is observed on an oscilloscope. For gain measurements, the peak-to-peak amplitudes of the individual bursts are measured and compared. The accuracy of measurement is subject to the limitations of the oscilloscope. The principal uses are to observe:

1. Quick check of amplitude-frequency response.
2. Changes in setup.
3. Black or white compression.
4. Compression which may be selective with frequency (axis shift).

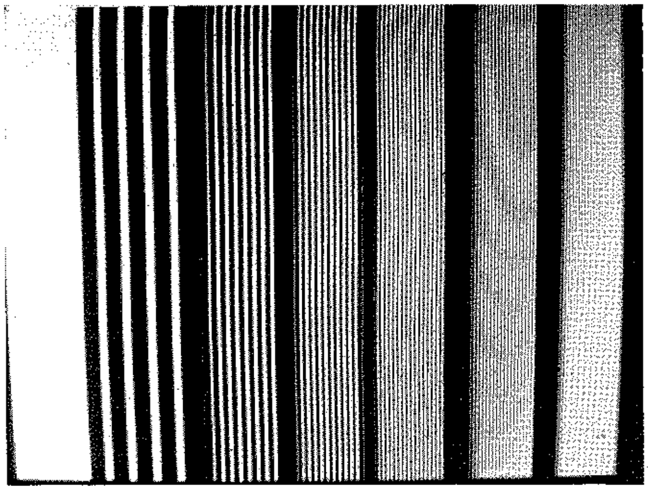

FIG. 21 — MULTIBURST SIGNAL — PICTURE

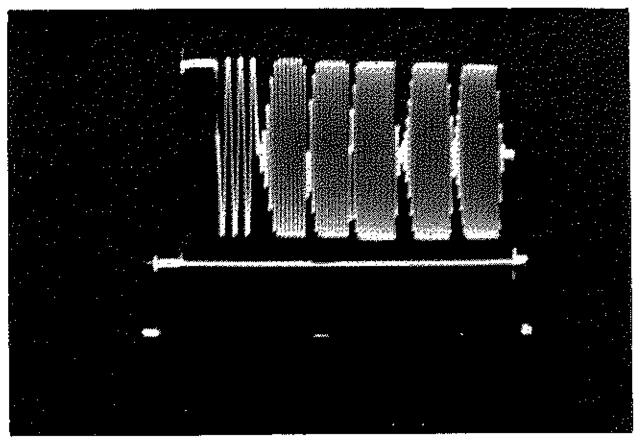

FIG. 22 — MULTIBURST SIGNAL — HORIZONTAL

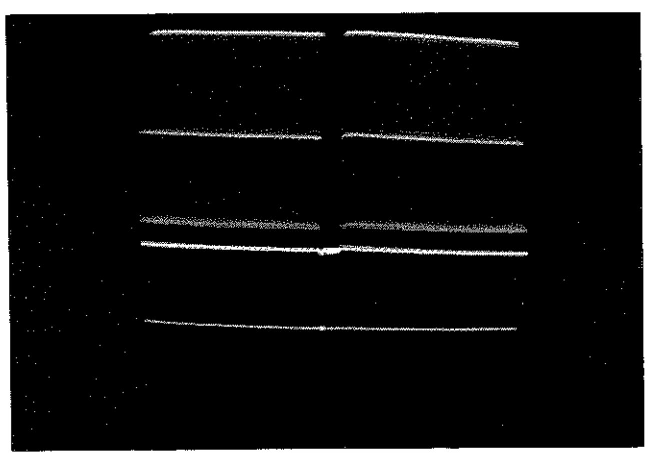

FIG. 23 — MULTIBURST SIGNAL — VERTICAL

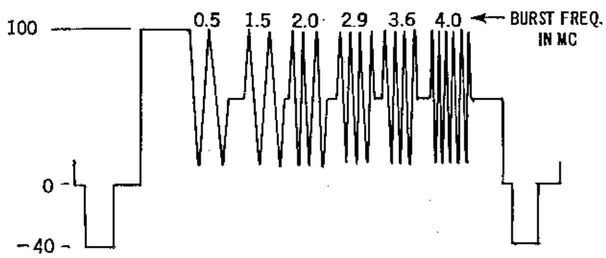

FIG. 24 — MULTIBURST SIGNAL — HORIZONTAL — FREQUENCIES NORMALLY USED

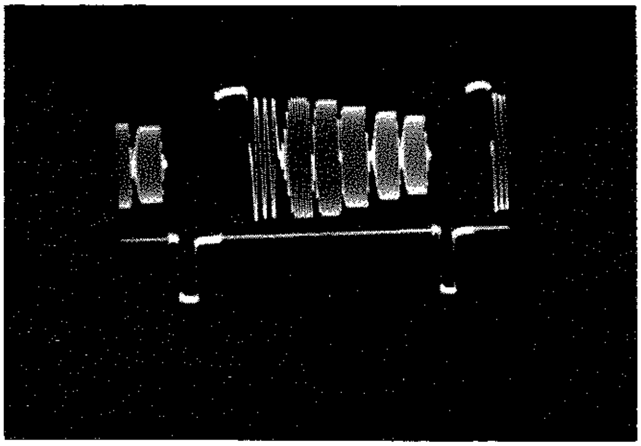

FIG. 25 — MULTIBURST SIGNAL — HORIZONTAL — IMPAIRED WITH GRADUAL LOSS OF HIGHER FREQUENCIES

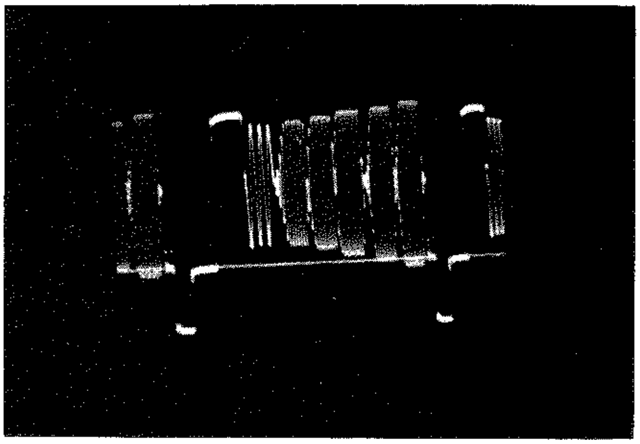

FIG. 26 — MULTIBURST SIGNAL — HORIZONTAL — IMPAIRED WITH GRADUAL GAIN AT HIGHER FREQUENCIES

Figs. 25 and 26 illustrate respectively gradual dropping and rising gain-frequency characteristics. These figures should be compared with the normal signal illustrated by Fig. 22. For information, the A-scope vertical presentation is shown by Fig. 23.

An arrangement has been made to facilitate identification of the originating source of a multiburst signal. All West Coast broadcasters will send three cycles of .5 mc burst, as shown in Fig. 22. East Coast broadcasters will set up their generators with four cycles of .5 mc burst, while all telephone company offices will transmit 5 cycles. Thus, with only a general knowledge of network routes, a casual glance will indicate the source of a particular signal.

6. Stairstep

The techniques most commonly used by the broadcasters at present for the measurement of differential phase and differential gain involve the transmission of a 10-step stairstep signal, as in Fig. 29. A sine wave of 20 IRE divisions at 3.6 mc is superimposed on the 10 steps which extend progressively from black to white level. At the receiving point, the high-frequency sine wave is separated from the low-frequency steps by a high-pass filter and displayed on the oscilloscope as in Fig. 30. The largest amplitude 3.6 mc sine-wave block is normally adjusted on the monitoring oscilloscope to 100 IRE divisions and becomes a reference block. Then the 3.6 mc sine waves from the other steps are measured in relation to the reference block. Any difference in the amplitudes of the remaining blocks represents differential gain. By means of a color signal analyzer, used in conjunction with the receiving oscilloscope, differential phase may be measured.

The stairstep signal, without sine wave added, is also used in some cases as a linearity check, as shown in Fig. 28. In this case, the relative height between steps is used as an indication of compression or nonlinearity. Fig. 27 shows a stairstep signal on a picture monitor.

7. Vertical Interval Signals

FCC transmission standards [FCC Rules & Regulations, Section 3.682 (a)21] specify that the interval beginning with the last 12 microseconds of line 17 and continuing through line 20 of the vertical blanking interval of each field may be used for the transmission of

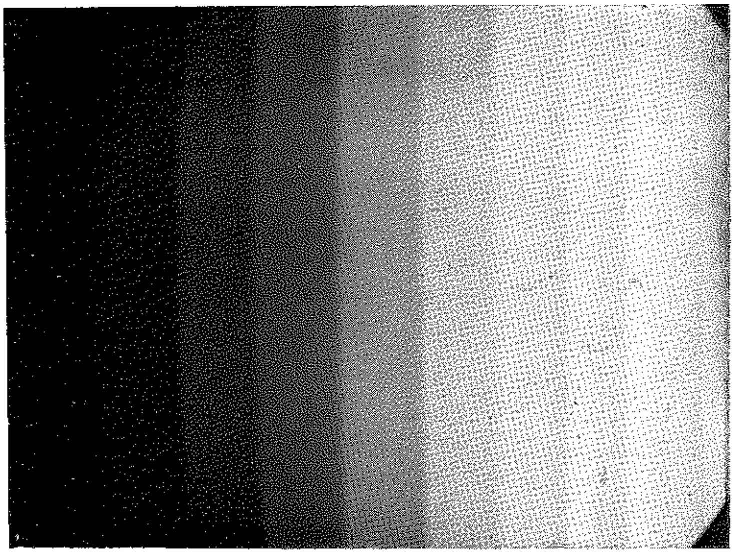

FIG. 27 — STAIRSTEP SIGNAL — PICTURE

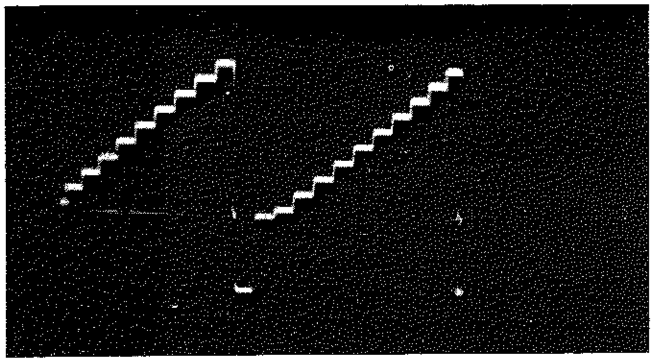

FIG 28 — STAIRSTEP SIGNAL — UNMODULATED — HORIZONTAL

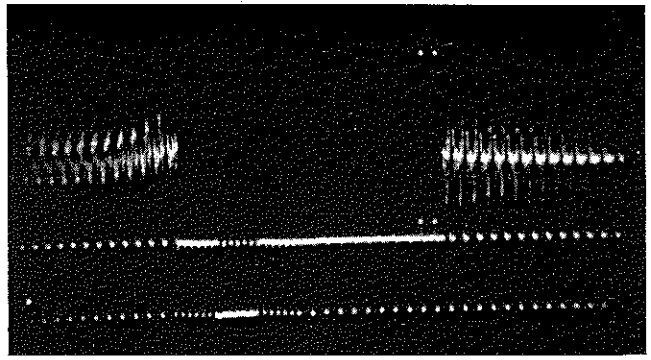

FIG. 31 — VERTICAL INTERVAL SIGNAL PLACEMENT

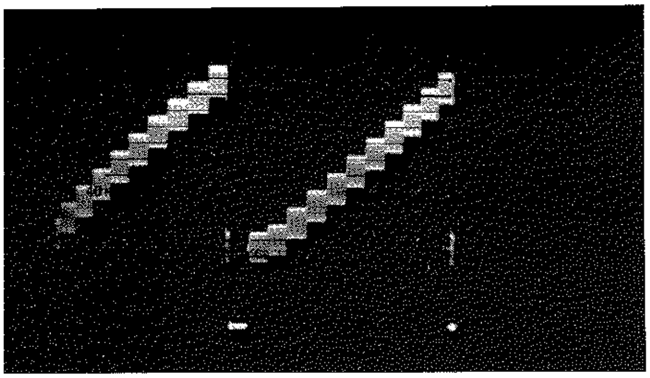

FIG. 29 — STAIRSTEP SIGNAL — MODULATED — HORIZONTAL

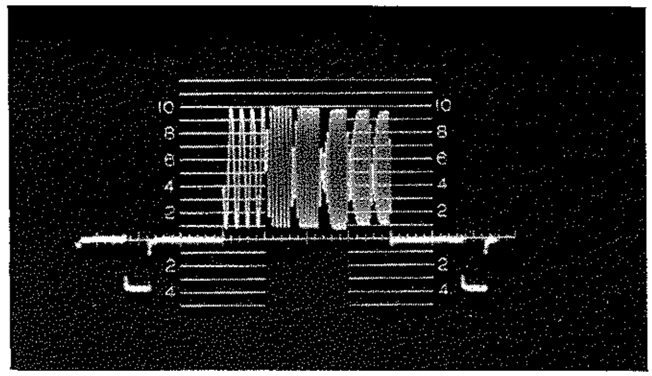

FIG. 32 — VERTICAL INTERVAL — MULTIBURST WITHOUT THE WHITE FLAG

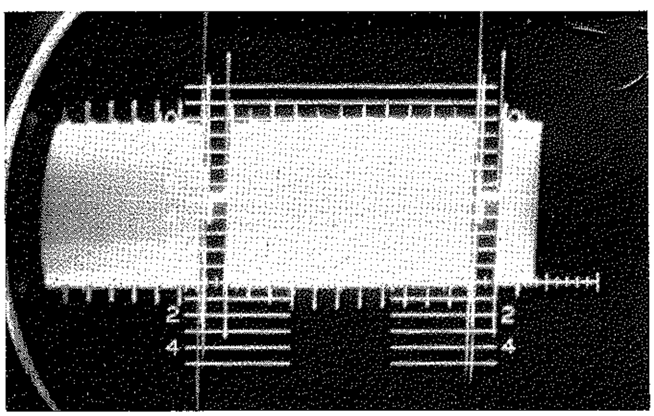

FIG. 30 — STAIRSTEP SIGNAL — MODULATED — HORIZONTAL — THROUGH HIGH-PASS FILTER

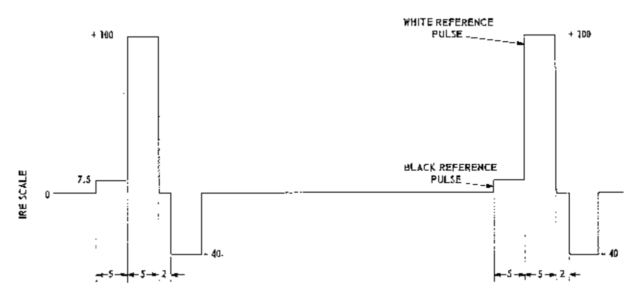

FIG. 33 — TYPICAL VERTICAL INTERVAL REFERENCE SIGNAL

test signals. Test signals may include signals used to supply reference modulation levels; signals designed to check the performance of the over-all transmission system or its individual components; and cue and control signals related to the operation of the television broadcast station. Fig. 31 shows the placement of these signals during the vertical interval.

At present, all the network broadcasters are using vertical interval test signals, each with some variations. The standard test signals, multiburst, window, and stairstep are being used in either their normal form or with slight alterations. These changes include transmitting

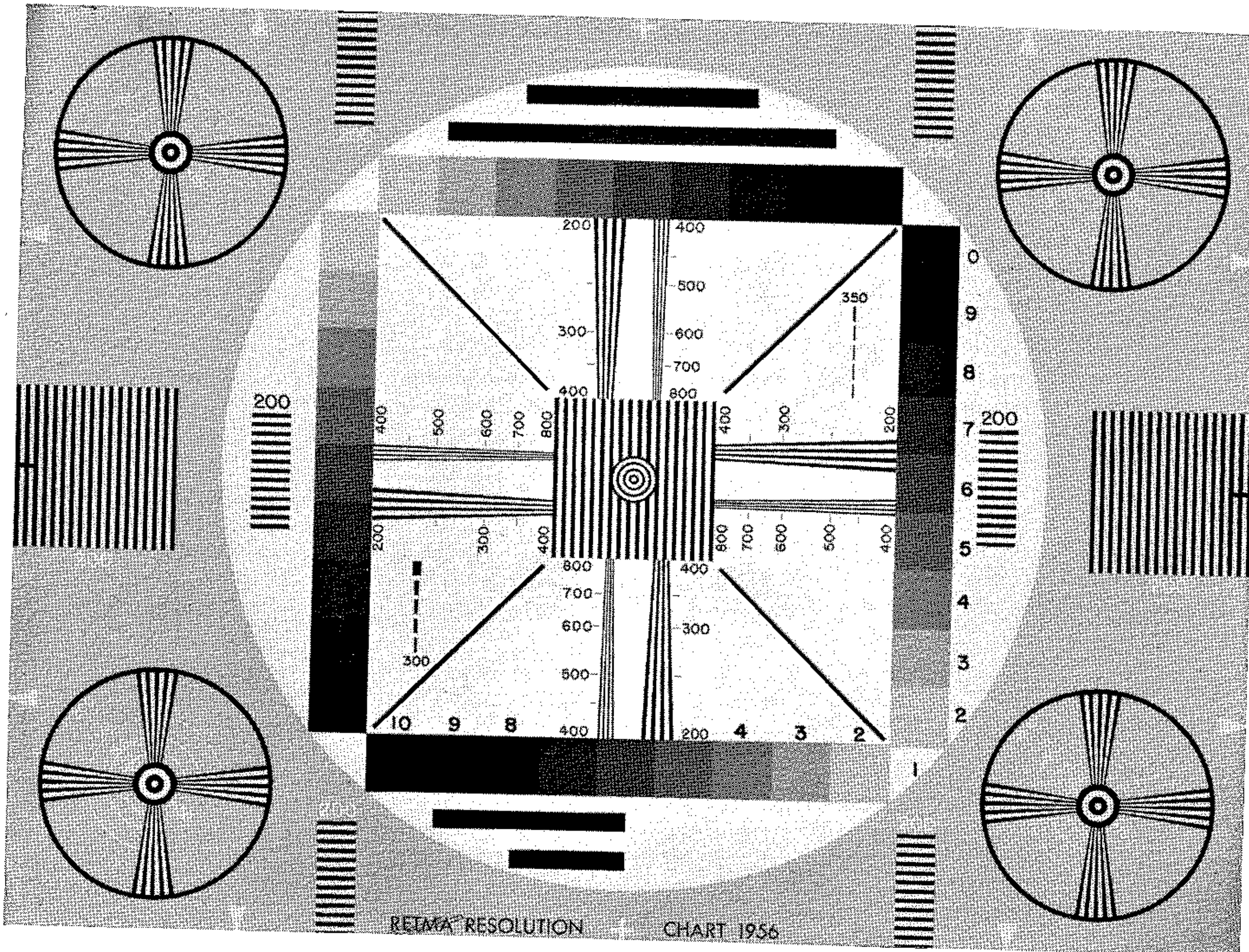

FIG. 34 — EIA TEST PATTERN — PICTURE

the window signal at half level, deleting the white flag of the multiburst, as in Fig. 32, and transmitting the stairstep signal without the 3.6 mc modulation. Normally when the vertical interval test signals are being used, they are transmitted on a rotation basis. For example, the multiburst, window, and stairstep might each be transmitted for about five minutes before the next one is automatically keyed into the proper place in the vertical interval.

Some of the broadcasting networks use vertical interval reference signals. Fig. 33 is one of those currently being used. In some instances the test signals are combined with the reference signals.

8. Test Pattern--EIA

Standard test patterns are valuable in determining the performance of video systems because the distant viewer knows what the original picture looks like, and can therefore readily detect distortions. The test pattern illustrated in Figure 34, is a reproduction of a test chart developed by the Electronic Industries Association. It is used mainly as source material for local test of broadcasters' equipment, such as cameras, etc.

The following is a description of the use of the pattern in checking the quality of the picture and interpreting the results. In all cases it is assumed that the picture monitor has been properly adjusted.

Horizontal Linearity — This may be determined by checking the large circle, the four corner circles, and the three squares of "200 line" vertical bars, one on each side of the picture and one in the center. The circles should show no distortion and the horizontal length of all squares should be equal.

Vertical Linearity — The circles plus the six sets of short "200 line" horizontal bars may be used to check linearity of the vertical sweep. The circles should show no distortion and the over-all height of the sets of bars should be equal.

Contrast — The four bars at the ends of the central wedges are the gray scales. Each is composed of 10 steps varying from maximum white brightness to approximately 1/30th of this value. If the received signal has the proper distribution of grays, it will be possible to distinguish all squares in the scales. Loss of distinction between the individual squares is an indication that the gain of the over-all system is not constant over the full range of the input voltages.

Aspect Ratio — The four gray scale bars should form a perfect square.

Interlace — The quality of interlace may be checked by noting the condition of the four diagonal lines in the center. A serrated or jagged line indicates pairing of the interlace lines.

Streaking — Streaking following any one of the two horizontal black bars, at top and bottom of the large circle, indicates low-frequency phase and/or amplitude distortion. The bars represent half cycles of square wave signals ranging from about 30 kc for the longest to 100 kc for the shortest. They help to locate the frequency range where the phase distortion takes place. For instance, if it is near 100 kc, the short bar will have more intense streaks than the others.

Ringing — The vertical wedges and the short vertical lines or ringing bars, between 100 and 300 in the lower left quadrant of the circle, along with those between 350 and 550 in the upper right quadrant, are used to check ringing. The frequency of the ring will be indicated on the vertical wedges by the vertical position at which the strongest ring is indicated to the right or left of the wedge. Similarly, the short vertical line that gives the strongest ring will also indicate the ringing frequency.

Resolution — Resolution is measured in terms of "lines."

Vertical resolution, the resolution from top to bottom of the picture, is expressed as the number of horizontal lines that can be resolved. Therefore, the horizontal wedges in the test pattern are used to measure vertical resolution. Vertical resolution depends primarily on the size and shape of the picture tube scanning beam spot, rather than the high-frequency response or bandwidth of the receiver or transmission path. For this reason, vertical resolution measurements are omitted from network operating tests.

Horizontal resolution is based upon the number of distinct black and white dots (vertical lines) that can be reproduced by the picture monitor in three-quarters of the usable (visible) length of a horizontal scanning line. This length of three-quarter width is selected because it equals the height of the picture, and therefore gives a basis for direct comparison between horizontal and vertical resolutions. The vertical wedges are used to determine horizontal resolution.

Vertical or horizontal resolution can be measured in terms of lines by determining the point on the horizontal or vertical wedges respectively up to which it is possible to distinguish distinct lines.

The wedges in the center and the four corners are calibrated in lines. The central wedges vary from 200 to 800 lines, while those in the corners vary between 200 and 600 lines. The vertical and horizontal linearity bars are all spaced for 200 line resolution. The concentric circles in the centers of the corner circles are at 150 line spacing. Those at the center of the large circle are at 300 line spacing.

9. Broadcaster's Test Pattern

Various types of test patterns are employed by broadcasters for alignment of their circuits and monitors, and for use by service men in the adjustment of home receivers. The test pattern illustrated in Fig. 1 is a typical pattern and employs many of the features included in the standard EIA pattern.

The following is a description of the use of this test pattern:

Linearity — The circles, and the horizontal and vertical wedges, can be used to check both the horizontal and vertical linearity. The circles should be round and the wedges of equal length.

Contrast — The five circles extending from black to white offer a check of the grays in the received signal. If the signal has the proper distribution of grays, all circles will be seen in varying shades of gray from black to white.

Streaking and Smearing — Streaking following any of the letters in the center of the test pattern indicates low-frequency distortion. Echo, smear, following whites, etc., can also be noted at these points. Streaking can also be seen at the right outside edge of the horizontal wedge.

Resolution — Resolution can be determined by noting the point to which the lines can be distinguished on the vertical and horizontal wedges. The resolution of the vertical wedges on the test pattern illustrated extend from 150 to 325 lines, and on the horizontal wedges from 150 to 350 lines. This value will differ among the various broadcasters' patterns, depending upon the width of the wedge lines.

Ringing — Ringing can be noted on the sides of the vertical wedges. Ringing frequency will be indicated by the vertical position at which the strongest ring is observed.

10. Color Bars

The broadcasters use various color bar signals for the adjustment of their equipment including color monitors.

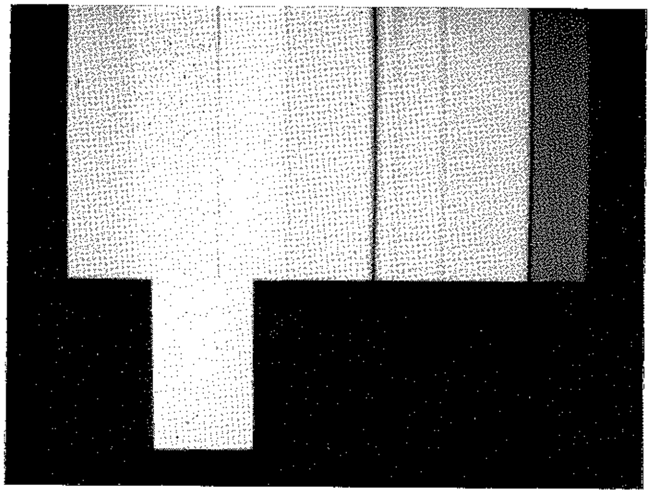

FIG. 35—COLOR BAR SIGNAL—MONOCHROME PICTURE

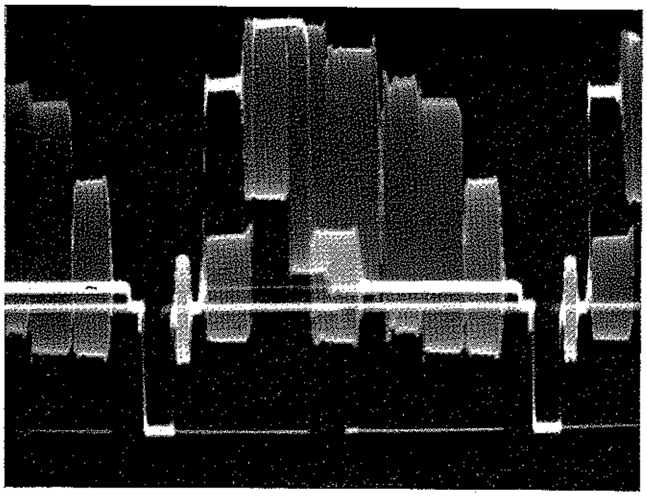

FIG. 36 — COLOR BAR SIGNAL — HORIZONTAL — WIDEBAND

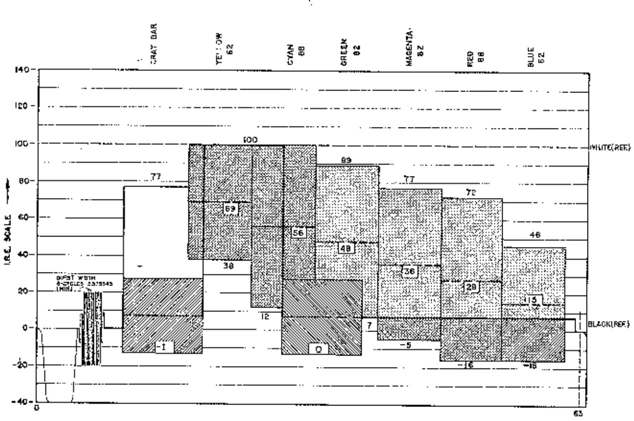

FIG. 37 — COLOR BAR SIGNAL — TYPICAL COLOR INFORMATION

They may also transmit this signal over transmission facilities for test purposes.

As shown in Fig. 35, on a monochrome picture monitor, the color bar signals will appear as corresponding

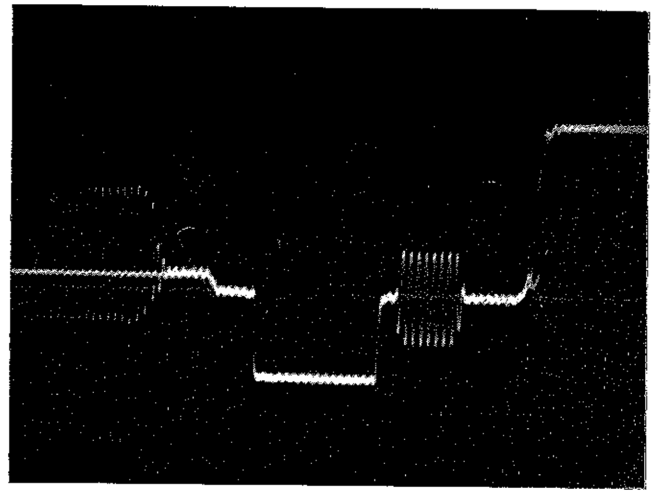

FIG. 38—COLOR BAR SIGNAL—EXPANDED HORIZONTAL

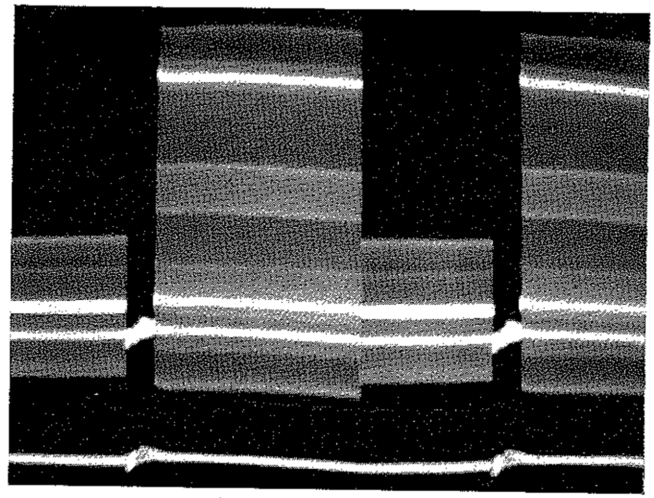

FIG. 39 — COLOR BAR SIGNAL — VERTICAL

bars in various densities of gray, the densities depending upon the individual values of luminance. The wideband A-scope horizontal presentation can indicate whether or not the white reference of the luminance signal and the color information have the proper amplitude relations. Fig. 36 illustrates a typical A-scope presentation, the colors for this particular pattern being identified in Fig. 37. For this color bar signal, if the color burst signal is of correct amplitude, and if the positive excursion of the cyan bar is at white level, with the negative excursion of the green bar at black level, it can be assumed that the over-all signal is in good condition from an amplitude standpoint. Figs. 38 and 39 show expanded horizontal and vertical presentations of this signal.

The broadcaster may observe the color bar signal on a vector display oscilloscope (variously known as a vectorimeter, vectorscope, chromascope, etc.) to measure absolute amplitudes and phase angles for equipment adjustments. Differential phase and gain measurements may also be made by this means.

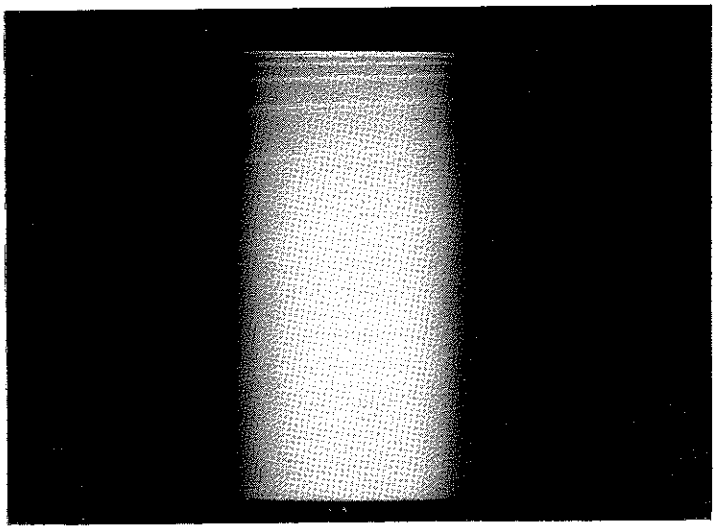

FIG. 40 — 47A TMS — TEST SIGNAL — PICTURE

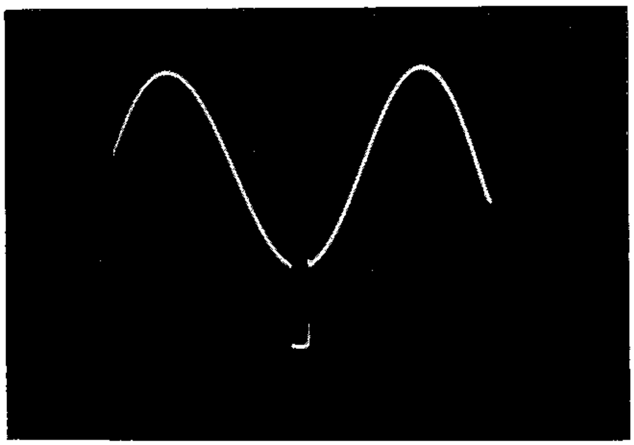

FIG. 41 — 47A TMS — TEST SIGNAL — UNMODULATED — HORIZONTAL

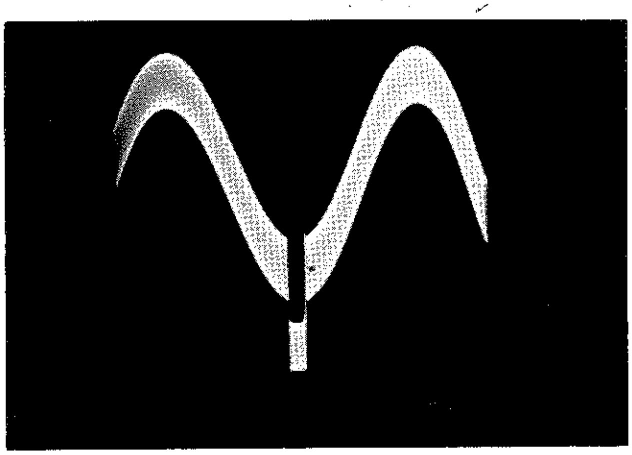

FIG. 42 — 47A TMS — TEST SIGNAL — MODULATED — HORIZONTAL

11. 47A Transmission Measuring System

The 47A Transmission Measuring System is used for the measurement of differential phase and gain of facilities used in color television transmission (change in phase or gain at 3.6 mc as the level is varied from black to white). The test signal consists of a 15.75 kc sine

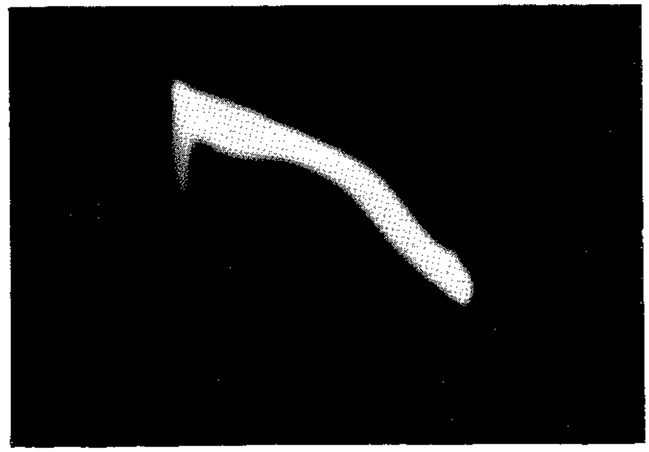

FIG. 43 — 47A TMS — RECEIVING UNIT PRESENTATION — MINUS DIFFERENTIAL GAIN

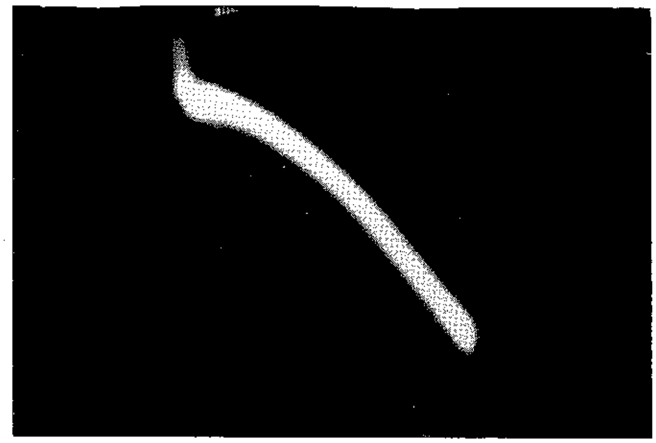

FIG. 44 — 47A TMS — RECEIVING UNIT PRESENTATION — MINUS DIFFERENTIAL PHASE

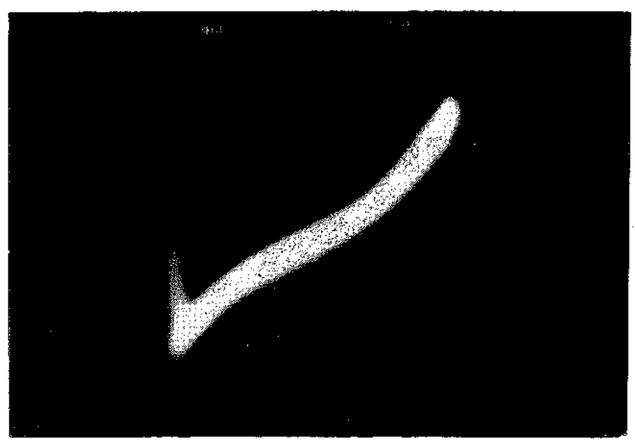

FIG. 45 — 47A TMS — RECEIVING UNIT PRESENTATION — PLUS DIFFERENTIAL PHASE

wave with positive peaks at reference white level and negative peaks at blanking level. Horizontal sync pulses are inserted on the negative peaks. On this sine wave, which corresponds to the luminance signal, there is superimposed a lower level 3.6 mc (3579.545 kc) sine wave signal corresponding to the chrominance signal. The 3.6 mc signal is thus periodically raised and lowered through the region between blanking and white levels. At the receiving locations, instantaneous differential phase or differential gain at 3.6 mc is displayed on a high gain oscilloscope with good low-frequency response. Differential phase is measured at the maximum departures, both plus and minus from the imaginary horizontal line beginning where the sync pulse disturbance meets the remainder of the trace. Measurements of differential gain are made between the maximum positive and negative deviations, disregarding the signs. To give an indication of the type of variation, the positive and negative deviations from the imaginary horizontal reference line may be given.

The 47A system consists of a transmitting unit (47B), and a receiving unit (47C). Test signals and presentations on receiving sets are illustrated by Figs. 40 through 45.

12. 9A Video Distortion Meter

The 9A Video Distortion Meter is used to measure amplitude and phase distortion at frequencies between 15kc and 300 kc, where most of the luminance energy of a TV signal is concentrated. This measurement indicates the amount of distortion in a circuit expressed in db below the signal level (1 volt peak-to-peak).

The 9A signal, illustrated by Fig. 46, consists of a one volt rectangular pulse generated at the horizontal rate. The pulse is such that all equipment, including working clampers, can be left in the circuit.

The amount of distortion is measured by generating and transmitting the rectangular pulse over a circuit, re-

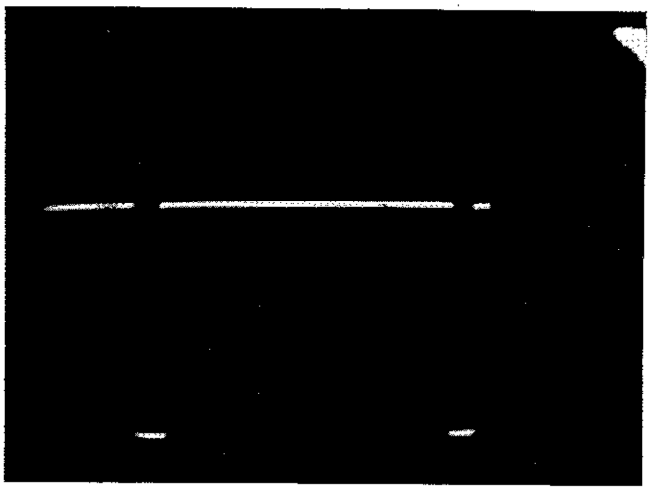

FIG. 46 — 9A DISTORTION METER — HORIZONTAL

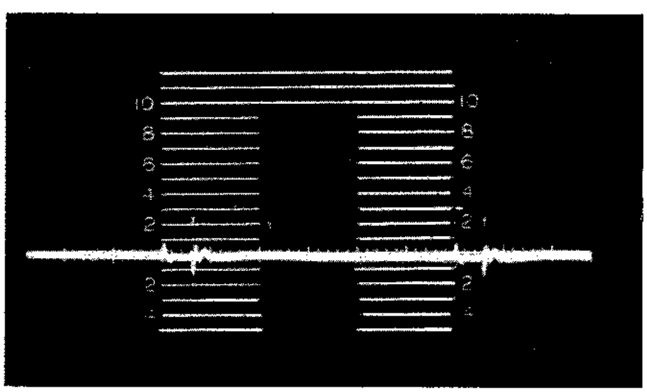

FIG. 47 — 9A DISTORTION READING — 48 DB WELL EQUALIZED CIRCUIT

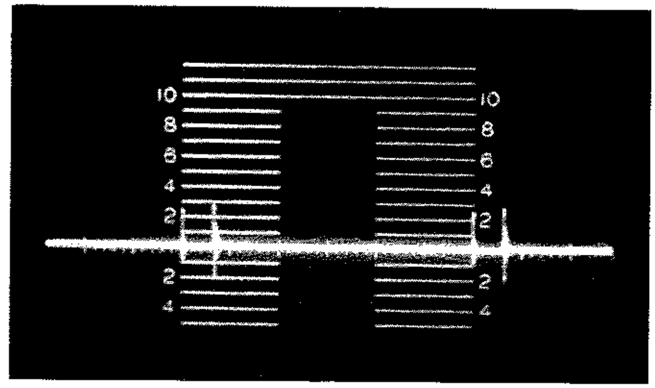

FIG. 48 — 9A DISTORTION READING — 59 DB SHARP CUTOFF AT 4.5 MC

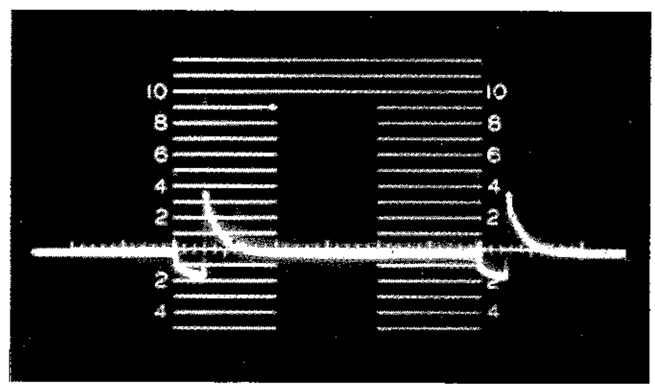

FIG. 49 — 9A DISTORTION READING — 37.5 DB .2 DB STEP LEVEL DROP AT 50 KC

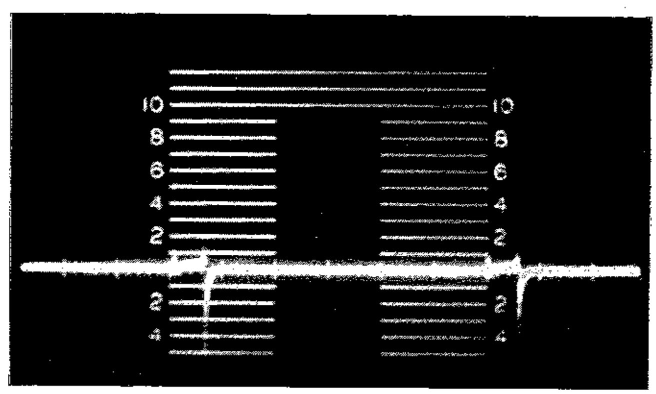

FIG. 50 — 9A DISTORTION READING — 46 DB .2 DB STEP LEVEL RISE AT 250 KC

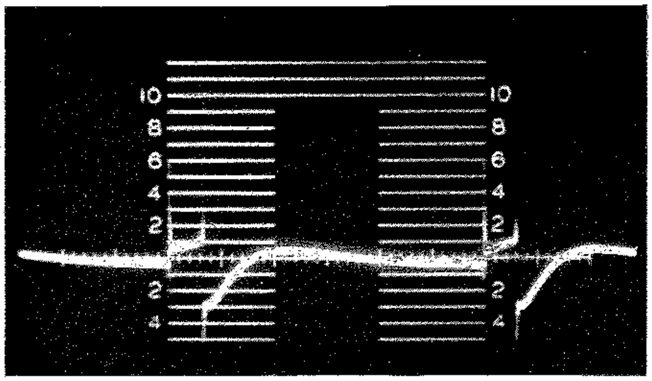

FIG. 51 — 9A DISTORTION READING — 34 DB
.2 DB BUMP LEVEL RISE AT 15 KC

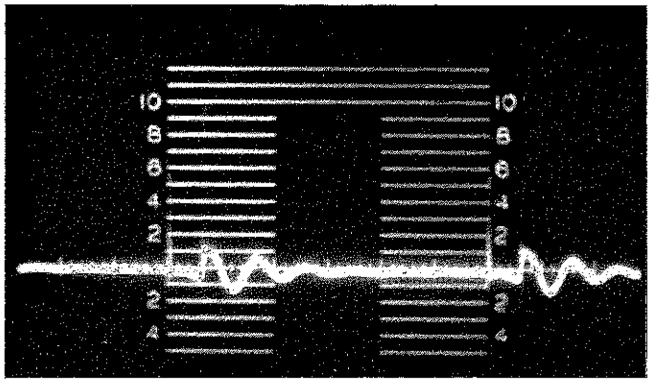

FIG. 52 — 9A DISTORTION READING — 42 DB
.2 DB BUMP LEVEL RISE AT 105 KC

moving the pulse from the received signal at the far end of the channel and measuring the remaining energy. If the transmitted pulse is received without impairment, the removal of the pulse leaves little or no energy.

A provision has been made for connecting an oscilloscope to observe the amplified received test signal after the pulse has been removed. The meter reading is a measure of the distortion at frequencies between 15 kc and 300 kc, but the oscilloscope display includes distortion effects outside this band of frequencies because the signal is applied before these frequencies are filtered out. Fig. 47 shows a well equalized circuit with a 9A reading of 48 db. Figs. 48 to 52 show what various circuit conditions would measure and how they would appear on an oscilloscope. A person with some experience in the observation of video signals may use the scope pattern to determine the probable cause of the distortion in terms of transmission irregularities.

13. 62 Video Visual Test Set

The 62 Video Visual Test Set measures the gain-frequency characteristics of a broadband transmission system and displays them as a trace on a cathode ray oscilloscope. The transmitter generates a sweeping oscillator signal which varies linearly with frequency from as

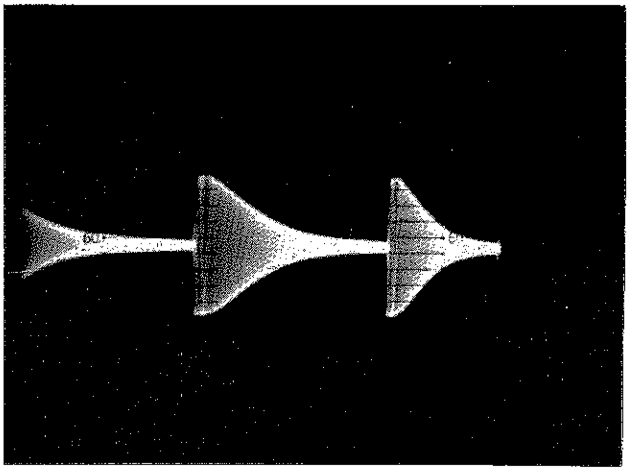

FIG. 53 — 62 VIDEO VISUAL SET — VERTICAL — IRE ROLL-OFF

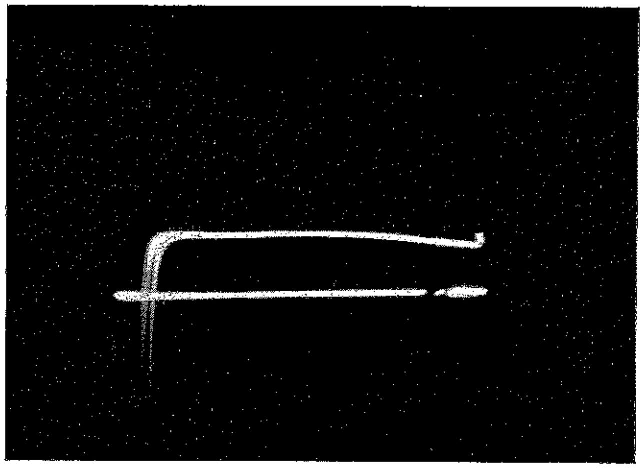

FIG. 54 — 62 VIDEO VISUAL SET — DETECTED — TRANSMITTER OUTPUT

low as 100 kc to as high as 10 mc at a rate of 74 times a second. The actual sweep width and the location of this sweep can be adjusted within these limits to suit the particular purpose. Since the test set transmitter sends a constant level signal, the gain-frequency response of the system being measured amplitude-modulates this signal. Fig. 53 illustrates the transmitted signal as seen on an A-scope having an IRE roll-off characteristic. A provision is made in the transmitter unit for adding simulated television horizontal synchronizing pulses to permit measurements on video equipment requiring sync for normal operation.

The test set receiver detects the envelope of the input wave and displays it on the CRO. In addition, a calibrated reference trace also appears on the CRO so that the characteristics of the system under test can be measured directly in db. The reference trace also includes a frequency marker in order to determine the amplitude of any given frequency. Figs. 54 and 55 illustrate the de-

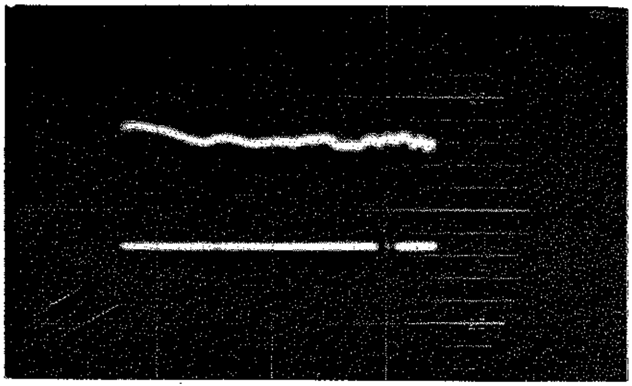

FIG. 55 — 62 VIDEO VISUAL SET —
DETECTED — ACTUAL CIRCUIT

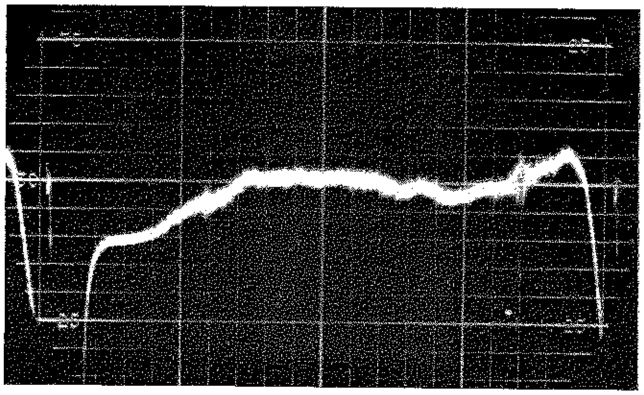

FIG. 56 — 62 VIDEO VISUAL SET —
SIMPLIFIED RECEIVER

tected appearance of this signal. In both cases, the frequency marker is on 3.6 mc.

Some receiving locations will use the simplified receiver, often called a detector, which serves the same purpose as the regular receiver. It does not, however, provide a reference trace or a frequency marker. Frequency can be determined by inserting a sine wave signal from an external signal generator and observing the marker caused by addition of the energy in the two signals. The simplified receiver includes a high-pass filter to eliminate the effects of the sync pulses. This filter limits the lower usable frequency to 500 kc. However, if no sync pulses are used with the test signal, this filter may be patched out, lowering the range to 200 kc. Fig. 56 illustrates the signal as detected by the simplified receiver. Note the roll-off below 500 kc and the "beat" from the external oscillator at 3.6 mc.

Signal Impairment Analysis

Television network facilities are designed to transmit picture signals in order that they will be received at the distant connection in a condition to give satisfactory reproduction of the signal furnished by the customer. The network transmission facility is only part of the transmission path from camera to receiver. The other elements contributing to the faithfulness of the reproduced scene are:

(a) Performance of cameras, video tape recorders, and other studio equipment (see Network Transmission Committee Engineering Report No. 2, Video Tape Signal Analysis, March 1959).

(b) Performance of local loop facilities not included as part of the network facilities; i.e., studio to transmitter link.

(c) Performance of the broadcaster's transmitting facilities.

(d) Radio path between broadcast transmitter and the receiver; i.e., distance, obstructions, interference and propagation effects.

(e) Ability of the receiving system to reproduce a picture from the signals received.

Since all of the above elements must work together, discrepancies occurring in any one of the individual elements will affect the received picture adversely. The broadcaster and the telephone company have no control over the last two links in the chain—the path from the transmitter to receiver, and the home receiver. However, network transmission from camera to the broadcaster's transmitter generally involves close co-operation. Because of the necessity of using different pickup points and cameras, or the necessity of rearranging the network facilities to meet customers' requirements, it is essential that each transmission element be engineered and maintained with this flexibility in mind.

The composition of a television signal, as discussed previously, determines the objectives for network facilities. Compared to telephone transmission, the bandwidth is of the order of 1000 times greater. Also, amplitude distortion, interference and delay distortion requirements are much more severe. Since color television signals are much more complex than monochrome signals, they are correspondingly more difficult to transmit.

Distortion of video signals during transmission may be the result of trouble or inherent limitations of the facilities within the transmission path. This distortion will usually be readily apparent in the oscilloscope signal presentation. The A-scope signal distortions and picture monitor impairments fall into several different categories. The following pages illustrate a number of these distortions as observed on picture monitors and A-scopes, together with an explanation of the causes. In many instances it has been necessary, for photographic reproduction reasons, to introduce impairments beyond the degree to which it would be expected to find them under actual conditions. This is particularly true of the picture monitor photographs where a given impairment generally has greater effect upon the eye under actual conditions than is evident in the photographs.

1. Level Irregularities

(A) General—An essential factor in good television operation is the maintenance of correct video levels both at broadcasters' and telephone company locations. The observed effect of incorrect levels as seen on picture monitors and A-scopes is dependent upon the magnitude of error, whether the level is constant or varying, and whether all or only part of the frequency range is affected. This section is concerned with level errors that affect the entire frequency range in a relatively uniform manner. Such level irregularities can be caused by improper amplifier gains or pad losses along the transmission path, defective electron tubes or other components, or by change in camera level from broadcasters' studios or pickup points.

(B) Long Duration Level Changes

(B-1) HIGH LEVELS—Excessive levels can result in serious defects such as blooming, bleeding whites, clipping and sync compression. These long duration effects are caused by overloading.

BLOOMING (Fig. 57) — is an increase in the size of the scanning spot with resultant loss of detail in white areas due to overloading the picture tube. When the A-scope presentation appears normal, the difficulty is probably due to a high gain setting of the monitor itself.

BLEEDING WHITES (Figs. 58-60)—As the level is increased to the extent that overloading occurs, the A-scope, in addition to indicating high level, will also show evidence of clipping, or compression, as indicated by the square tops of the wave forms in Figs. 59 and 60. The picture (Fig. 58), will have lost contrast, and may appear to have white areas "bleeding" into black, although the defocussing found under blooming may not exist.

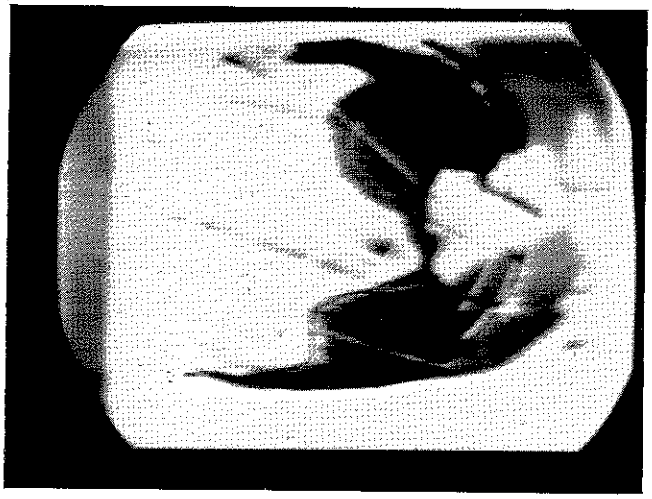

FIG. 57 — BLOOMING

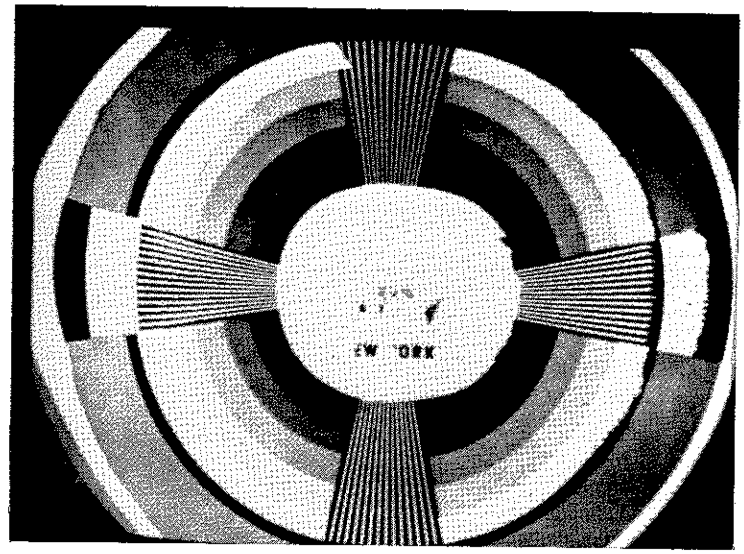

FIG. 58 — BLEEDING WHITES

BLACK OR SYNC COMPRESSION (Fig. 61)—High level conditions sufficient to cause overloading may also result in black peak or sync compression. Here the sync pulse amplitude is reduced and setup may be affected. If the sync signals are sufficiently compressed, difficulty with horizontal stability will be experienced. Fig. 61 illustrates sync compression as seen on the oscilloscope at horizontal rate. The sync level in this case reads approximately 30 on the IRE scale, or about 10 divisions lower than normal. The picture monitor, in this case however, showed no evidence of trouble.

(B-2) LOW LEVELS (Figs. 62, 63)—Lower than normal levels cause a decrease in average picture brightness and make the signal more susceptible to interference. When the television signal level is reduced by only a small amount, ill effects are not likely to be noticed. As the signal is transmitted through clamping or stabilizing circuits at still lower levels, clamping action may be partially or completely lost. Streaking, smearing and loss of synchronism may occur. Figs. 62 and 63 illustrate a signal transmitted through a clamper-amplifier at about one-half normal level. Partial failure of clamping can be seen on the A-scope, although the picture is not affected appreciably. The impairments observed, when clamper failure occurs, will depend upon the amount of low-frequency distortion present in the signal. The results of complete clamping failure are discussed later.

(C) Short Duration Level Changes—Intermittent level changes may have several causes. Fluctuating a-c line voltage and hunting regulators in power supplies or transmission facilities are some of the possible causes of this trouble. These usually give short changes in picture brightness, evident on A-scopes as momentary voltage changes. If of sufficient magnitude, frame rolls, momentary tearing, etc., may be observed.

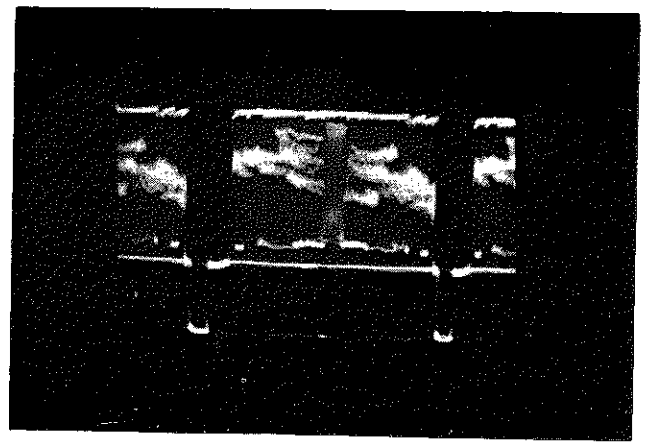

FIG. 59 — BLEEDING WHITES — HORIZONTAL

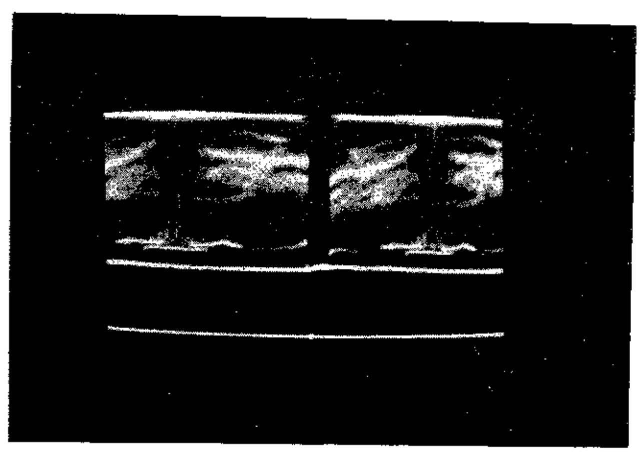

FIG. 60 — BLEEDING WHITES — VERTICAL

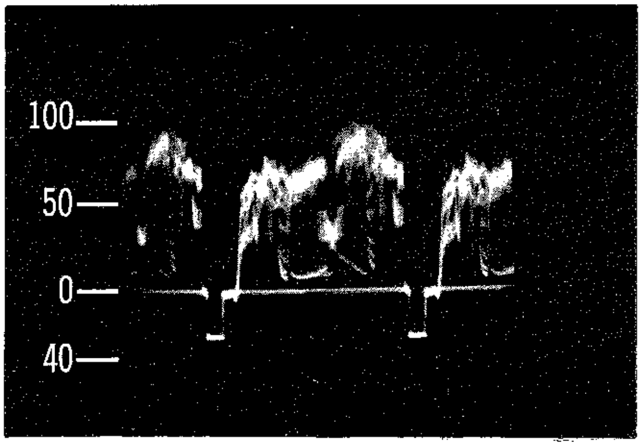

FIG. 61 — SYNC COMPRESSION — HORIZONTAL

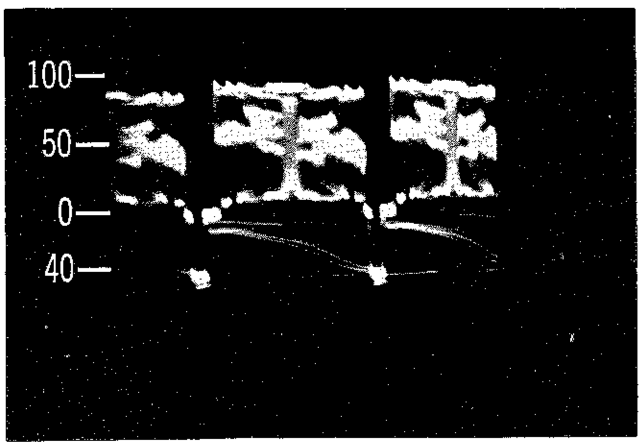

FIG. 62 — PARTIAL CLAMPING FAILURE — HORIZONTAL — (A-SCOPE PRESENTATION EXPANDED TO NORMAL HEIGHT)

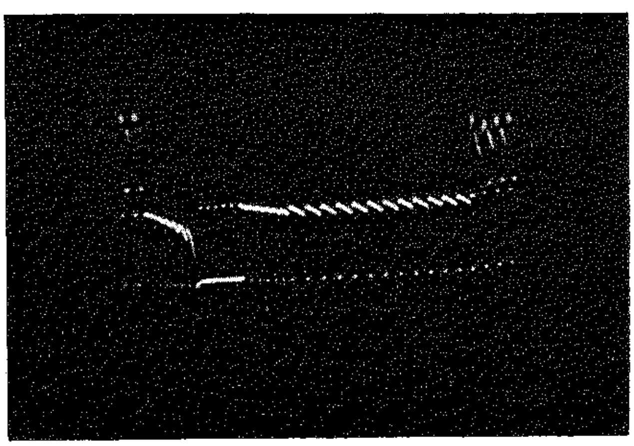

FIG. 63 — PARTIAL CLAMPING FAILURE — EXPANDED VERTICAL

BOUNCE AND BREATHING—In operating parlance **bounce** is the condition where there are sudden irregular changes in level, while **breathing** is the condition where the changes occur more slowly and at a regular rate.

2. Transmission-Frequency Irregularities

(A) **General**—Uniform amplitude response and linear phase shift throughout the pass band of a television network transmission system are two highly desirable characteristics. In addition, the gain characteristic should be such that it gradually rolls off beyond the pass band without affecting the phase characteristic. A large number of impairments to picture transmission are caused by inability to attain these conditions. In this section, the impairments resulting from distortion in different parts of the video band are grouped together; that is, those affecting field rate and harmonic frequencies, those affecting line rate and its first 10 or so harmonics, and those affecting frequencies above about 200 kc.

The set of figures from 64 to 70 shows some of the relationships between low- and high-frequency distortion. A telephone company window signal was used for these tests. Fig. 64 shows an essentially undistorted test signal for reference. In the remaining figures both attenuation and related phase distortion are present.

LOW-FREQUENCY GAIN CHANGES—Figs. 65 and 66 illustrate a relative 1.0 db increase and decrease, respectively, of frequencies below about 100 kc. With the low frequencies increased, Fig. 65 illustrates the case of positive streaking in which the length of time for the streak to disappear is determined by the shape of the curve at the transition from white to black. In the reverse case, Fig. 66, low frequencies are decreased causing long duration overshoots at transitions and negative streaking.

HIGH-FREQUENCY GAIN CHANGES—Figs. 67 and 68 show results when frequencies above 100 kc are affected. The networks used give a gradual modification of characteristics with frequency, so that at 3.0 mc the gain-frequency characteristic is changed by minus and plus 1.5 db, respectively. Fig. 67, with the high frequencies depressed, shows some loss of sharpness or rounding-off of transitions, much less and of shorter duration than Fig. 65. Fine picture detail would be impaired in this transmission. The small overshoot or spike evident in Fig. 68 is the result of raising 3.0 mc by only 1.5 db. This spiking is similar to that in Fig. 66 but of much shorter time duration. With even more distortion, and possibly at a somewhat lower frequency, this sort of thing will result in "edge effect"—a distinct outline following an object, of a tone opposite to that of the object itself.

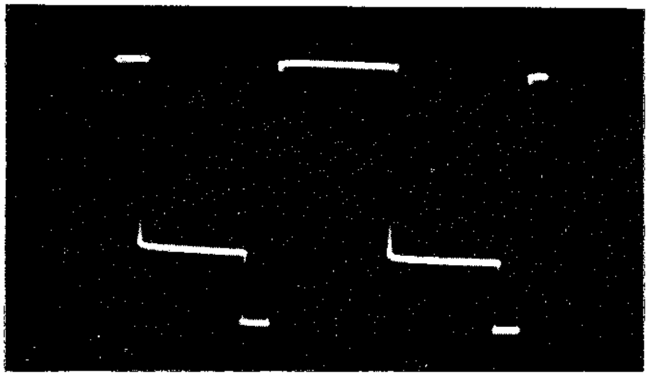

FIG. 64 — WINDOW SIGNAL NORMAL — HORIZONTAL

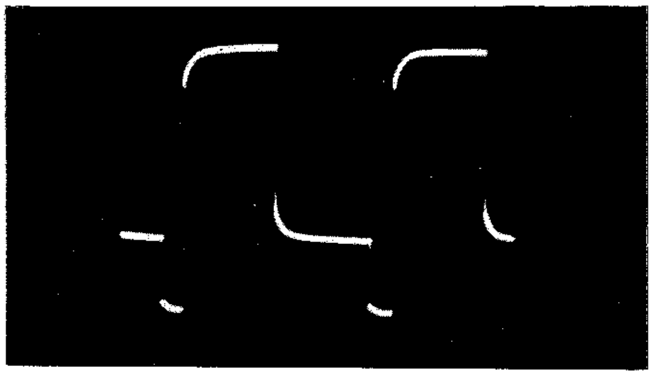

FIG. 65 — WINDOW SIGNAL — LOWS RAISED — HORIZONTAL

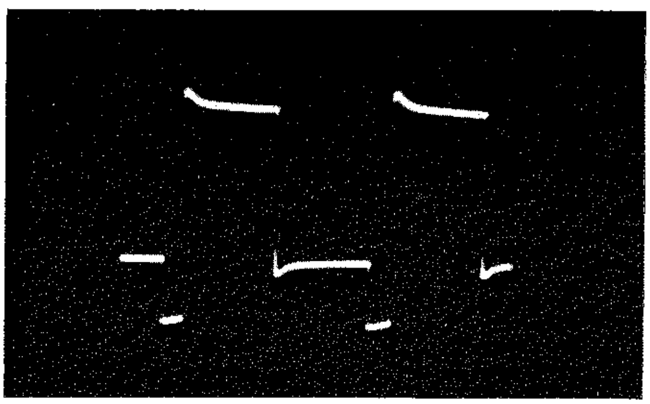

FIG. 66 — WINDOW SIGNAL — LOWS DEPRESSED — HORIZONTAL

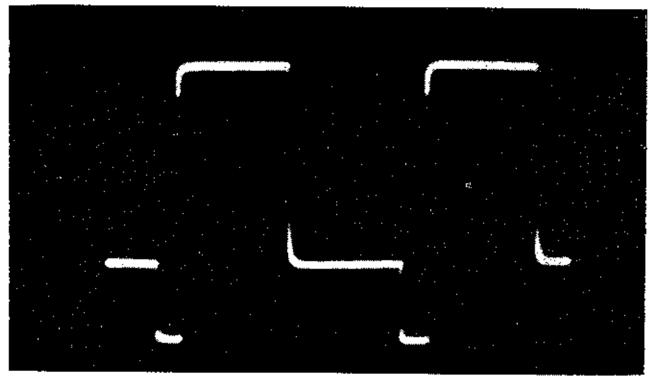

FIG. 67 — WINDOW SIGNAL — HIGHS DEPRESSED — HORIZONTAL

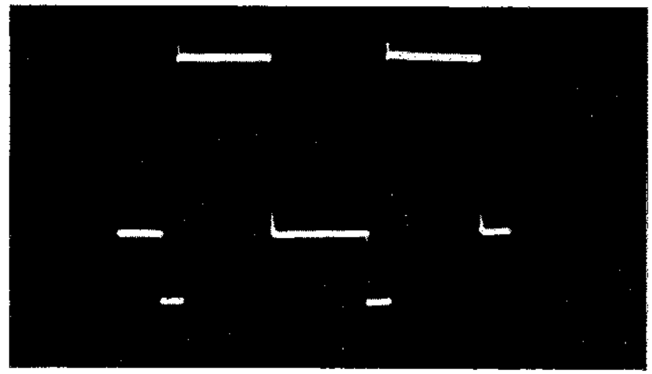

FIG. 68 — WINDOW SIGNAL — HIGHS RAISED — HORIZONTAL

BOTH LOW- AND HIGH-FREQUENCY GAIN CHANGES—Figs. 69 and 70 illustrate cases wherein the gain-frequency characteristic is not flat at either end of the spectrum. In each case there is a 3.0 db rise at approximately 3.0 mc. At the lower frequencies, Fig. 69 has a 1.0 db loss and Fig. 70 a 1.0 db gain. It can be seen that the individual characteristics previously illustrated are still recognizable, and that adjustments at one end of the band do not compensate, in general, for maladjustments at the other end. The short duration spike, for example, is evident regardless of the low frequency adjustment.

It should be noted that the sync pulse itself shows evidence of all these distortions. In some cases clamper action will tend to minimize these effects on the tips of sync pulses.

(B) Streaking and Smearing—Streaking is caused by transmission distortions in the frequency region up to about 200 kilocycles. Smearing generally is caused by distortions of somewhat higher frequencies. They affect almost equally color and monochrome transmission.

Distortions that cause streaking and smearing can occur in any part of the transmission system from the camera to the television receiver. Prevention of these defects requires very close control of transmission characteristics in the lower frequency portion of the video band.

The amplitude and phase characteristic tolerances

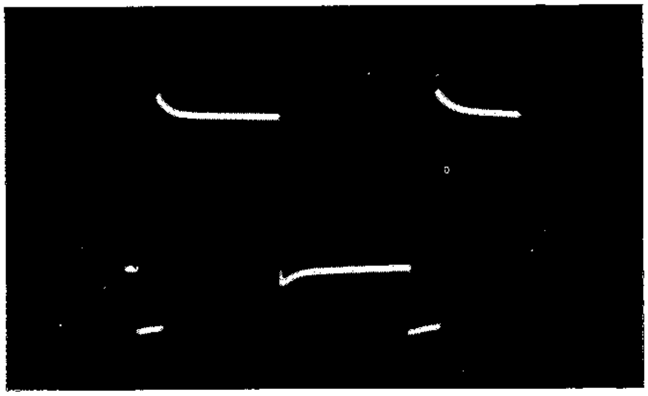

FIG. 69 — WINDOW SIGNAL —
LOWS DEPRESSED, HIGHS RAISED — HORIZONTAL

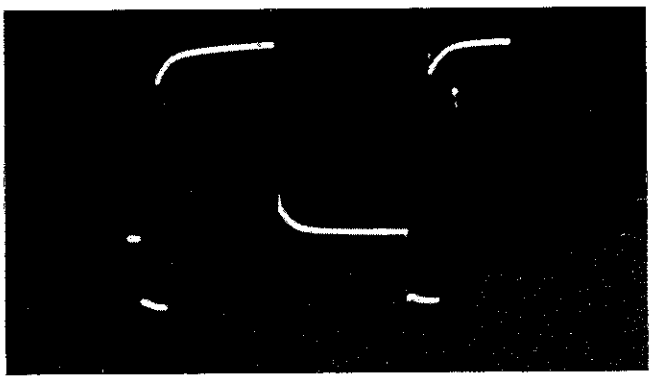

FIG. 70 — WINDOW SIGNAL —
LOWS RAISED, HIGHS RAISED — HORIZONTAL

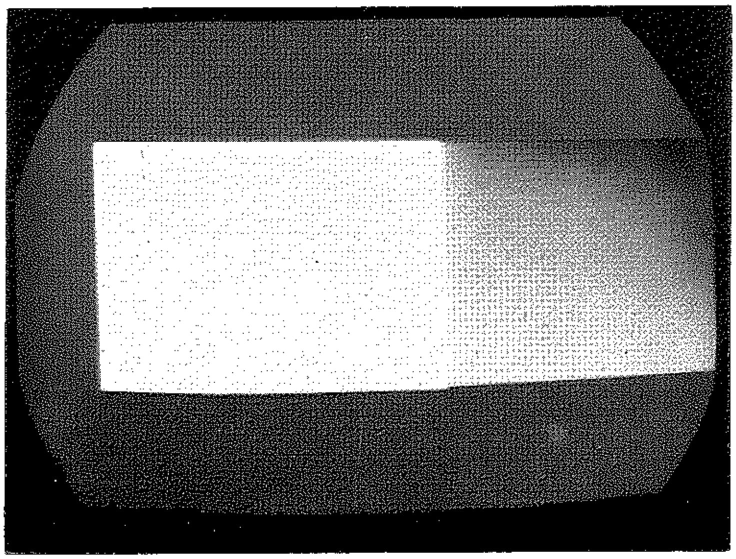

FIG. 71 — POSITIVE STREAKING — WINDOW SIGNAL

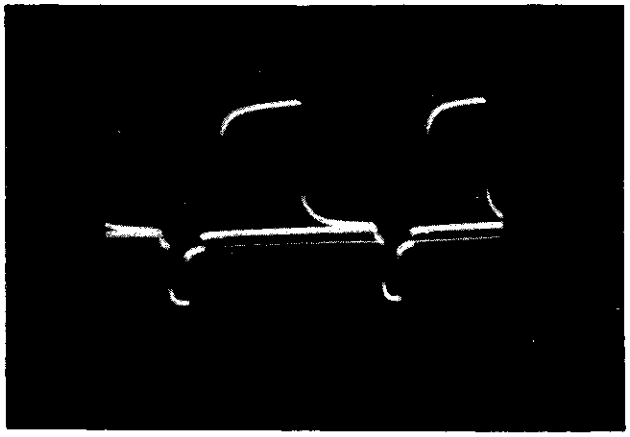

FIG. 72 — POSITIVE STREAKING —
WINDOW SIGNAL — HORIZONTAL

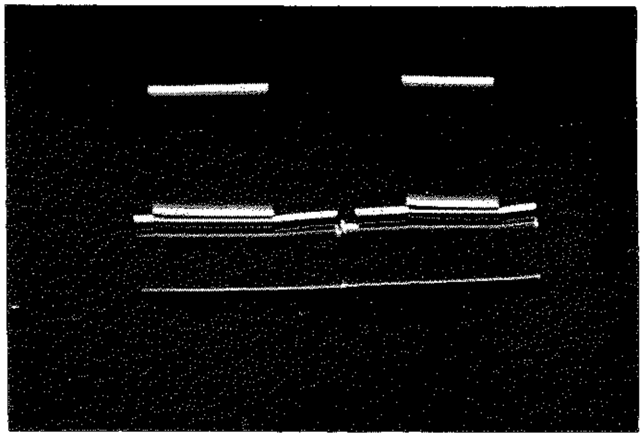

FIG. 73 — POSITIVE STREAKING —
WINDOW SIGNAL — VERTICAL

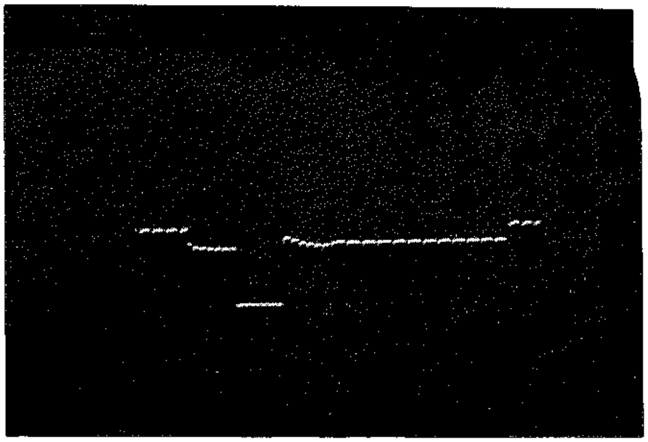

FIG. 74 — POSITIVE STREAKING —
WINDOW SIGNAL — EXPANDED VERTICAL

at the very low end of the frequency band, say below half line frequency, are probably not so critical. When a signal is clamped, the amplitude characteristic at 60 cycles can be allowed to vary considerably. Furthermore, it can be deliberately adjusted to depart from a uniform response at 60 cycles, or other points below half line frequency, in order to provide phase correction at line frequency and its harmonics.

At times it is expedient to make simultaneous in-service measurements of streaking and smearing using monitors and viewing picture information. Observation should be made at a time when the picture contains relatively prominent horizontal elements followed at the viewer's right by contrasting background. Block lettering used in titles is a good example. Suggested terminology to describe the degree of streaking, designed to encourage more uniform reporting of trouble are:

S0—streaking barely perceptible

S1—streaking up to approximately 1/10 of picture width

S2—streaking up to approximately 1/5 of picture width

S3—streaking in excess of 1/5 or more of picture width

The following paragraphs discuss streaking and smearing separately with emphasis on the use of test signals.

(B-1) STREAKING (Figs. 71-82) — Streaking is the appearance of an error luminance in the picture, extending horizontally towards the right edge of the picture from some point in the picture marked by a sharp transition in luminance. Streaking is most apparent in changes from high to low luminance or vice versa. Since this type of impairment is generally caused by transmission irregularities in the region of the 15,750-cycle line scanning rate, or its first few harmonics, the horizontal size of the object affects the amount of streaking. An object whose horizontal length is ½ that of a complete scanning line would generally be most vulnerable to streaking. Streaking is especially apparent when the objects move vertically in the scene and the streaking moves with them.

If the streaking is the same shade as the original figure (white following white, or black following black) it is called positive. If the streaking is the opposite shade, it is called negative. Figs. 71-82 illustrate picture monitor and A-scope presentations of positive and negative streaking.

In Fig. 72, the leading edge of the white window approaching white level is heavily rounded, while the trailing edge of the white window approaching black level rolls off gradually, indicating black following black, and white following white, or positive streaking. The vertical presentation, Fig. 73, reveals in the signal region below the white level, a heavy trace above black level,

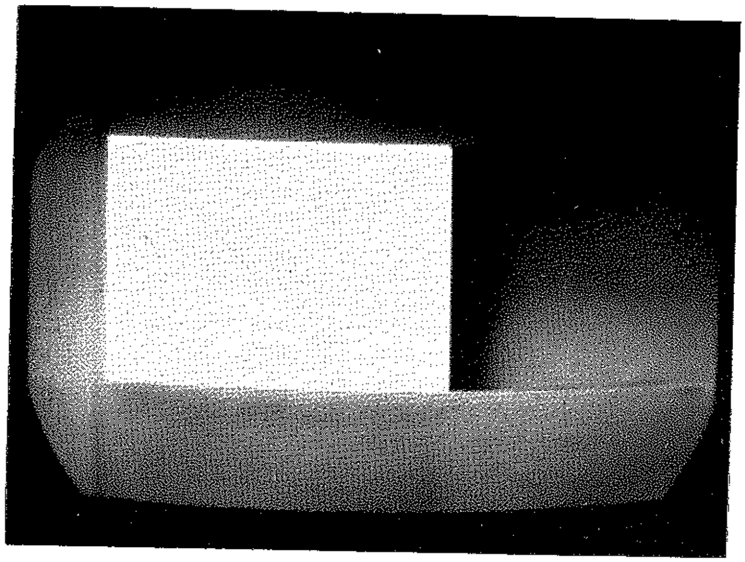

FIG. 75 — NEGATIVE STREAKING — WINDOW SIGNAL

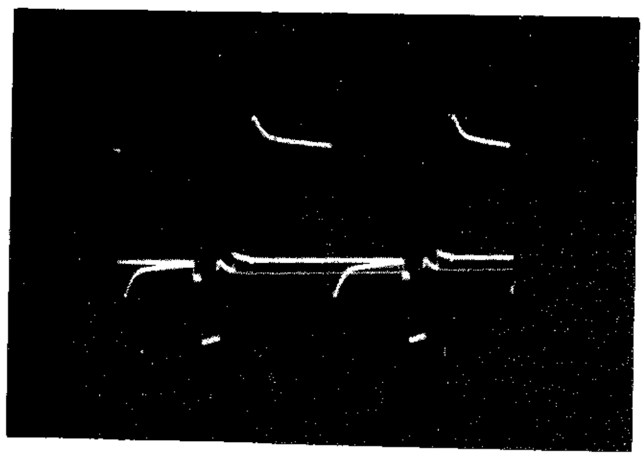

FIG. 76 — NEGATIVE STREAKING — WINDOW SIGNAL — HORIZONTAL

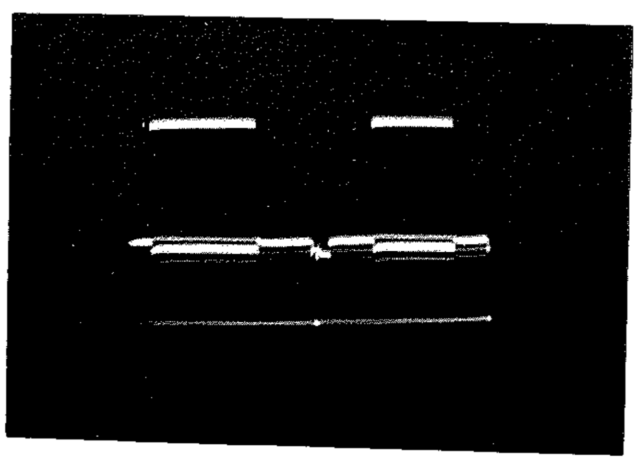

FIG. 77 — NEGATIVE STREAKING — WINDOW SIGNAL — VERTICAL

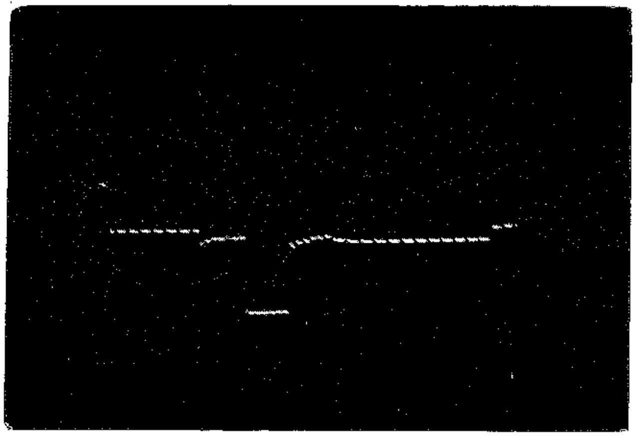

FIG. 78 — NEGATIVE STREAKING —
WINDOW SIGNAL — EXPANDED VERTICAL

the height of this trace being a measure of the streaking or white following white. In like manner, Fig. 76 is the horizontal presentation for negative streaking, or black following white, and white following black. Here the manifestations are just the opposite from Fig. 72; that is, there is a high peak, or white level, on the transition from black to white, while the trailing edge of the white window dips below blanking and gradually restores to reference black level. The vertical presentation, Fig. 77, shows a heavy trace, or following black, in the window signal region, which is the opposite of Fig. 73. The picture monitor presentations (Figs. 71, 75, 79) show this streaking; however, in practice, a comparison of A-scope presentations using suitable signals is preferred because of the possibility of streaking caused by the picture monitors.

In addition to the foregoing, comparison of the A-scope presentations for positive and negative streaking reveals opposite tilts of front and back porches and tip of sync for the horizontal presentations (Figs. 72, 76, 80); and of the trace between the first and second

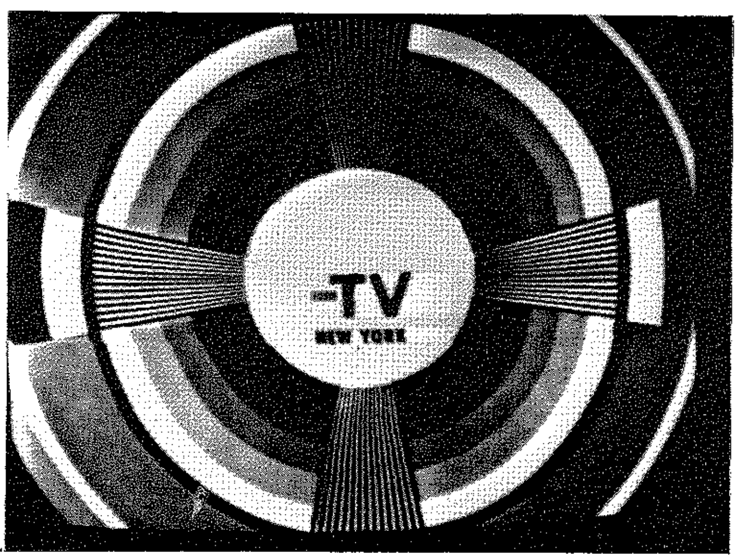

FIG. 79 — NEGATIVE STREAKING — TEST PATTERN

FIG. 80 — NEGATIVE STREAKING —
TEST PATTERN — HORIZONTAL

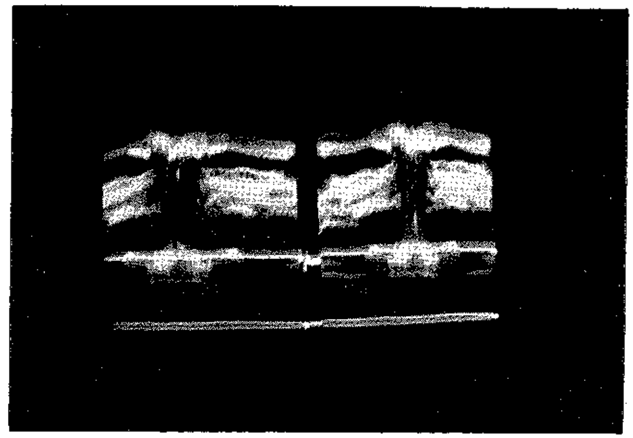

FIG. 81 — NEGATIVE STREAKING —
TEST PATTERN — VERTICAL

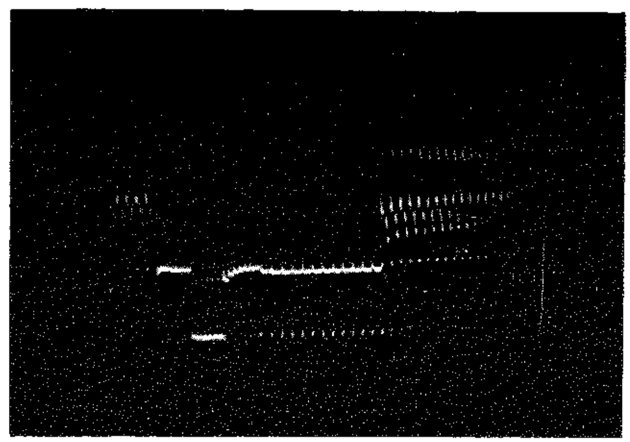

FIG. 82 — NEGATIVE STREAKING —
TEST PATTERN — EXPANDED VERTICAL

sets of equalizing pulses for the vertical presentations (Figs. 74, 78 and 82).

Streaking is indicated by tilt of the window signal. This is measured as the difference in height (because of curvature or tilt) along the top of the window pulse, expressed as a percentage of the window height above setup. A tilt of only a few percent will indicate objectionable streaking.

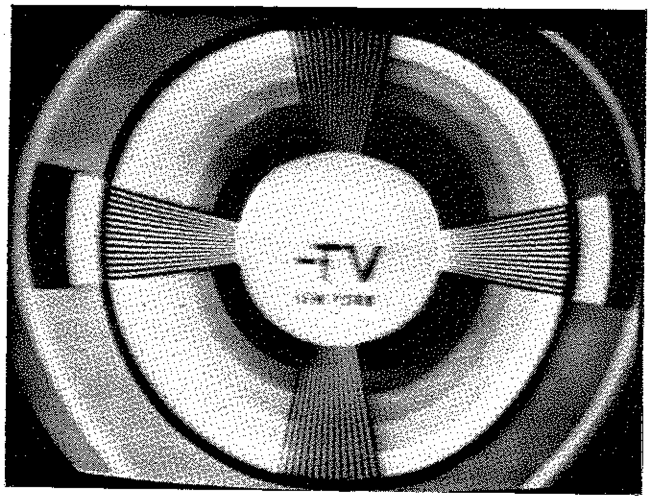

FIG. 83 — SMEARING — TEST PATTERN

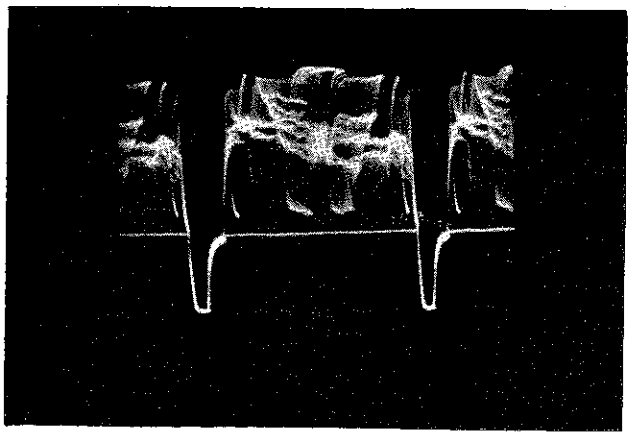

FIG. 84 — SMEARING — TEST PATTERN — HORIZONTAL

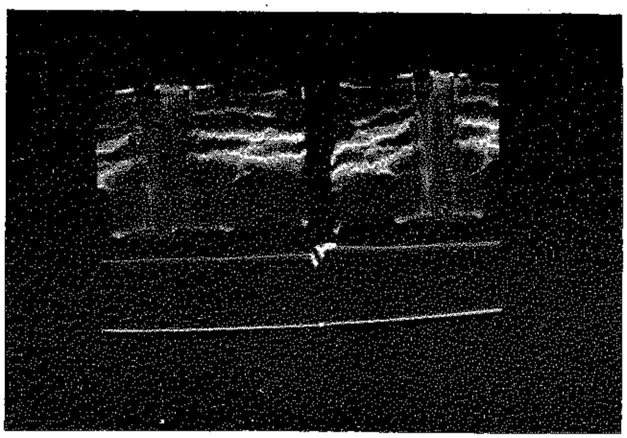

FIG. 85 — SMEARING — TEST PATTERN — VERTICAL

(B-2) SMEARING (Figs. 83-86)—Smearing is a distortion similar to streaking. Vertical edges of objects in the televised scene become indistinct and the whole picture looks blurred along the horizontal axis. The smearing error luminance may also be of the same or opposite sign as the luminance it follows.

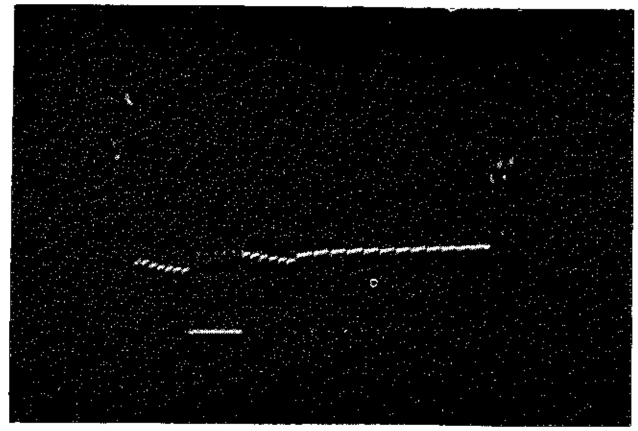

FIG. 86 — SMEARING — TEST PATTERN — EXPANDED VERTICAL

(C) Change of Setup (Figs. 87-92)—The setup of the picture is the difference between the blanking and reference black levels as viewed on the A-scope using IRE roll-off. For normal operation this is 7.5 divisions on the IRE scale. Setup variation on network facilities is mainly caused by distortion in the lower portion of the frequency band. Excessive transmission-frequency loss in this region causes too little setup, and excessive transmission-frequency gain in this region causes too much setup.

(C-1) LOSS OF SETUP (Figs. 87-89)—Low setup results in pictures having more contrast than normal. The whites in the scene will be unchanged but some of the normal grays may become almost black. Some streaking may also occur due to the deviations in the gain and phase characteristics at low frequencies. When loss of setup occurs to the degree where the picture signal punches through the blanking level, the normal clipping action of the customer's processing or stabilizing amplifier may cause loss of this picture information. In severe cases, erratic operation of the customer's equipment may occur, and the picture will be unusable.

(C-2) INCREASE IN SETUP (Figs. 90-92) — High setup results in reduced contrast range and reduced signal-to-noise ratio.

(D) Ringing (Figs. 93, 94)—Ringing generally results from the transmission of sudden tonal transitions over a system that has a finite pass band with a sharp cutoff at the upper end of the frequency range. It may also result from a marked transmission discontinuity at some frequency below cutoff. When a signal containing a sudden transition is applied to such a circuit, damped oscillations or ringing will occur at approximately the frequency of cutoff or other discontinuity, the duration of the ringing depending upon the sharpness of the discontinuity. Ringing will be accentuated by a rising gain characteristic preceding the discontinuity.

The EIA test pattern shown in Fig. 34 is a sensitive

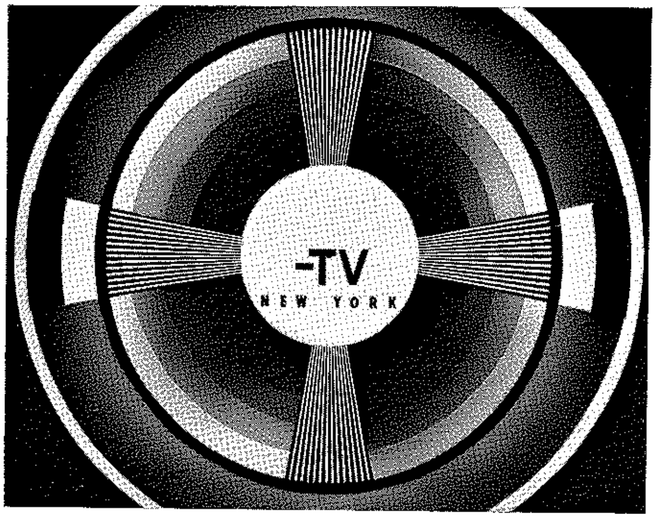

FIG. 87 — LOW SETUP — TEST PATTERN

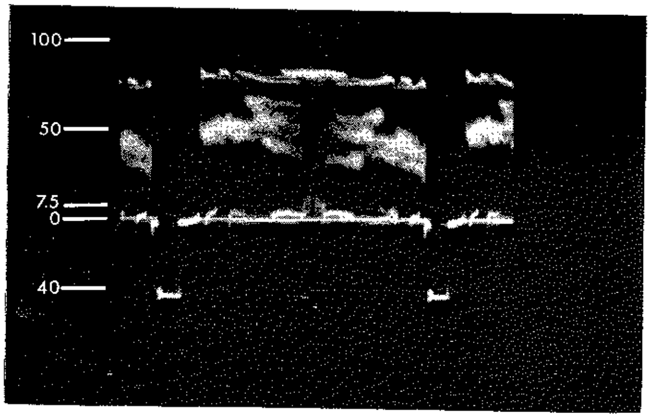

FIG. 88 — LOW SETUP — TEST PATTERN — HORIZONTAL

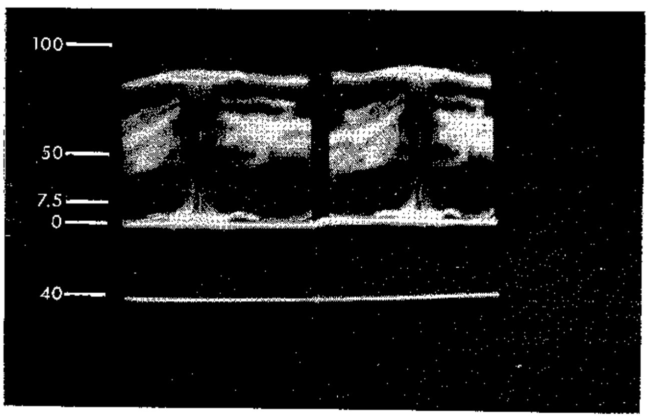

FIG. 89 — LOW SETUP — TEST PATTERN — VERTICAL

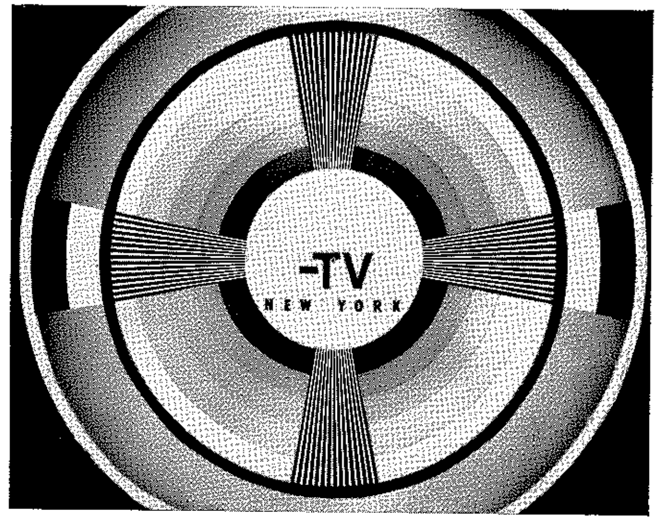

FIG. 90 — HIGH SETUP — TEST PATTERN

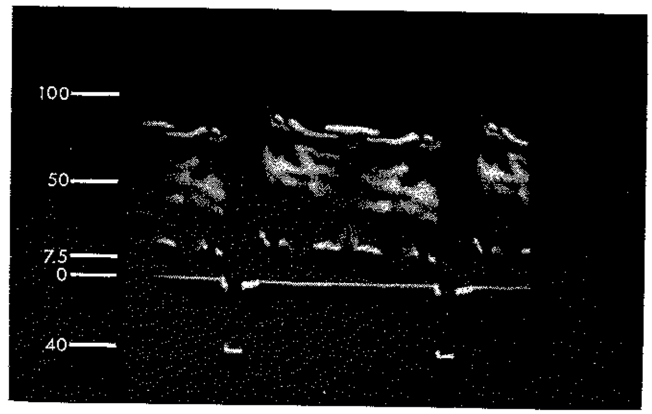

FIG. 91 — HIGH SETUP — TEST PATTERN — HORIZONTAL

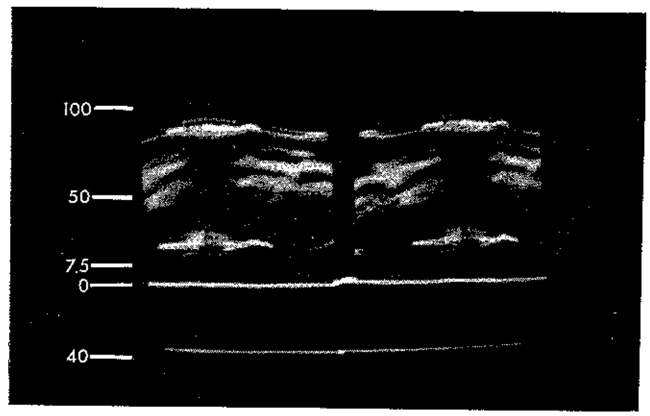

FIG. 92 — HIGH SETUP — TEST PATTERN — VERTICAL

indicator of ringing. The phenomenon will be apparent as additional lines on either or both sides of the vertical wedges. These lines will be strongest at the position along the vertical wedge corresponding to the frequency of cutoff or other discontinuity of the circuit elements causing the ring.

Ringing may also be detected by using the A-scope horizontal presentation to note the presence of damped oscillations following sharp transitions in the signal. It is recommended that observations be made of the transitions during the blanking interval, such as sync pulse to back porch. A sine-squared pulse or window with sine-squared characteristics is best suited for noting this type of distortion. There are several reasons for this: (1) the pulse represents one complete cycle of the upper cutoff frequency; (2) it has approximately the same shape as the output pulse of a camera scanning a minimum resolvable element; and (3) it has substantial energy in the vicinity of the cutoff frequency, making the pulse sensitive to cutoff characteristics.

The ringing frequency can be determined by counting the number of complete oscillations appearing in a known time interval and converting to frequency by using the following formula:

Ringing frequency = Number of oscillations × 10^6 ÷ Time interval in microseconds.

$$f = n \times \frac{10^6}{t\ (\mu s)}$$

(E) Overshoots (Figs. 95, 96) — In a television signal, an overshoot is an excessive response to a sudden change in signal. A sharp overshoot is commonly referred to as a spike. An overshoot is generally caused by excess gain at high frequencies.

(E-1) FOLLOWING WHITES OR BLACKS (Fig. 95)—Overshoots within the picture area result in impairments to the picture called following white or black (edge effect). These appear as a black outline to the right of white objects and a white outline to the right of black objects. In Fig. 95, this is most evident as a white edge following the man's head. A black edge follows the white of the handkerchief.

(E-2) OVERSHOOT ON BACK PORCH—An overshoot of the trailing edge of the sync pulse is called a "positive spike on the back porch." If this extends above black level, it may be visible in the picture as a gray vertical bar due to illuminating portions of the horizontal return traces. Fig. 96 illustrates a slight overshoot on the back porch.

(E-3) OVERSHOOT ON FRONT PORCH—An overshoot of the transition from picture to blanking is called

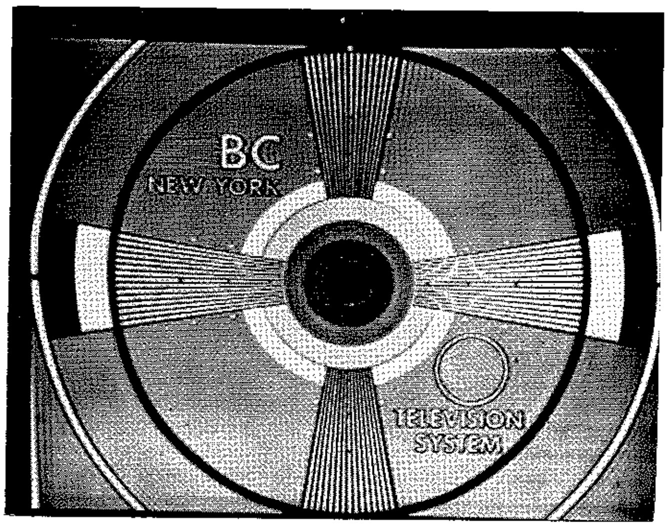

FIG. 93 — RINGING — TEST PATTERN

FIG. 95 — EDGE EFFECT

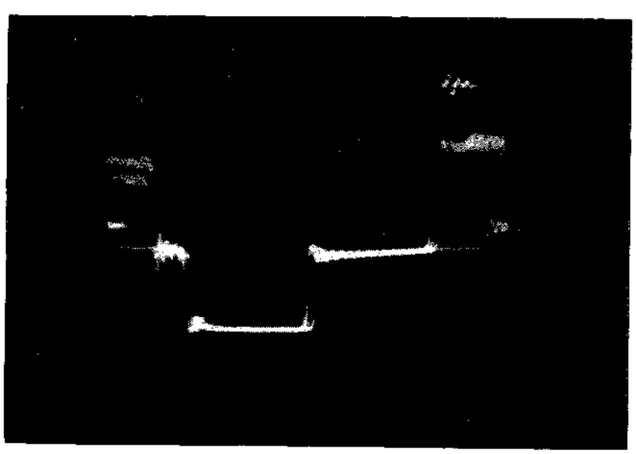

FIG. 94 — RINGING — TEST PATTERN EXPANDED HORIZONTAL

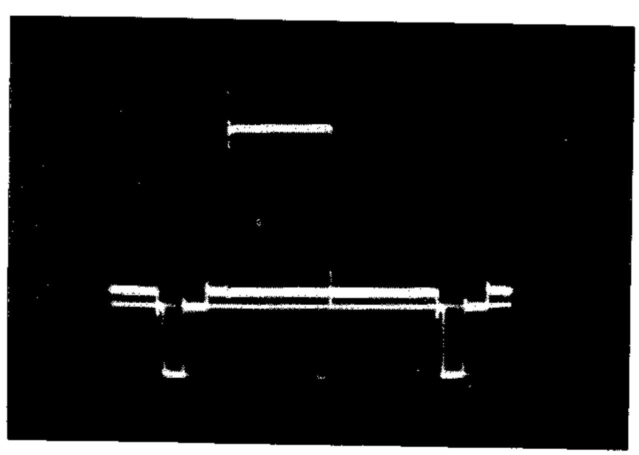

FIG. 96 — OVERSHOOTS — WINDOW SIGNAL — HORIZONTAL

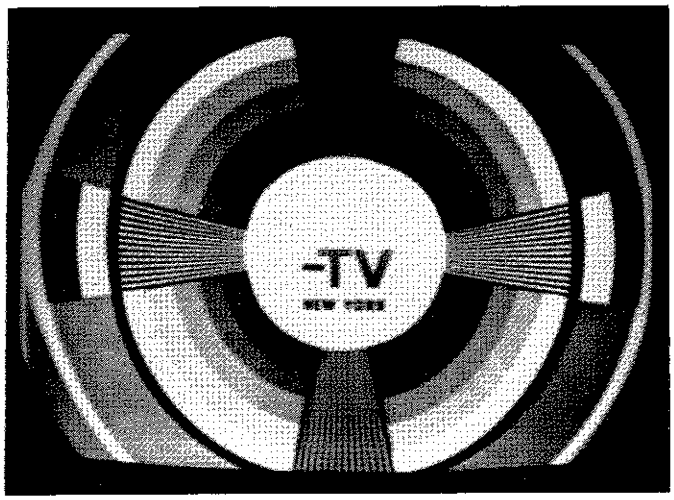

FIG. 97 — LOW RESOLUTION — ROLL-OFF FROM 1 MC

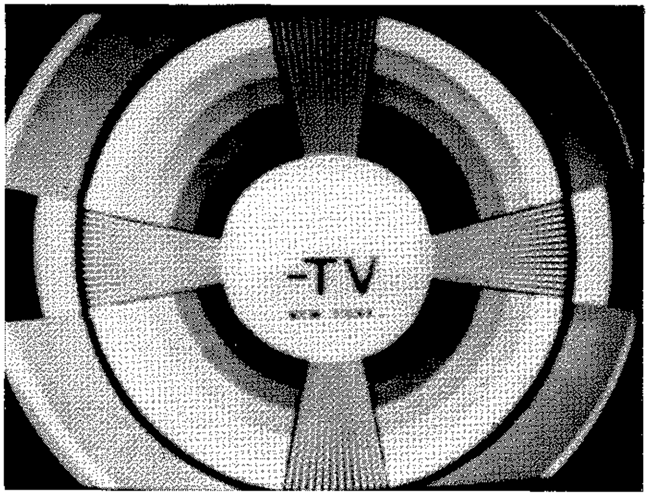

FIG. 99 — LOW RESOLUTION — RECEIVER SCANNING SPOT TOO LARGE

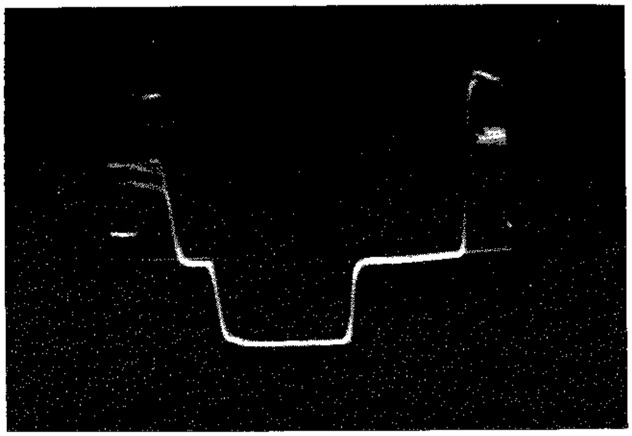

FIG. 98 — LOW RESOLUTION — ROLL-OFF FROM 1 MC — EXPANDED HORIZONTAL

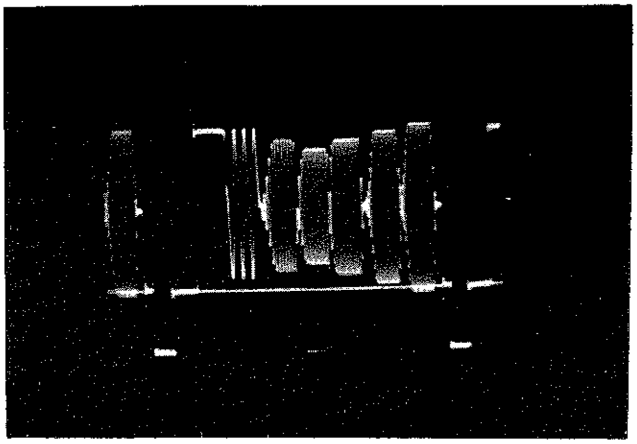

FIG. 100 — HOUR GLASS EFFECT

a "negative spike on the front porch." Since this is below black level, it will not be visible in the picture. However, if the overshoot is of sufficient magnitude, it can cause premature triggering of stabilizing amplifiers, monitors or clampers, resulting in serious tearing or complete loss of picture. A slight overshoot on the front porch is shown in Fig. 96.

(F) Resolution (Figs. 97-99)—Resolution is the ability to reproduce detail in a transmitted picture. Resolution is measured in lines, as discussed under the descriptions of the EIA and broadcasters' test patterns. Horizontal resolution is a function of bandwidth and also can be affected by the size of camera and receiver scanning beams. A rule of thumb is that 1.0 mc of bandwidth corresponds to 80 lines of resolution. For maximum resolution within a given bandwidth, a flat amplitude and linear phase characteristic up to the point of cutoff would be desired. Too sharp a cutoff will produce ringing transients. However, in a transmission system having the same pass band, but with gradual frequency roll-off, and resultant reduced transients, the resolution will become poorer as lower and lower frequencies are selected as the start of the roll-off. The actual shape of a pass band, is a compromise between transient effects in the region of cutoff and the loss of resolution introduced by the extent and shape of the roll-off.

In addition, excessive noise can mask fine picture detail exhibited by apparent loss of resolution.

Figs. 97 and 98 show test pattern transmissions when the high frequencies are strongly rolled off starting at about 1 mc. The A-scope expanded presentation shows loss of sharpness at transition points. Fig. 99 illustrates loss of both horizontal and vertical resolution caused by too large a receiver scanning spot.

(G) Hour Glass (Fig. 100) — When multiburst signals are transmitted over a video facility having an amplitude-frequency response characteristic such that the middle frequencies are attenuated with respect to both the lower and higher frequencies, the resulting A-scope

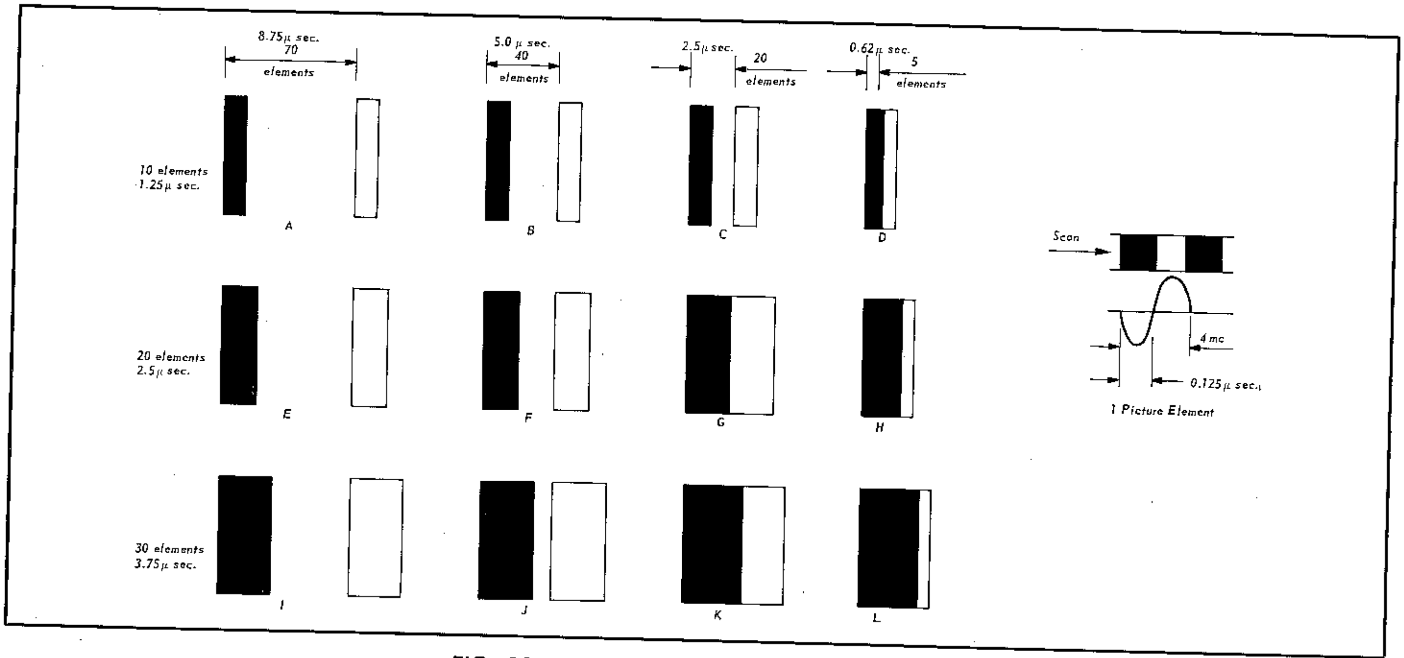

FIG. 101 — ECHO IMPAIRMENT EFFECT VS. IMAGE SIZE AND ECHO DISPLACEMENT

presentation of the multiburst test signal is referred to as the "hour glass" effect. This frequency characteristic usually results from partial equalization, such as would occur when compensating for a facility having a gradually increasing loss with frequency, using an equalizer effective only in the upper portion of the frequency band.

(H) Echoes (Figs. 101-111) — An echo signal, or ghost, is defined as a duplicate of the original video signal displaced horizontally from the original signal. A complete reproduction of the original signal is called a ghost, while a partial reproduction is called an echo or reflection. Ghosts and echoes are due to impairments in the transmission path which cause the signal pulses to reach the viewer at two or more discrete times. Generally, the echo signal is weaker than the original signal. When two or more echo patterns are present, one pattern usually predominates and the others are relatively weak.

The impairment effect of the echo picture not only varies with echo signal strength but also with the time offset and the nature of the original video signal. Fig. 101 attempts to illustrate this by showing bar patterns and their echoes. The bar patterns are of three different widths, corresponding to 10, 20, and 30 picture elements. The reference picture element is the smallest bit of picture information horizontally resoluble in a 4 mc system; as illustrated, this is 0.125 microseconds wide. The bars are arranged in three horizontal rows, each row shows four different echo spacings from the same pattern. Thus, A, B, C, and D illustrate echo spacing corresponding to 70, 40, 20, and 5 elements (8.75, 5.0, 2.5, and 0.62 microseconds) from a bar 10 elements in width.

Vertically the echo spacing is identical; thus, A, E, and I represent echo spacing corresponding to 70 elements (8.75 microseconds) from bars 10, 20, and 30 elements in width. With regard to echo spacing, the top row (A, B, C, and D) illustrates the impairment resulting from different spacing of the same echo. The impairment at D, for instance, is less than that at A, where the echo is considerably displaced from the original image. Conversely, for the same degree of impairment, the echo would be of greater magnitude for the spacing at D than the spacing at A. With regard to the video material, the same echo spacing for three different original images is shown at C, G, and K. The impairment here is less for K than for C, and this is a consequence of the size of the original bar pattern.

With regard to echo amplitude, it is apparent that where the echo can be clearly distinguished from the main image (A, E, I, and wider spacings), the degree of the resulting impairment is mostly controlled by its amplitude. These three factors are difficult to relate mathematically and as a practical matter, have been evaluated on the basis of experience and observations. Consequently, the concepts may be subject to some change. The present thinking on this can best be summarized by reference to a complete picture rather than the simple patterns and components considered so far.

The echo will be a weak duplicate of the picture superimposed and displaced laterally in the time scale proportional to the delay. Where this displacement is fairly large (long delay), the resulting impairment is largely independent of the spacing and is mostly a matter of the level of the echo picture (echo amplitude). For spacing less than this (short delay), the picture and echo are close together and the impairment resulting

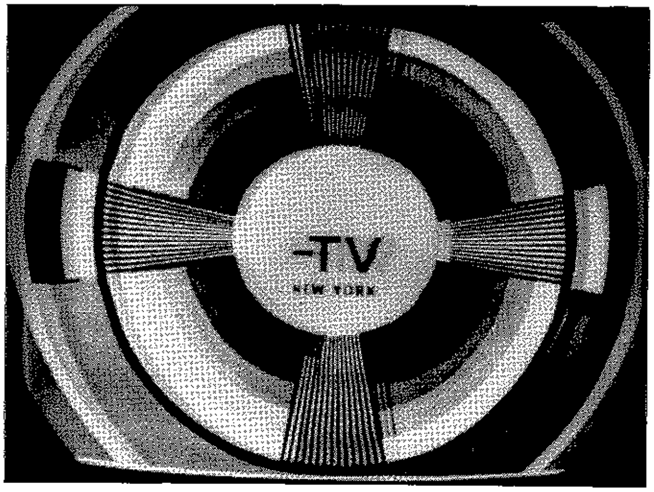

FIG. 102 — POSITIVE ECHO — TEST PATTERN

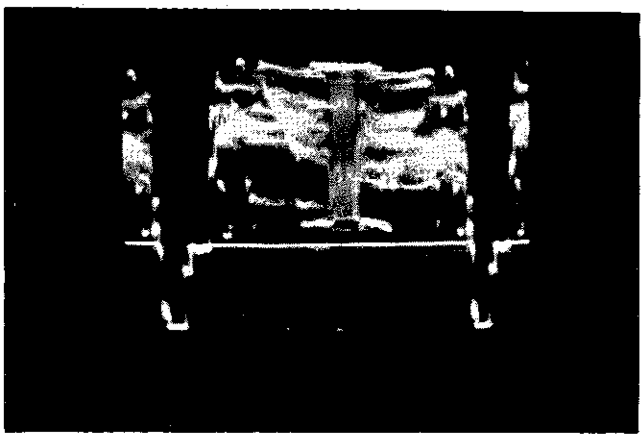

FIG. 103 — POSITIVE ECHO —
TEST PATTERN — HORIZONTAL

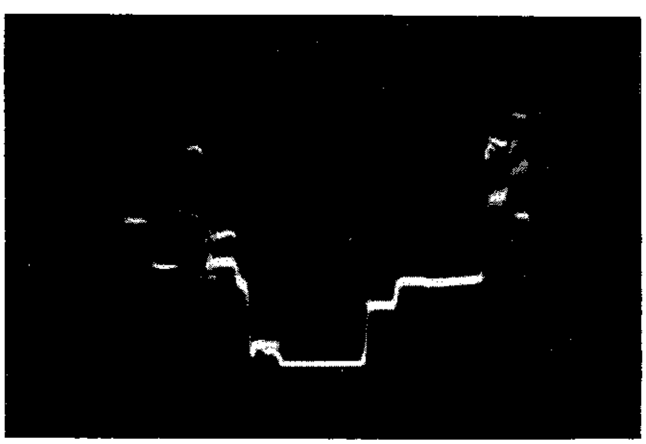

FIG. 104 — POSITIVE ECHO —
TEST PATTERN — EXPANDED HORIZONTAL

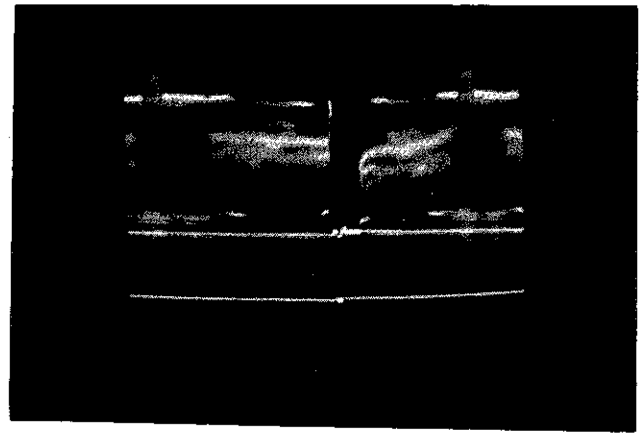

FIG. 105 — POSITIVE ECHO — TEST PATTERN — VERTICAL

from a fixed echo level may be expected to vary with the spacing and to decrease as the spacing decreases. This leads to separate considerations of the impairments resulting from widely and closely spaced echoes, and in turn, to separate limits on fine and coarse deviations in the parameters of the transmission medium (fine and coarse structures). For fine structure variations in attenuation and phase with the resultant widely spaced echoes, the echo amplitude is, therefore, controlling and must be held to a value that makes the echo picture practically invisible.

The value generally used as a system requirement is 40 db below a 1.0 volt peak-to-peak video signal. For coarse structure variations, both the echo amplitude and echo spacing are controlling and the limit is set on the envelope delay deviation. This results in a permissible echo amplitude that varies inversely with the spacing.

As a practical matter, echo signals are generally not a true reproduction of the original signal, since the conditions that give rise to echo signals are usually not linear throughout the band. This adds still another variable factor, since distorted echo signals result in a lesser picture impairment effect than undistorted echo signals. Echoes may be either leading or lagging, and they may be either positive (same tonal range) or negative (reverse tonal range). Figs. 102 to 108 show positive lagging echoes; Figs 109 to 111 show negative lagging echoes.

The usual cause of ghosts and echoes seen on home receivers is two transmission paths from the broadcast station to the receiving location — the direct path and a second path produced by a reflection from some tall building or high point of terrain. The ghost is offset to the right of the direct image by an amount of time equivalent to the difference in length of transmission time of the two paths. Transmission over the reflected path is generally attenuated, as compared with the direct path, so the ghost appears weaker than the direct signal. When FM radio signals are used, as in

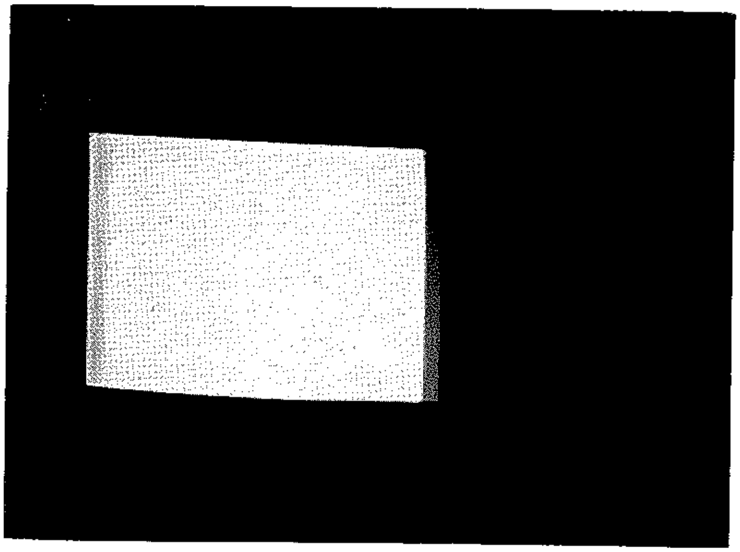

FIG. 106 — POSITIVE ECHO — WINDOW SIGNAL

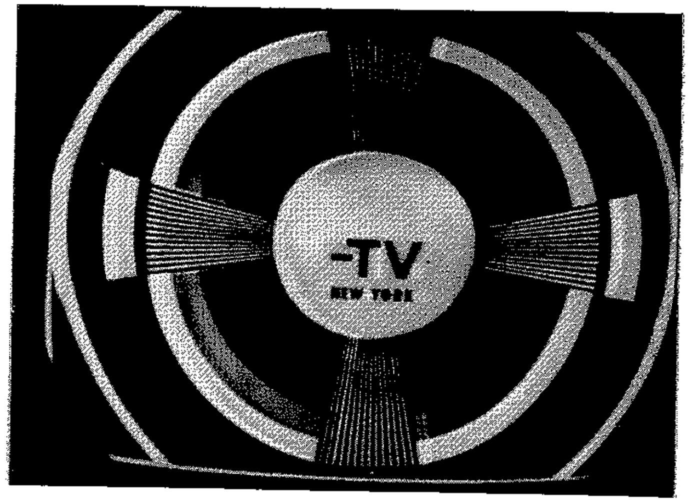

FIG. 109 — NEGATIVE ECHO — TEST PATTERN

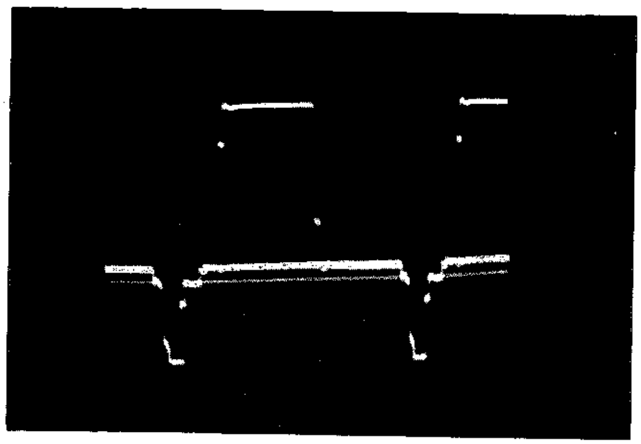

FIG. 107 — POSITIVE ECHO —
WINDOW SIGNAL — HORIZONTAL

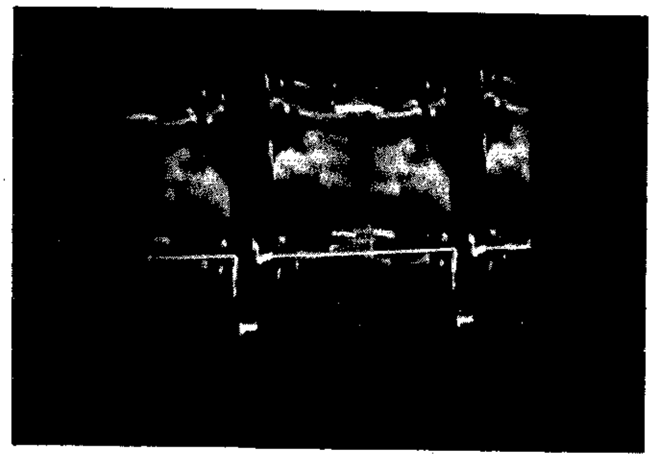

FIG. 110 — NEGATIVE ECHO —
TEST PATTERN — HORIZONTAL

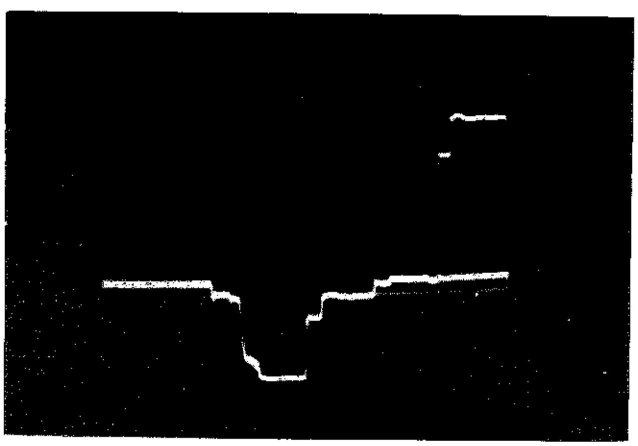

FIG. 108 — POSITIVE ECHO —
WINDOW SIGNAL — EXPANDED HORIZONTAL

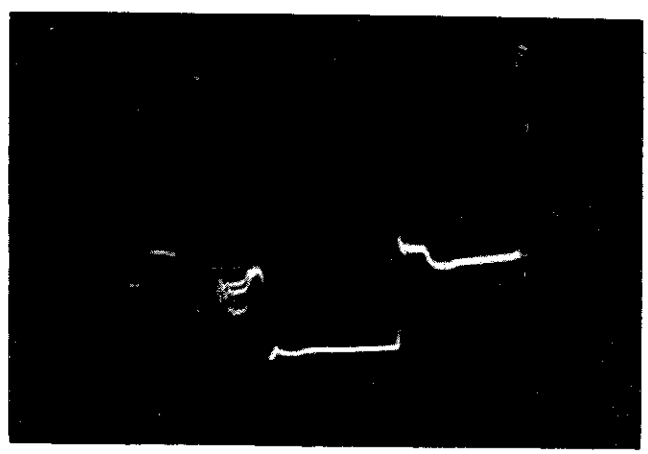

FIG. 111 — NEGATIVE ECHO —
TEST PATTERN — EXPANDED HORIZONTAL

radio relay systems, an impairment from a reflected path generally does not result in a television picture with a distinct echo, since its echo-producing signal would be smothered by the FM capture feature of the radio relay receivers.

Ghosts and echoes may also be produced in transmission facilities due to troubles or unsatisfactory adjustments. A trouble such as impedance irregularity in a cable section or an improperly terminated cable will produce electrical reflections which are delayed in transmission compared with the original signal, and thus produce ghosts or echoes. Ghosts will be produced if the irregularity affects substantially the whole video frequency band, and echoes when only a part of the frequency band is affected.

The same effects can also be caused by nonuniformity of gain- and delay-frequency characteristics. In particular, a gain-frequency characteristic having periodic peaks and valleys across the frequency band will act the same as an impedance irregularity on cable, affecting a broad band of frequencies.

The spacing of the reflected image or images from the original object and from each other is determined by the location of the irregularity in the frequency spectrum and usually may be calculated by the relationship that the reflection displacement in seconds is equal to the reciprocal of the frequency in cycles at which the irregularity occurs. For example, an irregularity occurring at 500 kc will produce reflections displaced from the original and from each other by two microseconds. Remembering that one line in a television picture (exclusive of blanking) is equal to about 53 microseconds, we can see that in this case, the reflections will be displaced by a fraction of the total picture width equal to 2/53. This equates to about 7/16 and 5/8 of an inch for 12 and 17 inch monitors, respectively. Where carrier type facilities are involved, it should be remembered that this is a video frequency calculation, and that further conversion to carrier frequencies may be required. The number of reflections is dependent upon the sharpness of the irregularity, being only one for a broad irregularity and increasing in number with irregularity sharpness.

3. Interference

(A) General — Interference is the introduction of extraneous signals into the desired signal. In the case of television transmission, the resulting picture impairments may be in the form of bars, moving spots, salt-and-pepper effect or erratic synchronizing. One form of interference is called noise, this term being used generally to describe natural phenomena such as thermal noise in electronic components; whereas, "interference" generally refers to man-made signals, such as extraneous single frequency voltages, crosstalk from another video channel and the like. The term "noise" is a carry-over from audio work. In television the effects are visual rather than aural.

Interference can be simply added into the path of the desired signal, or it can modulate the signal itself. Signal modulation by interference may occur in nonlinear circuit elements such as vacuum tubes, and results in the whole picture signal amplitude changing at the interfering rate. The two types of interference are difficult to distinguish in a television picture. Treatments that will minimize additive interference, such as filtering, use of clamper-amplifiers for low-frequency interference, etc., will not affect modulation products. Additive interference is the case discussed and illustrated in this section.

(B) Single-Frequency Interference — The appearance in a television picture of extraneous regularly spaced bars or lines indicates the presence of an interfering frequency. At low levels of interference the amount of single frequency interference that can be tolerated varies quite widely, depending on the part of the spectrum in which it is operative.

(B-1) LOW-FREQUENCY INTERFERENCE (Figs. 112-119)—A particularly sensitive portion of the spectrum is the immediate region of the field rate, 60 cycles per second. It has been found that as the level of such an extraneous frequency is increased from a very low value, flicker is much more objectionable than the brightness distortion corresponding to a broad bar pattern. The flicker effect is accordingly controlling in this region. The tolerable level of interference varies with the flicker frequency (difference between the extraneous and field frequencies), a flicker rate of about five cycles per second being the most objectionable. This holds for frequencies either side of the field rate; that is, the most critical frequencies are 55 and 65 cycles. To be tolerated, the peak-to-peak amplitude of these interfering frequencies has to be about 54 db less than the peak-to-peak amplitude of the television signal.

Figs. 112 and 115 are cases of 120-cycle and approximately 1000-cycle interference. For low-frequency interference which is an exact multiple of the field rate (60 cycles), the extraneous bars will be horizontal and will remain stationary. The interfering frequency may be determined by multiplying 60 cycles by the number of white or the number of dark bars observed. Two horizontal white bars may be distinguished in the first instance, and sixteen or seventeen for the 1000-cycle picture. When the extraneous frequency differs slightly from the 60-cycle field rate or its multiples, the bars will remain horizontal but will move vertically through the picture, the rate of motion increasing with the difference in frequency. Interference at 60 cycles and its first few harmonics is frequently called "hum" as it is often caused by defects in power supplies—similar to the audio case.

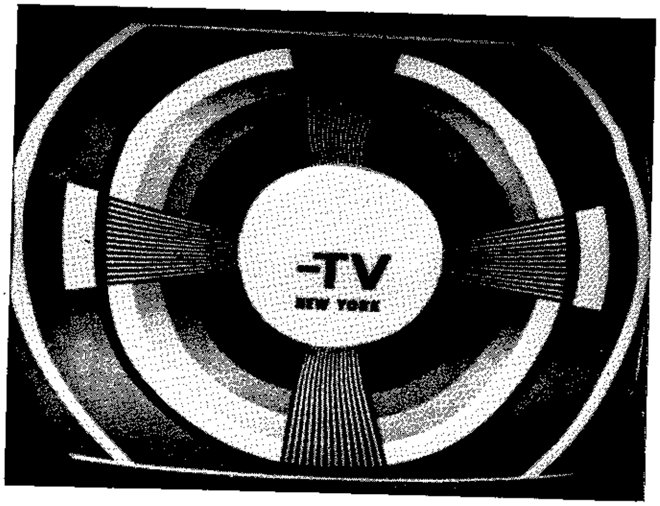

FIG. 112 — INTERFERENCE — 120 CYCLES

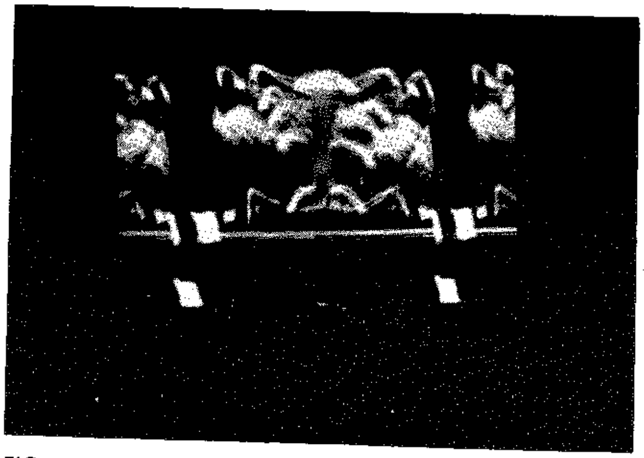

FIG. 113—INTERFERENCE—120 CYCLES—HORIZONTAL

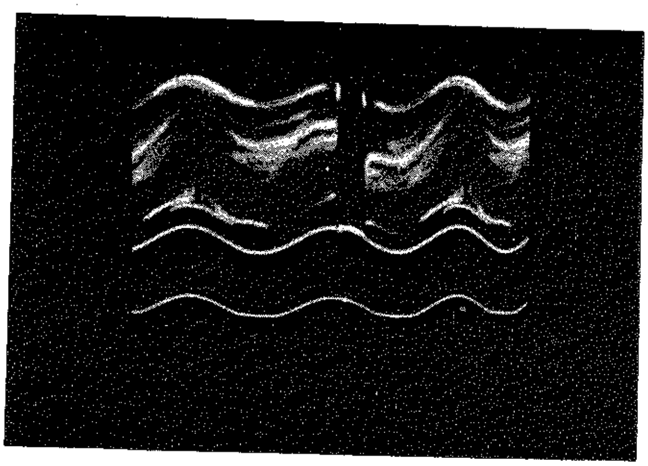

FIG. 114 — INTERFERENCE — 120 CYCLES — VERTICAL

Low-frequency interference shows on the A-scope horizontal presentation as thickened horizontal lines, the thickness indicating the relative amplitude of the interference, as in Figs. 113 and 116 for the 120- and 1000-cycle cases, respectively. The vertical presentation shows no thickening of the trace. The interference may

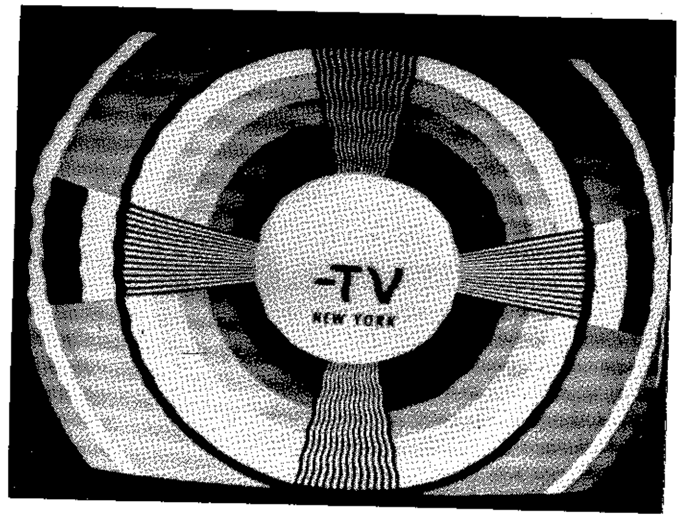

FIG. 115 — INTERFERENCE — 1000 CYCLES

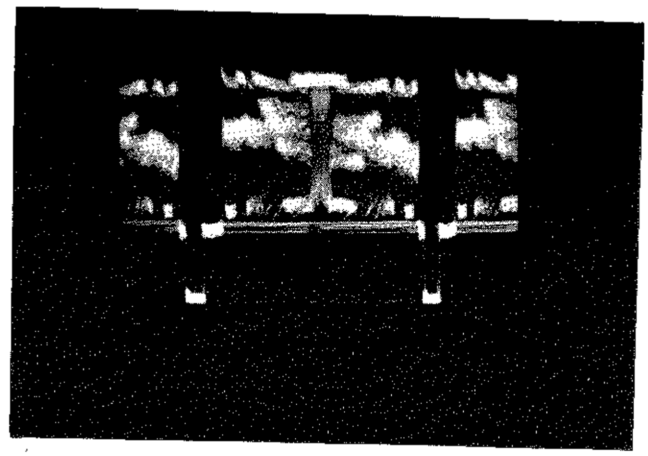

FIG. 116—INTERFERENCE—1000 CYCLES—HORIZONTAL

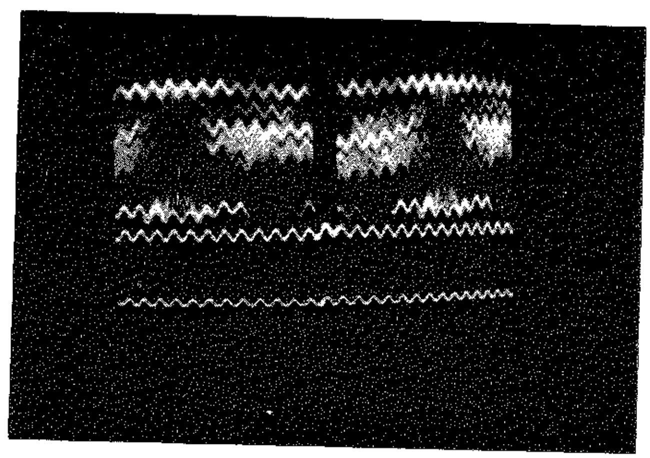

FIG. 117 — INTERFERENCE — 1000 CYCLES — VERTICAL

appear as a wave form on the blanking line, horizontal sync tips and sometimes the picture signal, as in Figs. 114 and 117 for the same two examples.

Clamper-amplifiers effectively reduce interference at 60 cycles by about 33 db. This figure reduces progressively as the interfering frequency is increased and the clamper is not effective on interference above about 2 kc. (This varies somewhat with the clamper time constant.) Figs. 118 and 119 show the 120-cycle interference of Figs. 113 and 114 after passing through a clamper-amplifier. No impairment is visible in the pictures.

(B-2) GLITCH (Figs. 120-22)—A type of low-frequency interference, which has been commonly referred to by the broadcasters as a "glitch," is observed as a narrow horizontal bar moving through the picture (Fig. 120). Simultaneous observation of the A-scope at field or frame rate will indicate one or more extraneous voltage pips moving along the signal at approximately reference black level. The pip in Fig. 121 was moving rapidly from right to left.

This may be present in the signal from the customer's pickup, as a result of a difference in frequency between a remote camera power supply and the customer's local 60-cycle power supply. When using some types of radio relay equipment, the impairment also may result from spiking on the positive and negative sine-wave peaks of commercial power supplies. The speed of movement of the dark bar depends on the difference between the frequency of the picture field rate and the frequency of the commercial power supply. Such spiking may be introduced by gaseous or solid state rectifiers or similar systems feeding back voltage pips at a 60-

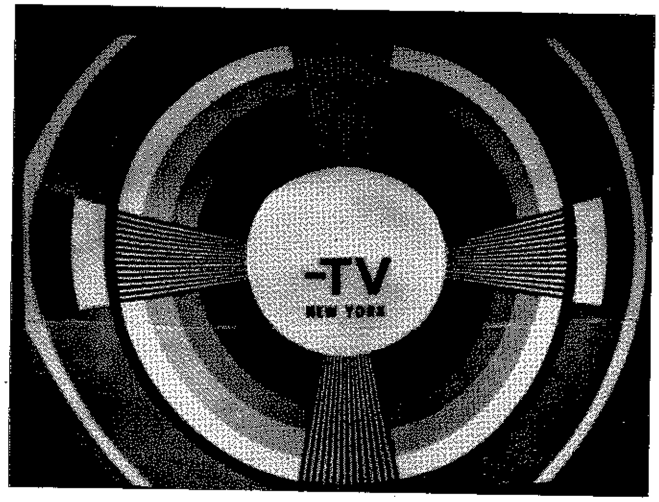

FIG. 120 — GLITCH

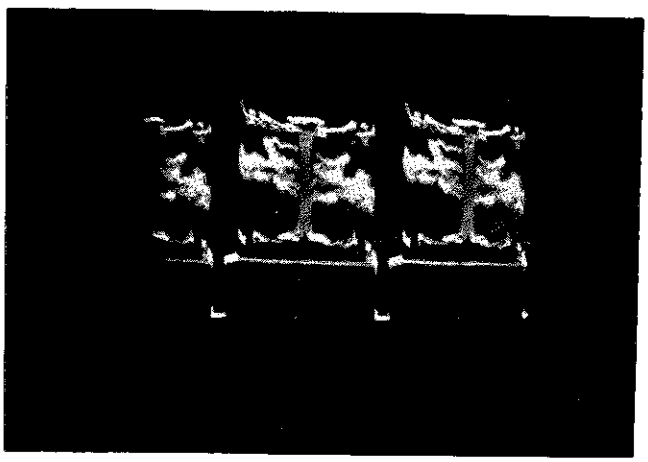

FIG. 118 — INTERFERENCE — CLAMPED — 120 CYCLES — HORIZONTAL

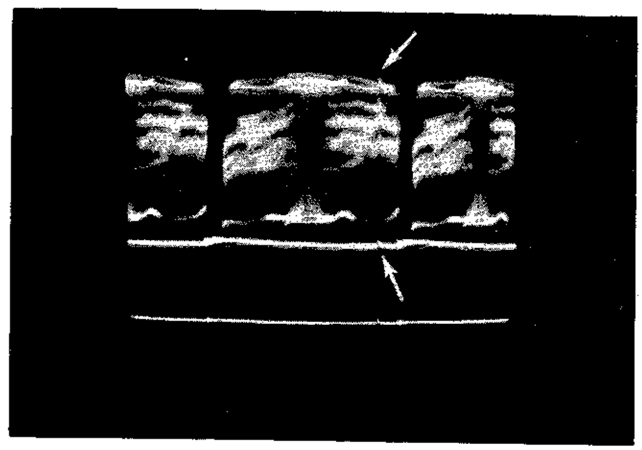

FIG. 121 — GLITCH — VERTICAL

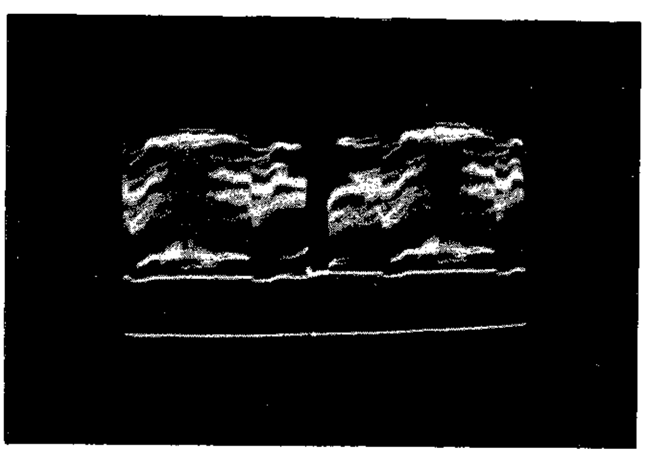

FIG. 119 — INTERFERENCE — CLAMPED — 120 CYCLES — VERTICAL

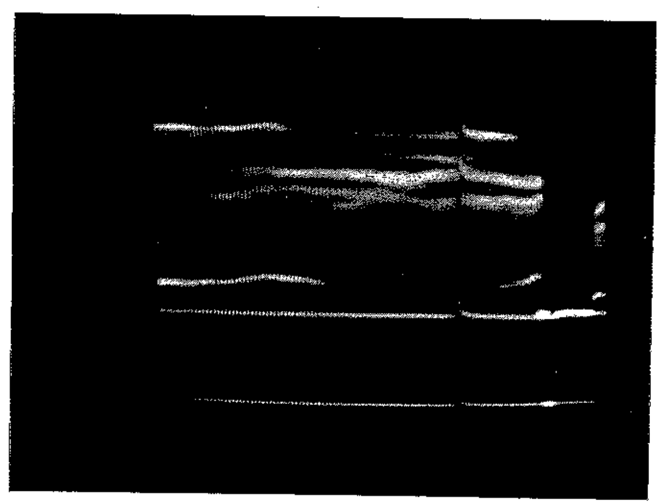

FIG. 122 — GLITCH — EXPANDED VERTICAL

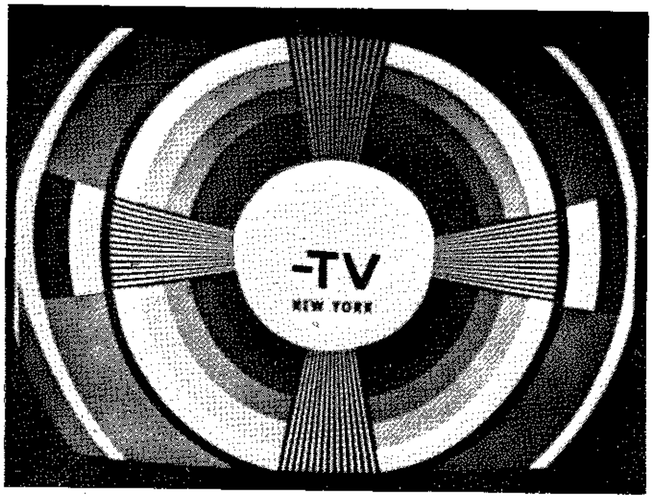

FIG. 123 — INTERFERENCE — 31.5 KC

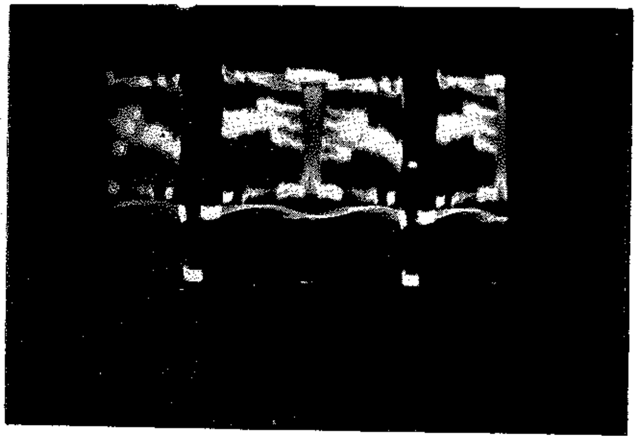

FIG. 124 — INTERFERENCE — 31.5 KC — HORIZONTAL

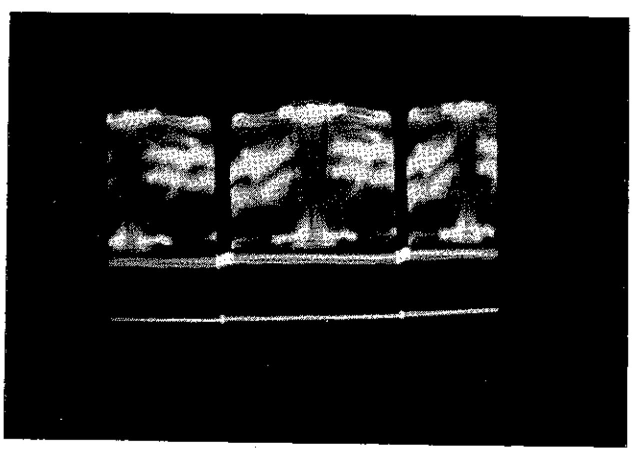

FIG. 125 — INTERFERENCE — 31.5 KC — VERTICAL

cycle rate into the commercial power supply. Thus, this is not pure single frequency interference, but has many similar characteristics. It is possible to observe this spiking from such power supplies through use of an

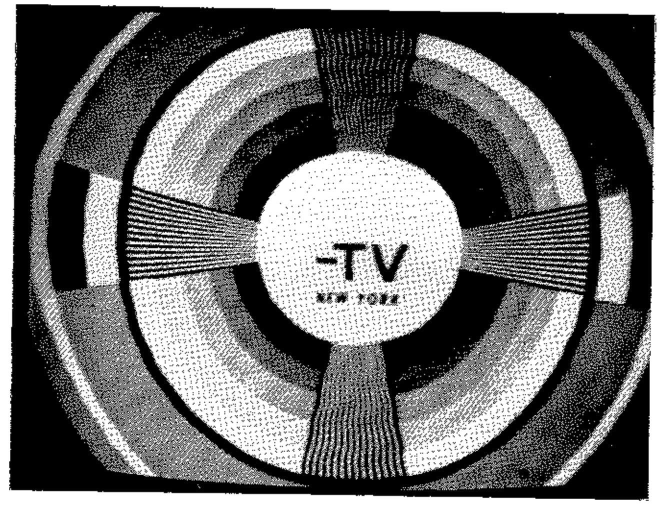

FIG. 126 — INTERFERENCE — 311 KC

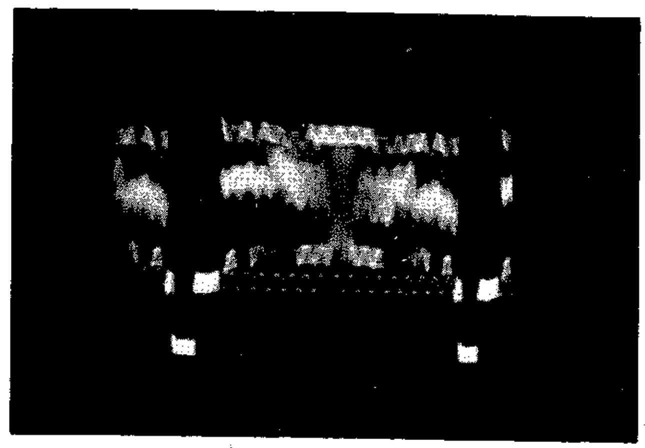

FIG. 127 — INTERFERENCE — 311 KC — HORIZONTAL

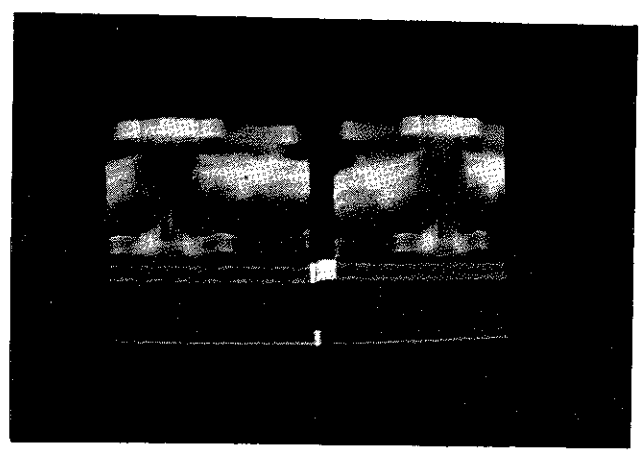

FIG. 128 — INTERFERENCE — 311 KC — VERTICAL

oscilloscope bridged on the power line. Effects are eliminated through filtering, either at the source of interference or at the point of connection to the radio relay equipment.

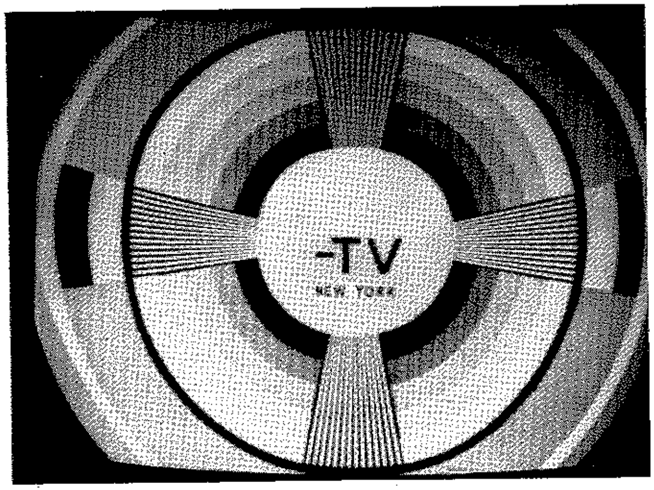

FIG. 129 — INTERFERENCE — 1 MC

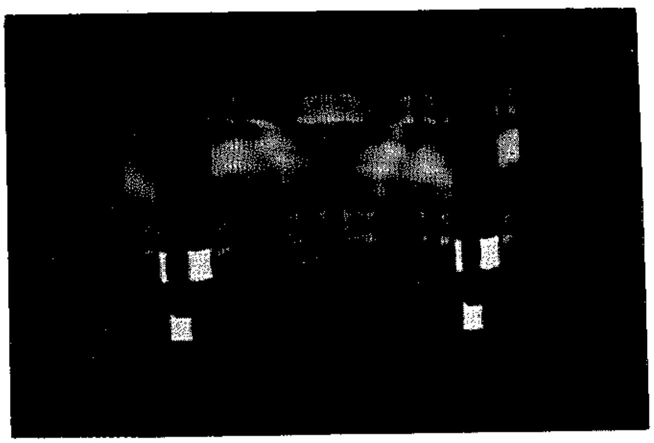

FIG. 130 — INTERFERENCE — 1 MC — HORIZONTAL

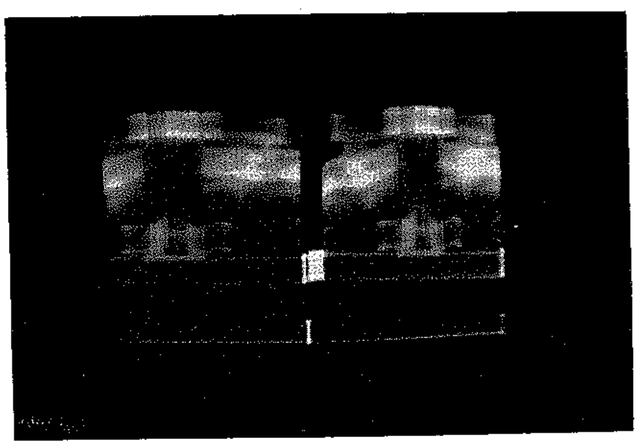

FIG. 131 — INTERFERENCE — 1 MC — VERTICAL

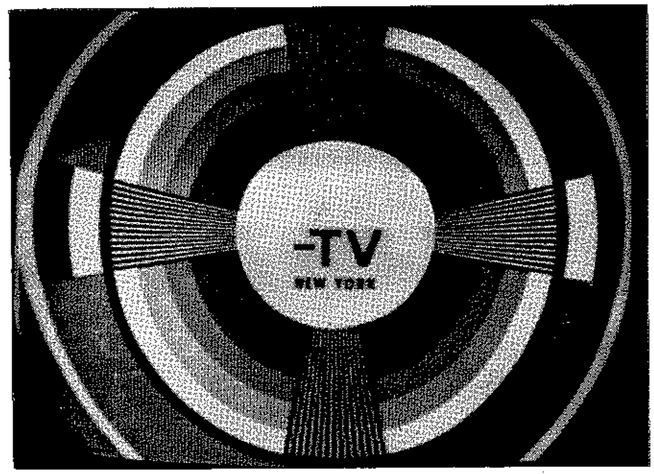

FIG. 132 — INTERFERENCE — 3.6 MC

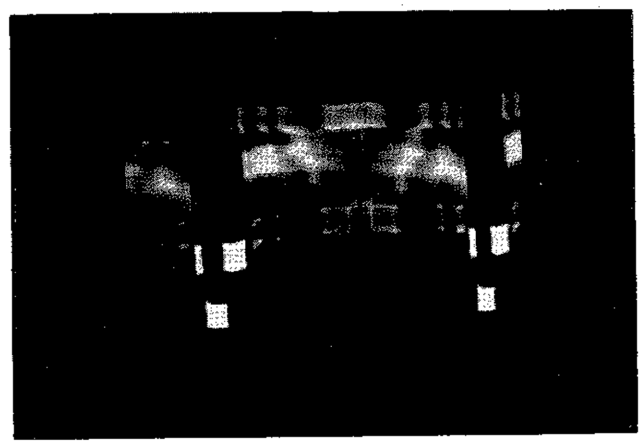

FIG. 133 — INTERFERENCE — 3.6 MC — HORIZONTAL

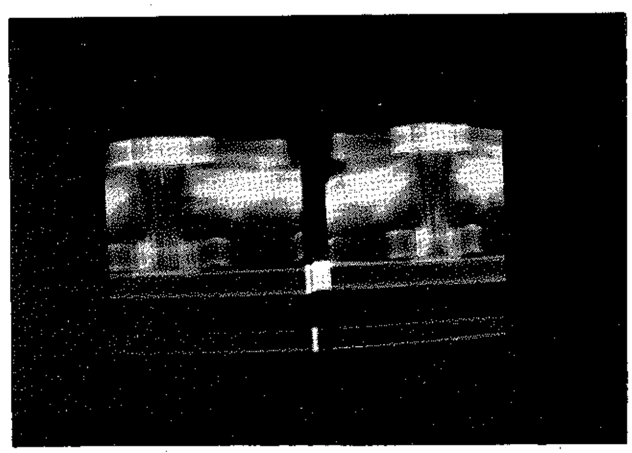

FIG. 134 — INTERFERENCE — 3.6 MC — VERTICAL

(B-3) HIGH-FREQUENCY INTERFERENCE (Figs. 123-134)—In the region above the line rate, 15,750 cycles, the most critical frequency is found to be in the ½- to ⅓-megacycle range. The maximum tolerable interference level at this point in the spectrum is about 65 db below the signal. High-frequency interference will appear as regularly spaced diagonal or vertical bars which become finer as the frequency increases.

If this frequency is an exact multiple of the line rate, the pattern will be stationary and vertical. The interfering frequency may be determined by multiplying the line rate by the number of white or the number of dark bars observed cutting a horizontal cross section of the picture. Figs. 123, 126, 129 and 132 are samples, respectively, of 31.5 kc, 311 kc, 1.0 mc and 3.6 mc interference. The first picture contains light vertical areas just to the left of center and on the right side of the pattern, which are difficult to distinguish. The bar patterns on the other three pictures are quite evident and a count of the bars will give the interfering frequency quite accurately.

The A-scope presentations are shown by Figs. 124, 127, 130 and 133 at horizontal rate, and Figs. 125, 128, 131 and 134 at vertical rate, respectively. It will be noted that, on the horizontal display, the interference shows as a wave whose frequency may be determined by counting the cycles appearing in the scanning interval. If the frequency is very high, expanding the scope presentation may be necessary to resolve the individual wave shapes. The vertical trace shows thickening as illustrated.

(C) Crosstalk (Figs. 135-137)—Crosstalk, as considered herein is the effect of undesired coupling between two television signal paths. If the coupling is strong enough, the result is a weak extraneous image, usually somewhat distorted, superimposed on the main image similar to Fig. 135. Since different video systems normally are not exactly synchronized, rather violent horizontal motion of the crosstalking image can occur. Vertical motion is not likely to be so violent, since the field rates usually will be closer together than the line rates.

The most prominent features of the crosstalking image will be the line and field blanking intervals. These are, of course, blacker-than-black and they effectively frame the crosstalking image. As crosstalk coupling is reduced, the crosstalking image is no longer visible, but the horizontal interval which appears as a wide black vertical bar, and the vertical interval which appears as a wide black horizontal bar, will be visible moving through the picture. The rate of horizontal and vertical motion will vary with the differences between the sync rates of the two signals. The horizontal interval is usually the most disturbing since it extends the whole height of the raster as a wide black bar, with appreciable motion. The vertical interval is usually less noticeable.

Depending upon the strength of the unwanted signal, the interference may or may not be seen on the A-scope. In the example used, it was necessary for photographic reasons to introduce the crosstalking signal only about 10 db below the desired signal. Therefore, the interfering signal is evident as modulation on both the horizontal and vertical presentations (Figs. 136 and 137).

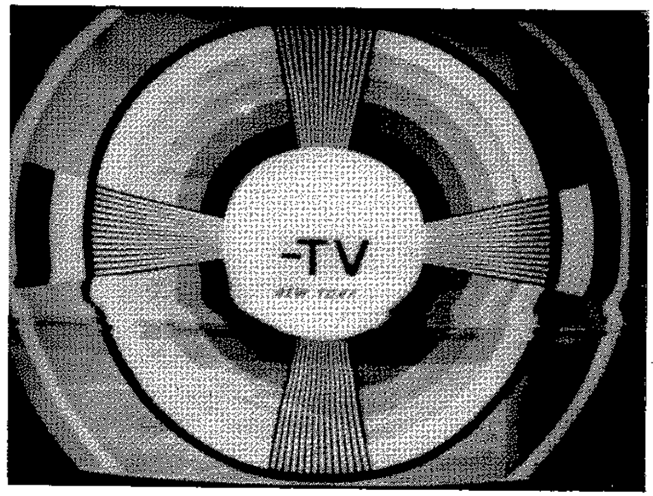

FIG. 135 — INTERFERENCE — CROSSTALK

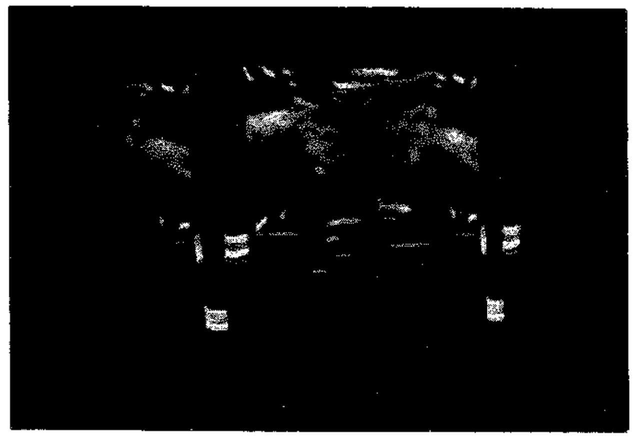

FIG. 136—INTERFERENCE—CROSSTALK—HORIZONTAL

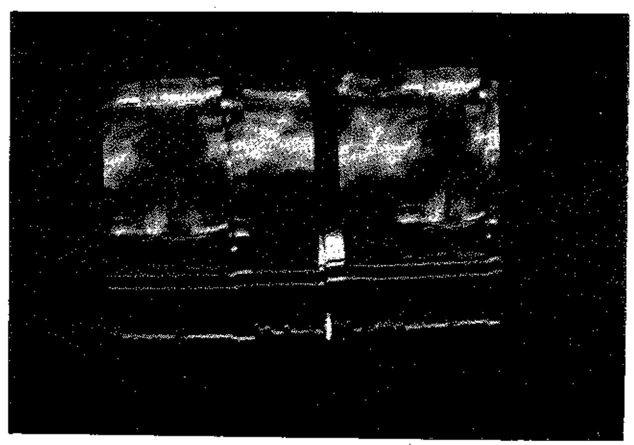

FIG. 137 — INTERFERENCE — CROSSTALK — VERTICAL

(D) Random Noise (Figs. 138-140)—This type of noise is of the general type obtained by amplification of thermal noise, but is not necessarily confined to that

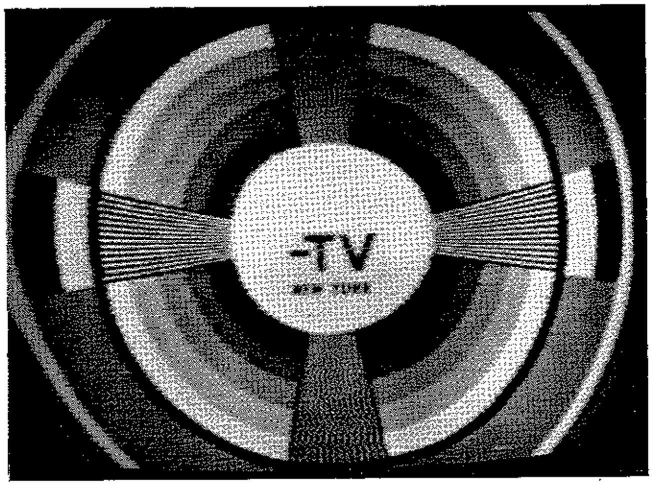

FIG. 138 — RANDOM NOISE

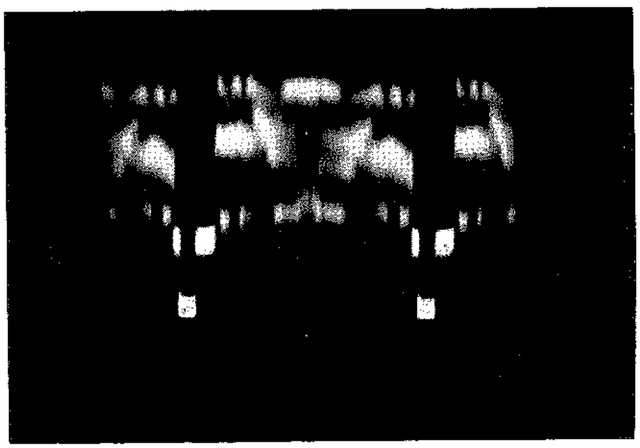

FIG. 139 — RANDOM NOISE — HORIZONTAL

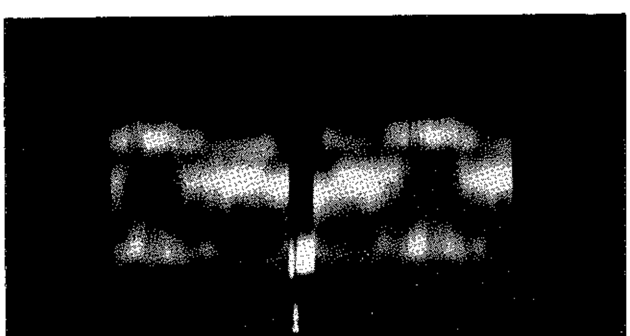

FIG. 140 — RANDOM NOISE — VERTICAL

source. It covers a wide band of frequencies without too much energy variation. The over-all rms amplitude is reasonably stable over time intervals corresponding to one line scan. Experience indicates that, assuming noise peaks about three times the rms value, peak random noise should be limited to approximately 30 db below the picture signal for a 4 mc bandwidth system. This 30 db limit applies to the entire length of circuit involved, including everything from the camera to the home receiver. Accordingly, any part of the transmission circuitry would necessarily be limited to a much lower noise level in order to meet the over-all limit. For quantitative measurements of noise it is necessary to eliminate energy in the frequency spectrum outside the video band.

The visual effect of random noise is that the picture acquires a pronounced graininess. When noise is strong enough, this may be called "snow" as shown in Fig. 138. Thickening of the blanking lines and tips of sync pulses is usually evident, as in Figs. 139 and 140 which show the horizontal and vertical scanning intervals of the picture of Fig. 138. Proper measurement of noise, however, is made by expanding the blanking lines in the vertical interval and observing them on a single line basis. These three illustrations are of noise caused by introducing a low level radio signal into a microwave repeater and restoring the radio signal to normal amplitude, thus amplifying the thermal noise in the equipment.

Another type of random noise is the result of a microwave message channel having a large number of busy circuits interfering with the picture channel.

Light random noise, visible only in the background of the picture, has been referred to sometimes as "busy background," since variations in intensity of the noise peaks usually cause the appearance of movement of the gray background, with minor thickening of the A-scope traces. This term is used with a different meaning by other groups connected with television and theatrical work, and its use is not recommended for description of television signal impairments. "Light noise" or "light high-frequency noise" are preferred terms.

(E) Impulse Noise (Fig. 141)—The effect of impulse noise, which is composed usually of intermittent bursts or pulses, is difficult to evaluate. Assuming noise peaks at one per minute, one objective thought to be reasonable is to limit the peak noise to 20 db below the signal level. The division between impulse noise and random noise is not sharp; as the rate of occurrence of noise pulses increases, the more nearly it approaches random noise. Picture impairments resulting from impulse noise, as shown in Fig. 141 are sometimes called "pigeons," since the spots seem to fly across the picture. Unless observation is made of the A-scope at the time of occurrence of the noise pulse, or unless the pulses occur fre-

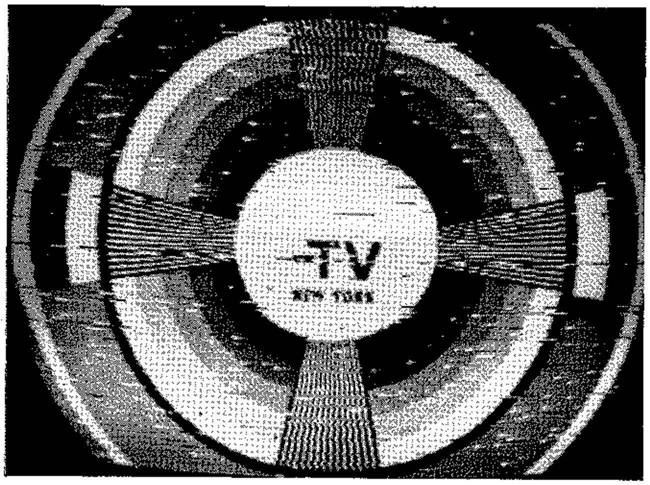

FIG. 141 — IMPULSE NOISE

quently, thickening of blanking lines or other signal indications will not be observed.

Radar interference is one type of impulse noise which is seen occasionally. Radar, as observed on a picture monitor, consists of intermittent groups of pulses, or "pigeons," falling into a pattern on the screen. This pattern may move or be stationary and will vary greatly depending on the length of the pulse and the rate at which it recurs. Another characteristic of radar is the way it will usually fade and reappear at regular intervals. This is due to the rotation of the radar antenna, so the rate of reappearance is determined by the speed of rotation. Although there may be a wide variation, the usual rate is every six to ten seconds.

(F) Microphonics (Figs. 142-144)—When some electron tubes are physically disturbed by vibrations due to nearby machinery, shocks from installation operations, or even by loud noises, their elements may vibrate, usually at a rate below 15,750 cycles per second. The varying tube characteristics will cause any signal being handled to be modulated at the vibration rate. Since this may be considered as low-frequency interference, the effect on pictures is to add a series of horizontal bars, usually moving and changing in size in accordance with the amplitude and frequency of the vibration. Note that in the A-scope pictures, Figs. 143 and 144, the sync portion of the signal is not varying with the microphonics in the picture information. These microphonics were found in a camera, with the sync information added later. Had the microphonics occurred in a transmission system, the sync would have been affected as well. In this case, the sync portion would look similar to Figs. 116 and 117.

4. Miscellaneous

(A) Clamping—The effect on a composite video signal

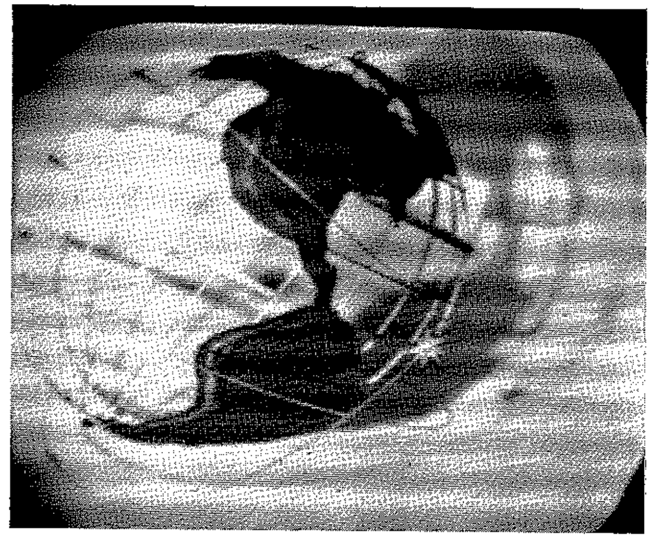

FIG. 142 — MICROPHONICS

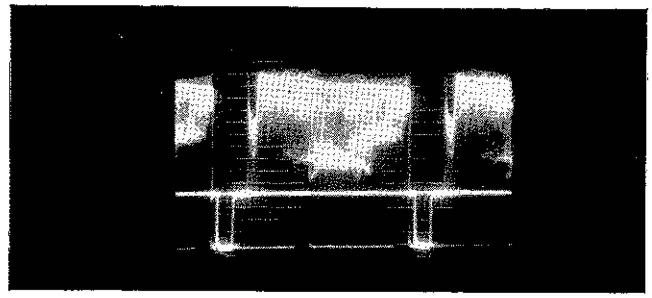

FIG. 143 — MICROPHONICS — HORIZONTAL

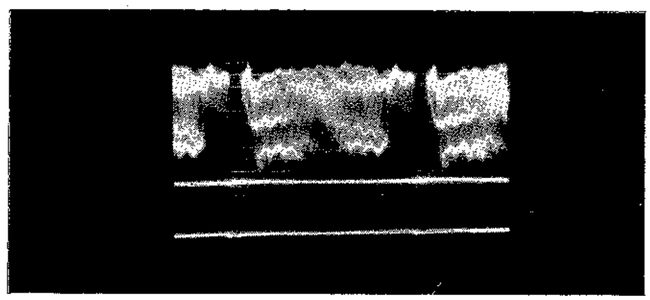

FIG. 144 — MICROPHONICS — VERTICAL

of low-frequency distortion is the same as though a low-frequency signal were added to the video signal. Thus low-frequency interference and low-frequency transmission deviations produce similar distortions of the video wave form. Clamping is a process whereby the effects of low-frequency interference and low-frequency transmission deviations are removed from the video signal. Telephone company clampers are designed so that a correcting bias voltage is added to the signal at the start of each horizontal synchronizing pulse, the magnitude and polarity of this correcting voltage being sufficient to keep the tips of the horizontal sync pulses at a fixed reference level.

Since the back porch immediately follows the tip of the synchronizing pulse which has been adjusted to a fixed reference voltage, it is subjected to approximately the full clamper correction. The front porch, however, occurs at the end of a line signal, and its level is displaced by the over-all frequency distortion change during the preceding line interval. Since the clamper is triggered by the leading edge of the sync pulse, the front porch is unaffected by any subsequent correction that is applied by the clamper. Therefore, if the levels of the front and back porches would be equal except for the low-frequency impairment experienced, the correcting voltage supplied by the clamper would be equal to the difference in the level of the two porches. However, porches are frequently displaced due to other causes, such as transmission over a vestigial sideband carrier system where front porch level may vary depending upon the signal level at the end of each scanning line. In general, therefore, porch displacement should not be depended upon as a measure of clamper correction voltage, except under known conditions.

(A-1) ABSENCE OF CLAMPING (Figs. 145-151) —Loss of clamping results when the output level of the clamper drops to such a low level as to exceed the range of the clamper and thus make the clamping action ineffective. Figs. 145-151 show the result of loss of clamping due to low level. Loss of clamping also may be caused by defective tubes or other defective components.

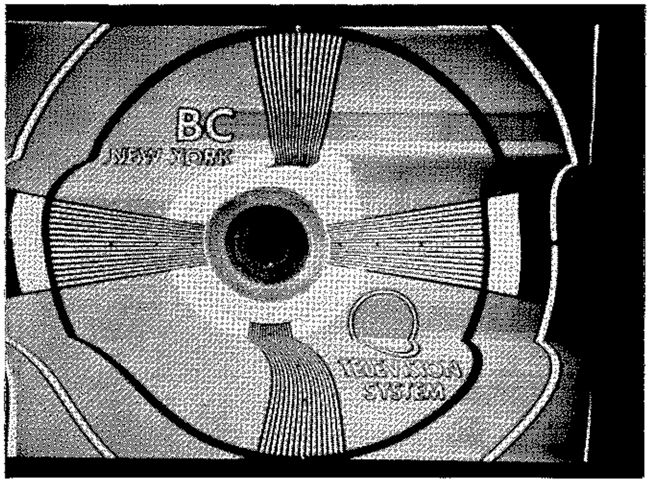

FIG. 145 — CLAMPING FAILURE

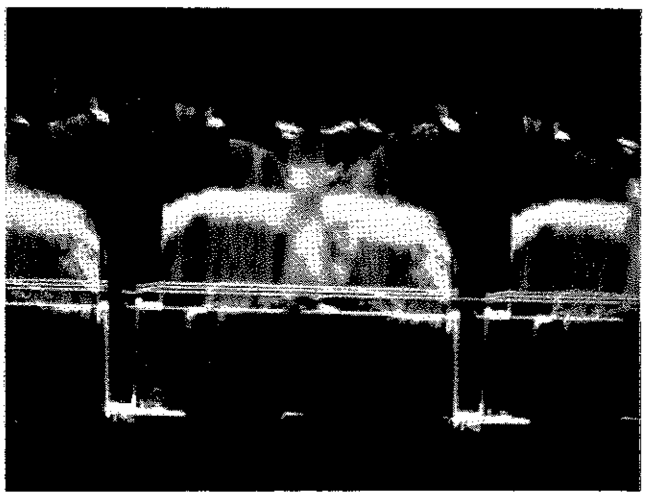

FIG. 146 — CLAMPING FAILURE — HORIZONTAL

FIG. 147 — CLAMPING FAILURE — EXPANDED HORIZONTAL

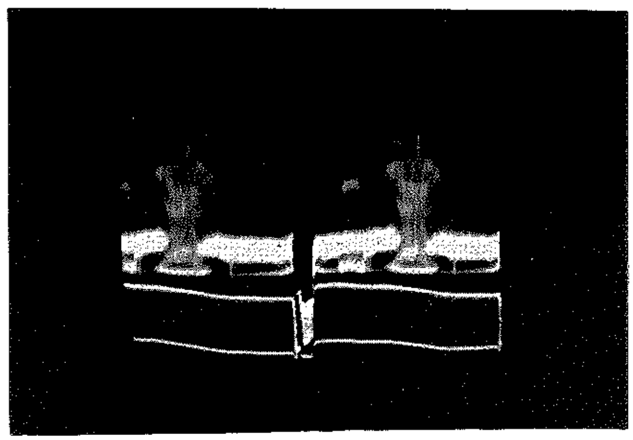

FIG. 148 — CLAMPING FAILURE — VERTICAL

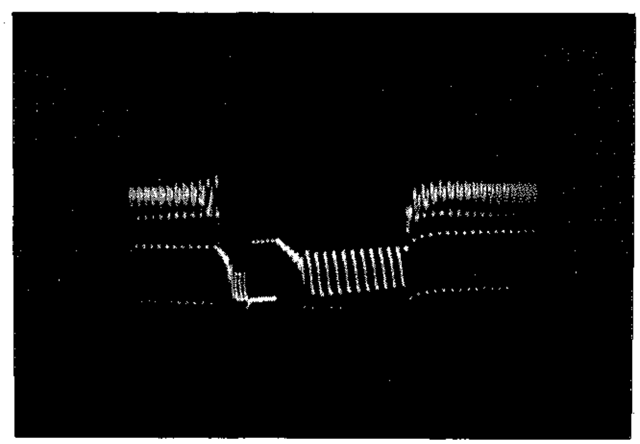

FIG. 149 — CLAMPING FAILURE — EXPANDED VERTICAL

Erratic or no clamping action may also result from an overshoot on the leading edge of the front porch sufficiently large to cause the clamper to be falsely triggered, resulting in complete tearing of the picture. In the examples, only a few lines of tearing are visible at the top of the pictures; however, the A-scope reveals an erratic horizontal interval and serious distortion of the vertical blanking interval.

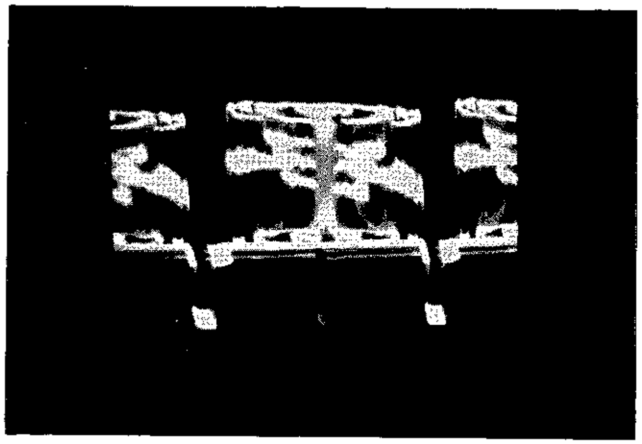

FIG. 150 — ABSENCE OF CLAMPING — HORIZONTAL

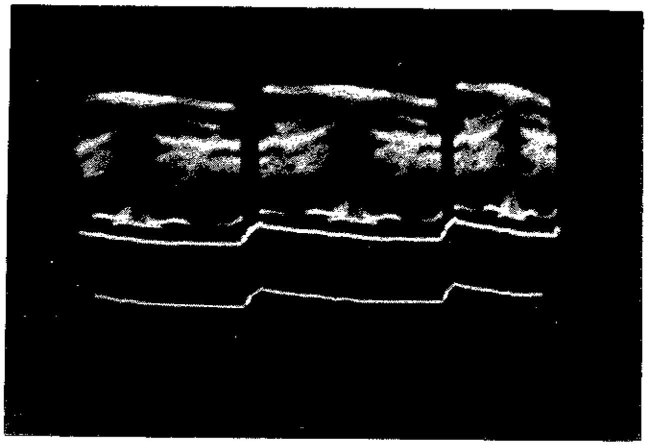

FIG. 151 — ABSENCE OF CLAMPING — VERTICAL

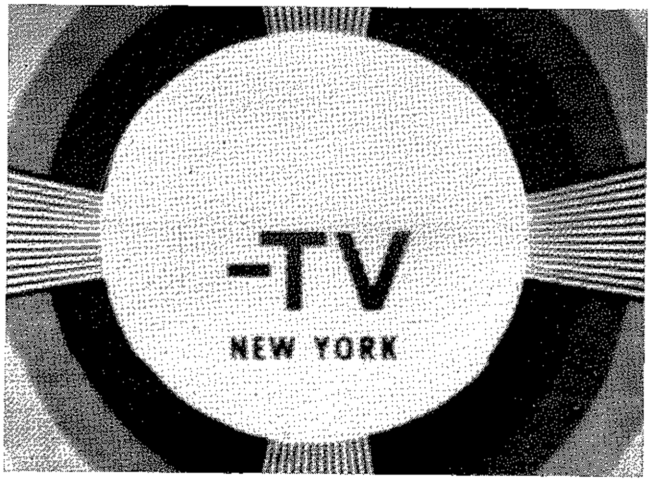

FIG. 152 — SERRATIONS

Absence of clamper action is illustrated in Figs. 150 and 151. As previously discussed, the impairments observed due to low-frequency distortion are the same as though a low-frequency interfering signal were introduced and, therefore, will vary depending upon the nature and amount of low-frequency impairment present in the signal being observed. This is shown on the horizontal presentation (Fig. 150) by the thickening of the traces, and in the vertical presentation (Fig. 151) by the varying tilts during vertical blanking and picture intervals.

(B) Serrations (Fig. 152)—Serrations are jaggedness in the vertical and diagonal structure of images as seen in a picture monitor. They result from horizontal displacement of some of the scanning lines due to nonuniformity in the triggering time of the horizontal sweep oscillator. This condition may be caused by a distortion of the leading edge of the sync pulse as a result of interference, streaking, etc. Fig. 152 shows serrations of vertical and diagonal lines in the center of the test pattern.

(C) Tearing (Figs. 153, 154)—Tearing is a horizontal displacement of the scanning lines to the extent that the picture appears torn. Tearing of the picture on the receiver or monitor may be caused by distortion or lack of horizontal sync pulses. It also may be caused by video black peaks or spikes which drop below blanking level near the horizontal sync pulse. Any other form of interference whose amplitude is such as to cause false triggering of the horizontal scanning circuit of a receiver or monitor will give similar effects. One illustration of such tearing is shown in Fig. 153.

Tearing at only the top of a picture, as in Fig. 154, is usually caused by impairment or loss of some equalizing pulses. This may be due to sync generator trouble, improper clamping action, or improper levels.

(D) Nonlinearity (Figs. 155-157)—The requirement in most transmission circuits and amplifiers that the output be directly proportional to the input over the working range of voltages or power, means that these circuits must be "linear." Operation outside the range of linearity may occur when exceeding ratings of equipment, when maladjustments occur, or when components such as vacuum tubes age. The departure from linearity that can be tolerated varies over wide ranges. For example, sync expansion circuits have been built into some telephone company clamper-amplifiers to deliberately "expand" the sync part of the video signal relative to the picture signal to compensate for unwanted compression which may accumulate in transmission. This illustrates that the results of nonlinearity may be either "compression," which is the more usual, or "expansion."

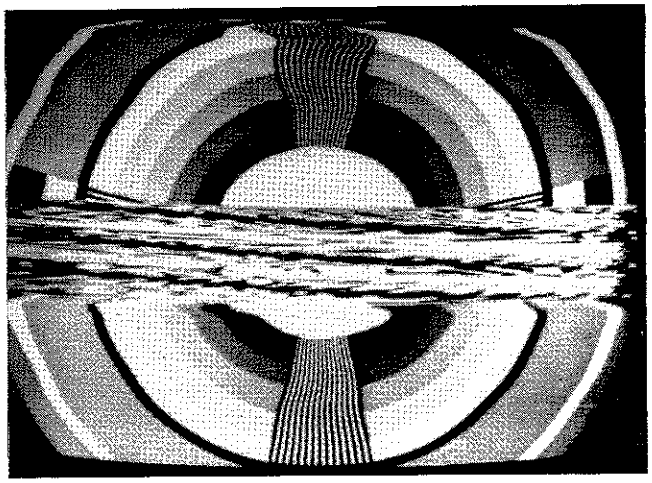

FIG. 153 — TEARING

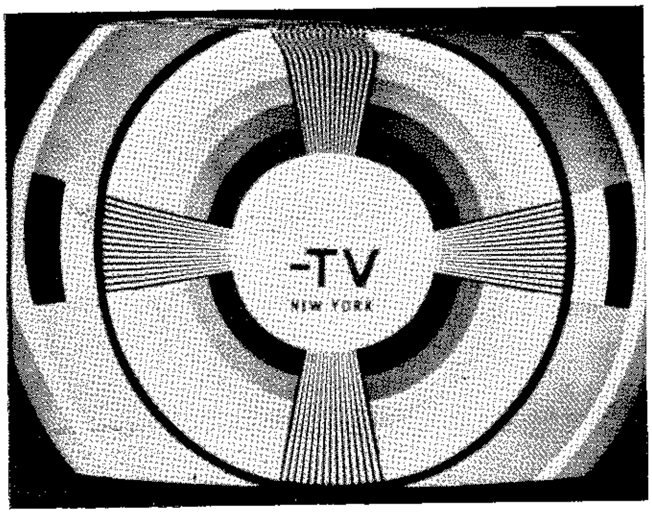

FIG. 154 — TEARING

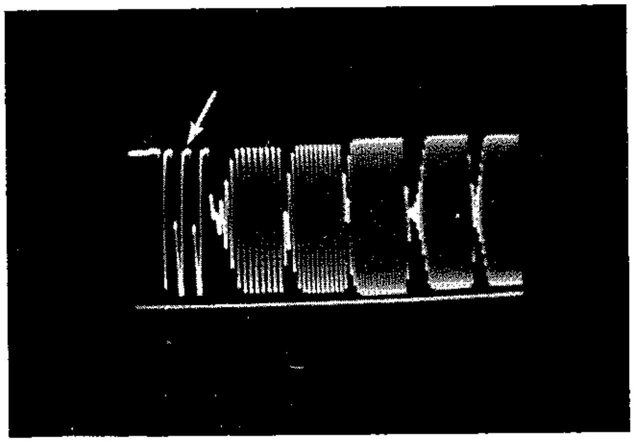

FIG. 155 — HARMONIC DISTORTION — 500 KC

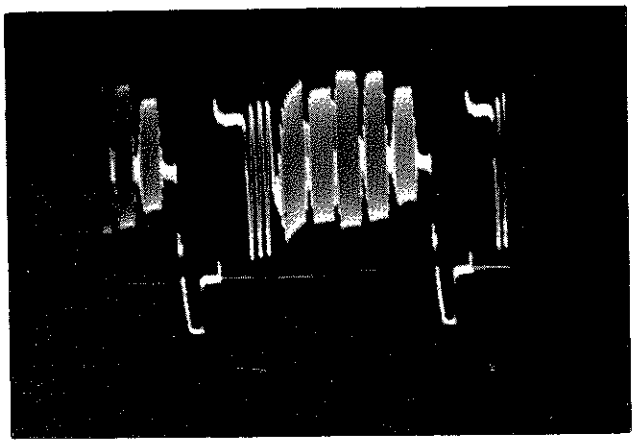

FIG. 156 — AXIS SHIFT

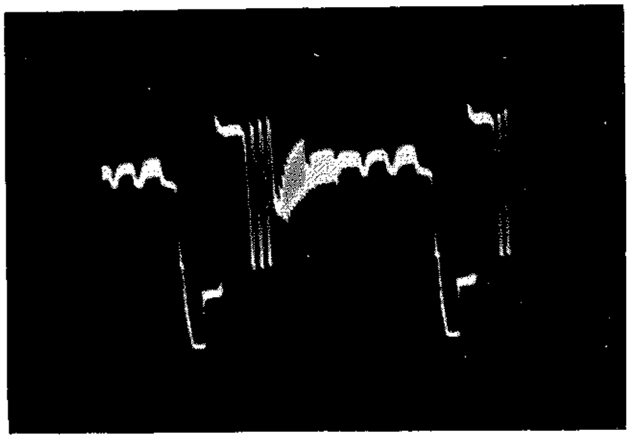

FIG. 157 — AXIS SHIFT — THROUGH LOW PASS FILTER

As discussed in the section on Level Irregularities, it is possible to compress either the negative or the positive peaks of a signal passing through an amplifier. The resulting video signal will contain either "black compression" or "white compression." In analyzing the effects of compression on a sine wave, it can be shown that the compressed signal, in addition to containing the fundamental sine wave, may include a dc component due to rectification, and other components made up of harmonics of the original sine wave frequency. When all of these components can be transmitted, the received wave is distorted and limited, as in Fig. 155, showing harmonic distortion on the 500 kc burst of a multiburst test signal. Other examples of compression effects are shown in the section of this booklet dealing with level variations such as blooming, bleeding whites, etc. When compression becomes severe, it sometimes is called "clipping" and is observed as a sharp line of demarcation in level beyond which no signal is found.

If the nonlinearity is not equal for different impressed frequencies, combinations of effects may result which may be difficult to analyze. Such unequal distortions may occur in feedback amplifiers, where the feedback is a function of frequency in order to maintain over-all flatness, or in circuits such as those of video cable amplifiers, where the high frequencies are transmitted at somewhat greater levels than the lows, in order to partially compensate for succeeding cable loss. Compression of higher frequency components of a signal compared to the lows has been noted fairly frequently.

The multiburst test signal has proved to be a good indicator for this selective type of compression, and may sometimes detect this condition when differential gain measurements indicate no trouble. When this distortion is present, close observation of the higher frequency burst will reveal that the axes of some or all of these bursts are shifted vertically by varying amounts, as in Fig. 156. As mentioned above, the distorted wave contains a dc, or, in the case of a video type signal, because of the horizontal scanning frequency, a 15,750-cycle component, and harmonics of the distorted burst. For frequencies above about 2.5-3.0 mc, most transmission facilities cut out the burst harmonics leaving only the 15,750-cycle component and the fundamental frequency. This 15,750-cycle component will shift the axis of the multiburst through the burst in question. For frequencies whose second or higher harmonics are passed by the system, the axis shift is not so pronounced, but an expansion of the wave will show distortion, as on the 500 kc burst illustrated in Fig. 155. This shifting of the axis of the bursts has sometimes been called "rectification," because of the production of the effective dc component. Fig. 157 is the same signal as Fig. 156, but in this case the signal has been put through a low-pass filter which effectively eliminates the higher frequency bursts and makes the axis shift more evident.

(E) Halo (Fig. 158)—Halo usually is the appearance of a black border around unusually bright objects in a televised scene. As shown in Fig. 158, the border may be irregular in size and shape but is easily distinguished from streaking and smearing. It is caused by overloading of the pickup tube in scanning bright objects. While the accompanying figure indicates halo around an object occupying a large part of the viewing screen, it also is commonly noticed when stage lights are reflected from jewelry, eyeglasses and other small objects. With certain camera tube operating adjustments, a white area may surround dark objects.

(F) Moiré (Figs. 159, 160)—Meshbeat or moiré effect is the appearance of vertical or diagonal lines on a picture, which resemble high-frequency interference. In Fig. 159, these lines are most noticeable across the top and bottom of the kitchen cabinet close-up. This difficulty may be caused by image-orthicon cameras

FIG. 158 — HALO

FIG. 159 — MOIRÉ

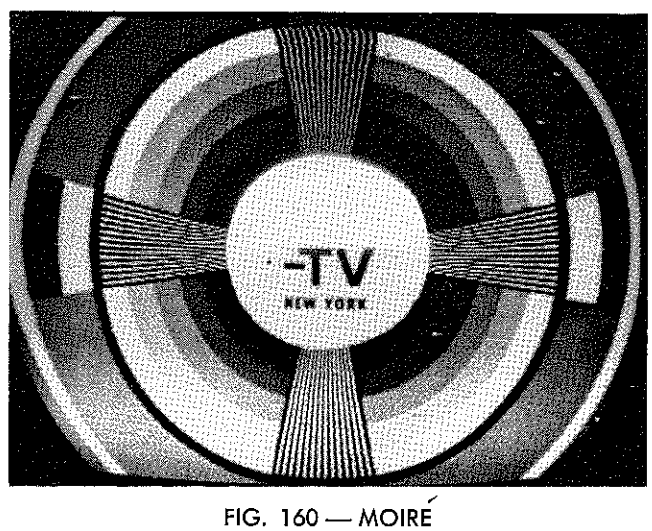

FIG. 160 — MOIRÉ

where a beat is obtained between the scanning signal and the screen, or mesh, associated with the target plate.

Moiré pattern is also a natural optical effect when scanning closely spaced picture lines which are almost horizontal. It is evident on the horizontal wedges of the test pattern shown in Fig. 160.

(G) Burned-In Image (Figs. 161, 162)—A burned-in image is one which persists in the camera output signal when the camera has been focussed on another scene. Fig. 161 illustrates the case of a camera having been shifted to one side of a cue card, with the original image still visible to the right of the new one. Fig. 162 shows a burned-in image of the EIA test pattern, originally being viewed, superimposed on a close-up of a stove top and grillwork. This phenomenon is associated with orthicon camera tubes where the persistence of the burned-in image depends upon the length of time that the camera is focussed on the original scene, and the brightness of the scene. It may last as long as several minutes in extreme cases.

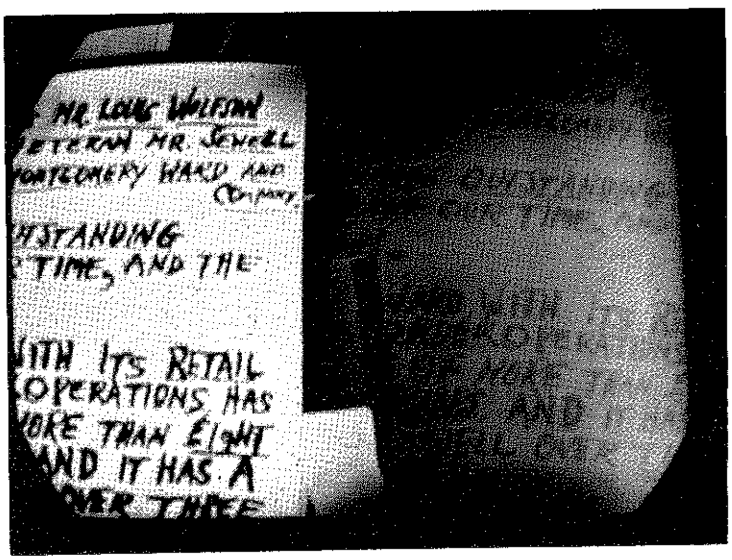

FIG. 161 — BURNED-IN IMAGE

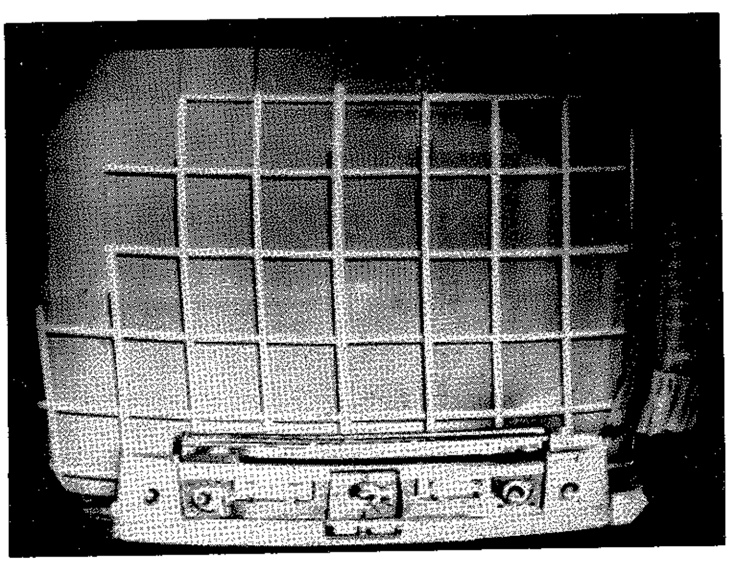

FIG. 162 — BURNED-IN IMAGE

5. Color Signal Impairments

In general, color television signals are subject to the same impairments as monochrome transmissions. However, color television signals may be impaired seriously by additional conditions that might not affect a monochrome picture adversely.

(A) High or Low Chrominance Signal Level – When the chrominance signal component of a color television signal is received at too high a level, colors will increase in saturation; when this component is received at too low a level, colors will tend to wash out. As long as overloading or differential gain is not evident, the proper relationship in saturation between various hues will be maintained.

A high or low chrominance signal level occurring when luminance signal levels are normal would result from excess gain or loss at the upper portion of the video signal frequency spectrum.

Since the color burst has the same frequency as the color subcarrier, any transmission characteristic affecting the amplitude of the chrominance signal will usually also affect the amplitude of the color burst (Figs. 163, 164). For rapid location of large deviations it is possible, using an A-scope with a wide band characteristic, to observe the color signal wave form for comparison of color burst and sync pulse amplitudes, which should be the same. However, a comparative measurement of color burst amplitudes is necessary for more precise locations.

Because results can be expressed quantitatively, A-scope location of impairments can usually be made more accurately and rapidly than would be possible using color monitors, although color monitors may also be used for verification.

(B) Loss of Color—In the general case, this is caused by very low chrominance signal level. However, such a condition has occurred with an apparently normal color burst, as viewed on an A-scope. In this case, the frequency of the apparent color burst had been shifted from the normal 3.6 mc value. Color monitors are required for quick location in such cases.

(C) Differential Phase (Figs. 165-167) – Differential phase is the change in phase of the 3.6 mc color subcarrier as the level of the luminance signal on which it rides is varied from blanking to white. It causes error in portrayal of hues. Figs. 166 and 167 illustrate large amounts of differential phase of opposite signs, as compared to Fig. 165 which is a "normal" picture.

In FM radio relay systems, this distortion is usually caused by a nonuniform deay-frequency characteristic in the IF equipment, where varying amplitudes of input

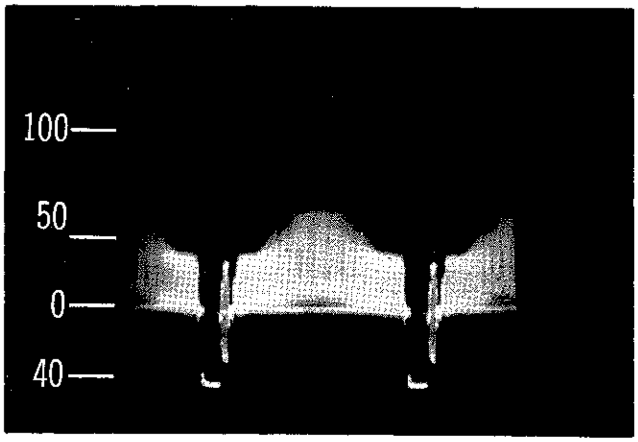

FIG. 163 — HIGH LEVEL CHROMINANCE SIGNAL — HORIZONTAL

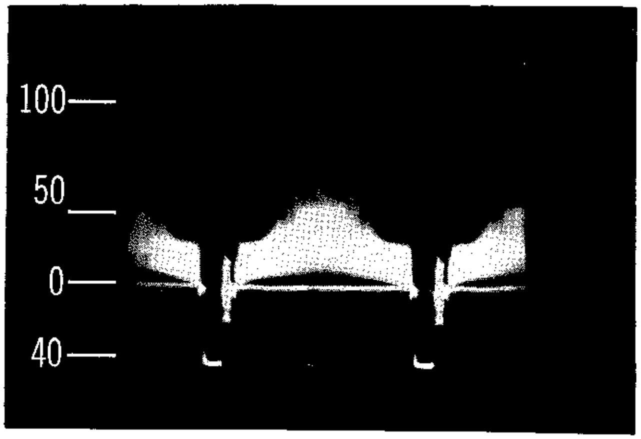

FIG. 164 — LOW LEVEL CHROMINANCE SIGNAL — HORIZONTAL

signal are represented by varying frequencies. The color burst is always at blanking level, and therefore, will always swing about the same frequency on the radio relay system. Color components of the signal generally are not at blanking level; therefore, the FM swing will be about a different frequency and any difference in delay between the two results in differential phase. In telephone company systems, delay equalizers in IF paths are used to correct differential phase.

In addition to FM radio systems, differential phase distortion may be experienced in any equipment having transmission paths that vary in phase with level. Hue impairments are observable in color picture monitors, but are not apparent in either monochrome picture monitors or in A-scopes. Color monitors are neither sufficiently precise nor stable to use as a basis for correction of differential phase, and it is, therefore, necessary to release facilities from service in order to make differential phase measurements. The 47A Transmission Measuring System is used by the telephone company for proper adjustment of differential phase equalizers, while the broadcasters usually use a modulated stairstep signal for measuring differential phase.

(D) Differential Gain—In color television transmission, differential gain is the change in gain of the 3.6 mc color subcarrier as the level of the luminance signal on which it rides is varied from blanking to white. It causes error in color saturation of the received picture.

Differential gain is generally observed as signal compression as luminance levels are increased, although expansion can be experienced. The effects of differential gain may be observable in color monitors, depending upon degree. Severe cases of such signal impairment should be evidenced in the A-scope presentation of a color bar test signal as an overloading or expansion condition of the chrominance components. Other than for severe conditions of this type, the facility or equipment to be tested must be released from service for differential gain tests to enable location of causative facility sections.

When excess differential gain is experienced, the first step is to assure that proper amplitude levels have been maintained. Further investigation would include location of the portions of the layout or piece of equipment contributing appreciably to this condition. Clearance is then generally accomplished by replacement of tubes or other defective components.

(E) Leading or Lagging Chrominance — When the chrominance signal is not received at the same time as the luminance signal, colors will appear in the color picture monitor either to one side or the other of the image. For example, a blob of red may occur at lip level on either side of the mouth. This is often called "funny paper" effect. A shift to the left results from leading chrominance information. When severe, this impairment might be observed as edge effect on monochrome pictures transmitted over the same facility.

This condition can result from improper delay relationship between the lower and the upper portions of the frequency spectrum over transmission facilities or through equipment. Therefore, envelope delay characteristics of television layouts in color condition should be checked, should leading or lagging chrominance be experienced.

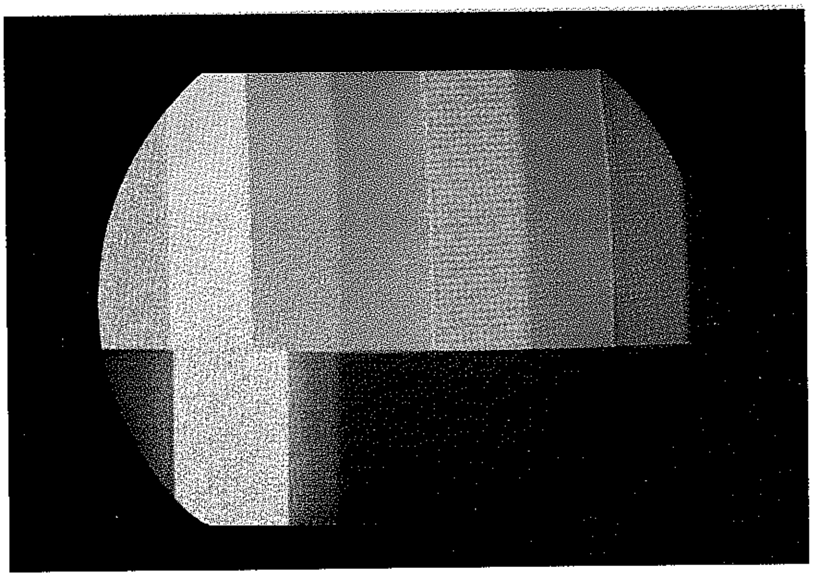

FIG. 165 — COLOR BAR SIGNAL — NORMAL PHASE

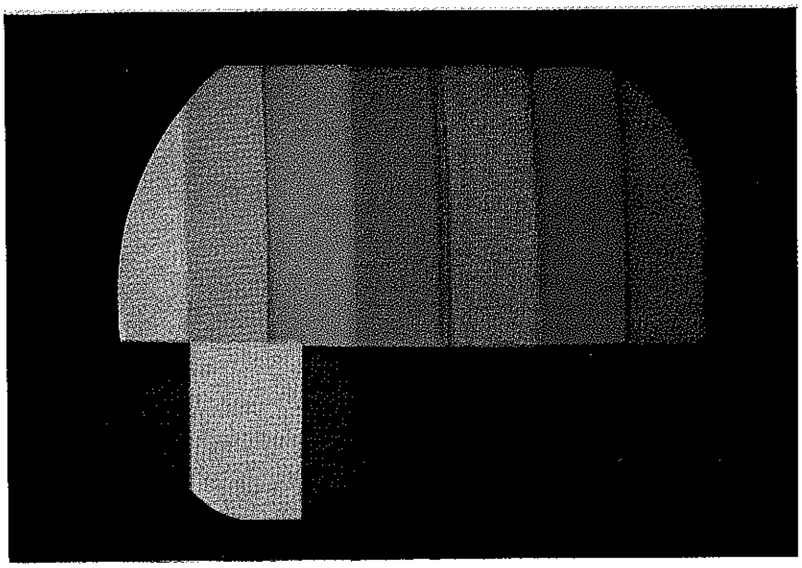

FIG. 166 — COLOR BAR SIGNAL — YELLOW SHIFTED TOWARD RED

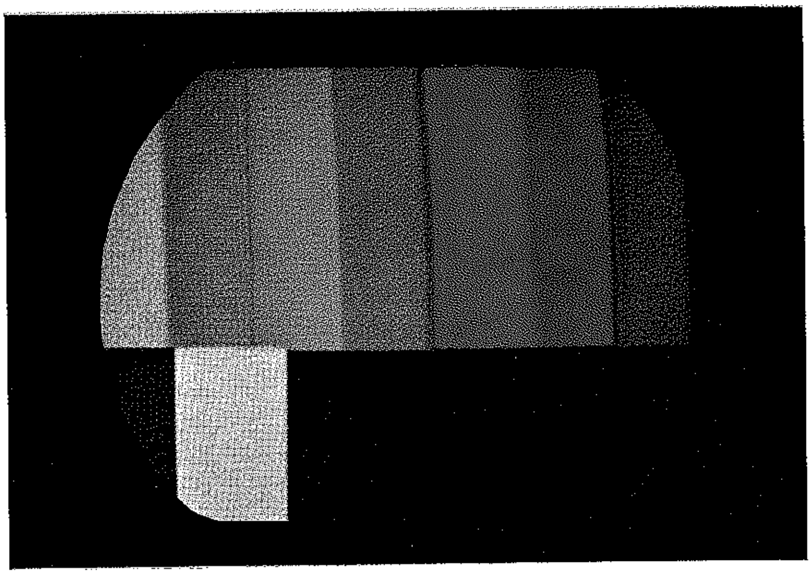

FIG. 167 — COLOR BAR SIGNAL — YELLOW SHIFTED TOWARD GREEN

Glossary of Television Terms

1. General

This section defines various terms presently used in the line-up, operation and maintenance of video transmission systems. Experience in providing video service has indicated that a common understanding and use of the terms outlined in this section by the telephone companies and the broadcasting companies is desirable. Because these terms are intended for practical use by operating personnel, they may differ somewhat in wording from published standards which are not as well suited for the intended purpose.

2. Terms and Definitions

Aspect Ratio: The numerical ratio of picture width to height.

Back Porch: That portion of the composite picture signal which lies between the trailing edge of the horizontal sync pulse and the trailing edge of the corresponding blanking pulse.

Back Porch Tilt: The slope of the back porch from its normal horizontal position. Positive or negative refers, respectively, to upward or downward tilt to the right.

Bandwidth: The number of cycles per second expressing the difference between the limiting frequencies of a frequency band. For example, the 2.5-3.5 mc band has a width of 1 mc.

Black Compression: Amplitude compression of the signals corresponding to the black regions of the picture, thus modifying the tonal gradient.

Black Peak: The maximum excursion of the picture signal in the black direction at the time of observation.

Blacker-than-Black: The amplitude region of the composite video signal below reference black level in the direction of the synchronizing pulses.

Blanking (Picture): The portion of the composite video signal whose instantaneous amplitude makes the vertical and horizontal retrace invisible.

Blanking Level: The level of the front and back porches of the composite video signal.

Bleeding Whites: An overloading condition in which white areas appear to flow irregularly into black areas.

Blooming: The defocussing of regions of the picture where the brightness is at an excessive level, due to enlargement of spot size and halation of the fluorescent screen of the cathode-ray picture tube.

Bounce: An unnatural sudden variation in the brightness of the picture.

Breathing: Amplitude variations similar to "bounce" but at a slow regular rate.

Breezeway: In NTSC color, that portion of the back porch between the trailing edge of the sync pulse and the start of the color burst.

Burned-in Image: An image which persists in a fixed position in the output signal of a camera tube after the camera has been turned to a different scene.

Camera Tube: See Pickup Tube.

Cathode-ray Tube: An electron tube assembly containing an electron gun arranged to direct a beam upon a fluorescent screen. Scanning by the beam can produce light at all points in the scanned raster.

Chrominance Signal: That portion of the NTSC color television signal which contains the color information.

Clamper: A device which functions during the horizontal blanking or sync interval to fix the level of the picture signal at some predetermined reference level at the beginning of each scanning line.

Clamping: The process that establishes a fixed level for the picture signal at the beginning of each scanning line.

Clipping: The shearing off of the peaks of a signal. For a picture signal, this may affect either the positive (white) or negative (black) peaks. For a composite video signal, the sync signal may be affected.

Color Burst: In NTSC color, normally refers to a burst of approximately 9 cycles of 3.6 mc subcarrier on the back porch of the composite video signal. This serves as a color synchronizing signal to establish a frequency and phase reference for the chrominance signal.

Color Subcarrier: In NTSC color, the carrier whose modulation sidebands are added to the monochrome signal to convey color information, i.e., 3.6 mc (3.579545 mc).

Color Transmission: The transmission of a signal which represents both the brightness values and the color (chrominance) values in a picture.

Composite Video Signal: The complete video signal. For monochrome, it consists of the picture signal and the blanking and synchronizing signals. For color, additional color synchronizing signals and color picture information are added.

Compression: An undesired decrease in amplitude of a portion of the composite video signal relative to that of another portion. Also, a less than proportional change in output of a circuit for a change in input level. For example, compression of the sync pulse means a decrease in the percentage of sync during transmission.

Contrast: The range of light and dark values in a picture, or the ratio between the maximum and minimum brightness values. For example, in a high contrast picture there would be intense blacks and whites, whereas a low contrast picture would contain only various shades of gray.

CRO: Cathode ray oscilloscope.

Crosstalk: An undesired signal interfering with the desired signal.

Cutoff Frequency: That frequency beyond which no appreciable energy is transmitted. It may refer to either an upper or lower limit of a frequency band.

Damped Oscillation: Oscillation which, because the driving force has been removed, gradually dies out, each swing being smaller than the preceding in smooth regular decay.

De-emphasis: See Restorer.

Definition: See Resolution–(Horizontal) and (Vertical).

Delay Distortion: Distortion resulting from nonuniform speed of transmission of the various frequency components of a signal; i.e., the various frequency components of the signal have different times of travel (delay) between the input and the output of a circuit.

Detail: Refers to the most minute elements in a picture which are distinct and recognizable. Similar to definition or resolution.

Differential Gain: The amplitude change, usually of the 3.6 mc color subcarrier, introduced by the over-all circuit, measured in db or per cent, as the picture signal on which it rides is varied from blanking to white level.

Differential Phase: The phase change of the 3.6 mc color subcarrier introduced by the over-all circuit, measured in degrees, as the picture signal on which it rides is varied from blanking to white level.

Displacement of Porches: Refers to any difference between the level of the front porch and the level of the back porch.

Distortion: The departure, during transmission or amplification, of the received signal wave form from that of the original transmitted wave form.

Driving Signals: Signals that time the scanning at the pickup device.

Echo (or Reflection): A wave which has been reflected at one or more points in the transmission medium, with sufficient magnitude and time difference to be perceived in some manner as a wave distinct from that of the main or primary transmission. Echoes may be either leading or lagging the primary wave and appear in the picture monitor as reflections or "ghosts."

Edge Effect: See Following or Leading White and Following or Leading Black.

EIA: Abbreviation for Electronic Industries Association.

Equalizing Pulses: Pulses of one half the width of the horizontal sync pulses which are transmitted at twice the rate of the horizontal sync pulses during the blanking intervals immediately preceding and following the vertical sync pulses. The action of these pulses causes the vertical deflection to start at the same time in each interval, and also serves to keep the horizontal sweep circuits in step during the vertical blanking intervals immediately preceding and following the vertical sync pulse.

Expansion: An undesired increase in amplitude of a portion of the composite video signal relative to that of another portion. Also, a greater than proportional change in the output of a circuit for a change in input level. For example, expansion of the sync pulse means an increase in the percentage of sync during transmission.

Field: One half of a complete picture (or frame) interval, containing all of the odd or even scanning lines of the picture.

Field Frequency: The rate at which a complete field is scanned, nominally 60 times a second.

Flash: Momentary interference to the picture of a duration of approximately one field or less, and of sufficient magnitude to totally distort the picture information. In general, this term is used alone when the impairment is of such short duration that the basic impairment cannot be recognized. Sometimes called "hit."

Fly-back: See Horizontal Retrace.

Following (or Trailing) Blacks: A term used to describe a picture condition in which the edge following a white object is overshaded toward black. The object appears to have a trailing black border. Also called "trailing reversal."

Following (or Trailing) Whites: A term used to describe a picture condition in which the edge following a black or dark gray object is shaded toward white. The object appears to have a trailing white border. Also called "trailing reversal."

Frame: One complete picture consisting of two fields of interlaced scanning lines.

Frame Frequency: The rate at which a complete frame is scanned, nominally 30 frames per second.

Front Porch: That portion of the composite picture signal which lies between the leading edge of the horizontal blanking pulse, and the leading edge of the corresponding sync pulse.

Frame Roll: A momentary roll.

Gain-frequency Distortion: Distortion which results when all of the frequency components of a signal are not transmitted with the same gain or loss. A departure from "flatness" in the gain-frequency characteristic of a circuit.

Ghost: A shadowy or weak image in the received picture, offset either to the left or right of the primary image, the result of transmission conditions which create secondary signals that are received earlier or later than the main or primary signal. A ghost displaced to the left of the primary image is designated as "leading" and one displaced to the right is designated as "following" (lagging). When the tonal variations of the ghost are the same as the primary image, it is designated as "positive" and when it is the reverse, it is designated as "negative."

Glitch: A form of low-frequency interference, appearing as a narrow horizontal bar moving vertically through the picture. This is also observed on an oscilloscope at field or frame rate as an extraneous voltage pip moving along the signal at approximately reference black level.

Halo: Most commonly, a dark area surrounding an unusually bright object, caused by overloading of the camera tube. Reflection of studio lights from a piece of jewelry, for example, might cause this effect. With certain camera tube operating adjustments, a white area may surround dark objects.

Height: The size of the picture in a vertical direction.

High-frequency Distortion: Distortion effects which occur at high frequency. Generally considered as any frequency above the 15.75 kc line frequency.

High-frequency Interference: Interference effects which occur at high frequency. Generally considered as any frequency above the 15.75 kc line frequency.

Highlights: The maximum brightness of the picture, which occurs in regions of highest illumination.

Hit: See Flash.

Horizontal Blanking: The blanking signal at the end of each scanning line.

Horizontal Displacements: Describes a picture condition in which the scanning lines start at relatively different points during the horizontal scan. See Serrations and Jitter.

Horizontal Retrace: The return of the electron beam from the right to the left side of the raster after the scanning of one line.

Horizontal (Hum) Bars: Relatively broad horizontal bars, alternately black and white, which extend over the entire picture. They may be stationary, or may move up or down. Sometimes referred to as a "venetian blind" effect. Caused by approximate 60-cycle interfering frequency, or one of its harmonic frequencies.

Hue: Corresponds to "color" in everyday use; i.e., red, blue, etc. Black, white and gray do not have hue.

Iconoscope: A camera tube in which a high-velocity electron beam scans a photoemissive mosaic which has electrical storage capability.

Interference: In a signal transmission path, extraneous energy which tends to interfere with the reception of the desired signals.

Interlaced Scanning (Interlace): A scanning process in which each adjacent line belongs to the alternate field.

Ion: A charged atom, usually an atom of residual gas in an electron tube.

Ion Spot: A spot on the fluorescent surface of a cathode-ray tube, which is somewhat darker than the surrounding area because of bombardment by negative ions which reduce the sensitivity.

Ion Trap: An arrangement of magnetic fields and apertures which will allow an electron beam to pass through but will obstruct the passage of ions.

IRE: The Institute of Radio Engineers. This organization combined with the American Institute of Electrical Engineers effective January 1, 1963, to form the Institute of Electrical and Electronic Engineers.

IRE Roll-off: The IRE standard oscilloscope frequency response characteristic for measurement of level. This characteristic is such that at 2 megacycles the response is approximately 8.5 db below that in the flat (low-frequency) portion of the spectrum, and cuts off slowly. The latest standards for this roll-off were issued in 1958. It is not anticipated that the usage of the term "IRE Roll-off" will be changed in any way.

IRE Scale: An oscilloscope scale in keeping with IRE Standard 50, IRE 23.S1 and the recommendations of the Joint Committe of TV Broadcasters and Manufacturers for Coordination of Video Levels.

Jitter: A tendency toward lack of synchronization of the picture. It may refer to individual lines in the picture or to the entire field of view.

Kinescope: Frequently used to mean picture tubes in general; however, this name has been copyrighted.

Kinescope Recording: A motion picture film recording of the presentation shown by a picture monitor. Also known as Television Recording (TVR), Vitapix, etc.

Leading Blacks: A term used to describe a picture condition in which the edge preceding a white object is overshaded toward black. The object appears to have a preceding or leading black border.

Leading Whites: A term used to describe a picture condition in which the edge preceding a black object is shaded toward white. The object appears to have a preceding or leading white border.

Line Frequency: The number of horizontal scans per second, nominally 15,750 times per second.

Low-frequency Distortion: Distortion effects which occur at low frequency. Generally considered as any frequency below the 15.75 kc line frequency.

Low-frequency Interference: Interference effects which occur at low frequency. Generally considered as any frequency below the 15.75 kc line frequency.

Luminance Signal: That portion of the NTSC color television signal which contains the luminance or brightness information.

Meshbeat: See Moiré.

Microphonics: In video transmission, refers to the mechanical vibration of the elements of an electron tube resulting in a spurious modulation of the normal signal. This usually results in erratically spaced horizontal bars in the picture.

Microsecond: One millionth of a second.

Moiré: A wavy or satiny effect produced by convergence of lines. Usually appears as a curving of the lines in the horizontal wedges of the test pattern and is most pronounced near the center where the lines forming the wedges converge. A moiré pattern is a natural optical effect when converging lines in the picture are nearly parallel to the scanning lines. This effect, to a degree, is sometimes due to the characteristics of color picture tubes and of image orthicon pickup tubes (in the latter termed "meshbeat").

Monochrome Transmission (Black and White): The transmission of a signal wave which represents the brightness values in the picture, but not the color (chrominance) values in the picture.

Multiple Blanking Lines: Evidenced by a thickening of the blanking line trace or by several distinct blanking lines as viewed on an oscilloscope. May be caused by hum.

Negative Image: Refers to a picture signal having a polarity which is opposite to normal polarity and which results in a picture in which the white areas appear as black and vice versa.

NTSC: National Television System Committee.

Noise: The word "noise" is a carryover from audio practice. Refers to random spurts of electrical energy or interference. May produce a "salt-and-pepper" pattern over the picture. Heavy noise sometimes is called "snow."

Orthicon (Conventional): A camera tube in which a low-velocity electron beam scans a photoemissive mosaic on which the image is focused optically and which has electrical storage capability.

Orthicon (Image): A camera tube in which the optical image falls on a photoemissive cathode which emits electrons that are focussed on a target at high velocity. The target is scanned from the rear by a low-velocity electron beam. Return beam modulation is amplified by an electron multiplier to form an over-all light-sensitive device.

Orthicon Effect: One or more of several image orthicon impairments that have been referred to as "Orthicon Effect" as follows:

1. Edge effect—usually a white outline of well defined objects.
2. Meshbeat or moiré.
3. Ghost—appears in connection with bright images and is not limited in position to leading or lagging the main image.
4. Halo
5. Burned-in image

It is obviously necessary to indicate specifically the effect or effects experienced and, therefore, it is recommended that use of this term be discontinued.

Overshoot: An excessive response to a unidirectional signal change. Sharp overshoots are sometimes referred to as "spikes."

Pairing: A partial or complete failure of interlace in which the scanning lines of alternate fields do not fall exactly between one another but tend to fall (in pairs) one on top of the other.

Peak-to-Peak: The amplitude (voltage) difference between the most positive and the most negative excursions (peaks) of an electrical signal.

Pedestal: This term is obsolete.

Pedestal Level: This term is obsolete; "blanking level" is preferred.

Percentage Sync: The ratio, expressed as a percentage, of the amplitude of the synchronizing signal to the peak-to-peak amplitude of the picture signal between blanking and reference white level.

Photoemissive: Emitting or capable of emitting electrons upon exposure to radiation in and near the visible region of the spectrum.

Pickup Tube: An electron-beam tube used in a television camera where an electron current or a charge-density image is formed from an optical image and scanned in a predetermined sequence to provide an electrical signal.

Picture Monitor: This refers to a cathode-ray tube and its associated circuits, arranged to view a television picture.

Picture Signal: That portion of the composite video signal which lies above the blanking level and contains the picture information.

Picture Tube: A cathode-ray tube used to produce an image by variation of the intensity of a scanning beam.

Pigeons: Noise observed on picture monitors as pulses or bursts of short duration, at a slow rate of occurrence—a type of impulse noise.

Polarity of Picture Signal: Refers to the polarity of the black portion of the picture signal with respect to the white portion of the picture signal. For example, in a "black negative" picture, the potential corresponding to the black areas of the picture is negative with respect to the potential corresponding to the white areas of the picture; while in a "black positive" picture the potential corresponding to the black areas of the picture is positive. The signal as observed at broadcasters' master control rooms and telephone company television operating centers is "black negative."

Pre-emphasis: A change in level of some frequency components of the signal with respect to the other frequency components at the input to a transmission system. The high-frequency portion of the band is usually transmitted at higher level than the low-frequency portion of the band.

Raster: The scanned (illuminated) area of the cathode-ray picture tube.

Reference Black Level: The level corresponding to the specified maximum excursion of the luminance signal in the black direction.

Reference Signals (Vertical Interval): Signals inserted into the vertical interval at the program source which are used to establish black and white levels. Such a signal might consist of five microseconds of reference black at 7.5 IRE divisions and five microseconds of reference white at 100 IRE divisions located near the end of lines 18 and 19 of the vertical interval.

Reference White Level: The level corresponding to the specified maximum excursion of the luminance signal in the white direction.

Reflections or Echoes: In video transmission this may refer either to a signal or to the picture produced.

1. Signal:
   (a). Waves reflected from structures or other objects.
   (b). Waves which are the result of impedance or other irregularities in the transmission medium.
2. Picture: "Echoes" observed in the picture produced by the reflected waves.

Resolution (Horizontal): The amount of resolvable detail in the horizontal direction in a picture. It is usually expressed as the number of distinct vertical lines, alternately black and white, which can be seen in three quarters of the width of the picture. This information usually is derived by observation of the vertical wedge of a test pattern. A picture which is sharp and clear and shows small details has good, or high, resolution. If the picture is soft and blurred and small details are indistinct it has poor, or low, resolution. Horizontal resolution depends upon the high-frequency amplitude and phase response of the pickup equipment, the transmission medium and the picture monitor, as well as the size of the scanning spots.

Resolution (Vertical): The amount of resolvable detail in the vertical direction in a picture. It is usually expressed as the number of distinct horizontal lines, alternately black and white, which can be seen in a test pattern. Vertical resolution is primarily fixed by the number of horizontal scanning lines per frame. Beyond this, vertical resolution depends on the size and shape of the scanning spots of the pickup equipment and picture monitor and does not depend upon the high-frequency response or bandwidth of the transmission medium or picture monitor.

Restorer: As used by the telephone company, a network designed to remove the effects of pre-emphasis, thereby resulting in an over-all normal characteristic.

Retrace (Return Trace): See Horizontal and Vertical Retrace.

R-F Pattern: A term sometimes applied to describe a fine herringbone pattern in a picture. May also cause a slight horizontal displacement of scanning lines resulting in a rough or ragged vertical edge of the picture. Caused by high-frequency interference.

Ringing: An oscillatory transient occurring in the output of a system as a result of a sudden change in input. Results in close-spaced multiple reflections, particularly noticeable when observing test patterns, equivalent square waves, sine-squared signal, or any fixed objects whose reproduction requires frequency components approximating the cutoff frequency of the system.

Roll: A lack of vertical synchronization which causes the picture as observed on the picture monitor to move upward or downward.

Roll-off: A gradual attenuation of gain-frequency response at either or both ends of the transmission pass band.

Saturation (Color): The "vividness" of a color described by such terms as pale, deep, pastel, etc. The greater the amplitude of the chrominance signal, the greater the saturation.

Scanning: The process of breaking down an image into a series of elements or groups of elements representing light values and transmitting this information in time sequence.

Scanning Line: A single continuous narrow strip of the picture area containing highlights, shadows, and halftones, determined by the process of scanning.

Scanning Spot: Refers to the cross section of an electron beam at the point of incidence in a camera tube or picture tube.

Serrated Pulses: A series of equally spaced pulses within a pulse signal. For example, the vertical sync pulse is serrated in order to keep the horizontal sweep circuits in step during the vertical sync pulse interval.

Serrations: This is a term used to describe a picture condition in which vertical or nearly vertical lines have a saw-tooth appearance. The result of scanning lines starting at relatively different points during the horizontal scan.

Setup: The separation in level between blanking and reference black levels.

Smear: A term used to describe a picture condition in which objects appear to be extended horizontally beyond their normal boundaries in a blurred or "smeared" manner.

Snow: Heavy random noise.

Spike: See Overshoot.

Streaking: A term used to describe a picture condition in which objects appear to be extended horizontally beyond their normal boundaries. This will be more apparent at vertical edges of objects when there is a large transition from black to white or white to black. The change in luminance is carried beyond the transition, and may be either negative or positive. For example, if the tonal degradation is an opposite shade to the original figure (white following black), the streaking is called negative; however, if the shade is the same as the original figure (white following white), the streaking is called positive. Long streaking may extend to the right edge of the picture, and in extreme cases of low-frequency distortion, can extend over a whole line interval.

Synchronization: The maintenance of one operation in step with another.

Sync: An abbreviation for the words "synchronization," "synchronizing," etc. Applies to the synchronization signals, or timing pulses, which lock the electron beam of the picture monitors in step, both horizontally and vertically, with the electron beam of the pickup tube. The color sync signal (NTSC) is known as the color burst.

Sync Compression: The reduction in the amplitude of the sync signal, with respect to the picture signal, occurring between two points of a circuit.

Sync Level: The level of the tips of the synchronizing pulses.

Tearing: A term used to describe a picture condition in which groups of horizontal lines are displaced in an irregular manner. Caused by lack of horizontal synchronization.

Television Recording (TVR): See Kinescope Recording.

Transients: Signals which endure for a brief time prior to the attainment of a steady state condition. These may include overshoots, damped sinusoidal waves, etc., and therefore, additional qualifying information is necessary.

Vertical Blanking: Refers to the blanking signals which occur at the end of each field.

Vertical Retrace: The return of the electron beam from the bottom to the top of the raster after completion of each field.

Vestigial Sideband Transmission: A system of transmission wherein the sideband on one side of the carrier is transmitted only in part.

Video: A term pertaining to the bandwidth and spectrum position of the signal which results from television scanning and which is used to reproduce a picture.

Video Band: The frequency band utilized to transmit a composite video signal.

Video-in-Black: A term used to describe a condition as seen on the wave-form monitor when the black peaks extend through reference black level.

Video Tape Recording (VTR): A magnetic tape recording of the composite video signal.

Wave-form Monitor: This refers to a cathode-ray oscilloscope used to view the form of the composite video signal for wave-form analysis. Sometimes called "A-scope."

White Compression: Amplitude compression of the signals corresponding to the white regions of the picture, thus modifying the tonal gradient.

White Peak: The maximum excursion of the picture signal in the white direction at the time of observation.

Width: The size of the picture in a horizontal direction.

3. Degrees of Impairments

Television picture impairments may be present in varying degrees. In the case of oscilloscope presentations, most impairments can best be described to remote points by indicating the IRE scale readings of the various signal components. In the case of picture monitor presentations, however, impairments generally must be described in qualitative terms rather than quantitative terms, and the exchange of intelligence between remote observers is more complicated. The following descriptive terms, without a sharp line of demarcation being possible, are in common usage for indicating the magnitude of impairments:

Detectable: Impairment is not readily noticeable in a normal picture or oscilloscope display, but can be discerned by a minute inspection of the signal, it sometimes being necessary to vary picture monitor brightness or expand oscilloscope presentations.

Noticeable: Impairment is readily observed.

Objectionable: Impairment interferes with the viewing of the picture.

Unfit For Broadcast (UFB): Impairment is present to such degree that the program or portion of the program is not used.

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