Camera Tube

Application Note

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Vidicon Camera Tubes in Television Film Camera Service

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Contents

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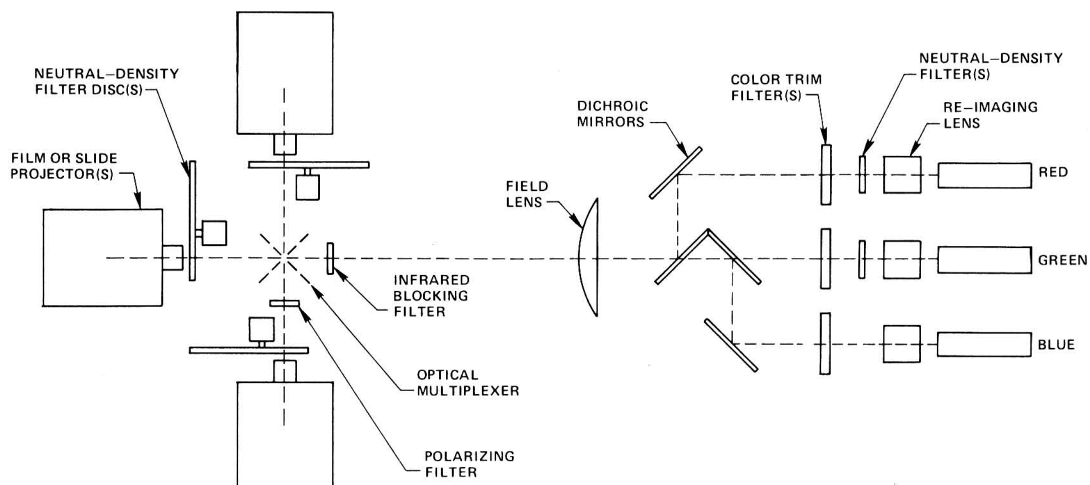
Introduction

Significant improvements in vidicon camera tubes have been attained since these devices were first used in television film-pickup service. Present-day vidicons have better resolution, improved signal uniformity, and increased sensitivity; there are also types designed, or selected, for use in specific camera systems.

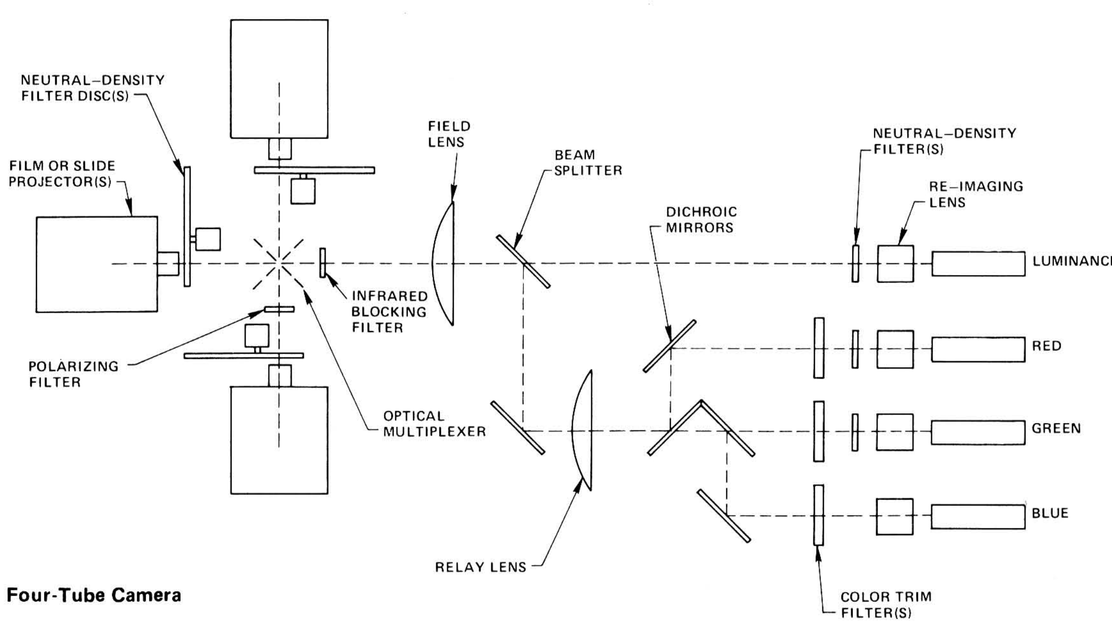
The performance of older TV cameras, and sometimes newer cameras, can be improved by using one of the newer vidicon types. This comprehensive outline of the basic principles and techniques used in vidicon film camera set-up and operation is a guide for selecting the best available vidicon type for the different cameras and as a general source of information that may be helpful in the design of vidicon film cameras.

No attempt is made to give a step-by-step set-up procedure for a particular camera but important practices, common to all cameras, are covered in some detail.

Schematics of a typical three-tube and a typical four-tube color film television camera are shown in **Figure 1**.



Three-Tube Camera



Four-Tube Camera

Figure 1 — Diagrams of Typical Three-Tube and Four-Tube Color TV Cameras

Section I — General Principles

Principal vidicon operating conditions and the influence of camera electronics and optics on film camera performance are summarized below with each factor being discussed in detail on subsequent pages.

A. **Vidicon Operating Factors**
   1. Illumination
   2. Vidicon Dark Current
   3. Signal Levels
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   4. Light Polarization Affects
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A. **Vidicon Operating Factors**

1. **Proper Illumination** is the most important requirement for best camera performance. Vidicons should always be exposed to the highest practical illumination levels available from the system's film or slide projectors. Typically, the illumination on the vidicon's faceplate should be approximately equivalent to 150 footcandles of white light from an incandescent source. High illumination levels permit vidicon operation at low dark current levels.

2. **Dark Current,** as implied, is the signal produced with no illumination on the photoconductor of the vidicon. Operation at low dark current levels improves lag (the signal persistence due to scene motion), reduces image retention (the signal persistence due to extended exposure), and produces a more uniform and stable background signal. Proper low dark current operation can only be achieved if the vidicon is exposed to the proper illumination levels.

   The curves of **Figure 2** illustrate typical reductions in lag and vidicon dark current that can be attained as functions of chosen vidicon faceplate highlight illumination.

   As shown by the curve, an increase in light level from 5 to 150 footcandles typically produces a 5:1 decrease in lag.

   A "bias" light is often used to illuminate the vidicon photoconductor to reduce lag. Some camera designs flood the vidicon faceplate with a controlled, uniform bias light to produce a signal current of 10 to 20 nanoamperes for this purpose.

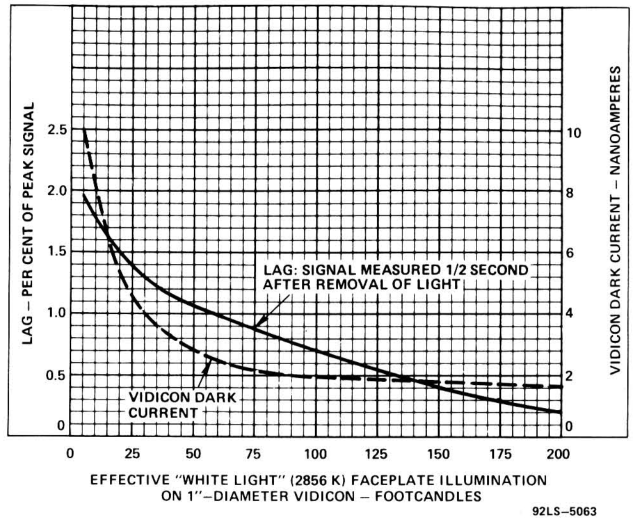

Figure 2 — Typical Lag and Dark Current as Functions of the Faceplate Illumination Required to Produce a 300 nA Signal at Each Dark Current Setting for a Typical Type II Photoconductor

   Dark current is controlled by adjusting target voltage and it should be noted that from tube-to-tube, the target voltage required for a given dark current may vary as much as 2:1. **Figure 3** and **Figure 4** are typical characteristic curves illustrating the rate of change of dark current as a function of target voltage and the range of dark current that may be expected from tube-to-tube.

   In properly adjusted film cameras, vidicon dark current is typically 2 nanoamperes. It should never exceed 10 nanoamperes.

   Although target voltage controls vidicon sensitivity, or signal output, dark current must be the primary consideration. Target voltage should **never** be set to some arbitrary value.

   The procedures used to adjust target voltage are described in a following section.

3. **Highlight Signal Levels**

   Highlight signal current from a vidicon is usually about 300 nanoamperes. Operation at signal currents in excess of 500 nanoamperes produces poorer resolution and tube life may be diminished. At low signal currents (below 300 nanoamperes), lag and image retention may become a problem. Lag and image retention are time-diminishing signals and their subjective (and measured) picture impairment will worsen as operating signal levels are reduced.

Signal-to-noise ratio is also poorer at low signal levels. The vidicon does not generate appreciable noise; virtually all of the noise is generated in the first stages of the video amplifier. When signal-to-noise problems are encountered, it is either the result of low signal output from the vidicon or high noise level from the input amplifier stage.

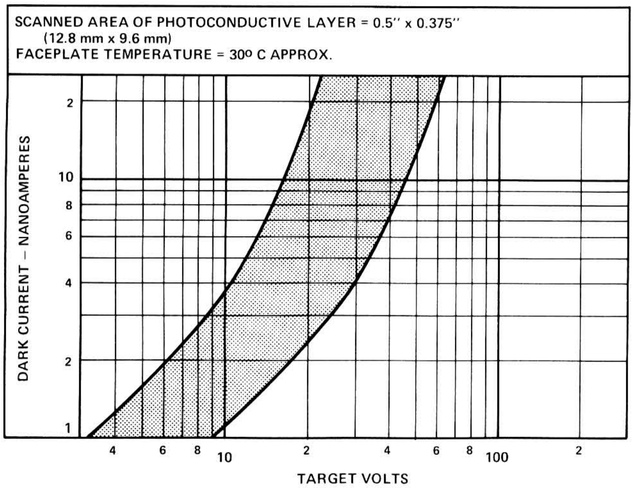

Figure 3 — Dark Current vs Target Voltage for RCA Photoconductor, Type I

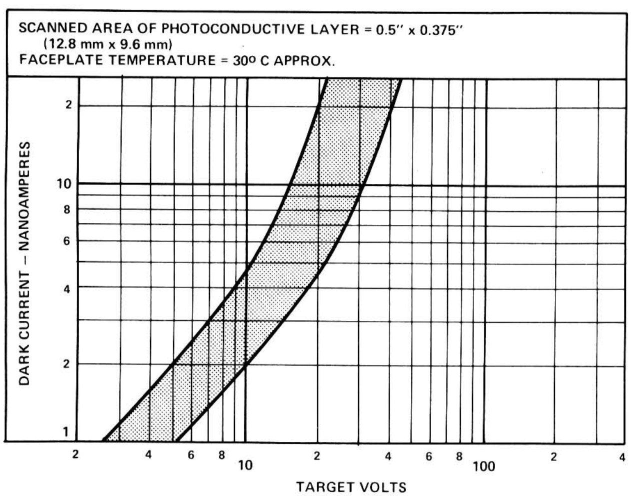

Figure 4 — Dark Current vs Target Voltage for RCA Photoconductor, Type II

a. **Measuring Signal Currents and Dark Currents.** Most film cameras have a provision to calibrate the vidicon signal level to a standard reference level. Cameras have either a calibrated pulse signal that can be switched in; a video amplifier system with fixed, regulated and calibrated gain, or a current meter in the vidicon target circuit.

In cameras having none of these provisions, the peak-to-peak signal current can be determined by measuring the voltage across the vidicon load resistor with a high-gain oscilloscope and calculating the current. The signal level is then adjusted to the level recommended by the camera manufacturer and the video amplifier adjusted and fixed to provide a calibrated reference level on the video waveform monitor.

It is convenient to establish the dark current level as a percentage of the calibrated peak signal current. This measurement is made with an oscilloscope, or the waveform monitor at the operator's console, at a point in the video amplifier prior to gamma correction or with the gamma set to unity.

The dark current level is determined by observing and measuring the pedestal shift as the vidicon beam is turned off and on, as illustrated in **Figure 5.** The dark current should preferrably be less than 3 nanoamperes (1.0% of the 300 nA video signal) and no more than 10 nanoamperes (3.3% of the 300 nA video signal).

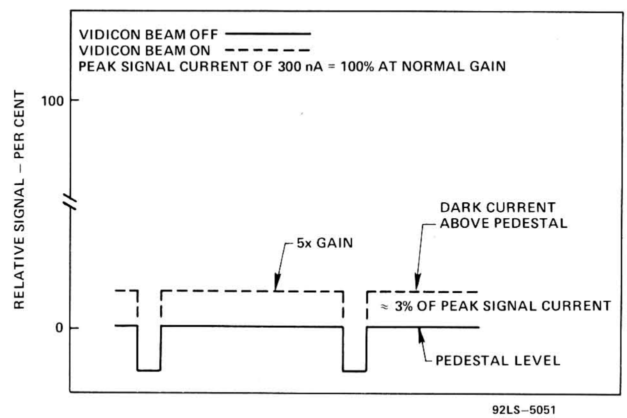

Figure 5 — Illustration of Dark Current Signal Measurement Technique as Observed on a Waveform Monitor

Because the oscilloscope or waveform monitor must resolve dark current signal levels that may be only 1.0 per cent of peak highlight levels, the measurement is more easily made using a calibrated oscilloscope gain of 5x or 10x after the peak signal current level is established.

Restricting the bandwidth at the oscilloscope, or bypassing the high frequencies with a capacitor at the input of the 'scope will reduce noise and further improve the accuracy of this measurement.

Some camera users adjust dark current signal levels by observing black areas of a picture on the waveform monitor. This practice may not produce accurate dark current settings where optical flare exists and is dissimilar in the chroma channels of the camera. Optical flare is discussed on page 12.

4, 5 **Operation with Equal Signal and Equal Dark Current for Best Color Tracking**
Signal levels from the chroma channels must track equally over the grey scale range (black to highlight signal level) specified for the camera. To achieve best signal tracking, vidicons should be operated with **Equal Signal and Equal Dark Current** levels. Equal signal levels are obtained by attenuating the light in the more "sensitive" channels to match the signal level of the least sensitive channel. The least sensitive channel is usually the blue channel. Neutral density filters are recommended for such light attenuation. The use of the lens iris for attenuating the light into each color channel should be discouraged as it generally produces color shading problems. As a practical matter, the signal balancing procedure is performed using that projector in the system that has the least light output with a neutral density filter placed in the light path between the projector and the camera to simulate the most dense film that may be encountered in day-to-day operation.

The illumination from the limiting projector in the system must be increased if this procedure results in signal levels that are too low or if the dark currents are greater than 10 nanoamperes.

To maintain white balance in the system, the projector lamps should be operated within a few volts of their maximum ratings and be adjusted to produce equal color temperatures.

a. **The Set-Up of Dark Current and Signal Levels for Color and Black-and-White Cameras Having Manual or Automatic Operation by Means of Light Control Systems**
These cameras should be set-up and adjusted as described in Section II.

The light control system usually used to accomodate the variations in film densities is a varying neutral-density filter disc in the camera optical path. This disc is either manually or automatically controlled to maintain the desired signal output level. During the set-up procedure described in Section II, the neutral density wheel is adjusted to simulate the most dense film that is expected in normal use. With this system of control, the vidicon tubes will always be exposed to the same light levels.

In black-and-white film cameras there is no necessity to maintain a constant color of illuminating light and therefore projector lamp brightness can be varied by controlling lamp voltage.

b. **The Set-Up of Dark Current and Signal Levels for Color Cameras Having Automatic Operation by Means of Target Voltage Control**
Some color film cameras are designed to automatically vary target voltage (sensitivity) to compensate for differences in film density or projector light level. These systems will have good signal tracking over a wide range of light level or film density if the target voltage control system varies the target voltage on each vidicon proportionally to produce equal dark currents throughout the range of target voltages needed to accomodate the variations in film densities.

The color film camera is initially set-up using a neutral-density filter to simulate the most dense film that may be encountered. To simulate high-transmission film, the filter is then removed and the automatic target voltage control system is re-adjusted to produce equal dark currents and equal signal currents. With this set-up procedure, any target voltage variations produced in response to variations in film densities (via the signal level control system) will result in good signal tracking because the dark currents are maintained equally for all the vidicons.

With automatic target control systems, the vidicons are always operated under the most advantageous conditions consistent with the available light. At high illumination levels (least dense film), target voltage and dark current are low, and after image and lag are at a minimum.

6. **Proper Beam Current Settings**
The vidicon beam control should be adjusted to discharge the picture highlights at the signal level specified for the camera plus a reserve of an additional 10 per cent signal level (after gamma correction) to properly handle peak signal excursions.

Overbeaming the vidicon should be avoided for, aside from any life considerations, both resolution and picture geometry are degraded by excessive beam current. This is especially true of vidicons having the G_3 and G_4 electrodes connected internally (mutual-mesh vidicon types).

7. **Vidicon Beam Alignment**
The vidicon beam is properly aligned when the alignment controls are adjusted so that the center of the picture does not move and the picture itself just rotates about its center as the electrical focus control is rocked back and forth through best focus.

Some cameras are provided with a focus "rock" circuit as a beam alignment convenience which simplifies the operation.

An alternate technique for obtaining good beam alignment is to increase the light level to its maximum value and reduce the target voltage to the point where a picture is just visible. The alignment controls are than adjusted to produce the highest signal output consistent with best signal uniformity. The target voltage should then be restored to its normal operating voltage.

Alignment should always be performed after the proper beam current setting is established.

Failure to properly align the beam usually results in poorer resolution and resolution uniformity, and poorer signal uniformity. It may also produce geometric distortions which can cause registration problems in color cameras.

8. **Vidicon Registration in Color Cameras**
   In a four-tube camera, the chroma channels are usually registered to the luminance channel. This technique is good practice because proper picture orientation for the camera system should be first established for the most critical, i.e., the luminance channel. It is advisable to first carefully register the green channel to the luminance channel and then register the blue and red channels to the green channel. Chroma channel registration errors are the most noticeable; they produce color errors at the picture edges while slight misregistration between the chroma and luminance channels is usually unnoticed.

   In a three-tube camera system, the green channel is carefully set-up to establish proper picture orientation for the system and then the blue and red channels are registered to the green channel. Registration is a more critical operation in three-tube cameras than in four-tube cameras because the combined outputs from the three chroma channels must also generate satisfactory picture detail.

   A common registration error results from misuse of the skew control. This control should be used to register the picture in the vertical plane after the horizontal plane has been registered by rotation of the deflection yokes. The skew control of the green or luminance channel should be adjusted to make the vertical and horizontal lines parallel to the lines of an electrical grating signal.

   Because beam alignment is important in obtaining good registration, it is advisable to check alignment before making registration adjustments. Proper beam alignment is especially important for electrostatically-focused vidicon types.

   At times, registration problems in cameras of older design are due to residual magnetism in metals that are in proximity to the vidicons. These residual fields can be eliminated with a degaussing coil and the same techniques employed for degaussing color picture tubes.

B. **Camera Electronic Factors**

1. **Focus and Deflection Components**
   Focus and deflection components determine many of the picture characteristics produced by a television camera. Focus uniformity, picture geometry, and signal output uniformity may not be as good in one camera as they are in another if the electrical and mechanical characteristics of the focus and deflection coils are dissimilar in the cameras.

2. **Proper Gun Voltages**
   Focus uniformity, signal uniformity, and picture geometry are also influenced by the ratio of G_3/G_4 voltages in magnetically-focused vidicons and by the ratio of G_5/G_6 voltages in electrostatically-focused types. Camera manuals generally indicate tube operating voltages and these should be checked as maintenance routine, especially if there is evidence of performance irregularities.

   For longest tube life, the cathode heater voltages should be maintained within published ratings. Experience indicates that tube operation at 10% above rated heater voltage will reduce tube life by nearly one-half. Heater voltage should be checked with the vidicon load on the supply.

3. **Video Amplifiers**
   Video amplifiers generate virtually all of the noise in the camera system. When excessive noise is encountered, the amplitude of the highlight signal current being used should be checked.

C. **Optical Factors Affecting Camera Performance.**

1. **Projector Lamp Color Temperature**
   White and color signal balance can only be maintained if all projectors are operated at the same color temperature. To obtain equal color temperatures, the projector lamps should be of the same type and be operated within a few volts of their rated values. Different types of lamps, e.g., tungsten or tungsten-halogen, usually operate at different color temperatures.

   When projector lamps are operated at reduced voltage ratings, the blue light output is noticeably less.

   Because the blue channel of a color camera is usually the limiting channel, any reduction in blue light reduces overall system sensitivity and the ability to handle a wide range of film densities. It should be noticed that as lamps age, a shift in color temperature can occur.

2. **Light Scattering in the Optical System**
Poor grey scale tracking, a common criticism of color film cameras, is traceable in most cases to light scattered by the numerous elements of the optical system. Light scattering by dirt and film deposits on optical surfaces will result in a shift of black level that may differ in the different color channels and may vary with the average brightness level of the image in that channel. Variable gamma controls are sometimes used to compensate for this problem but where possible, the defect should be corrected by proper maintenance procedures. Some cameras of more advanced design vary the individual black level of each channel slightly in response to the average signal in the channel to compensate for light scattering affects.

   Flare control systems should only be put into use and adjusted after the vidicon dark currents have been equalized.

3. **Infrared Radiation**
Unlike black-and-white film, color film is highly transparent to infrared light. Vidicons, especially those having the RCA Type II photoconductor, have substantial infrared sensitivity. When infrared light passes through the optical system of a color camera, colorimetry, and tracking problems sometimes occur. An infrared blocking filter placed in the optical path will often identify and correct this condition. Because the red channel of a color camera usually has more than adequate light, the insertion of the IR filter does not significantly reduce the overall sensitivity of the camera. However, infrared problems are not necessarily confined to the red channel. Some blue and green filters used in film camera systems do not sufficiently attenuate the infrared light and it is sometimes necessary to add IR blocking filters in these channels to correct colorimetry errors if such filters are not included in the projector optical system.

4. **Polarization Effects**
An unbalance of color signal or of luminance-chrominance signals can occur when the light source is switched from one projector to another. Such a mismatch may be due to polarization effects in the projector or the camera optical system. These effects can be identified and corrected by placing a polarizing filter in the common optical path and rotating the filter until the signal levels remain balanced as the light source is switched from one projector to another. However, a polarizing filter reduces the camera sensitivity by a factor of two or more and should only be used if absolutely necessary.

   Light polarization occurs at reflecting surfaces when the projector light sources have different numbers of surfaces at different angles to the optical axis.

5. **Vidicon Scan Size and Scan Location**
The size of the image and its location on the vidicon photoconductor have a noticeable affect on camera performance. Proper picture image size is that size specified for the camera. An 0.5" x 0.375" image is recommended for 1" vidicons and a 0.6" x 0.8" image for 1-1/2" vidicons. Failure to precisely scan the recommended image format at the vidicon photoconductor center will usually produce poor signal uniformity and may introduce registration errors in color cameras.

   It is good practice to periodically check the image size and its location on the photoconductor to assure that it has not been disturbed in day-to-day operation.

Section II — Typical Color Camera Set-Up Procedure

A. Typical Set-Up Routine

The following procedure is recommended for setting-up a color film camera. Adherence to this step-by-step procedure, which is generally applicable to any color film camera, will result in good camera performance and reduce set-up time.

Step	Adjustment	Procedure	Reason
1	Projector lamp voltage	Adjust the lamp voltage on the set-up* projector to the lamp manufacturers' rating. * The projector normally used to set up the camera.	To operate the lamp at optimum light output and color temperature.
2	Projector lamp iris	Set the lens iris to the stop specified—or where not specified—one f/stop below maximum aperture.	To obtain the greatest light output from the projector with good focus uniformity and a margin of reserve light. See Step 22.
3	Insert a neutral density filter into the light path.	Insert a neutral density filter into the light path from the projector. The N.D. value of the filter should simulate the most dense film that may be encountered. (Typical N.D., 1.0.)	To establish worst case operating conditions for the vidicons.
4	Camera system video amplifiers, gamma compensation	Turn off gamma compensation in all channels of the camera.	To properly adjust and evaluate vidicon signal and dark currents (levels). The video amplifiers at this point should have linear and equal gain characteristics.
5	Camera system video amplifiers, black level—pedestal	Set the black levels in all channels of the camera to the specified level and precisely equal.	To establish equal black signal reference for the camera system.
6	Camera system video amplifiers, white signal level.	(a) For cameras having a test pulse system to calibrate signal levels—adjust the white level controls (amplifier gains) in all channels of the camera to produce precisely equal white signal levels. (b) In cameras having calibrated and regulated video amplifier gains but not test pulses—set all channel gains equal.	To establish equal white signal reference for the camera system.
7	Vidicon set-up (preliminary).	With the vidicon exposed to a suitable test pattern, the lens open, and the target voltage control set at mid-point, bring up the vidicon beam to produce picture information. Now proceed to adjust beam alignment, optical and electrical focus to produce a reasonably sharp picture. Then adjust illumination and target voltage to produce a typical signal level.	To establish a preliminary vidicon set-up prior to proceeding with the more careful final adjustments.
8	Vidicon beam alignment.	Adjust the alignment controls to the point where the picture does not move and the picture rotates about the center point, as electrical focus is rocked back-and-forth through best focus. Some cameras have an electronic focus rock circuit that makes the beam alignment procedure easier and more precise.	To align the beam precisely coaxial with the beam forming and focusing electrodes of the tube—to establish best beam qualities.
8.a	Vidicon beam alignment (an alternate procedure).	Illuminate the vidicon fully to obtain a token picture at very low-target voltage. Now adjust the alignment controls to produce the highest signal output **consistent** with the best signal uniformity.	This alternate beam alignment procedure will also produce good results. **CAUTION:** Never misalign a vidicon beam to produce good signal uniformity to compensate for non-uniform illumination.

Step	Adjustment	Procedure	Reason
9	Vidicon beam focus.	Adjust the vidicon electrical focus to produce the highest and most uniform resolution. For example: do not peak the resolution for the vertical wedge of a test pattern to the point where it results in a loss of resolution in the horizontal wedge.	To obtain the highest and most uniform resolution.
10	Projector/Camera optical alignment.	Overscan the vidicon to check that the test pattern image is precisely sized, centered and focused on the photoconductor of each channel simultaneously. Make any optical re-alignments that may be necessary.	To establish the proper picture image format in the vidicon.
11	Projector-to-camera image orientation and focus.	Adjust the projector lens and projector-to-camera distance to produce a properly sized and focused image at the field lens of the camera.	To establish the proper image format into the camera.
12	Vidicon horizontal and vertical scan size, centering, linearity, skew and yoke rotation in the luminance channel of four-tube cameras or the green channel of three-tube cameras.	Using a linearity test pattern (ball chart) and a standard grating pattern test signal, establish the orientation and scan size with good linearity for the reference channel of the camera—the luminance channel in a four-tube camera, the green channel in a three-tube camera.	A preliminary requirement to establish the proper vidicon scan format for the luminance channel—or green channel—prior to registration.
13	Vidicon horizontal and vertical scan size, centering, linearity, skew and yoke rotation. (The three chroma channels of four-tube cameras or the blue and red channels in three-tube cameras.)	Using the registration test pattern, register the other channels to the reference channel established by Step 12. First yoke rotation, then skew. Now proceed with size, centering, and linearity.	To complete the camera registration. In four-tube cameras register the green tube to the luminance tube—then the blue and red tubes to the green tube.
14	Blue vidicon target control.	With the illumination level established by Steps 1, 2 and 3 and with no other light attenuation in the camera system (ND filters, lens iris, etc.) except a grey scale test pattern (made from silver halide film or the equivalent)—adjust the blue channel target voltage to set the "white" chip of the T.P. to the 100% level specified and established for the camera.	To establish set up for the most limiting color channel of the camera. **Note:** In some cameras the red channel is the limiting one. For these cameras, the red channel is set up first as described for the blue channel.
15	Blue vidicon dark current.	Optically cap the camera and read the blue vidicon dark current. For cameras not having a target current meter, read the dark current as a signal level on the system waveform monitor (as described in the text). The dark current should be low—never more than 10 nA. (Check illumination out of the projector if dark current is too high.)	The dark current or dark signal level is measured and in subsequent steps will be the reference to establish equal dark currents for all channels.
16	Green and Red vidicon dark current.	Adjust the green vidicon and red vidicon target voltage controls to the dark current level measured for the blue vidicon (Step 15).	A prerequisite to good signal tracking. It establishes equal picture blacks.

Step	Adjustment	Procedure	Reason
17	Insert neutral density filters in the chroma channels.	Uncap the camera and insert neutral density filters in the green and red channels to adjust the "white" chip of the T.P. to the 100% level.	To complete the vidicon signal tracking and establish equal picture whites.
18	Vidicon beam setting	Set each vidicon beam to discharge a signal level 110% of the specified level.	To establish the operating beam setting with a 10% reserve capability.
19	Vidicon beam alignment.	Repeat Steps 8, 9, 12 and 13 for each channel.	Final vidicon alignment and registration adjustments.
20	Camera system video amplifiers, gamma compensation.	Re-set the gamma controls for equal compensation in all channels of the camera. Differential gamma is sometimes used to compensate for tracking errors that may originate in the electronics or optics of the camera system.	To adjust the camera system gamma to best complement the picture tube characteristics.
21	Projector lamp voltage.	Adjust the lamp voltage at each projector multiplexed into the camera to produce a color temperature equal to that obtained from the "set-up" projector. This is conveniently done by adjusting lamp voltage to produce balanced "whites" from each projector.	Equal color temperatures from all projector lamps will provide consistent white balance and colorimetry.
22	Projector light output—iris and neutral density filter wheel.	Adjust the light output from each of the projectors to match that of the limiting projector. Both projector lens iris and the neutral density filter wheel can be used. Do not stop the projector lens down to the point where the depth of field becomes so great that the filament of the lamp is brought into focus. The neutral density filter wheel is the most convenient control, but be certain it is neutral through its range of control—(they tend to "color" with age or on accumulating dust or dirt film). When a projector light output is too dissimilar to the others, it is advisable to go to another size (wattage) lamp.	To establish equal light output from all the projectors multiplexed into the camera system. This is important for maintaining consistent signal levels in the day-to-day operation of the camera.

Note: In this procedure there is frequent reference to setting equal signal levels. Usually this is done by setting the level from each channel in turn to a reference level on the waveform monitor. The final adjustments can often be made more convenient, and more precise too, by observing the color signal output on the waveform monitor (wide band) and adjusting the levels to null the sub-carrier. With this refinement, the degree of signal level balance can be limited only by the precision of the color-plexer set-up.

B. **Signal Tracking Errors After Set-Up**

If signal tracking errors are encountered following the preceding routine, the errors may be due to optical flare, i.e., the darker areas of the picture are brightened beyond their true values. This condition may be caused by film or dirt on one or more of the optical surfaces of the camera system. If these surfaces are thoroughly cleaned and signal tracking errors still persist, the flare problem may then be a system design limitation and the extent of the grey scale signal tracking may have to be a compromise. Variable gamma correction in each channel is convenient for this purpose. However, target voltage adjustment should never be used to compensate for tracking errors.

Section III – Vidicon Characteristics and Features

A. **Photoconductors**

The two variations of antimony trisulfide photoconductors used in RCA vidicons for film cameras are shown in **Figures 6** and **7.**

The type I photoconductor is preferred in the larger 1-1/2" diameter vidicons because it has lower capacitance than the type II material. The lower the target capacitance, the lower the lag. The type I surface is lighter in color than the type II photoconductor, and is therefore less light absorbing. As a result, it reflects or scatters more light which may fall back onto the photoconductor causing unwanted brightening of areas. This highlight

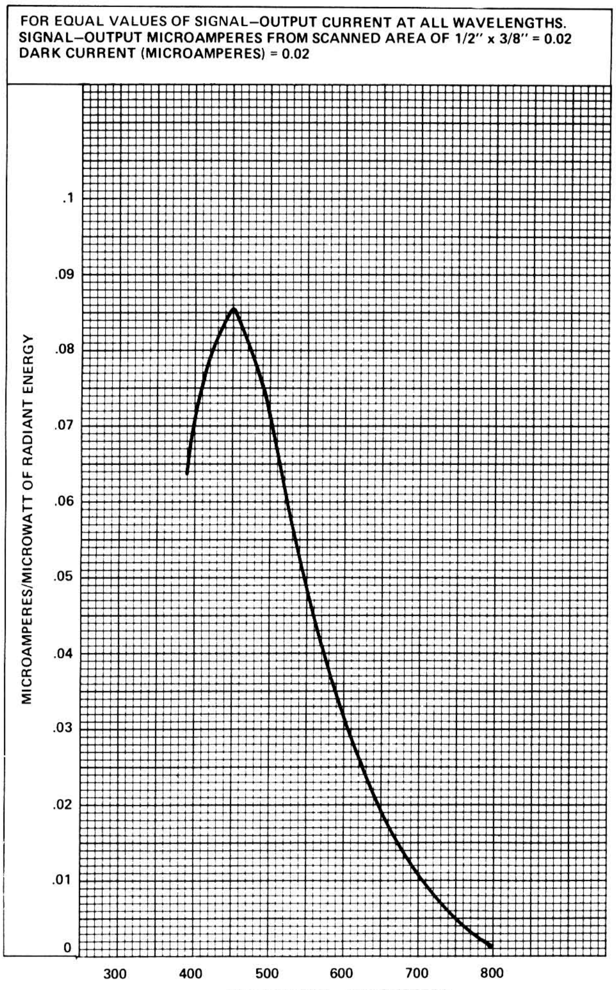

Figure 6 – Typical RCA Type I Spectral Response

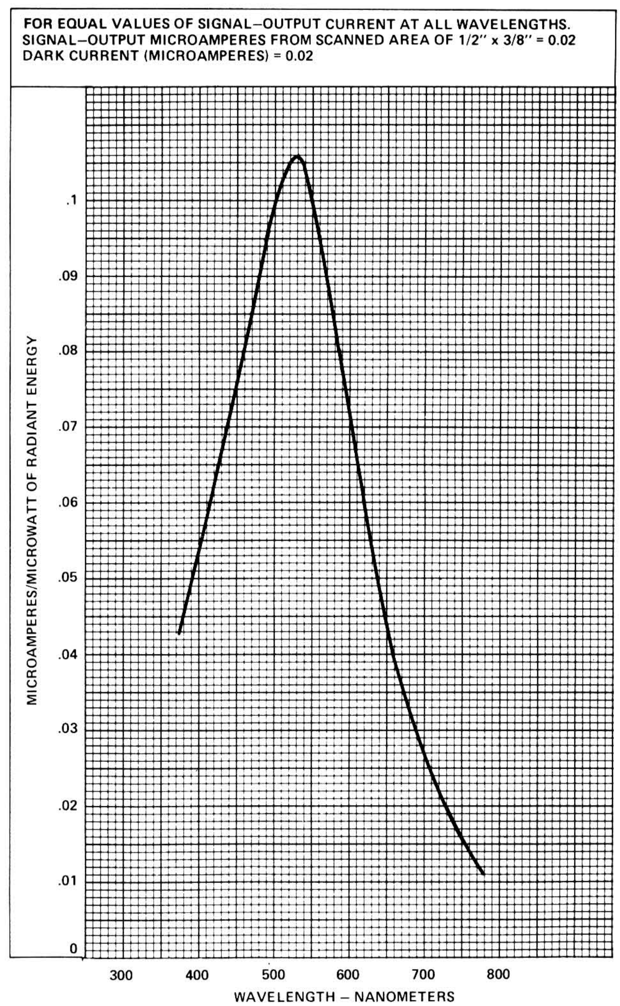

Figure 7 – Typical RCA Type II Spectral Response

flare effect is most noticeable in the red channel of color cameras where it causes a black level shift that is proportional to the amount of red light on the scene; the effect is less noticeable in the blue and green channels of the camera. Anti-halation discs are used on some vidicon types to circumvent highlight flare. See discussion on anti-halation faceplate on page 14.

The type II photoconductor material is now preferred in all but the larger (1-1/2" diameter) vidicons because of its higher sensitivity and because its darker color is more light absorbing and therefore less susceptible to highlight flare.

Both photoconductor types have adequate resistance to long-term burn-in when operated at recommended dark current levels.

B. **Light Transfer Characteristics**

The light transfer characteristics (the relationship of signal current to light input) are commonly called "gamma" characteristics. These characteristics are very similar from tube-to-tube and are essentially independent of the wavelength of the incident light. In a vidicon, signal output is proportional to the light input raised to a fractional exponent.

This exponent γ (gamma), is approximately 0.65 for both photoconductor types I and II. See **Figures 8** and **9**. To compensate for the non-linear characteristics of the picture tube and to attain true grey scale values, additional "gamma correction" is considered necessary. A correction following a 0.7 power law is usually adequate. Failure to use adequate gamma correction produces an excessively dark picture; the blacks are compressed and colors in the low lights shift toward the dominant primary color.

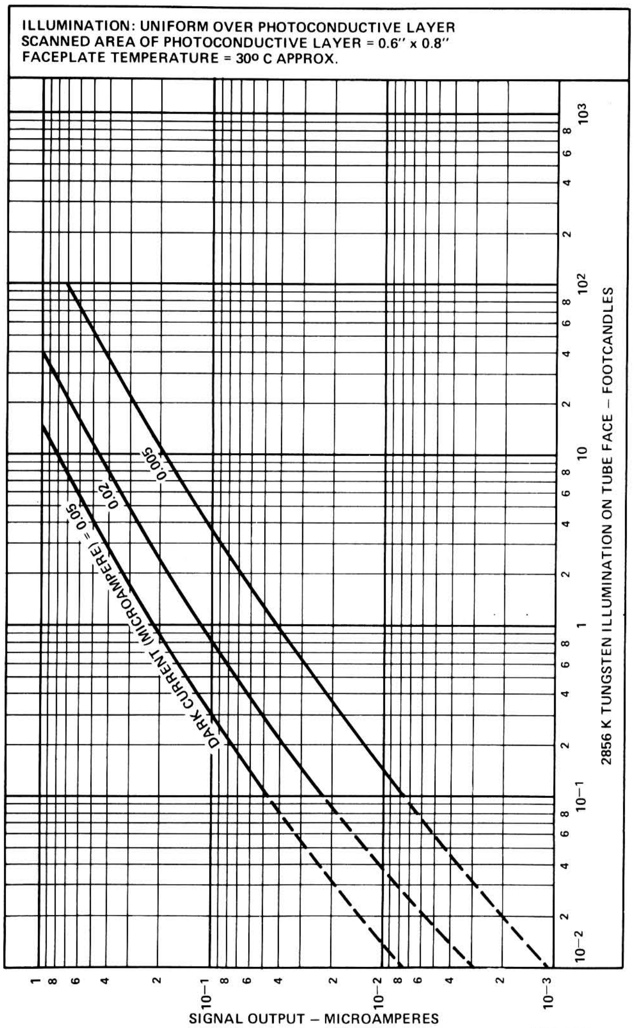

Figure 8 — Typical Light Transfer Characteristics of a Type I Photoconductor

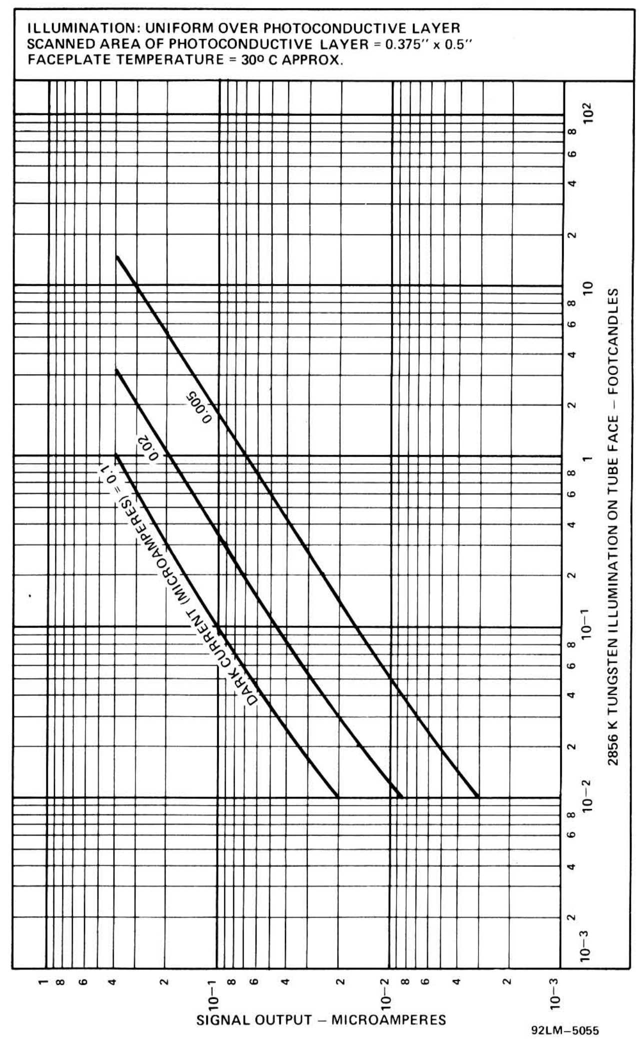

Figure 9 — Typical Light Transfer Characteristics of a Type II Photoconductor

C. **Blue Sensitive Tubes**

The photoconductors of some vidicons are specially processed to enhance the blue sensitivity of the tube. RCA vidicons having this surface are identified by the tube type designation followed by a /B suffix, e.g., 4809/B. These types, intended for use in the blue channel of color film cameras, will provide higher overall camera "sensitivity" and greater reserve for handling high-density film while maintaining dark current at recommended levels.

D. **Heater Power**

Vidicons for film cameras use either 3.8 or 0.6 watt heaters.

The lower heater power types (0.6 W) produce less heat and allow operation with more constant sensitivity and dark current. Variations in photoconductor temperature can produce noticeable changes in these two important performance characteristics.

The lower heater-power types also minimize registration problems by reducing gun distortion at initial warm-up and reducing the heating of associated camera electronics to allow quicker camera stabilization of registration.

E. **Anti-Halation Faceplates**

Some film camera vidicon types are supplied with an anti-halation faceplate button. This button is designed to prevent that portion of light scattered by the photoconductor surface from being reflected back onto the photoconductor by the front surface of the vidicon faceplate. Use of this anti-halation button, especially with vidicons having lighter colored photoconductors, will reduce black level variations as scene illumination changes. **Figure 10** illustrates the optics involved. (See **Photoconductors,** Section III). The glass button offers another advantage; any dust or film deposited on the button is out of focus and not noticeable in the picture. Vidicon types having the anti-halation faceplates are identified by the usual RCA-type number and a /V4 suffix.

F. **Separate-Mesh Construction**

Early vidicons were made with the mesh electrode (grid No.4 –G_4) connected internally to the focus electrode (Grid No.3 – G_3). Most modern vidicons have separate connections for these two electrodes. The separate-mesh design offers improved resolution and resolution uniformity that is independent of signal level and beam current variations. **Figure 11** illustrates the typical resolution improvement obtained from a separate-mesh vidicon when the G_4 voltage is higher than the G_3 voltage. The electrostatic lens formed by the G_3 and G_4 electrodes of separate-mesh vidicons can be adjusted to provide best resolution uniformity and best signal uniformity. In all cases, some improvement can be achieved by making the mesh electrode voltage just slightly higher than that of the focus electrode. A typical G_3/G_4 ratio for best performance is about 0.6 although it will differ for various focus and deflection coil designs.

Ideally, the vidicon and its "magnetics", i.e., the focus and deflection coils, should be a unified electron-optics assembly so that the fields of the coils and the potentials of the electrostatic lens of the vidicon gun complement one another. However, vidicons are operated in a wide variety of focus-deflection assemblies and identical performance can not be expected at the constant ratio of 0.6.

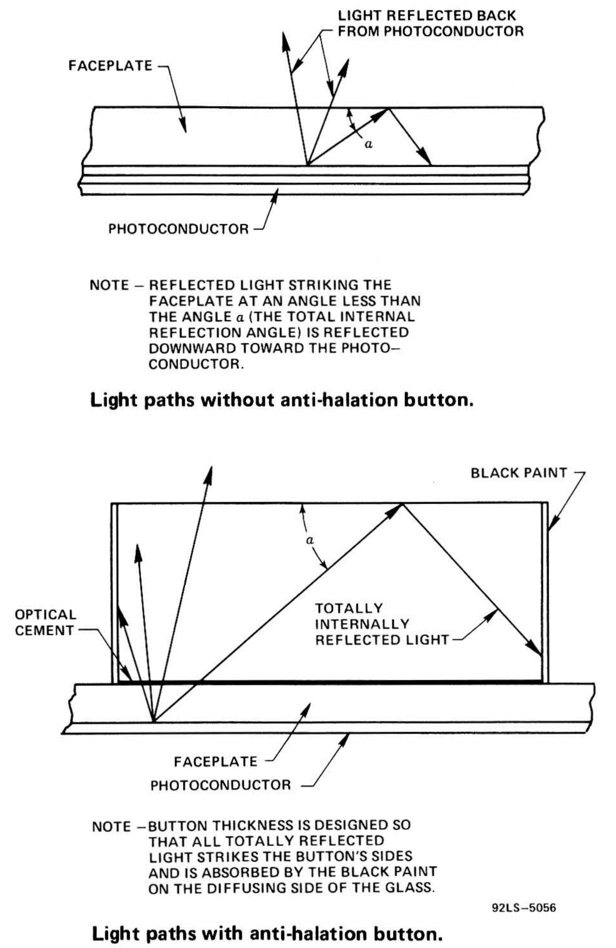

Figure 10 – Vidicon Faceplate and Anti-Halation Button

The best possible ratio of G_3 and G_4 voltage for a particular set of magnetics can be found with some experimentation. The criterion for the optimum ratio is that one which gives best signal uniformity consistent with resolution uniformity in all areas of the picture. Attention should also be given to picture geometry as a very low G_3/G_4 ratio can introduce pin cushion distortion. **Under no circumstances should G_4 be operated at a lower voltage than G_3 or the photoconductor will be damaged.**

1. **Replacement of Mutual-Mesh Vidicons with Separate-Mesh Vidicons**

Only minor camera circuitry changes are usually required to replace mutual-mesh vidicon types with separate-mesh vidicons. Improved resolution and beam characteristics can be obtained by operating the mesh electrode just a few volts more positive than the focus electrode.

Because the G_3 and G_4 electrodes draw only a few microamperes, a voltage difference between these electrodes can be obtained by a simple resistor-capacitor network at the tube socket. See **Figure 12.**

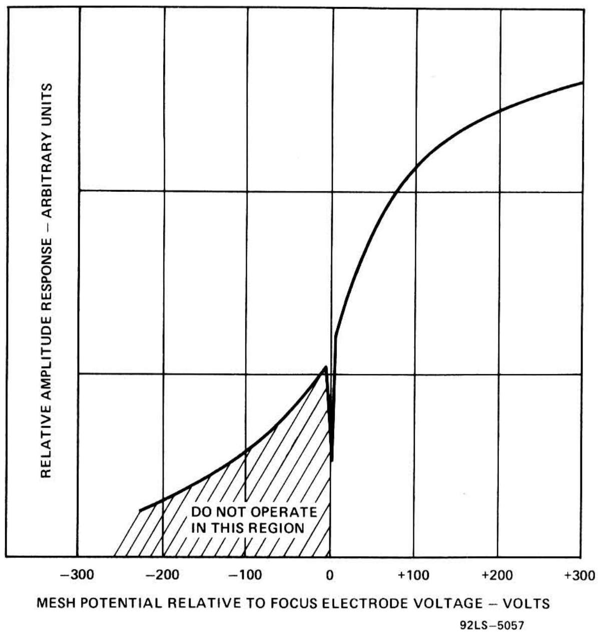

Figure 11 – Amplitude Response of a Separate-Mesh Vidicon as a Function of Focus Electrode and Mesh Electrode Voltages

A voltage difference may also be obtained, as shown in **Figure 13,** if the focus electrode is in the 250-volt range and the grid No.2 voltage is 300 volts.

G. **Magnetically-Focused vs Electrostatically-Focused Vidicons**

Camera design dictates whether the vidicon used will be a magnetically-focused or an electrostatically-focused type. The set-up procedure for electrostatically-focused vidicons is usually more critical than that for magnetically-focused types. Precise beam alignment is required to minimize any astigmatism present in the beam. Focus should be adjusted for best resolution in all directions and all areas of the picture. If focus is adjusted for best resolution in one direction only, e.g., peaking the resolution in the vertical wedge of the test pattern, there may be poor focus elsewhere in the picture. Once proper focus is obtained, electrostatically-focused vidicons will have better long-term focus stability than magnetically-focused types. If voltages for all the positive grids of an electrostatically-focused vidicon are supplied from a common power supply, the beam will remain in focus even if the supply voltage drifts. With the magnetically-focused tube, a variation in either focus coil current or tube electrode voltage supply will defocus the beam.

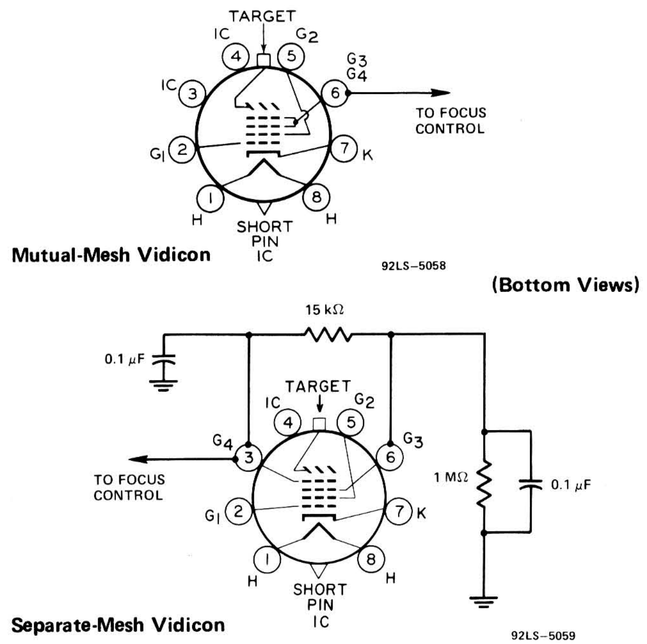

Figure 12 – A Circuit Modification for Replacing Mutual-Mesh Vidicons with Separate-Mesh Vidicons

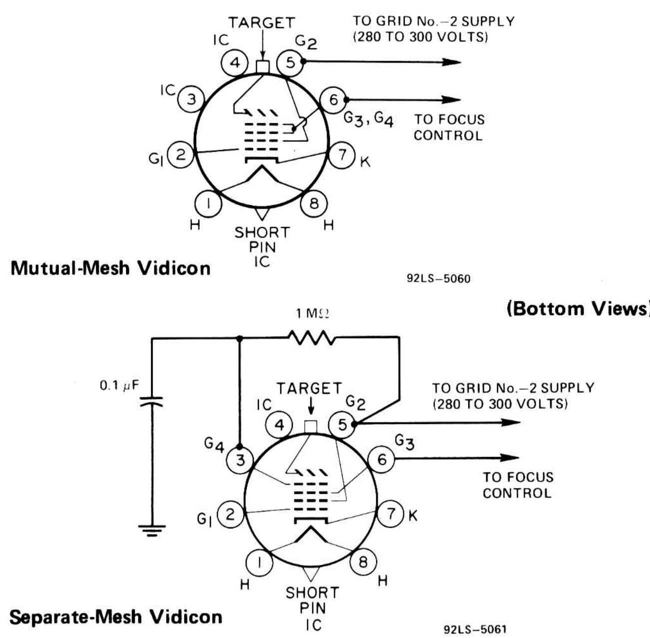

Figure 13 – A Circuit Modification for Replacing Mutual-Mesh Vidicons with Separate-Mesh Vidicons

Section IV – Selecting the Best Vidicon for Film Cameras

The following vidicon characteristics and selection charts are tabulations of the salient features of the vidicon types most often used in film camera service.

Table I groups the recommended RCA vidicons for film camera pickup by electro-mechanical structure, photoconductor type, and special features.

Table II shows the RCA vidicons recommended for use in some of the more popular film cameras. The preferred type(s) listed may not include the vidicon type originally specified for the camera model; this is especially true in those cases where the overall camera performance is greatly improved by a newer replacement type vidicon.

A. Vidicon Replacement Notes

1. In all cases, separate-mesh vidicons will provide superior performance over mutual-mesh connected vidicons. Camera conversion to accept these improved tubes is normally minimal. See suggested circuitry modifications under Separate Mesh Construction on page 15.
2. Cameras designed to use vidicons having low heater-power thermionic cathodes may not have sufficient heater power to accomodate the higher heater-power types. Conversely, replacing a high heater-power type may result in high heater voltage. It is advisable to check the heater voltage periodically and especially when installing a new vidicon. Otherwise, tube life may be seriously impaired. The heater voltage should be maintained within ± 10% of the rated 6.3 volt value for high-heater power types and within ± 5% for the lower heater-power vidicons.
3. Use of a high blue sensitivity vidicon type (/B) in the blue channel of a color camera eases the task of balancing signal levels and provides greater reserve in camera sensitivity.
4. Vidicons having Type I and Type II photoconductors should not be intermixed in the chroma channels of color cameras. The different characteristics may introduce color tracking errors.
5. If cameras are operated in environments where dirt or dust in the optical system may become a problem, the use of vidicon types with anti-halation buttons often provides a quick solution. Use of this type of vidicon will also reduce black level variations in the chroma channels of color cameras.
6. The 4809 vidicon type was designed for use in the RCA TK28 camera. This tube has an electron-optics structure that produces exceptional resolution and signal uniformity in the high G_3/G_4 voltage mode of operation. The 4809 vidicon types will similarly update camera performance in any of the newer camera models using the high-voltage mode of operation (C above 500 volts).

Table I – RCA Vidicon Classification Chart for Black-and-White and Color Film TV Cameras

RCA Vidicon Type	Photoconductor Type	Special Vidicon Features
1-1/2" Electrostatically-Focused types (B&W)		
8480	I (S)	
1-1/2" Electrostatically-Focused types (Color)		
*8480/4810	I (S)	
1" Electrostatically-Focused Types		
8134	II	
*8134/4811	II	
*8134/4811/B	II (S)	High Blue Sensitivity
1" Magnetically-Focused types (Mutual Mesh)		
7038	I	
*7038/V	II (S)	Low Target Voltage Range
*7038/V4	II	Anti-Halation Button
*7735B	II	
1" Magnetically-Focused Types (Separate Mesh)		
*8507A	II	
8572A	I	
*8572A/V	II	Low Target Voltage Range
*8572A/V4	II	Anti-Halation Button
4543	II	
*4809	II	
*4809/B	II (S)	High Blue Sensitivity
8541A	II	

*Preferred type.
(S) Special manufacturing process or selected for special characteristics.

Table II – Vidicon Selection Chart

Company	Camera Model	Type	Vidicon Type Originally Specified For Camera	Recommended Vidicon Type For Improved Performance (No camera modification required)	Recommended Vidicon Type For Best Performance (Minor camera modification required)*
RCA	TK26	Color	7038	7735B	8507A
	TK27	Color	8134, 8480	8134/4811,/B, 8480/4810	
	TK28	Color		4809,/B	
	PK610	Color	8507A	4809,/B	
	TK21	B&W	7038	7735B	8507A
	TK22	B&W		8480	
GE (Gates)	PE24†	Color	7038	7735B@	8507A
	PE240†	Color	7038, 8572A†	7735B@ 8507A	8507A
	PE245	Color	8572A	8507A	
Cohu	1500	Color	8507A	4809,/B	
IVC	92	Color	4543	8541A	
	92B	Color	4543	8541A	
	210	Color	4543	8541A	
	230	Color	4543	8541A	
	240	Color	4543	8541A	
Telemation	TCF-3000	Color	8507A	4809/B	

*Some minor camera circuit modification is required for separate-mesh vidicons and may be required for different heater-power types. See paragraphs in this section.
†In luminance channel only.
@For cameras not having manufacturers recommended modification to accomodate separate-mesh vidicons.