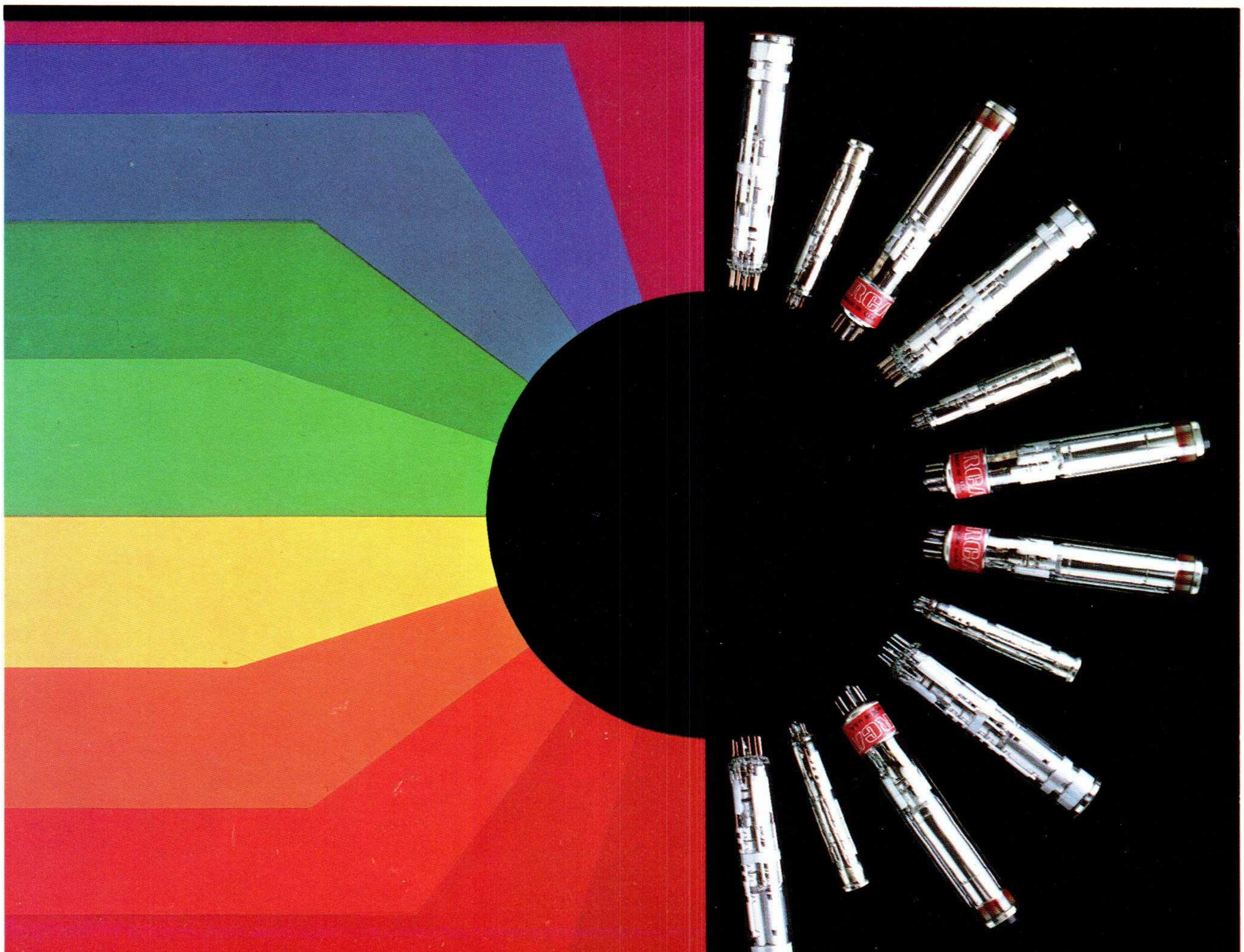
RCA

# The RCA CAMERA READY Broadcast Vidicon Series



# A new line of broadcast vidicons with specs, tests, and data... all fine-tuned to your broadcast needs.

RCA is proud to introduce the BC-series, a new line of television broadcast camera tubes for use in live colorcasting and telecine operation.

In both specifications and performance this new vidicon series is designed to provide TV broadcasters with a convenient and reliable program for maintaining the highest broadcast standards in camera tubes for both studio and remote cameras.

There's an RCA Camera Ready Vidicon for just about every important camera in color TV broadcast use. And RCA has made selection of the right tube easy. With just 16 tube types, including RCA Vistacons and the new 2/3" SATICON®*

This new vidicon series is tested to provide optimum picture-producing performance. Performance data is supplied with every Camera Ready Vidicon and performance features are backed by a new extended warranty. To help keep you on the air, delivery of BC tubes is on an off-the-shelf basis.

## Sulfide Vidicons

(Antimony Trisulfide)

*For Color Film Pickup*

- Reduced lag and after-image characteristics at the high light levels and low dark currents required by broadcast film cameras
- Reduced image-burn for extended exposure to still-frame images
- More stringent blemish criteria for cleaner pictures
- Improved performance uniformity of tube-to-tube product
- Low reflectivity photoconductor making the use of "anti-halation" buttons unnecessary
- High "blue" sensitive vidicons where required for the blue channel

## Vistacons

(Lead-Oxide)

*For Live Color Pickup*

- Matched sets for 3- and 4-tube color cameras available
- Each tube given a performance-assurance check in a TV color camera
- Guaranteed blemish-free color pictures
- Proven long life
- Square geometry for easier and more accurate registration
- Vibration damping construction to reduce mesh microphonics
- Ductile base pins to minimize pin breakage
- 30-mm types available with fixed light bias
- 25-mm and 30-mm types available with extended red response with or without integral IR blocking filters

## S-T Vidicons

(Silicon)

*For Live Color Pickup*

- Extremely high sensitivity (More than twice that of extended red lead-oxide vidicons)
- Intended primarily for improved red channel sensitivity
- Excellent discharge capability, minimal "comet-tail" effects
- High resistance to image burn-in

## SATICONS®*

(Selenium Arsenic Tellurium)

*For Live Color and Color Telecine Pickup*

- Extremely high amplitude response (The resolution capability of the 18-mm types rivals that of most 30-mm lead-oxide vidicons)
- Low lag that is independent of illuminance color
- Low reflectivity photoconductor which reduces color shift due to flare into the low lights
- Very low dark current
- High uniformity of tube-to-tube product

# RCA has a CAMERA READY broadcast tube for every important camera you own.

| Camera Manufacturer | Type of Pickup Service | These Camera Models | Use any/or all of these Recommended Direct Replacement BC-Line Camera Tubes (No camera modifications required except as noted) For camera models designed or modified to accept separate-mesh camera tubes |
|---|---|---|---|
| Ampex | Live (Color) | BCC1<br>BCC2<br>BCC3 | BC4892/B, /G, /R<br>BC4893/R<br>BC4894/G |
| | | BCC4 | BC4907● |
| Asaca | Live (Color) | ACC2000<br>ACC3000 | BC4907● |
| CEI | Live (Color) | BC280<br>BC285<br>BC287<br>BC290 | BC4892/B, /G, /R<br>BC4893/R<br>BC4894/G |
| Cohu | Film (Color) | 1500<br>1550 | BC4809, BC4809/B |
| EMI | Live (Color) | 2001 | BC4592/B, /G, /L, /R<br>BC4594/L |
| Fernseh (Bosch) | Live (Color) | KCK | BC4892/B, /L<br>BC4893/R<br>BC4894/L |
| GE (Gates Harris) | Live (Color) | PE250<br>PE350<br>PE400 | BC4592/B, /G, /L, /R<br>BC4594/L, /R |
| | | TE201 | BC4892/B, /G<br>BC4893/R<br>BC4894/G |
| | Film (Color) | PE24$<br>PE240$<br>PE245$ | BC8507, BC7735# |
| | | TE304<br>TF100 | BC4809, BC4809/B |
| Harris | Live (Color) | TC3 | BC4907● |
| | | TC80<br>(Non ACT Version)<br>TE301 | BC4892/B, /G<br>BC4893/R<br>BC4894/G |
| Hitachi | Live (Color) | FP1212 | BC4892/B, /G, /R<br>BC4893/R<br>BC4894/G |
| | | FP1010<br>FPC1000<br>HV1100A<br>SK80 | BC4907● |
| | | SK70 | BC4907 |
| Ikegami | Live (Color) | HK309B<br>HL77 | BC4907 |
| | | HK310/310S<br>HL351<br>TK355 | BC4892/B, /G, /R<br>BC4894/G, /R |
| | | HK312 | BC4592/B, /G, /R<br>BC4594/G, /R |
| | | HL35<br>HL37 | BC4907● |
| | Film (Color) | TKC950 | BC4809, BC4809/B |
| IVC | Live (Color) | 90<br>120<br>200 | BC8541 |
| | | 300 | BC4892/B, /G, /R<br>BC4894/G, /R |
| | | 150<br>500<br>500A | BC4892/B, /G<br>BC4532* |
| | | 7000<br>7000P | BC4892/B, /G<br>BC4893/R<br>BC4893/G |
| | Film (Color) | 92<br>92B<br>130<br>210<br>230<br>240 | BC8541 |
| Marconi | Live (Color) | BC3250 | BC4892/B, /G, /R<br>BC4894/G, /R |
| | | MKVII | BC4592/B, /G, /L, /R<br>BC4594/L, /R |
| | | MKVIII | BC4992/B, /G, /R<br>BC4993/R<br>BC4994/G |
| NEC | Live (Color) | MNC61 | BC4907● |
| Norelco-Philips | Live (Color) | LDH-1<br>LDH-16<br>LDH-20 | BC4892/B, /G, /R<br>BC4894/G, /R |
| | | LDK11 | BC4907● |
| | | LDK35<br>PC70<br>PC70B<br>PC70S<br>PC72<br>PCB701<br>PCP70 | BC4592/B, /G, /R<br>BC4594/G, /R |
| | Film (Color) | LDH-1+ | BC8541, BC4809, BC4809/B<br>BC4892/B, /G, /R<br>BC4894/G, /R |
| | | PCF-701 | BC4592/B, /G, /R<br>BC4594/G, /R |
| Panasonic | Live (Color) | AK900 | BC4892/B, /G, /R<br>BC4894/R |
| RCA | Live (Color) | TK44A<br>TK44B<br>TK45<br>TK46 | BC4592/B, /G, /R<br>BC4593/R<br>BC4594/G |
| | | TK76<br>(SATICON®) | BC4908/B, /G, /R |
| | | TK630<br>TKP45 | BC4892/B, /G, /R<br>BC4893/R<br>BC4894/G |

| Camera Manufacturer | Type of Pickup Service | These Camera Models | Use any/or all of these Recommended Direct Replacement BC-Line Camera Tubes (No camera modifications required except as noted) For camera models designed or modified to accept separate-mesh camera tubes |
|---|---|---|---|
| RCA (cont'd) | Film (Color) | TK26 | BC8507, BC8541□, BC7735# |
| | | TK27 | BC8134, BC8134/B, BC8480@ |
| | | TK28 | BC4809, BC4809/B |
| | | TK28 (PbO) | BC4592/B, /G, /R<br>BC4593/R<br>BC4594/G |
| | | PK310 | BC8541 |
| | | PK610 | BC8507, BC4809□, BC4809/B□<br>BC8541□ |
| | Film (B&W) | TK21 | BC8507, BC7735# |
| | | TK22 | BC8480 |
| Telemation | Live (Color) | TCC-3100 VLO | BC8507, BC4809□<br>BC4809/B□, BC8541□ |
| | | TCC-3100 BSD | BC4532 |
| | | TCC-3100 BLO | BC4892/B, /G, /R<br>BC4894/G, /R |
| | Film (Color) | TCF-3000 | BC8507, BC4809□,<br>BC4809/B□, BC8541□ |
| Thomson (CSF) | Live (Color) | TV1515 | BC4892/B, /G<br>BC4893/R<br>BC4894/G |
| Visual | Live (Color) | VP3 | BC4592/B, /G, /R<br>BC4593/R, BC4594/G |

●A new socket must be provided and the target voltage must be re-adjusted to 50 volts for camera models using lead-oxide vidicons.
$Variants of this camera model may use a separate-mesh vidicon in the luminance channel and mutual-mesh vidicons in the chroma channels.
*For the red channel.
□Type has 100 mA heater; other in group, 600 mA.
@For the luminance channel.
+Camera may use either 1" diameter sulfide vidicons or 1" diameter Vistacons.
#For cameras accepting mutual-mesh camera tubes.

# Camera Tube Replacement Guide

| Camera Tube Type to be Replaced | RCA Replacement Type Direct | Camera Tube Type to be Replaced | RCA Replacement Type Direct | Camera Tube Type to be Replaced | RCA Replacement Type Direct |
|---|---|---|---|---|---|
| 4543 | BC8541 | 8572/V | BC8507 | XQ1020G | BC4592/G |
| 4592/B | BC4592/B | 8572/V4 | BC8507* | XQ1020L | BC4592/L |
| 4592/G | BC4592/G | H8362 | BC4909 | XQ1020R | BC4592/R |
| 4592/L | BC4592/L | H8397 | BC4907 | XQ1023R | BC4593/R |
| 4592/R | BC4592/R | H8397A | BC4908 | XQ1025 | BC4594/L |
| 4593/R | BC4593/R | P841 | BC8507 | XQ1025L | BC4594/L |
| 4594/G | BC4594/G | P842 | BC8541 | XQ1025R | BC4594/R |
| 4594/L | BC4594/L | P843 | BC8507 | XQ1040 | BC8541 |
| 4594/R | BC4594/R | P846 | BC8507 | XQ1041 | BC8541 |
| 4809 | BC4809 | P847 | BC8541, BC4809, BC4809/B | XQ1042 | BC8541 |
| 4809/B | BC4809/B | P8021 | BC4892/L | XQ1240 | BC8541, BC4809, BC4809/B |
| 4846 | BC4809 | P8021B | BC4892/B | XQ1250 | BC8541, BC4809, BC4809/B |
| 4846/B | BC4809/B | P8021G | BC4892/G | XQ1252 | BC8541, BC4809, BC4809/B |
| 7038 | BC7735 | P8021/L | BC4892/L | XQ1070 | BC4892/L |
| 7038V | BC7735 | P8021/R | BC4892/R | XQ1070B | BC4892/B |
| 7038/V | BC7735 | P8023A | BC4893/R | XQ1070G | BC4892/G |
| 7038V4 | BC7735* | P8023GF | BC4894/G | XQ1070L | BC4892/L |
| 7038/V4 | BC7735* | P8023LF | BC4894/L | XQ1070R | BC4892/R |
| 7735B | BC7735 | P8023MF | BC4894/L | XQ1073R | BC4893/R |
| 8134 | BC8134 | P8023RF | BC4894/R | XQ1075 | BC4894/L |
| 8134V | BC8134 | P8038 | BC4809 | XQ1075R | BC4894/R |
| 8134V1 | BC8134 | P8038B | BC4809/B | XQ1400 | BC4532 |
| 8134/4811 | BC8134 | P8130 | BC4992/L | Z7975HR | BC4532 |
| 8134/4811/B | BC8134/B | P8130B | BC4992/B | | |
| 8480 | BC8480 | P8130G | BC4992/G | | |
| 8480/4810 | BC8480 | P8130L | BC4992/L | | |
| 8480V1 | BC8480 | P8130R | BC4992/R | | |
| 8507A | BC8507 | P8132AR | BC4993/R | | |
| 8541A | BC8541 | P8132GF | BC4994/G | | |
| 8541B | BC8541 | P8132LF | BC4994/L | | |
| 8572A | BC8507 | P8132MF | BC4994/L | | |
| 8572A/V | BC8507 | P8132RF | BC4994/R | | |
| 8572A/V4 | BC8507* | TV8000 | BC8541 | | |
| 8572V | BC8507 | XQ1020 | BC4592/L | | |
| 8572V4 | BC8507* | XQ1020B | BC4592/B | | |

*The types being replaced have "anti-halation" buttons; the BC replacement types do not. For optical reasons, replacement should be made as a trio in 3-tube color cameras.

# CAMERA READY BC-Line of Camera Tubes

| Nominal Tube Diameter in. | Focus and Deflection Method● | BC-Line Vidicons for Color Broadcast Television | | | | | Heater Current A |
|---|---|---|---|---|---|---|---|
| | | Sulfide Vidicons* | | Vistacons | S-T Vidicons | SATICONS® | |
| | | Separate Mesh | Mutual Mesh | Separate Mesh | Separate Mesh | Separate Mesh | |
| 2/3 (18 mm) | MM | | | | | BC4907<br>BC4908 | 0.1 |
| 1 (25 mm) | MM | BC8541<br>BC4809<br>BC4809/B | | BC4892/B, /G, /L, /R<br>BC4893/R<br>BC4894/G, /R, /L | BC4532 | BC4909 | 0.1 |
| | | BC8507 | BC7735 | | | | 0.6 |
| | EM | BC8134<br>BC8134/B | | | | | 0.1 |
| 1.2 (30 mm) | MM | | | | | | 0.1 |
| | | | | BC4592/B, /G, /L, /R<br>BC4593/R<br>BC4594/G, /L, /R<br>BC4992/B, /G, /L, /R<br>BC4993/R<br>BC4994/G, /R, /L | | | 0.3 |
| 1½ (38 mm) | EM | BC8480 | | | | | 0.1 |

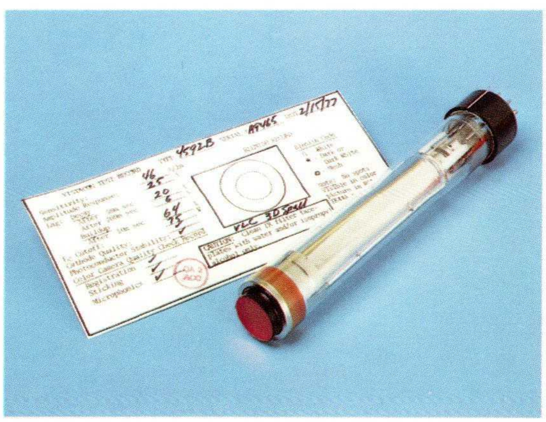
*All Sulfide Vidicons employ RCA's Type II antimony trisulfide photoconductor except the BC8480 which employs Type I.
●MM = magnetic focus, magnetic deflection; EM = electrostatic focus, magnetic deflection

# CAMERA READY Data and Specifications

We are confident these BC-series vidicons will meet your live and telecine colorcast needs because they meet our newest, most critical criteria for the camera-tube characteristics most important to maintaining broadcast quality standards: Amplitude response. Lag. Image retention. Dark current.

Pictures will not only be sharp and clear. They will be cleaner, because we've written a new set of blemish criteria to guarantee that spots and imperfections can't interfere with the broadcast quality you demand.

All BC camera tubes are tested and rated under simulated end-use conditions – and that includes subjecting each tube to the lighting conditions (telecine or live pickup) that typically will be encountered in actual broadcast service. Then, on an active sampling basis, tubes are performance-checked in broadcast cameras under broadcast conditions.



When you install a BC vidicon you know exactly what it will do – because you already know what it has done. Test conditions and specified data for every important performance characteristic are recorded on the test-data ticket that accompanies each tube.

Camera-Ready BC vidicons are available now through your RCA Distributor. Or for additional information, contact the RCA District Office nearest you.

## RCA Sales Offices

*For further information on Camera Ready Tubes call your nearest RCA Representative.*


**CALIFORNIA**
RCA Corp., 6363 Sunset Blvd.
Hollywood, California 90028
(213) 461-9171

**CALIFORNIA**
RCA Corp., 4546 El Camino Real
Los Altos, California 94022
(415) 948-8996

**FLORIDA**
RCA Corp., P.O. Box 12247
Lake Park, Florida 33403
(305) 626-6350

**ILLINOIS**
RCA Corp., 2700 River Road
Des Plaines, Illinois 60018
(312) 391-4380

**NEW JERSEY**
RCA Corp., 67 Walnut Ave.
Clark, New Jersey 07066
(201) 574-3550

**TEXAS**
RCA Corp., RCA Center
8700 Stemmons Freeway
Dallas, Texas 75247
(214) 638-6200

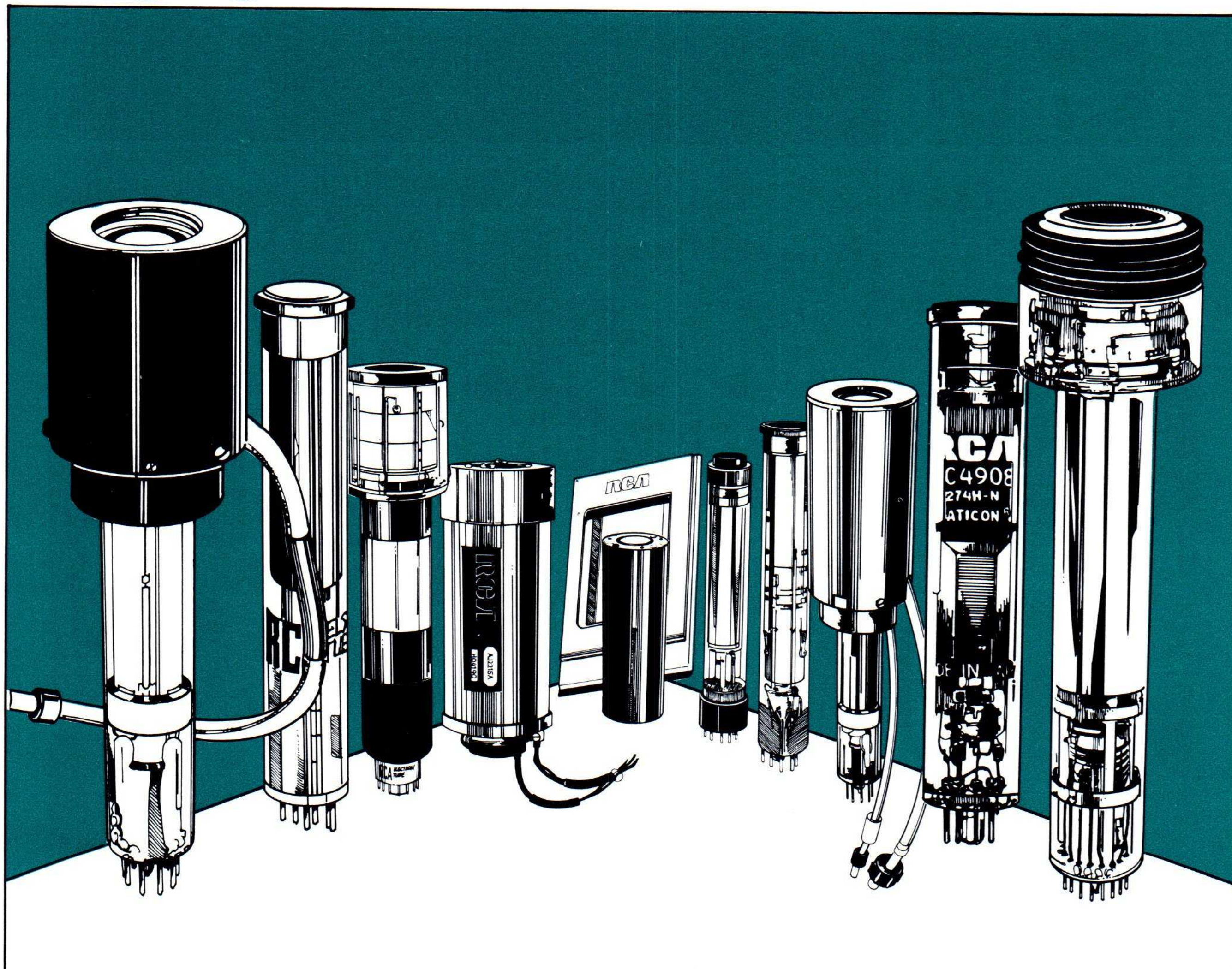
**CANADA**
RCA Limited, 1 Vulcan St.
Rexdale, Ontario, Canada M9W 1L3
(416) 247-5491





RCA | Solid State Division | Electro Optics and Devices Division | Lancaster, Pa. | 17604 Printed in U.S.A. | **3-77** **2M1179**

# Imaging Devices



IMD-100

# Characteristics of Imaging Devices

## Introduction

This product guide provides tabulated data for RCA's standard line of Imaging Devices. The types included are designed for use in communications, industrial, consumer and military applications.

For further information or application assistance on these products, please contact your RCA Sales Representative or RCA, Electro Optics Marketing, Lancaster, PA 17604. (717) 397-7661

## Contents



*Used by permission of trademark owner.

## Application Notes and Other Technical Literature Relating to Imaging Devices

| | |
|---|---|
| AN-4848 | An Elaboration of the Vidicon Set-Up Procedure for the RCA TK-27 Color Film Camera |
| AN-4906 | Upgrading an Intensifier — Vidicon Camera to SIT-Tube Operation |
| AN-4907 | General Information and Applications Guide for RCA 3-inch Image Isocons |
| AN-4974 | Modifying TV Cameras for Use of Silicon Target Vidicons |
| AN-5012A | Sulfide and SATICON Vidicon Tubes in Television Film Service |
| AN-5042 | Vistacon Update |
| CAM-704 | Converting RCA TK-28 Series Vidicon Film Cameras for Use with SATICON Vidicons |
| CAM-705 | Additional Operating Considerations — SATICON Vidicons in Broadcast Color Cameras |
| IB-32968-B | TK-76 NTSC Color Camera SATICON Conversion and Operational Set-Up |
| PE-696 | The Silicon-Target Vidicon |
| PE-697 | The Silicon Intensifier Target Tube — Seeing in the Dark |
| ST-4693 | Choose the Tube-for $L^3TV$ |
| ST-4989 | Charge-Coupled Imager for 525-Line Television |
| ST-6674 | The SATICON Color Television Camera Tube |

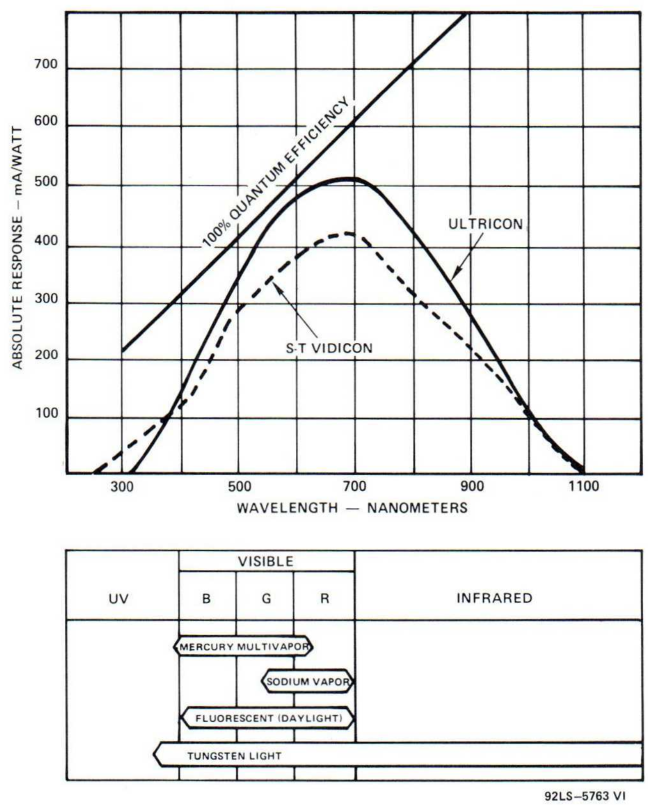
(Copies available by writing RCA, Box 3200, Somerville, NJ 08876.)

Type numbers with prefix letter "C" identify developmental types suitable for engineering evaluation. The number and identifying data are subject to change. Before specifying any of these types in production equipment, please contact RCA. No obligation is assumed by RCA as to future manufacture of developmental types unless otherwise arranged.

## Ultricon™-Improved Silicon-Target Vidicons

RCA introduces the Ultricon™ camera tubes for superior performance in CCTV cameras. Ultricon™ types feature further improvements in sensitivity through the visible spectrum extending into the near UV and into the near IR. In the visible range, they are 25% better than standard silicon-target vidicons. Ultricon™ camera tubes have all the low lag, non-burn performance characteristics of S-T vidicons with further improvements in highlight blooming.

They are identified in this product guide by a /U designation.




## Camera Tubes

The camera tube is an electro-optic device which converts an optical image into a video signal. There are many different kinds of camera tubes and devices; a description of the major types follows.

### Vidicons●

The vidicon is the most widely used camera tube. Its small size and simplicity of operation and adjustment permit its use to be relatively easy. Vidicons have moderate sensitivity and are usable in many locations without auxiliary lighting. The speed of response, generally, is somewhat less

## BC Types-Broadcast Quality Vidicons

Special attention is called to the BC-series of television broadcast camera tubes for use in live colorcasting and telecine operation. In both specification and performance this vidicon series is designed to provide TV broadcasters with a convenient and reliable program for maintaining the highest broadcast standards in camera tubes for both studio and remote cameras.

These BC-series vidicons meet RCA's most critical criteria for camera tube characteristics most important to maintaining broadcast quality standards: Amplitude Response, Lag, Image Retention, and Dark Current. Selection aids for these "Camera Ready" vidicons appear in the section entitled "Selection Guide".

than that of most other camera tube types. A schematic representation of a vidicon tube is given in **Figure 1**.

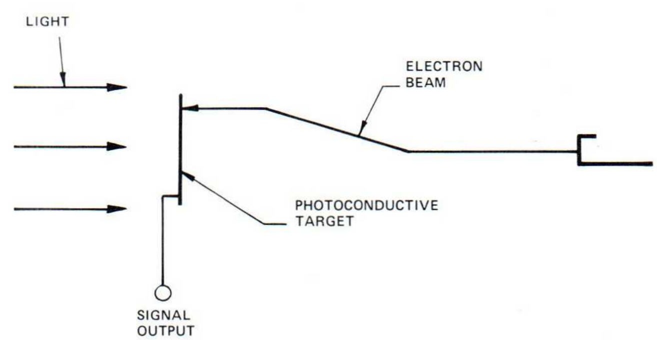



**Figure 1 — Schematic Representation of a Vidicon Camera Tube**

The vidicon utilizes an electron beam to scan a light sensitive photoconductive target. A transparent conductive layer applied to the front side of the photoconductor serves as the signal (target) electrode. The signal electrode is operated at a positive voltage with respect to the back side of the photoconductor which operates at the cathode (near zero) voltage. In operation, the scanning beam initially charges the back side of the target to cathode potential. When a light pattern is focused on the photoconductor, its conductivity increases in the illuminated areas and the back side of the target charges to more positive values. The electron beam then reads the signal by depositing electrons on the positively charged areas thereby providing a capacitively-coupled signal at the signal electrode.

●RCA invented the vidicon and coined the term, which has now achieved a generic meaning. The name vidicon is often applied to any of the variety of tubes having a photoconductive target.

# Characteristics of Imaging Devices (cont'd)

*Sulfide Vidicons*

Sulfide vidicons contain antimony trisulfide photoconductors. The Type II photoconductor is used in vidicons for CCTV and for film service due to its higher sensitivity and better light reflection and dispersion characteristics. Vidicons utilizing this photoconductor exhibit less highlight flare and, as a result, produce sharper and more accurate colors in low lights of the picture. The Type I photoconductor is used only in a 1-1/2"-diameter type. The capacitance of this photoconductor is low and contributes to keeping lag to the low level required for film service. Both types have adequate resistance to long-term burn-in when operated at recommended dark-current levels. A Type IV photoconductor is available for use on vidicons for signal storage applications.

*Intensifier Vidicon Tubes*

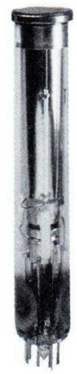
Intensifier vidicons (IV and $I^2V$) are all magnetic vidicons coupled to one or two image intensifier stages. This combination provides a camera tube having a sensitivity between 50 and 1200 times greater than that of the vidicon itself. IVs can be readily incorporated into existing cameras and use conventional vidicon camera circuitry.

*SATICON Vidicons*

SATICON vidicons utilize a selenium-arsenic-tellurium photoconductor having low reflectivity which results in minimal flare from highly illuminated portions of a scene. The spectral sensitivity is high in the blue and negligible in the infrared regions of the spectrum making them especially suited for live color-TV pick-up such as ENG cameras and medical X-ray systems. The SATICON vidicon is superior to the sulfide vidicon in film service; it produces substantially less lag when using high-contrast, or high-density, color film; it maintains resolution and its photoconductor produces sharper and more definitive color transitions and much less flare into the low lights of the signal in the presence of picture highlights.

*Vistacons*

Vistacons contain a lead-oxide photoconductive target (Type VI and VIII) which is characterized by high sensitivity, low-dark current, low lag, and a "gamma" of nearly unity. The type VIII photoconductor is employed to enhance the red response in the red channel of color cameras. In addition to use in color cameras, vistacons are employed in medical X-ray television systems where low lag is of importance.



*Ultricon™ and Other Silicon-Target Vidicons*

These vidicons employ a silicon diode array target structure generally utilizing a Type V photoconductor. They feature very high sensitivity extending into the near IR region, broad spectral response, very low dark current, low lag, exceptional resistance to image burn, and good resolution capability with minimum blooming effects caused by bright light sources and intense specular reflections within a scene. The new Ultricon™ types feature better sensitivity and further improvements in blooming.

**Silicon-Intensifier Target Tubes and Intensifier-Silicon-Intensifier Target Tubes**

Silicon-Intensifier Target (SIT) and Intensifier-Silicon-Intensifier Target (ISIT) camera tubes employ a multialkali (NaKCsSb) photocathode as the image sensor; the scanning and read-out methods are similar to that of the vidicon. A schematic representation of the SIT tube is given in **Figure 2**. The photoelectrons are focused onto a special target which provides relatively high gain before the scanning operation commences. For the SIT camera tube, the target is a very thin silicon wafer upon which a tightly spaced matrix of p-n junction diodes is formed. The center-to-center spacing of the diodes is approximately 14 $\mu$m. The gain mechanism is provided when a primary photoelectron, accelerated to perhaps 10 keV, impinges on the target and causes multiple dissociations of electron-hole pairs. Gains of 1000 or more may be achieved. The holes are collected at the p-side of the diode where the charge is neutralized by the scanning beam. The signal is read out on the backplate of the target.

SIT tubes have been used extensively for low-light-level pickup. The SIT tube is capable of a very wide range of operation because of the flexibility of its gain mechanism.

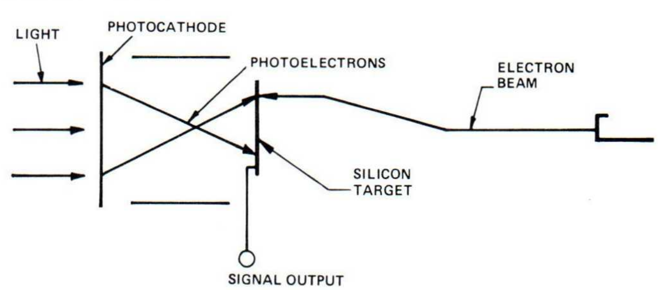



**Figure 2 — Schematic Representation of a SIT Camera Tube**

### *Silicon-Intensifier Target Tubes*

Silicon-Intensifier Target camera tubes are designed for use in very low light level TV systems. They employ an improved silicon diode array target that reduces blooming effects caused by bright light sources and intense specular reflections within a scene. These tubes operate at light levels near the photoelectron noise limit.

### *Intensifier-Silicon-Intensifier Target Tubes*

Intensifier-Silicon-Intensifier Target camera tubes are two-stage devices employing a SIT tube that is fiber-optically coupled to a single-stage image intensifier stage. This combination provides a camera tube having sensitivity approximately 30 times greater than that of the SIT tube itself.

### Image Isocons

Image isocons are television camera tubes employing a photocathode as a light sensor. The photocathode may be bialkali or multi-alkali. They are high sensitivity devices designed for high resolution TV systems where low light levels, low lag, and exceptional dynamic range are important.

They are available with glass or fiber-optic faceplates. The latter are especially useful in systems where an image intensifier (another fiber-optic device) is to be coupled to the fiber-optic faceplate. The targets are sturdy and highly resistant to intense bursts of light. They offer simple set-up procedures, minimal background shading, and non-critical beam current adjustment. This tube is used in low-light level TV and as a pickup tube for monitoring the output of X-ray image intensifiers in medical applications.

A schematic representation of the image isocon is given in **Figure 3**. When the electron scanning beam approaches the target, several events occur: electrons may enter the target and neutralize a positive charge, electrons may fail to land and be electrostatically reflected, or electrons may land on the target and be scattered back at various angles. The scattered electrons constitute the signal in the return beam. The reflected electrons are eliminated by means of a carefully aligned baffle positioned to assure separation of the return beam components caused by the different electron paths.

### Image Orthicons

Image orthicon type camera tubes are primarily replacement types for outdoor, studio, color, and/or black-and-white television service. They employ a long-life glass target that is characterized by high gain, resistance to "burn-in", and absence of any granular structure.

The image orthicon is a more intricate camera tube type than the vidicon. However, it has very high sensitivity and the ability to handle a wide range of light levels and contrasts. A disadvantage of the tube is that the return-beam mode of operation results in noise in the dark areas of the image. For many years, the image orthicon was used almost exclusively for live pickup in studio and outdoor broadcast television cameras. In recent years the image orthicon has been replaced by certain vidicon types (e.g., the lead oxide and SATICON types) in cameras designed for this service. A schematic representation of an image orthicon is given in **Figure 4**. The image orthicon utilizes an S-10 photocathode as the light sensor. The photoelectron image pattern developed at the photocathode is focused by an axial magnetic field producing one spiral loop onto a thin, moderately-insulating target surface. When the photoelectrons from the photocathode strike the target, secondary emission occurs causing the establishment of net positive charges on the target. The electron beam scans the charged target pattern, deposits some electrons on the more positively charged areas, and the modulated beam returns to an electron multiplier surrounding the electron gun. The output signal is the amplified anode current of the electron multiplier.

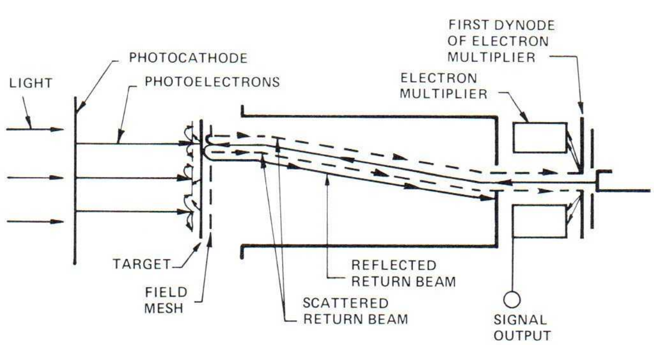



**Figure 3 – Schematic Representation of An Image Isocon Camera Tube**

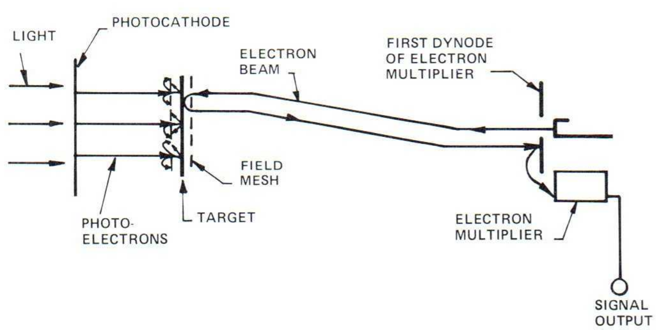



**Figure 4 – Schematic Representation of An Image Orthicon Camera Tube**

# Characteristics of Imaging Devices (cont'd)

## RCA Focus-Deflection Assemblies

These assemblies consist of a focus coil, deflection (or scanning) coil, and in some cases an alignment coil mounted in a single assembly. The full performance capabilities of imaging devices are readily achieved when they are operated in these assemblies. In most cases the need for an alignment system is eliminated due to the unique electro-optics design of these assemblies. Focus-deflection assemblies are also available as integral components matched and permanently attached to the imaging devices.

## Image Intensifiers

An image-intensifier tube (often called an image or image-converter tube) is an electron device that reproduces on its fluorescent screen an image of the radiation pattern focused on its photosensitive surface. These tubes are used when it is desired to have an output image that is brighter than the input image or to convert non-visible radiation from an image into a visible display. The image tube consists basically of a photocathode upon which a radiant image is focused, an electron lens, and a phosphor screen upon which the output is displayed. Image intensification results when the electrons emitted by the photocathode strike the phosphor screen after being accelerated by high voltage. Luminance gains in a single-stage image tube are usually in the order of 50 to 100. When image tubes are coupled, it is possible to obtain luminance gains of $10^5$ to $10^6$. With such gains it is possible to make observations that are limited by photoelectron statistics only.

The several different families of image tubes which have been developed can be categorized by "generation", photocathode, nominal useful diameter of photocathode, and type of electron-optical focusing mechanism. Typical photocathodes are ERMA 6-1 and S-20. Typical diameter values are 18, 25, and 40 mm. In the first generation electrostatically focused image tube (see **Figure 5**), an electrostatic field directs the photoelectrons through an anode cone and focuses an inverted image on the phosphor screen.

See **Figure 6** for schematic of a typical three-stage image tube. Electrostatically focused image tubes are relatively simple to operate requiring only a suitable optical lens for focusing the scene on the photocathode, an ocular for viewing, and a power supply. These tubes frequently use a fiber optic faceplate to minimize the fall off in image resolution toward the edge of the tube. The fiber optics also permit efficient coupling to another image tube, to a camera tube, or to photographic film. Although image tubes have, at times, been coupled by conventional optics, the efficiency loss is quite severe.

The magnetic-type image tube combines an electrostatic field with an axial magnetic field provided by either a solenoid or a permanent magnet. With a uniform magnetic field, the resolution is good over the entire screen and distortion effects are very low. Magnetic-type image stages are normally coupled by means of a thin mica or fiber-optic layer with a phosphor on one side and a photocathode on the other, all within the same vacuum. **Figure 7** shows the construction techniques of a typical three-stage magnetically focused image intensifier tube.

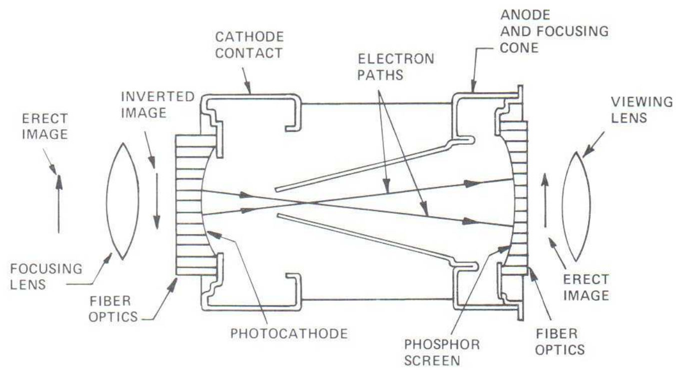



**Figure 5 — Schematic Diagram of a Typical Single-Stage First Generation Electrostatically-Focused Image Tube**

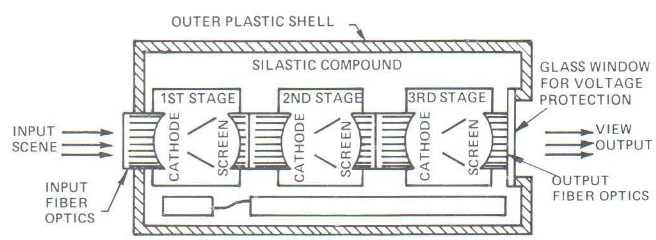



**Figure 6 — Schematic Diagram of a Typical Three-Stage First Generation Electrostatically Focused Image Tube**

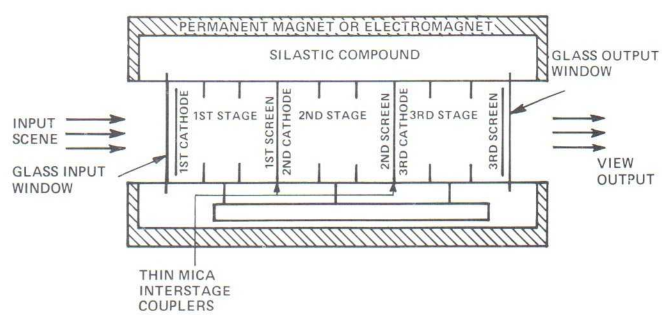



**Figure 7 — Schematic Diagram of a Typical Three-Stage Magnetically Focused Image Tube**

Second generation image tubes make use of microchannel plates (MCPs) to achieve luminance gains in the order of $10^4$. Although high gain is achieved in a small space by means of the MCP structure, the pulse height statistics of the image are degraded by the inherent fluctuation of noise from the MCP. The MCP is essentially a thin secondary-emission current amplifier located between the photocathode and the phosphor screen. This amplifer makes possible a high-gain tube having not only minimum size and weight, but also a saturable-gain characteristic which minimizes blooming (or halation) effects. The microchannel plate itself consists of parallel array of hollow glass cylinders about 10 $\mu$m in diameter and about 1 mm, or less, in length. The inside walls of the cylinders are coated with a secondary emitting material. Primary electrons strike the inside walls near the entrance end and cause secondary electrons to be emitted. These secondary electrons in turn strike the wall further into the depth of the cylinder and create additional secondary electrons. This cascading mechanism produces the high gain. An inverted design image tube utilizing MCPs is illustrated in **Figure 8.**

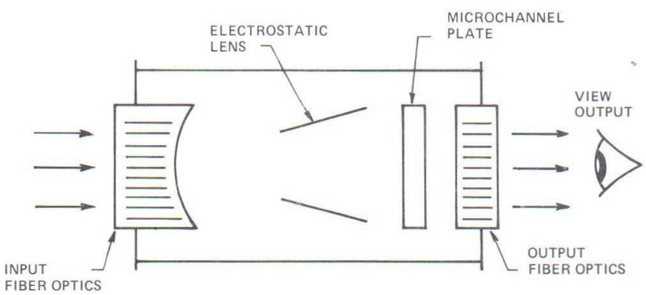
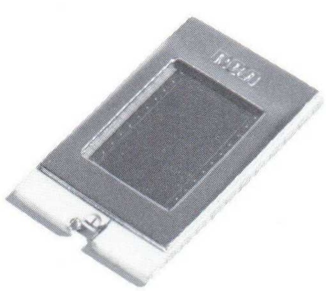



**Figure 8 – Schematic Diagram of a Typical Second Generation Electrostatically-Focused Image Tube Utilizing an MCP to Increase Gain**



## Charge-Coupled Devices

The RCA SID Silicon Imaging Device is a charge-coupled device (CCD) intended for the generation of standard interlaced 525 line television picture signals. It is a self scanning imager using an array of CCD shift registers for both sensing and readout. The organization and construction of the RCA SID is depicted in **Figure 9.**

Each sensing element (pixel) in the image area is a metal oxide semiconductor (MOS) capacitor. The pixel size is defined by each grouping of the three phase transfer electrodes in the vertical direction and by the adjacent channel stops in the horizontal direction. The three phase electrodes of each row of pixels are connected in parallel with the corresponding electrodes of the other rows. Clocking voltages applied to these connections accomplish charge transfer. In operation, an optical image focused on the image area is integrated into a charge pattern of electrons during an active field interval and transferred to the temporary storage area during the following vertical blanking interval. To control blooming of image speculars during picture integration, the three phase transfer electrodes that are not biased to form the sensing site are biased more negative. This mode of operation, a unique feature of the RCA SID, electronically extends channel stops completely around each pixel and thus prevents excessive charge from overexposed sites from spreading (blooming). Interlace is achieved by the alternation of the phase two and phase three electrodes on successive fields. The transfer electrodes are polysilicon and are transparent to the visible spectrum. The entire sensing area is therefore light sensitive. There are no opaque areas as exists with interline transfer devices and thus there is no "aliasing" (the results of a pattern of picture information lost at the monitor display).

The storage area has the same construction as the image area. It is the temporary storage site for the image charge pattern for sequential readout. The storage area three phase transfer electrodes are clocked in unison with the image area during the vertical blanking interval to transfer the complete field of image charge from the image area to the storage area. During each horizontal blanking interval, the charge pattern is advanced toward the horizontal register, one line at a time, and loaded into the horizontal register to be read out during the next active horizontal interval.

The horizontal register is also a three phase transfer construction. The horizontal register receives one line of picture information from the storage area during each horizontal blanking interval. In the active horizontal interval to follow, each line is clocked out at a 6.1 MHz rate so that all active pixels are read out in the standard active horizontal line time of 52.7 $\mu$s.

The picture signal is extracted from the horizontal register by the output gate electrode; it is the last CCD gate in the horizontal register. The signal charge is collected at the floating diffusion and the signal voltage is sensed by the output transistor. The output signal is taken from the source load of that transistor.

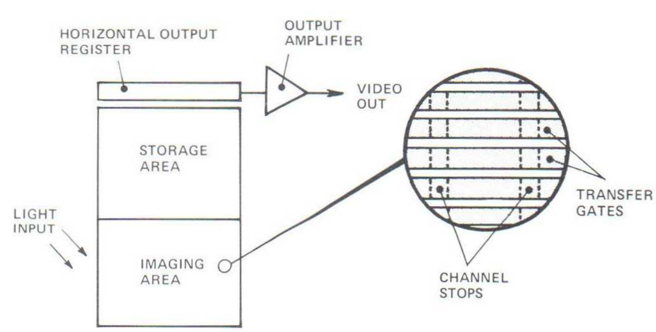
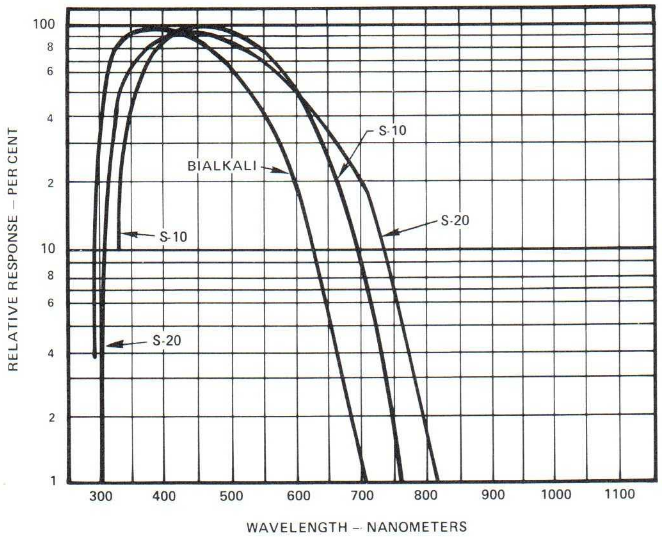



**Figure 9 – Schematic Representation of a CCD Solid-State Imager**

# Typical Spectral Response Characteristics

## Bialkali, S-10, S-20

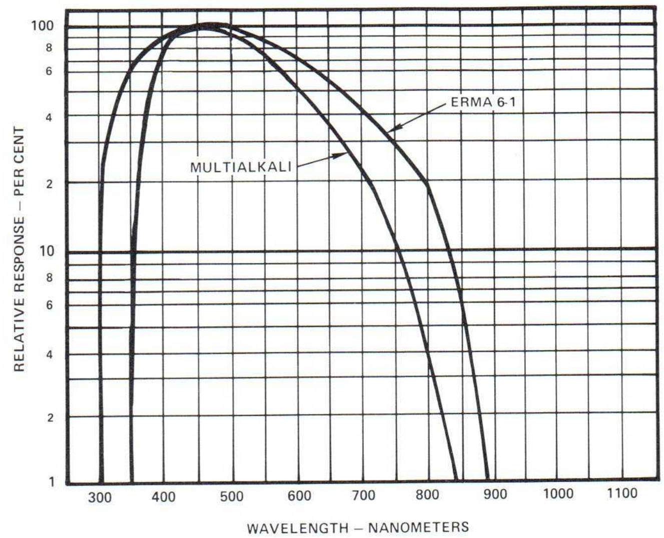



**Bialkali** – The bialkali photocathode provides high sensitivity concentrated in the visible portion of the spectrum. Its use is particularly desirable when the color tone scale should not be distorted by infrared response.

**S-10** – The S-10 spectral response is the most commonly employed photocathode for image orthicons. Its panchromatic response covers the entire visible range.

**S-20** – The S-20 spectral response (multialkali photocathode) provides high sensitivity over the entire visible range, as well as having significant sensitivity in the near infrared region of the spectrum. This photocathode is also characterized by low thermionic dark current.

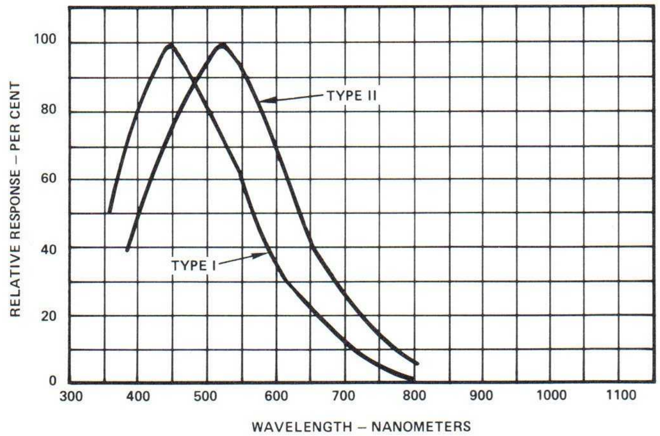
## ERMA 6-1, Multialkali (As Modified by Fiber Optic Window)




**ERMA 6-1** – The ERMA spectral response (extended red multialkali) is enhanced in the near infrared region of the spectrum and is tested specifically in that region.

**Multialkali** – The NaKCsSb photocathode spectral response is between the EIA S-20 and the ERMA 6-1 in the near infrared region of the spectrum. Response in the near ultraviolet region of the spectrum is limited when using a fiber optic window.

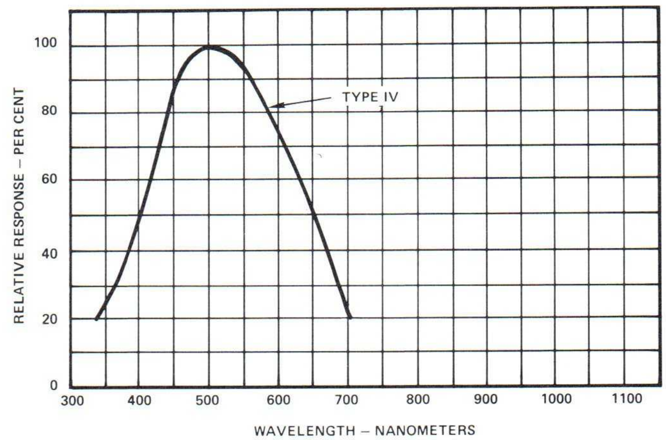
## Photoconductors I and II




**Photoconductor I** – Vidicons employing this medium-sensitivity, low-lag photoconductor are intended for use at the relatively high-light levels of film pick-up service.

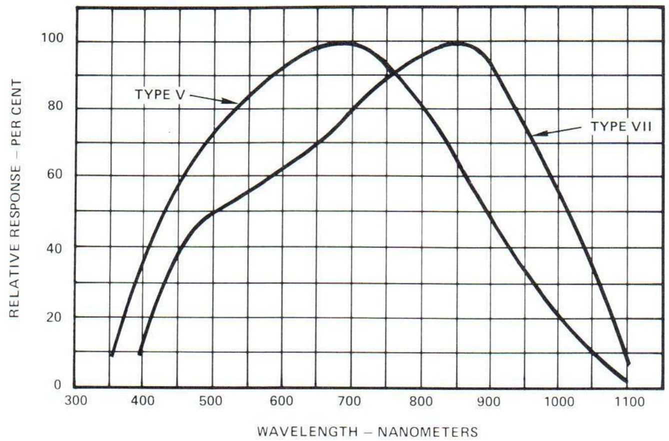
**Photoconductor II** – Vidicons employing this high-sensitivity, low-lag photoconductor are intended for use primarily in live TV pick-up service.

## Photoconductor IV




**Photoconductor IV** – This photoconductor has very long lag characteristics. Vidicons employing this material are intended for signal-storage applications such as the telecasting of PPI-type radar displays.

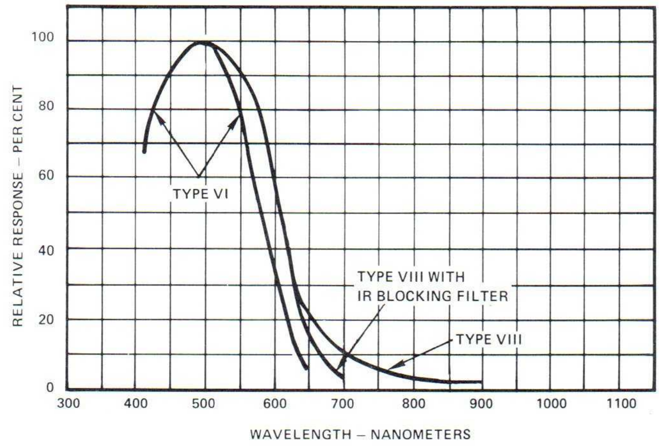
## Photoconductors V and VII




**Photoconductor V (Silicon-Target Diode-Mosaic)** – Vidicons employing this extremely high-sensitivity and very low lag photoconductor are especially suited for operation in the visible portion of the spectrum. They are controlled to provide uniformly good resolution even at the very short wavelength (blue-violet) end of the light spectrum. They are also useful in near infrared television systems. Where primary interest is in the near infrared, photoconductor VII should be specified.

**Photoconductor VII (Silicon-Target Diode-Mosaic)** – This photoconductor has very low lag with an enhanced infrared response. Where primary interest is in good detail response to visible light, photoconductor V should be specified.

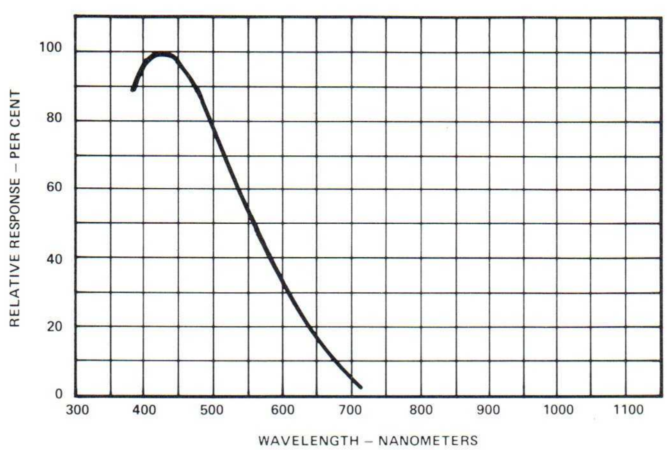
## Photoconductors VI and VIII




**Photoconductor VI** – This lead-oxide photoconductor used in vistacons, has high sensitivity and extremely low lag.

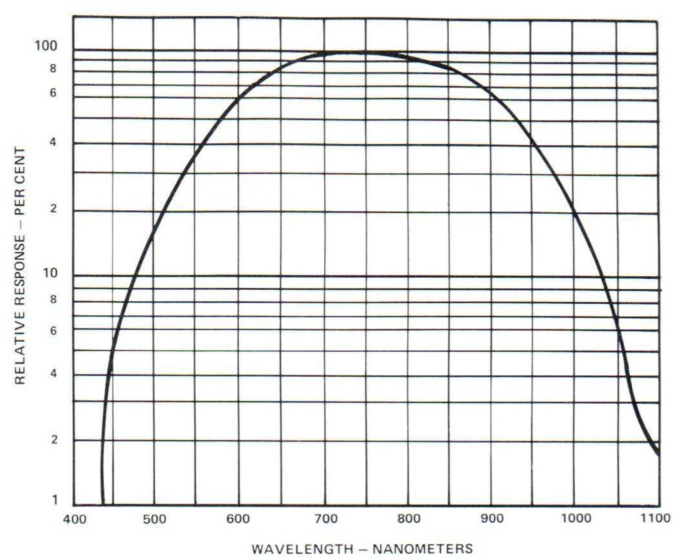
**Photoconductor VIII** – This lead-oxide photoconductor used in vistacons has enhanced red response and is especially useful in the red channel of color broadcasting cameras. This photoconductor is also available with integral infrared blocking filters.

## Photoconductor IX




**Photoconductor IX** – This selenium arsenic tellurium photoconductor used in SATICON vidicons has a response that encompasses the entire visible spectrum. The spectral response is especially suited to color TV pickup both live and film. Spectral sensitivity is high in the blue and negligible in the infrared regions of the spectrum.

## Charge-Coupled Devices



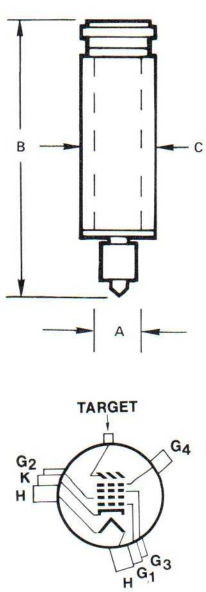

This device is a silicon imaging device that utilizes an array of charge-coupled device shift registers for photosensing and readout. The useful spectral response range extends from 420 nm to 1100 nm.

# Sulfide Vidicons

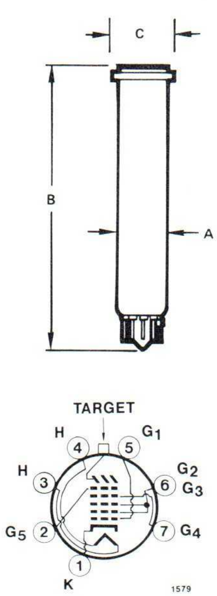
- 16, 18, 25, 38 and 51 mm Bulb Diameters
- Type I, II and IV Photoconductors
- Electrostatic and Magnetic Focus and Deflection Types
- For Broadcast, CCTV and Military Applications

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) mm/in | Max. Overall Length (B) mm/in | Max. Clearance Dia. (C) mm/in | | A/W | | mm/in | | |
| C23271/P1 | 16/0.6 | 82.0/3.23 | 23.0/0.9 | – | 0.22/1.25 | II | 11.0/0.43 | M | M |
| 4848 | 18/0.7 | 108.1/4.25 | 19.8/0.78 | E7-91 | 0.1/0.6 | II | 11.0/0.43 | E | M |
| 8844 | | 103.1/4.06 | 19.8/0.78 | E7-91 | 0.1/0.6 | II | 11.0/0.43 | M | M |
| 4493 | 25/1.0 | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 8.1/0.32 | E | M |
| 4494 | | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 8.1/0.32 | E | M |
| 4495 | | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 8.1/0.32 | E | M |
| 4503A | | 133.4/5.25 | 29.0/1.14 | E8-11 | 0.3/1.9 | II | 16.0/0.63 | M | M |
| 4514 | | 147.6/5.81 | 29.0/1.14 | E13-90 | 0.3/1.9 | II | 16.0/0.63 | E | E |
| 4542 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | IV | 16.0/0.63★ | M | M |
| 4569 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| 4589 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| 7262A | | 131.6/5.18 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| 7735 | | 165.1/6.50 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| 7735A | | 165.1/6.50 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| 7735B | | 165.1/6.50 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| 8134 | | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | E | M |
| 8507 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| 8507A | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |

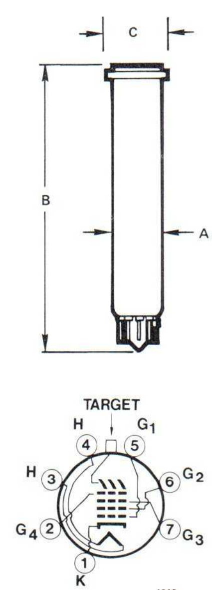
C23271/P1



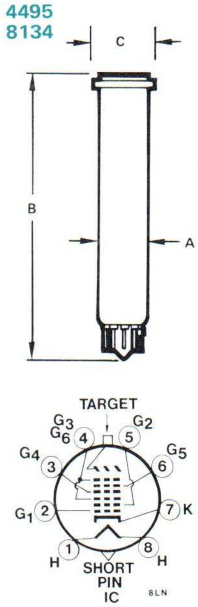

4848




8844




4493
4494
4495
8134



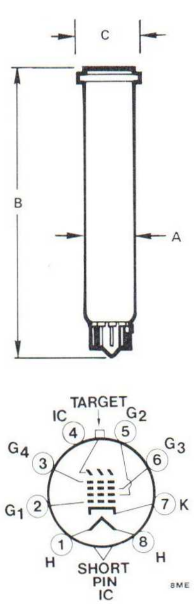
| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current nA | Output Signal nA @ lm/ft$^2$ | At Mesh Volts V | Amplitude Response at 400 TV Lines/PH % | Limiting Resolution TV-Lines | | |
| 20 | 135 @ 0.5 | 450 | 15 | 700 | Yes | Very rugged, ceramic-envelope vidicon with magnetic components. See page 36 for magnetics. |
| 20 | 200 @ 1 | 500 | 20 | 550 | Yes | For compact closed circuit television (CCTV) cameras. |
| 20 | 200 @ 1 | 500 | 25 | 600 | Yes | For compact CCTV cameras. |
| 10 | 60 @ 4.5▲ | 750 | 60♦ | 500 | Yes | For red channel of RCA TK-42 and TK-43 cameras. |
| 10 | 60 @ 4.5▲ | 750 | 60♦ | 500 | Yes | For green channel of RCA TK-42 and TK-43 cameras. |
| 5 | 20 @ 4▲ | 750 | 60♦ | 500 | Yes | For blue channel of RCA TK-42 and TK-43 cameras. |
| 20 | 270 @ 1 | 500/900 | 50/55 | 1000/1100 | Yes | Ruggedized type for CCTV applications. |
| 20 | 270 @ 1 | 300 | 35 | 750 | Yes | For light-weight, compact, low-power CCTV cameras. |
| 20 | 200 @ 0.1 | 500/750 | 50/60 | 850/1000 | Yes | Radar scan converter. Extended storage to enhance TV presentation of PPI-type radar pictures. |
| 20 | 210 @ 1 | 500/900 | 50/55 | 850/1000 | Yes | Fiber-optic faceplate variant of 8541A - for X-ray linkage. |
| 20 | 210 @ 1 | 500/900 | 50/55 | 850/1000 | Yes | Fiber-optic faceplate variant of 8507A - for X-ray linkage. |
| 20 | 270 @ 1 | 300/750 | 30/45 | 700/800 | No | Reduced length, low heater power variant of 7735A. |
| 20 | 240 @ 1 | 300 | 30 | 700 | No | For CCTV applications: 7735B – Premium (1st) Level |
| 20 | 270 @ 1 | 300 | 30 | 700 | No | 7735A – Commercial (2nd) Level |
| 20 | 300 @ 1 | 300/750 | 30/45 | 700/800 | No | 7735 – Industrial (3rd) Level |
| 10 | 120 @ 1 | 500 | 25 | 600 | Yes | For CCTV applications. |
| 20 | 270 @ 1 | 500/900 | 50/55 | 900/1100 | Yes | For CCTV applications: 8507 – Industrial (2nd) Level |
| 20 | 270 @ 1 | 500/900 | 50/55 | 900/1100 | Yes | 8507A – Premium (1st) Level |

♦At 125 TV lines

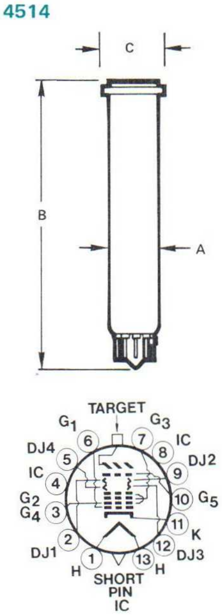
★Denotes diameter of usable circular image area

▲2856 K tungsten illumination on (1) Wratten 25 (red) for 4493, (2) Wratten 58 (green) for 4494, and (3) Wratten 47 (blue) for 4495.

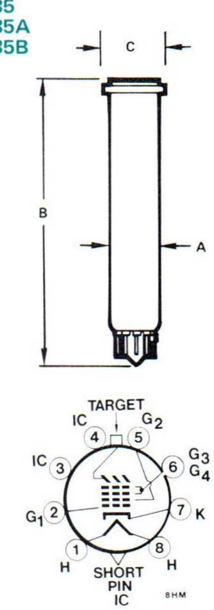
4503A
4542
4569
4589
8507
8507A




4514



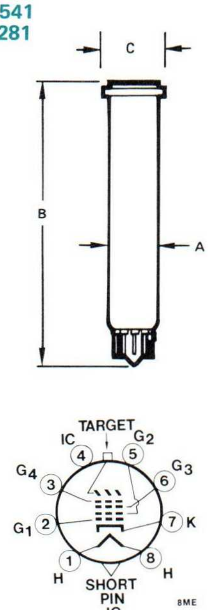

7262A
7735
7735A
7735B



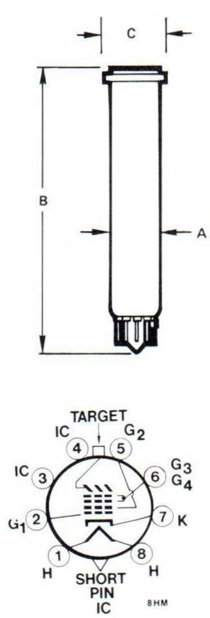
# Sulfide Vidicons (cont'd)

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) mm/in | Max. Overall Length (B) mm/in | Max. Clearance Dia. (C) mm/in | | A/W | | mm/in | | |
| 8541 | 25/1.0 | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| 8541A | (cont'd) | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| 8541A/X | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 17.8/0.70★ | M | M |
| BC4809 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| BC4809/B | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| BC7735 | | 165.1/6.50 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| BC8134 | | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | E | M |
| BC8134/B | | 161.3/6.35 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | E | M |
| BC8507 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.6/3.8 | II | 16.0/0.63 | M | M |
| BC8541 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| C23151 | | 102.0/4.0 | 36.8/1.45 | E8-11 | 0.1/0.6 | II | 16.0/0.63 | M | M |
| C23257A/P2 | | 107.0/4.2 | 36.8/1.45 | – | 0.1/0.6 | II | 16.0/0.63 | M | M |
| C23281 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.3/1.9 | IV | 16.0/0.63 | M | M |
| 8480 | 38/1.5 | 263.7/10.38 | 40.6/1.60 | E8-78 | 0.1/0.6 | I | 25.4/1.00 | E | M |
| BC8480 | | 263.7/10.38 | 40.6/1.60 | E8-78 | 0.1/0.6 | I | 25.4/1.00 | E | M |
| C23225 | | 203.2/8.00 | 40.6/1.60 | E8-78 | 0.6/3.8 | II | 25.4/1.00 | M | M |
| C81000E | 51/2.0 | 196.0/7.7 | 53.5/2.10 | E8-78 | 0.3/1.9 | II | 32.0/1.25 | M | M |

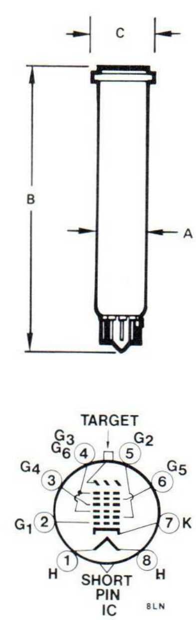
**8541 Series**
**BC4809**
**BC4809/B**
**BC8507**
**BC8541**
**C23281**



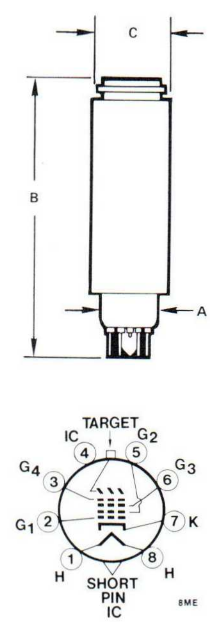

**BC7735**




**BC8134**
**BC8134/B**




**C23151**



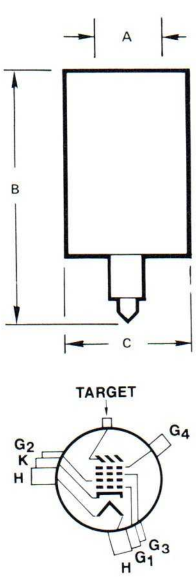
| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current<br>nA | Output Signal<br>nA @ lm/ft$^2$ | At Mesh Volts<br>V | Amplitude Response at 400 TV Lines/PH<br>% | Limiting Resolution<br>TV-Lines | | |
| 20 | 270 @ 1 | 500/900 | 50/55 | 800/1100 | Yes | For CCTV applications:<br>8541A – Premium (1st) Level<br>8541 – Industrial (2nd) Level<br>8541A/X – TV viewing of X-ray excited image screens (X-ray linkage). |
| 20 | 270 @ 1 | 500/900 | 50/55 | 900/1100 | Yes | |
| 20 | 300 @ 1 | 500/900 | 50/55 | 900/1100 | Yes | |
| 10 | 120 @ 1 | 900 | 40 | – | Yes | Provides highly uniform resolution in broadcast color film cameras. BC4809/B for blue channel of broadcast color film cameras. |
| 10 | 175 @ 1● | 900 | 40 | – | Yes | |
| 10 | 120 @ 1 | 300 | 30 | – | No | For broadcast color film cameras. |
| 10 | 120 @ 1 | 500 | 25 | – | Yes | For broadcast color film cameras. BC8134/B for blue channel of broadcast color film cameras. |
| 10 | 175 @ 1● | 500 | 25 | – | Yes | |
| 10 | 120 @ 1 | 500/900 | 50/55 | – | Yes | For broadcast color film cameras. |
| 10 | 120 @ 1 | 500/900 | 50/55 | – | Yes | For broadcast color film cameras. |
| 20 | 270 @ 1 | 500 | 60⊕ | 1200⊕ | Yes | Short ruggedized tube and focus deflection assembly. See page 36 for magnetics. |
| 20 | 270 @ 1 | 500 | 50 | 1000 | Yes | Ceramic tube, focus-deflection assembly potted in shield. Very rugged. See page 36 for magnetics. |
| 20 | 200 @ 0.1 | 500/750 | 50/60 | 850/1000 | Yes | Radar scan converter. Extended storage to enhance TV presentation of PPI-type radar pictures. |
| 20 | 125 @ 1 | 1400 | 60 | 1500 | Yes | For broadcast service black and white cameras. |
| 5 | 300 @ 20 | 1400 | 60 | – | Yes | For luminance channel of color film cameras. |
| 20 | 200 @ 1 | 1150 | 80 center<br>65 corner | 1700 | Yes | Very uniform resolution center to corner, for document reading. Uses C23227 yoke assembly. See page 36. |
| 100 | 180 @ 0.1 | 800 | 85 | 2000 | Yes | High resolution vidicon for document reading and special applications. |

●20 lm/ft$^2$ with BG-12 - 3 mm thick Schott filter

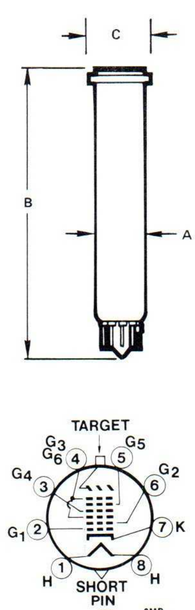
★Denotes diameter of usable circular image area

⊕1 x 1 aspect

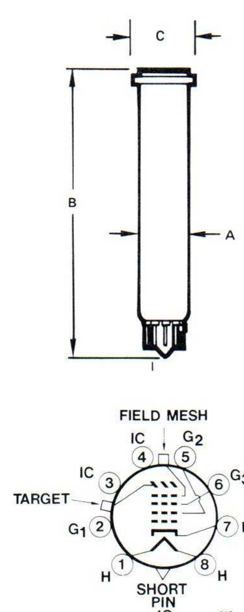
C23257A/P2



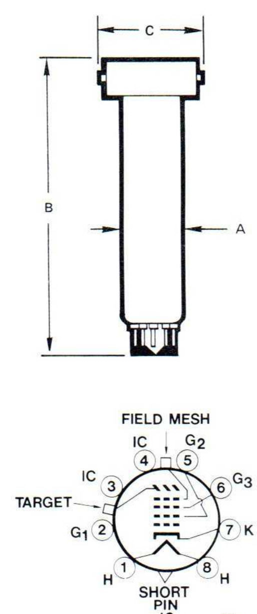

8480
BC8480




C23225




C81000E

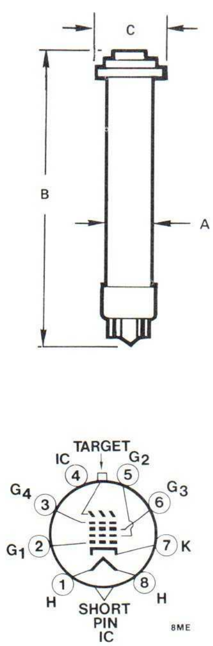


# Vistacons (Lead-Oxide Vidicons)

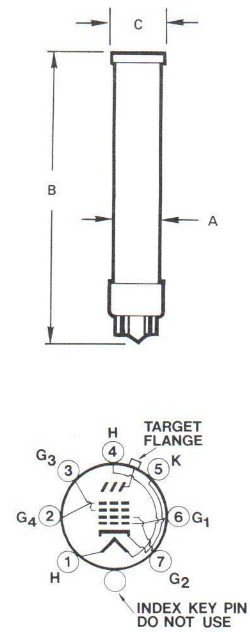
- 25 and 30 mm Bulb Diameters
- Type VI and VIII Photoconductors
- For CCTV Applications
- Magnetic Focus and Deflection
- Plumbicon* Replacement Types
- "Camera Ready" Broadcast Types for Live and Film Service

| Type Number | Dimensions & Outline | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) mm/in | Max. Overall Length (B) mm/in | Max. Clearance Dia. (C) mm/in | | A/W | | mm/in | | |
| BC4892/B | 25/1.0 | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VI | 16.0/0.63 | M | M |
| BC4892/G | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VI | 16.0/0.63 | M | M |
| BC4892/L | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VI | 16.0/0.63 | M | M |
| BC4892/R | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VI | 16.0/0.63 | M | M |
| BC4893/R | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VIII | 16.0/0.63 | M | M |
| BC4894/G | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | VIII (with integral IR blocking filter) | 16.0/0.63 | M | M |
| BC4894/R | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | | 16.0/0.63 | M | M |
| BC4894/L | | 167.1/6.58 | 28.7/1.13 | E8-11 | 0.095/0.6 | | 16.0/0.63 | M | M |
| 4817 | 30/1.2 | 214.1/8.43 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4392/B | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VI | 21.0/0.83 | M | M |
| BC4392/G | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VI | 21.0/0.83 | M | M |
| BC4392/L | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VI | 21.0/0.83 | M | M |
| BC4392/R | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VI | 21.0/0.83 | M | M |
| BC4393/R | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VIII | 21.0/0.83 | M | M |
| BC4394/G | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | VIII (with integral IR blocking filter) | 21.0/0.83 | M | M |
| BC4394/L | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | | 21.0/0.83 | M | M |
| BC4394/R | | 220.0/8.66 | 30.7/1.21 | – | 0.4/2.5 | | 21.0/0.83 | M | M |

**BC4892/B**
**BC4892/G**
**BC4892/L**
**BC4892/R**
**BC4893/R**
**BC4894/G**
**BC4894/R**
**BC4894/L**

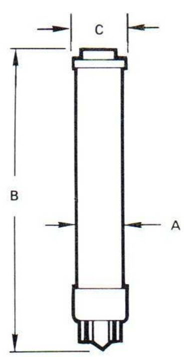


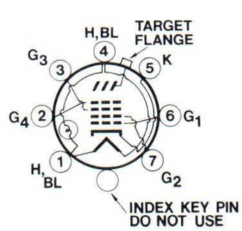

**4817**



| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current nA | Output Signal nA @ lm/ft² | At Mesh Volts V | Amplitude Response at 400 TV Lines/PH % | Limiting Resolution TV-Lines | | |
| 0.5 | 80 @ 1▲ | 800 | 20 | – | Yes | "Camera Ready" vistacons for broadcast cameras–live presentations. |
| 0.5 | 160 @ 1▲ | 800 | 20 | – | Yes | /B – Blue channel in color cameras |
| 0.5 | 400 @ 1▲ | 800 | 20 | – | Yes | /G – Green channel in color cameras |
| 0.5 | 88 @ 1▲ | 800 | 20 | – | Yes | /L – Luminance channel in color cameras or for use in black and white cameras |
| 1.5 | 125 @ 1♦ | 800 | 20 | – | Yes | /R – Red channel in color cameras |
| 1.5 | 170 @ 1● | 800 | 25 | – | Yes | |
| 1.5 | 250 @ 1● | 800 | 20 | – | Yes | |
| 1.5 | 900 @ 1● | 800 | 25 | – | Yes | |
| 0.5 | 800 @ 1 | 900 | 30 | 700 | Yes | TV viewing of X-ray excited image screens (X-ray linkage). No anti-halation disc. |
| 7★ | 80 @ 1▲ | 900 | 35 | – | Yes | "Camera Ready" Vistalite™ vistacons for broadcast cameras–live presentations. |
| 5★ | 320 @ 1▲ | 900 | 30 | – | Yes | /B – Blue channel in color cameras |
| 5★ | 800 @ 1▲ | 900 | 30 | – | Yes | /G – Green channel in color cameras |
| 7★ | 196 @ 1 | 900 | 25 | – | Yes | /L – Luminance channel in color cameras or for use in black and white cameras |
| 9★ | 250 @ 1♦ | 900 | 40 | – | Yes | /R – Red channel in color cameras |
| 9★ | 340 @ 1● | 900 | 45 | – | Yes | These types contain an internal bias light powered by the filament supply. |
| 9★ | 900 @ 1● | 900 | 45 | – | Yes | |
| 9★ | 280 @ 1● | 900 | 40 | – | Yes | |

BC4392/B
BC4392/G
BC4392/L
BC4392/R
BC4393/R
BC4394/G
BC4394/L
BC4394/R




★Including bias light current.

▲These characteristics are measured using the following optical filters, or equivalent:
For /R types – Schott, OG570 (Formerly OG2), 3 mm thick.
For /G types – Schott, VG9, 1 mm thick
For /B types – Schott, BG12, 3 mm thick
For /L types – No filter

♦These characteristics are measured using the following optical filters, or equivalent:
For /R types – Schott, OG570, 3 mm thick, and Fish-Schurman No.6143 IR "heat deflector" filter

●These characteristics are measured using the following optical filters, or equivalent:
For /G types – Schott, VG9, 1 mm thick
For /L types – No filter
For /R types – Schott, OG570, 3 mm thick

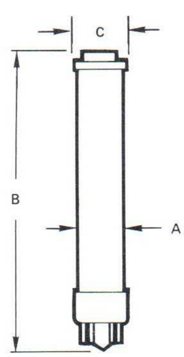
*Trademark of Amperex Electronic Corporation

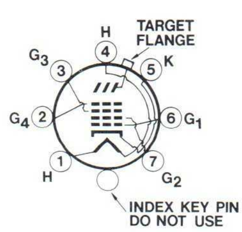
# Vistacons (cont'd)

| Type Number | Dimensions and Outline | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | | |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | |
| BC4592/B | 30/1.2 | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4592/G | (cont'd) | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4592/L | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4592/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4593/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VIII | 21.0/0.83 | M | M |
| BC4594/G | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VIII (with | 21.0/0.83 | M | M |
| BC4594/L | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | integral IR | 21.0/0.83 | M | M |
| BC4594/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | blocking filter) | 21.0/0.83 | M | M |
| BC4992/B | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4992/G | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4992/L | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4992/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VI | 21.0/0.83 | M | M |
| BC4993/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VIII | 21.0/0.83 | M | M |
| BC4994/G | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | VIII (with | 21.0/0.83 | M | M |
| BC4994/L | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | integral IR | 21.0/0.83 | M | M |
| BC4994/R | | 220.0/8.66 | 30.7/1.21 | – | 0.3/1.9 | blocking filter) | 21.0/0.83 | M | M |

**BC4592/B**
**BC4592/G**
**BC4592/L**
**BC4592/R**
**BC4593/R**
**BC4594/G**
**BC4594/L**
**BC4594/R**

**BC4992/B**
**BC4992/G**
**BC4992/L**
**BC4992/R**
**BC4993/R**
**BC4994/G**
**BC4994/L**
**BC4994/R**



| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current<br>nA | Output Signal<br>nA @ lm/ft$^2$ | At Mesh Volts<br>V | Amplitude Response at 400 TV Lines/PH<br>% | Limiting Resolution<br>TV-Lines | | |
| 0.7 | 80 @ 1▲ | 900 | 35 | – | Yes | "Camera Ready" vistacons for broadcast cameras—live and film service. |
| 0.7 | 320 @ 1▲ | 900 | 30 | – | Yes | /B – Blue channel in color cameras |
| 0.7 | 800 @ 1▲ | 900 | 30 | – | Yes | /G – Green channel in color cameras |
| 0.7 | 180 @ 1▲ | 900 | 25 | – | Yes | /L – Luminance channel in color cameras or for use in black and white cameras |
| 1.5 | 240 @ 1♦ | 900 | 40 | – | Yes | /R – Red channel in color cameras |
| 1.5 | 340 @ 1● | 900 | 45 | – | Yes | |
| 1.5 | 900 @ 1● | 900 | 45 | – | Yes | |
| 1.5 | 240 @ 1● | 900 | 40 | – | Yes | |
| 3.0★ | 80 @ 1▲ | 900 | 35 | – | Yes | "Camera Ready" vistacons for broadcast cameras—live presentations. |
| 3.0★ | 320 @ 1▲ | 900 | 30 | – | Yes | /B – Blue channel in color cameras |
| 3.0★ | 800 @ 1▲ | 900 | 30 | – | Yes | /G – Green channel in color cameras |
| 3.0★ | 180 @ 1▲ | 900 | 25 | – | Yes | /L – Luminance channel in color cameras or for use in black and white cameras |
| 6.0★ | 240 @ 1♦ | 900 | 40 | – | Yes | /R – Red channel in color cameras |
| 6.0★ | 340 @ 1● | 900 | 45 | – | Yes | These types have internal bias lighting which is obtained from the filament. |
| 6.0★ | 900 @ 1● | 900 | 45 | – | Yes | |
| 6.0★ | 240 @ 1● | 900 | 40 | – | Yes | |

★Including bias light current

▲These characteristics are measured using the following optical filters, or equivalent:
For /R types – Schott, OG570 (Formerly OG2), 3 mm thick
For /G types – Schott, VG9, 1 mm thick
For /B types – Schott, BG12, 3 mm thick
For /L types – No filter

♦These characteristics are measured using the following optical filters, or equivalent:
For /R types – Schott, OG570, 3 mm thick, and Fish-Schurman No.6143 IR "heat deflector" filter

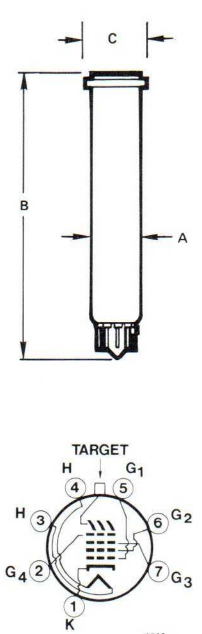
●These characteristics are measured using the following optical filters, or equivalent:
For /G types – Schott, VG9, 1 mm thick
For /L types – No filter
For /R types – Schott, OG570, 3 mm thick

# SATICON Vidicons

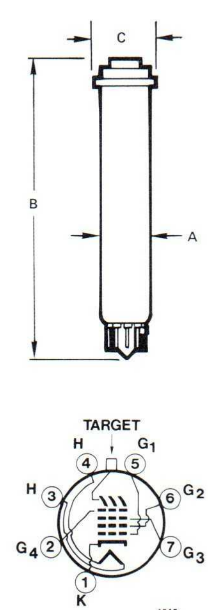
- 18 and 25 mm Bulb Diameters
- Magnetic Focus and Deflection
- For Broadcast and CCTV Color Cameras
- Plumbicon* Replacement Types

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) mm/in | Max. Overall Length (B) mm/in | Max. Clearance Dia. (C) mm/in | | A/W | | mm/in | | |
| 4911 | 18/0.7 | 105.0/4.13 | 19.8/0.78 | E7-91 | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4390/B | | 105.0/4.13 | 19.8/0.78 | E7-91 | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4390/G | | 105.0/4.13 | 19.8/0.78 | E7-91 | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4390/R | | 105.0/4.13 | 19.8/0.78 | E7-91 | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4908/B | | 105.0/4.13 | 19.8/0.78 | ● | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4908/G | | 105.0/4.13 | 19.8/0.78 | ● | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4908/R | | 105.0/4.13 | 19.8/0.78 | ● | 0.095/0.6 | IX | 11.0/0.43 | M | M |
| BC4909 | 25/1.0 | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | IX | 16.0/0.63 | M | M |
| S81007E | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | IX | 16.0/0.63 | M | M |
| S81008E | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | IX | 16.0/0.63 | M | M |

**4911**




**BC4390/B**
**BC4390/G**
**BC4390/R**

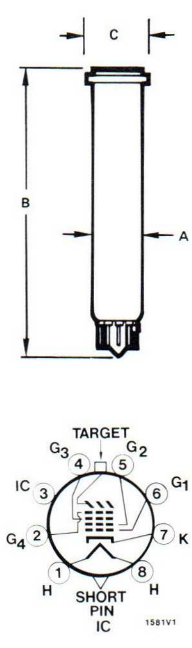


| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current<br>nA | Output Signal<br>nA @ lm/ft$^2$ | At Mesh Volts<br>V | Amplitude Response at 400 TV Lines/PH<br>% | Limiting Resolution<br>TV-Lines | | |
| 3 | 200 @ 1 | 425/700 | 35 | – | Yes | SATICON vidicon for CCTV – color applications |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | "Camera Ready" SATICON vidicon – mechanically and |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | electrically interchangeable (in sets of three) with 2/3" |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | Plumbicon* in most color cameras |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | "Camera Ready" SATICON vidicon for broadcast cameras |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | live presentations |
| 0.3 | 200 @ 1 | 425/700 | 35 | – | Yes | /B – Blue channel in color cameras<br>/G – Green channel in color cameras<br>/R – Red channel in color cameras |
| 0.3 | 400 @ 1 | 900 | 45 | – | Yes | "Camera Ready" SATICON vidicon for broadcast – color film service |
| 0.3 | 400 @ 1 | 900 | 45 | – | Yes | SATICON vidicon for CCTV, medical electronics, and X-ray linkage |
| 0.3 | 400 @ 1 | 900 | 45 | – | Yes | Fiber optic faceplate version of S81007E |

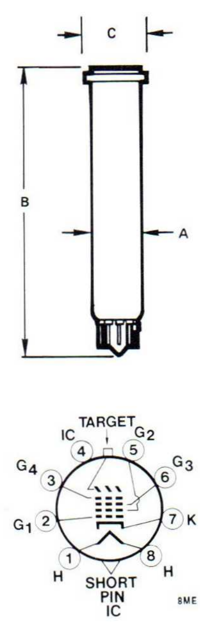
●8-pin miniature base (mates with RCA socket AJ2234)

*Trademark of Amperex Electronic Corporation

BC4908/B
BC4908/G
BC4908/R




BC4909
S81007E
S81008E

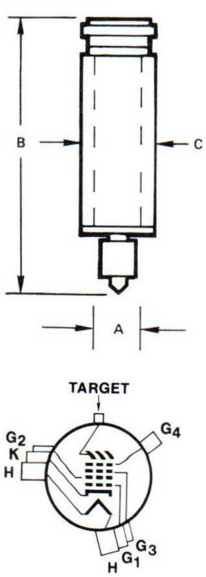


# Ultricon™ and Other Silicon-Target Vidicons

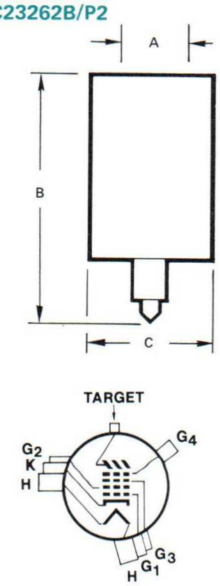
- **16, 18, 25, and 38 mm Image Burn Resistant Types With Low Blooming and Very High Sensitivity**

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Photo-conductor | Max. Image Diagonal | Focus Method | Deflection Method |
|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) mm/in | Max. Overall Length (B) mm/in | Max. Clearance Dia. (C) mm/in | | A/W | | mm/in | | |
| C23240/P1 | 16/0.6 | 82.0/3.23 | 23.0/0.9 | – | 0.1/0.6 | V | 11.0/0.43 | M | M |
| 4833/U | 18/0.7 | 107.4/4.23 | 19.8/0.78 | E7-91 | 0.1/0.6 | V | 11.0/0.43 | M | M |
| 4833A/U | | 107.4/4.23 | 19.8/0.78 | E7-91 | 0.1/0.6 | V | 11.0/0.43 | M | M |
| 4875/U | | 103.1/4.06 | 19.8/0.78 | E7-91 | 0.1/0.6 | V | 11.0/0.43 | E | M |
| 4532/U | 25/1.0 | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| 4532A/U | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| 4532B/U | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| BC4532 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23174 | | 133.4/5.25 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23174A | | 133.4/5.25 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23174B | | 133.4/5.25 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23174C | | 133.4/5.25 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23219 | | 102.0/4.0 | 36.8/1.45 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23231 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23246 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23250 | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | VII | 16.0/0.63 | M | M |
| C23250A | | 162.0/6.38 | 29.0/1.14 | E8-11 | 0.1/0.6 | VII | 16.0/0.63 | M | M |
| C23262A/P2 | | 107.0/4.2 | 36.8/1.45 | – | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23262B/P2 | | 107.0/4.2 | 36.8/1.45 | – | 0.1/0.6 | V | 16.0/0.63 | M | M |
| C23213 | 38/1.5 | 203.2/8.00 | 40.6/1.60 | E8-78 | 0.1/0.6 | V | 25.4/1.0 | M | M |

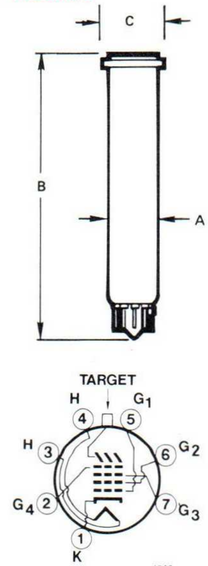
**C23240/P1**



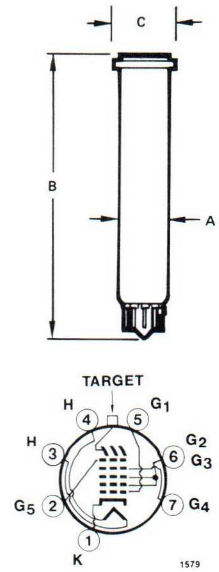

**C23262A/P2**
**C23262B/P2**




**4833/U**
**4833A/U**



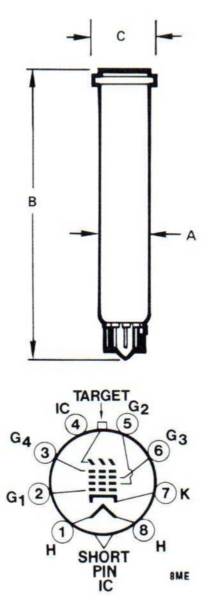

**4875/U**



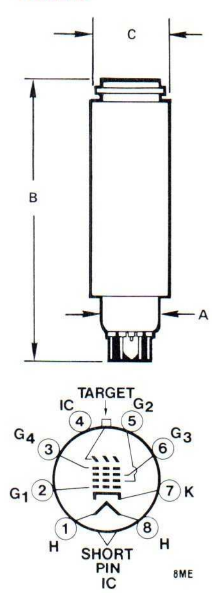
| Typical Operation (2856 K Source) | | | | | Separate Field Mesh Connection | Remarks |
|---|---|---|---|---|---|---|
| Sensitivity | | Detail Response (4 x 3 Aspect) | | | | |
| At Dark Current nA | Output Signal nA @ lm/ft$^2$ | At Mesh Volts V | Amplitude Response at 400 TV Lines/PH % | Limiting Resolution TV-Lines | | |
| – | 270 @ 0.1 | 480 | 35** | 500 | Yes | Very rugged, ceramic envelope. Supplied with magnetic components. See page 36 for magnetics. |
| – | 345 @ 0.1 | 350 | 45** | 450 | Yes | Ultricon™ types – for superior performance in CCTV cameras. |
| – | 345 @ 0.1 | 350 | 45** | 450 | Yes | Lower blooming, lower flare, lower lag, extremely high sensitivity, broad spectral range and image burn resistant. |
| – | 345 @ 0.1 | 500 | 42** | 425 | Yes | /U – Industrial (3rd) Level<br>A/U – Commercial (2nd) Level |
| – | 720 @ 0.1 | 480 | 35 | 700 | Yes | Ultricon™ types – for superior performance in CCTV cameras. |
| – | 720 @ 0.1 | 480 | 35 | 700 | Yes | Lower blooming, lower flare, lower lag, extremely high sensitivity, broad spectral range and image burn resistant. |
| – | 720 @ 0.1 | 480 | 35 | 700 | Yes | /U – Industrial (3rd) Level<br>A/U – Commercial (2nd) Level<br>B/U – Premium (1st) Level |
| – | 565 @ 0.1 | 480 | 35 | – | Yes | "Camera Ready" type for broadcast – live color presentations |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | Ruggedized, reduced length variants of 4532/U series. |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | C23174, C23174B – Commercial (2nd) Level |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | C23174A, C23174C – Premium (1st) Level |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | C23174B, C23174C – Bonded target versions |
| – | 565 @ 0.1 | 480 | 44☆ | 300☆ | Yes | Short, ruggedized tube, focus deflection assembly. See page 36 for magnetics. |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | Variants of 4532/U series.<br>C23231 – Enhanced UV response (90 mA/W @ 300 nm) |
| – | 565 @ 0.1 | 480 | 35 | 700 | Yes | C23246 – Enhanced UV response (20 mA/W @ 300 nm) |
| – | 360 @ 0.05 | 500 | 25 | 650 | Yes | C23250, C23250A – Enhanced red and near IR response (60 mA/W @ 1060 nm) |
| – | 360 @ 0.05 | 500 | 25 | 650 | Yes | C23250A – Premium (1st) Level<br>C23250 – Commercial (2nd) Level |
| – | 565 @ 0.1 | 480 | 40 | 700 | Yes | Ceramic tube, focus-deflection assembly potted in shield. |
| – | 565 @ 0.1 | 480 | 40 | 700 | Yes | Very rugged. See page 36 for magnetics.<br>C23262B/P2 – Bonded target version |
| – | 435 @ 0.03 | 480 | 57 | 1100 | Yes | High-resolution vidicon for CCTV. |

**At 240 TV Lines. ☆1 x 1 Aspect.

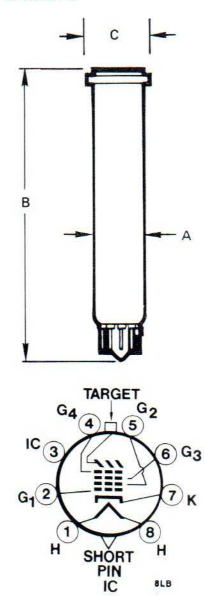
4532/U
4532A/U
4532B/U
BC4532
C23174
C23174A
C23174B
C23174C
C23231
C23246
C23250
C23250A




C23219




C23213

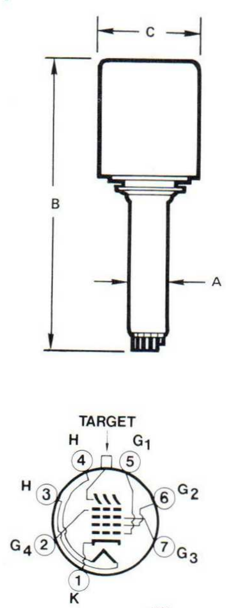


# Silicon-Intensifier Target Tubes

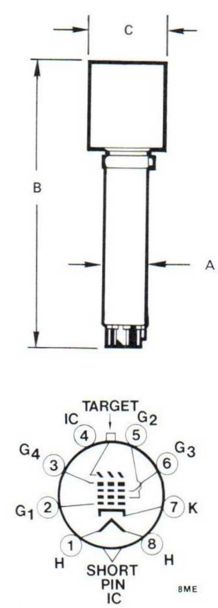
- 12, 16, 25, 40 and 80 mm Image Diagonals
- Multialkali Photocathodes
- Low Blooming
- For Very Low Light Level Applications
- Potted Types:
  For Greater Safety and Ease of Use

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Spectral Response | Max. Image Diagonal | Focus & Deflection Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | Image Section Focus | Scan. Sec. | |
| | | | | | | | | | Focus | Deflection |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | | |
| C21199/P1 | 16/0.6 | 161.3/6.35 | 53.1/2.09 | E7-91 | 0.1/0.6 | Multialkali● | 12.0/0.47 | E | M | M |
| 4804/H | 25/1.0 | 190.5/7.50 | 38.6/1.52 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804/H/P1 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804/H/P2 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804/H/P4 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804/H/P5 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804A/H | | 190.5/7.50 | 38.6/1.52 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804A/H/P1 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804A/H/P2 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804A/H/P4 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804A/H/P5 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804B/H | | 190.5/7.50 | 38.6/1.52 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804B/H/P1 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804B/H/P2 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804B/H/P4 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |
| 4804B/H/P5 | | 196.4/7.73 | 53.4/2.1 | E8-11 | 0.1/0.6 | Multialkali● | 16.0/0.63 | E | M | M |

**C21199/P1**

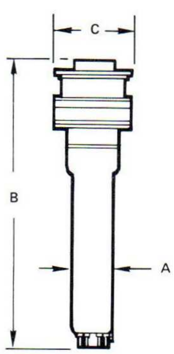


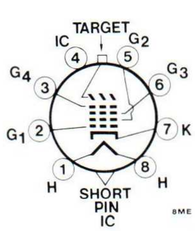

**4804/H/P1**
**4804/H/P2**
**4804/H/P4**
**4804/H/P5**
**4804A/H/P1**
**4804A/H/P2**
**4804A/H/P4**
**4804A/H/P5**
**4804B/H/P1**
**4804B/H/P2**
**4804B/H/P4**
**4804B/H/P5**



| Faceplate Illuminance (2856 K) To Obtain Signal Output of 60 nA | Typical Operation (2856 K Source) | | | | Remarks |
|---|---|---|---|---|---|
| | Sensitivity | Detail Response (4 x 3 Aspect) | | | |
| | μA/lm/ft² At Image Section | At Mesh Volts | Amplitude Response at 400 TV Lines/PH | Limiting Resolution | |
| lm/ft² | kV | V | % | TV-Lines | |
| 3 x $10^{-4}$ | 190 @ −9 | 500 | 40⊕ | 450 | Short, sturdy 12 mm type for very low light levels. |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | Sturdy 16 mm types especially useful in passive low light level TV surveillance systems, astronomy, and law enforcement applications.<br>4804B/H — 1st level specifications<br>4804A/H — 2nd level specifications<br>4804/H — 3rd level specifications<br>The suffix P— indicates a specific potting configuration used on the image section of the tube. (No designation — unpotted).<br>P1 — Ground strap anode connector<br>P2 — Built-in shield protects target<br>P4 — Target lead exposed for low capacitance<br>P5 — Separate high voltage focus lead for gating<br>It does not include an internal image-section focusing voltage-divider network. It has a separate high voltage gating lead internally connected to the focusing electrode for pulsing the image section of the device. Except for these differences, the /P5 configuration is identical to other members of the 4804/H series. The separate high-voltage gating lead of the focusing electrode makes these devices highly useful in active systems using pulsed illuminators, e.g., laser ranging, and in passive systems operating over a wide dynamic range of light levels.<br>The types in this series feature an internal mask which aids in minimizing microphonics. The mask may be used as a guide in obtaining proper set-up and scanning orientation. |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 34 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 36 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 36 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 36 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 36 | 700 | |
| 2 x $10^{-4}$ | 350 @ −10 | 500 | 36 | 700 | |

4804/H
4804A/H
4804B/H



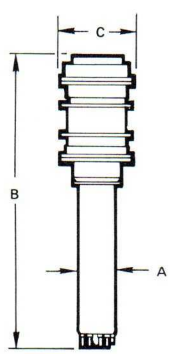

♦These types can be supplied with UV transmitting fiber optics which will provide absolute responsivity in excess of 10 mA/W at 330 nm.

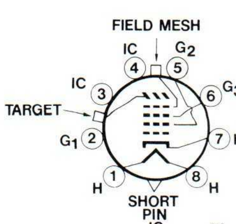
⊕At 200 TV lines.

# Silicon-Intensifier Target Tubes (cont'd)

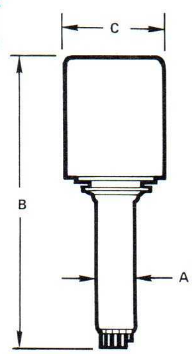
| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Spectral Response | Max. Image Diagonal | Focus & Deflection Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | Image Section Focus | Scan. Sec. | |
| | | | | | | | | | Focus | Deflection |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | | |
| 4826/H | 25/1.0 (cont'd) | 224.8/8.85 | 58.9/2.32 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826/H/P1 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826/H/P2 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826A/H | | 224.8/8.85 | 58.9/2.32 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826A/H/P1 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826A/H/P2 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826B/H | | 224.8/8.85 | 58.9/2.32 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826B/H/P1 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| 4826B/H/P2 | | 230.4/9.07 | 76.2/3.00 | E8-11 | 0.1/0.6 | Multialkali● | 25.0/1.0 | E | M | M |
| C21190 | | 190.5/7.5 | 37.4/1.47 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E | M | M |
| C21202 | | 251.5/9.9 | 76.7/3.02 | E8-11 | 0.1/0.6 | Multialkali | 40.0/1.6 | E | M | M |
| C21202/P1 | | 259.1/10.2 | 96.5/3.8 | E8-11 | 0.1/0.6 | Multialkali | 40.0/1.6 | E | M | M |
| C21207 | | 190.5/7.5 | 37.4/1.47 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E | M | M |
| C21145 | 38/1.5 | 318.0/12.5 | 76.7/3.02 | E8-78 | 0.1/0.6 | Multialkali | 40.0/1.6 | E | M | M |
| C21145/H | | 318.0/12.5 | 76.7/3.02 | E8-78 | 0.1/0.6 | Multialkali | 40.0/1.6 | E | M | M |
| C21146 | | 402.0/15.8 | 120.0/4.7 | E8-78 | 0.1/0.6 | Multialkali | 80.0/3.15 | E | M | M |
| C21146/P | | 420.0/16.5 | 153.0/6.0 | E8-78 | 0.1/0.6 | Multialkali | 80.0/3.15 | E | M | M |

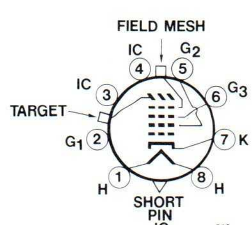
**4826/H**
**4826A/H**
**4826B/H**
**C21145**
**C21145/H**
**C21202**



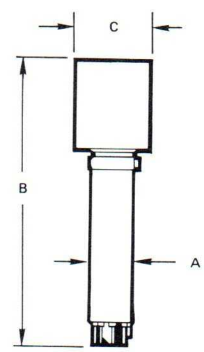



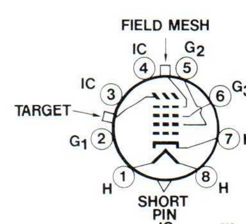

**4826/H/P1**
**4826/H/P2**
**4826A/H/P1**
**4826A/H/P2**
**4826B/H/P1**
**4826B/H/P2**
**C21202/P1**




**C21190**

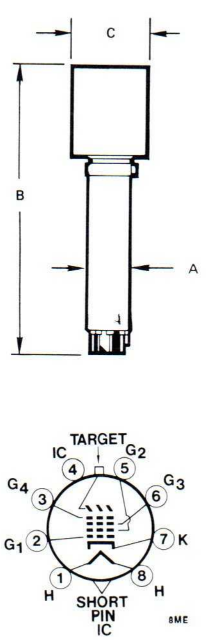


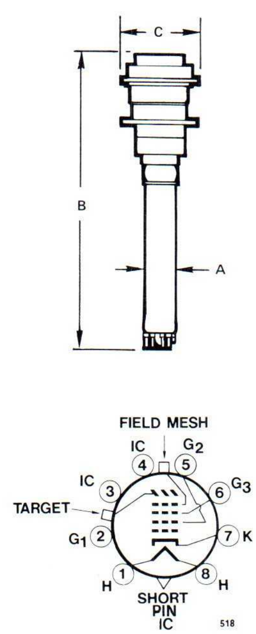
| Faceplate Illuminance (2856 K) To Obtain Signal Output of 60 nA | Typical Operation (2856 K Source) | | | | Remarks |
|---|---|---|---|---|---|
| | Sensitivity | Detail Response (4 x 3 Aspect) | | | |
| | $\mu A/lm/ft^2$ At Image Section | At Mesh Volts | Amplitude Response at 400 TV Lines/PH | Limiting Resolution | |
| $lm/ft^2$ | kV | V | % | TV-Lines | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | Sturdy, 25-millimeter photocathode silicon-intensifier target tubes incorporating an 18-millimeter diode array target; designed for use in very low light level TV systems.<br>4826B/H – 1st level specifications<br>4826A/H – 2nd level specifications<br>4826/H – 3rd level specifications<br>The suffix P– indicates a specific potting configuration used on the image section of the tube. (No designation – unpotted).<br>P1 – Single high voltage lead connected to an internal voltage divider.<br>P2 – Separate high voltage focus lead for gating.<br>These types were formerly available in four grades:<br>4826/PRE – 1st level specifications<br>4826/PRO – 2nd level specifications<br>4826/SUR – 3rd level specifications<br>4826/SCI – 4th level specifications |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $5 \times 10^{-5}$ | 940 @ –10 | 500 | 36 | 750 | |
| $2 \times 10^{-4}$ | 350 @ –10 | 500 | 34 | 700 | 16 mm, appendage processed photocathode; ruggedized gun assembly. |
| $2 \times 10^{-5}$ | 3300 @ –12 | 500 | 34 | 750 | 40/18 SIT. |
| $2 \times 10^{-5}$ | 3300 @ –12 | 500 | 34 | 750 | Potted version of C21202. |
| $2 \times 10^{-4}$ | 350 @ –10 | 500 | 34 | 700 | 16 mm, appendage processed photocathode for low light level applications. |
| $2 \times 10^{-5}$ | 3350 @ –12 | 500 | 56 | 1100 | 40/27 SIT. |
| $2 \times 10^{-5}$ | 3350 @ –12 | 500 | 56 | 1200 | 40/32 reduced bloom SIT. |
| $4.5 \times 10^{-6}$ | 13300 @ –12 | 500 | 56 | 1100 | 80/32 SIT, /P potted version |
| $4.5 \times 10^{-6}$ | 13300 @ –12 | 500 | 56 | 1100 | |

♦These types can be supplied with UV transmitting fiber optics which will provide absolute responsivity in excess of 10 mA/W at 330 nm.

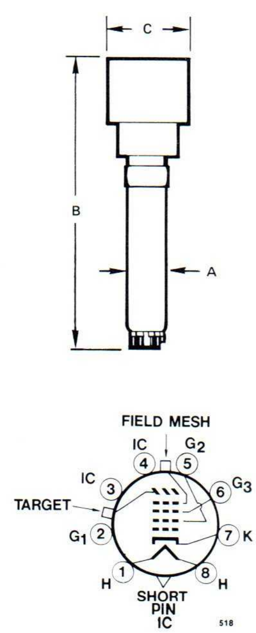
C21207




C21146




C21146/P



# Intensifier SIT Tubes

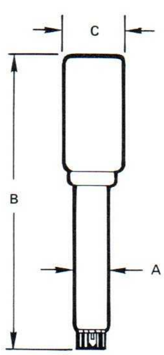
- 16 mm Image Diagonals
- Extremely Low Light Level Applications
- One and Two Stage Types
- Vidicon Flexibility

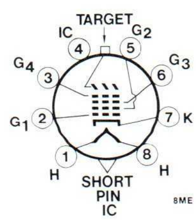
| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Spectral Response | Max. Image Diagonal | Focus & Deflection Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | Image Section Focus | Scan. Sec. Focus | Scan. Sec. Deflection |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | | |
| 4849/H | 25/1.0 | 245.5/9.67 | 58.0/2.28 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E + E | M | M |
| 4849A/H | | 245.5/9.67 | 58.0/2.28 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E + E | M | M |

# Intensifier Vidicons

| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Spectral Response | Max. Image Diagonal | Focus & Deflection Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | Image Section Focus | Scan. Sec. Focus | Scan. Sec. Deflection |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | | |
| C23165D | 25/1.0 | 217.4/8.56 | 52.8/2.08 | E8-11 | 0.6/3.8 | Multialkali | 16.0/0.63 | E | M | M |
| C23165E | | 217.4/8.56 | 52.8/2.08 | E8-11 | 0.6/3.8 | Multialkali | 16.0/0.63 | E | M | M |
| C23185 | | 267.0/10.5 | 58.0/2.28 | E8-11 | 0.6/3.8 | Multialkali | 16.0/0.63 | E | M | M |
| C23185A | | 267.0/10.5 | 58.0/2.28 | E8-11 | 0.6/3.8 | Multialkali | 16.0/0.63 | E | M | M |
| C23185C | | 267.0/10.5 | 58.0/2.28 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E | M | m |
| C23185D | | 267.0/10.5 | 58.0/2.28 | E8-11 | 0.1/0.6 | Multialkali | 16.0/0.63 | E | M | M |

4849/H
4849A/H
C23165D
C23165E
C23185
C23185A
C23185C
C23185D



| Faceplate Illuminance (2856 K) To Obtain Signal Output of 60 nA | Typical Operation (2856 K Source) | | | | Remarks |
|---|---|---|---|---|---|
| | Sensitivity | Detail Response (4 x 3 Aspect) | | | |
| | $mA/lm/ft^2$ At Image Section | At Mesh Volts | Amplitude Response at 400 TV Lines/PH | Limiting Resolution | |
| $lm/ft^2$ | kV | V | % | TV-Lines | |
| $4 \times 10^{-6}$ | 15 @ –21 | 500 | 15 | 600 | Sturdy, 16-millimeter Intensifier Silicon-Intensifier Target (ISIT) camera tubes designed for use in extremely low light level TV systems.<br>4849A/H – 1st level specifications<br>4849/H – 2nd level specifications<br>These types are two-stage TV camera tubes employing a SIT tube of the 4804/H series that is fiber-optically coupled to a single-stage image intensifier stage. This combination provides a camera tube having a sensitivity that is approximately 30 times greater than that of the SIT tube itself. |
| $4 \times 10^{-6}$ | 15 @ –21 | 500 | 15 | 600 | |

| Typical Operation (2856 K Source) | | | | | Remarks |
|---|---|---|---|---|---|
| Sensitivity | | At Mesh Volts | Amplitude Response at 400 TV Lines/PH | Limiting Resolution | |
| At Dark Current | Output Signal | | | | |
| nA | nA @ $lm/ft^2$ | V | % | TV-Lines | |
| 20 | 370 @ 0.05 | 500 | 22 | 700 | 4589 vidicon coupled to an 18 mm image intensifier.<br>C23165D – 1st level specifications<br>C23165E – 2nd level specifications |
| 20 | 370 @ 0.05 | 500 | 22 | 700 | |
| 20 | 370 @ $2.5 \times 10^{-3}$ | 500 | 50★ | 500 | Two-stage ($I^2V$) TV camera tubes employing a separate-mesh, magnetic focus and deflection vidicon that is fiber-optically coupled to two image intensifier stages. This combination provides a camera tube having a sensitivity that is approximately 1200 times greater than that of the vidicon itself.<br>Types C23185, A use 4589 vidicons<br>Types C23185C, D use 4569 vidicons<br>Types C23185A, D – 1st level specifications<br>Types C23185, C – 2nd level specifications |
| 20 | 370 @ $2.5 \times 10^{-3}$ | 500 | 50★ | 500 | |
| 20 | 370 @ $2.5 \times 10^{-3}$ | 500 | 50★ | 500 | |
| 20 | 370 @ $2.5 \times 10^{-3}$ | 500 | 50★ | 500 | |

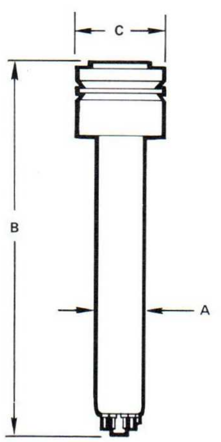
★ At 200 TV lines.

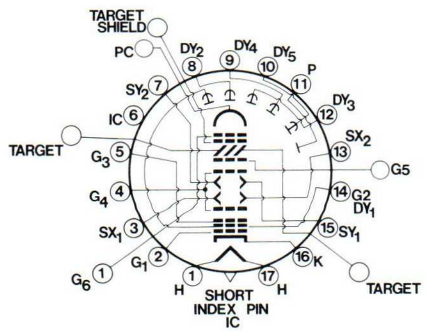
# Image Isocons

- 33 mm Image Diagonals
- Bialkali and Multialkali Photocathodes
- Improved Beam Masking
- For Low Light Level High Definition TV Systems

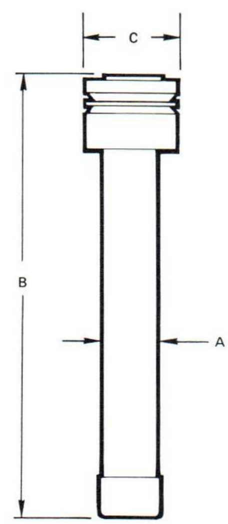
| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Spectral Response | Max. Image Diagonal | Focus & Deflection Method | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | Image Section Focus | Scan. Sec. | |
| | | | | | | | | | Focus | Deflection |
| | mm/in | mm/in | mm/in | | A/W | | mm/in | | | |
| C21194 | 38/1.5 | 313.0/12.3 | 77.7/3.06 | – | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| C21198 | | 313.0/12.3 | 77.7/3.06 | – | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| 4807 | 51/2.0 | 427.0/16.8 | 77.7/3.06 | – | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| 4807/V1 | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| 4807A | | 427.0/16.8 | 77.7/3.06 | – | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| 4807A/V1 | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | S-20 | 33.0/1.3 | M | M | M |
| C21203 | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | Multialkali | 33.0/1.3 | M | M | M |
| C21203A | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | Multialkali | 33.0/1.3 | M | M | M |
| C21204 | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | Bialkali | 33.0/1.3 | M | M | M |
| C21204A | | 427.0/16.8 | 77.7/3.06 | B20-102 | 0.6/3.8 | Bialkali | 33.0/1.3 | M | M | M |

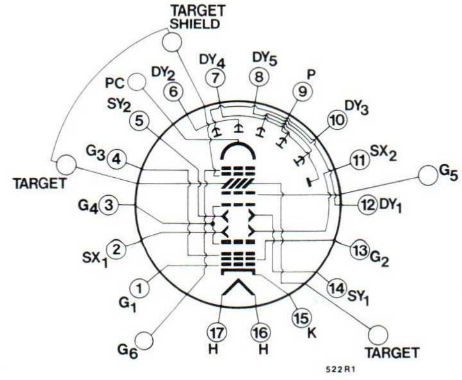
C21194
C21198



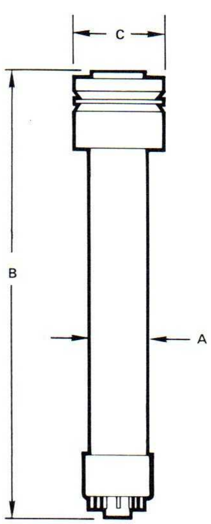

4807
4807A

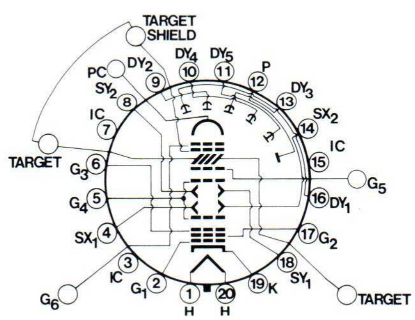


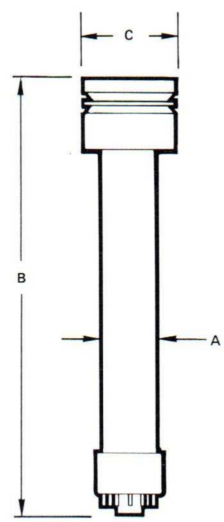
| Typical Operating Illuminance Level on Faceplate (2856 K) | Typical Operation (2856 K) | | | | Remarks |
|---|---|---|---|---|---|
| | Sensitivity | Detail Response (4 x 3 Aspect) | | | |
| | Output Signal (Peak-to-Peak) | At Mesh Volts | Amplitude Response At 400 TV Lines/PH | Limiting Resolution | |
| lm/ft$^2$ | µA | V | % | TV-Lines | |
| 0.02 | 7 | 360-380 | 60 | 1200 | Glass faceplate, close target-to-mesh spacing. |
| 0.001 | 3 | 360-380 | 60 | 1100 | Fiber optic faceplate, wide target-to-mesh spacing. |
| 0.001 | 5 | – | 80 | 1100 | Ruggedized, fiber-optic faceplate image isocon television camera tubes designed for high-resolution, real-time, "low light level" TV systems. They are especially useful in systems where an image intensifier (another fiber-optic device) is to be coupled to the fiber-optic faceplate. |
| 0.001 | 5 | – | 80 | 1100 | 4807, 4807A – "Flying Lead" types |
| 0.001 | 5 | – | 80 | 1100 | 4807/V1, 4807A/V1 – Permanent base types |
| 0.001 | 5 | – | 80 | 1100 | 4807, 4807/V1 – Blemishes evaluated at unity aspect ratio<br>4807A, 4807A/V1 – Blemsihes evaluated at 4x3 aspect ratio |
| 0.001 | 5 | – | 75 | 1000 | Image isocon television camera tubes designed for use in high-definition TV systems (1000 TV lines, or more). |
| 0.001 | 5 | – | 75 | 1000 | C21203, C21203A – Wide target-to-mesh spacing |
| 0.02 | 7 | – | 85 | 1200 | C21204, C21204A – Close target-to-mesh spacing |
| 0.02 | 7 | – | 85 | 1200 | C21203A, C21204A – 1st level specifications<br>C21203, C21204A – 2nd level specifications |

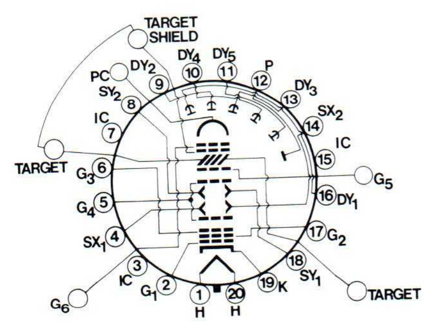
4807/V1
4807A/V1




C21203
C21203A
C21204
C21204A



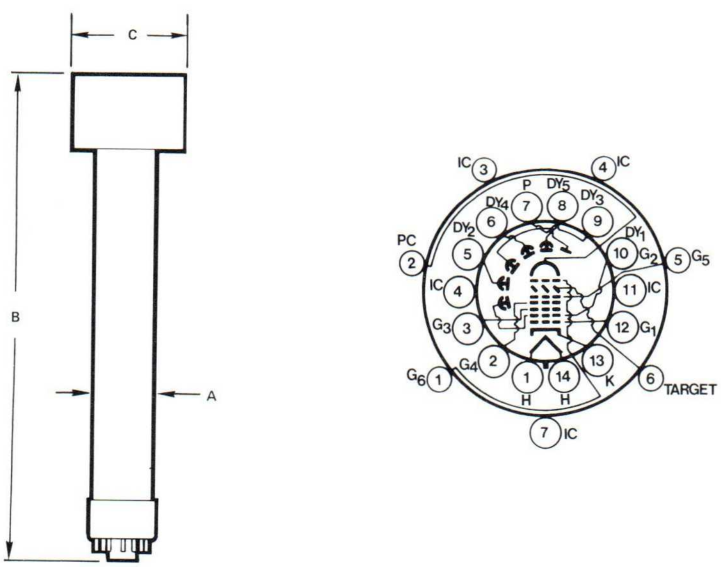



# Image Orthicons

- Replacement Types
- Resistant to Burn-In
- Long Life Targets
- For Color and Black-and-White Service

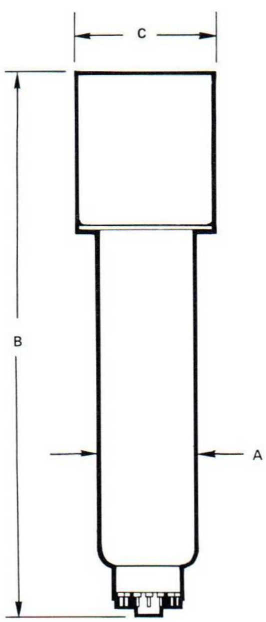
| Type Number | Dimensions and Outlines | | | JEDEC Base Designation | Heater Current/ Power | Field Mesh | Spectral Response | Max. Image Diagonal | Target-to-Mesh | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Approx. Bulb Dia. (A) | Max. Overall Length (B) | Max. Clearance Dia. (C) | | | | | | Spacing | Capacitance |
| | mm/in | mm/in | mm/in | | A/W | | | mm/in | mm/in | pF |
| 5820A/L | 51/2.0 | 392.5/15.45 | 77.7/3.06 | B14-45 | 0.6/3.8 | No | S-10 | 45.0/1.8 | 0.056/0.0022 | 100 |
| 4536 | 81/3.2 | 500.1/19.69 | 116.8/4.60 | B14-45 | 0.6/3.8 | Yes | S-10 | 41.0/1.6 | 0.0254/0.0010 | 600 |
| 7295C | | 500.1/19.69 | 116.8/4.60 | B14-45 | 0.6/3.8 | Yes | S-10 | 41.0/1.6 | 0.051/0.0020 | 300 |
| 7389C | | 500.1/19.69 | 116.8/4.60 | B14-45 | 0.6/3.8 | Yes | S-10 | 41.0/1.6 | 0.0254/0.0010 | 600 |

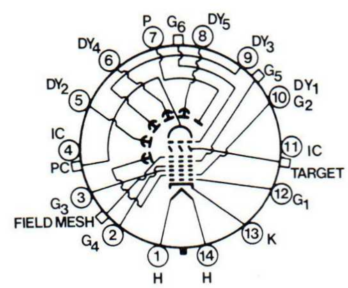
5820A/L



| Tube Operating Point | Illuminance on Tube Face at Operating Point (2856 K) lm/ft$^2$ | Resolution at Operating Light Level | | Signal-to-Noise Ratio — dB | | | Remarks |
|---|---|---|---|---|---|---|---|
| | | Amplitude Response At 400 TV Lines | Limiting Resolution TV-Lines | Target Volts Above Cutoff | | | |
| | | | | 2 | 2.3 | 3 | |
| At knee<br>1 stop over knee | $1 \times 10^{-2}$<br>$2 \times 10^{-2}$ | 55<br>60 | 600<br>600 | 34.0<br>34.5 | —<br>— | —<br>— | Replacement type for remote or studio TV cameras. |
| At knee | $4 \times 10^{-2}$ | 60 | 800 | — | — | 40.5 | An improved image orthicon for use in the luminance channel of RCA color cameras TK-42 and TK-43. Has high signal-to-noise ratio and high resolution. |
| At knee | $3 \times 10^{-2}$ | 75 | 800 | — | 38.0 | — | A versatile tube for outdoor as well as studio use. |
| 1 stop over knee | $6 \times 10^{-2}$ | 75 | 800 | — | — | — | |
| At knee<br>1/2 stop over knee | $5 \times 10^{-2}$<br>$7 \times 10^{-2}$ | 75<br>75 | 800<br>800 | —<br>— | 39.5<br>— | —<br>— | For very high-quality black and white studio pickup and magnetic tape recording service. |

4536
7295C
7389C



# Charge-Coupled Devices (CCDs)

- Low Voltage and Power Requirements
- Small Size
- Ultra-Low Blooming
- No Lag or Microphonics

## SID52501 – SID Silicon Imaging Devices

SID52501 is available in two grades. SID52501BD is the higher performance device and is intended for the more demanding applications. SID52501AD is intended for those applications where less stringent electrical and blemish criteria are permissible.

### Typical Performance Data

Conditions: Standard EIA RS-170 525-line TV format operating at 25$^{\circ}$ C.

**Electrical**

| Horizontal Clock Rate<br>MHz | Vertical Transfer Rate<br>MHz | Light Integration Time<br>ms | Image Area Dark Current<br>nA | Image Area Light Bias Current<br>nA | Peak-to-Peak Signal Current<br>nA | Peak-to-Peak Signal Voltage<br>mW |
|---|---|---|---|---|---|---|
| 6.1 | 0.28 | 16.67 | 4[a] | 60[a] | 250[a] | 100[b] |

**Notes**

a DC current from image area measured at RD.

b Developed across 3 kilohm load resistor at OS. Observed with EIA Resolution Chart and good quality monitor.

c Typical performance in an RCA TC1160 camera.

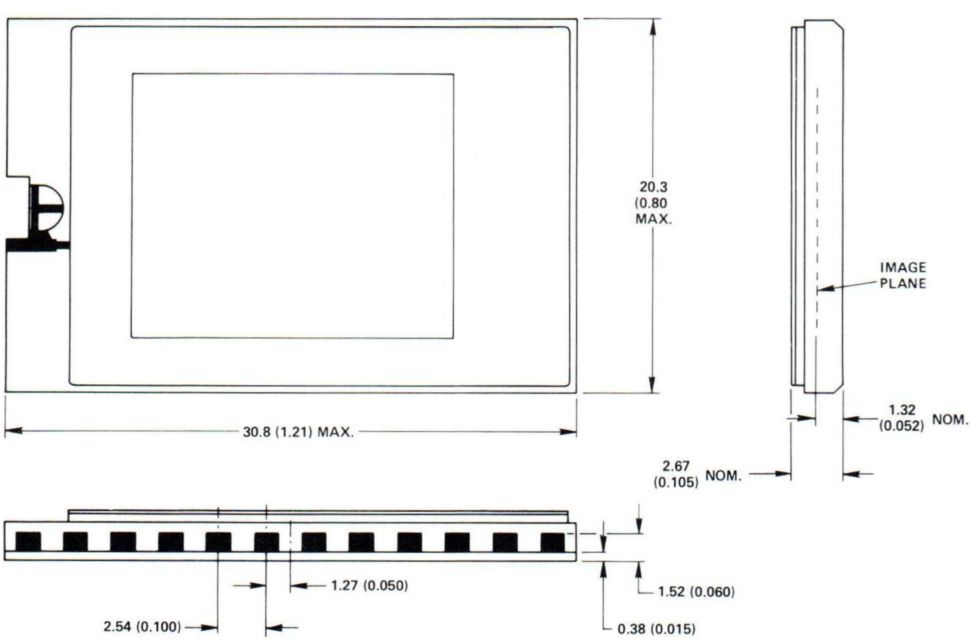
d Measured at 200 TVL/PH with an infrared blocking filter (2 mm HA-11).

e Measured between 4 and 400 nA signal current.

f Video peak signal (250 nA DC) to RMS noise.

g Measured with 2856 K illumination.

**Dimensional Outline**




**Socket**

RCA SIDA 1001

**Insertion Tool**

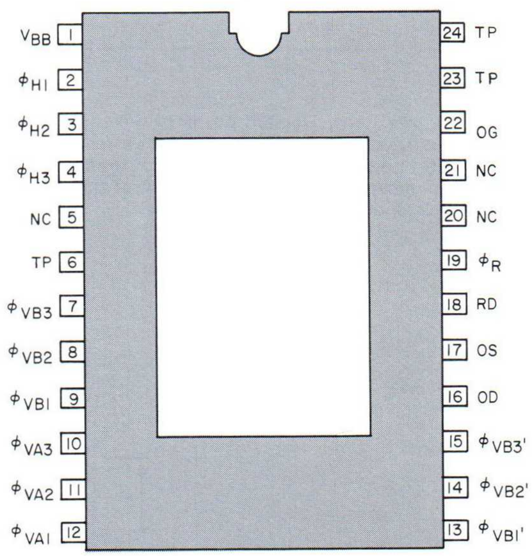
RCA SIDA 1003

**Drive Circuit**

RCA SIDA 1002

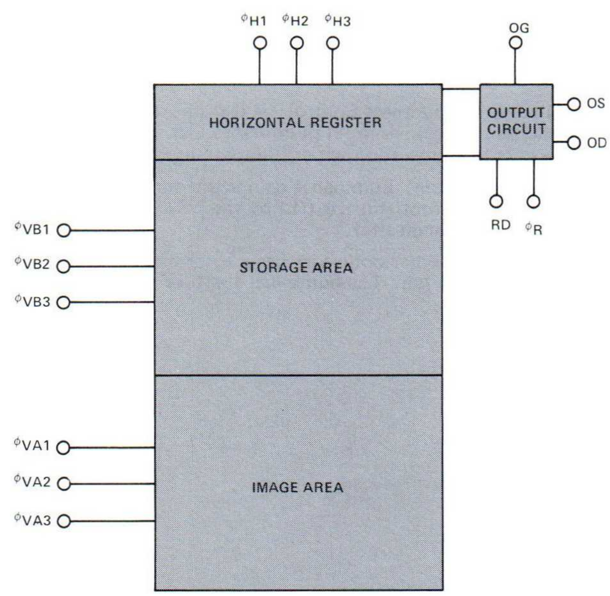
| | | | | | Optical | |
|---|---|---|---|---|---|---|
| Horizontal Limiting Resolution TVL/PH | Vertical Limiting Resolution TVL/PH | Contrast Transfer Function (CTF) | Gamma | Signal-to-Noise Ratio dB | Sensitivity (Radiant) mA/W-2856 K | Faceplate Illumination (250 nA Signal) lm/ft$^2$ |
| 240[c] | 425[c] | 0.67[c,d] | 1[e] | 50[f] | 65[g] | 0.1[g] |

Connection Diagram
(Top View)



92LS-5019R1

Block Diagram



92LS-5023R1

Connection Names

| | |
|---|---|
| VBB | Substrate Bias Voltage |
| ΦH1 ΦH2 ΦH3 | Horizontal Register Clocks |
| ΦVA1 ΦVA2 ΦVA3 ΦVB1 ΦVB2 ΦVB3 ΦVB1' ΦVB2' ΦVB3' OD | Vertical Register Clocks |
| OD | Output Transistor Drain |
| OS | Output Transistor Source |
| RD | Output Reset Transistor Drain |
| ΦR | Output Reset Transistor Gate Clock |
| OG | Output Gate |
| TP | Test Points |

# Image Intensifiers

The Image Intensifiers described below are designed for use in a wide variety of applications including passive night viewing, low light-level TV, laser ranging, astronomy, low-light-level photography and surveillance, high speed photography, and spectroscopy.

| Type Number | Input/ Output | Dimensions and Outlines | | No. of Stages | Photocathode | | | Photocathode Sensitivity | |
|---|---|---|---|---|---|---|---|---|---|
| | | Max. Overall Length (B) | Max. Clearance Dia. (C) | | Min. Useful Dia. | Window Material | Type | Min. Luminous[a] | Typical Radiant[b] |
| | mm | mm/in | mm/in | | mm | | | µA/lm | mA/W |
| **First-Generation Electrostatically-Focused Image Tubes** (In first-generation image tubes the gain mechanism is provided | | | | | | | | | |
| 4550 | 18/18 | 150.6/5.93 | 52.8/2.08 | 3 | 18 | FO | ERMA 6-1 | 175 | 10 @ 800 |
| **Magnetically-Focused Image Tubes** (Magnetically-focused image tubes are those in which electrons from the photocathode or permanent magnet.) | | | | | | | | | |
| C33063EP3 | 38/38 | 165.0/6.5 | 102.9/4.05 | 2 | 38 | G | S-20 | 150 | 70 |
| C33089P3 | 38/38 | 92.2/3.63 | 102.9/4.05 | 1 | 38 | G | S-20 | 135 | 70 |
| **Special-Purpose Electrostatically-Focused Image Tubes — Image-Stabilization Types** | | | | | | | | | |
| C33004H | 25/18.5 | 106.5/4.19 | 48.5/1.91 | 1 | 25.4 | G | S-20 | 150 | 70 |
| **Special-Purpose Electrostatically-Focused Image Tubes — Light-Shutter Types** | | | | | | | | | |
| C73435U | 35/28 x 71 | 252.2/9.93 | 102.6/4.04 | 1 | 35 | G | S-20 | 70 | 30 |
| C73435Z | 35/28 x 71 | 252.2/9.93 | 102.6/4.04 | 1 | 35 | S | S-20 | 70 | 30 |
| C73435Q | 35/28 x 71 | 252.2/9.93 | 102.6/4.04 | 1 | 35 | G | Bialkali | 40 | 32 |
| C73435AK | 35/28 x 64 | 247.9/9.76 | 102.6/4.04 | 1 | 35 | G | S-20 | 70 | 30 |
| C73435AG | 35/28 x 64 | 247.9/9.76 | 102.6/4.04 | 1 | 35 | G | S-1 | 20 | 1.5 |
| C73435AJ | 35/28 x 64 | 250.5/9.86 | 102.6/4.04 | 1 | 35 | FO | S-20 | 35 | 15 |

ABC Automatic Brightness Control. A feature which automatically reduces tube gain as input illuminance increases. This feature permits tube operation under fluctuating light input levels.

B Luminance Gain. Luminance gain is the quotient of the screen luminance in footlamberts (fL) by the photocathode illuminance in footcandles(fc).

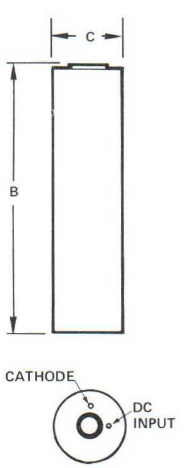
FO Fiber Optic. Fiber optic surfaces are normally supplied having a flatness of 1 µm. The numerical aperture is 1.0.

G Glass.

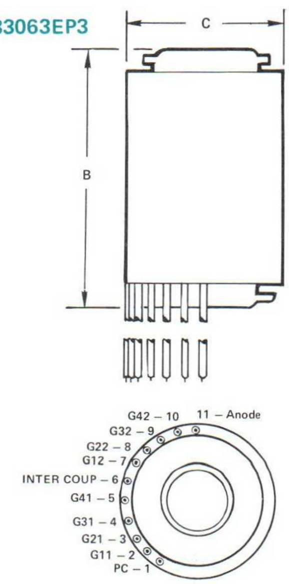
RP Radiant Power Gain. Radiant power gain is the quotient of the total output power (W) within the spectral distribution of the output phosphor by the power (W) of the incident monochromatic radiation on the input window at the wavelength of maximum response of the photocathode.

S Sapphire.

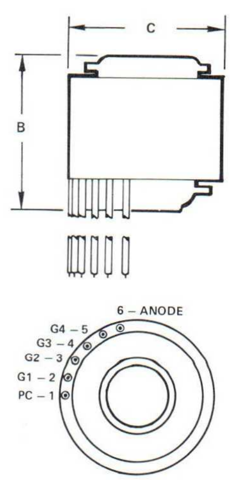
**4550**




**C33063EP3**




**C33089P3**



Variants of these image intensifiers having different photocathodes, different phosphor screens, and different input and output windows can often be supplied on special request. RCA can also supply potted image tubes in a variety of configurations including voltage dividers and/or complete high voltage power supplies.

| Phosphor Screen | | | Gating Electrode | Operating Voltage | Minimum Resolution | | Min. Gain | Max. Equivalent Screen Background Input | Typical Paraxial Magnification | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| Min. Useful Dia. mm | Window Material | Type | | | Center lp/mm | Edge lp/mm | | W/cm² | | |
| by electrons from the photocathode being accelerated by the applied field and striking the phosphor screen.) | | | | | | | | | | |
| 18 | FO | P20 | No | 2.7 V | 35 | 35 | 3.5 x $10^4$ B | 2 x $10^{-11}$ lm/cm² | 0.825 | Potted type having integral oscillator and voltage multiplier. Features ABC. |
| are accelerated by a longitudinal electric field and are focused by means of a longitudinal magnetic field provided by an external solenoid | | | | | | | | | | |
| 38 | Glass | P22B | No | 30 kV | 50 | 45 | 1.5 x $10^4$ RP | 1 x $10^{-14}$ | 1.0 | Type has controls to prevent excessive "fogging" of film during long exposures and to minimize low contrast fixed pattern noise. |
| 38 | FO | P22B | No | 15 kV | 63 | 50 | 50 RP | 1 x $10^{-14}$ | 1.0 | Potted, ceramic-to-metal construction. |
| 18.5 | Glass | P20 | Yes[d] | 15 kV | 60 | 50 | 150 B | 1 x $10^{-10}$ lm/cm² | 0.8 | Unpotted type having focusing electrode. External magnetic deflecting coils are required for image stabilization applications. |
| 28 x 71 | Glass | P11 | Yes | 15 kV | 25 | 15 | 45 RP | 5 x $10^{-12}$ | 0.74 | Unpotted type with gating and deflecting electrodes. |
| 28 x 71 | G | P11 | Yes | 15 kV | 25 | 15 | 45 RP | 5 x $10^{-12}$ | 0.74 | Variant of C73435U with sapphire input window for UV applications. |
| 28 x 71 | G | P11 | Yes | 15 kV | 25 | 15 | 50 RP | 5 x $10^{-12}$ | 0.74 | Variant of C73435U with bialkali photocathode. |
| 28 x 64 | FO | P11 | Yes | 15 kV | 25 | 15 | 27 RP | 5 x $10^{-12}$ | 0.74 | Variant of C73435U with fiber optic output surface. |
| 28 x 64 | FO | P11 | Yes | 15 kV | 25 | 15 | 1.5 RP | 5 x $10^{-9}$ | 0.74 | Variant of C73435AK with S-1 photocathode. |
| 28 x 64 | FO | P11 | Yes | 15 kV | 25 | 15 | 14 RP | 5 x $10^{-12}$ | 0.74 | Variant of C73435AK with fiber optic input surface. |

a The quotient of photocathode current in microamperes by the incident flux in lumens. The light source is a tungsten-filament lamp having a lime-glass window. The lamp is operated at a color temperature of 2856 K.

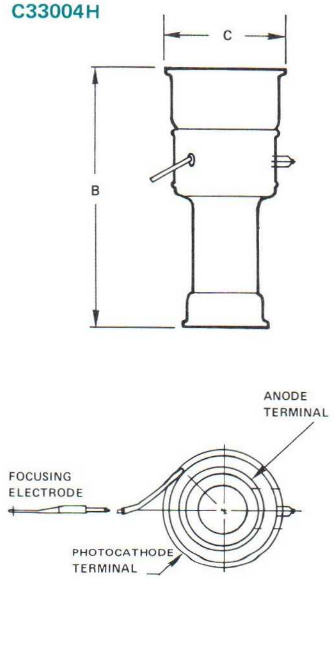
b For incident flux at the wavelength of maximum response of the spectral response characteristic unless otherwise specified.

c Electrode provided to allow swinging of electrode voltage from cutoff value to focus value for high-speed gating.

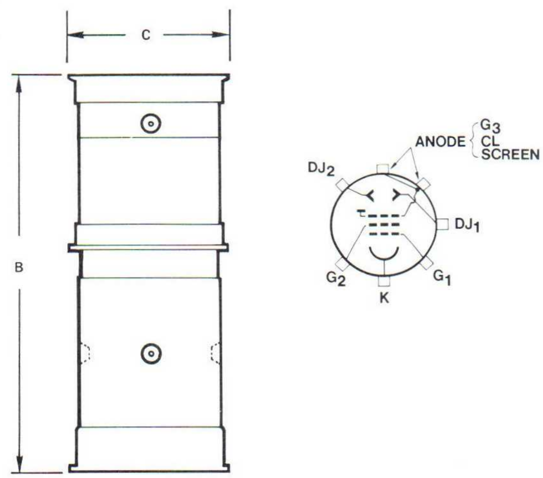
d Type can be gated by applying pulse voltage to focusing electrode.

e Modified.

C33004H




C73435U
C73435Z
C73435Q
C73435AK
C73435AG
C73435AJ



# Accessories

## Focus-Deflection Assemblies

■ For Full Performance Capability

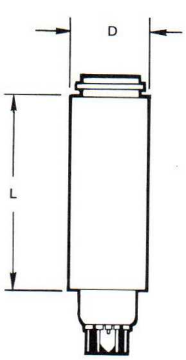
| Type Number | For Use With | Mechanical Data | | | Focusing-Coil Electrical Data | | |
|---|---|---|---|---|---|---|---|
| | | Max. Outside Dia. (D) mm/in | Max. Overall Length (L) mm/in | Approx. Weight kg/lbs | Current mA | Field Strength Tesla | Resistance ohms |
| Magnetics for → | C23151<br>C23219 | 36.8/1.45 | 57.4/2.26 | 0.18/0.39 | 100 | – | 80 |
| Magnetics for → | C23240/P1<br>C23271/P1 | 22.9/0.9 | 43.2/1.70 | 0.2/0.44 | 200 | – | 25 |
| Magnetics for → | C23257A/P2<br>C23262A/P2<br>C23262B/P2 | 25.9/1.02 | 107.0/4.2 | 0.3/0.67 | 100 | – | 87 |
| AJ2206A | 4807 Series | 109.5/4.31 | 403.4/15.88 | 7.4/16.3 | 600 | 0.0070 | 60 |
| AJ2215A | 4532/U Series<br>8507A, 8541A<br>8541A/X, BC8541 | 56.2/2.21 | 143.5/5.65 | 0.68/1.5 | 103 | 0.0050 | 131 |
| AJ2216 | 4804/H Series<br>4849/H Series | 38.1/1.50 | 85.3/3.36 | 0.22/0.48 | 110 | 0.004 | 47 |
| C21196 | C21194<br>C21198 | 180.0/4.25 | 305.3/12.02 | 4.31/9.5 | 615 | 0.0070 | 33 |
| C23227 | C21145<br>C23225<br>C81000E | 95.3/3.75 | 184.2/7.25 | 2.5/5.5 | 70 | 0.0045 | 525 |

## Power Supplies

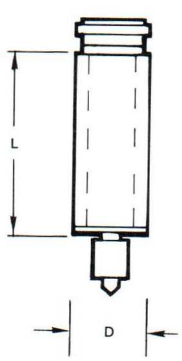
■ Small Size ■ Light Weight

| Type Number | For Use With | Max. Length (L) mm/in | Max. Width (W) mm/in | Max. Height (H) mm/in | Approx. Weight g/oz | Maximum Ratings | |
|---|---|---|---|---|---|---|---|
| | | | | | | Program Volt – V | Output Volt – kV |
| PF1040 | 4804/H<br>C23165 Series | 59.0/2.3 | 30.0/1.2 | 26.0/1.0 | 70.0/2.5 | 8.5 | –10 |
| PF1040B | 4849/H<br>C23185 Series | 59.0/2.3 | 36.0/1.4 | 30.0/1.2 | 70.0/2.5 | 8.5 | –21 |

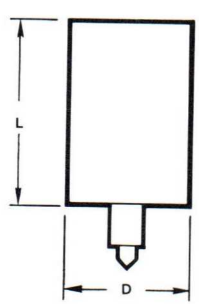
**Magnetics For:**
**C23151**
**C23219**



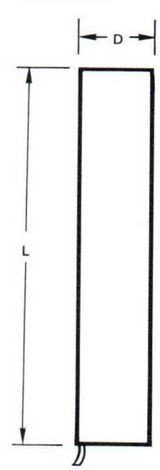

**Magnetics For:**
**C23240/P1**
**C23271/P1**




**Magnetics For:**
**C23257/P2**
**C23262A/P2**
**C23262B/P2**



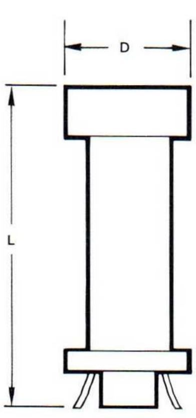

**AJ2206A**



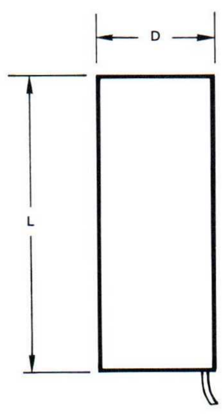
| Scanning-Coil Electrical Data | | | | | | Alignment (Electro-Magnetic) A/Tesla Each Coil | Remarks |
|---|---|---|---|---|---|---|---|
| Horizontal | | | Vertical | | | | |
| Inductance μH | Resistance ohms | Deflection Factor Peak-to-Peak A/in | Inductance mH | Resistance ohms | Deflection Factor Peak-to-Peak A/in | | |
| 160 | 4.0 | 1.0 | 0.16 | 4.0 | 1.00 | None | Printed circuit (precision) deflection coils. Not available separately |
| 150 | 5.5 | 0.92 | 0.15 | 5.5 | 0.92 | None | (Dimensions apply to magnetics only) |
| 300 | 8.0 | 0.68 | 0.30 | 8.0 | 0.68 | None | |
| 195 | 0.5 | 2.5 | 1.2 | 1.70 | 1.0 | None | Ruggedized for military. No sockets employed. |
| 920 | 2.9 | 0.60 | 50 | 166 | 0.093 | None | High performance type providing uniformity of resolution and signal output. Also useful in document reading. |
| 195 | 3.8 | 0.72 | 0.195 | 3.8 | 0.72 | 150 | Printed circuit (precision) deflection coils. |
| 188 | 0.56 | 2.5 | 16.5 | 32 | 0.26 | None | Base socket with decoupler network. |
| 2350 | 12.0 | 0.62 | 41.0 | 200 | 0.120 | 330 | High performance type, uniform resolution, anastigmatic. |

| Input Characteristics | | | | Output Characteristics | | | Remarks |
|---|---|---|---|---|---|---|---|
| Program Volt – V | Horiz. Drive Volt – V | Frequency Hz | Horiz. Drive Imp. – Ω | Output Volt – kV | Load Res. – GΩ | Ripple % | |
| 2 to 7 | 3 to 6 pk-pk | 15,750 | 2000 (cap coupled) | –2.0 to –10 | 1 | 0.1 | Small, light weight, low cost synchronous power supplies |
| 2 to 7 | 3 to 6 pk-pk | 15,750 | 2000 (cap coupled) | –4 to –21 | 2 to 4 | 0.1 | PF1040 – replaces RCA PF1028<br>PF1040B – replaces RCA PF1028B |

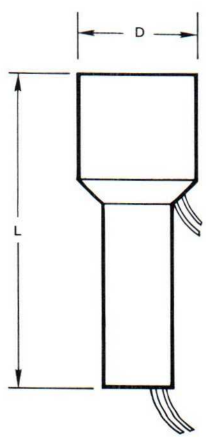
AJ2215A



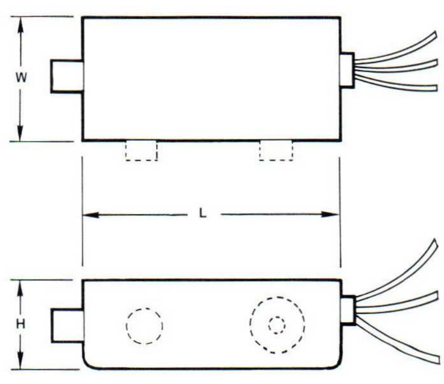

AJ2216
C23227




C21196




PF1040
PF1040B



# Terms and Definitions

Amplitude Response . . . A measurement of the resolution capability of a tube. It is the ratio of the amplitude of the signal developed by the tube from an optical square wave test pattern to the peak black-to-white signal developed from the large black and white portions of the test pattern.

Angstrom (Å) . . . . A unit of wavelength of light; 1 Å = $10^{-10}$ m = 0.1 nanometers.

Anode . . . . . . . . . . The electrode which normally has the highest voltage present.

CCTV . . . . . . . . . . Closed circuit television.

Cutoff . . . . . . . . . . The cutoff of a device is the level of operation below which its output is effectively zero.

Deflection Plates . . Electrodes used to produce an electrostatic field for deflection of the electron beam(s).

Dynode . . . . . . . . . An electrode in an electron tube that functions to produce secondary emission of electrons.

Electrostatic. . . . . . Refers to the deflection or focusing of an electron beam through the use of electric fields.

Faceplate . . . . . . . . That portion of the envelope on which the optical image is directed.

Field Mesh . . . . . . . A fine mesh screen stretched across the tube near the target which causes the electron scanning beam to decelerate uniformly at all points and assist it to approach the target in a perpendicular manner.

Focus Electrode . . . An electrode the potential of which is adjusted for focusing an electron beam.

Footcandle (fc). . . . A unit of illuminance; fc = lm $ft^{-2}$. The name lumen per square foot is recommended for this unit.

Footlambert (fL) . . A unit of luminance; 1 fL = $(1/\pi)$ cd $ft^{-2}$.

Gauss (G) . . . . . . . . The gauss is the electromagnetic CGS unit of magnetic flux density. Use of SI unit, the tesla, is preferred.

Illuminance . . . . . . The luminous flux per unit area on a surface at any given point.

Lambert (L) . . . . . . A CGS unit of luminance; 1 L = $(1/\pi)$ cd $cm^{-2}$.

Lumen (lm) . . . . . . SI unit of luminous flux.

Lux (lx) . . . . . . . . . SI unit of illuminance; lx = lm $m^{-2}$.

Magnetic . . . . . . . . Refers to the deflection or focusing of an electron beam through the use of magnetic fields.

Raster . . . . . . . . . . A scan pattern composed of a number of parallel lines generated in sequence.

Resolution . . . . . . . A measure of ability to delineate picture detail. Limiting resolution is the smallest discernible or measurable detail in a visual presentation.

Scan . . . . . . . . . . . . Movement of the electron beam across a phosphor screen.

SI . . . . . . . . . . . . . Systeme International d'Unités (International System of Units)

Target . . . . . . . . . . A storage element or element array in a camera tube that stores the electrical charge representing the brightness pattern of the image being televised. This target is interrogated by the electron beam to develop the video signal. In vidicon types the target consists of the light sensor (photoconductor) which also serves as the storage medium. In the SIT, Isocon and Image Orthicon types the target is utilized to store and amplify charge patterns representing the brightness of the image.

Tesla (T). . . . . . . . . SI unit of magnetic flux density (magnetic induction). 1T = $10^4$ Gauss.

## Dimensions

Maximum overall lengths shown do not include exhaust appendages. Maximum clearance diameters exclude target pins, mounting screws, etc.

## Typical Operation

Heater voltages for all camera tubes in this product guide have a nominal value of 6.3 V.

## Light Levels

The choice of camera tube is based in part on the character and amount of scene illuminance.

Having determined the scene illuminance, the resulting illuminance on the camera tube (faceplate illuminance) will be influenced by properties of the lens system and by reflectance character of the scene. The relationship of these factors is:

$$E_{fp} = \frac{E_{sc} R T}{4 f^2 (1+m)^2}$$

Where: $E_{fp}$ = faceplate illuminance (in fc or lux)
$E_{sc}$ = scene illuminance (in fc or lux)
R = scene reflectance (typically 0.6)
T = lens transmittance
f = "f-number" of lens, i.e., ratio of focal length and aperture diameter
m = magnification from scene to faceplate

Since $T \approx 0.7$ for most lenses, $R \approx 0.7$ for most white surfaces, and m can usually be neglected (except for close-ups), a practical quick conversion factor can be used:

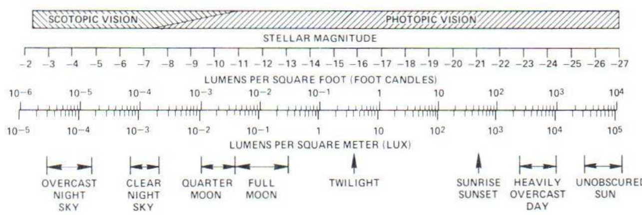
$$E_{fp} = \frac{E_{sc}}{8 f^2}$$

## Conversion Factors for Illuminance Quantities

| Illuminance Quantity | Lux (lx) | Footcandle (fc) | Phot (ph) |
|---|---|---|---|
| 1 lux ($lm\ m^{-2}$) = | 1 | 0.0929 | $1 \times 10^{-4}$ |
| 1 footcandle ($lm\ ft^{-2}$) = | 10.764 | 1 | 0.001076 |

## Natural Scene Illuminance

| Sky Condition | Approx. Levels of Illuminance | |
|---|---|---|
| | fc ($lm\ ft^{-2}$) | lux ($lm\ m^{-2}$) |
| Direct sunlight | $1\text{-}1.3 \times 10^4$ | $1\text{-}1.3 \times 10^5$ |
| Full daylight (Not direct sunlight) | $1\text{-}2 \times 10^3$ | $1\text{-}2 \times 10^4$ |
| Overcast day | $10^2$ | $10^3$ |
| Very dark day | 10 | $10^2$ |
| Twilight | 1 | 10 |
| Deep twilight | $10^{-1}$ | 1 |
| Full moon | $10^{-2}$ | $10^{-1}$ |
| Quarter moon | $10^{-3}$ | $10^{-2}$ |
| Moonless, clear night sky | $10^{-4}$ | $10^{-3}$ |
| Moonless, overcast night sky | $10^{-5}$ | $10^{-4}$ |




# Personal Safety Hazards

The following safety hazard applies to all products listed in this Product Guide with the exception of charge-coupled devices.

**Warning — Personal Safety Hazards**

**Electrical Shock** — Operating voltages applied to this device present a shock hazard.

# Selection Guide

This selection guide was designed as an aid in the initial selection of an RCA Imaging Device for a given application.

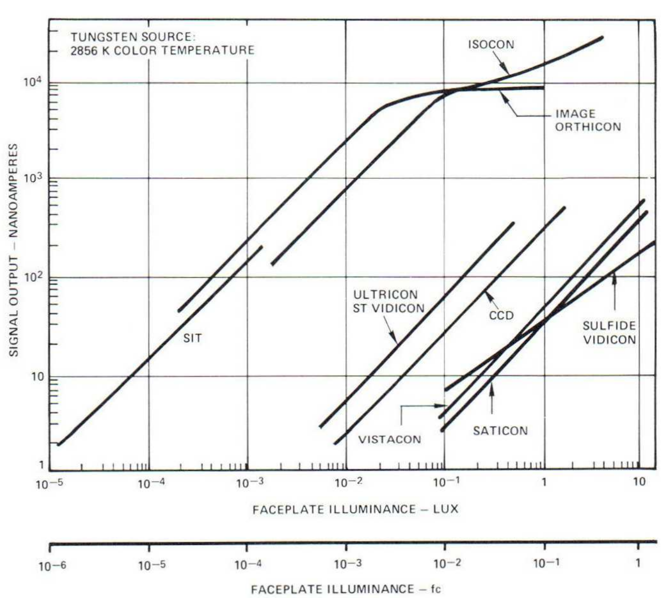
| RCA Type Number Designation | CCTV | Low Light | X-Ray Linkage | Ruggedized | High Resolution | Other | Device Description |
|---|---|---|---|---|---|---|---|
| 4503A | O | | | O | | | Sulfide |
| 4514 | O | | | | | | Sulfide |
| 4532/U | O | | | | | | S-T |
| 4532A/U | O | | | | | | S-T |
| 4532B/U | O | | | | | | S-T |
| 4542 | | | | | | a | Sulfide |
| 4569 | | | O | | | | Sulfide |
| 4589 | | | O | | | | Sulfide |
| 4804/H Series | | O | | | | | SIT |
| 4807 Series | | O | | | O | | Isocon |
| 4817 | O | | O | | | | Vistacon |
| 4826 Series | | O | | | | | SIT |
| 4833/U | O | | | | | | S-T |
| 4833A/U | O | | | | | | S-T |
| 4848 | O | | | | | | Sulfide |
| 4949/H | | O | | | | | ISIT |
| 4849A/H | | O | | | | | ISIT |
| 4875/U | O | | | | | | S-T |
| 4911 | O | | | | | | SATICON |
| 7262A | O | | | | | | Sulfide |
| 7735 | O | | | | | | Sulfide |
| 7735A | O | | | | | | Sulfide |
| 7735B | O | | | | | | Sulfide |
| 8134 | O | | | | | | Sulfide |
| 8480 | O | | | | O | | Sulfide |
| 8507 | O | | | | | | Sulfide |
| 8507A | O | | | | | | Sulfide |
| 8541 | O | | | | | | Sulfide |
| 8541A | O | | | | | | Sulfide |
| 8541A/X | | | O | | | | Sulfide |
| 8844 | O | | | | | | Sulfide |
| S81007E | O | | O | | | | SATICON |
| S81008E | O | | O | | | | SATICON |
| SID52501 | O | | | | | | CCD |

| RCA Type Number Designation | CCTV | Low Light | X-Ray Linkage | Ruggedized | High Resolution | Other | Device Description |
|---|---|---|---|---|---|---|---|
| C21145 | | O | | | O | | SIT |
| C21145/H | | O | | | O | | SIT |
| C21146 | | O | | | O | | SIT |
| C21190 | | O | | | | | SIT |
| C21194 | | O | | | O | | Isocon |
| C21198 | | O | | | O | | Isocon |
| C21199/P1 | | O | | | | | SIT |
| C21202 | | O | | | | | SIT |
| C21202/P1 | | O | | | | | SIT |
| C21203 | | O | | | O | | Isocon |
| C21203A | | O | | | O | | Isocon |
| C21204 | | O | | | O | | Isocon |
| C21204A | | O | | | O | | Isocon |
| C21207 | | O | | | | | SIT |
| C23151 | | | | O | | | Sulfide |
| C23165 Series | | O | | | | | IV |
| C23174 Series | | | | O | | | S-T |
| C23185 Series | | O | | | | | $I^2V$ |
| C23213 | O | | | | O | | S-T |
| C23219 | | | | O | | | S-T |
| C23225 | | | | | O | | Sulfide |
| C23231 | O | | | | | b | S-T |
| C23240/P1 | | | | O | | | S-T |
| C23246 | O | | | | | b | S-T |
| C23250 | O | | | | | c | S-T |
| C23250A | O | | | | | c | S-T |
| C23257/P2 | | | | O | | | Sulfide |
| C23262A/P2 | | | | O | | | S-T |
| C23262B/P2 | | | | O | | | S-T |
| C23271/P1 | | | | O | | | Sulfide |
| C23281 | | | | | | a | Sulfide |
| C81000E | | | | | O | | Sulfide |
| Image Intensifiers | | O | | | | d | Im Int |

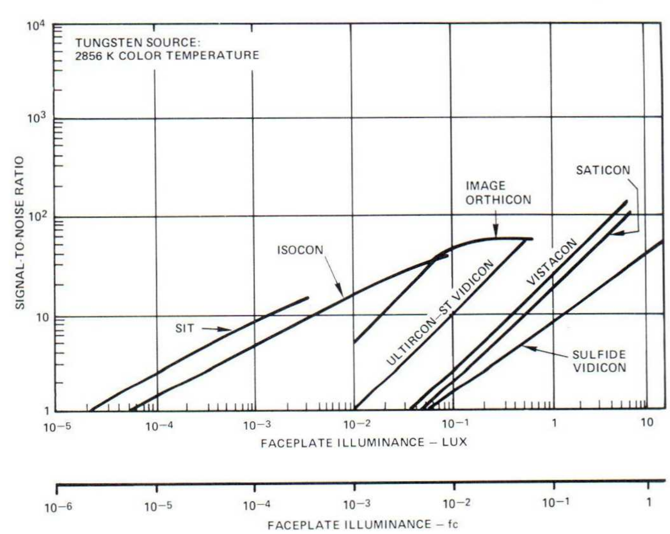
a Slow scan for radar applications.
b For operation in near UV.
c For operation in near IR.
d See page 34 for application.

## Broadcast Service

| RCA Type Number Designation | Live | | Film | | Device Description |
|---|---|---|---|---|---|
| | Color | B&W | Color | B&W | |
| 4493 | O | | | | Sulfide |
| 4494 | O | | | | Sulfide |
| 4495 | O | | | | Sulfide |
| 4532/U | | O | | | S-T |
| 4536 | O | | | | I O |
| 5820A/L | O | O | | | I O |
| 7295C | | O | | | I O |
| 7389C | | O | | | I O |
| 8480 | | O | | O | Sulfide |
| BC4390 Series | O | | O | | SATICON |
| BC4392 Series | O | | | O | Vistacon |
| BC4393/R | O | | | | Vistacon |
| BC4394 Series | O | | | | Vistacon |
| BC4532 | O | | | | S-T |
| BC4592 Series | O | O | O | O | Vistacon |
| BC4593/R | O | | O | | Vistacon |
| BC4594 Series | O | O | O | O | Vistacon |
| BC4809 Series | | | O | | Sulfide |
| BC4892 Series | O | O | O | | Vistacon |
| BC4893/R | O | | O | | Vistacon |
| BC4894 Series | O | O | O | O | Vistacon |
| BC4908 Series | O | | | | Saticon |
| BC4909 | | | O | | SATICON |
| BC4992 Series | O | | | | Vistacon |
| BC4993/R | O | | | | Vistacon |
| BC4994/R | O | | | | Vistacon |
| BC7735 | | | O | O | Sulfide |
| BC8134 Series | | | O | | Sulfide |
| BC8480 | | | O | O | Sulfide |
| BC8507 | O | | O | O | Sulfide |
| BC8541 | O | | O | | Sulfide |




**Transfer Characteristics of Typical Imaging Devices**




**Signal-to-Noise Ratio Characteristics of Typical Camera Tubes**

# Associated Components

Below is a listing of suggested manufacturers of associated components for use with RCA Imaging Devices. It should be noted that these manufacturers are indicated here based on the manufacturers representations as published in their sales literature. It is recommended that each user make a final suitability determination based on his own special requirements.

### Sockets, Mating Leads and Connectors

*Suggested Manufacturers*

Alden Products Co.
(617) 583-0160
117 N. Main St., Brockton, MA 02403

Amphenol-Bunker Ramo Corp.
(312) 345-4260
2875 S. 25th Ave., Broadview, IL 60153

AMP Inc.
(717) 367-1105
1595 Mt. Joy St., Elizabethtown, PA 17022

Eby Company
(215) 842-3000
4701 Germantown, Philadelphia, PA 19144

Rowe Industries, Inc.
(419) 729-9761
6225 Benore Rd., Toledo, OH 43612

TRW Cinch Connectors
(312) 439-8800
1501 Morse Ave., Elk Grove, IL 60007

### Deflection — Focus Components

*Suggested Manufacturers*

Chuomusen Co., Ltd.
762-5151
9-12, 1-chome, Ohmori-Nishi
Ohta-ku, Tokyo 143, Japan

Cletronics
(216) 239-1351
1684 Medina Rd., Medina, OH 44256
(Formerly Solar Systems and Cleveland Electronics)

Constantine Engineering Labs Co.
(201) 327-1123
70 Constantine Drive, Mahwah, NJ 07430

Penn-Tran Corporation
(814) 355-1521
P.O. Box 508
1155 Zion Rd., Bellefonte, PA 16823

### Deflection — Focus Components (cont'd)

*Suggested Manufacturers*

RCA Corporation
(717) 397-7661
Electro Optics Marketing
New Holland Ave., Lancaster, PA 17604

### Magnetic Shields

*Suggested Manufacturers*

Ad-Vance Magnetics Inc.
(219) 223-3158
226 E. 7th St., Rochester, IN 46975

James Millen Mfg. Co.
(617) 324-4108
150 Exchange St., Malden, MA 02148

### Optical Components

*Suggested Manufacturers*

Schott Filters —

Fish-Schurman Corp.
(914) 636-1300
70 Portland Rd., New Rochelle, NY 10802

### Power Supplies

*Suggested Manufacturers*

AMP Incorporated
(717) 367-1105
1595 Mt. Joy St., Elizabethtown, PA 17022

Erie Technological Products of Canada, Ltd.
(613) 392-2581
5 Fraser Ave., Trenton, Ontario, Canada K8V 5S1

Galileo Electro-Optics Corp.
(617) 347-9191
Galileo Park, Sturbridge, MA 01518

RCA Corporation
(717) 397-7661
Electro Optics Marketing
New Holland Ave., Lancaster, PA 17604

Venus Scientific Inc.
(516) 293-4100
399 Smith St., Farmingdale, NY 11735

The vidicon interchangeability information contained herein lists RCA replacements, to the best of our knowledge, for many competitive vidicon types. It also includes replacements for most RCA discontinued types. The Guide is divided into two parts; Direct and Similar.

**Direct**

The RCA vidicons listed under "RCA Replacement-Direct" are *plug-in* replacements; they have the same basic set-up requirements and performance characteristics as the "Type to be Replaced". As such, they require only routine adjustment of camera controls to provide satisfactory pictures; no camera circuitry modifications are necessary.

**Similar**

The suggested RCA replacement vidicons shown under "RCA Replacement-Similar" represent the nearest RCA equivalent(s) to the "Type to be Replaced". In general, use of these tubes as replacements will require minor circuitry changes to give satisfactory performance. It should be noted, however, that a "Similar" type may offer significant performance advantages over the "Type to be Replaced" even though some differences in set-up procedure or minor circuit modifications may be required.

**Footnote References**

Footnote references following the recommended RCA replacement vidicons refer to the applicable "Notes" which indicate the degree of interchangeability between the tube types and suggested circuitry modifications needed to *socket* the replacement vidicon.

**Other Considerations**

Premium quality selections are available for many RCA types; quality grades are indicated by either a prefix or a suffix designation. Note that prefix and suffix designations are also used to denote other distinctive meanings.

**Prefix Designations**

BC- Premium quality types recommended for Broadcast Service.

**Suffix Designations**

A – Commercial or 2nd level type
B – Premium or 1st level type
/U – Designation for RCA Ultricon types
/H – Designation used on some RCA low bloom types

The following suffixes are for designating a particular vidicon type for use in color and B&W cameras:

/B – Blue channel
/G – Green channel
/L – Luminance channel in color cameras or for B&W cameras
/R – Red channel

**Replacement Routine**

A suggested routine to follow when replacing any vidicon in a camera is shown below. The specific steps that are applicable will depend on the camera design; some of the lower-cost cameras may not have controls for making all the adjustments.

Step 1 – Make sure camera power is off and beam (grid No.1) control is set to its most negative value (beam cutoff) before inserting the replacement vidicon in its socket. The target voltage control should be set as follows:

| | |
|---|---|
| Sulfide | Approx. 20 volts |
| Vistacon | 45 to 50 volts |
| SATICON | 50 volts |
| Ultricon™ | 8 to 10 volts |
| Other ST | 8 to 10 volts |

Increase deflection to completely overscan target.

Step 2 – Expose vidicon to a suitable test pattern.

Step 3 – After the vidicon is *socketed*, power may be applied to the camera with its lens stop set to its mid-point or normal opening. Increase the beam control to that point which just brings out picture highlight details on the monitor.

Step 4 – Adjust the beam focus voltage, the lens stop, and optical focus to produce a reasonably sharp picture.

Step 5 – Apply properly sized and centered mask or test pattern.

Step 6 – Adjust scan size and centering controls for proper scan format.

Step 7 – Adjust the target voltage of sulfide vidicons to that value which provides the desired operating dark current or to the highest value that still gives uniform background.

Step 8 – Adjust lens stop and beam control for required video output level without overbeaming.

Step 9 – Adjust the alignment controls to the point where center of picture does not move but peripheral areas rotate about the center point as beam focus is "rocked" back and forth through best focus.

Step 10 – Re-adjust beam focus, the lens stop, scan size, centering, and optical focus to obtain the best picture.

# Interchangeability Guide (cont'd)

| Type To Be Replaced | RCA Replacement Direct | Similar |
|---|---|---|
| 20PE11 | | 8844[a] |
| 20PE13 | 8844 | |
| 20PE13A | 8844 | |
| 20PE13A/8844 | 8844 | |
| 20PE14 | 4848 | |
| 20PE14A | 4848 | |
| 20PE14P | 4848 | |
| 20PE15 | | 4833/U, 4833A/U[b] |
| 20PE19 | 4848 | |
| 20PE20 | 4848 | |
| 25PE14 | | 4532/U[b,c,d] |
| 4462 | 7735 | |
| 4478 | 7735 | |
| 4480 | 7735A | |
| 4488 | 7735A | |
| 4502 | 8507A | |
| 4503 | 4503A | |
| 4508 | 7735 | |
| 4520 | 8507A | |
| 4532 | 4532/U | |
| 4532/H Series | 4532/U Series | |
| 4532A | 4532A/U | |
| 4532AMR | 4532/U | |
| 4532B | 4532B/U | |
| 4538 | 7735 | |
| 4542 | | C23281[e] |
| 4543 | BC8541 | |
| 4559 | 8507A | |
| 4559A/8507A | 8507A | |
| 4591/B | | BC4592/B[a] |
| 4591/G | | BC4592/G[a] |
| 4591/L | | BC4592/L[a] |
| 4591/R | | BC4592/R[a] |
| 4592/B | BC4592/B | |
| 4592/G | BC4592/G | |
| 4592/L | BC4592/L | |
| 4592/R | BC4592/R | |
| 4593/R | BC4593/R | |
| 4594/G | BC4594/G | |
| 4594/L | BC4594/L | |
| 4594/R | BC4594/R | |
| 4599 | 8507A | |
| 4806 | 4514 | |
| 4809 | BC4809 | |
| 4809/B | BC4809/B | |
| 4810 | BC8480 | |
| 4811 | BC8134 | |
| 4816 | | 4817[a,e] |
| 4833 | 4833/U | |
| 4833A | 4833A/U | |
| 4833/H | 4833/U | |
| 4833A/H | 4833A/U | |
| 4846 | BC4809 | |
| 4846/B | BC4809/B | |
| 4875 | 4875/U | |
| 4875/H | 4875/U | |
| 4904 | | 4875/U[b] |
| 4905 | | 4833/U, 4833A/U[b] |
| 4906 | | 4532/U Series[b] |
| 4909 | S81007E | |
| 7038 | 7735 Series (Incl BC) | |
| 7038V | BC7735 | |
| 7038/V | BC7735 | |
| 7038V4 | BC7735[f] | |
| 7038/V4 | BC7735[f] | |
| 7226 | | 7262A[e] |

| Type To Be Replaced | RCA Replacement Direct | Similar |
|---|---|---|
| 7263A | | 4503A[a] |
| 7325 | 7735 | |
| 7522 | | 4514[c] |
| 7697 | 7735 Series (Incl BC) | |
| 7735A/M | 7735 Series | |
| 7735B | 7735B, BC7735 | |
| 8134V | BC8134 | |
| 8134V1 | BC8134 | |
| 8134VB | BC8134 | |
| 8134/4811 | BC8134 | |
| 8134V1/4811 | BC8134 | |
| 8134/4811/B | BC8134/B | |
| 8480/4810 | BC8480 | |
| 8480V1 | BC8480 | |
| 8480V1/4810 | BC8480 | |
| 8484 | 7735A | |
| 8484H | 7735B | |
| 8507A | 8507 Series (Incl BC) | |
| 8511 | 7262A | |
| 8541A | 8541 Series (Incl BC) | |
| 8541AX | 8541A/X | |
| 8541B | 8541B, BC8541 | |
| 8541X | 8541A/X | |
| 8566 | 8541 Series | |
| 8572 | 8507 Series | |
| 8572A | 8507 Series (Incl BC) | |
| 8572A/V | BC8507 | |
| 8572A/V4 | BC8507[f] | |
| 8572V | BC8507 | |
| 8572V4 | BC8507[f] | |
| 8572/V | BC8507 | |
| 8572/V4 | BC8507[f] | |
| 8573 | 8541 Series | |
| 8604 | 8541 Series | |
| 8625 | 8507 Series | |
| 8626 | 8541 Series | |
| 8638 | BC4809 | |
| 8638B | BC4809/B | |
| 8758A | 7262A[e] | |
| 8823 | 8844 | |
| 8823L | 8844 | |
| 8823S | 8844 | |
| 8844(H) | 8844 | |
| 8844(W) | 8844 | |
| 8929 | | 4848[d] |
| 55851AM | 8541 Series | |
| 55851F | 8541 Series | |
| 55851N | 8541 Series | |
| 55851S | 8541 Series | |
| 55851SR | 8541 Series | |
| 55852AM | | 8541 Series (Incl BC)[e] |
| 55852F | | 8541 Series (Incl BC)[e] |
| 55852N | | 8541 Series (Incl BC)[e] |
| 55852S | | 8541 Series (Incl BC)[e] |
| 55852SR | | 8541A/X[e] |
| 55875 | | BC4592/L[a] |
| 55875B | | BC4592/B[a] |
| 55875BIG | | BC4592/B[a] |
| 55875GIG | | BC4592/G[a] |
| 55875IG | | BC4592/G[a] |
| 55875R | | BC4592/R[a] |
| 55875RIG | | BC4592/R[a] |
| E5001 | | S81007E[b] |
| E5022 | | 4911[b] |
| E5036 | | 4532/U, 4532A/U[a] |
| E5040 | BC4592/L | |

| Type To Be Replaced | RCA Replacement | |
|---|---|---|
| | Direct | Similar |
| E5040B | BC4592/B | |
| E5040G | BC4592/G | |
| E5040R | BC4592/R | |
| E5041 | | 4532/U, 4532A/U[b] |
| E5045 | 4848 | |
| E5052 | | 4833/U, 4833A/U[b] |
| E5052W | | 4833/U, 4833A/U[b] |
| E5054 | 4817 | |
| E5055 | 4594/L | |
| E5058 | | 4532/U[b] |
| E5061 | | 4911[b] |
| E5063 | | S81007E[b] |
| E5071 | | 4875/U[b] |
| H8362 | BC4909 | |
| H8397 | | BC4908[h] |
| H8397A | BC4908 | |
| H9311A | 4911 | |
| H9324 | BC4909 | |
| H9326 | BC4909 | |
| H9362 | S81007E | |
| LLSA-100 | BC4532, 4532/U | |
| M7075 | 8844 | |
| N513 | 4848 | |
| N887 | 4848 | |
| P810 | 7735 Series | |
| P826/4478 | 7735 Series | |
| P831 | 4503A | |
| P841 | 8507 Series (Incl BC) | |
| P841/8507A | 8507 Series (Incl BC) | |
| P841X | | 8541A/X[e] |
| P842 | 8541 Series (Incl BC) | |
| P842/8541A | 8541 Series (Incl BC) | |
| P842X | 8541A/X | |
| P843 | 8507 Series (Incl BC) | |
| P843/8572A | 8507 Series (Incl BC) | |
| P844 | 8541 Series (Incl BC) | |
| P846 | 8507 Series (Incl BC) | |
| P846/8625 | 8507 Series (Incl BC) | |
| P847 | BC8541, BC4809, BC4809/B | |
| P847/8626 | BC8541 | |
| P848 | 8507 Series | |
| P848D | 8507 Series | |
| P849 | 8541 Series | |
| P849D | 8541 Series | |
| P863 | | 4503A[e] |
| P864 | | 7262A[a] |
| P868 | 4542 | C23281[e] |
| P893 | 4493 | |
| P893/4493 | 4493 | |
| P894 | 4494 | |
| P894/4494 | 4494 | |
| P895 | 4495 | |
| P895/4495 | 4495 | |
| P8000 | | BC4592/L[a] |
| P8000B | | BC4592/B[a] |
| P8000G | | BC4592/G[a] |
| P8000L | | BC4592/L[a] |
| P8000R | BC4592/R[a] | |
| P8001 | BC4592/L | |
| P8001B | BC4592/B | |
| P8001G | BC4592/G | |
| P8001L | BC4592/L | |
| P8001R | BC4592/R | |
| P8003 | BC4594/L | |
| P8003A | BC4593/R | |
| P8003AR | BC4593/R | |

| Type To Be Replaced | RCA Replacement | |
|---|---|---|
| | Direct | Similar |
| P8003G | BC4594/G | |
| P8003GF | BC4594/G | |
| P8003L | BC4594/L | |
| P8003LF | BC4594/L | |
| P8003MF | BC4594/L | |
| P8003R | BC4594/R | |
| P8003RF | BC4594/R | |
| P8005 | BC4992/L | |
| P8005B | BC4992/B | |
| P8005G | BC4992/G | |
| P8005L | BC4992/L | |
| P8005R | BC4992/R | |
| P8021 | BC4892/L | |
| P8021B | BC4892/B | |
| P8021G | BC4892/G | |
| P8021/L | BC4892/L | |
| P8021/R | BC4892/R | |
| P8023A | BC4893/R | |
| P8023GF | BC4894/G | |
| P8023LF | BC4894/L | |
| P8023MF | BC4894/L | |
| P8023RF | BC4894/R | |
| P8031 | | 8541 Series[e] |
| P8034 | 4542 | C23281[e] |
| P8034A | 4542 | C23281[e] |
| P8038 | BC4809 | |
| P8038B | BC4809/B | |
| P8120 | 4532/U | |
| P8120A | 4532/U | |
| P8120B | 4532/U | |
| P8130 | BC4992/L | |
| P8130B | BC4992/B | |
| P8130G | BC4992/G | |
| P8130HG | BC4994/G | |
| P8130HL | BC4994/L | |
| P8130HR | BC4994/R | |
| P8130L | BC4992/L | |
| P8130R | BC4992/R | |
| P8132AR | BC4993/R | |
| P8132GF | BC4994/G | |
| P8132LF | BC4994/L | |
| P8132MF | BC4994/L | |
| P8132RF | BC4994/R | |
| P8400B | BC4992/B | |
| P8400G | BC4992/G | |
| P8400HG | BC4994/G | |
| P8400HL | BC4992/L | |
| P8400HR | BC4994/R | |
| P8400L | BC4992/L | |
| P8400R | BC4992/R | |
| P8401AR | BC4993/R | |
| P8401RF | BC4994/R | |
| S1200 | | 4532/U[b] |
| S1201 | | 4532/U[b] |
| S1202 | | 4532/U[b] |
| S4075 | | 4533/U, 4533A/U[b] |
| S4076 | | 4532/U Series[b] |
| S4092 | | 4875/U[b] |
| S4097 | 4848 | |
| S7001 | | 4804/H Series |
| S7002 | | 4804/H Series |
| S7003 | | 4804/H Series |
| T44H-14 | 4817 | |
| TV8000 | 8541 Series (Incl BC) | |
| TV8000H | | 8541 Series (Incl BC)[e] |
| TV8050 | | 4503[e] |

# Interchangeability Guide (cont'd)

| Type To Be Replaced | RCA Replacement | |
|---|---|---|
| | Direct | Similar |
| TV8800 | 8844 | |
| TV9231 | | 4833/U, 4833A/U[b,g] |
| TV9901 | | 4532/U, 4532/U[b,d,g] |
| XQ1002 | 7735 Series (Incl BC) | |
| XQ1003 | 7735 Series | |
| XQ1004 | 7735 Series | |
| XQ1020 | BC4592/L | |
| XQ1020B | BC4592/B | |
| XQ1020/G | BC4592/G | |
| XQ1020L | BC4592/L | |
| XQ1020R | BC4592/R | |
| XQ1020/P8001 | BC4592/L | |
| XQ1020/P8001B | BC4592/B | |
| XQ1020/P8001G | BC4592/G | |
| XQ1020/P8001L | BC4592/L | |
| XQ1020/P8001R | BC4592/R | |
| XQ1021 | BC4592/L | |
| XQ1021B | BC4592/B | |
| XQ1021G | BC4592/G | |
| XQ1021R | BC4592/R | |
| XQ1022 | 4817 | |
| XQ1023R | BC4593/R | |
| XQ1024R | BC4593/R | |
| XQ1025 | BC4594/L | |
| XQ1025G | BC4594/G | |
| XQ1025L | BC4594/L | |
| XQ1025R | BC4594/R | |
| XQ1026 | BC4594/L | |
| XQ1026R | BC4594/R | |
| XQ1031 | 7262A | |
| XQ1032 | 7262A | |
| XQ1040 | 8541 Series (Incl BC) | |
| XQ1041 | BC8541, 8541A/X | |
| XQ1042 | 8541 Series (Incl BC) | |
| XQ1043 | 8541 Series | |
| XQ1044 | 8541 Series (Incl BC) | |
| XQ1061 | | 8541 Series (Incl BC)[e] |
| XQ1062 | | 8541 Series (Incl BC)[e] |
| XQ1063 | | 8541 Series (Incl BC)[e] |
| XQ1064 | | 8541 Series (Incl BC)[e] |
| XQ1065 | | 8541 Series (Incl BC)[e] |
| XQ1066 | | 4569[e] |
| XQ1067 | | 4569[e] |
| XQ1070 | BC4892/L | |
| XQ1070B | BC4892/B | |
| XQ1070G | BC4892/G | |
| XQ1070L | BC4892/L | |
| XQ1070R | BC4892/R | |
| XQ1073R | BC4893/R | |
| XQ1075G | BC4894/G | |
| XQ1075R | BC4894/R | |

| Type To Be Replaced | RCA Replacement | |
|---|---|---|
| | Direct | Similar |
| XQ1120 | | BC8134[e] |
| XQ1121 | | BC8134[e] |
| XQ1160 | 4503A | |
| XQ1161 | 4503A | |
| XQ1240 | 8541, BC8541, BC4809, BC4809/B | |
| XQ1241 | 8541, BC8541 | |
| XQ1250 | BC8541, BC4809, BC4809/B | |
| XQ1252 | BC8541, BC4809, BC4809/B | |
| XQ1271 | 8844 | |
| XQ1272 | 4848 | |
| XQ1310 | 8844 | |
| XQ1311 | 8844 | |
| XQ1400 | 4532/U Series, BC4532 | |
| XQ1401 | 4532/U Series | |
| XQ1402 | 4532/U Series | |
| XQ1410B | BC4392B | |
| XQ1410G | BC4392G | |
| XQ1410R | BC4392R | |
| XQ1410L | BC4392L | |
| XQ1413R | BC4993/R | |
| XQ1415G | BC4993/G | |
| XQ1415L | BC4993/L | |
| XQ1415R | BC4993/R | |
| XQ1427 | | BC4390/B[h] |
| XQ1427G | | BC4390/G[h] |
| XQ1427R | | BC4390/R[h] |
| Z7856 | 4542 | C23281[e] |
| Z7910 | 4569 | |
| Z7911 | 7735 Series | |
| Z7912 | 4503A | |
| Z7919 | 8541 Series (Incl BC) | |
| Z7927 | 4833/U | |
| Z7927IND | 4833/U, 4833A/U | |
| Z7927INDRB | | 4833/U, 4833A/U[b] |
| Z7929 | 8134 | |
| Z7929B | | 4495[d] |
| Z7929G | | 4494[d] |
| Z7929R | | 4493[d] |
| Z7933 | | 4503[e] |
| Z7936 | 8541A/X | |
| Z7951 | | 7735 |
| Z7971 | 4589 | |
| Z7975 | 4532A/U | |
| Z7975A | 4532B/U | |
| Z7975AMR | 4532/U | |
| Z7975B | 4532A/U | |
| Z7975C | BC4532, 4532/U | |
| Z7975HR | 4532B/U | |
| Z7975IND | BC4532, 4532/U | |
| Z7975INDRB | | 4532[b] |
| Z7975RB | | 4532B[b] |

[a] The replacement type has a separate mesh connection. For improved performance, supply a higher voltage to G4 than to G3 or operate as a mutual mesh type by connecting G3 to G4.

[b] Adjust target voltage to value specified in Replacement Routine.

[c] The vidicon type being replaced is a shorter version of the replacement type.

[d] The maximum voltage rating of the vidicon type being replaced is slightly higher than that of the RCA replacement vidicon.

[e] The vidicon being replaced has a different heater current rating than the RCA replacement type. After replacement, the heater voltage should be within ± 5% of its rated 6.3 voltage rating. For cameras having regulated (constant) current heater supplies, modification of the camera is required.

[f] The type being replaced has an "anti-halation" button; the BC replacement type does not; for optical reasons, replacement should be made as a trio in 3-tube color cameras.

[g] The type being replaced has a slightly higher spectral response than the replacement vidicon.

[h] Replacement should be made as a complete set in color cameras. A slightly higher G1 voltage (beam control) may be required with some cameras to completely cut off the beam.

## Camera Tubes



## Charge-Coupled Devices



## Image Intensifiers



## Focus-Deflection Assemblies



## Power Supplies

# RCA Sales Offices

## International

| | | |
|---|---|---|
| Argentina | RCA SAIC, Calle Paroissian 3930, Buenos Aires | 70-4171 |
| Belgium | RCA S.A., 100, rue de La Fusee 1130 Brussels | (02) 720.89.80 |
| Brazil | RCA Electronica Ltda., Av. Ipiranga 1097 CP30443, Sao Paulo | 36-6951 |
| Canada | RCA Ltd., 6303-30th St. S.E., Calgary, Alberta T2C 1R4 | (403) 273-1815 |
| | RCA Ltd., 21001 No. Service Rd., Trans-Canada Highway, Ste Anne de Bellevue, Quebec H9X 3L3 | (514) 457-9000 |
| Canada (cont'd) | RCA Ltd., 1 Vulcan St., Rexdale, Ontario M9W 1L3 | (416) 247-5491 |
| Germany | RCA GmbH, Zeppelinstrasse, 35 7302 Ostfildern 4 | (0711) 45.40.01 |
| Mexico | RCA S.A. de C.V., Avenida Cuitalhuac 2519, Mexico 16, D.F. | (905) 527-6020 |
| UK | RCA Ltd., Sunbury-on-Thames, Middlesex TW17 7HW | (09327) 855.11 |

## U.S. (OEM)

| | | |
|---|---|---|
| Alabama | RCA, Holiday Office Center, Suite 41, 3322 So. Memorial Parkway, Huntsville, AL 35801 | (205) 881-4100 |
| Arizona | RCA, 4227 N. Brown Ave., Suite 4, Scottsdale, AZ 85251 | (602) 947-7235 |
| California | RCA, 4827 Sepulveda Blvd. Sherman Oaks, CA 91403 | (213) 469-4200 |
| | RCA, 4546 El Camino Real, Los Altos, CA 94022 | (415) 948-8996 |
| | RCA, 8333 Clairemont Mesa Blvd., Suite 105, San Diego, CA 92111 | (714) 279-0420 |
| | RCA, 17731 Irvine Blvd., Suite 104, Magnolia Plaza, Tustin, CA 92680 | (714) 832-5302 |
| Colorado | RCA, 2785 N. Speer Blvd., Room 346, Denver, CO 80211 | (303) 433-8841 |
| Florida | RCA, PO Box 12247, Lake Park, FL 33403 | (305) 626-6350 |
| | RCA, 1850 Lee Road, Suite 135, Winter Park, FL 32789 | (305) 647-7100 |
| Illinois | RCA, 2700 River Road, Des Plaines, IL 60018 | (312) 391-4380 |
| Indiana | RCA, Parkwest Office Plaza, 3811 Illinois Rd., Suite 4000, Fort Wayne, IN 46804 | (219) 432-1589 |
| | RCA, 2511 E. 46th St., Suite Q-1, Atkinson Square, Indianapolis, IN 46205 | (317) 267-6375 |
| Massachusetts | RCA, 20 William St., Wellesley, MA 02181 | (617) 237-7970 |
| Michigan | RCA, 30400 Telegraph Rd., Suite 440, Birmingham, MI 48010 | (313) 644-1151 |
| Minnesota | RCA, 6750 France Ave., S., Suite 122 Minneapolis, MN 55435 | (612) 929-0676 |
| Kansas | RCA, 5750 W. 95th St., Suite 111, Overland Park, KS 66207 | (913) 642-7656 |
| New Jersey | RCA, 1998 Springdale Rd., Cherry Hill, NJ 08003 | (609) 338-5042 |
| | RCA, 67 Walnut Ave., Clark, NJ 07066 | (201) 574-3550 |
| New York | RCA, 160 Perinton Hill Office Park, Fairport, NY 14450 | (716) 223-5240 |
| | RCA, One Huntington Quadrangle, Suite 2C14, Huntington Station, LI, NY 11746 | (516) 293-0180 |
| North Carolina | RCA, 5311 77 Center Drive, Charlotte, NC 20210 | (704) 525-3424 |
| Ohio | RCA, 29525 Chagrin Blvd., Pepper Pike, OH 44122 | (216) 831-0030 |
| Texas | RCA Center, 8700 Stemmons Freeway, Dallas, TX 75247 | (214) 638-6434 |
| Virginia | RCA, 1901 N. Moore St., Arlington, VA 22209 | (703) 558-4161 |

## U.S. (Distributor)

### Distributor & Special Products Division, Deptford, NJ

| | | |
|---|---|---|
| Eastern Region | RCA, 2000 Clements Bridge Rd., Deptford, NJ 08096 | (609) 963-8000 |
| Western Region | RCA, 6363 Sunset Boulevard, Hollywood, CA 90028 | (213) 468-4092 |
| Central Region | RCA, 2700 River Road, Des Plaines, IL 60018 | (312) 391-4350 |



Printed in U.S.A./**3-79**
**IMD-100**
Supersedes CAM-703C, 3-75

RCA Solid State

# The SATICON™ Color Television Camera Tube


by R. G. Neuhauser
RCA Electro-Optics and Devices
Lancaster, Pa. 17604


ST-6674


Reprinted from
The Journal of The Society of
Motion Picture and Television Engineers
March 1978 · Vol. 87 · No. 3

# The Saticon™ Color Television Camera Tube

By ROBERT G. NEUHAUSER

**The Saticon is a vidicon-type camera tube with a *S*elenium—*A*rsenic—*T*ellurium photoconductor. The tube was developed specifically for small high-performance color television cameras, but has proven useful for many other television-camera applications. The photoconductor represents an improvement in resolution, stability, and reduction of optical flare over the presently used lead oxide photoconductors. The Saticon employs a new gun structure specifically designed to produce improved registration and registration stability in color cameras, and to reduce the lag of the tube.**

## Introduction

Selenium is not a new photoconductor; in fact, it is the oldest known. In 1873 a rod of selenium was being used as a resistor in a piece of equipment for testing the resistance of transatlantic cables as they were being laid. It was observed that the instrument readings varied regularly during the course of a day; these changes were traced to the influence of light on the selenium resistor. Since that time, selenium has been used in a host of light-sensitive devices, including photographic exposure meters and xerographic copying-machine plates.

The first photoconductive vidicons made by RCA employed selenium.[1,2] The high sensitivity, low dark current, and low lag were distinctly advantageous features. The disadvantages were that the tubes suffered from lack of red sensitivity and short life, and the glassy amorphous selenium layer tended to crystallize, even at room temperature, to produce conductive white spots. Unless some method of cooling the tube was employed, this latter characteristic definitely limited tube life. In subsequent development work at RCA, it was found that adding arsenic greatly reduced the tendency for selenium to crystallize. It was also established that adding tellurium would increase the red sensitivity through the entire visible spectrum, and the concept of developing a selenium photoconductor in a heterojunction configuration was explored. Work on the photoconductor was discontinued by RCA before a commercial tube was introduced.

Subsequently, the research laboratory of NHK, the Japanese Broadcasting Corporation, took up the search for a way of making a satisfactory selenium-based photoconductor. After some initial success at NHK, the Central Research Laboratory of Hitachi began to collaborate with them in the development of a practical photoconductor and associated camera tube, with the intent of producing a tube specifically for color-television cameras. The result of this collaboration was a tube they called the Saticon.

---

Presented on 17 October 1977 at the Society's Technical Conference in Los Angeles by Robert G. Neuhauser, RCA Electro-Optics and Devices, New Holland Ave., Lancaster, PA 17604. This paper was received on 9 November 1977.

Saticon™ is a registered trademark of NHK (Japan Broadcasting Corp).

## Developmental Objectives

Any new camera tube must show improved or at least equivalent performance in resolution, lag, and sensitivity when compared to tubes in use. Beyond these are a number of other characteristics, uniquely necessary for a color camera, that must also be maintained or improved. These are:

- Registration ability,
- Registration stability,
- Spectral response,
- Light dispersion from the photolayer,
- Signal uniformity,
- Low dark current,
- Small size,
- Predictable light-transfer characteristics.

Several additional factors necessary for practicality and economic viability are:

- Long life,
- Freedom from blemishes,
- Resistance to image burns,
- Usefulness over a wide temperature range,
- Reproducibility in manufacture.

## Photoconductor Development

The evolution of the method of stabilizing selenium in the glassy state by the use of arsenic allowed the further development of the selenium photoconductor. The addition of small amounts of arsenic does not appreciably lower the very high resistivity of the selenium (approximately $10^{13}$ ohm-cm) and the material is still high enough in resistivity to allow it to store a charge image on the scanned surface. The task then was to incorporate the tellurium without appreciably altering this characteristic while at the same time lowering the bandgap from 2 eV to some value that would allow the absorption of red light and the generation of carriers by the photons absorbed.

In order to intelligently develop a satisfactory photoconductor using selenium, tellurium, and arsenic, it was first necessary to develop an understanding of the electronic structure of the photoconductive materials. It was determined that when the *p*-type selenium is deposited on the typical transparent signal electrode consisting of tin oxide, or other suitable transparent conductor (or semiconductor) which has *n*-type conductivity (Fig. 1), a reversed-biased junction prevents excess holes from being injected into the photoconductor and contributes to the desired low dark current. On the opposite side of the photoconductor, the natural *p*-type conductivity of the layer traps electrons in all available surface sites during the initial scan of the layer and prevents unwanted electrons from the beam from contributing to dark current. These two barriers produce, in effect, two heterojunctions, and the photoconductor operates with low dark current with the entire target voltage impressed reasonably uniformly across its bulk.

The first task in developing the photoconductor was to introduce the stabilizing material into the photolayer without seriously disturbing desirable electrical characteristics. An appropriate arsenic concentration was developed that balances the stability of the selenium at high temperatures without producing unwanted electrical characteristics. The transparent signal plate on the inside of the glass faceplate enters into the problem of photoconductor stability; its crystalline structure as well as certain mechanical imperfections and discontinuities on its surface can act as nucleation centers for crystalline growth. Therefore, the surface of this layer must be appropriately treated prior to photoconductor deposition to minimize selenium nucleation tendencies. In addition, a very thin buffer layer of cerium oxide provides a surface that retards nucleation of the selenium while maintaining a wide bandgap and providing an *n*-type contact.

The next problem was to introduce tellurium into the layer to increase the red sensitivity. It was found that tellurium enhances the tendency for crystallization and that the low bandgap tends to promote breakdown of the *n*-*p* barrier if the tellurium is incorporated in the portion of the selenium layer that is deposited directly on the signal plate. If the tellurium were incorporated only on the scanned portion of the layer (Fig. 2), the poor electron conductivity of the selenium-arsenic layer would impede the electron carrier flow through the photoconductor and result in recombination of carriers and loss of potential sensitivity.

The solution, shown in Fig. 3, was to incorporate the tellurium in the neighborhood of the signal plate to achieve good red sensitivity, but far enough away from it to prevent disruption of the barrier and any recrystallization tendencies. The thickness and the concentration of tellurium in the tellurium-bearing layer determine the increase in the red sensitivity. If the tellurium concentration is too high or the tellurium-bearing layer too thick, the recrystallization tendency increases, which in turn increases the tendencies for image retention.

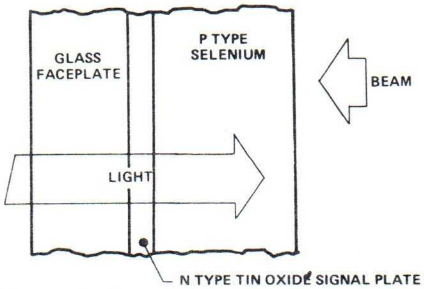



**Fig. 1. Configuration of a selenium photoconductor in a camera tube.**

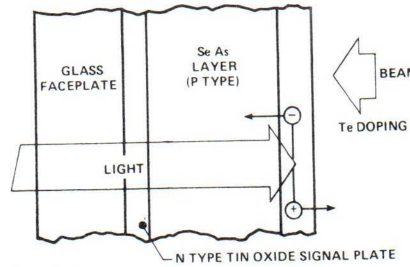



**Fig. 2. Selenium-arsenic photoconductor doped with tellurium on the scanned side.**

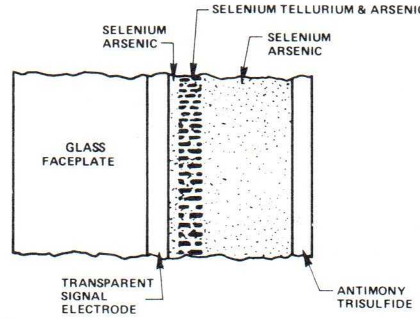



**Fig. 3. Configuration of the Saticon tube photoconductor.**

Hence, a balance must be struck between red sensitivity and photoconductor stability and lag.

The thickness of the remainder of the photolayer is also critical because the capacitance of the layer (and thus the lag) will be high if the layer is thin, while too thick a layer requires too high a target voltage. With a given hole-carrier lifetime and mobility in the selenium-arsenic layer, the electric field must be high enough to pull the carriers through before they are lost by recombination. If the layer is too thick, the target voltage necessary to produce this field is too high and the beam develops "edge crawl" effects near the edges of the picture where the beam seems to oscillate in position and produce a rippled appearance.

The maximum useful target voltage is about 50 V, but even at this voltage there could be problems with secondary emission from the surface of the selenium. This secondary emission would introduce instability in the beam or even cause the scanned area to flip over to the "high-velocity" scan mode if the secondary emission becomes greater than unity at this target voltage. A thin, porous layer of antimony trisulphide is deposited on the scanned area as shown in Fig. 4, to reduce this tendency for secondary emission. This layer also enhances the resistance of the photoconductor to the entry of excess beam electrons and produces a reverse-biased junction effect on the scanned surface that reinforces the barrier to excess electrons.

Doping of the photoconductive selenium-arsenic layer with tellurium produces a narrowing of the bandgap in the doped region; this narrowing has an effect on the required field and target voltage. An energy diagram of the photoconductor is shown in Fig. 5. The field should be high enough so that the saddle caused by the doped region flattens out and allows charge carriers generated in this region to travel through the photoconductor. If the target voltage (or the field) is not high enough, carriers trapped in this saddle cause unwanted image retention and lower sensitivity.[3-5]

## Photoconductor Performance

The photoconductor that evolved based on the above considerations, the selenium-tellurium-arsenic photoconductor used in the Saticon tube, exhibits the following characteristics.

### *Sensitivity*

In the band of wavelengths approximating the blue channel of a color television camera, the photoconductor has nearly 80% quantum efficiency, which is very close to the sensitivity of a lead-oxide photoconductor (one charge carrier per photon is 100% quantum efficiency). The sensitivity decreases through the visible spectrum, as shown in Fig. 6. The color camera green-channel sensitivity of the selenium-arsenic-tellurium photoconductor is 15–20% less than the green-channel sensitivity of a lead-oxide photoconductor, and the red channel sensitivity is midway between the red-channel sensitivity of a standard and an extended-red lead-oxide photoconductor. At the present time, the red sensitivity of the Saticon photoconductor extends beyond 800 nm; the band of light between 700 and 800 nm must be excluded from the optical system of a color camera. In substance, then, the present sensitivity of the selenium-arsenic-tellurium photoconductor is not superior to that of the lead-oxide photoconductor, but it is comparable. In one respect, the photoconductor sensitivity balance is better since there is a better balance between the signal levels of the three channels of a color camera, compared to when lead-oxide tubes are used in the same camera with tungsten light scene illumination.

The photoconductor has a linear light-transfer characteristic (gamma of unity) over the useful range of signal current.

### *Dark Current and Reflectivity*

The dark current in the Saticon tube is extremely low, typically 0.5 $nA/cm^2$, testifying to the efficiency of the reverse-biased junctions. Thus the dark current in a 25-mm Saticon tube with a useful scanned area of approximately 1 $cm^2$ is 0.5 nA; in an 18-mm tube it is 0.25 nA.

The optical absorption and reflectance of the photoconductive layer is of particular importance. Glassy selenium is red in color (i.e., it reflects and transmits red light). The addition of the tellurium reduces this reflectivity and the photoconductor appears nearly black. Measurements of the reflectivity of various typical camera-tube photoconductors are shown in Fig. 7.

The consequences of this low reflectivity and high absorption are twofold. First, very little light is reflected back into the optical system from the photoconductor. With some camera tubes, particularly with red and green light, an appreciable amount of light is reflected back into the optical system where it appears unwanted in portions of the image and deteriorates the contrast and color fidelity of lowlights in the picture. It is evident that this reflected light can cause a significant deterioration of image quality, especially in view of the fact that more than 1 or 2% reflectivity from the other optical surfaces of a color camera optical system is considered unacceptable. The improvements in this characteristic in Saticon tubes are evident in the signal waveforms produced by a high-contrast image transition, and very little flare compensation is needed in the video processing to compensate for light reflected from the photoconductor and scattered over the remainder of the image. The low reflectivity of the Saticon photoconductor, therefore, obviates the need for an antihalation button on the faceplate of this type of tube.

A second benefit accrues from the light-absorbing characteristics and from the homogeneous noncrystalline nature of the Saticon photoconductor. Very little light is dispersed through the photoconductor, a quality that contributes to the good resolution characteristics of this photoconductor as compared to lead-oxide tubes where the crystalline photoconductor disperses red and green light through the photoconductive layer and causes loss in resolution. In Saticon tubes, the resolution is independent of the wavelength of light.

### *Lag*

Lag in a photoconductive camera tube is produced by two factors: trapping effects and storage capacitance. The trapping effects in the photolayer are, in turn, of two types: those that delay the read-out of the charge carriers and those that temporarily lower junction barriers and allow unwanted dark current to flow where the photosurface was previously illuminated. In the Saticon tube, these trapping effects are negligible, and the lag is caused primarily by the second factor — the storage capacitance of the photolayer in series with the effective beam resistance. The storage

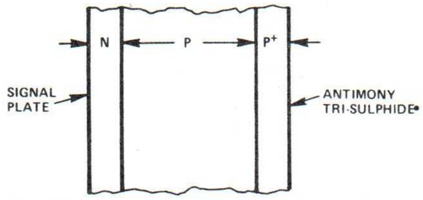



**Fig. 4. Cross section of Saticon photoconductor showing the electrical-conductivity characteristics.**

capacitance of the Saticon photoconductor is higher than of lead-oxide photoconductive tubes. This higher capacitance in itself could make the Saticon tube noncompetitive if means did not exist for reducing the resulting lag.

Means do exist, however, and the first and most effective of them is the use of bias lighting. Bias lighting is the technique of putting uniform light on the photoconductor to bring the zero-signal (picture blacks) charge voltage up to some voltage that is nearly as high as the velocity spread of the electrons in the scanning beam. This spreading, expressed in electron volts, represents an effective beam resistance. It was discovered quite accidentally in 1967 that this method of operating a tube (inserting a "dc" illumination level on top of the optical image on the tube and later electrically subtracting this uniform signal or black level pedestal from the signal) is an effective and acceptable method of reducing the lag of a photoconductor when the lag is primarily the result of the storage capacitance of the photolayer. Most television cameras using lead-oxide or Saticon camera tubes now employ this technique. Bias lighting is particularly effective used with Saticon tubes because the photoconductor sensitivity is uniform. The use of uniform bias lighting does not introduce unwanted black-level nonuniformities.

In the 18-mm Saticon tube, another means is used to further reduce the lag, namely the low-beam-impedance gun. This gun is discussed in a later section of this paper.

*Uniformity and Stability*

Other properties of the photoconductor satisfy some of the other developmental objectives. The Saticon photoconductor is a glassy impervious layer that can be exposed to air, sealed to a tube by a cold indium pressure-sealing technique, and even pretested for electrical characteristics. Thus, the photoconductor can be made very uniform in thickness since it does not have to be fabricated within the confines of a small bulb, and a large number of faceplates can be processed at one time. Fabricating it with uniform thickness contributes to the Saticon's highly uniform sensitivity over the scanned area; making many faceplates at a time contributes to similar characteristics from tube to tube and makes possible the selection of only those photoconductor lots that meet the desired performance characteristics.

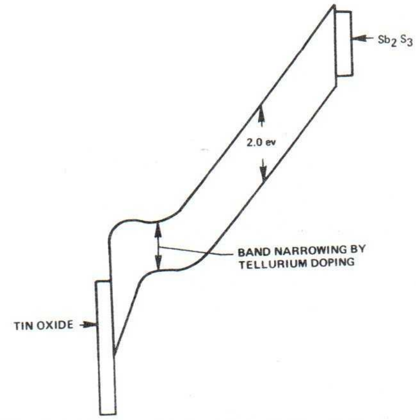



**Fig. 5. Bandgap and energy diagram of reverse-biased Saticon tube photoconductor.**

The glassy layer also produces unusual stability of the electrical characteristics with time. It is impervious to doping by gases generated within the tube, and it is not subject to deterioration or change caused by electrolysis effects when current is drawn through the photoconductor. These effects can and do change the characteristics of the porous photoconductive layers of both lead-oxide and antimony trisulfide tubes as they are used or stored.

The Saticon-tube photolayer is a material that is stable over a wide temperature range and that also maintains, practically constant, all of the important performance characteristics such as lag, resolution, sensitivity, and resistance to image retention over this temperature range. The tube is rated to operate from −30°C (−22°F) to +50°C (122°F) and can operate for short periods of time at temperatures as high as 65°C (149°F). It appears that operation at high temperatures within this range does not shorten the life of the tube, as is the case with lead oxide.

Another beneficial characteristic of the Saticon photoconductor manufacturing process is the ability to make the tube reasonably defect-free (from spots, etc.). The photoconductor is also relatively resistant to damage that can cause spots after it is manufactured, unlike the relatively fragile antimony trisulfide layer. The occurrence of any defects or spots during operation is indeed a rare occurrence.

Camera tubes are often called upon to operate with scene contrasts that are beyond the normal range. When specular highlights (such as the reflections of the sun or spotlight from chrome surfaces) or a direct view of a light bulb are encountered, the tube should cope with the situation gracefully. It is obvious, however, that available tubes cannot properly respond to and faithfully reproduce the contrast ratios of more than 10,000 to 1 which typically occur in these situations.

In the Saticon tube, if the beam produces enough current to rapidly respond to a light level that completely discharges the target, the after-effects of specular highlights are very minimal. If the beam is insufficient to respond to these highlights, the field across the photoconductor will momentarily collapse and a retained image will be seen upon restoration of normal operation. Continuous operation at the very high beam current necessary to respond to the peak signal and restoration of the field across the photoconductor regardless of the illumination level would result in unacceptable resolution and would shorten the life of the gun cathode. Demonstrations have been made of circuitry (called by its inventor ABO, for *A*utomatic *B*eam *O*ptimization) that increases the beam nearly instantaneously as highlights are encountered. This technique will not affect resolution of the normal components of a scene nor the life of the cathode, and it promises to greatly improve the operating capabilities under conditions where there are specular highlights. The present technique in existing cameras involves operation with beam currents set three to four times the normal highlight signal level. This technique greatly reduces the undischarged tail that follows a moving highlight, and the residual effects disappear in approximately 2 s.

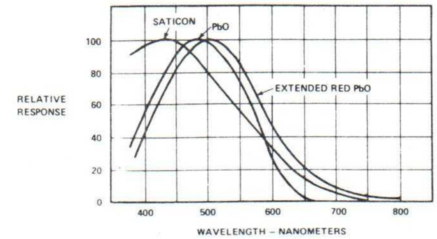



**Fig. 6. Comparative spectral response.**

If the camera is uncapped during stand-by — i.e., when the camera (or the beam) is turned off, any stationary image focused on the photoconductor can be "burned in." However, the tube is resistant to image burn-in for many minutes of stationary exposure when the beam is turned on and the field is maintained across the photoconductor.

*Gun Design*

The performance of the Saticon tube in a color camera is determined in great part by the design of the electron gun. The foremost innovation in gun design is the low-lag capability incorporated in the gun used in the 18-mm tube. This gun reduces the lag of the tube by reducing the beam resistance. A word is necessary on the source of the effective beam resistance. In

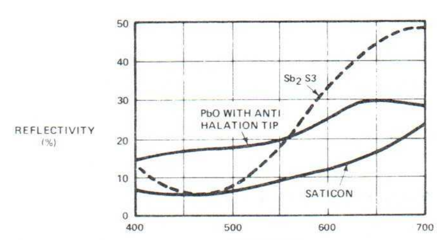



**Fig. 7. Comparative photoconductor reflectivity.**

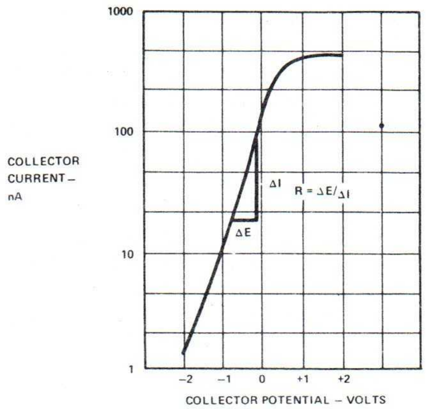



**Fig. 8. Current/voltage plot of beam current collected from a vidicon-type gun.**

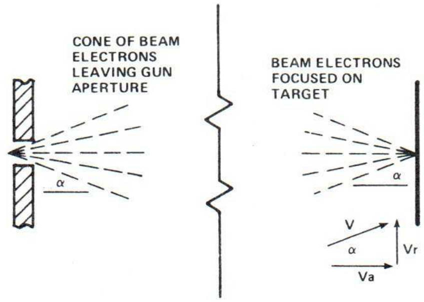



**Fig. 9. Schematic of the electron trajectories of a vidicon beam showing radial ($V_r$) and axial ($V_a$) components of velocity ($V$).**

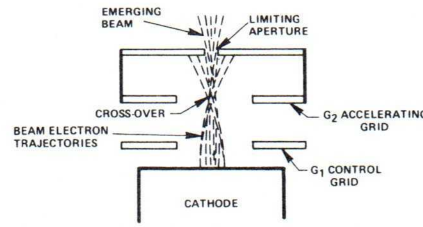



**Fig. 10. Trajectories of electrons inside of the electron gun showing the crossover region where space charge alters the velocity spread of the electrons.**

any vidicon tube, the beam lands on the target with low velocity; in the absence of a positive charge, the beam slows to zero velocity and actually turns around and does not land on the target. When a positive charge is encountered, electrons land on the charged area until the voltage approaches zero, when the remainder of the electrons are repelled. The electrons that land constitute the signal current. All of the electrons in the beam do not have the same energy or velocity nor are they all directed perpendicularly toward the target. A typical plot of the current collected from a beam as the collector voltage is increased from a negative to a positive potential is shown in Fig. 8. The beam resistance is the reciprocal of the slope of this current-voltage characteristic. The spread of these velocities is caused by emission of electrons from a hot cathode, the angular (or radial) component of velocity of the individual electrons within the beam, and space-charge effects that repel electrons from one another (and thus speed up some and slow down others). If all of the electrons had the same velocity and were traveling in parallel paths, the current-voltage characteristic would approach a step function, and the beam resistance would be effectively zero. Furthermore, the lag of a camera tube as a result of *RC* beam capacitance would approach zero.

The known divergence of the beam as the electrons emerge from the gun, Fig. 9, implies some radial components of velocity; the electrons maintain the same radial component of velocity as they travel through the tube. This radial energy is subtracted from the axial velocity of the electrons as they impinge on the target; the result is an effective spread of the axial velocities of these electrons. The lag caused by this factor can be minimized in the design of the electron gun.

It was discovered[6] that a substantial portion of the effective spread of electron velocities was caused by electron space-charge effects in the gun. In a conventional electron gun, the electrons from the cathode cross the axis at some point in their trajectory, causing a high space-charge density at this point, Fig. 10.

The mutual repulsion effects speed up some electrons and slow down others, and impart radial components of velocity to electrons around the periphery of the crossover. Two solutions are indicated to the problem of crossover. One is to reduce the space-charge density (or electron population) in the crossover; the second is to design an unconventional gun that does not produce a crossover. The first approach was taken on the improved 18-mm Saticon tube: the improved gun was designed to substantially reduce the electron density in the crossover. The only operational difference between this and a conventional gun is the requirement for a more negative $G_1$ (beam-control-grid) bias voltage (decreased from −100 to −130 V). This gun change has been achieved with no loss of the resolving power of the beam. The curves of Fig. 11 illustrate the improvement in lag when this gun is used.

*Use of Bias Lighting*

The use of bias lighting has proven to be a universally accepted method of reducing the lag of television camera tubes where the lag is determined primarily by the beam resistance and the target capacitance. Figure 12 illustrates the improvement in lag as the bias-lighting signal level is raised on the 18-mm Saticon tube. The *amount* of bias lighting that can be used is limited by the uniformity of the background signal produced, which is determined primarily by the *uniformity* of the bias lighting. When cameras are operated at very low light levels and low signal levels (approximately 30 nA in the lowest signal channel), the practical bias-current limitation is 5–10 nA.

Even more significant in the use of bias lighting is the improvement in signal build-up. In the absence of light, there are yet a few beam electrons that have enough energy to drive a low-dark-current photoconductor considerably below 0 V. When light is encountered, the target must be charged up to 0 V before the beam can begin to develop significant signal from the target. Figure 13 illustrates the build-up improvements as a function of bias lighting. It is easily seen that only a modest amount of bias-lighting current is needed to improve the build-up characteristics. Poor build-up of signal in a color camera is noted as changes in the color or brightness of the leading edge of an object moving against a dark background.

Contrary to what might be expected, the use of bias lighting does not distort the tonal values of the picture developed by a linear photoconductor. Bias light adds to the dc signal-level an amount that can be subtracted out by black-level adjustments in the video processing amplifier.

*Registration*

The need for registration of the three images of a multi-tube color camera is increasing in importance as standards of quality are upgraded. Registration has two aspects: good registration over the entire scanned area and maintenance of good registration during operation.

Registration ability is determined primarily by precision construction of the tube and by control of the electrical resistivity and the mass of the metal tube parts immersed in the deflection fields. The stability of registration is influenced by the stability of the gun within the tube and of the tube within the deflection system. All efforts must be directed toward maintaining registration during temperature changes and when the camera is subjected to mechanical abuse.

In the Saticon tube, precision construction takes the form of precision tube parts of high resistivity and precision part-mounting techniques that hold the parts in position. Tight tolerances on gun parts allow the gun to fit snugly into the precision bore of the glass bulb. Close spacing of the $G_4$ mesh to the target reduces edge electric-field effects which, when present, tend to pull the corners of the picture outward. The outside diameter of the bulb is held to very tight tolerances, so that the bulb fits snugly into a precision-bore coil and tube gripping fixtures. By "hard mounting" the tube in this manner, relative motion with respect to the coil can be reduced to negligible values, even under wide variations in the temperature and severe shock to the camera structure.

It is also important both that the back end of the gun be held on the axis of the tube as the tube heats up as a result of the power being dissipated in the cathode structure and that this suspension be immune to motion resulting from mechanical shock. The stem of the 18-mm tube has been changed to a 9-pin circle; the result is

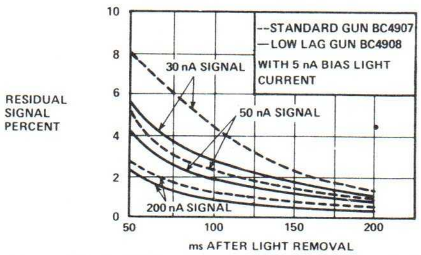



**Fig. 11. Reduction in lag obtained by the use of the low-lag gun.**

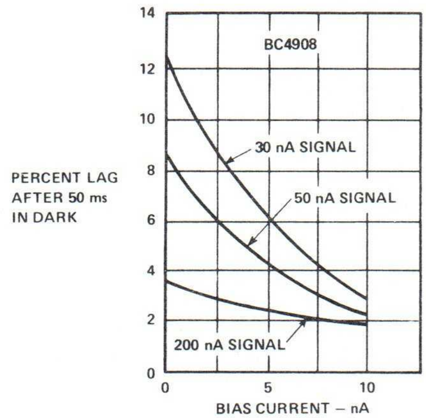



**Fig. 12. Lag reduction with bias lighting.**

a nonstandard 8-pin base (with one vacant key position). This 9-pin circle allows symmetrical 120° mechanical mounting of the gun directly to the base stem.

As a result of all these mechanical improvements, the new 18-mm Saticon tube has established an excellent reputation for achieving and maintaining good registration when operated in a camera with a coil system of equal precision and with rigid tube-mounting provisions.

*Resolution*

The size of the tube was determined by the resolution available. The high resistivity of the photoconductor and the lack of optical dispersion produced a target capable of excellent resolution with a small image size (6.6 × 8.8 mm); the electron gun was designed to maintain this resolution. The result is a tube with a resolution superior to that of 18- and 25-mm lead-oxide tubes and one that begins to rival the resolution of the 30-mm lead-oxide tube.

Figure 14 shows amplitude-response curves for the camera tubes discussed in this paper. Measurements were made in the same piece of test equipment with the same test methods.

It should be noted that the amplitude-response curves are not as high as those quoted by other tube manufacturers because the measurements were made using the RCA P200 slantline test chart, which eliminates the video-amplifier frequency-response characteristics as a major factor in the measurement. The numbers developed by this test are generally more pessimistic than those developed by other techniques, but they are very reproducible from one test unit to another.

*Size and Sensitivity*

The 18-mm tube also has less target shunt capacitance to ground than a 25- or 30-mm tube, a factor that contributes to lower noise in the video signal. The smaller size of the tube does not affect the camera sensitivity; the tube produces the same signal output from the same number of lumens of light as does a larger tube. When the depth of focus and angle of view of an optical system using this smaller tube is identical to that of a camera using a larger tube, the illumination (in lumens) of both tubes will be identical; therefore, there is no sacrifice in sensitivity in employing the smaller, lighter-weight tube. An added bonus to using the smaller-size tube is the lower lag that results from the lower storage capacitance of the smaller area of photoconductor, typically 1400 pF in the 18-mm tube.

**Summary of Objectives and Means**

In summary, the performance goals for a small high-performance color-television camera tube are achieved in the Saticon by virtue of inherent characteristics of the photoconductor and enlightened design techniques.[7] In particular, the objective of high resolution was attained by adapting an amorphous or glassy photoconductor with low-light dispersion and high-resistivity characteristics and combining this with the use of a well designed electron gun. Low lag was achieved by employing bias lighting, a low-current-density crossover in the electron gun, and a thick transport layer on the small-area photoconductor (made possible by the high resolution of the photoconductor). Sensitivity and spectral response depend on a highly absorbing photoconductor doped with tellurium to enhance red sensitivity, good hole transport characteristics, and a heterojunction structure that permits high target voltage with low dark current.

The Saticon's low dark current and linear light-transfer characteristic are due to the high-resistivity photoconductor (selenium) and heterojunction construction. The dispersion of light from the photoconductor is kept low by employing highly absorbent selenium doped with tellurium to enhance the red absorption. Faceplates evaporated in a vacuum chamber rather than within the bulb and the use of an indium seal to the bulb assure signal uniformity, and precision construction of gun and bulb guarantees accurate registration. Just as important as registration is *stability* of registration, and this is assured by a symmetrically supported gun and precision construction enabling hard-mounting of the tube in the coil.

The objective of a long life for the Saticon tube was met by employing a glassy-type photoconductor that is impervious to the tube atmosphere, arsenic doping of selenium to reduce the tendency for selenium to crystallize, and a photoconductor that does not out-gas and contaminate the cathode. Freedom from blemishes was achieved by using special substrate processing techniques and a tough, dense photoconductor that is not easily damaged. A competitive camera tube should be resistant to image burns, which implies for the Saticon not only low trapping in the photoconductor as a result of material purity and control but also an electronic design of the photoconductor that maintains adequate electric field throughout the photoconductor in spite of discrete doping sites. The Saticon is designed to be useful over a wide temperature range, and this required doping of the selenium with arsenic and treatment of the substrate to avoid nucleation sites. (The high resistivity of the selenium maintains resolution at higher temperatures, and proper deposition conditions prevent fracturing of the photoconductive layer under thermal stress.) Finally, it was essential that the Saticon be reproducible in manufacture. Such reproducibility is made possible in large part by batch processing of faceplates — with

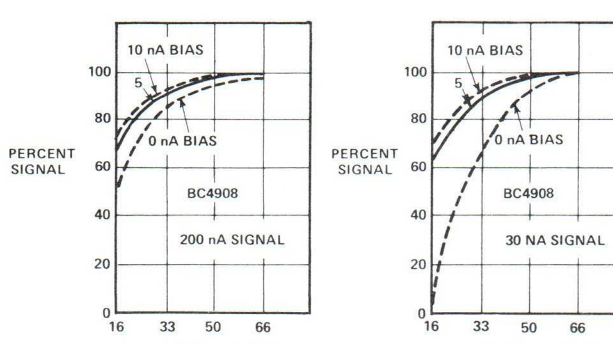



**Fig. 13. Improvement of build-up with bias lighting.**

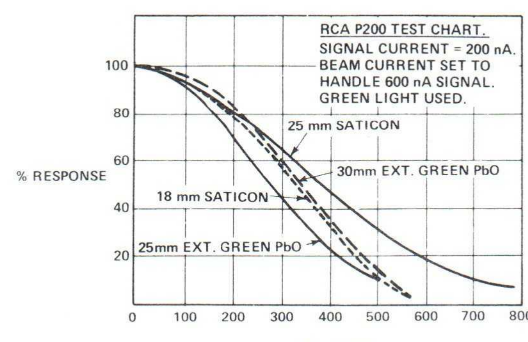



**Fig. 14. Relative amplitude-response curves of camera tubes used in broadcast service.**

adequate monitoring of the constituents of each part of the layer — and by batch pretesting of photoconductor layers.

As a result of achieving these objectives, the Saticon tube has become a serious challenger to the lead-oxide camera tube in broadcast cameras. The Saticon tube can replace 18-mm (⅔-in) and 25-mm (1-in) lead-oxide tubes in many cameras that are presently in use. The low lag and high resolution make the 25-mm tube a suitable replacement for vidicons in appropriately designed telecine cameras.

Two Saticon tube types eminently suited for broadcast color cameras are now in production. The 18-mm tube is designated BC4908 by RCA. Critical side-by-side lag tests and detailed lag measurements show it to be identical in lag to the 18-mm lead-oxide tubes. The resolution of this tube exceeds that of 18-mm and 25-mm lead-oxide tubes. The gun design allows the use of very high beam currents without a noticeable decrease in resolution. The sensitivity is quite uniform from tube to tube and comes within 15–20% of the sensitivity of a typical lead-oxide equipped camera tube for a given signal level. The effective sensitivity relative to the signal-to-noise ratio is *greater* because the higher resolution requires less aperture correction, and aperture correction increases the noise in the signal. The low dispersion of light from the photoconductor has been demonstrated to minimize or eliminate internal optical-system reflection effects and to produce cleaner lowlight colors in the presence of adjacent scene highlights.

The remarkable overall performance of this tube in three-tube color cameras will probably increase the use of small-tube cameras in portable, field, and studio applications in broadcasting.

### Conversion to Saticons

The Saticon can replace the 18-mm lead-oxide tubes in many existing cameras with basically just three changes: a minor mechanical modification of the optical-focus travel system to allow the coil system to be moved closer to the optical block, replacement of the base socket, and provision of 30 V more $G_1$ bias. The Saticon tube must be mounted approximately 1.5 mm nearer the optical system to achieve proper focus because there is no antihalation button as used on lead-oxide tubes which shortens the optical path; the Saticon tube does not require this button because of the low photoconductor reflectivity.

The 25-mm Saticon tube presently available is the BC4909. When used to replace sulfide vidicons in color telecine cameras, the lower lag, increased sensitivity, and lower light dispersion are quite evident. The BC4909 can be used in any three-tube telecine camera that uses magnetically focused 25-mm vidicons if the camera is capable of providing a modest amount of bias lighting and can correct the signal to a 0.4 gamma characteristic. The conversion of a system from vidicons or lead-oxide tubes to Saticon tubes requires that a fixed 50 V be provided for the target and that the system be recalibrated to operate with equal signal currents of 500 nA in each channel and with 15 nA of bias signal current.

If the efforts to incorporate the low-lag gun into the 25-mm Saticon are completely successful, the tube can be substituted for lead-oxide tubes in existing live-television 25-mm tube cameras, and will produce resolution and picture fidelity that exceeds that of 30-mm equipped lead-oxide cameras.

### Credits for Saticon Developments

The present Saticon tube is the result of many decades of work on selenium-type photoconductors and vidicon tubes in many locations. The author claims no more than an involvement in and a familiarity with the various developmental efforts over the past years.

The Saticon-tube photoconductor was developed through the efforts of Teruo Ninomiya, Naohiro Goto, and Keichi Shidara of NHK Laboratories, and Eiichi Maruyama and Tadaaki Hirai of Hitachi Central Research Laboratory. Photoconductor process development was the work of Tsutomu Fujita and Yasuhiro Nonaka of Hitachi Electron Tube Division. The precision gun design was the work of Hideyuki Sakai of Hitachi Electron Tube Division and Kyohei Fukuda of Hitachi Consumer Products Research Center.

The original selenium photoconductor and the basic vidicon tube were developed by Albert Rose, Paul Weimer, A. Danforth Cope, Stanley Forgue, and Robert Goodrich at RCA's David Sarnoff Research Laboratory, Princeton, New Jersey. The stabilization of the selenium vidicon photoconductor by the addition of arsenic and the enhancement of red response by doping with tellurium, as well as the concept of stabilization by chemical designing of the substrate and effecting mechanical refinements, are the achievements of Joseph Dresner and Frank Shallcross of the same laboratory. William Kramer, at RCA, Lancaster, Pennsylvania, developed the concept of the selenium photoconductor with heterojunction construction. The development of the indium seal process that permits the preprocessing of a faceplate prior to sealing it to a tube is the result of work by Benjamin Vine, Louis Miller, Timothy Benner, and this author at RCA, Lancaster. The discovery of the efficacy of bias lighting in reducing lag and speeding build-up is attributed to Thomas Shiferling of RCA, Camden, New Jersey, and the author. Reduction in lag by reducing the space charge in the beam was first proposed by J. H. T. Roosmalen of the Philips Research Laboratory-Eindhaven, who proposed a laminar-flow type gun. Reduction in lag by using a laminar-flow gun to reduce tangential electron velocities was proposed by Benjamin Vine of RCA, Lancaster. The technique of reducing the space charge of the beam in a conventional electron gun to reduce the lag of the Saticon tube is attributed to Chihaya Ogusu and Yukinao Isozaki of NHK Laboratories, Masao Fukushima of Hitachi Central Research Laboratory, and Shigeru Ehata of Hitachi Electron Tube Division.

### References


1. P. K. Weimer, S. V. Forgue, R. R. Goodrich, "The Vidicon Photoconductive Camera Tube," *Electronics, 23:* 7; *RCA Review, 12:* 306, 1951.
2. P. K. Weimer and A. D. Cope, "Photoconductivity in Amorphous Selenium," *RCA Review, 2:* 314, 1951.
3. N. Goto, Y. Isozaki, K. Shidara, E. Maruyama, T. Hirai, and T. Fujita, "SATICON, A New Photoconductive Camera Tube with Se-As-Te Target," *IEEE Transactions on Electron Devices*, Vol. ED 21, No. 11, p. 662, November 1974.
4. E. Maruyama, T. Hirai, N. Goto, Y. Isozaki, and K. Shidara, "Photoelectric Properties of Chalcogenide Glass Diodes and Their Application to TV Pick-Up Tubes," *Proceedings of 5th International Conference on Amorphous and Liquid Semiconductors*, Garmischi, 1973.
5. Eiichi Maruyama, Tadaaki Hirai, Tsuotmu Fujita, Naohiro Goto, Yukinao Isozaki, and Keichi Shidara, "Graded-Composition Chalcogenide Glass Photo-Diode," *Proceedings of 6th Conference on Solid State Devices*, 1974; Japan Society of Applied Physics Journal Supplement, Vol. 44, p. 97 1975.
6. J. H. T. Roosmalen, "New Possibilities for the Design of Plumbicon Tubes," p. 64 of *Abstracts of Papers* from International Electron Devices Meeting, sponsored by IEEE, Washington, D.C., Oct. 28–30, 1970.
7. Teruo Ninomiya, Kotaro Wakui, Naohiro Goto, Keichi Shidara, "SATICON and Its Application to Small-Sized Color TV Cameras," *Technical Monograph #25*, March 1976, Nippon Hoso Kyokai (Japanese Broadcasting Corp.).
8. S. Ehata, M. Fukushima, N. Goto, and C. Ogusu, "A New 18-Millimeter SATICON H8397A," Proceedings of International Television Symposium and Technical Exhibition, Montreux, 1977.

RCA ElectroOptics and Devices

Camera Tube
Application Note
AN-5042

# Vistacon Update

by R. G. Neuhauser
Camera Tube
Application Engineering

This Note describes the principles of operation of RCA 30-millimeter Vistacon camera tubes and compares the performance of these devices with both the Vidicon and other lead-oxide camera tubes. It also points out special features of the RCA 4591 and 4592 conventional types and 4593 and 4594 extended-red types of Vistacons and outlines the advantages of the extended-red Vistacons. In addition, the installation and set-up procedures required for optimum performance of Vistacons in TV cameras are explained, and performance considerations that are important to maximum camera-tube life and maintenance of picture quality are discussed. Possible failure modes are then considered, and performance data are evaluated.

### Principles of Operation

The RCA Vistacon, which is a direct replacement for the Plumbicon* and the Leddicon¢ lead-oxide camera tubes, is a photoconductive type of camera tube similar to the Vidicon. It employs the same basic type of scanning and focusing systems and electron gun as used in the Vidicon. The beam of the Vistacon is deflected and focused and the video signal is developed at the target in exactly the same manner as in the magnetic Vidicon. In general, the basic control operations perform the same functions and the set-up and operating procedures are similar to those for the Vidicon.

The Vistacon and Vidicon, however, differ significantly in the performance of the photoconductor and in the mechanisms by which the photoconductor generates a signal current. In the Vidicon, the photoconductor may be considered a variable resistor shunted by a capacitor. Incident light changes the resistance of the photoconductor and thereby causes a variation in the charge on the capacitor. The scanning beam in the Vidicon interrogates the changes in the charge pattern to develop the output signal. This simple analogy, however, does not fully explain the performance of the lead-oxide barrier-layer type of photoconductor used in the Vistacon.

Fig. 1 shows a cross-sectional view of the Vistacon faceplate and the photoconductor. The inside of the faceplate is coated with a transparent irridescent coating (TIC) layer which exhibits n-type electronic conductivity. The bulk of the photoconductor has an intrinsic (i) type of conductivity in which the electrons and hole carriers have similar mobility. A p-type layer, which allows a predominance of hole carriers, is formed on the scanned side of the photoconductor layer. The barrier depletion layers formed between the n- and the i-type materials and between the i- and the p-type materials prevent unwanted electrons from the beam and unwanted holes from the TIC surface from entering the photoconductor. As a result, the photoconductor has an extremely low dark current (less than 1 nanoampere for conventional Vistacons and slightly higher for Vistacons having extended-red response).

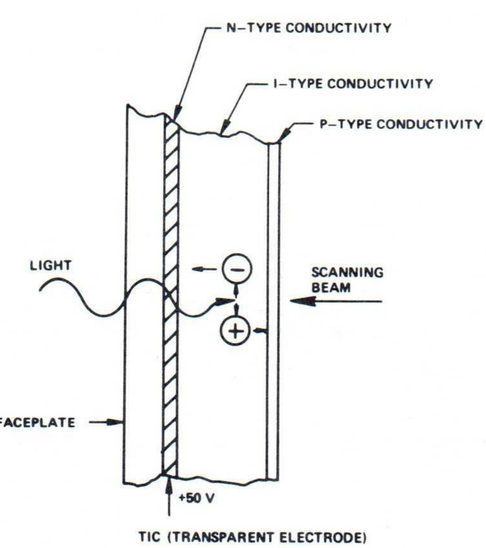



*Fig. 1–Cross-sectional view of Vistacon faceplate and photoconductor illustrating generation of output signal.*

*Plumbicon is a registered trademark of N. V. Philips of Holland.

¢Leddicon is a trade name of English Electric Valve (EEV) of England.



Printed in USA/10-75

*Supersedes AN-4814 dated 1-72*

When light is absorbed in the bulk of the photoconductor (in the i region), both electrons and holes are generated. A target voltage of 45 to 50 volts applied across the photoconductor is sufficient to attract both the electrons and the hole carriers to their respective destinations before trapping or recombination can take place. Because the electrons and holes are swept out very rapidly, Vistacons have low lag. Once the carriers are swept out, no additional carriers can enter the photoconductor because of the barriers. The photoconductivity process therefore, ceases until more light is applied to generate additional charge carriers.

The photoconductive layer of the Vistacon is considerably thicker than that of a Vidicon. The Vistacon photoconductor, however, is less porous, and the lead-oxide is more transparent. The 30-millimeter (1.2-inch) diameter Vistacons utilize a larger scan than conventional Vidicons which have a diameter of 25 millimeters (1-inch). The total capacitance, therefore, is somewhat higher for the Vistacon. The photoconductive layer in the Vistacon must be thicker so that it can absorb enough light to be adequately sensitive. Use of this thicker photoconductive layer results in less capacitance per unit area and, thereby, tends to negate the increased capacitance that results from the larger tube diameter. Consequently, the lag caused by the capacitance of the photoconductor is maintained at a low value.

The thickness of the photoconductive layer tends to limit the resolution of a Vistacon camera tube. Blue light, which is absorbed very strongly near the TIC coating of the tube, does not have much opportunity to scatter through the photoconductor. Therefore, the resolution for blue light is considerably better than the resolution for red light which scatters freely throughout the standard photoconductor. Accordingly, the photoconductor of the Vistacon limits the resolution of the tube. In the Vidicon, the beam limits the resolution of the tube. The scanning beam does have some influence on the resolution of the Vistacon, but the major limitation is the photoconductor.

### Current-Voltage Characteristics

The current-voltage curves of a Vistacon, shown in Fig. 2, are important characteristics that help explain many of the operating characteristics of this type of camera tube. The curves for red and blue light give the signal output as a function of target voltage with constant illumination. The dark-current curve is measured with no illumination. The curves produced with red and blue light rise rapidly at low target voltages and begin to flatten out, i.e., to saturate, near 40 volts. In the saturation region, nearly all the carriers are pulled out of the photoconductor before they are trapped or recombined with other carriers of opposite sign.

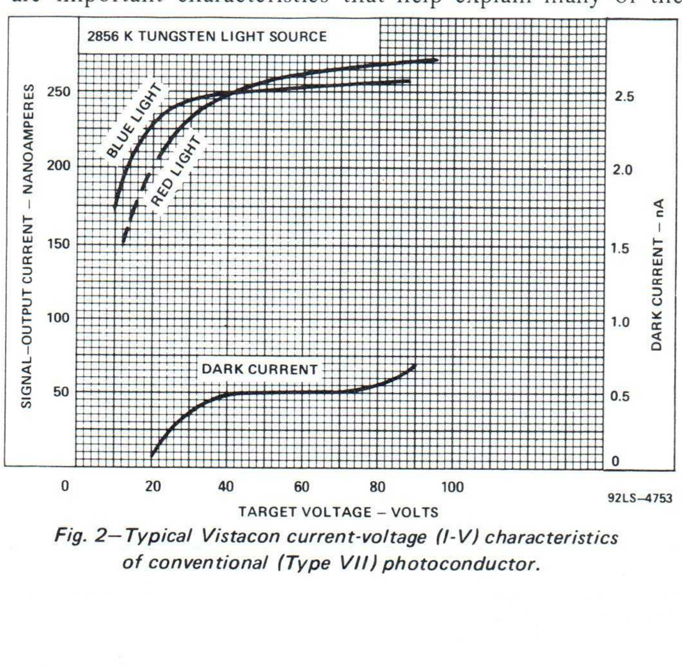



*Fig. 2–Typical Vistacon current-voltage (I-V) characteristics of conventional (Type VII) photoconductor.*

Lack of a fairly well saturated characteristic near the 40-to-50-volt operating point can adversely affect Vistacon performance. Lack of sensitivity may result because some of the carriers which are generated are not recovered as signal current. In addition, these carriers may be trapped and released at other times and thereby increase the lag of the tube. Tests show that if the photoconductor is not saturated at the operating target voltage, image burn-in problems may occur, particularly for specular highlights. The saturation characteristics are generally different for red and blue light. Blue-light saturation tends to occur more readily than the red-light saturation because most of the carriers produced by blue light are generated near the TIC layer and the electrons are pulled rapidly into the n-type layer of the TIC coating; the holes have to travel through the entire thickness of the photoconductor.

Since most of the electrons released by blue light are swept out rapidly, there is little possibility of holes recombining with free electrons, and the hole carriers are not lost in their transit to the opposite side of the photoconductor. Red light is absorbed uniformly throughout the photoconductor; therefore, both free electrons and holes produced by red light are present throughout most of the photoconductor. As a result, they can recombine and fail to produce signal current. Higher voltages have to be applied to the photoconductor to sweep out the carriers before they can recombine. Signal output current, therefore, does not saturate as readily for red light as for blue light; as a result, burn-in of highlights is more prevalent when a tube is exposed to such light. These characteristics change slightly during the life of the tube, and saturation is reached at lower target voltages with time. The performance characteristics of Vistacon camera tubes, particularly the red sensitivity and resistance to burn-in, tend to improve as the tube ages and the electron traps become minimized.

The current-voltage characteristic curve shows that dark current rises to about 0.5 nanoampere at very low voltages and then saturates. The increase in dark current at higher voltages indicates a start in the breakdown of the barriers. The tube should be operated at voltages well below the level at which the breakdown occurs. Unlike the Vidicon, the target voltage control is not a sensitivity control for the Vistacon. When the tube is operated in the saturated region, as it should be, there will be very little change in signal output with small changes in target voltage. Accordingly, a well-saturated Vistacon has a fixed sensitivity that is nearly independent of the target voltage.

### Lag

Lag in the Vistacon is primarily caused by the capacitance of the target and the resistance of the scanning beam. As signal levels are reduced, the effective beam resistance increases, and lag becomes greater.

**Spectral Response**

The spectral response of a conventional Vistacon is determined by the optical characteristics of the lead oxide. The type of lead oxide used in RCA Vistacons absorbs blue light very readily. This type of lead oxide converts almost all photons of blue light into charge-carrier pairs and is one of the most efficient photoconductors for blue light. Red light is absorbed less strongly, and very little light is absorbed at wavelengths longer than 650 nanometers. The spectral response, therefore, drops off rapidly in the red region and decreases to nearly zero at 650 nanometers. Visible light between 650 and 770 nanometers (the cut-off of human vision) is not detected by the standard Vistacon (Type VI ) photoconductor which is used in the RCA 4591 and 4592 Vistacons.

The spectral response of extended-red Vistacons is widened, by altering the optical and electrical characteristics of the photoconductor, so that it extends to wavelengths beyond 700 nanometers. As a result, light of these longer wavelengths is absorbed, and the red sensitivity of the tube is improved. This type of photoconductor, (Type VIII), is used in the RCA 4593 and 4594 Vistacons. An infrared blocking filter is also incorporated into the 4594 Vistacon to eliminate unwanted infrared radiation. The addition of this filter causes the spectral response to be modified. The 4594 tube has a long-wave cutoff of about 700 nanometers, while that of the 4593 tube is beyond 800 nanometers.

Fig. 3 shows typical spectral response characteristics of Type VI and Type VIII photoconductors and of the Type VIII photoconductor as modified by the infrared blocking filter.

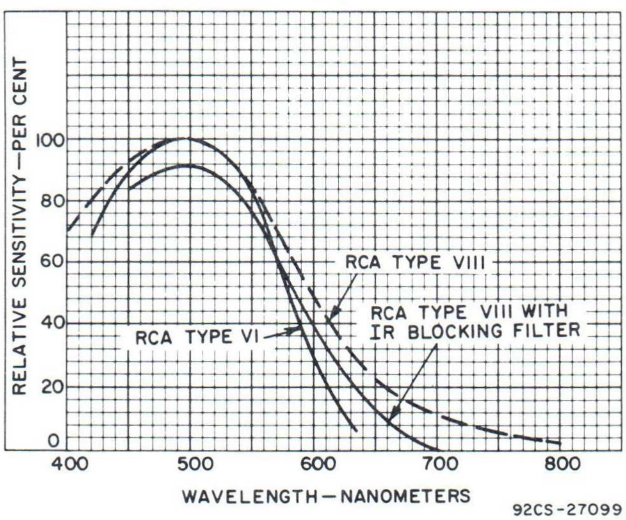



*Fig. 3—Typical spectral response of photoconductors used in RCA Vistacons.*

**Extended-Red Vistacons**

The Type VIII photoconductor used in extended-red Vistacons is very similar to the conventional lead-oxide photoconductor before it is processed. This photoconductor is sensitized by a dopant to form a crystal surface layer that absorbs red light and has a sufficiently low band gap to allow electrons and hole carriers to be released by the lower-energy red photons. Because red light is strongly absorbed, it is less likely to be scattered through the photo layer and thereby reduce resolution. This surface is noticeably darker in color than the conventional lead-oxide photoconductor.

Vistacons that employ the extended-red photoconductor provide much better resolution and contrast in the red and green channels than Vistacons that use the undoped conventional lead-oxide layer. When extended-red Vistacons are used in the green or luminance channels, resolution or depth of modulation is increased considerably, but there is an increased tendency for image retention of specular highlights and other residual images. The tendency toward increased image retention results because the doping agent produces some impurity centers that may trap the charge carriers for a period of time.

The extended-red (Type VIII) photoconductor has some sensitivity in the infrared portion of the spectrum. This infrared response is unwanted in color cameras. The RCA 4594, which uses the Type VIII photoconductor, is designed for use in television cameras that are not provided with adequate infrared blocking filters in the color optical channels. This Vistacon has a multi-layer interference-type infrared blocking filter on the front surface of the anti-halation faceplate button. The RCA type 4593 is designed for use in cameras that **do** have proper infrared blocking filters in the camera optical system, and the blocking filter, therefore, is not incorporated into this tube.

**Anti-Halation Feature**

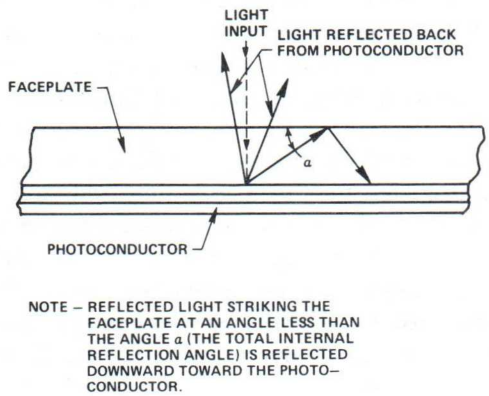
A glass button is cemented to the front of the faceplate of Vistacon camera tubes. This glass button reduces the spurious signal that results when light is reflected from the photoconductor and then reflected back to the photoconductor from the front surface of the faceplate. This problem, referred to as halation, is not significant in the Vidicon because its dark photoconductor absorbs most of the light.

The light tan-colored photoconductor used in conventional Vistacons reflects a considerable amount of red and yellow light, and a portion of this light is reflected back to the photoconductor from the front surface of the faceplate, as shown in Fig. 4. Because the glass button is cemented to the faceplate with a material that has the same index of refraction as the faceplate, any light reflected from the photoconductor is reflected back only from the front surface of the button. The thickness of the button is chosen so that most of this totally internally reflected light strikes the black painted walls of the button where it is absorbed. Because the reflected light does not reach the faceplate again, a higher contrast picture results, and spurious light signals surrounding a highlight are reduced.

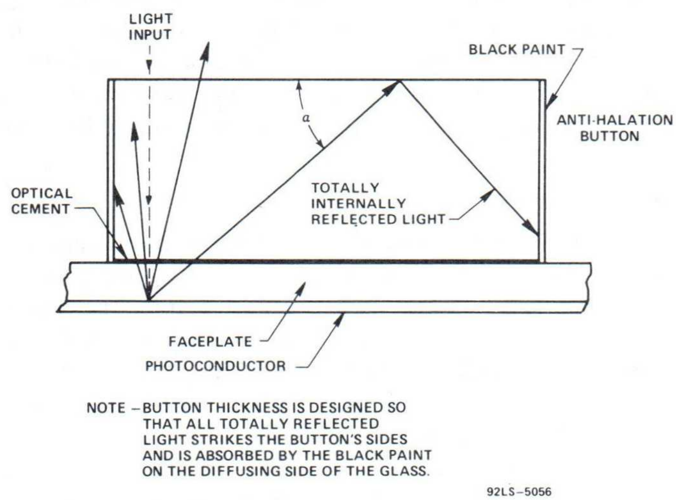
**Comparison with Other Lead-Oxide Camera Tubes**

As mentioned previously, the RCA Vistacons are intended as a direct replacement for Plumbicon and Leddicon tubes. There are, however, some physical differences in these tubes.

**Physical**—The RCA Vistacon is made of 7056 glass, which is similar to that used in other RCA camera tubes. The base pins of the Vistacon are made of Kovar. The Plumbicon and Leddicon tubes employ tungsten base pins and a Pyrex envelope. A significant advantage of the Vistacon is that the Kovar pins are extremely tough and if accidentally bent they can usually be straightened without breaking or damaging the tube. Tungsten pins, on the other hand, are extremely fragile and easily broken, thus making the tube unuseable. The electron gun of the Vistacon is identical to that used in RCA's high-performance Vidicons. The front-end structure of the tube,




*(a) Light paths without anti-halation button*




*(b) Light paths with anti-halation button*

*Fig. 4– Vidicon faceplate and anti-halation button.*

which includes a collimating lens and a mesh assembly, is also different from the collimating lens of the Plumbicon and Leddicon. This design, as used in the 4592, 4593, and 4594 in which the mesh is separate from the wall electrode, provides an improvement in the electron optics and reduces some of the electron optic aberrations present in other lead-oxide tubes. In particular, resolution uniformity is better, and the picture is maintained square and accurate out to the corners. These characteristics produce excellent registration from tube-to-tube.

One feature that may be noted in the Vistacon is that the opening for mesh at the front of the tube is not circular. This opening has a semi-rectangular shape and is constructed to reduce microphonics. This construction feature can be noted only when the tube is over-scanned. In operation, the key pin should be positioned so that it is approximately at 9 o'clock with the white line on the base located vertically exactly at 12 o'clock when viewed from the rear and in a plane parallel to the horizontal scan. With this positioning, the horizontal scan is parallel to the straight portions of the mesh mask.

**Electrical**–The RCA Vistacons are designed to replace any 30-millimeter Plumbicon and Leddicon lead-oxide camera tubes in existing color-television cameras with no required changes in voltage ranges. The RCA 4591 Vistacon has a 100-milliampere heater-current oxide-type cathode, and the 4592, 4593, and 4594 Vistacons have a 300-milliampere heater-current dispenser-type cathode having exceptionally long life.

**Photoconductor Performance**–Not only is the performance of the photoconductor used in the Vistacon and the Plumbicon practically identical, but the range of performance characteristics also is very similar. The lag characteristics, spectral response characteristics, sensitivity, resolution, image burn-in resistance, and dark-current characteristics are nearly identical.

### Installation

It should be emphasized that no changes are necessary in the camera, either mechanical or electrical, to install the RCA Vistacon as a replacement for the Plumbicon and Leddicon. For those cameras in which the yokes must be removed for the insertion of replacement tubes, the proper rotational orientation can be readily made. It is a good idea to clean the faceplate of the tube before it is inserted in the yoke. Cleaning action should be gentle to minimize the possibility of removing the black paint from the slight chamfer on the front of the anti-halation button. If paint is removed from this chamfer, a white ring of refracted light shows up having a diameter about 2/3 the picture width. When the tubes are inserted in the camera, they should be fastened by the clamp on the yoke assembly. It may be necessary to tighten the locking nut at the back of the yoke very firmly in some cameras to assure that the tube is firmly clamped because the diameter of the typical Vistacon is slightly smaller than that of the typical Plumbicon.

### Set-Up Techniques

After the tubes are inserted and the camera is turned on, a quick check should be made to ascertain whether any spots that may be present in the picture can be rotated to an unobjectionable location or rotated out of the picture completely by a slight turning of the tube within the yoke. This adjustment should be made before the tube is operated for any appreciable time or before registration operations are performed. Although it is not necessary to orient the tube in the yoke so that the horizontal portion of the mesh mask is exactly parallel to the horizontal scan, some caution on the rotation of the Vistacon in the yoke is advisable. If the tubes are rotated too much to move a spot to an inconspicuous point, the two side-rod connectors between the mesh and the base pin may pick up unwanted transients from the deflection yoke and interfere with proper clamping operations in the camera amplifiers, or the rotation angle may introduce an undesirable mesh beat or moiré pattern in the picture. In addition, rotation of the tube so that the scanned area is close to the horizontal straight portion of the mesh mask will result in poor corner registration.

When the tubes are first placed in the camera, the target voltage control should be advanced to the maximum value; in most cases, 45 to 50 volts. Any subsequent target voltage adjustments, for any reason, will be to decrease the target voltage.

The maximum recommended image size of the photoconductor, measured diagonally, is 0.840 inch. The portion of the photoconductor that can be seen during over-scan operation is 0.900 inch. Accordingly, the recommended size of the scanned area is approximately 6 per cent less in both horizontal and vertical dimensions than the total viewable light-sensitive area. Camera set up for the proper scanned area is usually accomplished by estimating the 6 per cent difference between the total area and the finally utilized scanned area.

The set-up of Vistacons in a color camera is very similar to the system used for Vidicon tubes although the sequence of adjustments is different. After the camera is turned on, a rough alignment should be made. The desired signal levels are then achieved by controlling the iris of the lens and the video amplifier gain controls and **not** by adjusting the target voltage controls. It is fairly easy to establish the proper signal levels in the RCA TK44A camera by means of step gain controls for the calibrated amplifiers. The red signal level control is set at 105 for the standard red tube and to 210 for the extended-red tube. The blue control is set at 150, and the green control is set at 425 for typical operation. The signal levels that correspond to these control settings represent the normal signal currents of a Vistacon in these cameras. These signal levels and signal ratios are also typical of most three-tube color cameras. If the signal levels are lower or higher, problems may be encountered. If the signal levels are significantly less than 100 nanoamperes, lag will be rather high. If the signal levels are raised by a factor of 2 to 1, the green signal level will then be 600 nanoamperes, and the beam-setting necessary for operation under these conditions may be high enough to cause poor resolution.

Once the proper signal levels have been established, the beam control should be set. This adjustment is important because there is no limiting action in the Vistacon. The Vistacon has a linear transfer characteristic and if light levels of 2 to 1 above the normal highlights are encountered, the signal level will be 2 to 1 above the normal highlight signal level. The usual procedure is to set up the camera so that the beams can handle highlights at least 2 to 1 above the normal maximum signal level. This set-up is done by increasing the lens opening one stop, or until the signal on the waveform oscilloscope (before gamma correction) has been doubled beyond the desired signal levels. The beam should be set precisely at this time to just discharge the signal from each of the tubes. Highlights up to 2 to 1 above the normal highlight value are nearly unavoidable in any scene. If the beam does not discharge the highlights adequately there will be a "bleeding out" or "blooming action" around these undischarged areas. The video amplifier can be set to clip the amplitude of the signal just above the normal signal level; but if this undischarged highlight moves, it will produce an undischarged trail that can be very objectionable. If the beam current is set too high, however, the lag will become worse and the high peak signal level may overload the amplifiers.

This adjustment procedure for the beam will not handle specular highlight reflections, which can be several orders of magnitude higher than a normal scene highlight. If the beams are adjusted to handle exactly the same amount of signal overload, the specular highlights will tend to be white, rather than a particular color, and, therefore, will be less conspicuous. Although there is no complete answer to the problem of specular highlight reflections in these cameras, adjustment of the beam to handle identical overload signal levels in each channel will minimize the annoyance when specular highlights are encountered.

Final alignment of the Vistacon is performed in the same manner as for a Vidicon, and the images are registered in a straightforward manner. It is important that the alignment be done after the beams are set to the proper value because different alignment conditions are usually required for different values of beam current. Failure to make the alignment adjustments after the proper beam settings are achieved affects the ability to register the three tubes.

The signal uniformity match of the three tubes is dependent primarily upon the characteristics of the tubes and cannot be altered by camera readjustments. The blue signal level produced by the Vistacon is extremely flat and uniform. The red and green signal levels are generally a few per cent higher in the center than at the corners of the raster. Do not try to change signal uniformity by misaligning the tube because this practice will destroy registration and produce practically no change in the signal shading characteristics.

### Performance and Operation

**Image Burn-In**—Vistacons are resistant to image burn-in for normal scene lighting. Tubes that have been idle for a period of time have a tendency to develop image burn-in, but after the tube has been operated for a short time this characteristic should disappear completely. Minimization of this characteristic can be accelerated by exposing the camera to a uniform white area and operating it at maximum signal level for several hours or more.

Specular-highlight burn-in is a second problem that may be encountered in lead-oxide camera tubes. This type of burn-in is usually more noticeable in new tubes, but becomes negligible after several hundred hours of operation as the tubes develop a more highly saturated characteristic. This "burn-in" occurs primarily in the red and green channels, and is almost negligible in the blue channel. If a specular highlight has "burned-in", it can be erased almost completely and almost instantly by exposing the camera to a white scene and cutting the beam current off for several seconds. This erasure is easily done in cameras that have a beam cutoff switch. This switch allows the beam to be restored to its normal value without loss of proper current adjustment. A method of erasure for cameras without a beam cutoff switch is to focus the camera on a flat white scene and open the iris sufficiently wide so that the entire photoconductor cannot be discharged. The burned-in image will disappear when the light is reduced.

**Lag**—Lag (or the smearing of a moving object) of the Vistacon is extremely low when the tube is properly operated. Two factors tend to cause lag in Vistacons. (1) Lag is inherent in the storage mode of operation of the tube, which unavoidably shows all the motion of the image between successive scans of each field. This effect cannot be reduced except by strobing the scene illumination or by equipping the camera with a synchronous, short-duty-cycle shutter that chops the light for each field. (2) The capacitance of the target and the effective resistance of the scanning beam also affects lag. Lag produced by this factor can be controlled by proper operation.

Three operating conditions which can cause an increase in lag are: (1) operating with low signal currents, (2) misalignment of the scanning beam, and (3) operation with excessive beam current.

Lag can be decreased by operating the tubes with scene backgrounds that are light rather than dark and by light-biasing the tubes. Cameras designed to operate at the lower light levels and, therefore, lower signal levels are generally equipped to provide 5 to 10 nanoamperes of artificial dark current. In such cameras, a uniform bias light is applied on the tubes to reduce and equalize the visible effects of lag in each channel in order to compensate for the different signal levels of each tube.

**Microphonics**–Basic design features are incorporated into the design of the Vistacon to virtually eliminate microphonic problems. Microphonics were deemed more of a problem in lead-oxide camera tubes than in the Vidicon for several reasons. First, the signal current in the red and blue channels of the color camera is lower than the signal current normally used in most Vidicon cameras. Consequently, microphonic signal coupled into the target is proportionally higher with respect to the signal level. Second, the tubes are operated at high focus electrode voltages to maintain good resolution. Microphonic signals increase in direct proportion to this voltage. RCA Vistacons incorporate a specially designed mesh-damper assembly which effectively eliminates microphonics as a problem. This improvement is particularly important in four-tube cameras because the video signal level from the chroma channels in these cameras is normally very low.

**Operation at Low Target Voltages**–Some operators of cameras using lead-oxide tubes prefer to operate the tubes with the target voltage as low as possible. This practice is followed to prolong the tube life, to better handle high-contrast outdoor scenes, and to reduce the prominence of spots. However, during the early hours of tube life, low-voltage operation will result in highlight burn-in. The tendency for this burn-in will disappear after several hundred hours of operation; it is recommended, therefore, that the target voltage not be lowered until this period has passed. The lower limit of target voltage is established by an increase in burn-in tendencies, increased lag, and a noticeable reduction of signal output. There is no reason that the Vistacon should not be operated at low target voltage if these factors are considered.

### Possible Failure Modes

Lead-oxide camera tubes experience four major types of failure modes: (1) spots that may develop, (2) dark-current breakdown, (3) "slumping" in blue light, and (4) failure of the thermionic cathode. In the subsequent paragraphs these failure modes are discussed and remedies and preventive measures are described.

**Spots**–The types of spots that develop in lead-oxide tubes are described as white spots, "3-D" spots, "twinklers", and mesh spots. The white spots are high-contrast spots which are seen both with illumination on the tube and in the dark. "3-D" spots (which have a three-dimensional appearance) have a black core surrounded by a white halo. This type of spot disappears in the absence of illumination. "Twinklers" are usually white with no black core and seem to scintillate. These spots do not persist in the dark although they may twinkle for a short period of time after light is removed. Mesh spots are formed because of defects of contamination on the mesh and usually have a fairly low contrast. A mesh spot can usually be identified if it moves with respect to the picture when the alignment controls are varied.

Most of the spots in the photoconductor have been found to originate from peculiar cone-shaped growths in the layer that are formed during the photoconductor deposition. Only about one out of every five growths show up as a spot. Unfortunately, spots are not a constant factor; some spots tend to come and go during tube operation. It is not possible, therefore, to be entirely certain that a tube will never develop spots.

White spots are the most objectionable. They show up in the color picture regardless of the color channel in which they occur. Fairly small high-contrast white spots can be very objectionable in any channel. The "twinkler" type spots are ephemeral; they come and go and usually disappear after a period of operation and age-in. "3-D" spots also come and go, but to a lesser extent than white spots and "twinklers". "3-D" spots, although they may be seen in the blue and red channels of a color camera, are usually invisible in the color picture unless their contrast is extremely high and their size extremely large. "3-D" spots in the green or luminance channel are usually very visible and are unacceptable. Mesh spots usually increase in contrast with higher beam current.

No permanent cure for spots is available although the effects from several types can be minimized. The twinkling white type of spot and the 3-D spots can sometimes be reduced in contrast or made to disappear entirely by reducing the target voltage slightly. This expedient is an acceptable one unless the sensitivity of the tube drops drastically or an increase in burn-in is noted when the tube is operated at the reduced target voltages. As spots occur during tube life, reducing the target voltage is usually acceptable because the tubes become more saturated and have greater resistance to burn-in.

**Dark-Current Breakdown**–Dark-current breakdown is the term applied to the extremely high dark current which results when the barrier layer of the photoconductor breaks down. Breakdown usually starts around the periphery of the scanned area and eventually moves into the scanned area, particularly in the corners of the picture where it produces an objectionable flare. It seems to be a rare but typical failure mode of lead-oxide tubes and there is no cure for it. Recent processing improvements at RCA have nearly eliminated this failure condition.

**Blue Slump**–Blue slump is noted first when a tube begins to develop a negatively burned-in pattern from a specular highlight and lag begins to increase. If a tube begins to slump, it is first noticed in the blue channel of the camera or when a tube is exposed to blue light. As the problem becomes worse, the slump in sensitivity becomes noticeable in the picture. Sensitivity tends to slump first in the central part of the picture. When a tube exhibits this characteristic, its red sensitivity usually increases. In the worst stages of the blue slump, the blue signal will be fairly high when the camera lens is first opened but will drop rapidly to a lower equilibrium level in the center of the picture.

Once sensitivity is lost because of blue slump it cannot be recovered. However, if the target voltage is less than 45 volts, increasing the target voltage may eliminate the slump for a period of time. Another method of extending the life of the tube is to exchange it with the tube used in the red channel of the camera. This expedient is acceptable because red sensitivity increases as the blue slump develops.

This slumping characteristic can sometimes be noted in the green or the red channel; in this case, the tube has a "spongy" characteristic. When the lens is opened after being capped for a period of time, the red signal may be slow in building up to its equilibrium value. Again, there is no remedy for this characteristic in the red or blue channel other than to raise the target voltage to the maximum 50-volt value.

**Cathode Failure**–When the thermionic cathode in the tube fails or slumps, there is insufficient beam to handle the desired signal levels. However, the dispenser-type cathode used in most RCA Vistacons makes cathode failure a rarity provided the filament is not subjected to voltages outside of the rating of 6.3 volts ± 5%.

**Poor Registration**–Registration problems are occasionally caused by a wrinkled mesh or by distortions of the gun mount. If registration problems are encountered, the tube should be checked to see if it is correctly aligned while using the proper operating beam current. The tube orientation should also be checked to assure that the scan is essentially parallel to the horizontal straight portions of the mesh damper mask. After these adjustments, a registration check should be made again before the tube is rejected for poor registration ability.

### Operating Techniques to Extend Tube Life

During standby and other idle periods when pictures are not required from the camera, the lens should be capped and the Vistacon beam cut off. Life data suggests that continuous operation of the camera, rather than shutting down during idle periods, will prolong the effective life of both the Vistacons and the camera itself.

New tubes should be placed in operation as soon as practical after receipt; in no case should they be stored for more than two months before their first use. After a period of operation of about 1000 hours, the Vistacons can be stored for longer periods of time with little change in performance. Spare Vistacons, however, should not be stored for more than four months before being operated again.

Operation of the tubes at temperatures higher than room temperature will produce greater lag and will probably also reduce tube life. Spare Vistacons should be stored at room temperature (25°C) or below.

The tubes should be operated with no more than twice the amount of beam current necessary to handle normal scene highlights. Prolonged exposure to specular highlights should be avoided.

### Performance Measurements (Preshipment Quality Checks)

Vistacons are tested for many performance factors and ratings before they are shipped. They are checked first in a test set in which the characteristics are measured. In addition, prior to shipment, each tube is checked twice in the RCA-TK44A color camera. First, the Vistacon tube is checked to make sure that it is suitable for the color channel for which it has been selected. The second and final check is made just before the tubes are shipped. If the tubes are to be in a matched set, the set is checked for satisfactory operation in the TK44A camera. When the matched tubes are put in the TK44A camera, the final check is made for registration ability, signal uniformity match, visibility of spots in the color picture, image and highlight burn-in, appropriate signal level, and microphonic characteristics. RCA Vistacons are rejected at this point if any blemishes are present in the color picture with the camera adjusted for optimum setting for aperture and gamma correction.

Experience in the camera tube business has proven that test data and tube performance measured in one manufacturer's test equipment does not necessarily coincide with the test data and performance measured on the same tubes in another manufacturer's test equipment. The important factors are not whether the data are identical but whether the tubes are comparable in performance. It is not claimed that all measurements made on the Vistacons produce data identical to the performance characteristics quoted for Plumbicons and Leddicons. However, it can be stated with confidence that the performance characteristics of both tubes are essentially identical despite any differences in measurement techniques or equipment.

The amplitude response data specified on the Vistacon data sheets are obtained with the RCA P200 slant-line burst pattern. This test pattern and test method produce a true amplitude response characteristic for the television camera tube because it eliminates abnormalities and variations in the frequency response of the video amplifier system.

# Saticon tubes: growing importance in color video cameras

**By R. G. Neuhauser,**

Image Device Application Engineering, RCA Electro Optics and Devices

The Saticon™ is a vidicon-type camera tube with a Selenium-Arsenic-Tellurium photoconductor. The tube was developed specifically for small high performance color television cameras, but has proven useful for many other television-camera applications. The photoconductor represents an improvement in resolution, stability and reduction of optical flare over the presently used lead oxide photoconductors. The Saticon employs a new gun structure specifically designed to produce improved registration and registration stability in color cameras and to reduce the lag of the tube.

It is capturing an increasing portion of the tube sockets for color television cameras. It has already captured more than half the market for new electronic journalism type color cameras and new telecine color cameras, and a substantial number of additional users are converting existing cameras to Saticons to take advantage of its high performance characteristics and longer life.

There is a normal reluctance on the part of camera manufacturers to swing to a new technology away from a long accepted standard such as the role that lead oxide photoconductor tubes have played in the last decade or more. And there is also a reluctance on the part of users to live through the inevitable growing pains that a new product encounters during its introduction. Fortunately, these growing pains for the Saticon tubes have been minimal and relatively insignificant and very amenable to a swift correction.

The decision by RCA to utilize Saticon tubes in the cameras using 18mm diameter tubes for electronic journalism (EJ) was based on detailed laboratory performance and life tests of the tubes themselves. It was further based upon rigorous side-by-side tests of identical cameras equipped with BC4908 Saticon tubes and with lead oxide tubes, all of the precautions of blind test, color monitor interchange and skilled critical observers being employed. The predicted advantages of Saticon resolution (lack of flare, equivalent or better lag, and signal and background uniformity) were evident. The concern that different characteristics of handling specular highlights, spectral sensitivity and other secondary problems might produce a fatal flaw was also dispelled by these rigorous tests. The tests showed that nothing was lost and significant improvements in picture quality were obtained. This, coupled with the good photoconductor stability and the protected long life (now borne out by field experience), has resulted in the swing towards Saticon tubes in EJ cameras.

In telecine cameras, the use of high contrast film produces lag problems with vidicon tubes. The 25mm BC4909 Saticon tube produces great improvements in lag with cameras that are equipped to provide individually controlled bias light and 0.4 gamma correction or more. In this field, the number of new cameras being sold with Saticon tubes started almost immediately at 40%. Conversion of existing cameras also is accelerating.

### The photoconductor

The Saticon is essentially a conventional type vidicon with a Selenium-Arsenic-Tellurium photoconductor. Hence the Saticon name. Selenium, the oldest known photoconductor, was discovered in 1873 and has been used in a host of light-sensitive devices, including photographic exposure meters and xerographic copying-machine plates.

The first photoconductive vidicons made by RCA employed selenium. The high sensitivity, low dark current, and low lag were distinctly advantageous features. The disadvantages were that the tubes suffered from lack of red sensitivity and short life, and the glassy amorphous selenium layer tended to crystallize, even at room temperature, to produce conductive white spots. Unless some method of cooling the tube was employed, this latter characteristic definitely limited tube life. Later development work showed that adding arsenic greatly reduced the tendency for selenium to crystallize. It also was established that adding tellurium would increase the red sensitivity through the entire visible spectrum, and the concept of developing a selenium photoconductor in a heterojunction configuration was explored.

Subsequently, the research laboratory of NHK, the Japanese Broadcasting Corporation, took up the search for a way of making a satisfactory selenium-based photoconductor. After some intiial success at NHK, the Central Research Laboratory of Hitachi began to collaborate with NHK in the development of a practical photoconductor and associated camera tube, intending to produce a tube specifically for color-television cameras. The result of this collaboration was a tube they called the Saticon.

### Developmental objectives

Any new camera tube must show improved or at least equivalent performance in resolution, lag and sensitivity when compared to tubes in use. Beyond these are a number of other characteristics, uniquely

Reprinted with permission from the April, 1979 issue of BROADCAST ENGINEERING.

necessary for a color camera, that also must be maintained or improved. These are registration ability, registration stability, spectral response, light dispersion from the photo-layer, signal uniformity, low dark current, small size and predictable light-transfer characteristics. Several additional factors necessary for practicality and economic viability are long life, freedom from blemishes, resistance to image burns, usefulness over a wide temperature range, and reproducibility in manufacture.

### Photoconductor development

In order to intelligently develop a satisfactory photoconductor using selenium, tellurium and arsenic, it was first necessary to develop an understanding of the electronic structure of the photoconductive materials. It was determined that when the p-type selenium is deposited on the typical transparent signal electrode consisting of tin oxide which has n-type conductivity (Figure 1), a reversed-biased junction prevents excess holes from being injected into the photoconductor and contributes to the desired low dark current. On the opposite side of the photoconductor, the natural p-type conductivity of the layer traps electrons in all available surface sites during the initial scan of the layer and prevents unwanted electrons from the beam from contributing to dark current. In effect the two barriers produce effect, two heterojuntions, and the photoconductor operates with low dark current. The entire target voltage is impressed reasonably uniformly across its bulk.

The first task in developing the photoconductor was to introduce the stabilizing material into the photolayer without seriously disturbing desirable electrical characteristics. An appropriate arsenic concentration was developed that balances the stability of the selenium at high temperatures without producing unwanted electrical characteristics.

The next problem was to introduce tellurium into the layer to increase the red sensitivity. The solution, shown in Figure 2, was to incorporate the tellurium in the neighborhood of the signal plate to achieve good red sensitivity, but far enough away from it to prevent disruption of the barrier and any recrystallization tendencies. The thickness of this layer and the concentration of tellurium in the tellurium-bearing layer determine the increase in the red sensitivity.

The thickness of the remainder of the photolayer is also critical because the storage capacitance of the layer (and thus lag) will be high if the layer is thin, while too thick a layer requires too high a target voltage. With a given hole-carrier lifetime and mobility in the selenium-arsenic layer, the electric field must be high enough to pull the carriers through before they are lost by recombination.

The target voltage was centered on about 50 V, but even at this voltage there could be problems with secondary emission from the surface of the selenium. This secondary emission would introduce instability in the beam or even cause the scanned area to flip over to the "high-velocity" scan mode if the secondary emission becomes greater than unity at this target voltage. A thin, porous layer of antimony trisulphide is deposited on the scanned area to reduce this tendency for secondary emission.

### Photoconductor performance

The photoconductor that evolved exhibits the following characteristics.

**Sensitivity and spectral response—** In the band of wavelengths approximating the blue channel of a color television camera, the photoconductor has nearly 80% quantum efficiency, which is very close to the sensitivity of a lead-oxide photoconductor (one charge carrier per photon is 100% quantum efficiency). The sensitivity decreases through the visible spectrum, as shown in Figure 3. The color camera green-channel sensitivity of the selenium-

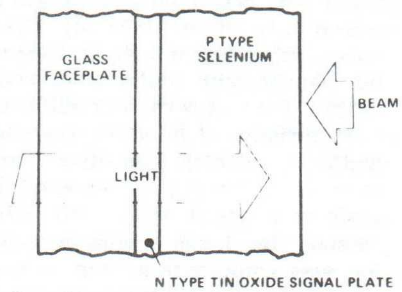



**Figure 1** The cross section schematic of a selenium-type photoconductor shows the electronic configuration of its layers. When a positive voltage is applied to the signal plate, a reversed bias junction is formed between the N & P type materials. The beam scans the right side and charges the target negatively to the cathode voltage.

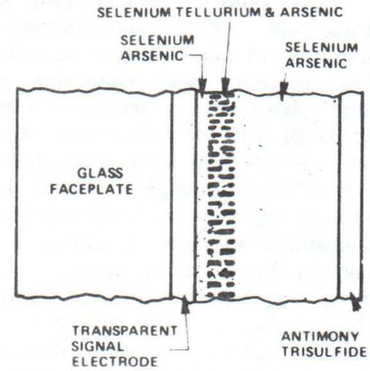



**Figure 2** This cross section of the Saticon tube photoconductor shows where the stabilizing arsenic and red sensitivity enhancing tellurium is introduced into the photoconductor and the location of the secondary emission suppressing antimony trisulphide.

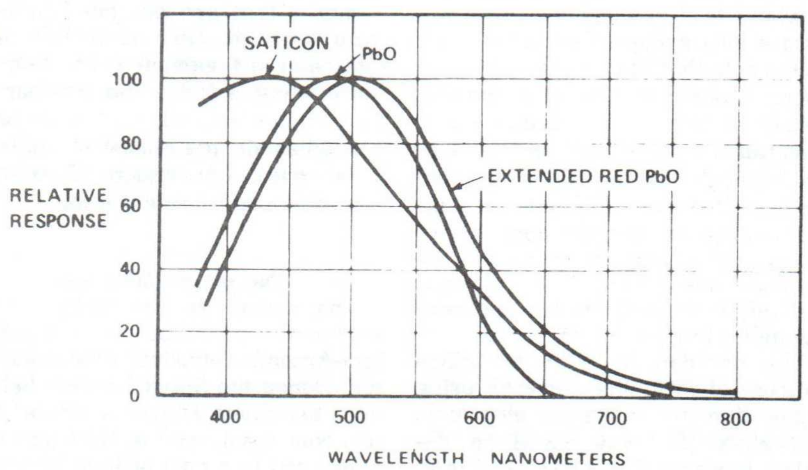



**Figure 3** Spectral sensitivity characteristics differ between the Saticon tube photoconductor and the lead-oxide photoconductor.

arsenic-tellurium photoconductor is 10-15% less than the green-channel sensitivity of a lead-oxide photoconductor.

For live cameras, the tubes are selected for maximum sensitivity in the intended channel, hence R, B and G versions are available as BC4908R, B and G or BC4390R, B and G.

The red sensitivity is higher than a non-doped lead oxide and is in the range of the red sensitivity of highly doped extended red doped lead oxide photoconductors. The sensitivity extends beyond the 700 nm threshold of the visible spectrum to nearly 800 nm. This band of light must be excluded from the optical system by the use of appropriate IR filters in the camera.

The photoconductor, line lead oxide, has a linear light-transfer characteristic (gamma of unity) over the useful range of signal current. In terms of sensitivity, RCA measurements show that Saticon tube sensitivity is greater than that of lead oxide tubes by 18% in the red channel, lower by 11% in the green and a toss-up (within 3%) in the blue channel.

**Dark Current and Reflectivity**—The dark current in the Saticon tube is extremely low, typically 0.5 nA/$cm^2$, testifying to the efficiency of the reverse-biased junctions. Thus the dark current in a 25mm Saticon tube with a useful scanned area of approximately 1 $cm^2$ is 0.5 nA; in an 18mm tube it is 0.25 nA.

The optical absorption and reflectance of the photoconductive layer is of particular importance. Glassy selenium is red in color (i.e., it reflects and transmits red light). The addition of the tellurium reduces this reflectivity and the photoconductor appears nearly black. Measurements of the reflectivity of various typical camera-tube photoconductors as shown in Figure 4.

The consequences of this low reflectivity and high absorption are two-fold. First, very little light is reflected back into the optical system from the photoconductor. With some camera tubes, particularly with red and green light, an appreciable amount of light is reflected back into the optical system where it appears unwanted in portions of the image and deteriorates the contrast and color fidelity of lowlights in the picture.

It is evident that this reflected light can cause a significant deterioration of image quality, especially in view of the fact that more than 1 or 2% reflectivity from the other optical surfaces of a color camera optical system is considered unacceptable. The improvements in this characteristic in Saticon tubes are evident in the signal waveforms produced by a high-contrast image transition, and very little flare compensation is needed in the video processing to compensate for light reflected from the photoconductor and scattered over the remainder of the image.

A second benefit accrues from the light-absorbing characteristics and from the homogeneneous noncrystalline nature of the Saticon photoconductor. Very little light is dispersed through the photoconductor, a quality that contributes to the good resolution characteristics of this photoconductor as compared to lead-oxide tubes where the crystalline photoconductor disperses red and green light through the photoconductive layer and causes loss in resolution. In Saticon tubes, the resolution is independent of the wavelength of light.

**Lag**—In the Saticon tube, trapping effects are negligible, and the photoconductor lag is caused primarily by the storage capacitance of the photolayer in series with the effective beam resistance. The storage capacitance of the Saticon photoconductor, higher than of lead-oxide photoconductive tubes, could make the Saticon tube noncompetitive if means did not exist for reducing the resulting lag.

**Bias-Light**—Means do exist, however, and the first and most effective of them is the use of bias lighting. Bias lighting is the technique of putting uniform light on the photoconductor to bring the zero-signal (picture blacks) charge voltage up to some voltage that is nearly as high as the velocity spread of the electrons in the scanning beam.

This velocity spread, expressed in electron volts, represents an effective beam resistance. It was discovered accidentally in 1967 that this method of operating a tube (and later electrically subtracting this uniform signal or black level pedestal from the signal) is an effective and acceptable method of reducing the lag of a photoconductor when the lag is primarily the result of the storage capacitance of the photolayer. Most television cameras using lead-oxide or Saticon camera tubes now employ this technique. Bias lighting is particularly effective when used with Saticon tubes because the photoconductor sensitivity is uniform. The use of uniform bias lighting does not introduce

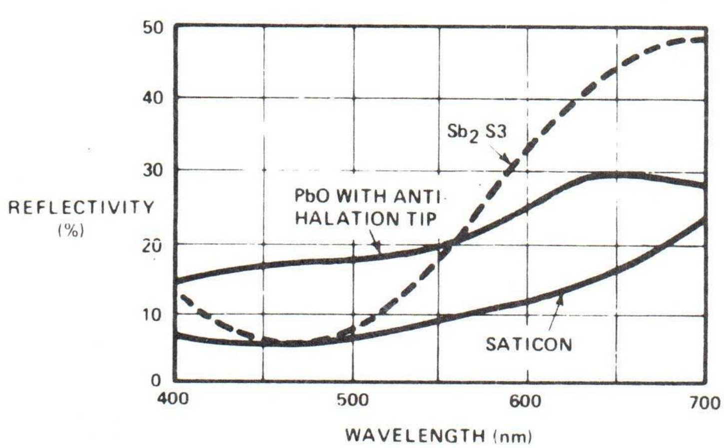



**Figure 4** Relative light reflecting characteristics differ between types of photoconductors as a function of wavelength in the visible spectrum. Low reflectivity means low scattering of light over the image and better color fidelity at low light-levels.

unwanted black-level non-uniformities.

In the newer versions of the Saticon tube, another means is used to further reduce the lag; namely, the low-beam-impedance gun. This gun is discussed in a later section of this article.

**Uniformity and Stability**—The Saticon photoconductor is a glassy impervious layer that can be exposed to air, sealed to a tube by a cold indium pressure-sealing technique, and even pretested for electrical characteristics. Thus, the photoconductor can be made very uniform in thickness since it does not have to be fabricated within the confines of a small bulb, and a large number of faceplates can be processed at one time. Fabricating it with uniform thickness contributes to the Saticon's highly uniform sensitivity over the scanned area. Making many faceplates at a time contributes to similar characteristics from tube to tube and makes possible the selection of only those photoconductors lots that meet the desired performance characteristics.

The glassy layer also produces unusual stability of the electrical characteristics with time. It is impervious to doping by gases generated within the tube, and it is not subject to deterioration or change caused by electrolysis effects when current is drawn through the photoconductor. These effects can and do change the characteristics of the porous photoconductive layers of both lead-oxide and antimony trisulfide tubes as they are used or stored.

The Saticon-tube photolayer is a material that is stable over a wide temperature range. It also maintains, practically constant, all of the important performance characteristics such as lag, resolution, sensitivity, and resistance to image retention over this temperature range. The tube is rated to operate from -30 C (-22 F) to +50 C (122 F) and can operate for short periods of time at temperatures as high as 65 C (149 F). It appears that operation at high temperatures within this range does not shorten the life of the tube, as is the case with lead oxide. To our knowledge, no tubes have been lost because of overheating in cameras.

Another beneficial characteristic of the Saticon photoconductor manufacturing process is the ability to make the tube reasonably defect-free (from spots, etc.). The photoconductor is also relatively resistant to damage that can cause spots after it is manufactured, unlike the relatively fragile antimony trisulfide layer. The occurrence of any defects or spots during operation is indeed rare.

**Resistance to Image Burns**—Camera tubes are often called upon to operate with scene contrasts that are beyond the normal range. When specular highlights (such as the reflections of the sun or spotlight from chrome surfaces) or a direct view of a lightbulb are encountered, the tube should cope with the situation gracefully. It is obvious, however, that the available tubes cannot properly respond to and faithfully reproduce the contrast ratios of more than 10,000 to 1 which typically occur in these situations.

The two effects of specular highlight overloads are a bright comet-tail on a moving specular where the beam cannot handle the signal level for a number of frames and the persistence of an image after normal operation is restored. Saticons are operated at beam currents set to handle 4 times the normal highlight signal current in EJ and studio cameras. This removes most of the comet-tailing and also minimizes the persistent image. The persistent image is higher contrast than it is with a lead oxide tube but it decays more rapidly. It is white instead of the characteristic lead-oxide "red-trail" and is generally accepted as less objectional than the characteristic of the lead-oxide tubes.

Newer cameras are being provided with circuitry that turns the beam on more fully when specular highlights are encountered. This circuitry reduces comet-tail, amplitude and duration of the persistent image caused by specular highlights.

In film pickup where improved signal to noise ratio is desired to offset the film grain, highlight signal currents are typically operated at 500 nA. Long exposures of stationary slides and leaders sometimes produce image burns in these cameras. On some Saticons it is necessary to adjust the target voltage a few volts from the nominal 50 V to correct this problem. If the retained image is positive, the correction is to lower the target a few volts. If negative, the target voltage is raised.

If a camera is uncapped during stand-by (when the camera or the beam is turned off), any stationary image focused on the photoconductor can be "burned in." However, the tube is resistant to image burn-in for very long periods stationary exposure when the beam is turned on and the field is maintained across the photoconductor. Any image burn is temporary and disappears with operational use.

**Gun Design**—The performance of the Saticon tube in a color camera is determined in great part by the design of the electron gun. The foremost innovation in gun design is the low-lag capability incorporated in the gun first used in the 18mm tube. This gun reduces the lag of the tube by reducing the beam resistance.

A word is necessary on the source of the effective beam resistance. In any vidicon tube, the

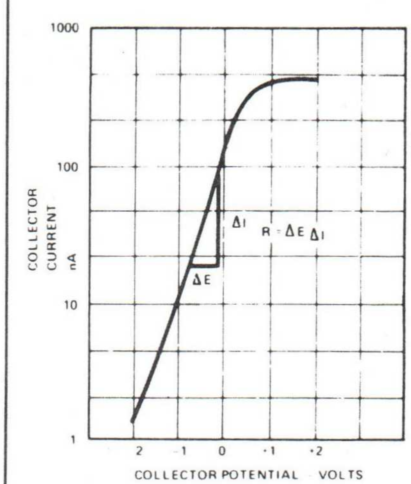



**Figure 5** The plot of beam current collected from a typical vidicon type electron gun as a function of the collector voltage reveals a $\frac{\Delta E}{\Delta I}$ beam resistance which is a major contributor to lag in many camera tubes.

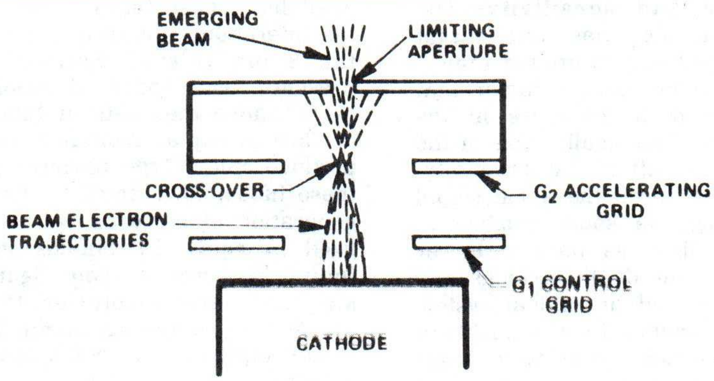



**Figure 6** This schematic cross section view of a portion of a typical electron gun used for vidicon type tubes shows the trajectory of electrons and the high density cross-over region of the beam. Here electron repulsion speeds up some electrons, slows down others and produces an increase in the beams resistance when it scans the target.

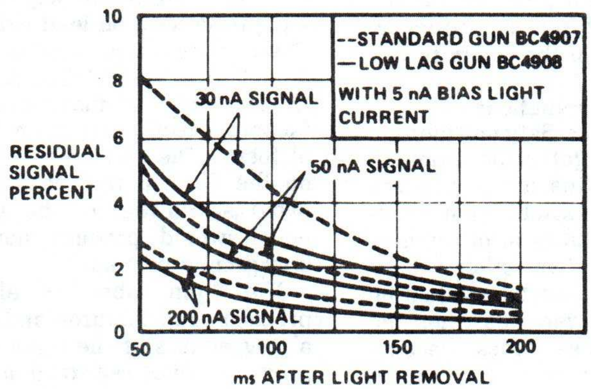



**Figure 7** This plot of residual signal (lag) as a function of time after the light is removed illustrates the improvements in lag obtained by a low lag gun (solid lines) compared to a conventional gun (dotted line). The improvement is greatest at low signal levels where lag is more noticeable.

beam lands on the target with low velocity; in the absence of a positive charge, on the target, the beam slows to zero velocity and actually turns around and does not land on the target. When a positive charge is encountered, electrons land on the charged area until the voltage approaches zero, when the remainder of the electrons are repelled. The electrons that land constitute the signal current.

All of the electrons in the beam do not have the same energy or velocity nor are they all directed perpendicularly toward the target. A typical plot of the current collected from a beam as the collector voltage is increased from a negative to a positive potential is shown in Figure 5. The beam resistance is the reciprocal of the slope of this current-voltage characteristic.

It was discovered that a substantial portion of the effective spread of electron velocities was caused by electron space-charge effects in the gun. In a conventional electron gun, the electrons from the cathode cross the axis at some point in their trajectory, causing a high space-charge density at this point, Figure 6.

The mutual repulsion effects speed up some electrons and slow down others, and impart radial components of velocity to electrons around the periphery of the cross-over. The improved gun in the Saticon tubes was designed to substantially reduce the electron density in the crossover, thus lowering the beam resistance and the lag. The only operational difference between this and a conventional gun is the requirement for a more negative G1 (beam-control-grid) bias voltage (decreased from -100 to -130 V). This gun change has been achieved with no loss of the resolving power of the beam. The curves of Figure 7 illustrate the improvement in lag when this gun is used.

**Use of Bias Lighting**—Figure 8 illustrates the improvement in lag as the bias-lighting signal level is raised on the 18mm Saticon tube. The amount of bias lighting that can be used is limited by the uniformity of the background signal produced, which is determined primarily by the uniformity of the bias lighting. When cameras are operated at very low light levels and low signal levels (approximately 30 nA in the lowest signal channel), the practical bias-current limitation is 5 to 10 nA.

Even more significant in the use of bias lighting is the improvement in signal build-up. In the absence of light, there are yet a few beam electrons that have enough energy to drive a low-dark current photoconductor considerably below zero volts. When light is encountered, the target must be charged up to zero volts before the beam can begin to develop significant signal from the target. Figure 9 illustrates the build-up improvements as a function of bias lighting. It is easily seen that only a modest amount of bias lighting current is needed to improve the build-up characteristics. Poor build-up of signal in a color camera is noted as changes in the color or brightness of the leading edge of an object moving against a dark background.

Contrary to what might be expected, the use of bias lighting does not distort the tonal values of the picture developed by a linear photoconductor. Bias light adds dc signal that can be subtracted out by black-level adjustments in the video processing amplifier.

**Registration**—The need for registration of the three images of a multi-tube color camera is increasing in important as standards of quality are upgraded. Registration has two aspects: good registration over the entire scanned area and maintenance of good registration during operation.

In the Saticon tube, precision construction takes the form of precision tube parts of high resistivity and precision part-mounting techniques that hold the parts in position. Tight tolerances on gun parts allow the gun to fit snugly into the precision bore of the glass bulb. Close spacing of the G4 mesh to the target reduces edge electric-field effects which, when present, tend to pull the corners of the picture outward. The outside diameter of the bulb is held to very tight tolerances, so that the bulb fits snugly into a precision-bore coil and tube gripping fixtures. By *hard mounting* the tube in the coil, relative motion with respect to the coil can be reduced to negligible values, even under wide variations in the temperature and severe shock to the camera structure.

As a result of these mechanical design features, the BC4908 (H8397A) Saticon tube has established an excellent reputation for achieving and maintaining good registration when operated in a camera with a coil system of equal precision and with rigid tube mounting provisions.

**Resolution**—The size of the 18mm tube was determined by the resolution available. The high resistivity of the photoconductor and the lack of optical dispersion produced a target capable of excellent resolution with a small image size (6.6mmx8.8mm): the electron gun was designed to maintain this resolution. The result is a tube with a resolution superior to that of 18mm and 25mm lead-oxide tubes and one that begins to rival the resolution of the 30mm lead-oxide tube.

Figure 10 shows amplitude-response curves for the camera tubes discussed here. Measurements were made in the same piece of test equipment with the same test methods. It should be noted that the amplitude response curves are not as high as those quoted by other tube manufacturers because the measurements were made using the RCA P200 slantline test chart, which eliminates the video-amplifier frequency-response characteristics as a major factor in the measurement. The numbers developed by this test are generally more pessimistic than those developed by other techniques, but they are very reproducible from one test unit to another, and more accurately reflect the relative resolution characteristics of different tubes.

**Tube size and sensitivity**—The 18mm tube also has less target shunt capacitance to ground than a 25mm or 30mm tube, a factor that contributes to lower noise in the video signal. The smaller size of the tube does not affect the sensitivity; the tube produces the same signal output from the same number of lumens of light as does a larger tube. When the depth of focus and angle of view of an optical system using this smaller tube is identical to that of a camera using a larger tube, the illumination (in lumens) of both tubes will be identical; therefore, there is no sacrifice in sensitivity in employing the smaller, lighter-weight tube. An added bonus to using the smaller-size tube is the lower lag that results from the lower storage capacitance of the smaller area of photoconductor, typically 1400pF in the 18mm tube.

### Users' evaluations

Reaction to the Saticon tube in electronic news gathering cameras has been good. One major network has started to switch from lead-oxide to Saticon tubes after running field tests. The two other major networks recently started evaluating Saticon equipped cameras when the BC4390 7-pin base tubes became available. These tubes do not pose the interchangeability obstacle that the 8 pin BC4908 Saticon tube presents. The improved resolution performance that Saticon tubes offer has prompted manufacturers to produce studio type cameras using these tubes. RCA predicts that this generation of cameras will be utilized in many TV studios in the future because of their lightness, simplicity and resolution that is closely approaching 30mm lead-oxide equipped camera performance.

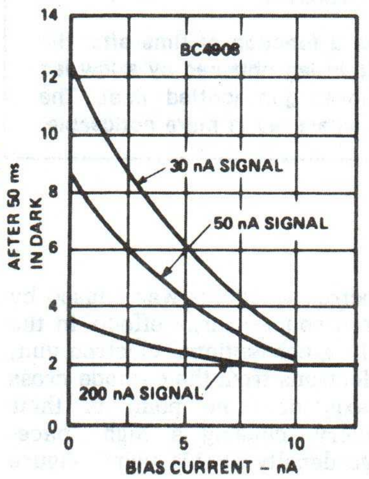
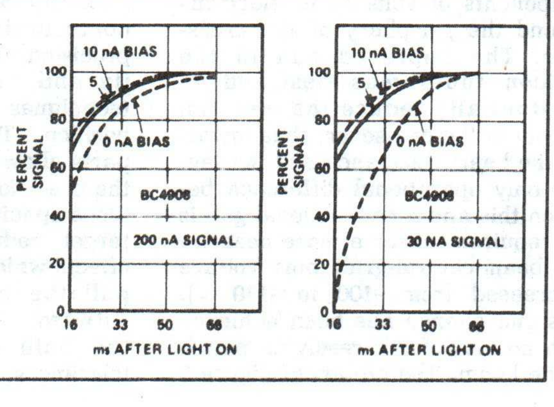



**Figure 8 The lag of a Saticon photoconductor improves rapidly as the bias light is increased.**

**Figure 9 Bias affects the build-up of signal against a dark background for various values of bias light. A very modest amount of bias light produces a large improvement.**




### Conversion to Saticon tubes

Conversion of existing 18mm tube equipped cameras to Saticon tubes is now much easier since the recent introduction of the BC439OR, B and G tubes. These employ the same 7-pin base used on lead oxide tubes. These tubes also employ a glass faceplate extender that is intended to keep any dust that settles on the faceplate well away from the plane of focus. The glass extender button on the Saticon tube is designed to avoid shadowing of the bias light which would produce non-uniform background signals.

The 7-pin tube has all of the precision gun features and structural ruggedness of the 8-pin tube and provides equal registration and stability of registration while in use. In some cameras, additional G1 bias voltage range is necessary to provide proper control of the beam.

The 25mm Saticon tube presently available is the BC4909. When used to replace sulfide vidicons in color telecine cameras, the lower lag, increased sensitivity, and lower light dispersion are quite evident. The BC4909 can be used in any 3-tube telecine camera that uses magnetically focused 25mm vidicons if the amount of bias lighting can individually be adjusted to produce approximately 20 nA of bias signal and the video processing amplifier can correct the signal to a 0.4 gamma (or lower) characteristic. The conversion of a system from vidicons or lead-oxide tubes to Saticon tubes requires that a fixed 50 V be provided for the target and that the system be recalibrated to operate with equal signal currents of 500 nA in each channel and with 15 nA of bias signal current.

### Predictions

The development of the Saticon tube is still in its infancy and more improvements are anticipated in the near future. Lower lag photoconductors are a good probability. The low lag gun will also be provided in the 25mm tube to further reduce lag in telecine cameras. Circuitry is now available for the RCA TK28 to increase the black stretch to pull detail out of high density films where black information is crushed. Improved lag will be desired with this additional black stretch.

Smaller Saticon tubes will allow the design of even smaller E.J. type cameras with no loss in performance. Lower noise in the video signal will also be provided by the use of a low shunt capacitance output from the tube. It is anticipated that a 25mm tube will also be provided that will be a replacement in existing cameras that employ 25mm lead oxide tubes with some minimal camera modifications. The bonus anticipated from this conversion will be a camera that out performs the 30mm lead oxide equipped cameras.

**Credits for Saticon developments**

The present Saticon tube is the result of many decades of work on selenium-type photoconductors and vidicon tubes in many locations. The author claims no more than an involvement in and a familiarity with the various developmental efforts over the past years.

The Saticon-tube photoconductor was developed through the efforts of Teruo Ninomiya, Naohiro Goto and Keichi Shidara of NHK Laboratories, and Eiichi Maruyama and Tadaaki Hirai of Hitachi Central Research Laboratory. Photoconductor process development was the work of Tsutomu Fujita and Yasuhiro Nonaka of Hitachi Electron Tube Division. The precision gun design was the work of Hideyuki Sakai of Hitachi Electron Tube Division and Kyohei Fuduka of Hitachi Consumer Products Research Center.

The original selenium photoconductor and the basic vidicon tube were developed by Albert Rose, Paul Weimer, A. Danforth Cope, Stanley Forgue and Robert Goodrich at RCA's David Sarnoff Research Laboratory in Princton, NJ. The stabilization of the selenium vidicon photoconductor by the addition of arsenic and the enhancement of red response by doping with tellurium, as well as the concept of stabilization by chemical designing of the substrate and effecting mechanical refinements, are the achievements of Joseph Dresner and Frank Shallcross of the same laboratory. □

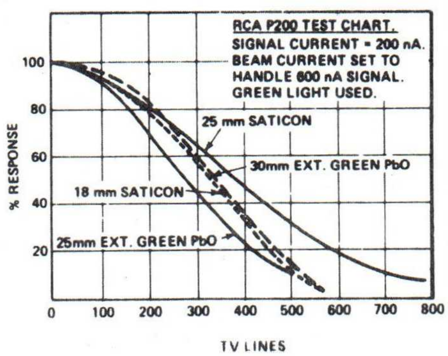



**Figure 10** Comparative resolving characteristics are shown here for camera tubes under typical operating conditions in a color camera. These data show the performance when the beam is focused for best sharpness and balanced resolution in all planes.

STUDIO

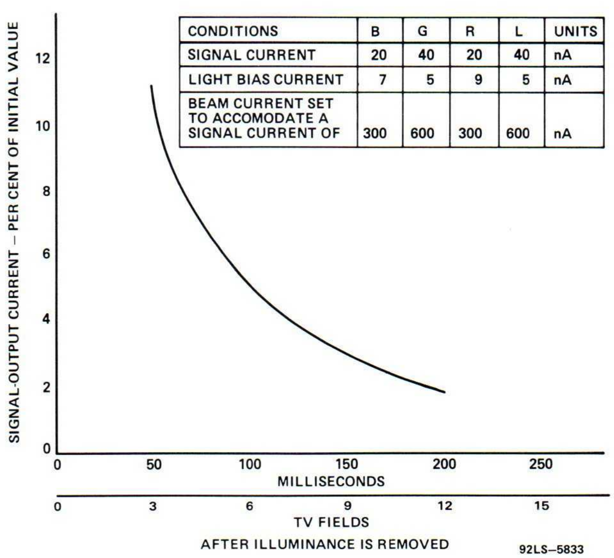
# RCA ELECTRO OPTICS
# New Product Information

## BC4392 Series (BC4392/B, BC4392/G, BC4392/R, BC4392/L)
## BC4393/R (Extended Red Response Type)
## BC4394 Series (BC4394/G, BC4394/R, BC4394/L – Extended Red Response Types With IR Blocking Filters)

### New 30-mm (1.2") Diameter Vistalite™ Camera Tubes with Integral Bias Light.

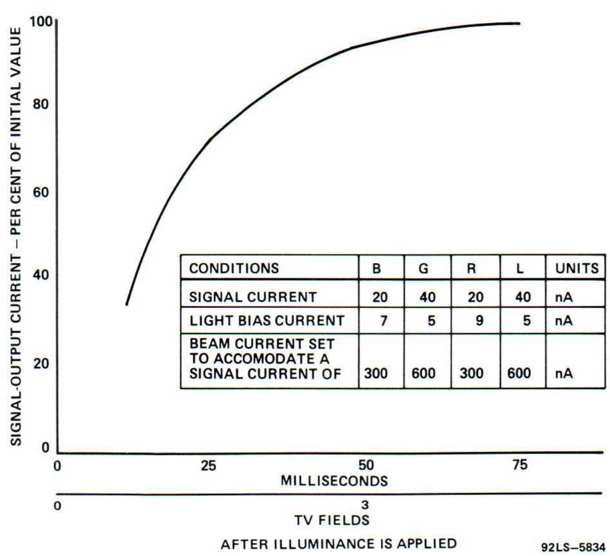
### For Broadcast Cameras – Live Presentations

- Replaces Most 30 mm Diameter Separate Mesh Lead-Oxide Types
- Microphonic Resistant Design
- Square Geometry For Good Registration
- Ductile Metal Base Pins
- Ultra-Uniform Bias Level Background
- Dispenser Type Long Life Cathode
- Color Camera Certified and Tested




| CONDITIONS | B | G | R | L | UNITS |
|---|---|---|---|---|---|
| SIGNAL CURRENT | 20 | 40 | 20 | 40 | nA |
| LIGHT BIAS CURRENT | 7 | 5 | 9 | 5 | nA |
| BEAM CURRENT SET TO ACCOMODATE A SIGNAL CURRENT OF | 300 | 600 | 300 | 600 | nA |

Typical Persistence (Lag) Characteristic




| CONDITIONS | B | G | R | L | UNITS |
|---|---|---|---|---|---|
| SIGNAL CURRENT | 20 | 40 | 20 | 40 | nA |
| LIGHT BIAS CURRENT | 7 | 5 | 9 | 5 | nA |
| BEAM CURRENT SET TO ACCOMODATE A SIGNAL CURRENT OF | 300 | 600 | 300 | 600 | nA |

Typical Build-Up Characteristic

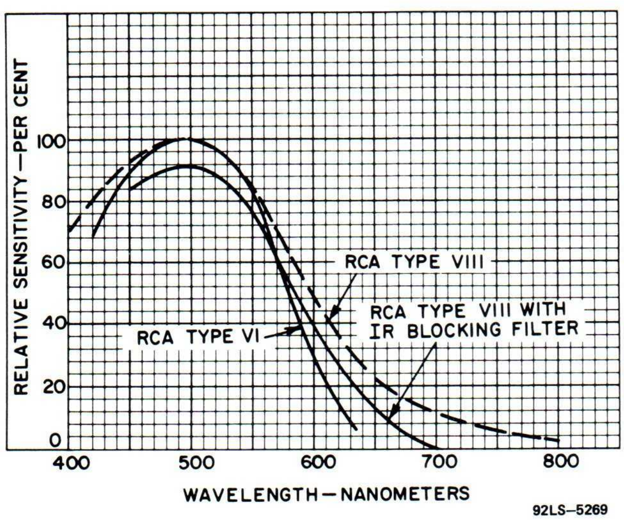
## General

| | |
|---|---|
| Focus and Deflection Method | Magnetic |
| Heater, for Unipotential Cathode: | |
| Voltage (ac or dc) | 6.3 ± 10% V |
| Current at 6.3 V | 0.4 A |
| Spectral Response: | |
| BC4392 Series | RCA Type VI |
| BC4393/R | RCA Type VIII |
| BC4394 Series | RCA Type VIII with integral IR blocking filter |

## Performance Characteristics

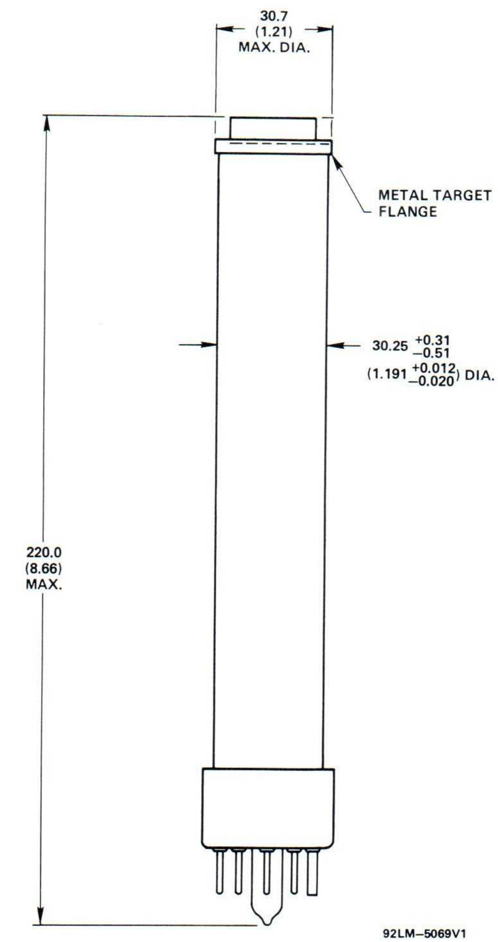
Typical Sensitivity (2856 K tungsten source):

| | | |
|---|---|---|
| BC4392/R | 90 | μA/lm |
| BC4392/G | 155 | μA/lm |
| BC4392/B | 45 | μA/lm |
| BC4392/L | 420 | μA/lm |
| BC4393/R | 130 | μA/lm |
| BC4394/R | 130 | μA/lm |
| BC4394/G | 160 | μA/lm |
| BC4394/L | 480 | μA/lm |



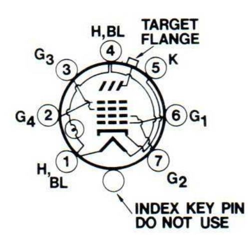

**Typical Spectral Response Characteristics**

> **Warning – Personal Safety Hazards**
>
> **Electrical Shock** – Operating voltages applied to this device present a shock hazard.




Dimensions in millimeters. Dimensions in parentheses are in inches.

**Dimensional Outline**




**Basing Diagram – Bottom View**

For further information or application assistance on this device, contact your RCA Sales Representative or write Camera Tube Marketing, RCA, Lancaster, PA 17604.

# RCA ELECTRO OPTICS
# New Product Information

## BC4395

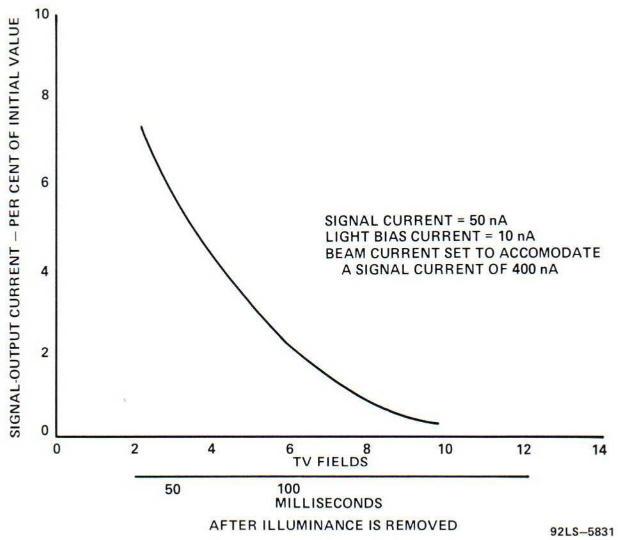
### 25-mm (1") Diameter SATICON* Vidicon for High Performance Studio Color Cameras

**NEW**

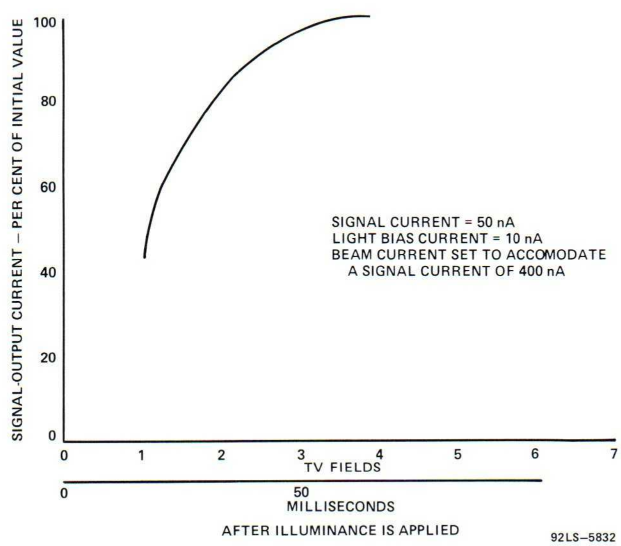
- Low Capacitance, Low Lag Photoconductor
- Low Lag, Low Resistance Electron Gun
- Faceplate Button for Proper Optical Path

*and the Proven SATICON Features:*

- Superior Resolution-Independent of Wavelength
- Low Reflectivity-Low Flare
- Freedom From Blemishes
- Long Life
- Stability
- Precision Construction for Excellent Registration, Signal and Background Uniformity
- No Long Lead-Oxide Tail or Lag
- No Unusual Horizontal Deflection Loading
- High Sensitivity in all Channels
- Unity Gamma
- Low Dark Current




**Typical Persistence (Lag) Characteristic**




**Typical Build-Up Characteristic**

*Used by permission of trademark owner.




Printed in U.S.A./3-79
BC4395

## General Data

Heater, for Unipotential Cathode:

| | | |
|---|---|---|
| Voltage (AC or DC) | 6.3 ± 10% | V |
| Current at 6.3 volts | 0.095 | V |
| Focusing Method | Magnetic | |
| Deflection Method | Magnetic | |
| Operating Position | Any | |

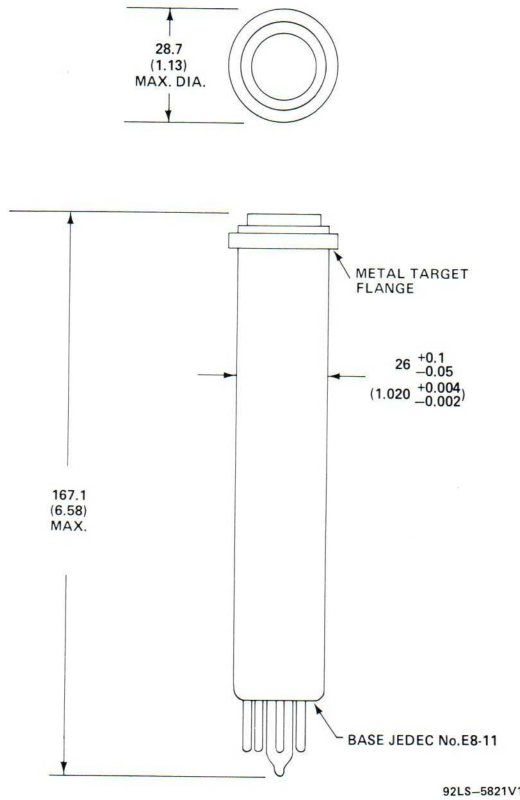
## Absolute-Maximum Ratings

| | Limiting Values | |
|---|---|---|
| Grid-No.4 Voltage ($V_{G4}$) | 1000 | V |
| Grid-No.3 Voltage ($V_{G3}$) | 1000 | V |
| Grid-No.2 Voltage ($V_{G2}$) | 750 | V |
| Grid-No.1 Voltage ($V_{G1}$) | −125 | V |
| Peak Heater to Cathode Voltage | +80 | V |
| Target Voltage | 100 | V |
| Faceplate Temperature | 50 | °C |
| Bias Light Signal | 10 | nA |

## Typical Performance Data

With a scanned area of 12.7 mm x 9.5 mm (0.5" x 0.375"), a faceplate temperature of 25° to 35° C; and a standard CCIR "M", or EIA, TV scanning rate (525 lines, interlaced 2:1, frame time 1/30 second).

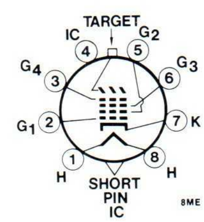
| | | |
|---|---|---|
| Grid-No.4 Voltage | 900 | V |
| Grid-No.3 Voltage | 720 | V |
| Grid-No.2 Voltage | 300 | V |
| Grid-No.1 Voltage for Picture Cutoff | −30 to −100 | V |
| Target Voltage | 75 | V |
| Bias Light Signal | 4 to 10 | nA |
| Amplitude Response to a 400 TV Line Per Picture Height Square-Wave Test Pattern (RCA P200, transparent slant-line burst test chart): | | |
| At center of picture – | | |
| Typical value | 45 | % |
| Sensitivity: | | |
| For 2856 K "white light" | 410 | µA/lm |
| For 2856 K "white light" incident of specified filter – | | |
| Blue (BG12) | 40 | µA/lm |
| Green (VG9) | 135 | µA/lm |
| Red (OG570) | 130 | µA/lm |




Dimensions in millimeters. Dimensions in parentheses are in inches.

**Dimensional Outline**

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Grid No.4
Pin 4: Internal Connection – Do Not Use
Pin 5: Grid No.2
Pin 6: Grid No.3
Pin 7: Cathode
Pin 8: Heater
Flange: Target
Short Index Pin: Internal Connection – Make No Connection




**Basing Diagram, Bottom View**

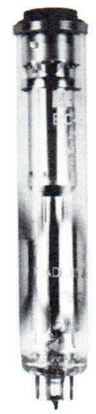
### Warning – Personal Safety Hazards

**Electrical Shock** – Operating voltages applied to this device present a shock hazard.

For further information or application assistance on this device, contact your RCA Sales Representative or write Camera Tube Marketing, RCA, Lancaster, PA 17604.

ENG

# BC4390/B, BC4390/G, BC4390/R



L-964

## 18-mm (2/3") Diameter, SATICON* Vidicons for Compact TV Color Broadcast Cameras

- Typical Amplitude Response at 400 TV Lines –
  35% in low-voltage mode
  40% in high-voltage mode
- Low Dark Current –
  0.3 nA typical at target voltage of 50 volts
- 7 Pin Base –
  provides interchangeability for cameras with lead-oxide vidicons
- Very Low Lag –
  3% maximum for 200 nA signal and 5 nA bias-light current after 50 ms
- Low Reflectivity Selenium Arsenic Tellurium Photoconductor
- Precision Construction for Easier and More Accurate Registration
- Unity Gamma for Predictable Contrast and Colorimetry
- Faceplate Button – keeps dust out of the focal plane

RCA BC4390/B, BC4390/G, and BC4390/R are short, 18-mm (2/3") diameter, magnetic focus and deflection SATICON camera tubes having separate-mesh construction and low-power 0.6 watt heaters. These tubes are designed specifically for use in 3-tube TV color broadcast cameras: the BC4390/B is intended for the blue channel; the BC4390/G, for the green channel; and the BC4390/R, for the red channel.

The photoconductor employed by these vidicons is an amorphous selenium-arsenic-tellurium layer having low reflectivity throughout the visible spectrum. This low reflectivity results in minimal flare in highly illuminated portions of a scene and makes the use of anti-halation buttons and flare compensation circuitry unnecessary.

The spectral response of the SATICON vidicon is expecially suited to color TV pickup. Spectral sensitivity is high in the blue and negligible in the infrared regions of the spectrum.

Resolution of these tubes is excellent; at 400 TV lines, amplitude response is typically 35% with the tube operating in the low-voltage mode and typically 40% in the high-voltage mode. This resolution is maintained at the high beam settings needed to handle highlights within a scene.

The electron gun used in the BC4390 series of vidicons is designed to reduce lag caused by target capacitance and the beam electron-velocity spread to a low value. However, the use of bias light is highly recommended to achieve the least possible lag and the fastest signal build-up.

The combination of small size, excellent resolution, and low lag enhances the use of these SATICON vidicons in either compact studio or remote hand-held TV color cameras.

These SATICON tubes are also recommended for improving the performance of existing cameras employing 2/3" lead-oxide vidicons. Such replacement requires adjustment of the target voltage to 50 volts, and extension of the grid-No. 1 voltage range to – 130 volts. Provisions should also be made to adjust the bias-light current to the recommended value of 6 to 8 nanoamperes.

**General Data:**

Heater, for Unipotential Cathode:

Voltage (AC or DC) . . . . . . . . . . . . . . . . . . . 6.3 + 5% V

Current at 6.3 volts . . . . . . . . . . . . . . . . . . . 0.095 A

Direct Interelectrode Capacitance:

Target to all other electrodes . . . . . . . . . . . . . . . . 3.5 pF

Photoconductive Layer:

Maximum useful size of rectangular image . . . 8.8 mm x 6.6 mm (0.346 in x 0.260 in)

Orientation of quality rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.

Focusing Method . . . . . . . . . . . . . . . . . . . . . . . Magnetic

Deflection Method . . . . . . . . . . . . . . . . . . . . . . . Magnetic

Operating Position . . . . . . . . . . . . . . . . . . . . . . . . Any

*Used by permission of trademark owner.

### Absolute-Maximum Ratings[a]

For scanned area of 8.8 mm x 6.6 mm (0.346" x 0.260")

| | Limiting Values | | |
|---|---|---|---|
| Grid-No.4 Voltage ($V_{G4}$)[b] | $V_{G3}$ to | 750 | V |
| Grid-No.3 Voltage ($V_{G3}$)[b] | | 750 | V |
| Grid-No.2 Voltage ($V_{G2}$) | | 350 | V |
| Grid-No.2 Current[c] | | 1000 | μA |
| Grid-No.1 Voltage ($V_{G1}$) | -300 to | 0 | V |
| Peak Heater to Cathode Voltage | -125 to | 65 | V |
| Target Voltage | | 80 | V |
| Faceplate: | | | |
| Illuminance[d] | | 50 | lm/ft$^2$ |
| | | 540 | lux |
| Temperature[e] | | 50 | °C |

### Typical Operating Values

With the tube operated in an RCA AJ2233 Assembly, or equivalent, a scanned area of 8.8 mm x 6.6 mm (0.346" x 0.260"), a faceplate temperature of 25° to 35°C, and standard CCIR "M", or EIA, TV scanning rate (525 lines, interlaced 2:1, frame time 1/30 second).

| | Low-Voltage Operation | High-Voltage Operation | |
|---|---|---|---|
| Grid-No.4 Voltage[b] | 425 | 700 | V |
| Grid-No.3 Voltage[b] | 290 | 475 | V |
| Grid-No.2 Voltage | 300 | 300 | V |
| Target Voltage[f] | 50 | 50 | V |
| Peak-to-Peak Beam Current[g] | 400 to 800 | 400 to 800 | nA |
| Minimum Peak-to-Peak Blanking Voltage: | | | |
| When applied to grid No.1 | 75 | 75 | V |
| When applied to cathode | 20 | 20 | V |
| Field Strength at Center of Focusing Coil | 56 | 72 | G |
| Peak-to-Peak Deflecting Coil Current: | | | |
| Horizontal | 130 | 167 | mA |
| Vertical | 30 | 38 | mA |
| Field Strength of Adjustable Alignment Coil | 2 | 2 | G |

### Typical Performance Data

For the conditions shown under Typical Operating Values, Low-Voltage Operation.

| | | |
|---|---|---|
| Grid No. 1 Voltage for Picture Cutoff[h] | -80 to -130 | V |
| Average "Gamma" of Transfer Characteristic for Signal Output Between 20 nA and 400 nA | 1.0 | |
| Lag—Per Cent of Initial Value of Signal Output After Illuminance is Removed:[j] | | |
| For 200 nA signal current and 6 nA bias-light current — | | |
| Maximum value after 50 ms | 3 | % |
| Maximum value after 150 ms | 1 | % |
| For 50 nA signal current and 6 nA bias-light current — | | |
| Maximum value after 50 ms | 5 | % |
| Maximum value after 150 ms | 1.5 | % |
| Amplitude Response to a 400 TV Line per Picture Height Square-Wave Test Pattern: | | |
| At center of picture — | | |
| Typical value | 35 | % |
| Sensitivity:[k] | | |
| For 2856 K "white light" | 365 | μA/lm |
| For 2856 K "white light" incident on specified filter — | | |
| Type 4390/B | 42 | μA/lm |
| Type 4390/G | 125 | μA/lm |
| Type 4390/R | 125 | μA/lm |
| Dark Current: | | |
| Typical value | 0.3 | nA |
| Maximum value | 0.5 | nA |
| Geometric Distortion: | | |
| Maximum value | 0.6 | % |
| Shading (Uniformity): | | |
| White level — | | |
| Variation of highlight signal (percent of maximum highlight signal) | | |
| Maximum Value | 15 | % |
| Microphonic Duration:[m] | | |
| Maximum value | 3 | s |

### Average-Sensitivity Operation

| | | |
|---|---|---|
| Faceplate Illuminance (2856 K, highlight) | 1 | lm/ft$^2$ |
| | 10.8 | lux |
| Target Voltage[f] | 50 | V |
| Signal Output Current:[n] | | |
| Minimum value | 150 | nA |
| Typical value | 200 | nA |

---

a In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.

b Grid-No.4 voltage must always be greater than the grid-No.3 voltage. The recommended ratio of grid No.3 to grid No.4 voltage for the specified RCA assembly AJ2233 is 0.68. For other magnetics the criterion for the best ratio is a compromise between that which gives best signal uniformity, best resolution uniformity, and best picture geometry in all areas of the picture. It should be noted that very low G3/G4 ratios can introduce pin-cushion distortion.

c With grid-No.1 voltage equal to 0 volts.

d For uniformly diffused "white light" over the entire tube face. Exposure to specular highlights having an illuminance as high as 21,500 lux (2,000 lm/ft$^2$) for a period of 20 seconds, however, will not damage the tube.

e The tubes may be operated for short periods of time (up to an hour) at temperatures as high as 65°C. Although the tubes should be stored at temperatures of 30°C, or below, storage for about 3 to 5 hours at ambient temperatures of up to 60°C is allowed, and for periods up to one week, storage at 45°C is permitted.

f The target voltage should be set to 50 volts. Operation at a much lower target voltage adversely affects the performance capabilities of the tube while operation at a much higher target voltage reduces tube life. If image retention is noted during operation, the target voltage may have to be adjusted slightly to correct this problem. If the retention is positive, i.e., scene whites produce a light image retention, reduce the target voltage by 2 to 3 volts. If the retention is negative, i.e., scene whites produce a dark image retention, increase the target voltage by 2 to 3 volts. Target voltage is defined as the difference between the voltage applied to the target and the voltage on the cathode during active scanning.

g Grid No.1 is adjusted to provide just enough beam current to handle signal currents four times the normal highlight signal in that channel.

h For no blanking voltage on grid No.1 and for a grid-No.2 voltage of 300 volts.

j Beam current is set to accommodate a signal current of 600 nA.

k The light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2856 K. The sensitivity values are the quotient of the signal current to the unfiltered light flux incident on the filter specified below and, for "white light", the quotient of the signal current to the unfiltered light flux incident on the tube faceplate.

Red filter – Schott, 0G570, 3 mm thick
Green filter – Schott, VG9, 1 mm thick
Blue filter – Schott, BG12, 3 mm thick

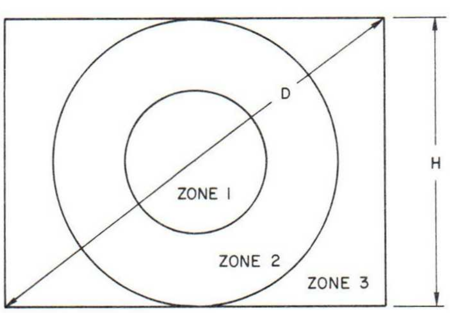
In the U.S.A., Schott filters are available from Fish-Schurman Corporation, 70 Portland Road, New Rochelle, NY 10802.

m For slight shock applied directly to tube.

n Defined as the component of the highlight target current after the dark-current component has been subtracted.

## Warning – Personal Safety Hazards

**Electrical Shock** – Operating voltages applied to this device present a shock hazard.




D – Active Target Diameter
H – Raster Height (4 x 3 Aspect Ratio)
Zone 1 – Diameter = H/2, Area ≈15%
Zone 2 – Diameter = H, Area ≈45%
Zone 3 – Peripheral Area ≈40%

**Figure 1 – Spurious Signal Zones**

### Spurious Signal Test

This test is performed with the tube carefully focused on a uniformly illuminated test pattern which identifies the zones as pictured in **Figure 1**. The tube is operated in accordance with "Typical Operating Values" and illuminance is adjusted to provide a highlight reference signal current of 200 nanoamperes. After completion of the setup adjustments, light is excluded and the picture examined to locate and measure bright spots. Thereafter, reference level illuminance is applied and the picture examined for additional spots and blemishes other than bright spots.

**Blemishes:** Blemishes are defined as either bright spots and/or smudges whose contrast exceeds 10% of the 200 nanoampere reference signal. The size of spots or smudges (diameter, or length plus width divided by two) is measured in terms of the pitch of the raster lines in a 525-line system.

The allowable blemishes are shown in Table I which defines the acceptable distribution by zones and size.

**Table I**

| Blemish Size (Equivalent Scan Lines) | Zone 1 Allowed Spots Total | Zone 1 & 2 Allowed Spots Total | Zone 1, 2 & 3 Allowed Spots Total |
|---|---|---|---|
| Over 4 | 0 | 0 | 0 |
| Over 3 | 0 | 0 | 1 |
| Over 1 | 0 | 1** | 2 |
| 1 or smaller | * | * | * |

*Spots of this size are allowed unless concentration causes a smudged appearance.
**No white spots allowed.
Minimum separation between 2 spots greater than 1 raster line limited to 16 raster lines.

## Operating Considerations

### Beam Current Setting

Proper beam current is important for best highlight handling ability and for lowest lag performance. Beam current should be carefully set in each channel to four times the normal highlight operating signal level in that channel. Measurement should be made at a point in the video amplifier prior to gamma correction and white level clipping. Excessive beam currents will produce excessive lag, whereas inadequate beam current will produce poor handling of highlights.

### Flare Control Setting

The SATICON tube has very little light reflection from the photoconductor; therefore it requires very little flare compensation. When SATICON tubes are used to replace lead-oxide tubes, the video amplifier flare controls must be readjusted to avoid overcompensation and low-light color distortion.

### Standby Operation

The camera must be capped during standy or idle periods (when the camera and/or the camera tube beams are turned off) to avoid a temporary image on the photoconductor.

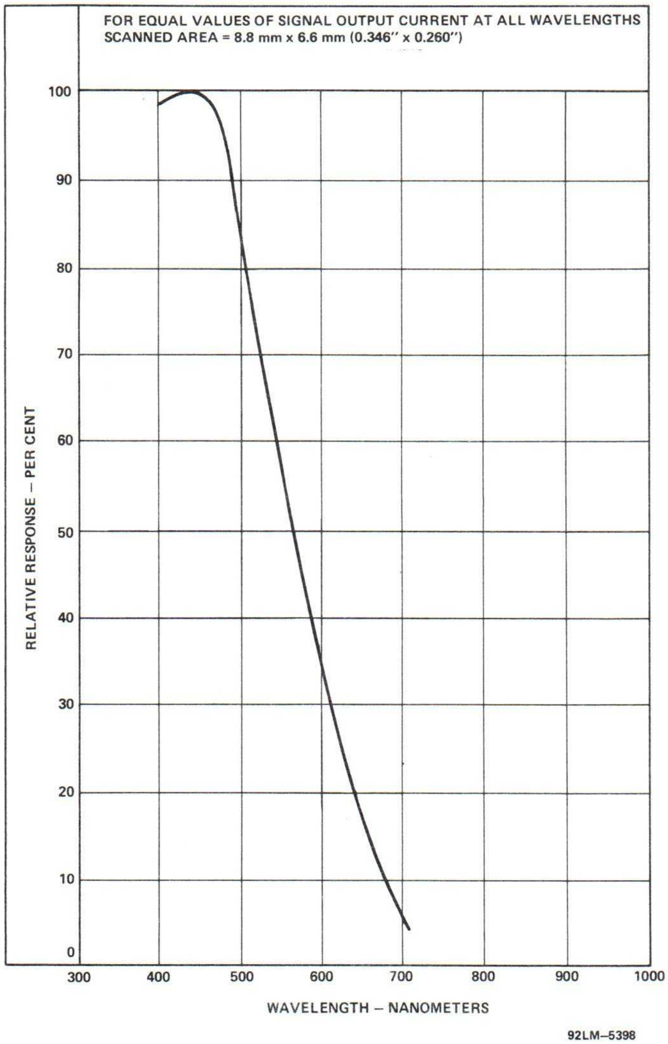



Figure 2 – Typical Spectral Response Characteristic

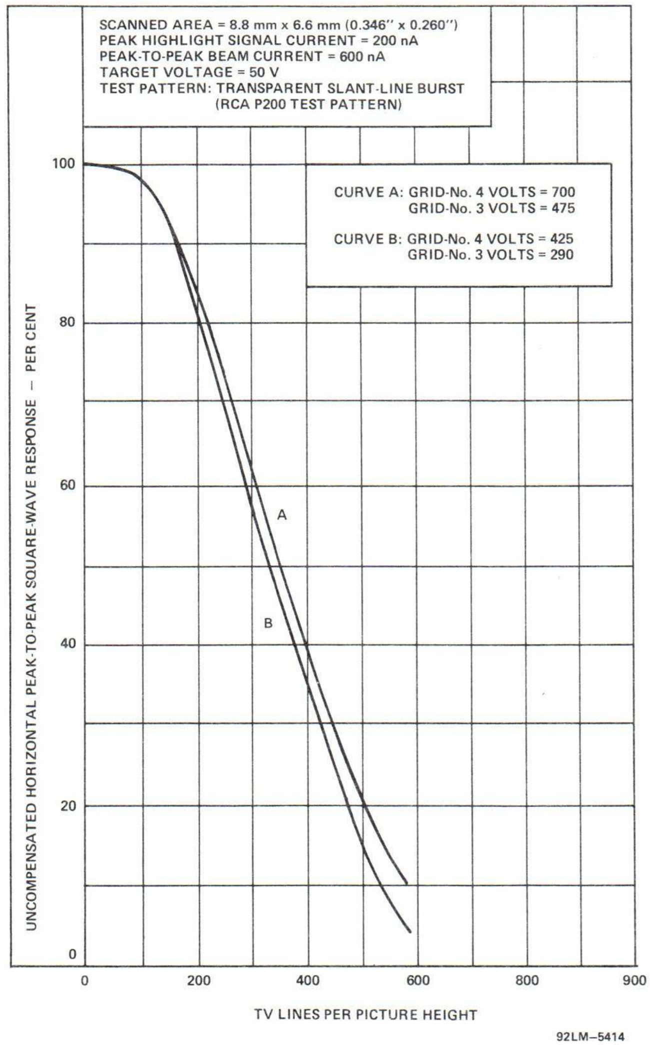



Figure 3 – Horizontal Square-Wave Response

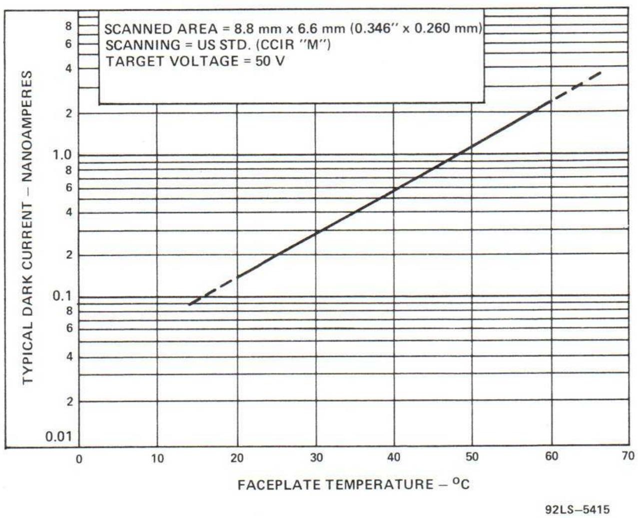



**Figure 4 – Typical Dark Current as a Function of Tube Faceplate Temperature**

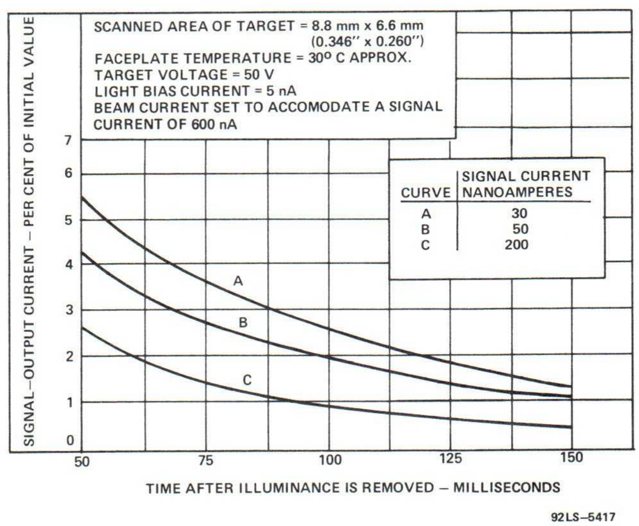



**Figure 6 – Typical Persistence (Lag) Characteristics**

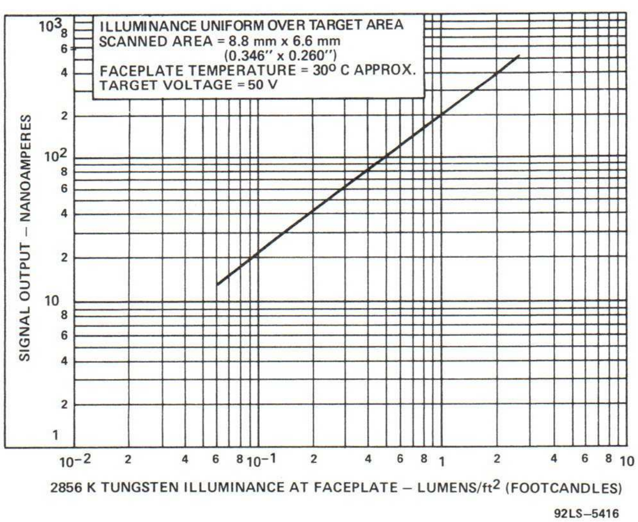



**Figure 5 – Typical Light Transfer Characteristic**

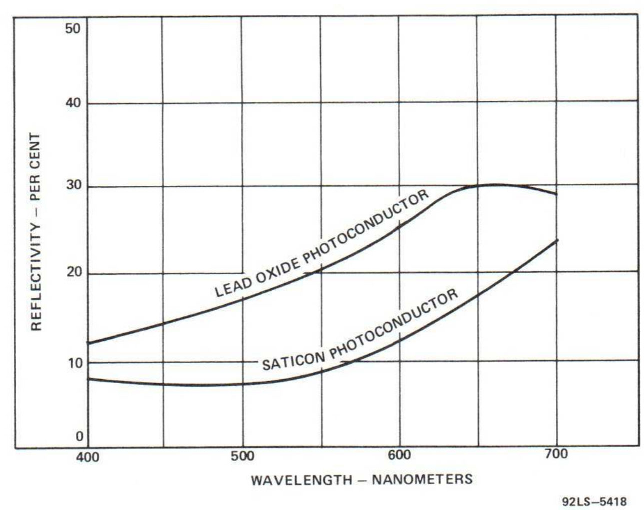
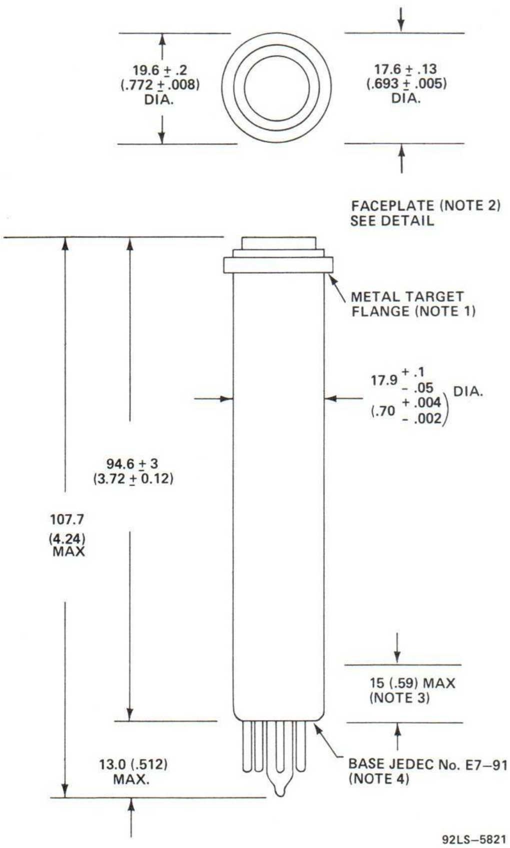



**Figure 7 – Spectral Reflectivity as a Function of Wavelength for SATICON and Lead Oxide Photoconductors**




Dimensions in millimeters. Dimensions in parentheses are in inches.

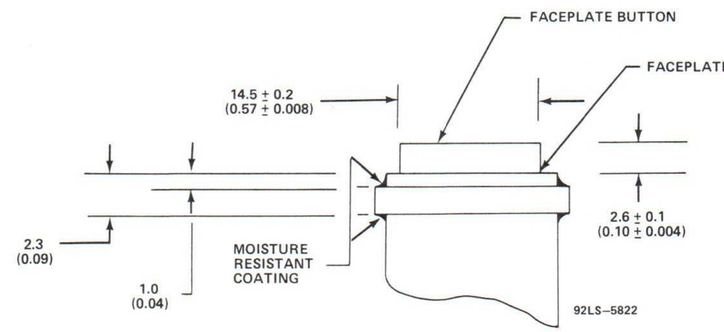
**Note 1** — The target connection is made by a suitable spring contact bearing against the edge of the metal target flange.

**Note 2** — Faceplate thickness is 1.5 mm ± 0.2 mm (0.059″ ± 0.008″). Refractive index of faceplate and faceplate extender is 1.505.

**Note 3** — Within this length, the maximum diameter of the tube is 18mm (0.71″).

**Note 4** — A typical socket for use with this tube is an RCA stock No. 436500 available from: RCA Distributor And Special Products Division, 2000 Clements Bridge Rd., Deptford, NJ 08096, (609) 963-8000.

**Figure 8 — Dimensional Outline**




Dimensions in millimeters. Dimensions in parentheses are in inches.

**Figure 9 — Detail of Faceplate-Target Area**

Pin No.1 — Cathode
Pin No.2 — Grid No.4
Pin No.3 — Heater
Pin No.4 — Heater
Pin No.5 — Grid No.1
Pin No.6 — Grid No.2
Pin No.7 — Grid No.3
Flange — Target

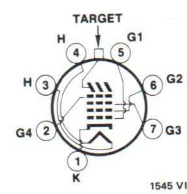



**Figure 10 — Basing Diagram, Bottom View**

# BC4908/B, BC4908/G, BC4908/R

L-784

## 18-mm (2/3") Diameter, SATICON®* Vidicons for Compact TV Color Broadcast Cameras

- **Typical Amplitude Response at 400 TV Lines –**
  **35% in low-voltage mode**
  **40% in high-voltage mode**
- **Low Dark Current –**
  **0.3 nA typical at target voltage of 50 volts**
- **Very Low Lag –**
  **3% maximum for 200 nA signal and 5 nA bias-light current after 50 ms**
- **Low Reflectivity Selenium Arsenic Tellurium Photoconductor**
- **Precision Construction for Easier and More Accurate Registration**
- **Unity Gamma for Predictable Contrast and Colorimetry**

RCA BC4908/B, BC4908/G, and BC4908/R are short, 18-mm (2/3") diameter, magnetic focus and deflection SATICON camera tubes having separate-mesh construction and low-power 0.6 watt heaters. These tubes are designed specifically for use in 3-tube TV color broadcast cameras: the BC4908/B is intended for the blue channel; the BC4908/G, for the green channel; and the BC4908/R, for the red channel.

The photoconductor employed by these vidicons is an amorphous selenium-arsenic-tellurium layer having low reflectivity throughout the visible spectrum. This low reflectivity results in minimal flare in highly illuminated portions of a scene and makes the use of anti-halation buttons and flare compensation circuitry unnecessary.

The spectral response of the SATICON vidicon is especially suited to color TV pickup. Spectral sensitivity is high in the blue and negligible in the infrared regions of the spectrum.

Resolution of these tubes is excellent; at 400 TV lines, amplitude response is typically 35% with the tube operating in the low-voltage mode and typically 40% in the high-voltage mode. This resolution is maintained at the high beam settings needed to handle highlights within a scene.

The electron gun used in the BC4908 series of vidicons is designed to reduce lag caused by target capacitance and the beam electron-velocity spread to a low value. However, the use of bias light is highly recommended to achieve the least possible lag and the fastest signal build-up.

The combination of small size, excellent resolution, and low lag enhances the use of these SATICON vidicons in either compact studio or remote hand-held TV color cameras.

These SATICON tubes are also recommended for improving the performance of existing cameras employing 2/3" lead-oxide vidicons. Such replacement requires replacement of the tube sockets, adjustment of the target voltage to 50 volts, and extension of the grid-No.1 voltage range to −130 volts. Provisions should also be made to adjust the bias-light current to the recommended value of 5 nanoamperes.

### General Data

Heater, for Unipotential Cathode:

| | | |
|---|---|---|
| Voltage (AC or DC) | 6.3 ± 5% | V |
| Current at 6.3 volts | 0.095 | A |

Direct Interelectrode Capacitance:

| | | |
|---|---|---|
| Target to all other electrodes | 3.5 | pF |

Photoconductive Layer:

Maximum useful size of rectangular image . . . 8.8 mm x 6.6 mm (0.346 in x 0.260 in)

Orientation of quality rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.

| | |
|---|---|
| Focusing Method | Magnetic |
| Deflection Method | Magnetic |
| Operating Position | Any |

*Used by permission of trademark owner.

### Maximum and Minimum Ratings, Absolute-Maximum Values[a]

For scanned area of 8.8 mm x 6.6 mm (0.346" x 0.260")

| | Min. | Max. | |
|---|---|---|---|
| Grid-No.4 Voltage ($V_{G4}$)[b] | $V_{G3}$ | 750 | V |
| Grid-No.3 Voltage ($V_{G3}$)[b] | – | 750 | V |
| Grid-No.2 Voltage ($V_{G2}$) | – | 350 | V |
| Grid-No.2 Current[c] | 1000 | – | µA |
| Grid-No.1 Voltage ($V_{G1}$) | –300 | 0 | V |
| Peak Heater to Cathode Voltage | –125 | 65 | V |
| Target Voltage | – | 80 | V |
| Faceplate: | | | |
| Illuminance[d] | – | 50 | lm/ft$^2$ |
| | – | 540 | lux |
| Temperature[e] | – | 50 | °C |

### Typical Operating Values

With the tube operated in an RCA AJ2233 Assembly, or equivalent, a scanned area of 8.8 mm x 6.6 mm (0.346" x 0.260"), a faceplate temperature of 25° to 35° C, and a standard CCIR "M", or EIA, TV scanning rate (525 lines, interlaced 2:1, frame time 1/30 second).

| | Low-Voltage Operation | High-Voltage Operation | |
|---|---|---|---|
| Grid-No.4 Voltage[b] | 425 | 700 | V |
| Grid-No.3 Voltage[b] | 290 | 475 | V |
| Grid-No.2 Voltage | 300 | 300 | V |
| Target Voltage[f] | 50 | 50 | V |
| Peak-to-Peak Beam Current[g] | 600 | 600 | nA |
| Minimum Peak-to-Peak Blanking Voltage: | | | |
| When applied to grid No.1 | 75 | 75 | V |
| When applied to cathode | 20 | 20 | V |
| Field Strength at Center of Focusing Coil | 56 | 72 | G |
| Peak-to-Peak Deflecting Coil Current: | | | |
| Horizontal | 130 | 167 | mA |
| Vertical | 30 | 38 | mA |
| Field Strength of Adjustable Alignment Coil | 2 | 2 | G |

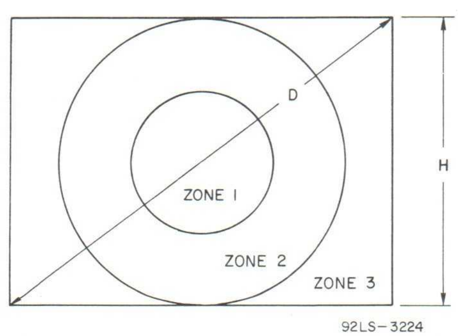
### Typical Performance Data

For the conditions shown under Typical Operating Values, Low-Voltage Operation.

| | | |
|---|---|---|
| Grid No.1 Voltage for Picture Cutoff[h] | –80 to –130 | V |
| Average "Gamma" of Transfer Characteristic for Signal Output Between 20 nA and 400 nA | 1.0 | |
| Lag—Per Cent of Initial Value of Signal Output After Illuminance is Removed:[j] | | |
| For 200 nA signal current and 5 nA bias-light current – | | |
| Maximum value after 50 ms | 3 | % |
| Maximum value after 150 ms | 1 | % |
| For 50 nA signal current and 5 nA bias-light current – | | |
| Maximum value after 50 ms | 5 | % |
| Maximum value after 150 ms | 1.5 | % |
| Amplitude Response to a 400 TV Line per Picture Height Square-Wave Test Pattern: | | |
| At center of picture – | | |
| Typical value | 35 | % |
| Sensitivity:[k] | | |
| For 2856 K "white light" | 365 | µA/lm |
| For 2856 K "white light" incident on specified filter – | | |
| Type 4908/B | 42 | µA/lm |
| Type 4908/G | 125 | µA/lm |
| Type 4908/R | 125 | µA/lm |
| Dark Current: | | |
| Typical value | 0.3 | nA |
| Maximum value | 0.5 | nA |
| Geometric Distortion: | | |
| Maximum value | 0.6 | % |
| Shading (Uniformity): | | |
| White level – | | |
| Variation of highlight signal (per cent of maximum highlight signal) | | |
| Maximum value | 15 | % |
| Microphonic Duration:[m] | | |
| Maximum value | 5 | s |

### Average-Sensitivity Operation

| | | |
|---|---|---|
| Faceplate Illuminance (2856 K, highlight) | 1 | lm/ft$^2$ |
| | 10.8 | lux |
| Target Voltage[f] | 50 | V |
| Signal Output Current:[n] | | |
| Minimum value | 150 | nA |
| Typical value | 200 | nA |




D – Active Target Diameter
H – Raster Height (4 x 3 Aspect Ratio)
Zone 1 – Diameter = H/2, Area ≈ 15%
Zone 2 – Diameter = H, Area ≈ 45%
Zone 3 – Peripheral Area ≈ 40%

**Figure 1 — Spurious Signal Zones**

**Spurious Signal Test**

This test is performed with the tube carefully focused on a uniformly illuminated test pattern which identifies the zones as pictured in **Figure 1**. The tube is operated in accordance with "Typical Operating Values" and illuminance is adjusted to provide a highlight reference signal current of 200 nanoamperes. After completion of the setup adjustments, light is excluded and the picture examined to locate and measure bright spots. Thereafter, reference level illuminance is applied and the picture examined for additional spots and blemishes other than bright spots.

**Blemishes:** Blemishes are defined as either bright spots and/or smudges whose contrast exceeds 10% of the 200 nanoampere reference signal. The size of spots or smudges (diameter, or length plus width divided by two) is measured in terms of the pitch of the raster lines in a 525-line system.

The allowable blemishes are shown in Table I which defines the acceptable distribution by zones and size.

**Table I**

| Blemish Size (Equivalent Scan Lines) | Zone 1 Allowed Spots Total | Zone 1 & 2 Allowed Spots Total | Zone 1, 2 & 3 Allowed Spots Total |
|---|---|---|---|
| Over 4 | 0 | 0 | 0 |
| Over 3 | 0 | 0 | 1 |
| Over 1 | 0 | 1 | 2 |
| 1 or smaller | * | * | * |

*Spots of this size are allowed unless concentration causes a smudged appearance.

Minimum separation between 2 spots greater than 1 raster line is limited to 16 raster lines.

---

a The Maximum Ratings in the tabulated data are established in accordance with the Electronic Industries Association Standard RS-239-A, formulated by the JEDEC Electron Tube Council.

b Grid-No.4 voltage must always be greater than the grid-No.3 voltage. The recommended ratio of grid No.3 to grid No.4 voltage for the specified RCA assembly AJ2233 is 0.68. For other magnetics the criterion for the best ratio is a compromise between that which gives best signal uniformity, best resolution uniformity, and best picture geometry in all areas of the picture. It should be noted that very low G3/G4 ratios can introduce pin-cushion distortion.

c With grid-No.1 voltage equal to 0 volts.

d For uniformly diffused "white light" over the entire tube face. Exposure to specular highlights having an illuminance as high as 21,500 lux (2,000 lm/ft$^2$) for a period of 20 seconds, however, will not damage the tube.

e The tubes may be operated for short periods of time (up to an hour) at temperatures as high as 65° C. Although the tubes should be stored at temperatures of 30° C, or below, storage for about 3 to 5 hours at ambient temperatures of up to 60° C is allowed, and for periods up to one week, storage at 45° C is permitted.

f The target voltage should be set precisely to 50 volts. Operation at lower target voltage adversely affects the performance capabilities of the tube while operation at higher target voltage reduces tube life. Target voltage is defined as the difference between the voltage applied to the target and the voltage on the cathode during active scanning.

g Grid No.1 is adjusted to provide this beam current value.

h For no blanking voltage on grid No.1 and for a grid-No.2 voltage of 300 volts.

j Beam current is set to accomodate a signal current of 600 nA.

k The light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2856 K. The sensitivity values are the quotient of the signal current to the unfiltered light flux incident on the filter specified below and, for "white light", the quotient of the signal current to the unfiltered light flux incident on the tube faceplate.

Red filter — Schott, OG570, 3 mm thick
Green filter — Schott, VG9, 1 mm thick
Blue filter — Schott, BG12, 3 mm thick

In the U.S.A., Schott filters are available from Fish-Schurman Corporation, 70 Portland Road, New Rochelle, NY 10802.

m For slight shock applied directly to tube.

n Defined as the component of the highlight target current after the dark-current component has been subtracted.

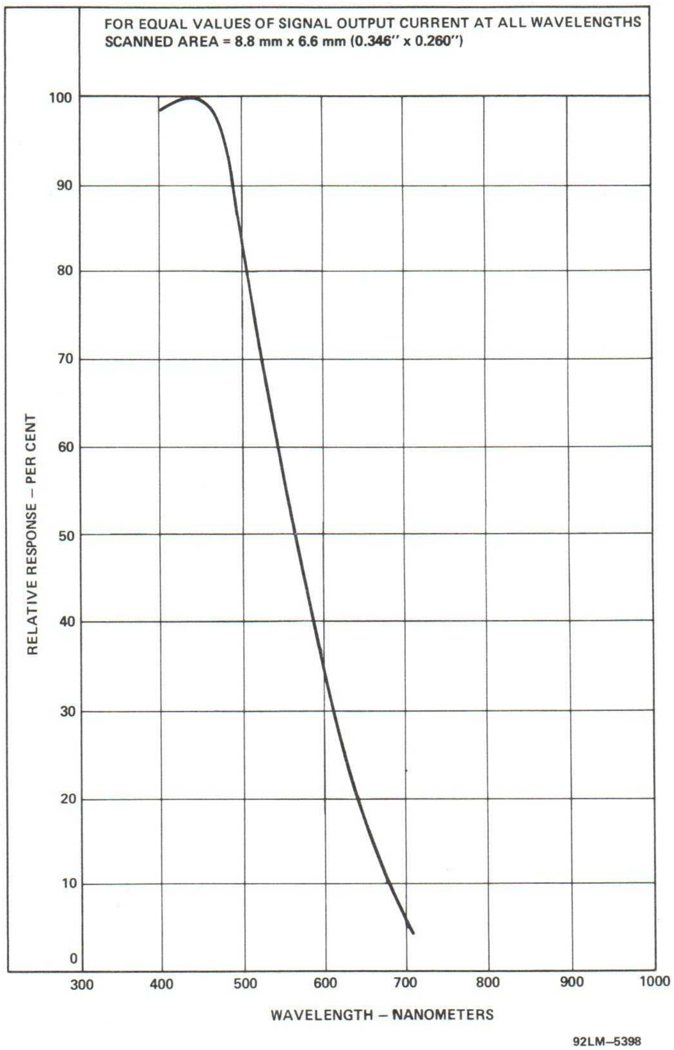



Figure 2 — Typical Spectral Response Characteristic

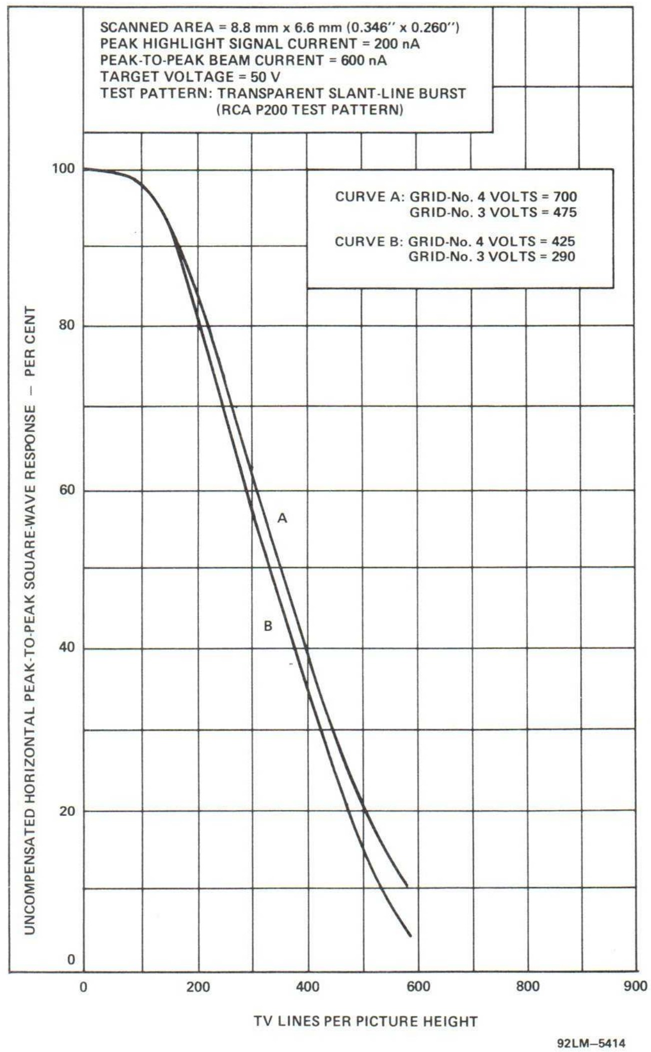



Figure 3 — Horizontal Square-Wave Response

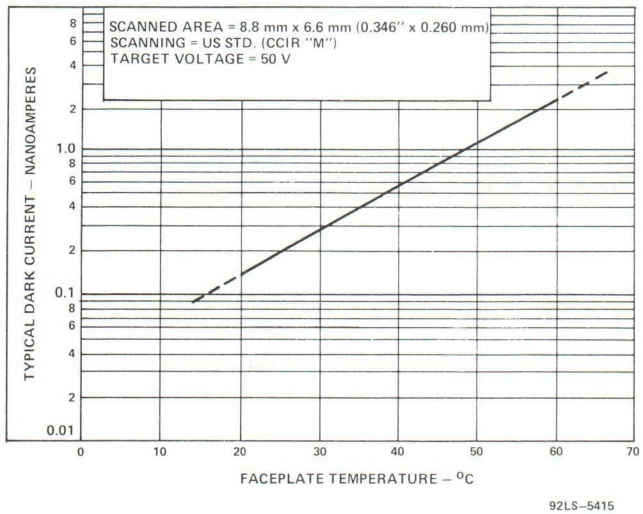



**Figure 4 – Typical Dark Current as a Function of Tube Faceplate Temperature**

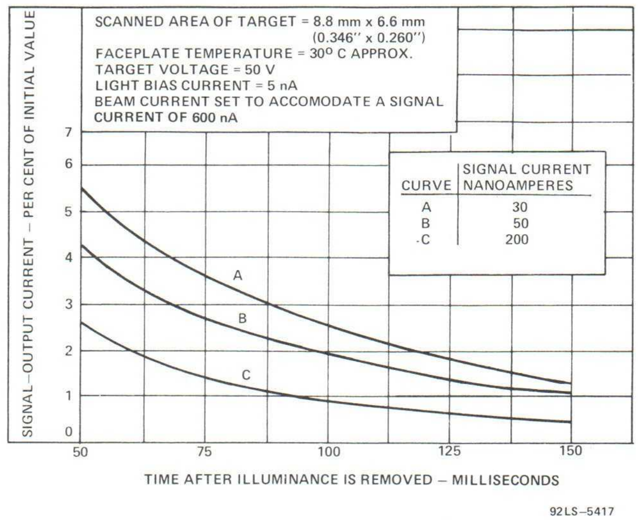



**Figure 6 – Typical Persistence (Lag) Characteristics**

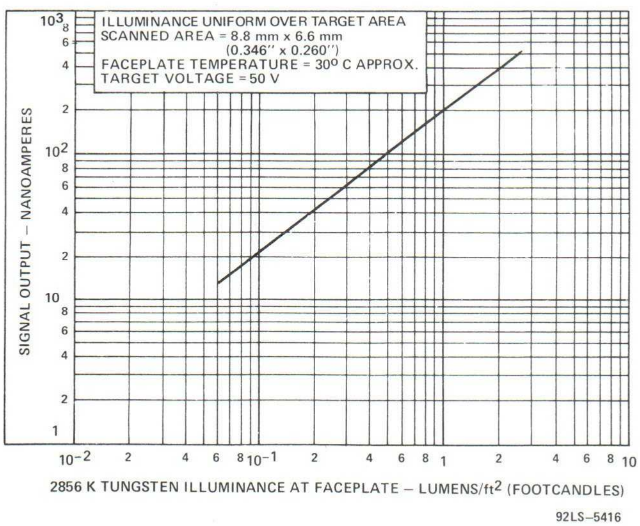



**Figure 5 – Typical Light Transfer Characteristic**

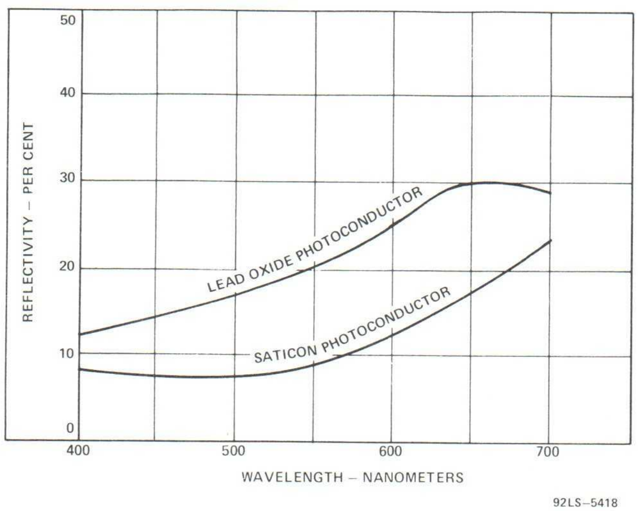
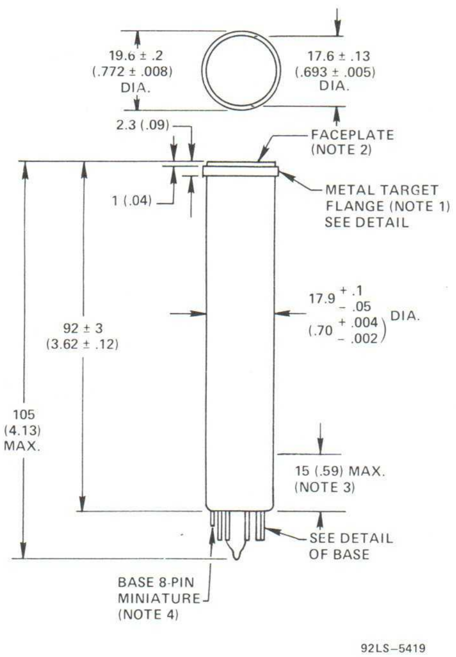



**Figure 7 – Spectral Reflectivity as a Function of Wavelength for SATICON and Lead Oxide Photoconductors**




Dimensions in millimeters. Dimensions in parentheses are in inches.

**Note 1 –** The target connection is made by a suitable spring contact bearing against the edge of the metal target flange.

**Note 2 –** Faceplate thickness is 1.5 mm ± 0.2 mm (0.059" ± 0.008"). Its refractive index is 1.505.

**Note 3 –** Within this length, the maximum diameter of the tube is 18 mm (0.71").

**Note 4 –** A typical socket for use with this tube is the RCA AJ2234.

**Figure 8 – Dimensional Outline**

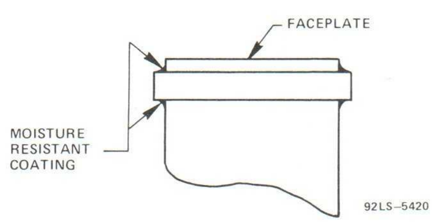



**Figure 9 – Detail of Target Flange**

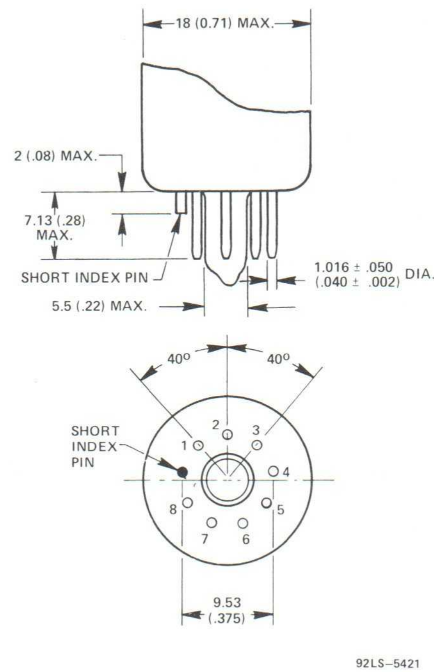



**Figure 10 – Detail of Base**

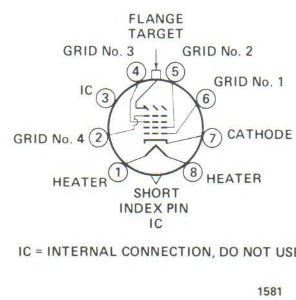



**Figure 11 – Basing Diagram, Bottom View**

RCA Electro Optics and Devices

**Camera Tube**

**Application Note**

**AN-6821**

# TK-76 Color Camera

# SATICON Conversion and Operational Set-Up for RCA BC4390 SATICON Tubes

## Addendum

**Note:** TK76B and TK760 cameras require no SATICON conversion. Operational set-up provisions for the camera tubes are identical for all versions of TK76 and TK760 cameras. System set-up in this Application Note refers to the NTSC model only.



Printed in USA/5-79
AN-6821
*Supersedes IB-32968-B (Rev.)*

# ADDENDUM TO IB-32968

## PURPOSE

Part I of this addendum supercedes Addendum IB-32968-A and provides revised Color Encoder Setup, Pickup tube and Yoke Adjustment Procedures and Video System Adjustment Procedures for the TK-76 Color Camera.

Part II of this addendum delineates camera circuit and adjustment requirements for Saticon pickup tubes.

## PART I – REVISIONS

Page 5 *PRE-OPERATIONAL CHECKS:*

Add under *Registration:* 4. Monitor switches should be returned to the G and B positions following registration.

Page 8 *Color Encoder Adjustment Procedure:*

Disregard the COLOR ENCODER ADJUSTMENT PROCEDURE in IB-32968 and use the procedure in this addendum.

Page 11 *Yoke Removal and Installation:*

Add under *Step 2:*

NOTE: Prior to yoke removal, use the mechanical focus adjustment to fully rack the pickup tube away from the prism to avoid damage to the tube or prism.

Page 11 *Pickup Tube Removal and Installation:*

Disregard Steps 1 and 2 under *Pickup Tube Removal* and use Steps 1 and 2 of this addendum:

1. Remove the nose cone and rear cover from the yoke assembly; remove the pickup tube socket.

2. Unscrew and remove the lock rings to free the thrust washer and rubber support ring. Remove the rings from the tube. Some yokes are equipped with a spring clip type tube clamp instead of a screw locking arrangement. For these yokes, it is only necessary to open the spring clip to release the tube for removal.

Page 12 *Pickup Tube Adjustment and Registration:*

1. Disregard the paragraph under *General* and use the following paragraph:

Note that yoke FOCUS and ROTATION adjustments and the adjustment locking screw require a 7/64-inch (across flats) hexagonal key or wrench. These screws are factory set to 6 lb-in. (7kg cms) torque.

2. Add as Step 7 under *Test Equipment:*

7. A coax extension cable can be fabricated to facilitate connection of the Preamplifier output coaxial cable (normally connected to the Input Proc) directly to a high impedance scope input for ready measurement of signal levels prior to processing. High frequencies will be attenuated by the capacitance of the coax extension used, however, direct measurement of R, B, and G signals can be made using the simple conversion that nanoamps = 1 times millivolts due to the fixed gain nature of Preamps with a 1 megohm (665K ohm for units with serial numbers below 7400) feedback resistor. The removal of the lead from the Input Proc removes the 75 ohm termination thereby permitting nearly direct sampling of that point in the Preamp where millivolts of signal are directly proportional to nanoamperes of tube current generating the signal.

Page 13 *Pickup Tube Adjustment and Registration:*

Revise Step 1 to read: Turn camera ON; turn "Filter" wheel to "Cap". Revise Step 2, second paragraph, under *Preliminary Steps* as follows:

If required, adjust the E ADJ, R26, (+650 volt potentiometer in earlier units) for –12 volts at the –12 volt test point (+650 volts will track with +12 volts).

Page 14, 15, 16 *Pickup Tube Adjustment Procedure:*

Disregard the *PICKUP TUBE ADJUSTMENT PROCEDURE* in IB-32968 and use the procedure in this addendum. Note that certain items in this procedure are also covered in Part II of this addendum which relates to Saticon pickup tubes in TK-76 cameras.

Page 15, 16 *Figure 17 – Green Target Waveform:* Change caption to read *Target Waveform.*

Change voltage to read –45VDC for Plumbicons, –50VDC for Saticons.

Page 18 *Video System Adjustment Procedure:*

For cameras with SERIAL NUMBERS 1100 and above *ONLY,* disregard the VIDEO SYSTEM ADJUSTMENT PROCEDURE, in IB-32968 and use the procedure in this addendum.

Page 21, 22 Note the *FACTORY ADJUSTED CONTROLS TABLE* in this Addendum following the VIDEO SYSTEM ADJUSTMENT PROCEDURE table. Controls referenced in this table are factory set and require adjustment only if the original component has been changed.

## COLOR ENCODER ADJUSTMENT PROCEDURE

| *Step* | *Function* | *Monitor* | *Module* | *Operation* |
|---|---|---|---|---|
| 1 | Chroma bandpass | WFM H-rate 2X norm. gain | Lum. | With Luminance module on extender, adjust C30 (behind DL1) for black and white balance free of S.C. second harmonic. |
| 2 | I/Q black balance | WFM H-rate, 2X norm gain | Chroma | Adjust I and Q BLK BAL controls; repeat adjustment for minimum subcarrier at black reference level. (See Figures 5 and 7). |
| 3 | I/Q white balance | WFM H-rate, 2X norm | Chroma | Adjust I and Q WHT BAL controls for minimum subcarrier on white bar (See Figures 5 and 7). |
| 4 | I/Q symmetry (Misalignment will effect luminance amplitude of bars) | Scope H-rate | Chroma | With Chroma module on an extender, ascertain that WHT CLIP, on Luminance module, is set high (Full CW) above 77 units. Attach scope probe to TP-5 Chroma symmetry test point) and observe the waveform which is now I alone. Attach scope probe to TP4 and observe the Q Chroma symmetry waveform. Adj. I and Q symmetry pots R108 and R107. |
| 5 | Luminance gain and black reference level | WFM H-rate calibrated for 140 units = 1V | Lum. | Adjust BLK REF for 7.5 units. Adjust LUM GAIN to set white bar at 77 units (See Figure 8). |
| 6 | Quadrature need not be changed from its factory adjustment if correct I and Q levels have been obtained. | Vectorscope | Chroma | With Chroma module on extender, temporarily short R53 to ground (end towards rear of board). This has the effect of removing the Q signal thereby leaving only I. Rotate Vectorscope PHASE control to set I vector along I axis. Transfer short from R53 to R56 (see Figure 5). This has the effect of removing the I signal thereby leaving only Q. Adjust QUADRATURE, R34 to align Q vector along the Q axis. To check quadrature, repeat I and Q vector adjustments. Remove short from R56 and replace the Chroma module. |
| 7 | I/Q gain; correct chroma level is set when tops of first and second color bars = 100 units and last two bars are equal at -16 units (also see Step 9). | WFM H-rate Vectorscope Vector display | Chroma | Turn I and Q gain pots CCW 20 turns; turn pots CW 10 turns to set pots to mid-range. To set CHRM for nominal (approx.) level, carefully trim I and Q GAIN for correct level. Refer to calibrated Vectorscope (see Figure 5). If it becomes necessary to adjust chroma Geometry for final vector position, place the Chroma module on extender, carefully adjust CHROMA GEOMETRY for best vector position of MAGENTA and CYAN. Re-adjustment of Vectorscope phase and camera chroma level will be required. The chroma level adjustment is to compensate for chroma level changes. Trim I and Q and burst gains if required. Replace module. |
| 8 | Burst phase | Vectorscope | Chroma | Adjust BURST PHASE for burst vector to lie along the -180° axis. |

## COLOR ENCODER ADJUSTMENT PROCEDURE (Continued)

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| 9 | Burst gain | WFM H-rate | Chroma | Adjust BURST GAIN for 40 units p-p amplitude. |
| 10 | Sync gain | WFM H-rate | Lum. | Adjust SYNC LVL for 40 units p-p (0 to -40). |
| 11 | Bars width adj. | WFM H-rate | Sync | With Sync module on extender, adjust the bar width capacitor, C35, for equal black reference width at bar start and finish (see Figures 10 and 13). Replace Sync module. |
| NOTE: The Color Encoder System is now adjusted to provide Standard NTSC color bars and correct sync level. Steps 7 and 11 provide adjustment procedures which may be required if components on the color encoder modules (Chroma, Luminance or Sync) have been changed. | | | | |

## PICKUP TUBE ADJUSTMENT PROCEDURE

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| 1 | Set target voltages | Triggered Test scope, H rate | Deflection | Remove deflection module cover from the camera (see Figures 2, 16 and 33). |
| | RED target | | | Connect scope to collector of Q7 (case). DO NOT SHORT Q7 CASE TO Q8. Adj. R44 to set Red target to -45 volts for PbO or -50 volts for Saticon pickup tubes (see Figure 17). |
| | GREEN target | | | Connect scope to collector of Q107 (case). DO NOT SHORT Q107 CASE TO Q108. Adj. R144 to set Green target to -45 volts for PbO or -50 volts for Saticon pick-up tubes. |
| | BLUE target | | | Connect scope to collector of Q207 (case). DO NOT SHORT Q207 CASE TO Q208. Adj. R244 to set Blue target to -45 volts for PbO or -50 volts for Saticon pick-up tubes. |
| | | | | Negative (active scan position) of the cathode wave-form is effectively target volts since target element operates at nearly zero volts due to direct Preamplifier coupling. |
| | | | | Replace the heat sink cover. |
| 2 | GREEN preliminary adjustments (These adjustments not re-quired if Green channel is already optimized). | Set PIX MON sw. on camera to G | Deflection | Disconnect the coax yoke connectors from the Blue and Red channel inputs of the Input Proc. Center the Green FOCUS control. (see Figure 33). |
| | | | | With the camera framing the Resolution uncap the camera (clear) and set iris for 100% level chart, dis-charge the Green beam. FOCUS THE LENS FOR SHARPEST PICTURE. |
| | | WFM to -B input Ext. trigger | Power | Adjust the focus current control, FOC I, for optimum picture focus. Some picture rotation should be expected. |
| 3 | RED preliminary adjustments | Set PIX MON sw to R. Fol-low with WFM check. | Deflection | Disconnect the coax yoke connector from the Green channel input of the Input Proc. Replace the coax con-nector at the Red Input Proc channel. Discharge the Red beam. Release yoke adjust lock. Focus the Red yoke using the hexagonal key. Adjust for optimum Red electrical focus. |

## PICKUP TUBE ADJUSTMENT PROCEDURE (Continued)

| *Step* | *Function* | *Monitor* | *Module* | *Operation* |
|---|---|---|---|---|
| 4 | BLUE preliminary adjustments | Set PIX MON sw. to B. Follow with WFM check. | Deflection | Replace the coax connector at the Blue Input Proc channel. Discharge the Blue beam. Focus the Blue yoke using the Hexagonal key.<br>Adjust for optimum Blue electrical focus. |
| 5 | Optical focus tracking (Required only if Green Yoke/Pickup tube has been disturbed). | Set PIX MON sw to G. Follow with WFM check | Lens/Grn Yoke | Replace the coax connector at the Green Input Proc channel. Disconnect the coax connectors at the Blue, Red Input Proc channels. Set the IRIS switch to MAN. Open the iris to fl. 9 (wide open). Reduce light on the Resolution chart until video falls below 100 units. Alternately select a filter (wheel) for the same effect). Zoom the lens for narrow angle then focus the lens. Zoom lens to wide angle then focus Green yoke with hexagonal key. Repeat this operation until focus tracks over the full zoom range. |
| 5A | Optical focus tracking | Set PIX MON sw to R | Lens Red, Blu Yokes | Use zoom at mid-range. Reconnect Red coax to Input Proc and disconnect the Green coax. Focus the Red yoke with the hexagonal key.. Repeat these adjustments for the Blue yoke. |
| 6 | Set Beam Reserve GREEN, RED, BLUE | WFM-B, Scope H rate at In Proc U101-9(G) U1-9(R) U201-9(B) (Figure 19) | Deflection In Proc | With Input Proc on an extender and the coax cable for the Green (only) channel connected, adjust MANUAL IRIS for 100 units of video at the W.F.M. Open the iris one f-stop for PbOs, two f-stops for Saticons, and adjust Green beam to just discharge the highlights as observed on the scope connected at U101-9. Repeat these adjustments for Red and Blue channels. Disconnect the coax connectors of the channels not being adjusted. Replace the Input Proc and restore the iris to 80 units (see Figures 18 and 19). |
| 6A | | Color Monitor | Deflection | Direct the camera toward a bright object such as a specular reflection while panning continuously. If a colored trail is observed, slightly increase the beam for the tube which produces the color seen in the trail. |
| 7 | GREEN picture size (Use output system blanked picture). | Switch picture monitor to VID OUT | Deflection | Zoom the lens into the Registration Chart; switch to OVERSCAN. With the Green (only) coax connected to the Input Proc, adjust Green H and V CENT, Green HGT and WIDTH to center the picture and just cut corners with target ring as seen on the picture monitor. *Switch to normal scan.* Green scan now has correct size, location and 4/3 aspect ratio. Other image control should be with pan, tilt, zoom and focus (See Figure 20). |
| 8 | GREEN rotation | Set PIX MON sw to G | Deflection | Be sure that the camera is resting on a stable, level plane. Check with a level if uncertain. Level the bottom of the Registration chart. Adjust Green yoke ROTATION for parallelism in the horizontal plane. Adjust Green SKEW for vertical plane (picture sides). Tighten yoke locking screw to 6 (DO NOT OVER TIGHTEN). Recheck yoke focus after setting rotation and correct for any effects of control interaction which may have occurred. |
| 9 | GREEN linearity | Video Out | Deflection | Accurately frame the Linearity chart. Genlock an external sync source with the camera output from VIDEO. Use sync generator grating signal and mix at picture monitor with video output made from Green only. Superimpose *ball* pattern on grating intersections |

## PICKUP TUBE ADJUSTMENT PROCEDURE (Continued)

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| | | | | over the picture area using Green H LIN, V LIN, LH LIN (Left Hand Linearity). It may be necessary to trim height or width a small amount, however, check first with zoomed picture. Frame the Registration chart and remove genlock and grating. (See Figure 33). |
| 10 | RED and BLUE registration | Set PIX MON sw. to -G; set R, B sw. to R | Deflection | Connect the coax connectors for Red and Blue to their Input Proc channels. To register Red, first set Red yoke rotation, then adjust Red SKEW, H and V CENT, HGT, WIDTH, H LIN and LH LIN. Trim all controls to best cancel R to -G picture. Look for maximum cancellation at large center areas of the picture. (See Figure 33) |
| | | Set PIX MON sw to B | | Repeat above steps for Blue registration. Tighten yoke locking screws. |

## VIDEO SYSTEM ADJUSTMENT PROCEDURE

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| 1 | Temporarily eliminates flare correction | -- | In Proc | Set the R, G and B flare (FLRE) controls (at the module front panel) fully clockwise (if in doubt about the end stops, turn 20 full turns). |
| 2 | Green black level balance | Scope H rate E101TP (Green) | In Proc Out Proc | Cap the camera using No. 2 filter position. Adjust Green BLK BAL for picture black to be coincident with level observed during horizontal retrace period, i.e., adjust for minimum pulse amplitude in the scope display (see Figure 23). |
| 3 | Bias light level | Scope V interval | Blue coax to In Proc exten. to scope | Adjust BIAS LEVEL for desired Blue bias light level (approx. 3.3 mV typical for Plumbicons represents 5na; for units with serial Nos. above 7400, 6mv = 6na). |
| 4 | Black level balance | Scope H rate E-1 Red E101-Green E201-Blue | Out Proc | Adjust Red, Green then Blue BLK BAL, in that order, for picture level to be co-incident with level observed during horizontal retrace period. |
| 5 | Green Shading | Scope H and V Rate E101 | In Proc Out Proc | Adjust Green H SAW for optimum flatness on scope display (H rate). Adjust Green V SAW for optimum flatness on scope (V rate). Recheck H rate display and readjust H SAW if necessary. Recheck V rate display and readjust V SAW if necessary. |
| 6 | Red and Blue shading | Scope H and V Rate E1-Red E-201-Blue | In Proc Out Proc | Repeat procedure for Green shading (Step 5 above) |
| 7 | Aperture delay gain calibration | Scope H rate | Delay 525 | Place the Delay module on an extender. Position the camera to frame the gray scale chart and adjust the lens for normal focus. Observe signal at Pin 3 on the Delay module connector (OT IN), and adjust the manual iris on the lens for a 1.4 volt p-p signal. With the scope connected at Pin 36 (1T OUT), adjust the 1T GAIN control for 1.4 volts p-p. (see Figures 27 and 28). |

# VIDEO SYSTEM ADJUSTMENT PROCEDURE (Continued)

| *Step* | *Function* | *Monitor* | *Module* | *Operation* |
|---|---|---|---|---|
| | | | | Connect the scope to Pin 42 (2T OUT) and adjust the 2T GAIN control for 1.4 volts p-p.<br>Replace the Delay 525 module. |
| 8 | Green gain calibration | Scope H rate | In Proc | With camera framing the gray scale chart, adjust incident lighting for 125 foot-candles. Set the IRIS switch to MAN position and set the lens opening to f2.8. |
| | | | Out Proc | Calibrate scope to observe a 1.4 volt signal at TP E101 on the Output Proc. Adjust Green GAIN on the Input Proc to place the top white chips in the chart 1.4 volts above retrace black level (see Figures 23, 26 and 28). |
| 9 | Red and Blue gain | Scope H rate | In Proc | Frame the camera on the white chip of the Gray Scale Chart. With the Input Proc on an extender, attach scope to Pin 3 on the Input Proc module connectors. While pushing the Auto White Balance button, adjust Red GAIN for -2 volts D.C. Remove scope from pin 3 and attach at Pin 38 of the connector. Push Auto White Balance and adjust Blue GAIN for -2 volts DC. Remove scope and replace Input Proc. |
| 10 | Color Balance | WFM | Camera VIDEO OUT (J4) | Observe output signal and open the manual iris to be sure that the white clipper is set beyond 100%. (If not, adjust the WHT CLIP control on the Luminance module to approximately 110%; this adjustment will be trimmed later.) Readjust the iris to place the brightest chips in the gray scale test pattern at 100 on the waveform scale. |
| | | | Auto | Reframe the camera to place one of the brightest chips at the center of the picture and press the WHT BAL button. Observe the subcarrier level during the white-patch interval. If the automatic white balance operation failed to reduce the residual subcarrier to zero, place the Auto module on an extender and trim the Red and Blue reference level controls, R76 and R78 so that pressing the WHT BAL button results in a properly balanced signal with minimum subcarrier at white. Replace the Auto module (see Figure 24). |
| 11 | Preamplifier frequency response adjustments | Scope H rate | Preamp, Out Proc | Frame the camera on a sharp black-to-white transition at the edge of one of the black bars in the resolution chart. Set the manual iris to hold peak whites slightly below 100 on the waveform monitor scale. Connect the scope to TP E1 (Red) on the Output Proc. Adjust the M, L and H FREQ response controls on the Red preamp (see Figure 29) for the best transition between black and white levels (minimum rise time consistent with freedom from spikes, tails or ringing). Connect the scope successively to TP E101 (Green) and TP E201 (Blue) and adjust Green and Blue preamp frequency response as described above for Red (see Figures 23 and 29). |
| 12 | Flare correction | Scope H rate<br>TP E1 (Red)<br>E101 (Grn)<br>E201 (Blue)<br>W F M | Out Proc | Frame the camera on a flare chart (described under Preliminary Considerations) and observe the signal at TP E101. Slowly rotate the manual iris from its minimum setting to the setting which just takes white video into clipping as seen on the W F M while observing the voltage level which corresponds to the black hold signal. Adjust the Green FLRE control on the Input |

## VIDEO SYSTEM ADJUSTMENT PROCEDURE (Continued)

| *Step* | *Function* | *Monitor* | *Module* | *Operation* |
|---|---|---|---|---|
| | | | | Proc CCW to the point where the black information maintains the same level with iris rotation. Move the scope successively to TP E1 and TP E201 and adjust Red FLRE, Blue FLRE in the same manner described above for Green FLRE. Observe the signal on the W F M at a horizontal rate. Move the iris through its range and trim the Red and Blue FLRE controls to maintain minimum subcarrier on the black level throughout the iris range. (See Figures 23 and 26). |
| 13 | Automatic iris level | W F M | Camera | Frame the camera on the resolution chart and set the IRIS switch to AUTO. |
| 14 | Horizontal drive width | W F M<br>H rate | Sync | Place the Sync module on an extender. Observe the camera output at the W F M and adjust horizontal drive width (R76) on the Sync module to cause picture scan to start in the back porch interval. Correct adjustment is indicated when there is a clean burst waveform and minimum left-edge spike at the beginning of the picture information (see Figure 31). Replace the Sync module. |
| 15 | Clamp width adjustment | Scope (dual trace, H-rate | Sync | Use R73 to adjust clamp WRT pulse leading edge at Pin 34 to be advanced 3/4 usec wvt blanking at Pin 28. Misadjustment will result in clamp streaking on video (Figure 30). Replace Sync module. |
| 16 | Contour adjustments | Scope H rate<br>W F M | Luminance | Set the CORE and CONTOUR LEVEL controls fully CCW. (If uncertain about the location of the end stops, turn 20 turns CCW. (see Figure 32).<br><br>Frame the camera on the resolution chart and set the IRIS switch to AUTO (Multiburst Chart may be better).<br><br>Place the Luminance module on an extender, and connect a scope probe to the emitter of Q28.<br><br>Adjust R89 (APERTURE BALANCE) for minimum video in the scope display.<br><br>Frame the camera on a uniform white surface, switch the IRIS to MAN and set the iris for a video level of approximately 50 on the W F M scale.<br><br>Still observing the signal at the emitter of Q28 on the scope, adjust the CORE control on the Luminance module to just eliminate the noise in the scope trace. Replace the module.<br><br>Frame the camera on typical picture content, set the IRIS switch to AUTO and adjust the CONTOUR LEVEL control on the Luminance module for the most pleasing picture sharpness. (This is a subjective adjustment). |
| 17 | White Clip level | W F M<br>Camera<br>VIDEO<br>OUT (J4) | Luminance | Set the WHITE CLIP control on the Luminance module to clip white peaks at 110% (or some other value in accordance with local operating practices). This adjustment can be checked by using a manual iris adjustment and opening the lens to observe the clipping point on the W.F.M. |
| 18 | Calibrate Viewfinder indicators 100% indicator | W F M<br>H rate<br>Visual at VF | Luminance | Frame the Gray Scale chart and place the white chip near the center of the picture. Set manual iris to 100% video. Switch IRIS switch to LEVEL. Adjust VF IND |

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| | 70% indicator. Set for flesh tone at 70% Oscillation (shimmer) is added to the Viewfinder picture at THIS LEVEL. | | | 100% so that video at the top white chip just starts to invert. Check the setting by opening the iris to 105% and watch for more inversion (top chip will be darker). Reset iris for 100% video. Set the V.F. Switch to LEVEL. Adjust the 70% IND for an oscillation (shimmer) on the lower gray scale chip (approx. 70% level). This control can be varied over a range of 0 to 100% and can be set as dictated by operational experience. |
| 19 | Low battery level ind. | | Power | Adjust for Viewfinder indicator to light at 10.8 volts thereby signaling 5 minute battery life remaining. |

## FACTORY ADJUSTED CONTROLS

| Step | Function | Monitor | Module | Operation |
|---|---|---|---|---|
| 1 | Preamplifier Bias adjustment | Scope, H rate | Preamp | Connect a high impedance scope to the Preamp coaxial cable output. Adjust BIAS ADJ. (R20) for 0.0VDC. Access to this control is provided by removing the yoke assembly from the camera. |
| 2 | Peak Response of Composite Video Amplifier | Scope, H rate | Luminance | With the Luminance module on an extender adjust C10 for maximum response. Replace the Luminance module. |
| 3 | Subcarrier Trap Adjustment | Scope, H rate | Sync | Genlock the camera to an external signal. With the Sync module on an extender adjust C8 for minimum ripple at Q13 source. Replace the Sync module. |

## PART II – SATICON VS. PbO PICKUP TUBE REQUIREMENTS

### General

Requirements for Saticon pickup tube operation in TK-76 Cameras are somewhat different from the requirements for PbO pickup tubes. These parameters are described below:

### Power

Cameras equipped with Power B modules require only minor voltage adjustments when Saticon pickup tubes are installed. However, for earlier Power modules, note the following requirements. Power transformer, T1, should be Drawing No. 3416364-4 (RCA Stock No. 439171) instead of Drawing No. 3416364-3 (RCA Stock No. 435056). Transformer substitution may be made on a wire-for-wire (same color) basis. This effectively converts the module to a Power B unit. Note that a transformer installed to accommodate Saticons is also satisfactory for Plumbicons.

With a transformer installed, set the VOLT ADJ., R26, (formerly +650V control on the front panel for –12 volts (at TP-4). Other voltage will now be as indicated except that –125 volts will be –140 volts and +270 volts will be +220 volts. This assures that the Saticon beams can be reduced to 600 na.

### Viewfinder

Before applying power to the Viewfinder, be sure that the Viewfinder circuit includes R20, a 68 K ohm resistor which provides protection against damage to the kinescope and capacitors. R20 (68K ohm, 5%, 1/8W) should be located between board terminal "C" and the Brightness control. To add the resistor, cut the trace between the module board terminal "C" and R10-1, the Brightness control. Substitute R20 for the cut trace on the underside of the board. Refer to the schematic diagrams in the Viewfinder module books, IB-32995-1 or IB-32995-2.

## Pickup Tube Sockets

The RCA BC4390 SATICON tubes are directly pin-interchangeable in the 7-pin Plumbicon socket.

## Target Voltages

Target voltages for Saticons should be increased to –50 from –45 volts set for Plumbicons, to insure optimum lag performance. If target voltages are reset, the other steps in the *Pickup Tube Adjustment Procedure* should be reviewed.

## Beam Reserve

Beam Reserve (highlight discharge capability) for Saticons should be set to two f-stops *over* instead of one f-stop *over* as required for Plumbicons. (Refer to Step 6 of the *Pickup Tube Adjustment Procedure* in IB-32968.)

## *Deflection*

Saticon pickup tubes have a different tube target ring dimension. Therefore, the *Overscan-Normal* ratio should be revised so that when Green height and width are adjusted for target corners to *just* show on *Overscan* in the color output signal, (Overscan-Normal switch in *Overscan*) the correct image size will result when the switch is in the *Normal* scan position.

To determine the proper changes on the **Deflection Module**, the **module itself** must be examined for the following, since there are several modifications of this module existing in cameras. **Your camera manual may not have the same resistor values as the deflection board.**

| | Stock No. |
|---|---|
| If R57 is 7150 ohms, change R164 to 90.9K ohms. | 436850 |
| If R57 is 6340 ohms, change R164 to 76.8K ohms. | 431933 |
| If R58 is 7150 ohms, change R164 to 90.9K ohms. | 436850 |
| If R58 is 6190 ohms, change R163 to 75K ohms. | 428740 |

These are special 1/4 watt 1% metal film resistors.

## Bias Light (Alternate method to Step 3, page 6)

The bias light signal of 6mv p-p (4mv for Preamp serial numbers below 7400) is the same for Plumbicons and Saticons since this equals 6na with a 1 megohm (665K ohm for Preamp serial numbers below 7400) feedback resistor. Note that with standard setup involving 125 fc incident light, 60% reflectance white from the crossed gray scale chart, iris set at f/2.8, scan switch at normal; a nominal Green signal of 200 na and 100 na in the Blue channel would exist. At *Normal*, sensitivity Blue Gain would have been adjusted for 100% level= 1.4V P-P at Out Proc. test point E101. Bias level should be adjusted so that the bias level in the Blue channel is at least 5na. Bias light can be estimated accurately at this test point if LK101 is temporarily shifted to unity gamma and Bias Light Control on the Deflection Module is adjusted for 5na/100na=5% of 1.4V or 70mv. This is to be measured from camera blanking which equals zero beam (which is more readily seen during the vertical blanking interval) to bias light signal level during the unblanked region. Once established, the gamma link can be restored and standard low lag should prevail after complete camera set-up. Any new bias light level requires Black Balance readjustment to cancel the new arbitrary black signal and possibly Black Shading re-evaluation. More bias light tends to reduce lag but magnifies any lack of bias light signal flatness. The reverse is true for less bias light.

## Flare Correction

Flare correction adjustments are necessary after conversion to SATICON tubes because of the reduced flare of those tubes.

# CHECKING THE SET-UP ON SATICON TUBES IN A TK76 OR TK760 CAMERA

## Checking:

Beam setting levels
Signal current levels
Bias light levels
Black balance settings
Shading settings
Flare settings

## Setting Beam Currents

Remove both sides of the camera. The camera lens iris control must be set on the manual position. Focus the camera on a "step" chart and then adjust the lens iris manually to produce an output white highlight signal that matches the 100% signal level of the internal color bar generator. (Switch between bars and picture by using the switch on the side of the camera.)

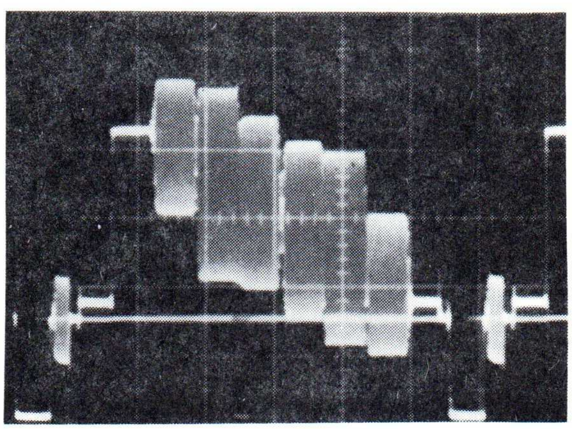


FIG. 1

Color Bar Output Signal

(Horizontal Rate)

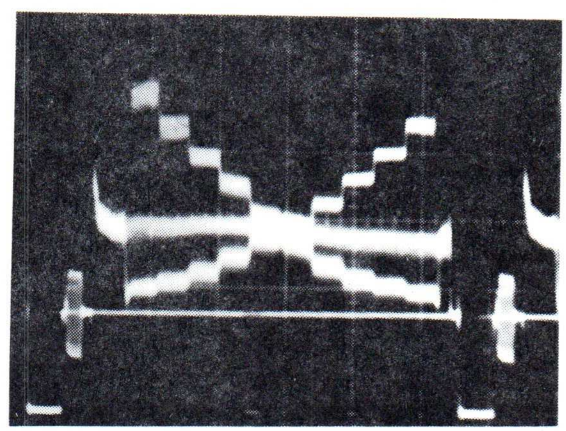


FIG. 2

Camera Video Output

(Horizontal Rate)

Next, the coax cable that comes from the green camera tube coil assembly should be unplugged from the Input Proc. board. (If the iris control is not on manual, the iris will open as soon as this cable is unplugged, and there goes your calibration of signal level.) See Figure 3.

The test cable #AJ2236*should be plugged into the coax cable and attached directly to the input of the oscilloscope, which is set at the horizontal rate. The peak black-to-white signal level (horizontal retrace level to peak white) should be measured in millivolts. This level will be approximately 200 mV, which is equivalent to 200 nA of signal current. A signal between 200 and 250 mV means the tube and preamp signal levels are correct.

The iris should then be adjusted to produce exactly 4 times the originally measured signal level. The green beam control should be adjusted slowly to just handle the peak highlight and no more. The beam controls are on the deflection board of the camera.

With no change in the iris setting, the test cable should be plugged directly into the blue and red pre-amp coaxial cables in turn and the red and blue beam currents adjusted in exactly the same manner.

The adjustments of 4:1 beam reserve will also enable the TK76 or TK760 equipped with Saticon tubes to handle difficult scenes where a bright background must be over-exposed to bring out the foreground objects, such as scenes shot against the sky or a sunlit wall.

## Bias Light Adjustment

The bias light signal level can then be measured using the same test cable. Plug the test cable into the green channel coaxial cable connector and cap the lens. Use the vertical rate trace on the oscilloscope and adjust the bias light control so that the average signal level above the negative vertical pulse is 6 to 8 mV.

*Available from RCA Solid State Division/ ElectroOptics and Devices/Lancaster, PA 17604

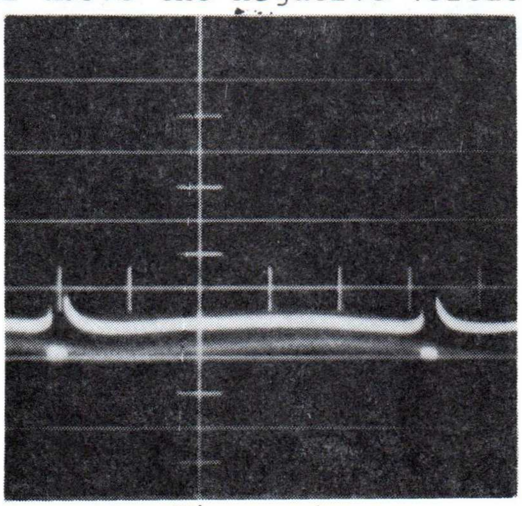
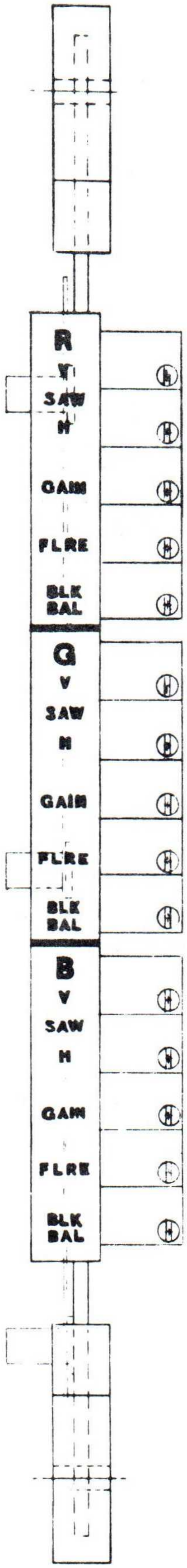
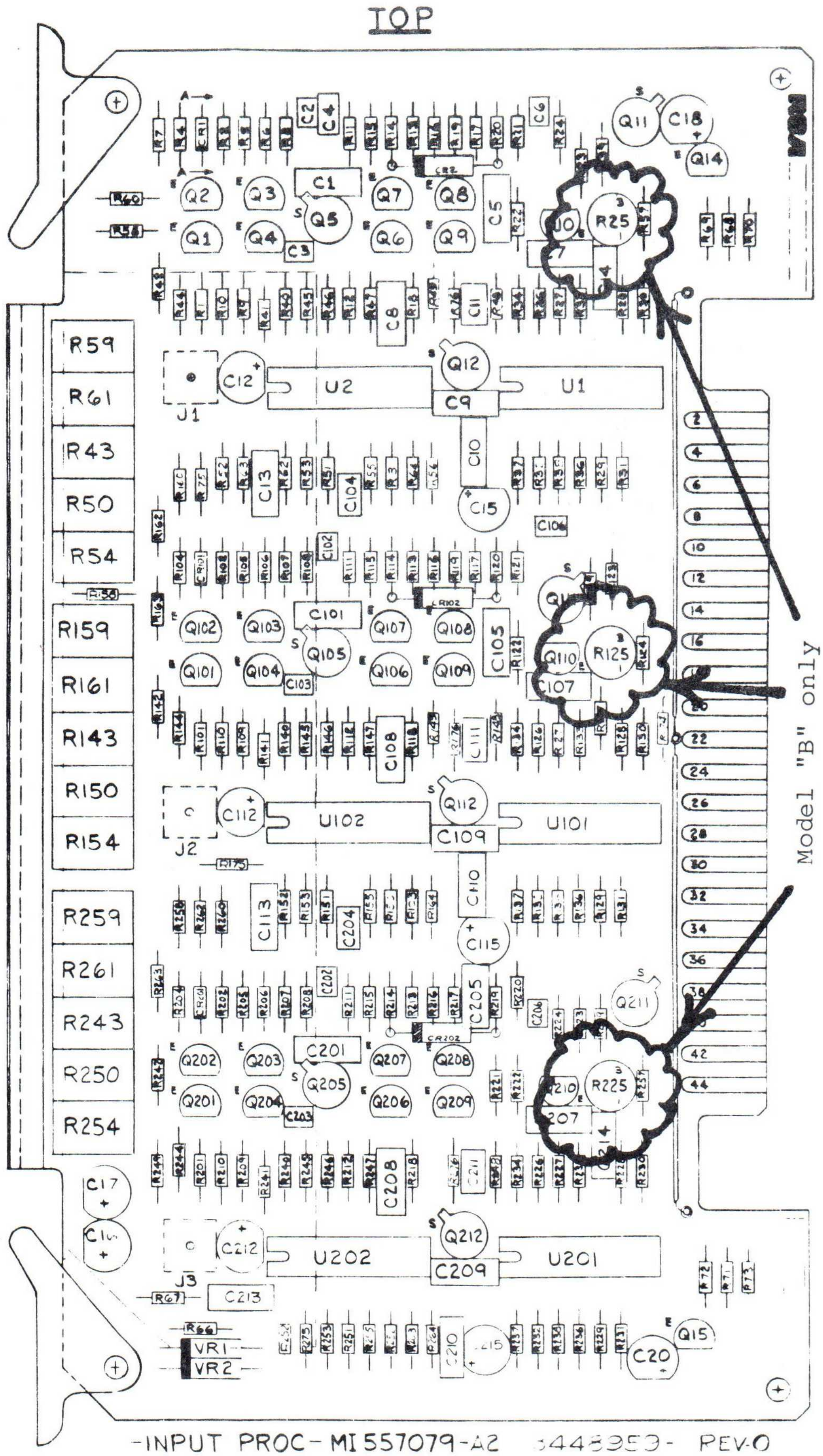


Figure 4
Signal when measuring bias level scope set on 10 mV/cm.
Bias level ≈ 5 mV = 5 nA.




(Side View)



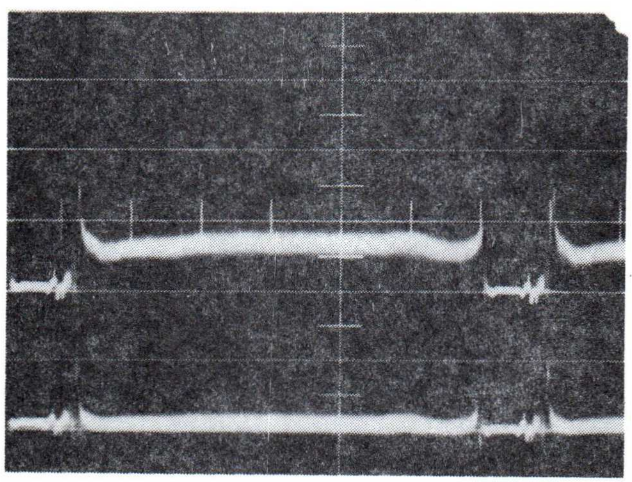

**—Input Proc Module, Assembly Drawing**

FIGURE 3

Check the bias level of the other 2 channels in the same manner to make sure none are below 5 mV (5 nA). If any are below 5 mV, increase the bias light until the bias signal is above 5 mV, but lower than 10 mV. (All channels are not equal.) After the beam controls and bias light controls have been properly adjusted, black balance and shading controls must be readjusted.

## Shading and Black Balance Adjustments

With the camera capped and a 10:1 scope probe, monitor the appropriate test point on the output proc. board; Figure 5. These are little pins sticking out from the side of the board. Use the scope on horizontal trace and adjust the respective black balance control until the signal during scan time is equal to the level during retrace. This is done on all three channels: (red = test point E1; green = test point E101; blue = test point E201). Figure 6.



Before black level adjustment

Proper black level adjustment.

FIG. 6

Black level adjustment by means of black balance control.

With the scope probe at the same points, adjust the H and V SAW of the corresponding channel for the flattest signal. It is advisable to view the vertical rate for V SAW adjustments and the horizontal rate for the H SAW adjustment to assure best overall flatness. If the horizontal trace is bowed, Model "B" cameras only have a parabola shading control. To adjust this, you put the input proc. on an extender and adjust the controls (circled on Figure 3) for flattest signal.

Readjust the green black level balance monitoring test point E101, after shading adjustments are completed. Check proper adjustment level by switching on and off the high sens. switch on the left side of the camera. Adjust the black balance control so that the trace does not shift position as the switch position is changed. Final complete black level balance will be performed later.

## Flare Adjustments Are Made Next

Put an appropriate flare test pattern in front of the camera (a closed white carton with a hole equal to 10% of the area). Focus and zoom the lens so that the black square occupies 10% of the picture and open the iris so the highlights are at 100% or 1.4 volts at the output proc. test points.

Cap the lens and observe the scan trace on the scope (D.C. amplifier setting) at the green channel test point (E101). Open the lens and adjust the green flare control (on input proc.) until the black hole signal lies on the capped signal level of the scope. Repeat for Red (E1) and Blue (E201) channels. Figures 7 and 8.

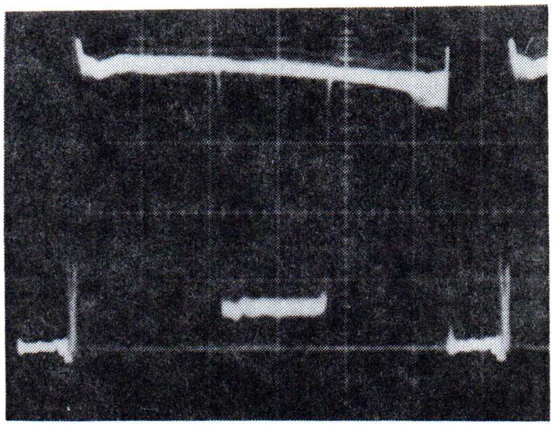


FIG. 7

Signal before flare correction. (Horizontal rate)

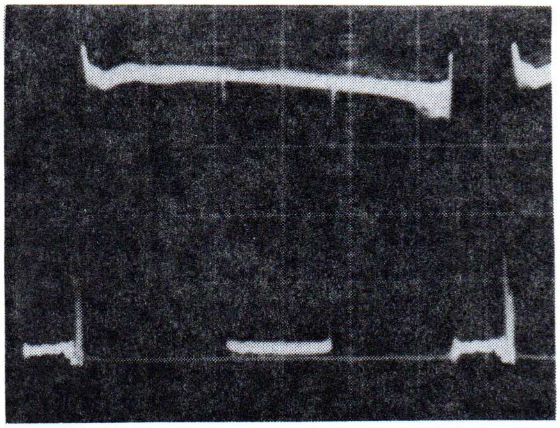
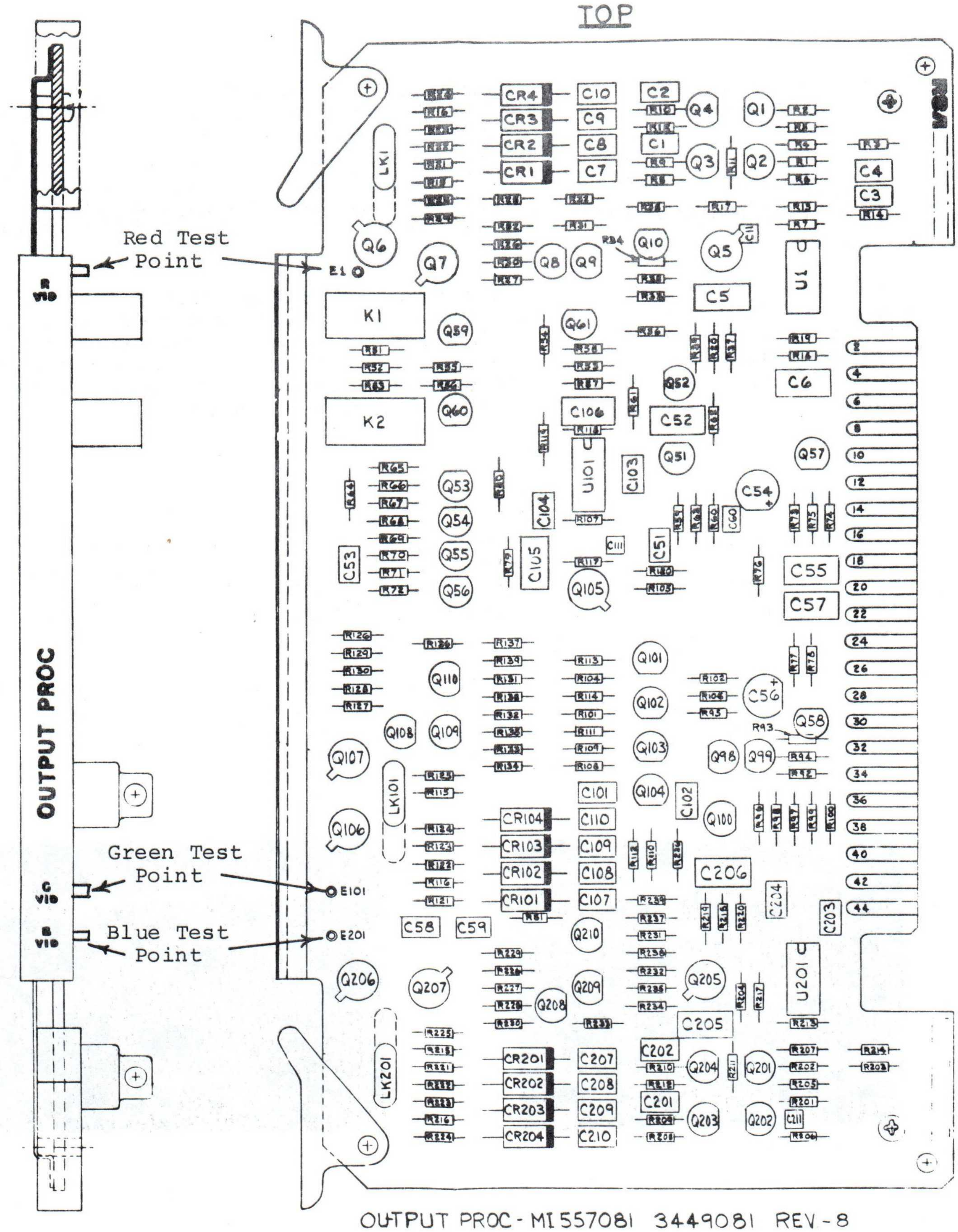


FIG. 8

Signal after proper flare correction. (Horizontal rate)




(Side View)

**Output Proc Module, Assembly Drawing**

FIG. 5

Final black balance and flare adjustments are made by monitoring the composite camera output signal on an oscilloscope using increased range in both vertical and horizontal directions to stretch the display for ease of showing.

Cap the camera and adjust the R & B black balance controls for zero sub-carrier. Check balance with the switch thrown to "High Sens." If unbalanced, favor balance adjusted while on high sens., or make a reasonable compromise.

Open the lens and focus on the "flare test" pattern. Adjust the blue and red flare controls for minimum sub-carrier on the black hole signal.

<u>You're finished with set-up controls!</u>

## <u>Target Voltage</u>

Image burn can develop on some tubes. In most cases, the target voltage can be adjusted to eliminate the operational burn tendencies. It cannot alter burn characteristics on specular highlights or the burn that can be produced when an image is on the tube with the camera turned off.

Take off the right side of the camera.

### <u>TK76A</u>

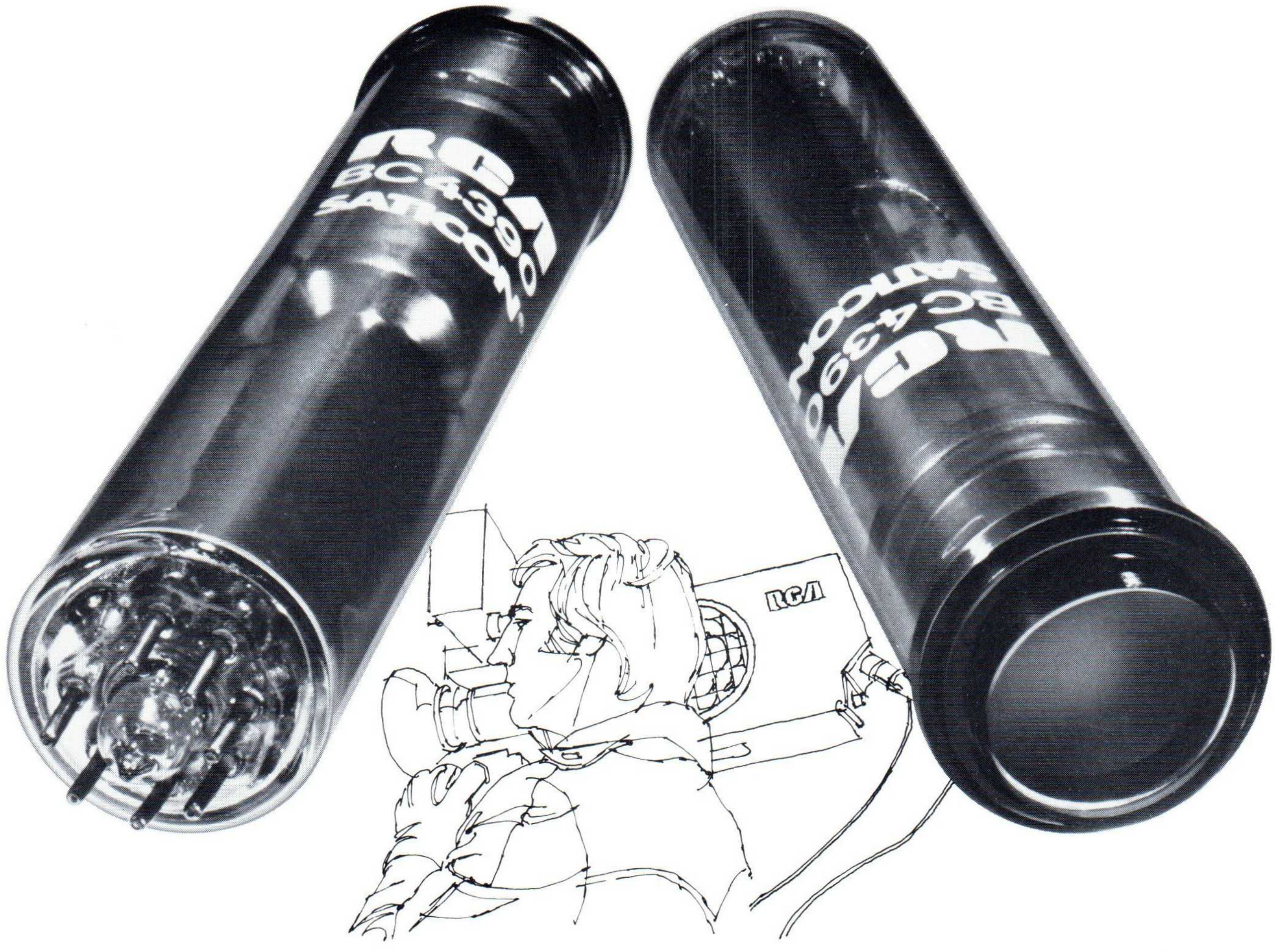
Remove the heat sink board from the deflection chassis (pull off). Ask for help when replacing. Find the appropriate transistor, Q7, Q107 or Q207. Put a scope probe on the transistor cover (scratch through the varnish) and measure the voltage below ground of the blanking waveform. Make adjustments of the required target control in 2-3 volt increments. If the burn is positive, reduce the target volts. If negative, increase. If the camera runs in a hot environment, the voltage will probably need to be lowered.

In Model "B" cameras, the targets are ganged on one control. You need <u>not</u> remove the heat sink cover. Q107 protrudes at the lower left of the heat shield. Measure the voltage here and adjust the master target control. In most cases you can achieve a voltage which will prevent any channel from burning.

After adjusting target volts <u>more</u> than 2 volts, readjust beam currents per previous instructions.

R. G. Neuhauser/C. A. Mock
May 10, 1979
/sdk

# For the best in ENG action, get the new LEAD-FREE 2/3" SATICON® from RCA.




Now RCA offers you a new 2/3" SATICON tube with a 7-pin base that equals or exceeds lead oxide performance in every way. The new BC 4390 SATICON provides the best picture quality available for ENG cameras. With the new RCA LEAD-FREE tube you get:

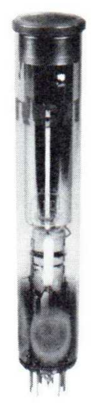
- Better resolution.
- Longer life expectancy.
- Uniformly high sensitivity.
- Low lag.
- Excellent temperature stability.

For more information on how you can get better ENG action with the new LEAD-FREE BC 4390, see your RCA Distributor. Or, contact: Camera Tube Marketing, RCA Electro Optics and Devices, Lancaster, Pa. 17604.

**RCA**
**Electro Optics and Devices**

1G5546

TELECINE



L-965

# 25-mm (1") Diameter Sulfide Vidicons For Broadcast TV Color Film Pickup Cameras

- Uniform Resolution
- Separate Mesh Connection
- Very Low Lag
- 0.6 Watt "Dark Heater"
- Resistance to Image Burn-In
- Excellent Signal Uniformity

The 4809 and 4809/B are 25 mm (1-inch) vidicons specially designed, manufactured and tested to produce best performance at conditions imposed by color film pickup service. The BC4809/B is specially processed and tested to meet the blue channel sensitivity requirements.

Design features of these improved types include low lag in film pickup service, freedom from focus-related signal non-uniformities, resistance to pattern burn-in and close control of target voltage/dark current range.

These tubes are designed to operate in cameras employing G4 voltages above 750 volts to achieve uniformity of focus and high resolution. They contain a low power (0.6 watt) dark heater for fast warm-up. Temperature changes are minimized in the gun with this structure thus gun movement and changes in registration are reduced during warm-up. This heater minimizes the effect of temperature on the photoconductor resulting in more uniform performance. A separately connected field mesh design improves beam landing and provides control of resolution uniformity. The separate mesh design allows for good performance at the overbeam conditions typicals in film pickup service.

The Type II antimony-tri-sulphide photoconductor is specially processed for film pickup service. The transparent signal electrode is controlled in thickness and uniformity to avoid color shading caused by optical interference effects. The photoconductors utilized in the BC4809 series are designed to meet critical criteria for image burn, lag and after image characteristics making them excellent performers for film pickup service.

## General Data

| | | |
|---|---|---|
| Heater, for Unipotential Cathode: | | |
| Voltage (AC or DC) | 6.3 ± 5% | V |
| Current at 6.3 volts | 0.1 | A |
| Direct Interelectrode Capacitance[a]: | | |
| Target to all other electrodes | 3.6 | pF |
| Spectral Response | | See **Figure 4** |
| Photoconductive Layer: | | |
| Maximum useful diagonal of rectangular image (4 x 3 aspect ratio)[d] | 16 mm | (0.63 in) |
| Focusing Method | | Magnetic |
| Deflection Method | | Magnetic |
| Dimensions | | See **Figure 7** |
| Bulb | | See **Figure 7** |
| Base | | See **Figure 7** |
| Socket | Cinch[b] 8VT (133-98-11-015), or equivalent | |
| Deflecting Yoke-Focusing Coil-Alignment Coil Assembly | Penn Tran[c] | No.1511, or equivalent |
| Operating Position | | Any |
| Weight (Approx.) | 56.6 g | (2 oz) |

2

## Absolute-Maximum Ratings[e]

| | Limiting Values | |
|---|---|---|
| For scanned area of 12.8 mm x 9.6 mm (0.5 in x 0.375 in) | | |
| Grid-No.4 Voltage[f] | 1100 | V |
| Grid-No.3 Voltage[f] | 1100 | V |
| Grid-No.2 Voltage | 350 | V |
| Grid-No.2 Dissipation | 1 | W |
| Grid-No.1 Voltage: | | |
| Negative bias value | −150 | V |
| Positive bias value | 0 | V |
| Peak Heater-Cathode Voltage: | | |
| Heater negative with respect to cathode | 125 | V |
| Heater positive with respect to cathode | 10 | V |
| Target Voltage | 50 | V |
| Dark Current | 200 | nA |
| Peak Target Current[g] | 500 | nA |
| Faceplate: | | |
| Illumination[h] | 50,000 | lx |
| | 5000 | fc |
| Temperature | 71 | °C |

## Typical Operation and Performance Data

For scanned area of 12.8 mm x 9.6 mm (0.5 in x 0.375 in) with Penn Tran No. 1511 yoke or equivalent. Faceplate temperature of 30° C to 35° C and Standard TV Scanning Rate. Operation at a highlight signal current of 300 nA and a dark current of 10 nA. Beam set to handle a peak signal current of 400 nA. Voltages, unless otherwise indicated, are taken with respect to cathode.

| | | |
|---|---|---|
| Grid-No.4 (Decelerator) Voltage[f] | 900 | V |
| Grid-No.3 (Beam-Focus Electrode) Voltage[f] | 750 | V |
| Grid-No.2 (Accelerator) Voltage | 300 | V |
| Grid-No.1 Voltage for Picture Cutoff[j] | −65 to −100 | V |
| Average "Gamma" of Transfer Characteristic for Signal-Output Current Between 20 nA and 200 nA | 0.65 | |
| Noise Current in 300 nA signal current[k] | 0.7 | nA |
| Lag | See **Figure 3** | |
| After-Image – 3 Seconds After Illumination is Removed[m, w] | < 1 | % |
| Minimum Peak-to-Peak Blanking Voltage: | | |
| When applied to grid No.1 | 75 | V |
| When applied to cathode | 20 | V |
| Amplitude Response to a 400 TV Line Square Wave Test Pattern at Center of Picture[n] | 45 | % |
| Alignment Coil Field Strength[q] | $0–4 \times 10^{-4}$ (0.4) | T (G) |

## Recommended Operation; Film Camera

| | | |
|---|---|---|
| Dark Current – Adjusted to[r,t] | 10 | nA max. |
| Target voltage to obtain 10 nA[s] | 15 to 35 | V |
| Signal-Output Current (By adjustment of illumination)[u] | 300 | nA |
| Bias light (when used to further reduce lag) | | |
| Bias light signal | 20 | nA max. (above the dark current) |

## Sensitivity Specification Conditions

| | | |
|---|---|---|
| Faceplate Illumination (Highlight)[v] | | |
| Type BC4809 | 1 | fc |
| Type BC4809/B | 20 | "blue" fc |
| Dark Current – Adjusted to[r,t] | 10 | nA |
| Performance–Signal Output Current[u]: | | |
| Type BC4809 | 90 | nA min. |
| Type BC4809/B | 130 | nA min. |

**Notes:**

a This capacitance, which effectively is the output impedance of the tube is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

b Made by Cinch Manufacturing Corporation, 1501 Morse Ave., Elk Grove Village, IL, 60007.

c Made by Penn Tran Corp., P.O. Box 508, Bellefonte, PA, 16823.

d Orientation of quality rectangle – Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and the short index pin.

e In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.

f Grid-No.4 voltage must be greater than grid-No.3 voltage. The maximum voltage difference between these electrodes, however, should not exceed 600 volts. The recommended ratio of grid-No. 3 to grid-No. 4 voltage is 0.83 in the Penn Tran 1511 assembly. For most uniform signal output with best resolution uniformity, the operator should select the ratio of grid-No.3 to grid-No.4 voltage which provides the desired performance in the deflection/focus assembly used.

g Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

h For conditions were "white light" is uniformly diffused over entire tube face.

j With no blanking voltage on grid No.1.

k The predominate noise in a video signal from a vidicon camera is generated in the video amplifier. The noise in the vidicon signal current is considerably lower than the input amplifier noise.

m For initial signal-output current of 300 nanoamperes and a dark current of 10 nanoamperes.

n Amplitude response is the signal amplitude from a given TV line number (fine picture detail) expressed as a per cent of the signal amplitude from a low frequency (large area) picture element. In practice, the large-detail reference is usually 15 TV lines with the black to white signal amplitude set equal to 100 per cent. The TV line numbers are determined by the number of equal-width black and white lines that will fit into the physical height of the image focused on the camera tube faceplate. Measurements made with the RCA P200 Test Pattern.

p The polarity of the focusing coil should be such that the north-seeking pole of a compass placed in front of the yoke assembly is attracted to the image end of the focusing coil.

q The alignment coil should be located on the tube so that its center is at a distance 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

r The target voltage for each tube must be adjusted to that value which gives the desired operating dark current. The same dark current is to be used for each tube in three- (or four) tube cameras. For film pick-up, the dark current should be as low as possible.

s Indicated range serves only to illustrate the operating target-voltage range normally encountered.

t The deflecting circuits must provide extremely linear scanning for good dark-current signal and highlight signal uniformity. Any variations in scanning velocity produce black-level and highlight signal uniformity errors in direct proportion to changes in scanning velocity.

u Defined as the component of the highlight target current after the dark-current component has been substracted.

v One fc light for BC4809 sensitivity is obtained using a 2856 K tungsten lamp; 20 "blue" footcandles of illumination is obtained by adjusting an illuminate "A" source (2856 K tungsten lamp) for 20 fc and inserting a 3 mm-BG12 Schott glass filter.

w Tested under no-bias light conditions.

> **Warning — Personal Safety Hazards**
>
> **Electrical Shock** — Operating voltages applied to this device present a shock hazard.

**Spurious Signal**

This test is performed using a uniformly diffused white test pattern that is separated into two zones as shown in **Figure 1.** The tube is operated under the conditions specified under Typical Operation and Performance Data with the lens adjusted to provide a target current of 300 nanoamperes. The tubes are adjusted to provide maximum picture resolution. Spurious signals are evaluated by size which is represented by equivalent numbers of raster lines in a 525 TV line system. Allowable spot size for each zone is shown in **Table I.** To be classified as a spot, a contrast ratio of 1.5:1 must exist for white spots and 2:1 for black spots. Smudges, streaks, or mottled and grainy background must have a contrast ratio of 1.5:1 to constitute a reject item.

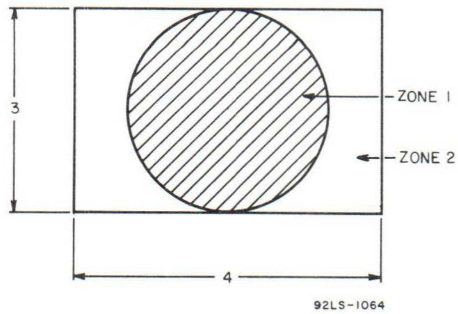



**Figure 1 — Spurious Signal Test**

**Table I**

For scanned area of 12.8 mm x 9.6 mm (1/2 in x 3/8 in)

| Blemish Size (Equivalent Number of Raster Lines) | Zone 1 Allowed Spots | Zone 2 Allowed Spots |
|---|---|---|
| over 3 | 0 | 0 |
| over 2 | 0 | 1 |
| over 1 | 1 | 2 |
| 1 or less | ▪ | ▪ |

Minimum separation between any 2 spots greater than 1 raster line is limited to 16 raster lines.

▪ Spots of this size are allowed unless concentration causes a smudged appearance.

**Operating Considerations**

The temperature of the faceplate should never exceed 71°C (160°F), either during operation or storage of the tube. Operation with a faceplate temperature in the range from about 25° to 35° (77° to 95°F) is recommended.

Dark current increases with increasing temperature. It is highly desirable to operate the tube at a steady temperature to maintain dark current as a preselected value. This mode of operation insures both optimum and stable day-to-day performance. If such provisions cannot be made, changes in target voltage may be required from time to time to maintain the desired picture quality.

As target voltage is increased, dark current also increases. The range of target voltage for various dark current levels of different BC4809's is shown in **Figure 2.** It should be noted that the range of target voltage to produce a given dark current and therefore a given sensitivity is very narrow for these tubes. Individual BC4809's will therefore have substantially identical performance characteristics when operated with an identical value of dark current. The camera should be designed to operate all three tubes in an identical manner, i.e., with equal dark currents and equal signal currents. For best and most consistent performance, the dark current should be low, about 10 nA, with the high-light signal current at 300 nA. This condition will assure best tracking of the three color signals thru a wide range of film densities with best resistance to image burn-in and minimum lag. (See Set-Up Procedure below).

Persistence or lage of the photoconductive layer is given in **Figure 3.** This curve shows the decay in signal output current from an initial value of 300 nanoamperes after the illumination is cut off. Operation with 6% bias light can reduce the lag of a vidicon tube operated in film camera service. A bias light level of 20 nA produced by uniform illumination of the faceplate can achieve the reduction in lag shown in **Figure 3.**

Spectral response of the BC4809 and BC4809/B is shown in **Figure 4.**

Horizontal square wave response is shown in **Figure 5.** A substantial reduction in both limiting resolution and amplitude response will be obtained if the operating voltages of grid No.4 and grid No.3 are decreased below those specified under "Typical Operation". The ratio of grid-No.3 to grid-No.4 voltage should always be adjusted for optimum performance for the deflection/focus components used.

The power dissipation at grid No.2 should not exceed one watt, a condition normally met when the tube is operated at the specified maximum grid-No.2 rating and when the specified peak target current rating is not exceeded. However, if the tube is operated continuously with grid-No.1 voltage at or approaching zero bias, grid-No.2 voltage should not exceed 350 volts dc maximum.

**Signal-output and Light Transfer Characteristics**

Typical signal output as a function of uniform illumination on the photoconductive layer for different values of dark current is shown in **Figure 6.**

The average "gamma", or slope, of the light transfer characteristic curves shown in **Figure 6** is approximately 0.65 and is relatively independent of wavelength in the visable spectrum. Close uniformity in the value of gamma between individual BC4809's is maintained to insure satisfactory operation of color film cameras in which the signal-output currents of the three BC4809's must match closely over a wide range of scene illumination.

The processing amplifier should provide an additional 0.7 power law correction to produce proper tonal rendition of normal color film.

Uniformity of the photoconductive layer is excellent. When the tube is operated with the recommended focus and deflection components, signal output over the entire picture area is also very uniform. When other components are employed, beam-landing errors at the target may contribute to poor signal uniformity or "shading" characteristics in the generated picture. In such instances, compensation for the beam-landing errors to achieve uniform sensitivity can be obtained by supplying a modulating voltage of a suitable waveform to the cathode of the tube. The modulating waveform should contain parabolic components of both the horizontal and vertical scanning frequencies.

Proper-size scanning of the photoconductive target area should be used. Both overscanning and underscanning impair performance. Overscanning, which produces a smaller-than-normal picture on the monitor, adversely affects corner resolution, signal uniformity, and geometrical accuracy. Underscanning, which produces a larger-than-normal picture on the monitor, should never be permitted as it may cause a permanent change in sensitivity and dark current of the underscanned area with a resulting loss in resolution and sensitivity. An underscanned area showing such a change will be visible when proper-size scanning is restored.

Failure of scanning even for a few seconds may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the tube during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. This protection can be achieved by increasing the grid-No.1 voltage to cutoff, biasing the target negatively, or by removing grid-No.4, grid-No.3, and grid-No.2 electrode voltages. Circuits should be incorporated to perform one or more of these functions automatically the instant scanning power fails or is reduced to an abnormally low value.

**Set-Up Procedure and Operation**

For set-up and operating conditions refer to Application Note AN-5012A, Sulfide and SATICON Vidicon Tubes in Television Film Camera Service. Copies are available by writing RCA, Box 3200, Somerville, NJ 08876.

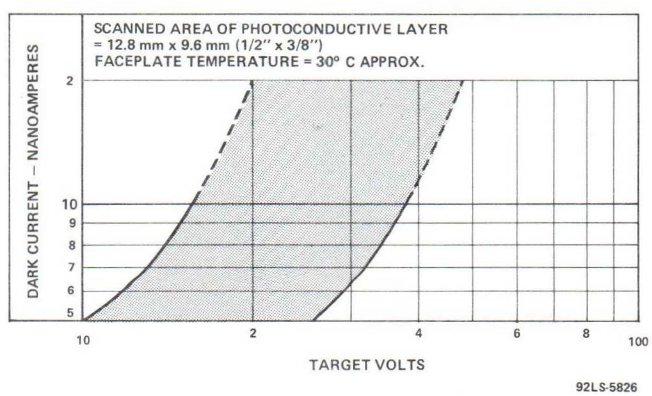



**Figure 2 – Range of Dark Current**

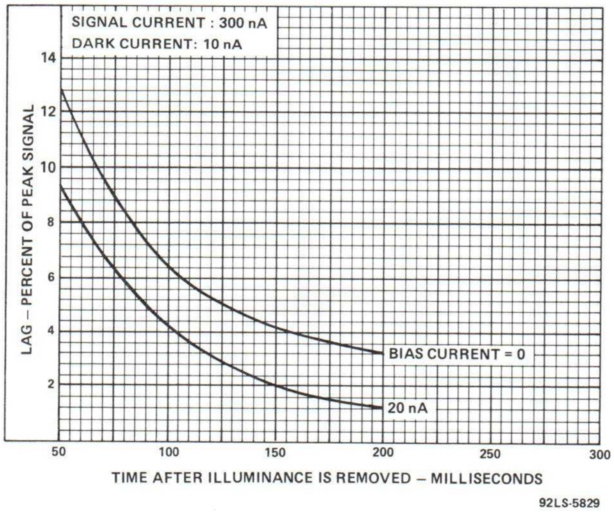



Figure 3 – Typical BC4809 Lag Reduction Obtained With Suitable Bias Lighting.

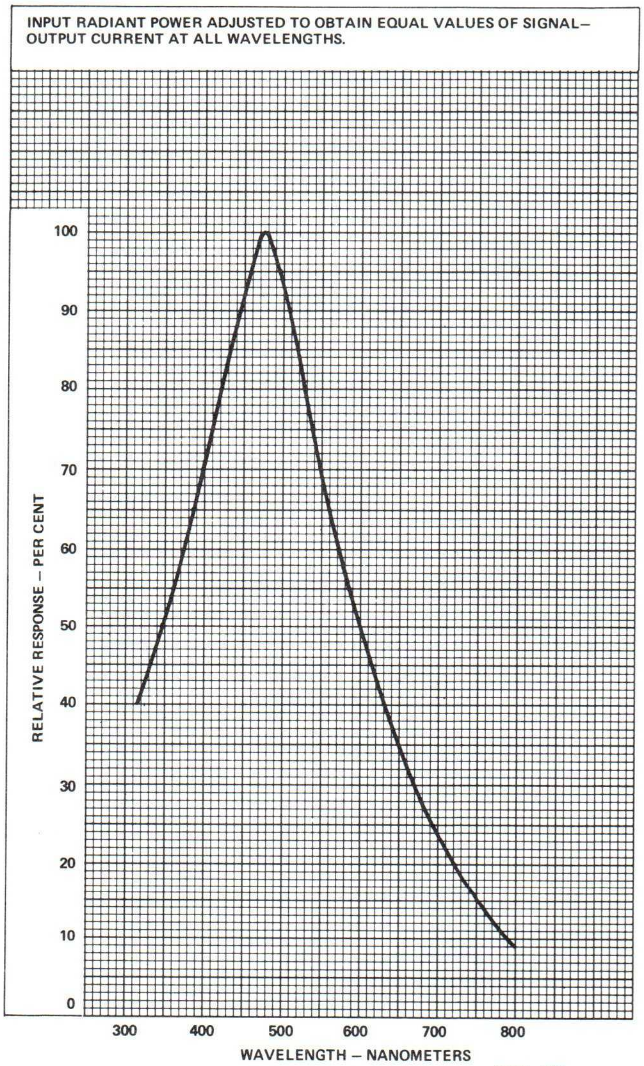
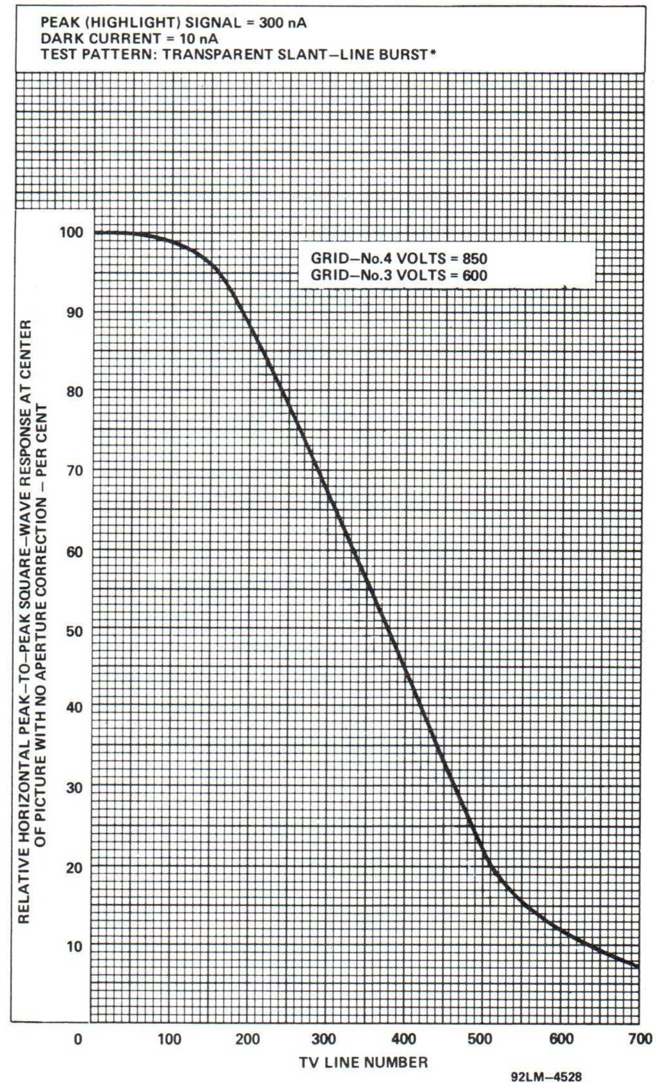



Figure 4 – Typical Spectral Response




*Amplitude response measured using the RCA P200 slant-line burst pattern with horizontal center response balanced on the 400 line chevrons.

Figure 5 – Horizontal Square Wave Response

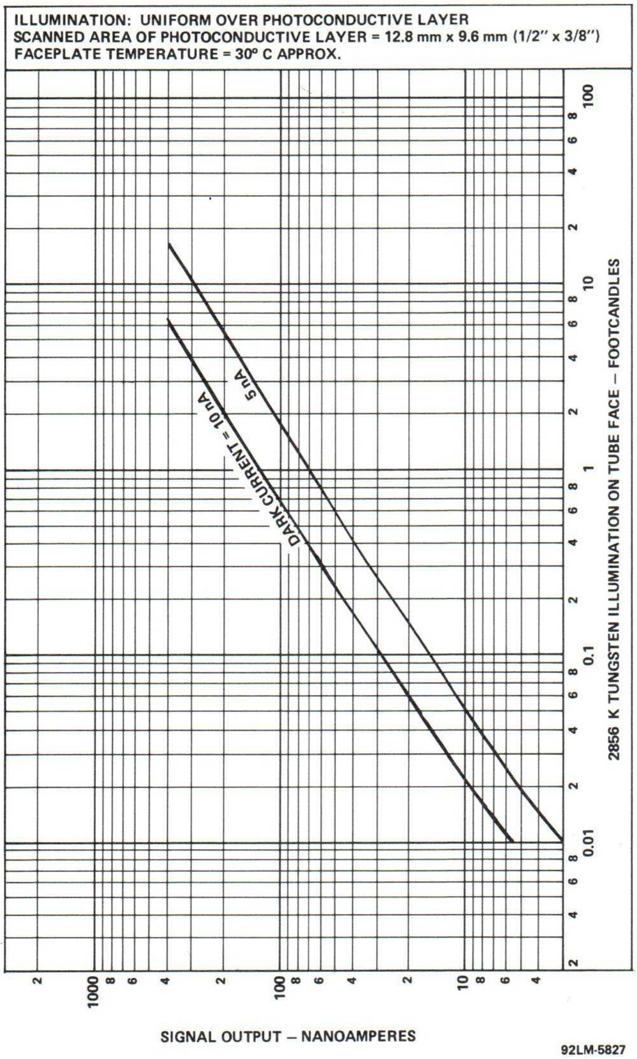
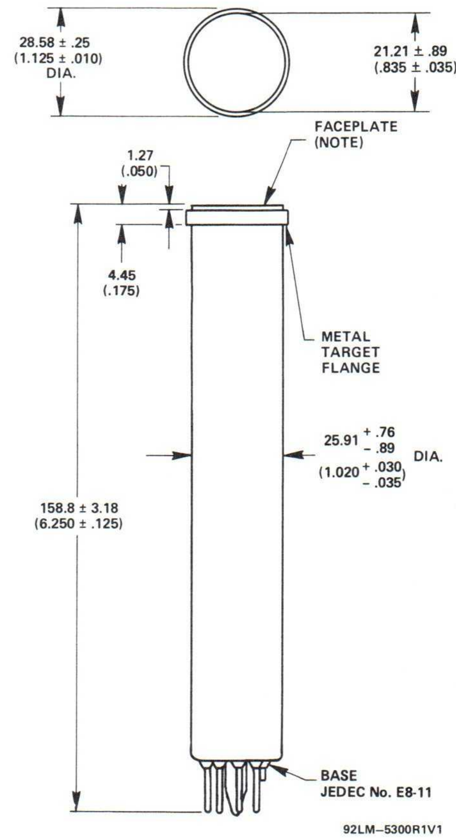



**Figure 6 – Light Transfer Characteristics**

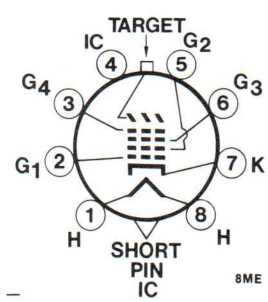



**Note:** Faceplate glass is Corning No. 7056 having a thickness of 2.39 ± 0.30 (0.094 ± 0.012).

Dimensions in millimeters, dimensions in parentheses are in inches.

**Figure 7 – Dimensional Outline**

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Grid No.4
Pin 4: Internal Connection – Do Not Use
Pin 5: Grid No.2
Pin 6: Grid No.3
Pin 7: Cathode
Pin 8: Heater
Flange: Target
Short Index Pin: Internal Connection – Make No Connection



L-870

# 25-mm (1") Diameter SATICON® * Vidicon For Broadcast TV Color Film Pickup Cameras

- **Amplitude Response at 400 TV Lines — 45% typical**
- **Low Dark Current — 0.3 nA typical at target voltage of 50 volts**
- **Very Low Lag — 2% typical for 500 nA signal and 15 nA bias-light current after 50 ms**
- **Low Reflectivity Selenium Arsenic Tellurium Photoconductor**
- **Precision Construction for Easier and More Accurate Registration**
- **Unity Gamma for Predictable Contrast and Colorimetry**

RCA BC4909 is a 25-mm (1") diameter, magnetic focus and deflection SATICON camera tube having separate-mesh construction and a low-power 0.6 watt heater. It is intended for use in 3- or 4-tube broadcast TV color film cameras employing bias light, exposure control in the optical system, and adequate gamma correction range.

The SATICON vidicon is superior to the sulfide vidicon in film service: it produces substantially less lag when using high-contrast, or high-density, color film; it maintains high-resolution at the beam currents used in film service in a manner that is equivalent to, or better than, that of the sulfide vidicon; and its photoconductor produces sharper and more definitive color transitions and much less flare into the low lights of the signal in the presence of picture highlights. The latter advantage is due to minimal light scattering from or within the photoconductor.

The spectral response of the SATICON vidicon is especially suited to color TV pickup. Spectral sensitivity is high in the blue and negligible in the infrared regions of the spectrum.

The BC4909 is directly interchangeable with most 25-mm, separate-mesh, low heater power vidicons. However, the BC4909 operates at fixed sensitivity, i.e., fixed target voltage. At its recommended target operating voltage of 50 volts, the sensitivity of the BC4909 is much higher than that of the sulfide vidicon under normal color TV film camera operating conditions. This higher sensitivity allows a reduction in projector lamp voltage or power to extend the normal life of the lamp.

## General Data

| | | |
|---|---|---|
| Heater, for Unipotential Cathode: | | |
| Voltage (AC or DC) | 6.3 ± 5% | V |
| Current at 6.3 volts | 0.095 | A |
| Direct Interelectrode Capacitance: | | |
| Target to all other electrodes | 4.6 | pF |
| Photoconductive Layer: | | |
| Maximum useful size of rectangular image | 12.7 mm x 9.5 mm (0.5 in x 0.375 in) | |

Orientation of quality rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.

| | |
|---|---|
| Focusing Method | Magnetic |
| Deflection Method | Magnetic |
| Operating Position | Any |

## Maximum and Minimum Ratings, Absolute-Maximum Values[a]

For scanned area of 12.7 mm x 9.5 mm (0.5" x 0.375")

| | Min. | Max. | |
|---|---|---|---|
| Grid-No.4 Voltage ($V_{G4}$)[b] | $V_{G3}$ | 1000 | V |
| Grid-No.3 Voltage ($V_{G3}$)[b] | – | 1000 | V |
| Grid-No.2 Voltage ($V_{G2}$) | – | 750 | V |
| Grid-No.2 Current[c] | 1000 | – | μA |
| Grid-No.1 Voltage ($V_{G1}$) | –300 | 0 | V |
| Peak Heater to Cathode Voltage | –125 | 50 | V |
| Target Voltage | – | 80 | V |
| Faceplate: | | | |
| Illuminance[d] | – | 50 | lm/ft² |
| | – | 540 | lux |
| Temperature[e] | – | 50 | °C |

*Used by permission of trademark owner.

## Typical Operating Values for Film Camera Operation

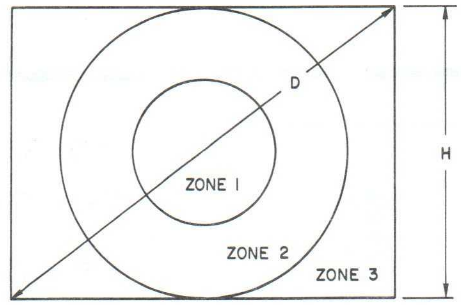
With the tube operated in a Penn Tran Assembly type 1511●, or equivalent, a scanned area of 12.7 mm x 9.5 mm (0.5" x 0.375"), a faceplate temperature of 25° to 35° C; and a standard CCIR "M", or EIA, TV scanning rate (525 lines, interlaced 2:1, frame time 1/30 second).

| | | |
|---|---|---|
| Faceplate Illuminance in Each Channel: | | |
| Light flux equivalent to specified 2856 K "white" illuminance level of | 13 / 1.2 | lux / lm/ft$^2$ |
| Grid-No.4 Voltage[b] | 900 | V |
| Grid-No.3 Voltage[b] | 750 | V |
| Grid-No.2 Voltage | 300 | V |
| Target Voltage[f] | 50 | V |
| Peak-to-Peak Signal Current | 500 | nA |
| Peak-to-Peak Beam Current[g] | 1000 | nA |
| Minimum Peak-to-Peak Blanking Voltage: | | |
| When applied to grid No.1 | 75 | V |
| When applied to cathode | 20 | V |
| Field Strength at Center of Focusing Coil | 68 | G |
| Field Strength of Adjustable Alignment Coil | 0 to 4 | G |

## Typical Performance Data

For the conditions shown under Typical Operating Values

| | | |
|---|---|---|
| Grid-No.1 Voltage for Picture Cutoff[h] | –45 to –100 | V |
| Average "Gamma" of Transfer Characteristic for Signal Output Between 20 nA and 400 nA | 1.0 | |
| Lag—Per Cent of Initial Value of Signal Output After Illuminance is Removed:[j] | | |
| For 500 nA signal current and 15 nA bias-light current — | | |
| Typical value after 50 ms | 2 | % |
| Typical value after 150 ms | 0.4 | % |
| Amplitude Response to a 400 TV Line Per Picture Height Square-Wave Test Pattern (RCA P200, transparent slant-line burst test chart): | | |
| At center of picture — | | |
| Typical value | 45 | % |
| Sensitivity:[k] | | |
| For 2856 K "white light" | 365 | µA/lm |
| For 2856 K "white light" incident of specified filter — | | |
| Blue (BG12) | 42 | µA/lm |
| Green (VG9) | 125 | µA/lm |
| Red (OG570) | 125 | µA/lm |
| Dark Current: | | |
| Typical value | 0.3 | nA |
| Maximum value | 0.5 | nA |
| Geometric Distortion: | | |
| Maximum value | 0.6 | % |
| Shading (Uniformity): | | |
| White level — | | |
| Variation of highlight signal (per cent of maximum highlight signal) | | |
| Maximum value | 15 | % |
| Microphonic Duration:[m] | | |
| Maximum value | 5 | s |




D — Active Target Diameter
H — Raster Height (4 x 3 Aspect Ratio)
Zone 1 — Diameter = H/2, Area ≈ 45%
Zone 2 — Diameter = H, Area ≈ 45%
Zone 3 — Peripheral Area ≈ 40%

**Figure 1 — Spurious Signal Zones**

## Spurious Signal Test

This test is performed with the tube carefully focused on a uniformly illuminated test pattern which identifies the zones as pictured in **Figure 1**. The tube is operated in accordance with "Typical Operating Values" and illuminance is adjusted to provide a highlight reference signal current of 200 nanoamperes. After completion of the setup adjustments, light is excluded and the picture examined to locate and measure bright spots. Thereafter, reference level illuminance is applied and the picture examined for additional spots and blemishes other than bright spots.

**Blemishes:** Blemishes are defined as either bright spots and/or smudges whose contrast exceeds 8% of the 200 nanoampere reference signal. The size of spots or smudges (diameter, or length plus width divided by two) is measured in terms of the pitch of the raster lines in a 525-line system.

The allowable blemishes are shown in Table I which defines the acceptable distribution by zones and size.

**Table I**

| Blemish Size (Equivalent Scan Lines) | Zone 1 Allowed Spots Total | Zone 1 & 2 Allowed Spots Total | Zone 1, 2 & 3 Allowed Spots Total |
|---|---|---|---|
| Over 4 | 0 | 0 | 0 |
| Over 3 | 0 | 0 | 1 |
| Over 1 | 0 | 1 | 2 |
| 1 or smaller | * | * | * |

*Spots of this size are allowed unless concentration causes a smudged appearance.

Minimum separation between 2 spots greater than 1 raster line is limited to 16 raster lines.

●The magnetic component No.1511 is made by Penn-Tran Corp., 1155 Zion Road, Box 508, Bellefonte, PA 16823.

a The Maximum Ratings in the tabulated data are established in accordance with the Electronic Industries Association Standard RS-239-A, formulated by the JEDEC Electron Tube Council.

b Grid-No.4 voltage must always be greater than the grid-No.3 voltage. The recommended ratio of grid No.3 to grid No.4 voltage for the specified assembly is 0.83. For other magnetics the criterion for the best ratio is a compromise between that which gives best signal uniformity, best resolution uniformity, and best picture geometry in all areas of the picture. It should be noted that very low G3/G4 ratios can introduce pin-cushion distortion.

c With grid-No.1 voltage equal to 0 volts.

d For uniformly diffused "white light" over the entire tube face. Exposure to specular highlights having an illuminance as high as 21,500 lux (2,000 $lm/ft^2$) for a period of 20 seconds, however, will not damage the tube.

e The tubes may be operated for short periods of time (up to an hour) at temperatures as high as 65° C. Although the tubes should be stored at temperatures of 30° C, or below, storage for about 3 to 5 hours at ambient temperatures of up to 60° C is allowed, and for periods up to one week, storage at 45° C is permitted.

f The target voltage should be set precisely to 50 volts. Operation at lower target voltage adversely affects the performance capabilities of the tube while operation at higher target voltage reduces tube life. Target voltage is defined as the difference between the voltage applied to the target and the voltage on the cathode during active scanning.

g Grid No.1 is adjusted to provide this beam current value.

h For no blanking voltage on grid No.1 and for a grid-No.2 voltage of 300 volts.

j Beam current is set to accomodate a signal current of 1000 nA.

k The light source is a tungsten-filament lamp having a lime-glass envelope. The lamp is operated at a color temperature of 2856 K. The sensitivity values are the quotient of the signal current to the unfiltered light flux incident on the filter specified below and, for "white light", the quotient of the signal current to the unfiltered light flux incident on the tube faceplate.

Red filter – Schott, OG570, 3 mm thick
Green filter – Schott, VG9, 1 mm thick
Blue filter – Schott, BG12, 3 mm thick

In the U.S.A., Schott filters are available from Fish-Schurman Corporation, 70 Portland Road, New Rochelle, NY 10802.

m For slight shock applied directly to tube.

n Defined as the component of the highlight target current after the dark-current component has been subtracted.

**Operating Considerations**

Bias light requirements for the BC4909 are modest. A bias light level sufficient to produce a 15 to 30 nanoampere signal (3 to 6% of the highlight signal) is all that is needed to provide very fast rise time with changing illuminance and to reduce any retained image to a negligible level. Bias light should be adjusted to produce equal signals in all channels. Higher levels of bias light may be used consistent with acceptable uniformity of background signal produced by the bias light.

Light levels in the different channels of the color camera should be adjusted to produce approximately 450 to 500 nanoampere highlight signal currents in each channel. Beam reserve should be set no higher than that needed to assure proper operation of automatic control circuitry or to accomodate unavoidable small highlights in a picture that exceed the normal average highlight signal and no greater than that necessary to handle 1000 nA of peak signal current.

The camera should be checked to insure that the target voltage is precisely 50 volts. This voltage is the DC voltage difference between the voltage on the target and the voltage on the cathode during active scan time.

The BC4909 has a linear light input-signal output characteristic, i.e., a "gamma" of unity. The gamma amplifiers of the video signal processing system should be capable of providing a 0.4 to 0.5 power law correction of the video signal to assure proper tonal values in both hue and brightness of the color picture.

Test slides or stationary patterns should not be projected on the faceplates of the tubes when the camera is in standby operation with the beam cutoff or when the camera is turned off.

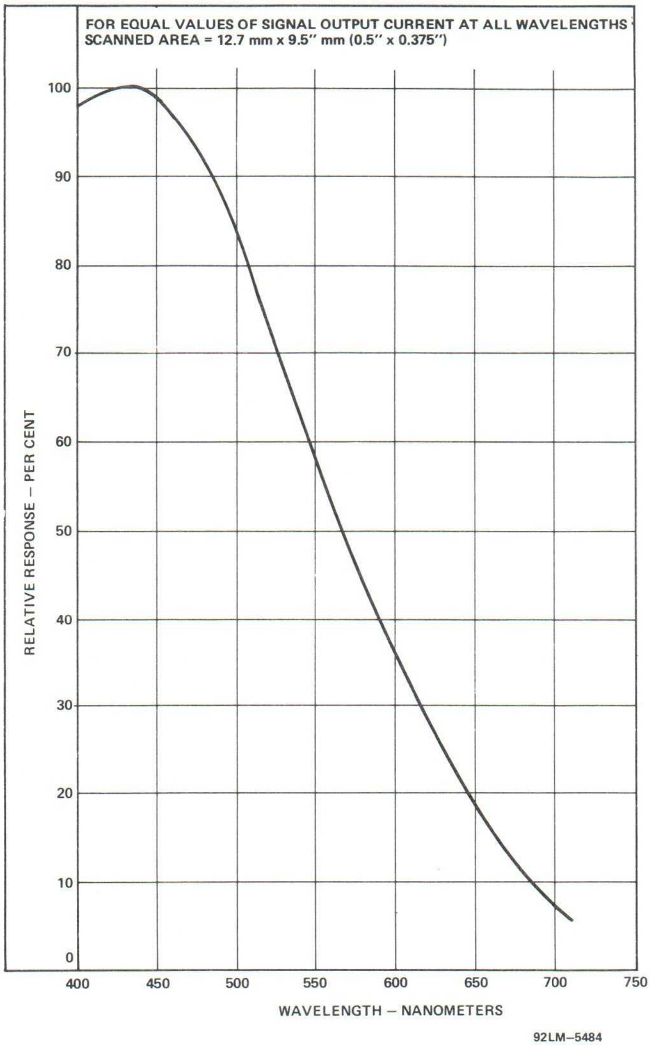



Figure 2 – Typical Spectral Response Characteristic

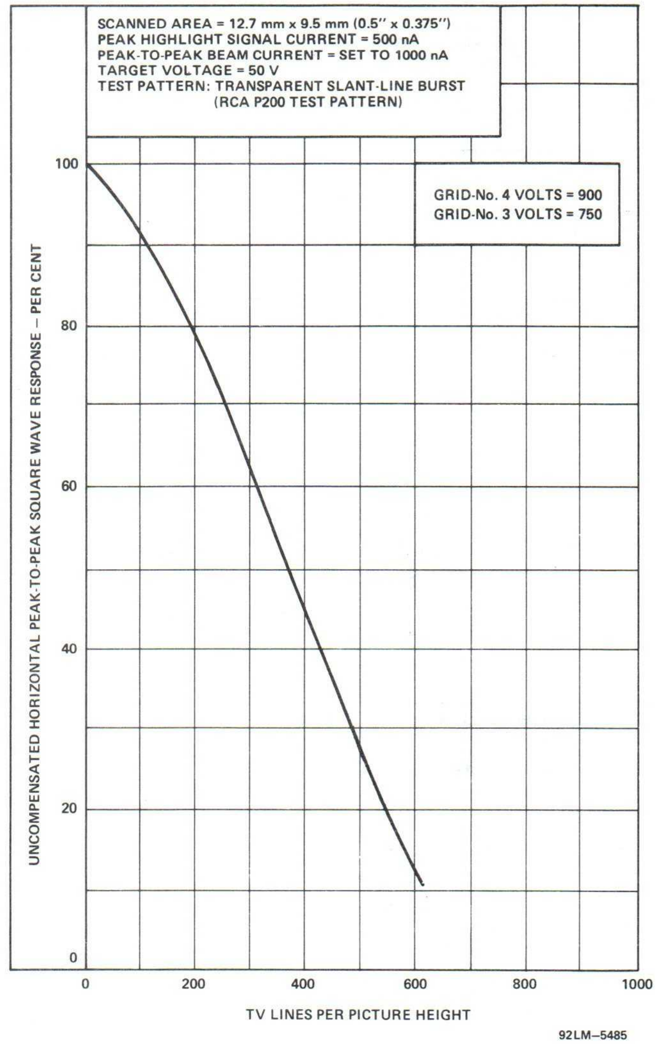



Figure 3 – Horizontal Square-Wave Response

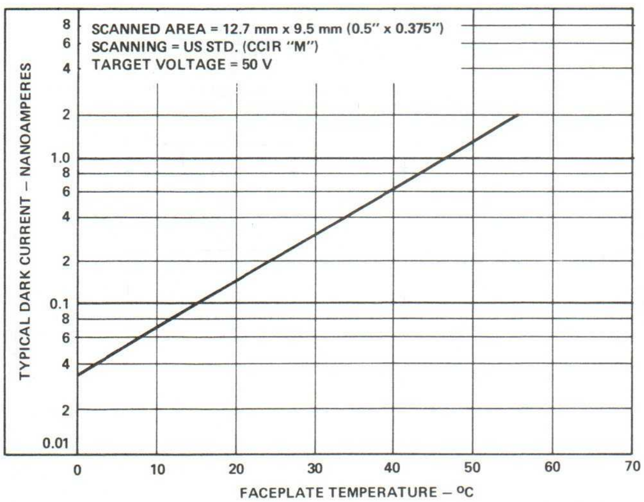



**Figure 4 – Typical Dark Current as a Function of Tube Faceplate Temperature**

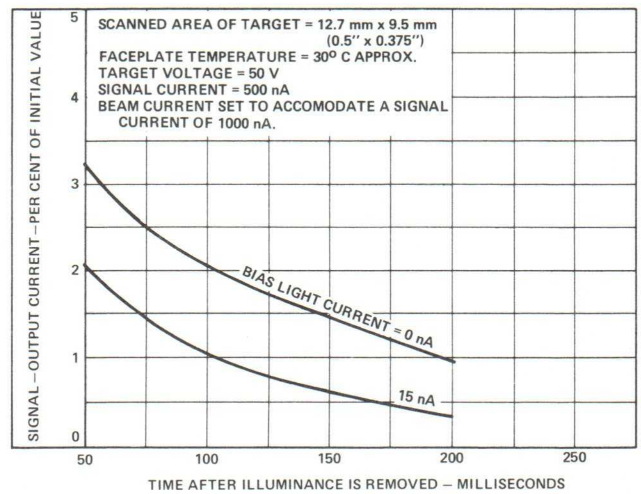



**Figure 6 – Typical Persistence (Lag) Characteristics**

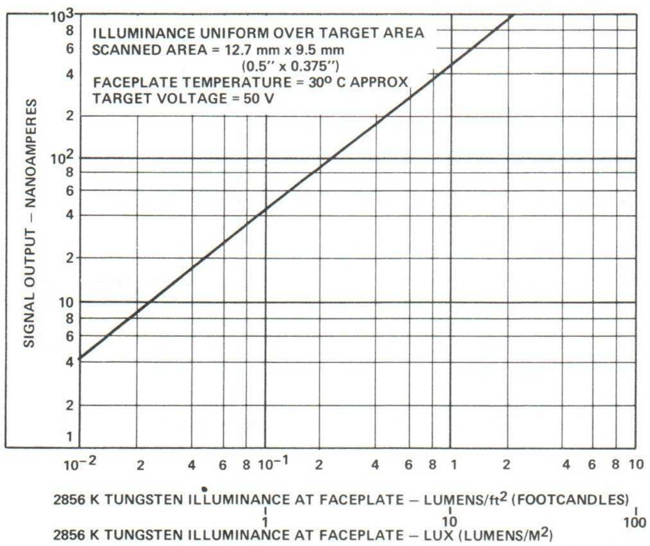



**Figure 5 – Typical Light Transfer Characteristic**

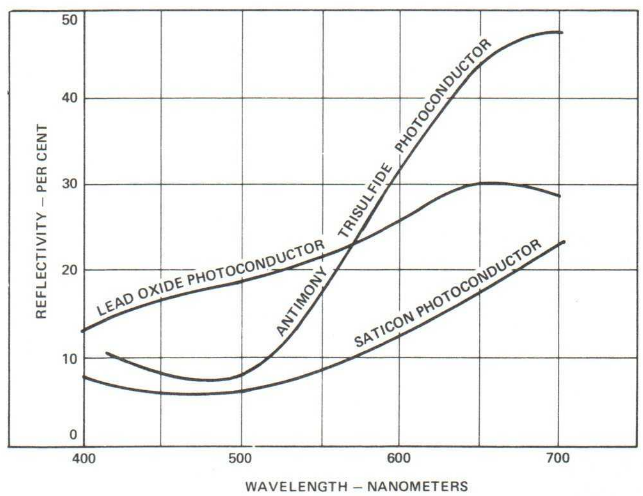
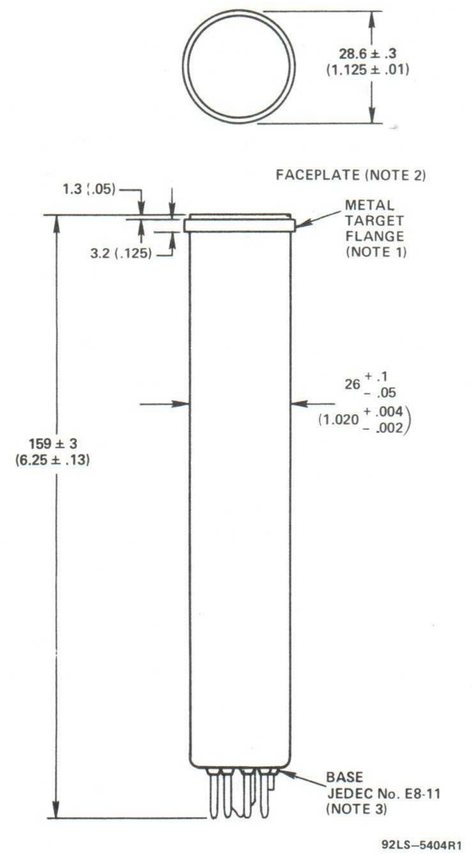



**Figure 7 – Spectral Reflectivity as a Function of Wavelength for Antimony Trisulfide, Load Oxide, and SATICON Photoconductors**




Dimensions in millimeters. Dimensions in parentheses are in inches.

**Note 1** — The target connection is made by a suitable spring contact bearing against the edge of the metal target flange.

**Note 2** — Faceplate index of refraction is 1.505. Faceplate thickness is 2.39 mm ± 0.2 mm.

**Note 3** — A typical socket for use with this vidicon is the Cinch type 8VT (133-98-11-015), or equivalent.

**Figure 8 — Dimensional Outline**

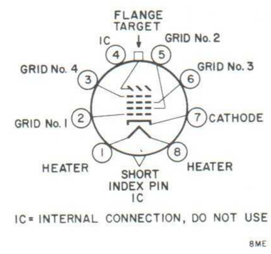



**Figure 9 — Basing Diagram, Bottom View**

Camera Tubes

Application Note
AN-5012A

# Sulfide and SATICON Vidicon Tubes in Television Film Camera Service

by

R. G. Neuhauser

RCA|Solid State Division|Electro Optics and Devices|Lancaster, PA 17604

# Table of Contents





Printed in USA/2-78

# Introduction

Significant improvements in sulfide (antimony trisulfide) vidicon camera tubes have been attained since these devices were first used in television film pick-up service. Present-day vidicons have better resolution, improved signal uniformity, and increased sensitivity. Moreover, there are types now available that are specially designed or selected for use in specific camera systems. Consequently, the performance of older TV cameras, and sometimes even of the newer ones, can be improved by the use of one of the newer vidicon types.

In addition to sulfide vidicons, this Note covers the SATICON® * vidicon, an improved camera tube specially suited for film service. These types, although more expensive than most sulfide vidicons, have a selenium-arsenic-tellurium photoconductor that improves the lag characteristics when high-contrast film is used. Resolution is equal or superior to that of sulfide vidicons. SATICON vidicons can be used to replace many other vidicon types in color film cameras, including 25-mm lead oxide types, where they will produce a substantial improvement in both color fidelity and resolution.

This Note describes the basic principles of vidicon operation and outlines the techniques used in vidicon film camera set up. 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. Sulfide vidicons and SATICON vidicons are covered in separate sections. A section is also included covering the solution of film pick-up problems caused by differences in film density ranges. The final section in this Note is a comprehensive guide to the selection of the best vidicon for a particular film camera. This last section may also be helpful as a general source of information in the design of new vidicon-type film cameras.

As a basic reference, schematics showing the major components of typical three-tube and four-tube color film television cameras are given in Fig. 1.

# Performance of Sulfide Vidicons in Television Film Camera Service

The performance of television film cameras using sulfide vidicons depends on a number of vidicon operating factors that are under the control of the camera user. These factors, together with the camera electronic and optical factors, are listed below and then discussed in the subsequent pages of this Note.

**Vidicon Operating Factors**

Illumination
Dark Current
Signal Levels
Equal Signal Currents
Beam Current Setting
Beam Alignment
Registration

**Camera Electronic Factors**

Focus and Deflection Components
Gun Voltages
Video Amplifiers

**Camera Optical Factors**

Projector Lamp Color Temperature
Light-Scattering Effects
Infrared Radiation Effects
Light Polarization Effects
Orientation and Size of Optical Image

*Used by permission of trademark owner.

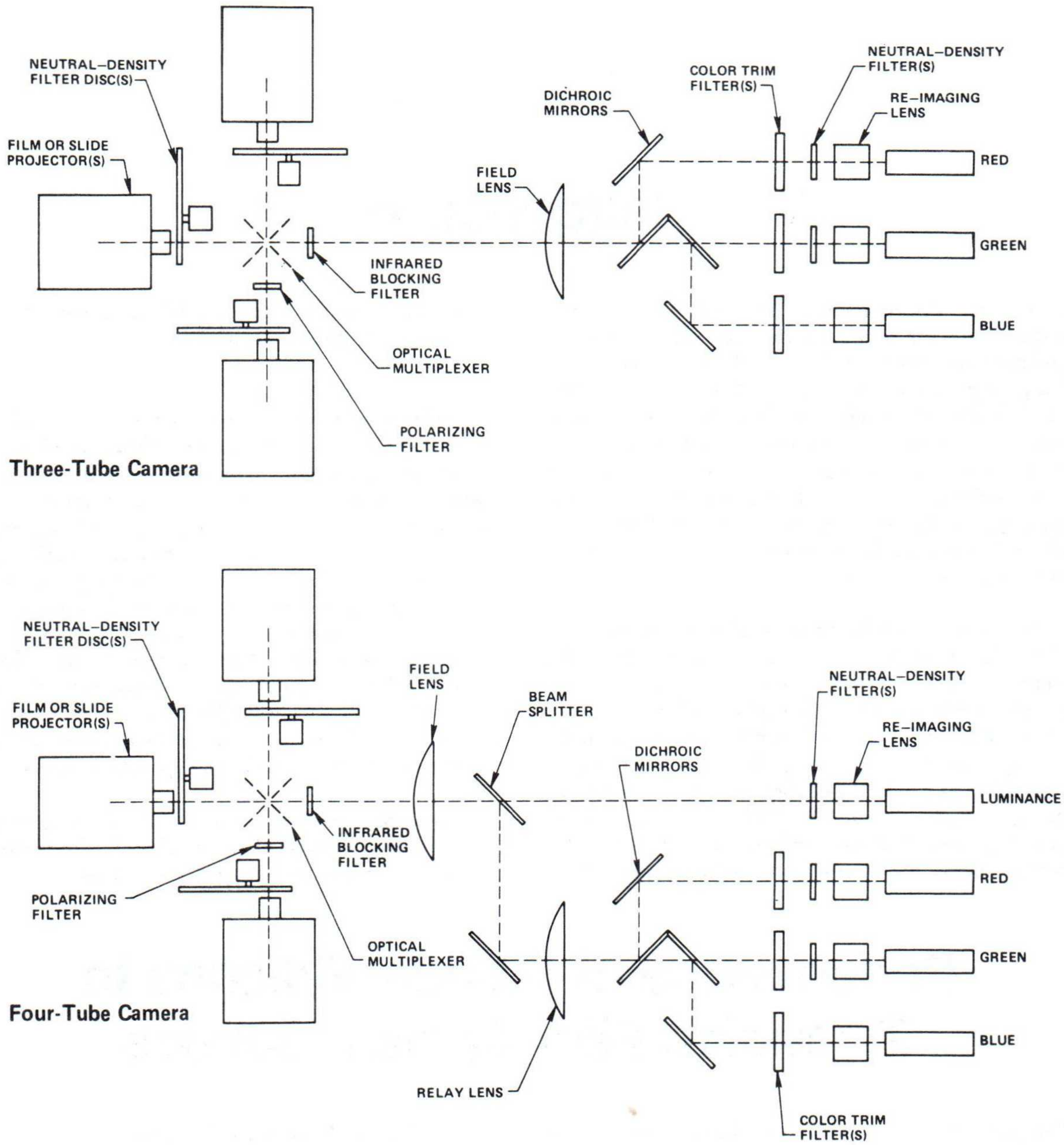



*Fig. 1 – Schematic diagrams of typical three-tube and four-tube color television cameras for film pickup showing major electrical and optical components.*

# Vidicon Operating Factors

## Illumination Requirements

**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 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.

## Dark Current, Lag, and Image Retention

**Dark Current**, as implied, is the signal produced with no illumination on the photoconductor of the vidicon. Operation at low dark current levels reduces lag (the signal persistence after 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 be achieved only if the vidicon is provided with suitable illumination levels.

Dark current is controlled by adjustment of the target voltage. 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. Fig. 2 and Fig. 3 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. The characteristics of

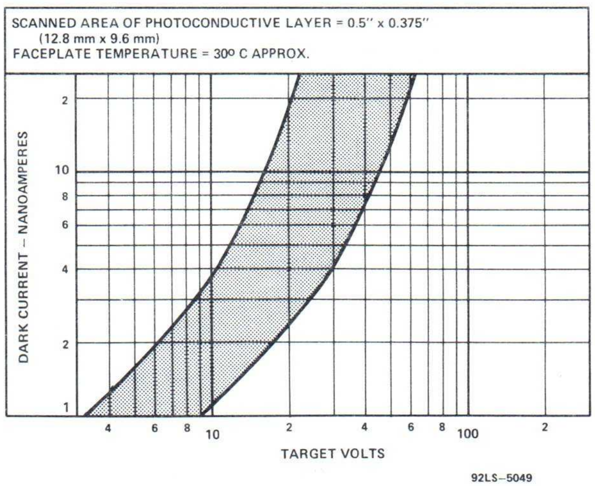



*Fig. 2 – Dark current as a function of target voltage for vidicons using RCA photoconductor Type I.*

Photoconductors Type I and Type II are given in a subsequent section, **Characteristics of Sulfide Vidicons.** 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 for adjusting target voltage are given in a following section.

The curves of Fig. 4 illustrate typical reductions in lag and vidicon dark current that can be attained by increasing 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.

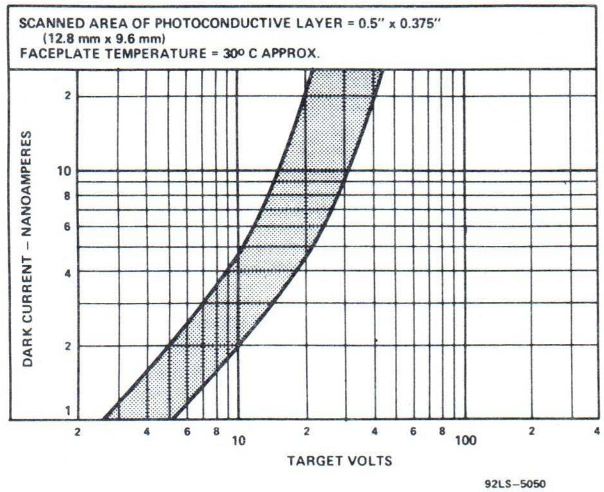



*Fig. 3 – Dark current as a function of target voltage for vidicons using RCA photoconductor Type II.*

Lag of a film-camera vidicon can also be reduced by bias-lighting methods. Bias lighting is the illumination of the vidicon faceplate with a uniform and controlled light level sufficient to produce a signal level of 10 to 20 nanoamperes above the dark current level, i.e., a signal level of about 3% to 6% of the peak video signal. Fig. 5 illustrates typical reductions in lag obtainable when suitable bias lighting is employed. This technique should be considered in new camera designs.

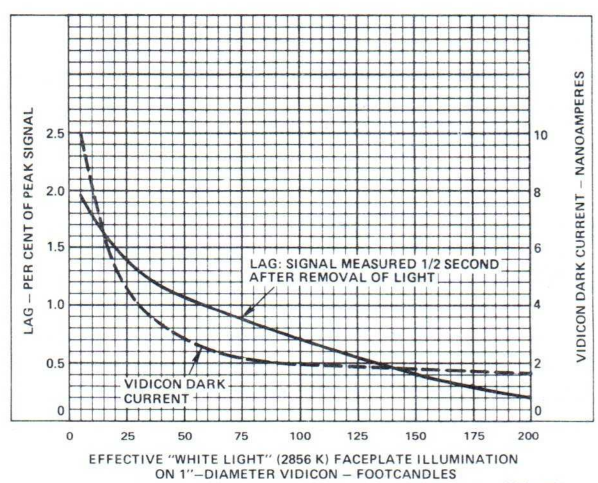



*Fig. 4 – Typical lag and dark current as functions of the faceplate illumination required to produce a 300-nA signal at each dark current setting for a typical Type II photoconductor.*

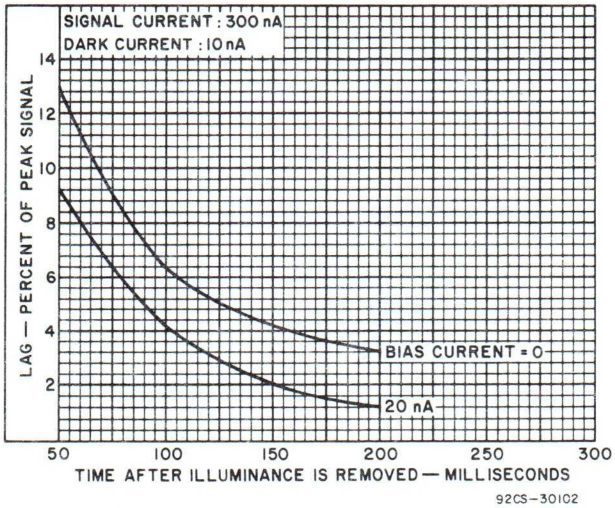



*Fig. 5 — Typical vidicon lag reduction obtained with suitable bias lighting.*

## Highlight Signal Levels and the Relation to Lag and Noise

**Highlight signal current** from a vidicon is usually about 300 nanoamperes. Operation at signal currents in excess of 500 nanoamperes produces poorer resolution and may diminish tube life. At lower signal currents (below 300 nanoamperes), lag and image retention may become a problem. Lag and image retention produce time-diminishing signals and their picture impairment (subjective and measured) 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 system noise is generated in the first stages of the video amplifier. When signal-to-noise problems are encountered, they are the result of either low signal output from the vidicon or high noise level from the input amplifier stage.

## Measuring Current Levels (Signal, Dark, Bias Light)

Most film cameras have a provision for calibrating 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 with 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, illustrated in Fig. 6, as the vidicon beam is turned off and on. The dark current should preferably 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).

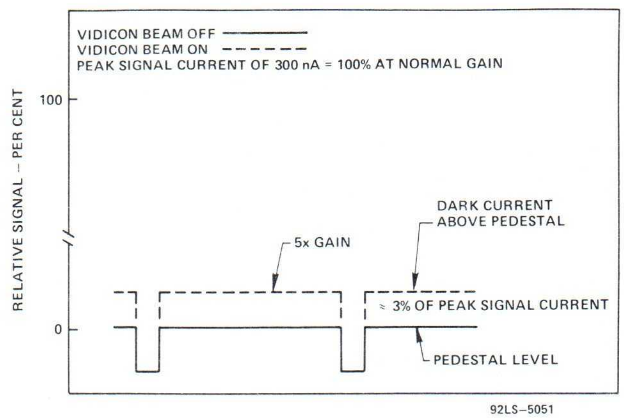



*Fig. 6 — Illustration of pedestal shift obtained with dark-current signal-measurement technique as observed on a waveform monitor.*

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 with a calibrated oscilloscope gain increase of 5x or 10x after the peak signal current level is established.

**Bias light current** levels are measured with the same instrumentation method as for dark current, except that the bias light is turned off and on instead of the beam current. 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 these measurements.

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 at the end of the next Section.

## Signal 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 because it generally produces color shading problems. As a practical matter, the signal balancing procedure is performed with that projector in the system that has the least light output and with a neutral density filter 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.

**Light Control Systems.** 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 should take place after these cameras have been set up and adjusted as described in the next Section, "**Typical Set-Up Procedure for Color Cameras Using Sulfide Vidicons**". The light control system used to accomodate the variations in film densities is an adjustable neutral-density filter wheel placed in the camera optical path. This wheel is either manually or automatically controlled to maintain the desired signal output level. During the set-up procedure described in the next Section, the neutral-density filter wheel is adjusted to simulate the most dense film expected in normal use. With this system of control, the vidicon tubes are always exposed to the same light levels.

In black-and-white film cameras because a constant color of illuminating light is not needed, projector lamp brightness can be varied by controlling the lamp voltage.

**Target-Voltage Control Systems.** Color film cameras designed to automatically vary target voltage (sensitivity) to compensate for differences in film density or projector light level will have good signal tracking over a wide range of light level or film density only if the target-voltage-control system varies the target voltage on each vidicon proportionally to produce equal dark currents and equal signal currents throughout the range of target voltages needed to accomodate the variations in film densities. Cameras having this method of sensitivity control should initially be set up for equal dark currents and equal signal currents using a neutral-density filter to simulate the most dense film that may be encountered. To simulate high-transmission film, the filter is removed after the initial set-up and the automatic target-voltage-control system is re-adjusted to again 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-voltage 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 image burn and lag are at a minimum.

## 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 20 per cent signal level (after gamma correction) to handle peak signal excursions.

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

## 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 then adjusted to produce the highest signal output consistent with best signal uniformity. The target voltage should then be restored to its normal operating value.

Alignment should always be performed after the proper beam current setting is established. Failure to align the beam properly usually results in poorer resolution and decreased uniformity of resolution and signal. It may also produce geometric distortions that can cause registration problems in color cameras.

### Registration

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 because they produce color errors at the picture edges. 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 caused by residual magnetism in metal parts close to the vidicons. These residual fields can be eliminated with a degaussing coil and the techniques used for degaussing color picture tubes.

## Camera Electronic Factors

### Focus and Deflection Components

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

### 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 specify tube operating voltages. These voltages should be checked regularly with a high-impedance meter as part of the 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 reduces tube life by nearly one-half. Heater voltage should be checked with the vidicon load on the supply.

### Video Amplifiers

Video amplifiers generate virtually all the noise in the camera system. Because the signal-to-noise ratio is the ratio of the highlight signal current to the amplifier noise, when excessive noise is encountered the first thing that should be checked is to see if the proper highlight signal current is being used. Then, the input stage of the preamplifier should be checked for proper operation.

# Camera Optical Factors

## Projector Lamp Color Temperature

White and color signal balance can be maintained only 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 over-all system sensitivity and the ability to handle a wide range of film densities. It should be noted that as lamps age, a shift in color temperature can occur.

## Light-Scattering Effects

Poor grey-scale tracking, a common problem 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 can cause 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 a particular channel. Adjustable gamma controls are sometimes used to compensate for this problem, but where possible, the defect should be corrected in the maintenance procedures. Some cameras of more advanced design utilize flare-control circuitry that will vary the individual black level of each channel slightly in response to the average signal in the channel to compensate for light-scattering effects.

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

## Infrared Radiation Effects

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, color distortion and tracking problems sometimes result. 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 over-all sensitivity of the camera.

Infrared problems, however, are not necessarily confined to the red channel. Because some blue and green filters used in film camera systems do not sufficiently attenuate the infrared light, it is sometimes necessary to add IR blocking filters in the blue and green channels to correct color fidelity errors if such filters are not included in the projector optical system.

## 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 caused by polarization effects in the projector or in the camera optical system. These effects can be identified and corrected by means of a polarizing filter placed in the common optical path and rotated until the signal levels remain balanced as the light source is switched from one projector to another. A polarizing filter, however, reduces the camera sensitivity by a factor of two or more and should be used only 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. In some cases an appropriate color-correcting filter can be used in the light path of the projector exhibiting these characteristics. Such a filter will reduce the over-all light much less than will a polarizing filter.

## Scan Size and Location on Photoconductor

The size of the image and its location on the vidicon photoconductor have a noticeable effect on camera performance. Proper picture image size is that size specified for the camera. An image 12.8 mm x 9.6 mm (0.5" x 0.375") is recommended for 25-mm (1") vidicons and 15.2 mm x 20.33 mm (0.6" x 0.8") for 38-mm (1-1/2") vidicons. Failure to scan the recommended image format precisely at the vidicon photoconductor center usually produces 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.

# Typical Set-up Procedure for Color Cameras Using Sulfide Vidicons

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.

In this procedure there is frequent reference to setting equal signal levels. Usually this adjustment 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 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.

## Set-up Routine

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| 1. | Projector lamp voltage | Adjust the lamp voltage on the projector normally used to set up the camera to the lamp manufacturer's rating. | 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 - to 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 25. |
| 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 or make set-up measurements at a point in the video amplifier prior to gamma correction. | To permit adjustment and evaluation of 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. | To establish equal white signal reference for the camera system. |

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| | | (b) In cameras having calibrated and regulated video amplifier gains but not test pulses, set all channel gains equal. | |
| 7. | Vidicon set-up (preliminary) | With the vidicon exposed to a suitable test pattern, 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 focus, 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 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.<br><br>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. |
| 8a. | 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.<br><br>**CAUTION:** Never misalign a vidicon beam to produce good signal uniformity to compensate for non-uniform illumination. | This alternate beam alignment procedure will also produce good results. |
| 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. |

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| 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 camera reference channel | 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 reference channel prior to registration. |
| 13. | Vidicon horizontal and vertical scan size, centering, linearity, skew and yoke rotation in the other channels | Using the registration test pattern, register the other channels (the three chroma channels of four-tube or the blue and red channels in three-tube cameras) to the reference channel established by Step 12. First yoke rotation, then skew, and then 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 test pattern to the 100% level specified for the camera. | To establish set-up for the most limiting color channel of the camera.<br><br>**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 | To measure the dark-current or dark-signal level and to provide a reference in subsequent steps for establishing equal dark currents for all channels.<br>**NOTE:** Dark current and bias cur- |

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| | | (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.) | rents must be measured with the gamma correction set to unity or measured at a point prior to gamma correction. |
| 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). | To establish equal picture blacks, a prerequisite for good signal tracking. |
| 17. | Adjust bias light levels (if applicable) | Adjust the individual bias light controls to produce the required equal bias light. Measure in the same manner as the measurement for vidicon dark current, but turn the bias light off and on. | To establish the bias light levels equally and to the proper level to produce equal lag reduction in all channels. |
| 18. | Adjust black-level controls | Adjust individual black-level controls to bring the pedestals to the zero signal level in each channel. | To establish "balanced" black levels and to set picture blacks to zero signal level. |
| 19. | 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 test pattern to the 100% level. | To complete the vidicon signal tracking and establish equal picture whites. |
| 20. | Camera system video amplifiers, gamma compensation. | Reset 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. | Vidicon beam setting | Set each vidicon beam to discharge a signal level 120% of the specified level. | To establish the operating beam setting with a 20% reserve capability. |
| 22. | Vidicon beam alignment | Repeat Steps 8, 9, 12, and 13 for each channel. | To complete vidicon alignment and registration adjustments. |
| 23. | Adjust flare controls (if applicable) | Adjust flare controls with a small opaque area (¼ of the image area) located at the field lens and with the remainder of the field fully illuminated. Adjust blacks on all channels to be equal to the black level previously established with the projector lamp turned off. | To compensate for flare in the optical system and to achieve optimum black-level tracking. |

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| 24. | 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 step is conveniently done by adjusting the lamp voltage to produce balanced "whites" from each projector. The use of a color-correcting filter may be necessary in some cases. | To obtain equal color temperatures from all projector lamps and provide consistent white balance and color fidelity. |
| 25. | 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 or signal shading results. The neutral-density filter wheel is the most convenient control, but be certain it is neutral through its range of control. (Filter wheels 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. When changing to a different lamp design, make sure that the signal uniformity does not deteriorate. | To establish equal light output from all the projectors multiplexed into the camera system. This step is important for maintaining consistent signal levels in the day-to-day operation of the camera. |

## 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.

# Characteristics of Sulfide Vidicons

In this Section, the characteristics and features of sulfide vidicons are described to provide a better understanding of their performance in camera systems.

## Photoconductors

The spectral response of the two antimony trisulfide photoconductors used in RCA vidicons for film camera service is shown in Figs. 7 and 8. The Type I photoconductor is now used only in RCA's larger-diameter vidicon type BC8480. The capacitance of this photoconductor is lower than that of the Type II photoconductor and contributes to keeping lag in this 1½" diameter tube to the low level required in film camera service.

The Type II photoconductor is used exclusively in all RCA 1"-diameter vidicons for film service because of its higher sensitivity and better light reflection and dispersion characteristics. Vidicons utilizing this photoconductor exhibit less highlight flare and, as a result, produce sharper and more accurate colors in the low lights of the picture.

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

## Light Transfer Characteristics

The light transfer characteristics (the relationship of signal current to light input) are commonly called

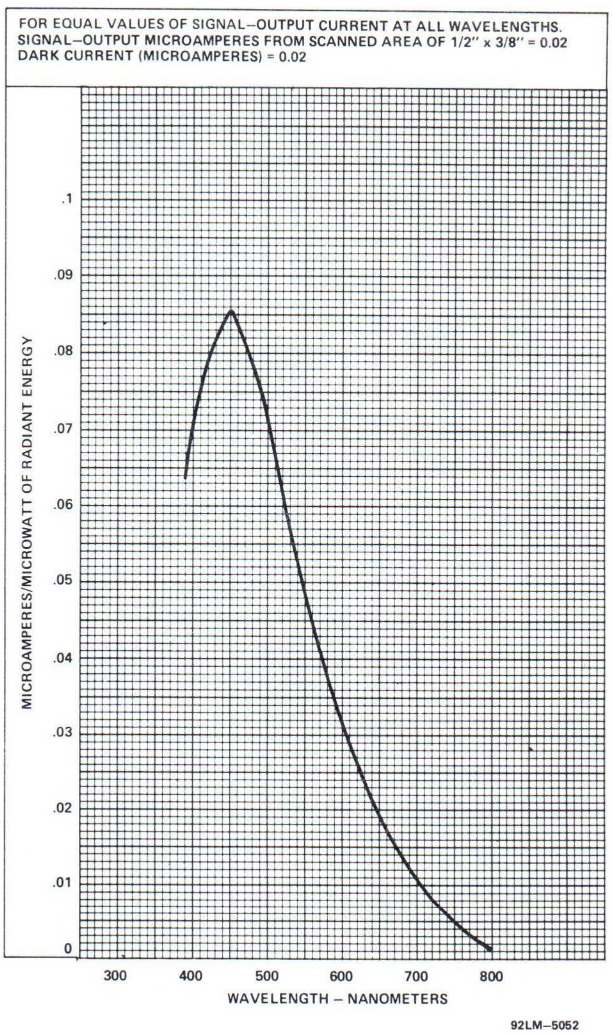



*Fig. 7 — Typical spectral response for vidicons using RCA photoconductor Type I.*

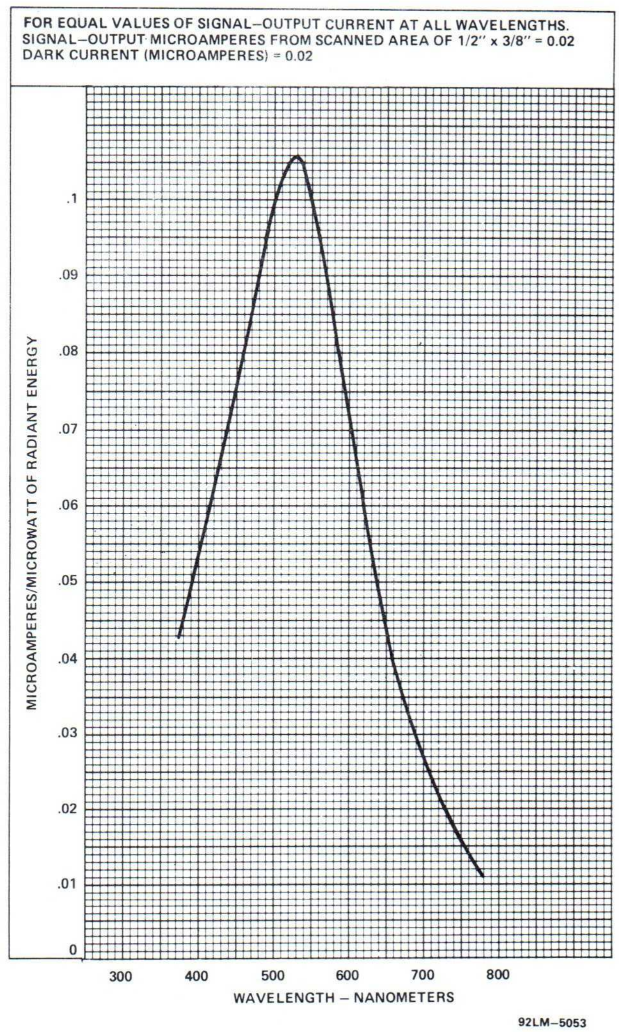



*Fig. 8 — Typical spectral response for vidicons using RCA photoconductor Type II.*

"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, (gamma), is approximately 0.65 for both photoconductor Types I and II. See Figs. 9 and 10. 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.

## Blue Sensitivity

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., BC4809/B. These types, intended for use in the blue channel of color film cameras, provide higher over-all camera "sensitivity" and greater reserve for handling high-density film while maintaining dark current at recommended levels.

## Heater Power Requirements

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.

## Mesh and Focus Electrode Connections

### G3/G4 Ratio

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. Fig. 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.

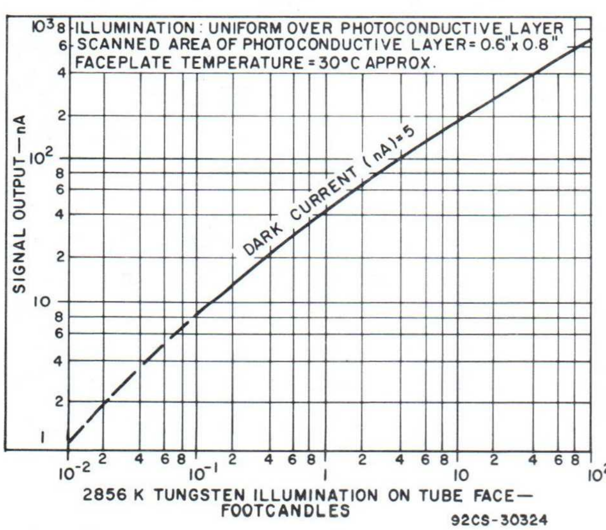



*Fig. 9 — Typical light transfer characteristics for vidicons using RCA photoconductor Type I.*

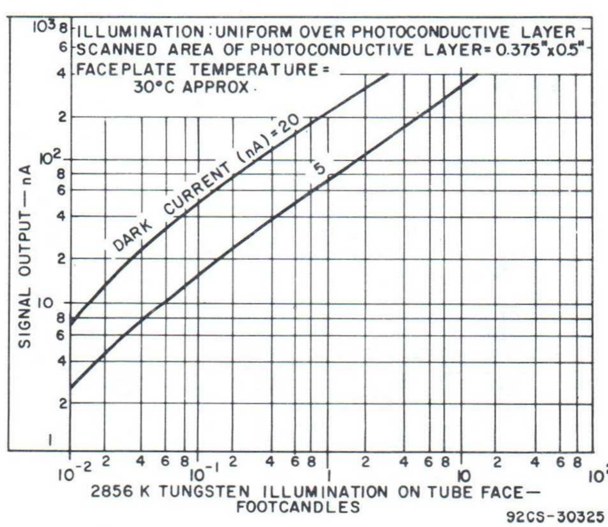



*Fig. 10 — Typical light transfer characteristics for vidicons using RCA photoconductor Type II.*

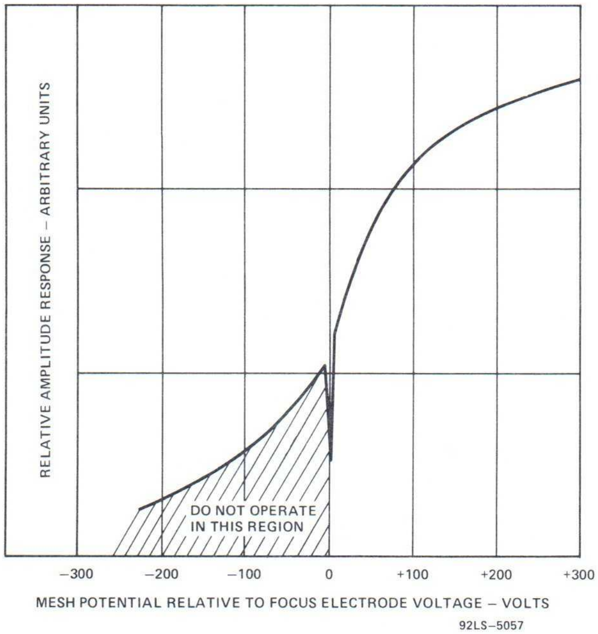



*Fig. 11 – Amplitude response of a separate-mesh vidicon as a function of focus-electrode and mesh-electrode voltages.*

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 each other. Vidicons, however, are operated in a wide variety of focus-deflection assemblies, and identical performance cannot be expected at the constant ratio of 0.6.

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 because 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.

## Replacement Considerations for 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 as shown in Fig. 12. A voltage difference may also be obtained, as shown in Fig. 13, if the focus electrode is in the 250-volt range and the grid-No. 2 voltage is 300 volts.

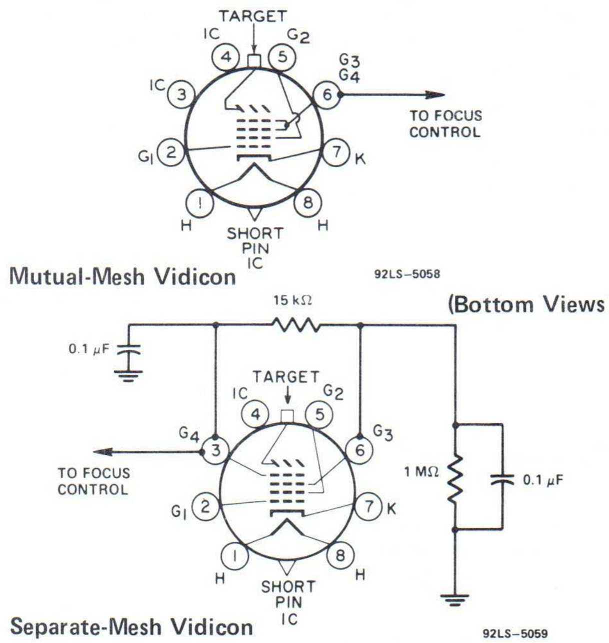



*Fig. 12 – Circuit modifications for replacing mutual-mesh vidicons with separate-mesh vidicons.*

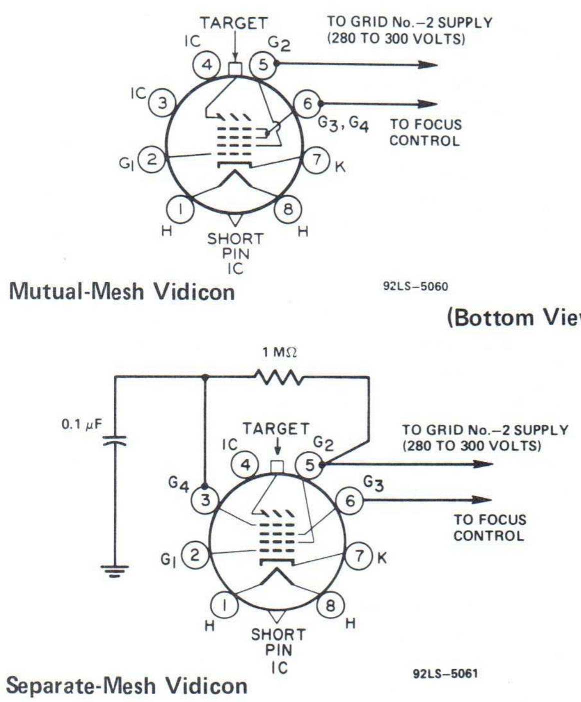



*Fig. 13 – Circuit modification for replacing mutual-mesh vidicons with separate-mesh vidicons when focus electrode is in the 250-volt range and grid-No. 2 voltage is 300 volts.*

## Magnetic vs. Electrostatic Focus

Camera design dictates whether the vidicon used is 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 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 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 remains 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.

# Performance of SATICON Vidicons in Television Film Camera Service

## Advantages

The 25-millimeter SATICON tube is uniquely suited to replace sulfide vidicon tubes in color TV film cameras when high contrast film is used and there is need to have the lowest possible lag. The BC4909 25-millimeter SATICON tube is directly interchangeable with 25-millimeter vidicon tube types having separate-mesh design and low-heater-power cathodes. The BC4909 can be used in any color-film camera that is designed to provide a modest amount of bias light and that has the ability to correct the signal to a 0.4 or 0.3 gamma characteristic in its video processing amplifier. The result will be a color picture with lower lag and faster signal buildup, resolution equal to or superior to that of a sulfide-type vidicon, uniform signal-level shading from tube to tube, and less flare light extending into the lowlights, thereby producing cleaner lowlight colors and color transitions.

In addition to the foregoing advantages, the camera can be expected to use less than 10 per cent of the light required by a camera equipped with a sulfide-type vidicon. This light reduction can be converted into savings in projector-lamp replacement costs and better resolution in the optical system of the camera. The projected life of SATICON tubes in film service is at least as long as that of the familiar sulfide vidicon tubes.

The important operating factors for SATICON tube use in a film camera service are:

A fixed target voltage of 50 volts
Operation with a signal current of 500 nanoamperes
Operation with a beam-current reserve of 2:1
Gamma correction of at least 0.4
Bias light of 3 per cent of signal level

These operating factors are discussed in the subsequent pages of this Note.

## Camera Conversion for SATICON Tubes

### Target Voltage

The target voltage of the SATICON tube should be fixed at 50 volts. The target voltage is the dc voltage difference between the voltage on the target and that on the cathode during the active scan time. Operation of tubes at lower target voltage will produce undesirable image retention. Operation at higher than 60 volts may cause damage to the photoconductor and shorten its life.

### Signal Current

The SATICON tubes should be adjusted by attenuation of the light level to produce peak white signal currents of 450 to 500 nanoamperes in each channel of the camera. This signal level is necessary to produce a signal-to-noise ratio that is compatible with that of a camera equipped with a sulfide vidicon. Because the SATICON tube has a linear transfer or gamma characteristic, additional black stretch is necessary to produce proper picture tonal values. This extra black stretch or gamma correction produces extra black-level noise that can be reduced in proportion by operating the SATICON tubes so that they produce higher signal-current levels than the levels utilized by sulfide vidicons.

The calibration system of the film-camera-video system for camera tube signal-current level should be recalibrated to this higher signal level. The differences in signal level from channel to channel and in picture white should be equalized by utilizing neutral-density filters in the optical path of the two channels with the highest signal output. Generally, these channels are the red and the green channels. This adjustment is best made when the projector is in "open gate".

## Illumination Requirements

The light level required for SATICON tubes is less than 10 per cent of the light level necessary for sulfide vidicon tubes. There are several recommended methods for reducing the light level. The best method consists of a combination of reduction of projector-lamp filament voltage, stopping down of the projector lens by two f/stops, and the placement of a diffuser in the condenser lens system of the projector.

Reduction of the filament voltage will prolong the life of the projector lamp and increase its reliability. Stopping the lens down will produce noticeable improvements in resolution and in resolution uniformity in the optical system. When the lens is stepped down, a means must be found to diffuse the projector lamplight to avoid bringing the projector bulb filament and any anomalies in the light source into focus as the depth of focus is increased. The requirement for diffusion can be met very effectively with a lightly sand-blasted sheet of glass placed midway through the condenser lens system of the projectors. When properly done, the light diffusion in the optical system will reduce the available light no more than 2:1, and yet will remove the visibility of the projector lamp filament and other sources of light variation in the projector light source. If the light is not diffused, the lens can be stopped down only slightly, but possibly enough to improve uniformity of resolution.

If the above steps are not taken, substantial neutral-density filtering will be required in all channels of the camera to reduce the light levels to the desired levels.

# Typical Set-up Procedure for Color Cameras Using SATICON Vidicons

The following procedure is recommended for setting-up a typical color film camera utilizing SATICON tubes. SATICON vidicons are mechanically and electrically interchangeable with many sulfide vidicons and can be plugged directly into any socket using separate-mesh low-heater-power 25-mm magnetically focused and deflected vidicons in cameras employing bias light. After altering the target voltage supply (if necessary) to provide 50 volts, the tubes are ready for final set-up.

**The set-up procedure for SATICON vidicons is the same as that shown on pages 10-14 for sulfide vidicons, except for the following steps:**

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| 1. | Projector lamp voltage | Adjust the lamp voltages to produce the same color temperature at the desired operating voltage. | To establish lower projector-lamp voltage settings for SATICON vidicons and take advantage of the higher sensitivity. |
| 2. | Projector lamp iris | Set to desired value consistent with best resolution and light uniformity. | To obtain any advantage of increased SATICON vidicon sensitivity and improve the resolution and depth of focus of the projector optical system. |
| 7. | SATICON vidicon set-up (preliminary) | With the camera exposed to a suitable test pattern, adjust the beam control to produce a usable picture. Adjust beam alignment and optical and electrical focus to produce a | To establish a preliminary SATICON vidicon set-up prior to final adjustments. |

| Step | Adjustment | Procedure | Function |
|---|---|---|---|
| | | reasonably sharp picture. Adjust the illumination level to produce the typical signal level. | |
| 8a. | Vidicon beam alignment (an alternate procedure) | Delete | Unsuitable for SATICON vidicons. |
| 14,15, 16 | Target Voltage | Adjust to 50 volts between cathode and target on all channels. | To provide the target voltage required for all SATICON vidicons. |
| 19. | Insert neutral-density filters | Insert neutral-density filters in all channels to produce the proper signal level with the light level utilized. | SATICON vidicon sensitivity is very high. Neutral density filters may be required in all channels. |
| 21. | SATICON vidicon beam | Set the beam current to handle highlights. Set for no more than 2:1 (100% over-beam) above the normal signal current. | To handle changes in light level and assure proper operation of the automatic light control system. SATICON vidicons with linear characteristics generally require more over-beam. |
| 26. | Stray light check | Turn room and work lights on and off with projector turned off. Look for black level shifts or indications of stray light in the optical system as the lights are turned on again. Take suitable precautions to avoid stray light during operation. | To check the system to see that the SATICON vidicons because of their additional sensitivity are not detecting stray light. |

# Characteristics of SATICON Vidicons

## Photoconductor

The selenium-arsenic-tellurium photoconductor of the SATICON vidicon has a spectral response that encompasses the entire visible spectrum. Its spectral response, shown in Fig. 14, is very similar to that of the two sulfide-vidicon types. The SATICON photoconductor features a low reflectivity that results in cleaner looking colors in shadow areas. The low reflectivity causes less light to be reflected back into the optical system where it can be redistributed over unwanted areas of the picture, or dispersed through the photoconductor where it could produce lower resolution. The relative reflectivity of the SATICON tube and other types of tubes used for film pickup is shown in Fig. 15.

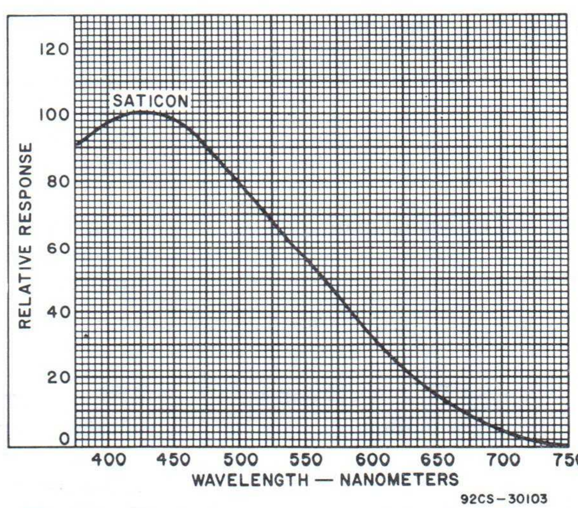



*Fig. 14 — Typical spectral response for SATICON vidicons using RCA photoconductor Type IX.*

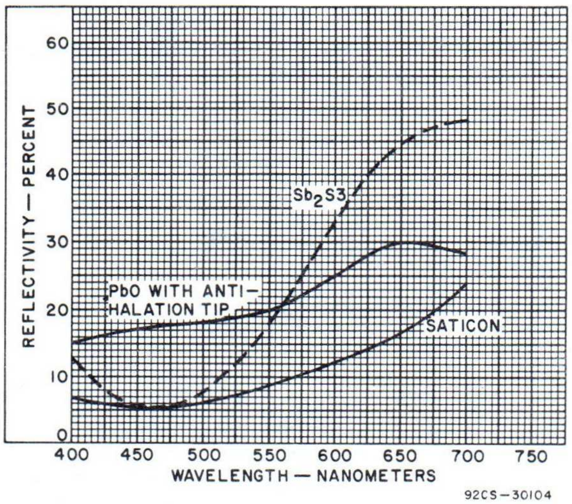



*Fig. 15 — Relative reflectivity of vidicons used in film pickup service.*

# Light Transfer Characteristics

The relationship between the input light and the signal current, as shown in Fig. 16, is linear (gamma = 1) for the photoconductor of the SATICON vidicon. The sensitivity is fixed and should not be altered by the adjustment of target voltage. Gamma-correction circuitry that follows a 0.4- (or lower) power law is necessary to produce proper tonal and chroma values in the reproduced color picture.

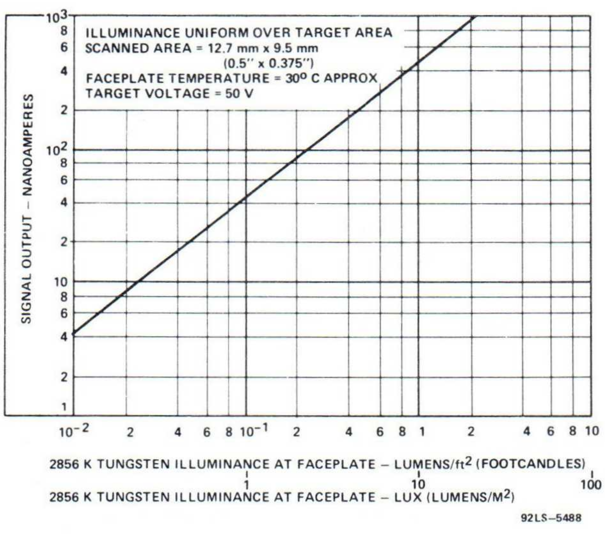



*Fig. 16 — Typical light transfer characteristic of SATICON vidicon.*

# Lag Characteristics

The capacitance of the SATICON vidicon photoconductor is much higher than that of the sulfide vidicon. However, the lag in the photoconductive process is less than that of the sulfide types. The resulting lag of the SATICON vidicon is shown in Fig. 17. It must be remembered that the apparent improvement in lag indicated in these curves is modified by the increased black stretch resulting from the gamma correction that is necessary for the SATICON vidicon.

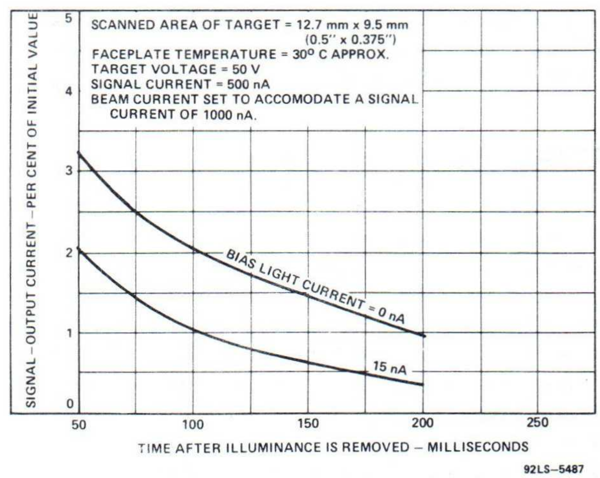



*Fig. 17 — Typical persistence (lag) characteristics of SATICON vidicon.*

Bias lighting is also needed to improve the rise time of the signal from the SATICON tube. Because the dark current is extremely low and the target capacitance high, the signal build-up would be very slow without bias lighting. Poor build-up leads to discoloration of the leading edges of moving images. Bias lighting improves the signal build-up as shown in Fig. 18.

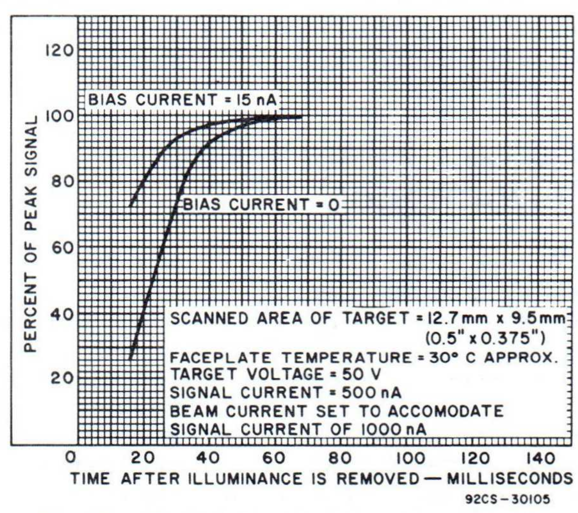



*Fig. 18 — Typical signal build-up characteristics of SATICON vidicon.*

## Construction Features

The SATICON tube is designed with a low-heater-power cathode (0.6 watt) and a separate-mesh construction. The physical dimensions and the base pin connections are identical to similar 25-mm sulfide vidicons used for film pickup.

# Film Density Ranges and Film Pickup Reproduction Problems

This Section applies to both sulfide and SATICON vidicons and deals with film pickup reproduction problems caused by differences in film density ranges.

## Film Density Specifications

Film is not a linear medium. It compresses the tonal ranges of the image at both ends of the density range. A typical film characteristic is shown in Fig. 19. This characteristic is a conventional D-$\log_{10}$E curve where D is the film density (density is $\log_{10}$ 1/Transmission) and E is the exposure or brightness of the original image in the scene. The Society of Motion Picture and Television Engineers has developed a specification for the density range for film prints intended for television transmission. This specification (RP7) acknowledges the characteristics of film and the reproduction characteristics of a television system, and recommends a maximum lowlight density and a minimum highlight density for film prints for television use. The minimum highlight density recommended is 0.3 and the maximum lowlight density is 1.9. This range assures that the picture will encompass for the most part the linear portion of the film characteristic and, in turn, assure the most trouble-free reproduction in a television camera. These values represent a contrast range of 40:1 in light transmission of the film print.

## Vidicon Film Pickup Performance

When a sulfide vidicon tube is operating with a peak signal current of 300 nA and is exposed to a film meeting the RP7 specification, the picture blacks will generate a signal of 25 nA. This value is roughly equivalent to the recommended level of bias light for a film camera equipped with a sulfide vidicon. When film with this characteristic is used, neither the blacks nor the whites of the picture are unduly compressed by the film characteristics, and the blacks are sufficiently above the zero-signal level from the tube to act effectively as a bias light. Film processed with these characteristics for television use appear to have low contrast on direct projection. When used in a film pickup camera, however, the blacks are set to the pedestal level and the scene contrast appears normal. The pictures produced also have low lag because picture blacks are not at the zero signal level.

Theatre-release-type film prints and films made primarily for direct projection, however, are printed with a much higher density range to improve the apparent contrast on the low-brightness theatre screen. As a consequence, a lot of useful scene information in the blacks is compressed. The same is true of news-reel film that is under-exposed and force-developed. These films produce problems when they are utilized in a film pickup camera. First of all, the effective light bias is lost and lag can become more apparent if bias lighting is not utilized. Secondly, the blacks are compressed. To compensate for the black compression in the film print, the tendency is to utilize more gamma correction than the 0.7-gamma amplifier characteristic normally utilized for sulfide vidicons or the 0.4-gamma used for the linear SATICON vidicons. Extra gamma correction stretches the blacks and improves the visibility of

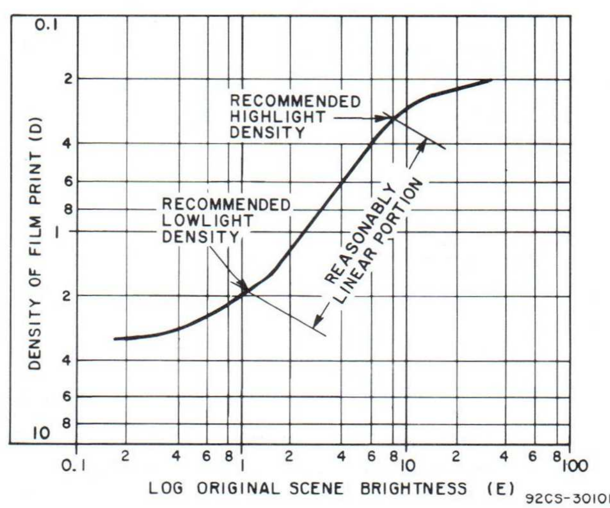



*Fig. 19 – Density characteristics of a typical film print.*

lowlight picture details and texture, but it also enhances the visibility of any lag in the picture. The lower 10 per cent of the video signal is the important region to consider to avoid either excessive black stretch or black compression. The characteristic may look normal on a video waveform oscilloscope, but the scene differs greatly from film to film in its appearance on a television monitor if there is excessive stretch or compression in this region of the signal.

The SATICON tube, on the other hand, with its greatly reduced lag performs admirably for lag with this type of film. In some cases it may be desirable to use a "lower" gamma correction than the 0.4 characteristic (if it is available) to bring out detail and texture in the darker regions of the picture. The sulfide vidicon characteristic has a slightly steeper curve at the lower end of its scale and, therefore, produces slightly more contrast in the last few per cent of signal than the SATICON vidicon when the signals from each are processed with the appropriate gamma correction.

# 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.

## RCA Broadcast (BC) Line of Vidicons

RCA's BC line of antimony trisulfide vidicons and SATICON vidicons designed specifically for television film camera service is shown in **Table I** together with the RCA vidicon types superseded.

The Type II photoconductor now used in all 1"-diameter sulfide vidicon tubes in the BC-line is specially processed and selected for resistance to image burn-in and for low lag at low dark-current levels. Blemish specifications for tubes in this line have also been made more stringent. The vidicon types BC4809 and BC4809/B are recommended for use only in cameras where the grid-No. 4 voltage is above 500 volts. The design, processing, and performance specifications of these two tubes make them superior to the other 1"-diameter sulfide vidicons in the BC line for resolution uniformity, image burn resistance, and lag.

The Type I photoconductor, which has also been improved, is used only in the 1-1/2"-diameter vidicon type BC8480. This tube is designed primarily for 4-tube color film cameras. Its companion tubes in these cameras are the 1"-diameter electrostatically focused types BC8134 and BC8134/B. Because of the performance capabilities of the vidicons in the BC line, vidicon types 7038, 7038/V, 7038/V4, 8572A, 8572A/V, and 8572A/V4 have been withdrawn from the RCA camera tube line.

*Table I – RCA's BC Line of Vidicons for Film Cameras*

| New RCA Vidicon Type | Vidicon Type Replaced |
|---|---|
| SULFIDE TYPES | |
| 25-mm (1") Electrostatically Focused Types | |
| BC8134 | 8134/4811 |
| BC8134/B | 8134/4811/B |
| 25-mm (1") Magnetically Focused Types (Mutual Mesh) | |
| BC7735 | 7735B |
| 25-mm (1") Magnetically Focused Types (Separate Mesh) | |
| BC4809 | 4809 |
| BC4809/B | 4809/B |
| BC8507 | 8507A |
| BC8541 | 8541A |
| 38-mm (1½") Electrostatically Focused Types | |
| BC8480 | 8480/4810 |
| 8480* | 8480 |
| SATICON TYPE | |
| 25-mm (1") Magnetically Focused Type (Separate Mesh) Low Heater Power | |
| BC4909 | Not applicable – New Type |

* For black-and-white cameras

**Table II** groups the recommended RCA vidicons for film camera pickup by electromechanical structure, photoconductor type, and special features.

**Table III** 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 because in those cases the over-all camera performance is greatly improved by the newer replacement-type vidicon.

*Table II – Classification Chart of RCA Vidicons for Black-and-White and Color Film Television Cameras*

| RCA Vidicon Type | Photo-conductor Type | Special Vidicon Features | Heater Power |
|---|---|---|---|
| **25-mm (1") Electrostatically Focused Types** | | | |
| BC8134 | II | High Blue Sensitivity (Designed Specifically for RCA TK27 Cameras) | Low |
| BC8134/B | II* | High Blue Sensitivity (Designed Specifically for RCA TK27 Cameras) | Low |
| **25-mm (1") Magnetically Focused Types (Mutual Mesh)** | | | |
| BC7735 | II | – | High |
| **25-mm (1") Magnetically Focused Types (Separate Mesh)** | | | |
| BC4909 | IX | SATICON | Low |
| BC4809 | II* | | Low |
| BC4809/B | II* | High Blue Sensitivity | Low |
| BC8507 | II | | High |
| BC8541 | II | | Low |
| **38-mm (1½") Electrostatically Focused Types (Black and White)** | | | |
| 8480 | I | | Low |
| **38-mm (1½") Electrostatically Focused Types (Color)** | | | |
| BC8480 | I | (Designed Specifically for RCA TK27 Cameras) | Low |

*Utilizes special manufacturing process or selected for special characteristics

*Table III – Selection Chart Giving Recommended Vidicons for Specific Camera Models*

| 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 | BC7735 | BC8507* |
| | TK27 | Color | 8134 | BC8134 | |
| | | | 8480 | BC8480 | |
| | TK28 | Color | 4809, /B | BC4809, /B | BC4909● |
| | PK610 | Color | 8507A | BC4809, /B | |
| | TK21 | B&W | 7038 | BC7735 | BC8507* |
| | TK22 | B&W | 8480 | 8480 | |
| GE (Harris) | PE24† | Color | 7038 | BC7735 | BC8507* |
| | PE240† | Color | 7038 | BC7735▲ | BC8507* |
| | | | 8572A† | BC8507 | |
| | PE245 | Color | 8572A | BC8507 | |
| | TE304 | Color | 8541A | BC4809, /B | |
| | TE100 | Color | 8541A | BC4809, /B | |
| | TF100 | Color | 8541A | BC4809, /B | BC4909♦ |
| Cohu | 1500 | Color | 8507A | BC4809, /B | BC4909♦ |
| | 1550 | Color | 8507A | BC4809, /B | BC4909♦ |
| Norelco-Philips | LDN1 | Color | 8541A | BC4809, /B | |
| IVC | 92 | Color | 8541A | BC8541 | |
| | 92B | Color | 8541A | BC8541 | |
| | 130 | Color | 8541A | BC8541 | |
| | 210 | Color | 8541A | BC8541 | |
| | 230 | Color | 8541A | BC8541 | |
| | 240 | Color | 8641A | BC8541 | |
| Telemation | TCF3000 | Color | 8541A | BC4809, /B | BC4909♦ |
| Ikegami | TKC950 | Color | 8541A | BC4809, /B | |

*Some minor camera circuit modification is required for separate-mesh vidicons and may be required for different heater-power types. See text.
†In luminance channel only.
▲For cameras not having manufacturer's recommended modification to accommodate separate-mesh vidicons.
♦Use only on models equipped with bias light (kits available from manufacturer).
●Minor target-voltage modification sometimes required.

# Replacement Notes

In all cases, separate-mesh vidicons provide superior performance over mutual-mesh-connected vidicons. Camera conversion to accept these improved tubes is normally minimal. For suggested circuit modifications, refer to "Replacement Considerations for Separate-Mesh Vidicons" in the Section **Characteristics of Sulfide Vidicons** and Figs. 12 and 13.

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 especially when installing a new vidicon (and periodically thereafter). 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.

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.

Vidicons having Type I and Type II photoconductors should not be intermixed in the chroma channels of color cameras. The slightly different characteristics may introduce color tracking problems.

The BC4809 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 BC4809 types will update camera performance in any of the newer camera models using the high-voltage mode of operation ($G_4$ above 500 volts).

The SATICON tube type BC4909 is recommended only for those cameras equipped with bias-light and gamma-correcting circuitry capable of correction to at least a 0.4-power law.

# Converting RCA TK 28 Series Vidicon Film Cameras For Use With SATICON®* Vidicons

SATICON vidicons are improved camera tubes specially suited for film service. These types have a selenium-arsenic-tellurium photoconductor that improves the lag characteristics when high contrast film is used. Resolution is equal or superior to that of sulfide vidicons.

One or more of the following conversion procedures is required when installing SATICON vidicons in a TK 28 series camera. Generally, older cameras will require more modification than newer cameras.

I **Target Voltage**
Perform minor changes in target voltage supply circuit to assure a fixed 50 volt target voltage. Current cameras may contain this conversion.

II **Delete "Black Crush" Circuitry**
Establish proper gamma characteristics by deletion of any "Black Crush" or "Soft Clipping" circuitry that may have been incorporated in the processing amplifier.

III **Set Gamma Switch**
Set gamma correction to 0.4 to compensate for the linear gamma characteristics of the SATICON vidicon.

IV **Calibrate Preamplifiers**
Calibrate preamplifiers to operate with a 500 nA signal (instead of 300 nA).

V **Adjust Light Levels and Camera Operating Controls**
Adjust the light levels, SATICON tube beam setting, and camera operating controls for proper SATICON tube operation.

**Conversion Procedure**

The following 3 inch square wratten geletin filters or the customized round ND filters supplied with the TK 28 camera should be available before attempting this conversion:

| Quantity | Filter |
|---|---|
| 3 | 0.1 ND |
| 3 | 0.2 ND |
| 4 | 0.3 ND |
| 3 | 0.6 ND |
| 4 | 1.0 ND |

Preferably, most of these filters should be the round ND filters supplied with the TK 28 for inserting in the filter holders to balance the light level to the tubes.

**CAUTION** – To avoid after image, do not turn on projectors when camera or beams are turned off or before light is attenuated with neutral density filters.

*Used by permission of trademark owner.

For further information or application assistance on this device, contact your RCA Sales Representative or write Camera Tube Marketing, RCA, Lancaster, PA 17604.

| Step | Operation | Reason |
|---|---|---|
| I | **Target Voltage** | **Set target voltage to 50 V for SATICON vidicons.** |
| | 1. On set-up panel, tie target control potentiometers directly to −60 V supply by connecting jumpers across 2R31, 2R32, and 2R65. | Provide greater target voltage range. |
| | 2. Check target voltage with respect to ground (Nominal value for Preamp H is between −6 and −8 V, for Preamp K close to 0 V). | The preamp applies a DC voltage on the target lead. |
| | 3. If difference between any target voltage and −60 volt supply is less than 50 volts, change R15 (located in WP-90 power supply) from 42.2 K to 48.7 K. | Some supplies regulate at slightly less than −60 volts, and the full 50 volts cannot be obtained across the tube due to the volts on the target. |
| | 4. Adjust potentiometers 2R31, 2R32 and 2R33 so that the terminal 2 (wiper arm) voltages are precisely −50 V with respect to their respective target signal lead at preamp input. If a precision meter is not available, an accurately calibrated DC oscilloscope can be used to measure the cathode voltage during the scan interval. | SATICON tubes must operate at a fixed target voltage of 50 volts. |
| II | **Delete "Black Crush" Circuitry** | **Eliminate compression in scene blacks** |
| | 1. For TK 28 and TK 28A cameras, which use the Proc H module, modify the Current Amplifier and black clip stage of each of the three color channels to be the same as shown in **Figure 1**. Note that the cathode end of the 1N4009 diode is connected to ground and the anode is connected directly to the transistor collector (terminal 7). The resistor connected to the transistor collector and diode anode junction must be 100 ohms. The capacitor (C39 for Green) should be 82 pF. | Remove soft clipping and to provide extra black stretch near black clipping level.<br><br>To eliminate black compression at the clipping level. |
| | In one version of the Proc H module the diode was connected to the other side of the 100 ohm resistor in parallel with a 700 ohm resistor. Another version used a 1N100 diode rather than a 1N4009. In other modules the diode cathode may be connected to a voltage divider. The capacitor (C39 for Green) may be a value other than as shown. | |
| | In all cases modify the circuitry to have the configuration shown. Cameras installed during or prior to 1973 should be checked to ascertain that they have been modified per RCA Tech Bulletin 73-19 Rev. 1. | |
| | 2. For TK 28B units refer to Note No.4 of Output Proc C and remove three jumpers "to eliminate black compression at the clipping level". | |
| | 3. Additional "site tailored" compression circuitry may have been installed in some units. Check collectors of Q302, Q402, and Q502 to ascertain that they are connected directly to −10V. If not, compression circuitry has been installed; remove. | |
| | Note: Elimination of black compression will result in an apparent increase in black level noise. | |
| III | **Set Gamma Switch** | **Provide adequate gamma correction for the linear characteristic of the SATICON tube.** |
| | 1. Set gamma switch to the 0.4 position. | |

| Step | Operation | Reason |
|---|---|---|
| IV | **Calibrate Preamplifiers** | **Set amplifiers to operate with 500 nA signal (instead of 300 nA)** |
| | 1. Place all level and balance controls in manual position | Establish manual operation conditions for set-up. |
| | 2. Turn bias lights off. | Bias light used for vidicons is much higher than light used for SATICON tubes. |
| | 3. Remove ND filters but not color trim filters from filter holders behind relay lenses. | |
| | 4. Install SATICONS and remove Preamp covers. | |
| | 5. Install ND filters in projector light path (Open Gate) – ND 0.3 & 1.0. | To facilitate set-up so that the automatic light control can handle either dense film or normal film. |
| | 6. Turn on camera. | |
| | 7. Adjust white level control and beam for each channel to supply more beam than necessary to handle normal signal levels. | Preamps will be set-up to operate on 500 nA instead of 300 nA. |
| | 8. Attach oscilloscope probe to proper point in green preamp (see below). Adjust the white level control (and beam if necessary) to produce the peak signals as indicated in steps 9 or 9a. | To measure the input target signal current to the preamp. |
| | 9. For Preamp H, where R28 the feedback resistor is 909 K, adjust the WHITE LEVEL control on the Set-up panel so that the peak-to-peak signal amplitude where it joins R92 and C31 is 0.45 V. | Establish 500 nA input signal to preamp. |
| | 9a. For Preamp K, where R55 the feedback resistor is 665 K, adjust the WHITE LEVEL control on the Set-up panel so that the peak-to-peak signal amplitude where it joins C5, is 0.34 V. | Establish 500 nA input signal to preamp. |
| | 10. Remove scope probe and connect to terminal B of the Green Preamp. | To measure output voltage of preamp. |
| | 11. Adjust preamp gain control (preamp H, R233 – Preamp K, R34) for 0.5 V output level at preamp terminal B. Preamp is now adjusted to handle 500 nA signal current. | Adjust preamp gain to produce proper signal output level with 500 nA input signal. |
| | 12. Repeat steps IV-8, IV-9, IV-10 and IV-11 for red and blue preamps. | Set all preamp gains equal. |
| | 13. Turn camera off and replace preamp covers. | |
| V | **Adjust Light Levels and Camera Operating Controls** | |
| | 1. Turn camera on and operate camera for 1/2 hour with white level control adjusted to produce no more than 500 nA signal. (Projector on with no test pattern.) | Stabilize tubes and camera. |
| | 2. Turn projector off. | |
| | 3. Set Proc H Red, Blue and Green Gain controls to mid-position on Input Proc C gain controls 180° from maximum CW. | |
| | 4. Block the light to the blue and red channels. | Prevent image burn on other channels while adjusting light level on green channel. |
| | 5. Insert inconel test slide. Turn white level control fully clockwise. | Provide standard set-up conditions. |
| | 6. Turn on the projector. Add ND filters in the green optical path until the signal current is as close to 500 nA (0.5 V peak-to-peak at preamp connector pin B) as possible. | Attenuate light in the green channel. |

| Step | Operation | Reason |
|---|---|---|
| V | **Adjust Light Levels and Camera Operating Controls (cont'd)** | |
| | 7. Turn projector off and install this ND or combination of ND filters in the green channel filter holder. | |
| | 8. Unblock the light to the next channel being set-up. | Balance the optical system in order that each channel operates at 500 nA highlight signal level on white light. |
| | Turn on projector and repeat steps V-6 and V-7 for the red and then for the blue channel. If precisely 500 nA signal cannot be achieved err on the low side for these channels. | |
| | Note (for Blue Channel): The ND filter must be taped to the filter holder because the blue filter is too thick to allow a second filter to be placed under the clamps. | |
| | 9. Turn projector light off. | Remove projector light in order that the bias light level can be established. |
| | Turn bias light switch on. | |
| | 10. Adjust green bias light to produce 3% signal above black level (30% on scope set for 10X gain) measured before gamma correction. | Establish proper bias level of 15 nA. |
| | 11. Turn bias light switch off and on to assure proper percent signal shift between on and off conditions. | |
| | 12. Repeat steps V-10 and V-11 for red and blue channels using appropriate test points. | To establish the same bias light levels in all three channels. |
| | 13. Remove the 0.3 ND filter in the projector light path and adjust each beam to just discharge the highlight signal. | Set beams to handle precisely 2:1 over-beam. |
| | 14. Remove 1.0 ND filter from optical path and re-adjust white level control for normal signal output level. | Prepare camera for use with normal light levels with 10:1 light reserve for dense film. |
| | 15. Insert appropriate test patterns, focus, align and register per Set-up Instruction Book. | |

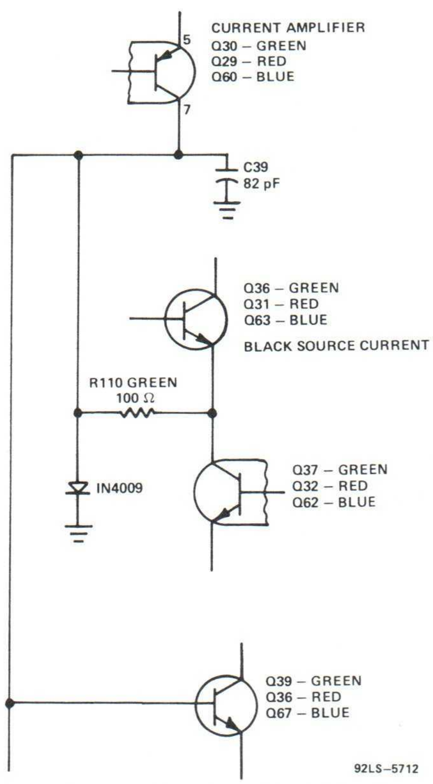



**Figure 1 – Proc Amp H Module – Black Clip Stage Detail**

# Additional Operating Considerations for SATICON®* Vidicons in Broadcast Color Cameras

SATICON vidicons are improved camera tubes for broadcast service; they feature a selenium-arsenic-tellurium photoconductor. The following operating factors should be considered when using SATICON tubes in broadcast color cameras.

### Target Voltage and Image Burn

Previous RCA literature on the use of SATICON tubes prescribes setting the target voltage at precisely 50 volts; in some cases a slight readjustment of the target voltage may be required. If a camera develops **image burn** of stationary scenes **while operating**, an improvement can be made by adjusting the target voltage of the individual tube that develops the burn.

If the burn is **positive**, i.e., scene whites produce a **light** image burn, **reduce** the target voltage by several volts.

If the burn is **negative**, i.e., scene whites produce a **dark** image burn, **increase** the target voltage by several volts.

The adjustment range should not be more than $\pm$ 5 volts from 50 volts and should be made in approximately 2 volt steps.

Note: The image burns described above are those that may be produced by normal scenes, not by specular highlights. This procedure does not apply to burns developed by prolonged exposure to an image when the camera is turned off and uncapped.

### Flare Controls and Lag

Improper adjustment of the flare controls can produce a phenomena that looks like lag or exaggerates the lag and build-up delay.

SATICON tubes require much less flare compensation than Plumbicon® tubes. If SATICON tubes are installed to replace Plumbicon tubes in a camera, the flare controls must be readjusted. When improperly adjusted, the blacks will be pushed below clipping level on some scenes, causing apparent lag and build-up problems.

### Adjustment of Flare Controls

Monitor the individual channel signal out of the camera process amplifier after gamma correction with an oscilloscope.

Use a white card with a " true" black that occupies less than 10% of the white card area. (A simple method is to cut a small hole in the side of a closed white carton and use this as a test chart.)

Expose the whites to the 100% signal level and adjust the flare control so that the "true" black signal level falls on the same signal level as when the lens is capped.

Do **not** use a test pattern with a reflecting black spot, since this black usually reflects some percentage of light and can cause significant set-up errors.

For further information or application assistance contact your RCA Sales Representative or write Camera Tube Marketing, RCA, Lancaster, PA 17604.

*Used by permission of trademark owner.



Printed in U.S.A./**8-78**

RCA|Solid State Division|Electro Optics and Devices|Lancaster, PA 17604

# CONTACTS FOR EUROPE, MIDDLE EAST & AFRICA

| | |
|---|---|
| MARKETING MANAGER: | MIKE RILEY<br>RCA BRUSSELS:MERCURE CENTRE<br>100, RUE DE LA FUSEE<br>1130 BRUSSELS BELGUIM<br>TEL: 02 720.8980 TLX: 61566 |
| SALES<br>AUSTRIA, GERMANY, EAST BLOCK, YUGOSLAVIA | PETER FEHER<br>RCA STUTTGART<br>ZEPPELINSTRASSE, 35<br>7302 OSTFILDERN 4 GERMANY<br>TEL: 0711/45.40.01 TLX: 723838 |
| UK & SCANDINAVIA | PETER CRABB<br>RCA U.K.<br>SUNBURY-ON-THAMES<br>MIDDLESEX TW17 7HW U.K.<br>TEL: 932785511 TLX: 24246 |
| BENELUX, FRANCE, ISRAEL, ITALY, SPAIN, SWITERZERLAND | GILBERT BONAMI<br>RCA BRUSSELS:MERCURE CENTRE<br>100, RUE DE LA FUSEE<br>1130 BRUSSELS BELGUIM<br>TEL: 02 720.8980 TLX: 61566 |

## DISTRIBUTORS:

### AUSTRIA
BACHER ELEKTRONISCHE GERAETE GMBH
ROTENMUEHLGASSE, 26
A-1120 VIENNA AUSTRIA
TEL: (0222)85.85.41 TLX: 011532

### BELGIUM
INELCO SA
AVENUE VAL DUCHESSE, 3
B-1160 BRUSSELS BELGIUM
TEL: (02) 660.00.12 TLX: 25441

### DENMARK
JORGEN ANDERSEN INGENIORFIRMA A/S
(J.A.I.)
PRODUKTIONSVEJ, 3
DK-2600 GLOSTRUP DENMARK
TEL: (02)91.88.88 TLX: 22378

### FINLAND
TELERCAS OY
P.O. BOX 2
SF-01511 VANTAA 51 FINLAND
TEL: 82.16.55 TLX: 121111

### FRANCE
RADIO EQUIPMENTS - ANTARES SA
(R.E.A.)
9, RUE ERNEST COGNACQ
F-92301 LEVALLOIS-PERRET FRANCE
TEL: PARIS 758.11.11 TLX: 620630

### WEST GERMANY
ALFRED NEYE - ENA TECHNIK GMBH
(E.N.A.)
SCHILLERSTRASSE, 14
D-2085 QUICKBORN/HAMBURG GERMANY
TEL: (04106) 61.21 TLX: 213590

### GREECE
OMMA LTD.
21, VOUKOURESTIOU STREET
ATHENS 134 GREECE
TEL: 36 180.58 TLX: 215412

### HOLLAND
INELCO BV
JOAN MUYSKENWEG, 22
NL-1008AD AMSTERDAM HOLLAND
TEL: (020) 93.48.24 TLX: 14622

DISTRIBUTORS: (CONT'D)

IRAN
BERKEH CO. LTD.
20, SALM ROAD
ROOSEVELT AVENUE
TEHRAN IRAN
TEL: 82.58.15 TLX: 212956

ISRAEL
ISRAEL RADIO CO
7, MACCABI STREET
TEL-AVIV ISRAEL
TEL: 289211 TLX: 341118

ITALY
SILVERSTAR LTD.
20, VIA DEI GRACCHI
I-20146 MILANO ITALY
TEL: (02) 49.96 TLX: 332189

NORWAY
EGA A/S
ULVENVEIEN, 75
/KERN - OSLO 5 NORWAY
TEL: 22.19.00 TLX: 11265

PORTUGAL
TELECTRA SARL
103, RODRIGO DA FONSECA
P-LISBON 1 PORTUGAL
TEL: 68.60.72 / 75 TLX: 12598

SPAIN
ATAIO INGENIEROS SA
ENRIQUE LARRETA, 10Y12
E-MADRID 16 SPAIN
TEL: (01) 215.35.43 TLX: 272449

SWEDEN
FERNER ELECTRONICS AB
SNOERMAKARVAEGEN, 35
P.O. BOX 125
S-16126 BROMMA/STOCKHOLM SWEDEN
TEL: (08) 80.25.40 TLX: 10312

SWITZERLAND
BAERLOCHER AG
P.O. BOX 485
CH-8021 ZURICH SWITZERLAND
TEL: (02) 42.99.00/05 TLX: 53118

TURKEY
TEKNIKA TAS
P.O. BOX KARAKOY 153
ISTANBUL TURKEY
TEL: 43.61.00 TLX: 22289

TEKNIM CO. LTD.
RIZA SAH PEHLEVI CADDESI, 7
KAVAKLIDERE - ANKARA TURKEY
TEL: 27.58.00 TLX: 42155

U.K.
CRELLON LTD.
380/386 BATH ROAD
SLOUGH
BERKS SL16JE U.K.
TEL: BURNHAMM 44.34 TLX: 847573

DISTRONICS LTD
50/51 BURNT MILL
ELIZABETH WAY
HARLOW
ESSEX CM20 2HU U.K.
TEL: HARLOW 397.01 TLX: 81387

BLACK ARROW LTD.
MILLBROOK ROAD
YATE - BRISTOL
BS17 5NX U.K.
TEL: (0454) 315.824

NORBAIN LTD.
NORBAIN HOUSE
ARKWRIGHT ROAD
READING
BERKSHIRE RG2 OLT U.K.
TEL: (0734) 864.411 TLX: 847203

YUGOSLAVIA
AVTOTEHNA
P.O. BOX 593
XI TITOVA 36
LJUBLJANA 61000 YUGOSLAVIA
TEL: 317.044 TLX: 31223

LANCASTER
RCA ELECTRO-OPTICS
NEW HOLLAND AVENUE
LANCASTER, PA 17604
(717) 397-7661

MARKETING: CARL RINTZ

APPLICATIONS: BOB NEUHAUSER