

# CBS-COLORTRON 15HP22

## DATA AND APPLICATION NOTES

15HP22

CBS-COLORTRON

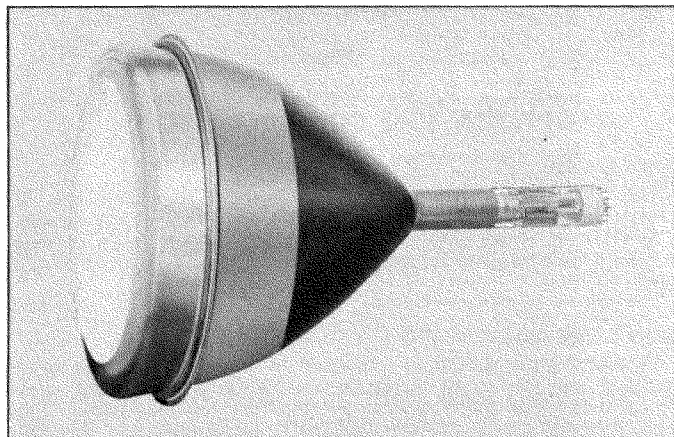


Fig. 1. The CBS-Colortron Type 15HP22

The CBS-Colortron is an aluminized, direct-view, tri-color picture tube designed for use in color-television receivers. Electromagnetically deflected and electrostatically focused, the CBS-Colortron has a deflection angle of 45 degrees, and an over-all length of 26 1/8 inches. It provides a choice of full-color or black-and-white pictures on a screen area of approximately 116 square inches.

This tube employs an all-glass construction and incorporates a unique mask-and-screen assembly. The simplicity of this assembly facilitates the use of low-cost mass-production techniques, and enhances the operational quality of the tube.

### ELECTRON-GUN ASSEMBLY

The electron-gun assembly contains three matched, electrostatic-focus electron guns, each similar to the gun used in the 5TP4 projection-type black-and-white tube. The three guns are arranged in a triangular configuration, with each gun aligned parallel to and equidistant from the tube axis. The guns are also displaced from each other by an angle of 120°, measured in a plane perpendicular to the tube axis.

### PHOSPHOR SCREEN AND APERTURE MASK

By a unique method of screen processing, the tri-color, phosphor-dot screen is placed directly on the inside surface of the spherical face plate of the CBS-Colortron. In addition to achieving simple construction and high-quality reproduction, many electrical and structural advantages are realized, because of this advanced design. Dynamic focusing and convergence requirements are reduced to a minimum; sharper, brighter pictures result; adjustment time is reduced to a minimum; and a simple, stable over-all tube construction is attained.

The phosphor screen of the CBS-Colortron contains some 250,000 phosphor dots of each primary color, a total of 750,000 phosphor dots. These dots are arranged in 250,000 triangular groups, or triads. Each triad contains one red, one blue, and one green phosphor dot.

Another component of the CBS-Colortron is the aperture mask. See Figure 2. This thin, arched mask is located between the phosphor screen and the electron-gun assembly. It contains approximately 250,000 round holes, one for each triad on the screen. Since the position of these holes relative to the triads is of paramount importance for proper tube operation, the mask is accurately positioned with relation to the triads and is approximately 0.4 inch behind the phosphor screen. Figure 3, graphically illustrates the orientation of the holes in the mask with the triads on the screen.

### MASK-AND-SCREEN ASSEMBLY

As can be seen in Figure 2, the entire mask assembly is the ultimate in simplicity. It consists of the curved mask with spring clips to hold it in place. This assembly is mounted on three

hemispheres, which are raised points of glass molded around the edge of the face plate, beyond the picture area.

The mask contains three "V"-shaped surfaces which rest over the hemispheres and make use of the kinematic principle of precise location. Since the mask is unstressed, it is free to expand and contract. This combination of a curved face plate and a curved, unstressed mask automatically permits expansion and contraction without misregistration.

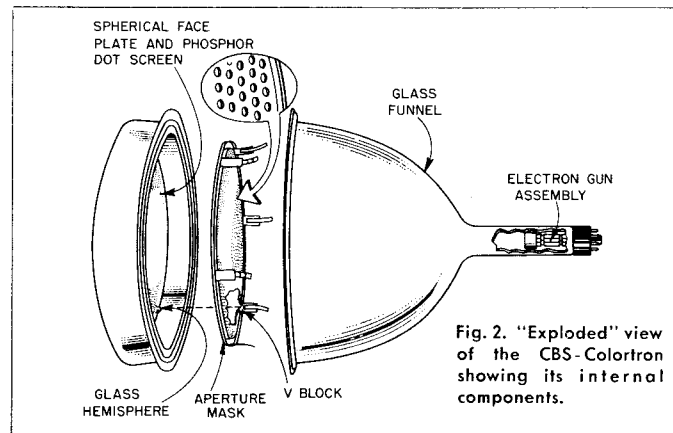


Fig. 2. "Exploded" view of the CBS-Colortron showing its internal components.

## PRINCIPLES OF TUBE OPERATION

A logical starting point to discuss tube operation is the electron gun. As was previously stated, the CBS-Colortron contains three identical electron guns arranged in a triangular configuration. It follows that the resultant beams are also in the same triangular arrangement relative to the tube axis.

Each of these beams is individually modulated by a composite voltage that consists of color and brightness information. This voltage is applied to the control grid of the gun. In addition, a common d-c restorer voltage is simultaneously applied to all cathodes. By utilizing a separate composite signal for each gun, the individual beams are modulated in accordance with the transmitted signal, and are of the proper intensities for their respective colors.

The modulated beams are also focused by their respective guns. This focusing, similar to that in conventional black-and-white tubes, is accomplished by the electrostatic lens formed by grids 2 and 3. Since the focusing electrodes (grid 3 of each of the three guns) are internally connected together, a common focusing voltage may be used. This feature simplifies the associated circuitry.

As the three electron beams emerge from the convergence electrode (grid 4), they are acted upon by the electrostatic convergence lens. This lens is formed by the potential gradient that exists between the convergence electrode and the inner conductive coating in the neck of the tube. This conductive coating is electrically part of the accelerating anode. It is the function of this lens to converge the three beams at the aperture mask. Convergence is necessary to insure that the three color images will be superimposed.

Adjustment of convergence is accomplished by varying the voltage applied to the convergence electrode. This voltage is a combination of a static voltage and a dynamic voltage derived from the horizontal- and vertical-deflection circuits. It varies the focal length of the convergence lens in accordance with the position of the beams as they scan the phosphor screen. The spherical shape of the mask and screen of the CBS-Colortron reduces the dynamic-convergence voltage and facilitates easy convergence adjustment in the receiver.

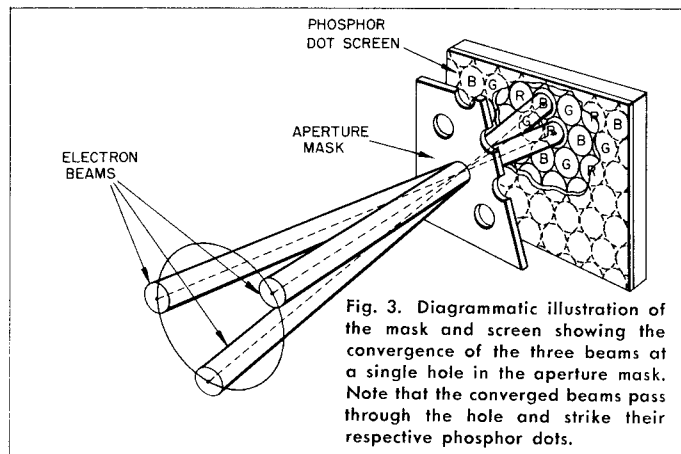
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**CBS-HYTRON**

A Division of Columbia Broadcasting System, Inc.  
DANVERS, MASSACHUSETTS

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In the ideal case, the three beams leave the convergence lens so aligned that, when deflected, they approach the aperture mask at the correct angles properly converged. In the practical case, however, this is not always true. For this reason, it is necessary to employ external components to align properly the three beams.



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

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

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

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

The electron beams travel in straight line paths from the deflection area to the screen, as seen in Figure 3. Between the phosphor screen and the deflection area is the aperture mask. This mask is positioned so that, when viewed from the deflection point of any of the beams, only the dots of a single color can be seen through the perforations in the mask. Figure 4 illustrates this condition.

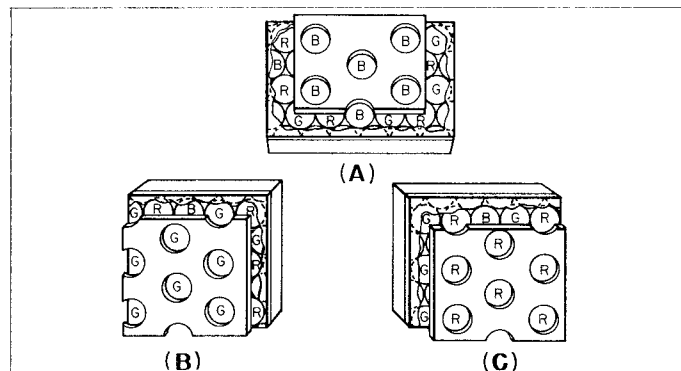


Fig. 4. Views of mask-and-screen assembly as seen from the deflection points of the three beams. (A) View from deflection point of blue gun. (B) View from deflection point of green gun. (C) View from deflection point of red gun.

With the mask in the position described above, one beam will strike only the red dots, another beam will strike only blue dots, and the third beam will strike only green dots. This mask, consequently, allows the three beams to reproduce the exact hue present in each portion of the televised scene.

## APPLICATION CONSIDERATIONS

### TUBE HANDLING

The CBS-Colortron should never be lifted by its neck alone. It is recommended that the tube be lifted by the glass bulb and neck, or by the bulb alone. Special care should be taken to avoid striking or otherwise damaging the metal flange near the face plate of the tube.

### COVER FOR FACE PLATE

A safety glass should be mounted in front of the tube when installed in a television cabinet to provide protection against accidental striking of the face plate and possible tube implosion. This precaution is similar to conventional black-and-white tube requirements.

### SUPPORT

Supports for the CBS-Colortron, which weighs approximately 18½ pounds, should be in the form of an insulated support at the large end of the tube and another near the small end of the bulb. Support for this tube should never be provided at the neck of the tube. Since the deflection yoke must be free to move in an axial and transverse direction, tube supports in this area are also not advisable.

### HIGH-VOLTAGE REQUIREMENTS

Briefly stated, the high-voltage requirements of the CBS-Colortron are: anode, 20,000 volts with a maximum current drain of 600 microamperes; convergence electrode, 9,300 volts with a maximum drain of 5 microamperes; and focus electrode, 3,100 volts with a maximum current drain of 300 microamperes. In addition, the regulation of the anode and convergence voltages must be maintained within two percent to prevent misregistration.

The regulated voltages for the convergence electrode and anode may be derived from a flyback-type deflection system that employs a tapped autotransformer. These voltages are obtained from the full winding of the autotransformer. A separate tap of the same autotransformer supplies the voltage to the focus rectifier tube.

Since two-percent regulation is required for the anode and convergence voltage supply, a shunt regulator or corona discharge tube should be employed.

Adjustment of the focus and convergence potentials can be achieved by the use of potentiometers in the high-voltage divider network.

### COLOR-PURIFYING COIL

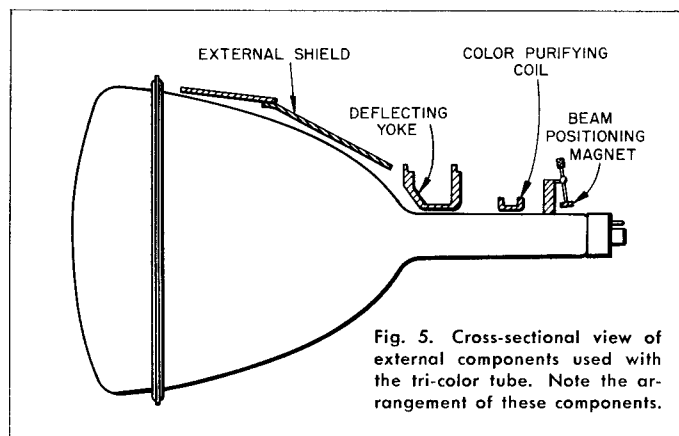
The function of this coil has been described in a preceding section. The approximate position of the coil on the neck of the tube is shown in Figure 5. By rotating the coil around the neck of the tube, the transverse magnetic field will move the beams in different directions. The current through the coil determines the magnitude of the movement. A typical coil requires a current source capable of supplying from 0 to 200 milliamperes. Sickles No. 17086-1 color-purifying coil or equivalent is recommended for use with the 15HP22.

### BEAM-POSITIONING MAGNETS

The function and description of this assembly have also been described in a preceding section. Figure 5 illustrates the position of these magnets on the neck of the tube. The field strength of each magnet is approximately 8 gauss. Sickles No. 17086-1 beam-positioning magnets or equivalent are recommended for use with the 15HP22.

### DEFLECTION YOKES

The deflection yoke recommended for use with the 15HP22 is Sickles No. 17080-1 or equivalent. To permit adjustment for color purity, the deflection yoke, when placed against the glass funnel, should be capable of being moved two inches toward the tube base.



## GRID NO. 1 DRIVE CHARACTERISTICS AND REQUIREMENTS

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

## PROTECTION AGAINST SCANNING FAILURE

Permanent damage may be done to the screen-and-mask assembly if scanning should cease during tube operation. For this reason, an electronic switch activated by the horizontal and vertical deflection voltages should be provided. The circuit should be arranged so that, in case of scanning failure, all beam current will be cut off.

A convenient method of achieving this protection is by obtaining the grid-No. 2 voltages from the boost voltage of the horizontal scanning circuit. This boost voltage also serves to power the vertical deflection system. Any failure of scanning, consequently, would remove the voltage from the No. 2 grids, and all beam current would cease.

## MAGNETIC SHIELDING

Optimum performance of the CBS-Colortron necessitates proper shielding against the effects of the earth's magnetic field and stray fields around the picture tube. A magnetic shield of MuMetal or equivalent material should be placed over the bulb portion of the tube. Placement of magnetic components of the receiver so that the effect of their fields on the picture tube is minimized will result in improved tube performance.

## INSTALLATION AND ADJUSTMENT PROCEDURE

By following a systematic adjustment procedure, adjustment time of the CBS-Colortron can be reduced to a minimum. Such a procedure is described in this section. In addition to the procedural steps, screen patterns that will be observed during each step are described.

When the CBS-Colortron is removed from its carton, it should be handled by the bulb and not by the neck of the tube. Care should be taken to prevent damage to the metal flange near the face plate of the tube. The tube should be mounted securely in the manner described in the SUPPORT Section of this bulletin.

After mounting, the color-purity coil, convergence magnets, and deflection yoke should be placed on the neck of the tube. The approximate position of each of these components is described in the APPLICATION CONSIDERATIONS Section of this bulletin.

Also, refer to Figure 5 for a graphic illustration of these external components. Once these components are positioned on the neck of the tube, the socket and high-voltage connections may be made.

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

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

The next step is to adjust the purity coil. This adjustment should be made in the following steps:

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

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

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

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

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

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

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

The following steps should be taken to achieve color balance.

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

This color-balancing procedure can be simplified by the use of a combination of a density wedge and flying-spot scanner.

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

# DATA ON TYPE 15HP22

## GENERAL CHARACTERISTICS

### Electrical Data

Heater for unipotential cathode, each gun\*  
Voltage .....6.3 volts  
Current .....1.8 amperes

Focusing method .....Electrostatic

Convergence method .....Electrostatic

Deflection method .....Magnetic

Deflection angle (approximate) .....45 degrees

Electron guns, three .....Red, Blue, Green

Phosphor JETEC Designation P22

|                 |        |        |        |
|-----------------|--------|--------|--------|
| Fluorescence    | Red    | Blue   | Green  |
| Phosphorescence | Red    | Blue   | Green  |
| Persistence     | Medium | Medium | Medium |

Direct interelectrode capacitances (approximate):

Grid No. 1 of any gun to all other electrodes except

No. 1 grids of other two guns .....7.5 uuf

Three cathodes externally tied together to all other

electrodes .....17.5 uuf

Grid No. 3 (all three No. 3 grids tied together in-

ternally) to all other electrodes .....12.0 uuf

Grid No. 4 (common to all three guns) to all other

electrodes .....7.0 uuf

External conductive coating .....1500 uuf min.

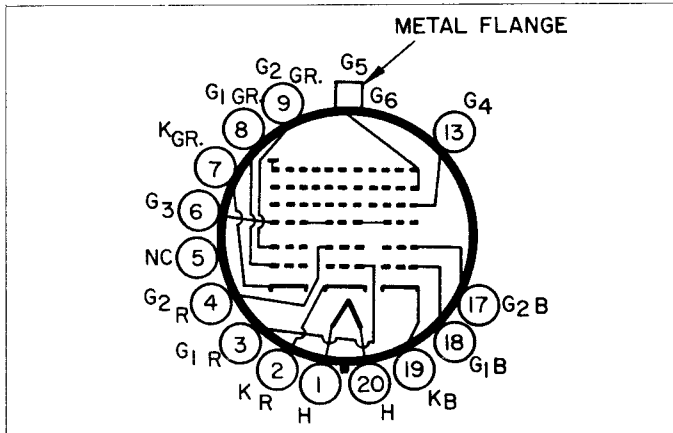
2500 uuf max.

Screen .....Metal-backed, tri-color, phosphor-dot type

Phosphor-dot arrangement .....Approximately 250,000 triangular groups,

each containing a blue, red, and green dot

(a total of 750,000 dots)



Basing Diagram

- |                              |                                |
|------------------------------|--------------------------------|
| Pin 1: Heater                | Pin 8: Grid No. 1 of green gun |
| Pin 2: Cathode of red gun    | Pin 9: Grid No. 2 of green gun |
| Pin 3: Grid No. 1 of red gun | Pin 13: Grid No. 4             |
| Pin 4: Grid No. 2 of red gun | Pin 17: Grid No. 2 of blue gun |
| Pin 5: No connection         | Pin 18: Grid No. 1 of blue gun |
| Pin 6: Grids No. 3           | Pin 19: Cathode of blue gun    |
| Pin 7: Cathode of green gun  | Pin 20: Heater                 |

Metal Flange: Anode

### Mechanical Data

Approximate weight .....18½ pounds  
Maximum over-all length .....26⅞ inches  
Maximum diameter .....15¾ inches  
Minimum screen diameter .....12 inches  
Bulb Contact .....Metal-flange seal  
Base .....Small-shell bidecal 14-pin JETEC No. B14-103  
Mounting position .....Any  
Socket .....Cinch No. 57C17902 or equivalent  
Horizontal output transformer .....Sickles No. 17081-1 or equivalent  
Purity coil and beam-positioning magnets .....Sickles No. 17086-1 or equivalent  
Deflection yoke .....Sickles No. 17080-1 or equivalent

## MAXIMUM RATINGS — Design-Center Values

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

## TYPICAL OPERATING CONDITIONS

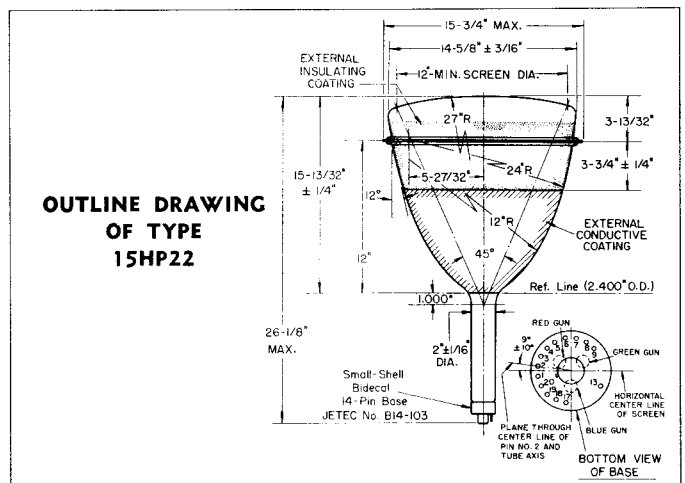
|                                                 |                   |
|-------------------------------------------------|-------------------|
| Anode voltage                                   | 20,000 volts      |
| Grid-No. 4 (convergence) voltage, approximate** | 9,300 volts       |
| Grid-No. 3 (focus) voltage, approximate         | 3,100 volts       |
| With grid-No. 2 voltage of 200 volts, each gun  |                   |
| Grid-No. 1 voltage, each gun                    | —45 to —100 volts |
| With grid-No. 1 voltage of —75 volts, each gun  |                   |
| Grid-No. 2 voltage, each gun                    | 240 volts         |
| Maximum grid-No. 4 current                      | .5 microamperes   |
| Maximum peak grid-No. 3 current                 | .300 microamperes |

## CIRCUIT VALUES

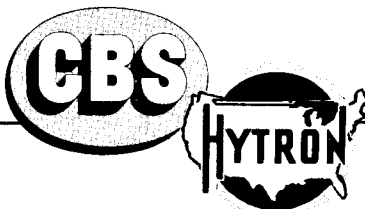
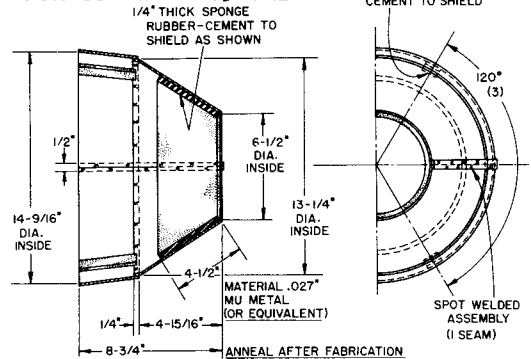
Maximum grid-No. 1 circuit resistance, each gun .....1.5 megohms  
Horizontal-dynamic-convergence voltage, approximate\*\* .....550 volts  
Vertical-dynamic-convergence voltage, approximate\*\* .....200 volts  
Dynamic-focus voltage, approximate\*\* .....150 volts  
\*Heaters electrically paralleled within the tube.  
\*\*Does not include the a-c component of the convergence voltage.  
†For visual extinction of focused raster.  
‡Peak-to-peak value. This a-c voltage is synchronized with the scanning and does not include any voltage developed during the blanking time.  
To reduce the effects of stray magnetic fields on color purity, a magnetic shield is recommended. This shield should fit snugly around the cone of the glass bulb. Outline drawing of a recommended shield is shown elsewhere in this bulletin.

## CAUTION

Because the rating of this tube permits operation at voltages as high as 20,000 volts, shielding of the tube for X-ray radiation may be necessary whenever operating conditions involve voltages in excess of 16,000 volts. Sufficient shielding is usually provided by the safety glass in front of the tube.



## MAGNETIC SHIELD RECOMMENDED FOR USE WITH 15HP22



CBS-HYTRON Main Office: Danvers, Massachusetts

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# CBS-COLORTRON "205"

RETMA TYPE 19VP22

Data and Application Notes

19VP22  
THE  
CBS-COLORTRON  
"205"

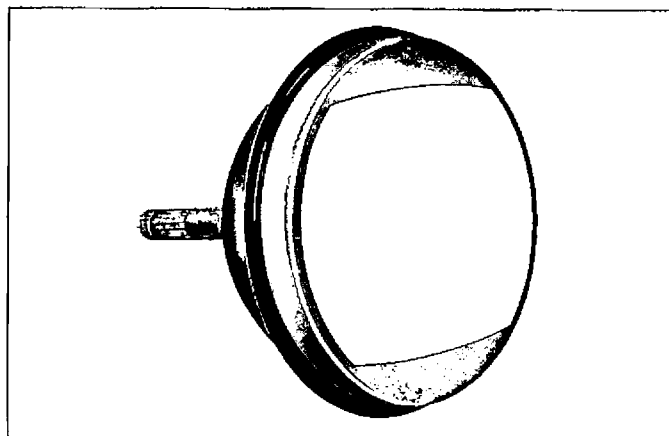


Fig. 1. The CBS-Colortron "205"

The CBS-Colortron "205" is a 19-inch, aluminized, glass-envelope, tri-color picture tube designed for use in color television receivers. By utilizing the CBS-Hytron method of applying the phosphor dots to the inner surface of the face plate, the "205" provides truly large-screen color television. The actual useful screen area of this 19-inch Colortron is 205 square inches. In addition to the large-screen surface, the CBS-Colortron "205" incorporates an electromagnetic convergence system that eliminates the high-voltage problems associated with electrostatic convergence. This convergence system and other features are described in detail in later sections of this bulletin.

The electrostatically-focused and magnetically-deflected CBS-Colortron "205", in short, provides: 205 square inches of useful viewing surface . . . electromagnetic convergence . . . wide-angle 62° deflection and 26 7/16-inch over-all length for cabinet economy . . . and the unique CBS-Hytron mask-and-screen assembly that facilitates the use of low-cost mass production techniques.

## ELECTRON-GUN ASSEMBLY

The electron-gun assembly of the "205" contains three matched electron beam sources arranged in a triangular configuration. Each of the three beam sources is tilted toward the common tube axis. This tilted structure provides proper convergence of the beams at the center of the screen. The electron-gun assembly of the "205" contains three pairs of pole pieces mounted 120° apart above the anode.

## PHOSPHOR SCREEN AND SHADOW MASK

By a new method of screen processing, the tri-color, phosphor-dot screen is placed directly on the inside surface of the spherical face plate of the CBS-Colortron. In addition to achieving simple construction and high-quality reproduction, many electrical and structural advantages are realized, because of this advanced design. Dynamic convergence requirements are reduced; sharper, brighter pictures result; adjustment time is reduced to a minimum; and a simple, stable over-all tube construction is attained.

The phosphor screen of the CBS-Colortron contains some 300,000 phosphor dots of each primary color, a total of 900,000 phosphor dots. These dots are arranged in 300,000 triangular groups, or triads. Each triad contains one red, one blue, and one green phosphor dot.

Another component of the CBS-Colortron is the shadow mask. See Figure 2. This thin, arched mask is located between the phosphor screen and the electron-gun assembly. It contains approximately 300,000 uniform-size, round holes, one for each triad on the screen. Since the position of these holes relative to the triads is of paramount importance for proper tube operation, the mask is accurately positioned with relation to the triads and is approximately 0.4 inch behind the phosphor screen.

## MASK-AND-SCREEN ASSEMBLY

As can be seen in Figure 2, the entire mask assembly is exceedingly simple. It consists of the curved mask with spring clips to hold it in place. This assembly is mounted on three

hemispheres, which are raised points of glass molded around the edge of the face plate, beyond the picture area.

The mask contains three "V"-shaped surfaces which rest over the hemispheres and make use of the kinematic principle of precise location. Since the mask is unstressed, it is free to expand and contract. This combination of a curved face plate and a curved, unstressed mask automatically permits expansion and contraction without misregistration.

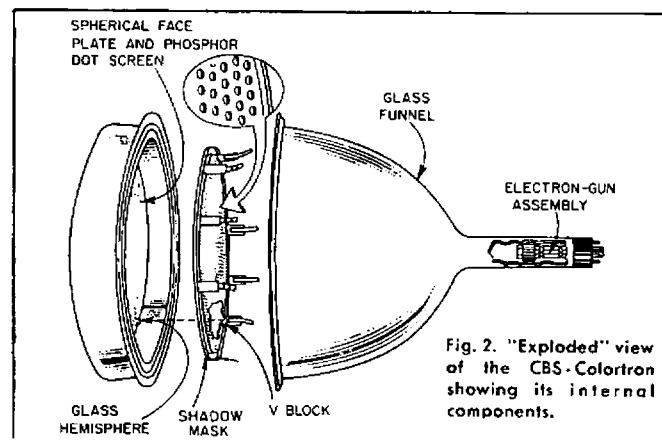


Fig. 2. "Exploded" view of the CBS-Colortron showing its internal components.

## PRINCIPLES OF TUBE OPERATION

A logical starting point to discuss tube operation is the electron-gun assembly made up of three identical electron beam sources arranged in a triangular configuration. The resultant beams are also in the same triangular arrangement relative to the tube axis.

Each of these beams is individually modulated by a composite voltage that consists of color and brightness information. By utilizing a separate composite signal for each beam source, the individual beams are modulated in accordance with the transmitted signal, and are of the proper intensities for their respective colors.

The modulated beams are also focused by their respective beam sources. This focusing, similar to that in conventional black-and-white tubes, is accomplished by the electrostatic lens formed by grids 2 and 3. Since the focusing electrodes (grid 3 of each of the three beam sources) are internally connected together, a common focusing voltage may be used. This feature simplifies the associated circuitry.

The three electron beams are then acted upon by the magnetic fields created by three external electromagnets mounted on the tube neck. The electron-gun assembly contains three sets of pole pieces mounted above the anode. Magnetic fields, created by three electromagnets on the tube neck, are induced in these three sets of pole pieces and provide dynamic convergence control of each of the three electron beams. Small d-c fields may also be induced in these pole pieces to compensate for slight manufacturing variations that might otherwise impair proper mechanical static convergence.

These electromagnets provide radial adjustment of each of the three beams. Since it may not always be possible to converge properly the three beams by radial adjustment only, an external blue-beam positioning magnet is used to provide tangential movement of the blue beam. The combination of the three external electromagnets and the blue-beam positioning magnet insures the realization of center convergence.

The dynamic convergence produced by the electromagnetic fields varies the point of convergence in accordance with the position of the beams as they scan the phosphor screen. The spherical shape of the mask and screen of the CBS-Colortron reduces the dynamic-convergence requirements and facilitates easy convergence adjustment in the receiver. A suggested circuit for the derivation of the convergence currents is shown in Figure 3.

PREPARED BY COMMERCIAL ENGINEERING DEPT.

CBS-HYTRON

A Division of Columbia Broadcasting System, Inc.  
DANVERS, MASSACHUSETTS

from JETEC release  
#1337, July 30, 1954

Bulletin #E-227  
June 1, 1954

quently, allows the three beams to reproduce the exact hue present in each portion of the televised scene.

## TUBE HANDLING

The CBS-Colortron should never be lifted by its neck alone. It is recommended that the tube be lifted by the glass bulb and neck, or by the bulb alone. Special care should be taken to avoid striking or otherwise damaging the metal flange near the face plate of the tube.

**COVER FOR FACE PLATE**

A safety glass should be mounted in front of the tube when installed in a television cabinet to provide protection against accidental striking of the face plate and possible tube implosion. This precaution is similar to conventional black-and-white tube requirements.

## SUPPORT

Supports for the CBS-Colortron, which weighs approximately 31 pounds, should be in the form of an insulated support at the large end of the tube and another near the small end of the bulb. Support for this tube should never be provided at the neck of the tube. Since the deflection yoke must be free to move in an axial and transverse direction, tube supports in this area are also not advisable.

## HIGH-VOLTAGE REQUIREMENTS

Briefly stated, the high-voltage requirements of the CBS-Colortron "205" are: anode, 25,000 volts with a maximum peak current of 3,000 microamperes; focus electrode, 8,000 volts with a maximum current drain of 300 microamperes. In addition, it is desirable that the regulation of the anode voltage be maintained within two percent.

The regulated voltage for the anode may be derived from a fly-back-type deflection system that employs a tapped autotransformer. This voltage is obtained by using a pulse doubler rectifier system from the tertiary winding of the autotransformer. A separate tap of the same autotransformer supplies the voltage to the focus rectifier tube.

Since two-percent regulation is desirable for the anode voltage supply, a shunt regulator tube should be employed, such as the CBS-Hytron 6BD4A.

Adjustment of the focus potential can be achieved by the use of a potentiometer in the high-voltage divider network.

## MAGNETIC CONVERGENCE COILS

The function of the three magnetic convergence coils has been described in a preceding section. The approximate position of the unit containing these coils is shown in Figure 5. The three individual electromagnets are positioned 120° apart around the circumference of this unit and over the internal pole pieces. Rola Type CC600 magnetic-convergence-coil unit is recommended for use with the CBS-Colartone "205".

## COLOR-PURIFYING COIL

The function of this coil has been described in a preceding section. The approximate position of the coil on the neck of the tube is shown in Figure 5. By rotating the coil around the neck of the tube, the transverse magnetic field will move the beams in different directions. The current through the coil determines the magnitude of the movement. A typical coil (Rola CP600) requires a current source capable of supplying from 0 to 200 milliamperes.

### FIELD NEUTRALIZING COIL

In order to reduce the effect of axial stray fields, a D.C. field neutralizing coil located around the periphery of the "205" face plate is required. It should be approximately 21 inches in diameter and capable of producing about 15 ampere-turns (150 turns of No. 24 wire and a current source with a range from +100 milliamperes to -100 milliamperes). Adjustment of this component is described in the INSTALLATION AND ADJUSTMENT PROCEDURE Section of this bulletin.

### BLUE-BEAM POSITIONING MAGNET

The function of this unit has also been described in a preceding section. Figure 5 illustrates the position of this magnet on the neck of the tube. The magnet is mounted to provide for reversal of its polarity and the position of the magnet controls the magnitude of the correction.

### DEFLECTION YOKE

The deflection yoke recommended for use with the "205" is Rola Type CY600 or equivalent. To permit adjustment for color purity, the deflection yoke, when placed against the glass funnel, should be capable of being moved two inches toward the tube base.

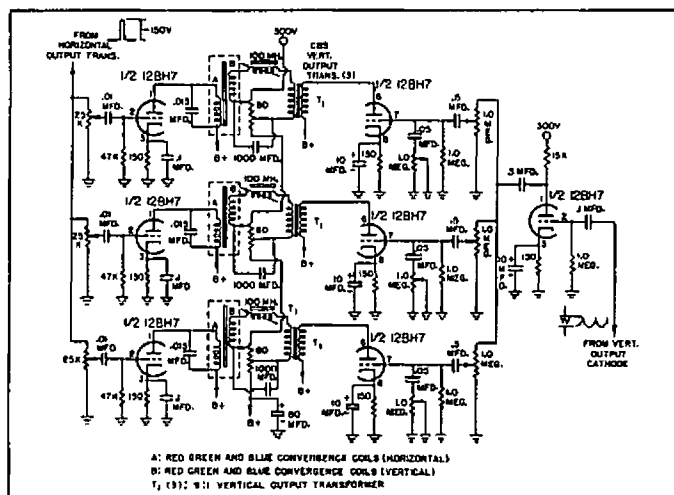


**Fig. 3. Suggested circuit for the derivation of convergence currents.**

Two of these external components, the blue-beam positioning magnet and the magnetic convergence coils, have already been described. The other external component necessary for proper beam alignment is the color-purifying coil. The magnetic field produced by this coil is perpendicular to the tube axis. This field acts upon the three beams simultaneously and, by proper adjustment of its strength, and its axial and rotational position, the common axis of three beams can be positioned to achieve optimum color purity. The coil is located on the neck of the tube in the region of grids 2 and 3. The construction of the coil should allow it to be rotated and moved along the neck of the tube.

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

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

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

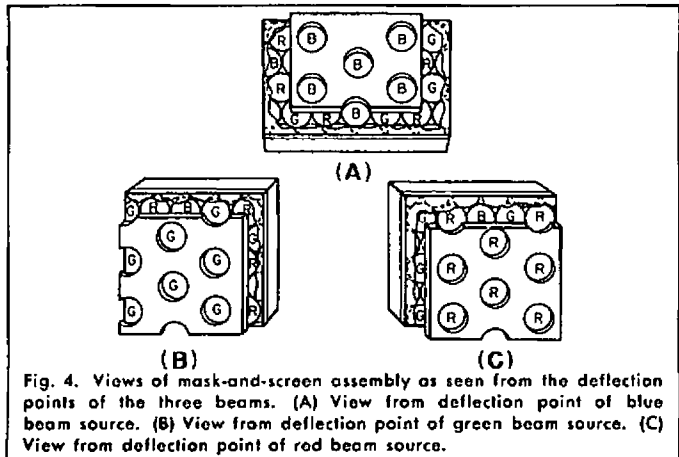


Fig. 4. Views of mask-and-screen assembly as seen from the deflection points of the three beams. (A) View from deflection point of blue beam source. (B) View from deflection point of green beam source. (C) View from deflection point of red beam source.

With the mask in the position described above, one beam will strike only the red dots, another beam will strike only blue dots, and the third beam will strike only green dots. This mask, conse-

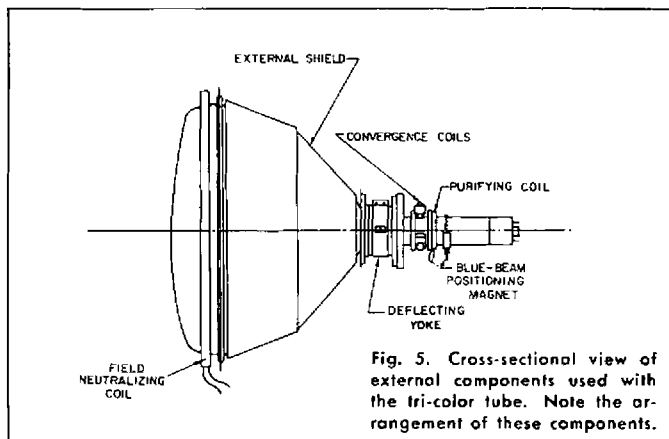


Fig. 5. Cross-sectional view of external components used with the tri-color tube. Note the arrangement of these components.

## GRID NO. 1 DRIVE CHARACTERISTICS AND REQUIREMENTS

The three electron beam sources of the CBS-Colortron have similar transfer characteristics. Due to the differences in phosphor luminescence efficiencies, however, the grid-No. 1 and grid-No. 2 voltages of each beam source must be adjusted to produce equal phosphor brightness or color balance. If color balance is not maintained when the tube is reproducing black-and-white pictures, for instance, color tinting of the gray scale will result. It is recommended that individual grid-No. 2 voltage controls and grid-No. 1 drive controls be provided. The grid-No. 2 controls should allow voltage adjustment from 100 to 450 volts.

## PROTECTION AGAINST SCANNING FAILURE

Permanent damage may be done to the screen-and-mask assembly if scanning should cease during tube operation. For this reason, an electronic switch activated by the horizontal and vertical deflection voltages should be provided. The circuit should be arranged so that, in case of scanning failure, all beam current will be cut off.

A convenient method of achieving this protection is by obtaining the grid-No. 2 voltages from the boost voltage of the horizontal scanning circuit. This boost voltage also serves to power the vertical deflection system. Any failure of scanning, consequently, would remove the voltage from the No. 2 grids, and all beam current would cease.

## MAGNETIC SHIELDING

Optimum performance of the CBS-Colortron necessitates proper shielding against the effects of the earth's magnetic field and stray fields around the picture tube. A magnetic shield of MuMetal or equivalent material should be placed over the bulb portion of the tube. Placement of magnetic components of the receiver so that the effect of their fields on the picture tube is minimized will result in improved tube performance. A typical shield is shown on page 4.

## INSTALLATION AND ADJUSTMENT PROCEDURE

By following a systematic adjustment procedure, adjustment time of the CBS-Colortron can be reduced to a minimum. Such a procedure is described in this section. In addition to the procedural steps, screen patterns that will be observed during each step are described.

When the CBS-Colortron is removed from its carton, it should be handled by the bulb and not by the neck of the tube. Care should be taken to prevent damage to the metal flange near the face plate of the tube. The tube should be mounted securely in the manner described in the SUPPORT Section of this bulletin.

After mounting, the color-purity coil, convergence magnets, and deflection yoke should be placed on the neck of the tube. The approximate position of each of these components is described in the APPLICATION CONSIDERATIONS Section of this bulletin. Also, refer to Figure 5 for a graphic illustration of these external components. Once these components are positioned on the neck of the tube, the socket and high-voltage connections may be made.

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

After allowing sufficient time for the various supplies to stabilize, slowly increase the grid-No. 2 voltage of the red beam source, simultaneously reducing the grid-No. 1 bias until the screen is illuminated.

The next step is to adjust the purity coil. This adjustment should be made in the following steps:

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

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

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

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

Initially, red and green static convergence is adjusted by varying the d-c current through the red and green magnetic convergence coils until the red and green dots at the center of the raster overlap. The blue static convergence is then adjusted by varying the d-c current through the blue magnetic convergence coil and by adjusting the blue-beam positioning magnet until the blue dot at the center of the raster overlaps the red and green dots.

Dynamic convergence can be optimized after static convergence is attained. Horizontal dynamic convergence is obtained by adjustment of the amplitude of the parabolic horizontal current wave applied to the three external convergence electromagnets. This current should be varied until each triad in the horizontal row that passes through the center of the screen is the same size. Then the d-c current through the three electromagnets should be adjusted to bring all the triangles of this horizontal row into proper convergence.

Vertical dynamic convergence is attained by varying the magnitude of the parabolic vertical current wave applied to the external electromagnets until each triad of the vertical row that passes through the center of the screen is the same size. The dots of each triangle can be converged by the readjustment of the d-c current through the electromagnets. Because of the interaction between the horizontal- and vertical-convergence adjustments, it is recommended that these adjustments be performed alternately until optimum convergence is attained.

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

The following steps should be taken to achieve color balance.

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

This color-balancing procedure can be simplified by the use of a combination of a density wedge and flying-spot scanner.

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





# technical information

**CBS ELECTRONICS**

*A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts*

**1J3A**

The CBS type 1J3A is a half-wave rectifier for cathode-ray tube anode supplies. It has a higher peak inverse plate voltage rating and higher d-c plate voltage rating than type 1J3. The 1J3A will directly replace the 1J3.

**MECHANICAL DATA**

|                        |               |
|------------------------|---------------|
| Cathode, filament      |               |
| Bulb                   | T-9           |
| Maximum overall height | 4.0625 inches |
| Maximum seated height  | 3.5 inches    |
| Base, JEDEC            | B6-8, B6-60   |
| Basing, JEDEC          | 3C            |
| Top Cap, JEDEC         | C1-34         |
| Mounting position      | any           |

**PIN CONNECTIONS**

|        |                      |        |                      |
|--------|----------------------|--------|----------------------|
| Pin 1: | Internal connection* | Pin 7: | Filament and         |
| Pin 2: | Filament             |        | internal shield      |
| Pin 3: | Internal connection* | Pin 8: | Internal connection* |
| Pin 5: | Internal connection* | Cap:   | Plate                |

**ELECTRICAL DATA****FILAMENT CHARACTERISTICS**

|               |      |       |
|---------------|------|-------|
| Voltage, a-c† | 1.25 | volts |
| Current       | 0.2  | amp   |

† Filament voltage must not exceed 1.45 volts or be less than 1.05 volts.

from JEDEC release #2830, June 6, 1960

## DIRECT INTERELECTRODE CAPACITANCES

|                                           |     |     |
|-------------------------------------------|-----|-----|
| Plate to filament, approx.: p to f + 1.s. | 1.6 | μμf |
|-------------------------------------------|-----|-----|

## MAXIMUM RATINGS (Design maximum values)

### Flyback Rectifier Service†

|                                  |     |    |
|----------------------------------|-----|----|
| Plate voltage, peak inverse      |     |    |
| Total d-c and peak               | 28  | kv |
| D-c                              | 24  | kv |
| Output current, d-c              | 0.5 | ma |
| Plate current, peak steady state | 50  | ma |

## CHARACTERISTICS

|                                    |     |       |
|------------------------------------|-----|-------|
| Tube voltage drop, conducting 7 ma | 225 | volts |
|------------------------------------|-----|-------|

### NOTES:

† Voltage pulse duration must not exceed 10μs in a 30-frame, 525-line system.

- \* Socket terminals 1, 3, 5 and 8 may be connected to pin 7 or its corona shield. Terminals 4 and 6 may be used as tie points for components at or near filament potential.

### WARNING

This tube may produce soft X-rays which constitute a health hazard. Proper shielding in equipment design will prevent this danger.

# engineering data for

## ULTRA-HIGH RESOLUTION CATHODE RAY TUBES

**2000 lines per inch resolution . . . . .**  
**short persistence phosphor . . . . .**  
**. . . used for photographic recording and UHR**  
**radar**

The CBS-Hytron cathode ray tubes, primarily ultra-high resolution read out tubes or monitors, are designed for high precision display and photographic use. They are capable of resolving 2000 lines per inch. For a line scan of 4.5 inches in a 5 inch diameter tube, a total of 8000 lines can be achieved.

By the immersion electron optical design, the beam is controlled over its entire post-acceleration path. Moreover the half-deflection angle of  $9.5^\circ$  insures accurate deflection linearity with suitable yokes\*. Defocusing at the edge of the usable screen is less than 2.5%, which is negligible, but may be corrected to near zero by simple dynamic focusing. It should be realized that some loss of resolution will occur at the extremes of deflection. This loss results from the geometry of a flat face plate and is held to less than 15%.



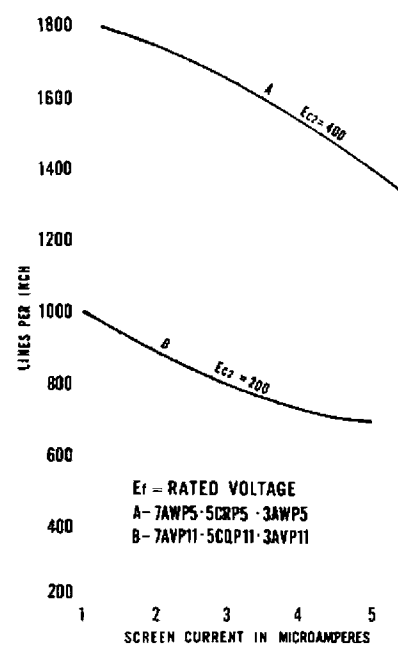
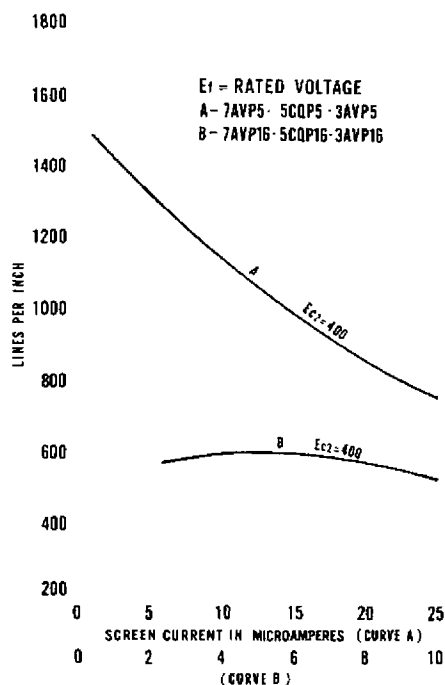
Tubes are available with P5 or P11 phosphor. These CR tubes are particularly suitable for photographic recording since the peak wavelengths of the phosphor fall within the blue region of the spectrum ( $4300\text{\AA}$  and  $4600\text{\AA}$  respectively).

Tubes are also available in P16 phosphor. P16 has a shorter persistence of 1  $\mu\text{s}$  permitting use of these tubes in flying spot scanner work.

These ultra high resolution cathode ray tubes open up whole new fields of application in strip radar, photo reconnaissance, visual indication, photo reproduction, information transfer, industrial and medical closed-circuit TV, and remote data pick up.

\*The magnetically shielded focus coil and deflection yokes, available from CBS-Hytron, have been designed for 1000 cps as well as the commercial TV scanning rate, are linear to within  $\pm 2.5\%$ , and are made for 20 Kv anode voltage.

## RESOLUTION VERSUS SCREEN CURRENT



**CBS-HYTRON**, Danvers, Massachusetts  
 A Division of Columbia Broadcasting System, Inc.

from JEDEC release #2419, March 30, 1959



## ULTRA-HIGH RESOLUTION CATHODE-RAY TUBES

| TYPE   | MECHANICAL DATA     |                       |                                          |                      |                                         |       |        | OPTICAL DATA      |                                          | ELECTRICAL DATA                                                    |                         |                                          |                             |                            |                                    |                   |                   |              |            |          |                   |               |                |                             |                                       |                                               |            |
|--------|---------------------|-----------------------|------------------------------------------|----------------------|-----------------------------------------|-------|--------|-------------------|------------------------------------------|--------------------------------------------------------------------|-------------------------|------------------------------------------|-----------------------------|----------------------------|------------------------------------|-------------------|-------------------|--------------|------------|----------|-------------------|---------------|----------------|-----------------------------|---------------------------------------|-----------------------------------------------|------------|
|        | OVERALL LENGTH      | GREATEST DIA. OF BULB | MIN. USEFUL (FACEPLATE SCREEN DIA. FLAT) | NECK LENGTH          | BULB CONTACT †<br>Recessed Small Cavity | BASE  | BASING | PHOSPHOR NUMBER † | RESOLUTION<br>TV LINES/INCH<br>AT CENTER | FOCUSING METHOD<br>DEFLECTING METHOD<br>DEFLECTION ANGLE (APPROX.) | CAPACITANCES (APPROX.)  |                                          | HEATER*                     |                            | MAXIMUM RATINGS<br>ABSOLUTE VALUES |                   |                   |              |            |          | TYPICAL OPERATION |               |                |                             |                                       |                                               |            |
|        |                     |                       |                                          |                      |                                         |       |        |                   |                                          |                                                                    | G1 TO ALL<br>ELECTRODES | FILAMENTARY CATHODE<br>TO ALL ELECTRODES | HEATER VOLTS,<br>A-C OR D-C | HEATER CURRENT,<br>AMPERES | ANODE KV                           | GRID VOLTS, +BIAS | GRID VOLTS, -BIAS | GRID 2 VOLTS | CATHODE MA | ANODE KV | G1 BIAS VOLTS     | G2 BIAS VOLTS | SCREEN $\mu$ A | SIGNAL GRID<br>CUTOFF VOLTS | MAGNETIC FOCUS FIELD<br>AMP. TURNS/CM | MAX. G1 CIRCUIT<br>RESISTANCE (MEG $\Omega$ ) |            |
| 7AWP5  | 26.0"<br>$\pm .5$ " | 7.00"<br>$\pm .13$ "  | 6.25"                                    | 6.13"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 2,000                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -45           | 400            | 3.5                         | 80-100                                | 50                                            | 1.0        |
| 7AVP5  | 26.0"<br>$\pm .5$ " | 7.00"<br>$\pm .13$ "  | 6.25"                                    | 6.13"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 1,500                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 50                                            | 1.0        |
| 7AVP16 | 26.0"<br>$\pm .5$ " | 7.00"<br>$\pm .13$ "  | 6.25"                                    | 6.13"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-16              | 500                                      | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 50                                            | 1.0        |
| 7AVP11 | 26.0"<br>$\pm .5$ " | 7.00"<br>$\pm .13$ "  | 6.25"                                    | 6.13"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-11              | 1,000                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -22           | 200            | 30                          | 43-50<br>90-120                       | 50<br>50                                      | 1.0<br>1.0 |
| 5CRP5  | 19.4"<br>$\pm .5$ " | 5.00"<br>$\pm .13$ "  | 4.25"                                    | 5.76"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 2,000                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -45           | 400            | 3.5                         | 80-100                                | 69                                            | 1.0        |
| 5CQP5  | 19.4"<br>$\pm .5$ " | 5.00"<br>$\pm .13$ "  | 4.25"                                    | 5.76"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 1,500                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 69                                            | 1.0        |
| 5CQP16 | 19.4"<br>$\pm .5$ " | 5.00"<br>$\pm .13$ "  | 4.25"                                    | 5.76"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-16              | 500                                      | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 69                                            | 1.0        |
| 5CQP11 | 19.4"<br>$\pm .5$ " | 5.00"<br>$\pm .13$ "  | 4.25"                                    | 5.76"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-11              | 1,000                                    | MAG                                                                | 19°                     | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -22           | 200            | 30                          | 43-50<br>90-120                       | 69<br>69                                      | 1.0<br>1.0 |
| 3AWP5  | 19.4"<br>$\pm .5$ " | 3.00"<br>$\pm .13$ "  | 2.25"                                    | 5.74"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 2,000                                    | MAG                                                                | 9.5°                    | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -45           | 400            | 3.5                         | 80-100                                | 69                                            | 1.0        |
| 3AVP5  | 19.4"<br>$\pm .5$ " | 3.00"<br>$\pm .13$ "  | 2.25"                                    | 5.74"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-5               | 1,500                                    | MAG                                                                | 9.5°                    | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 69                                            | 1.0        |
| 3AVP16 | 19.4"<br>$\pm .5$ " | 3.00"<br>$\pm .13$ "  | 2.25"                                    | 5.74"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-16              | 500                                      | MAG                                                                | 9.5°                    | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -50           | 400            | 120                         | 90-120                                | 69                                            | 1.0        |
| 3AVP11 | 19.4"<br>$\pm .5$ " | 3.00"<br>$\pm .13$ "  | 2.25"                                    | 5.74"<br>$\pm .13$ " | J1-21                                   | B5-57 | 12D    | P-11              | 1,000                                    | MAG                                                                | 9.5°                    | 7 $\mu$ uf<br>MAX.                       | 6 $\mu$ uf<br>MAX.          | 6.3                        | .600<br>$\pm 10\%$                 | 30                | 0                 | -300         | +1000      | 1        | 20                | -22           | 200            | 30                          | 43-50<br>90-120                       | 69<br>69                                      | 1.0<br>1.0 |

\* PEAK HEATER — CATHODE VOLTAGE

HEATER NEGATIVE TO CATHODE  
DURING WARM-UP PERIOD OF 15 SECONDS, MAX. .... 410 VOLTS  
AFTER EQUIPMENT WARM-UP PERIOD ..... 180 VOLTS  
HEATER POSITIVE WITH RESPECT TO CATHODE ..... 180 VOLTS

† Bulb contact alignment: Pin 3  $\pm 10$  degrees.

‡ P5: Fluorescent and Phosphorescent color, blue; Persistence (approx.), 10-5 sec.

P11: Fluorescent and Phosphorescent color, blue; Persistence (approx.), 5 x 10-5 sec.

P16: Fluorescent and Phosphorescent color, near ultra violet; Persistence (approx.), 10-6 sec.

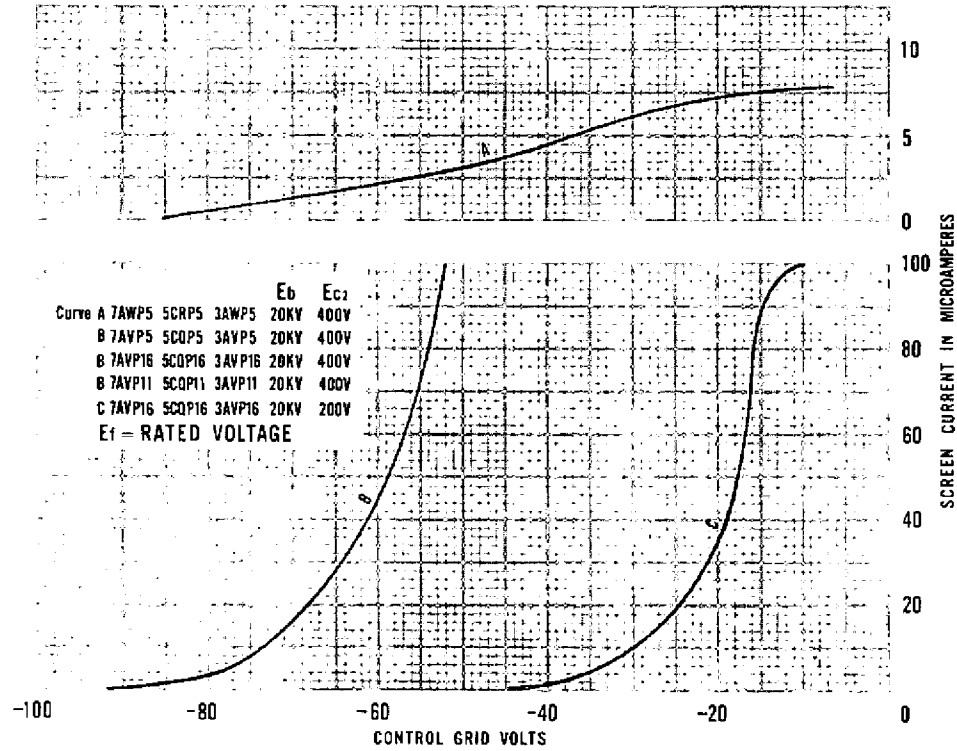
### BRIGHTNESS:

Brightness measured according to MIL-E-1D Par. 4.12.5.2 using a 105 line pattern and a 2" x 2" raster with a Weston light meter corrected for eye sensitivity.

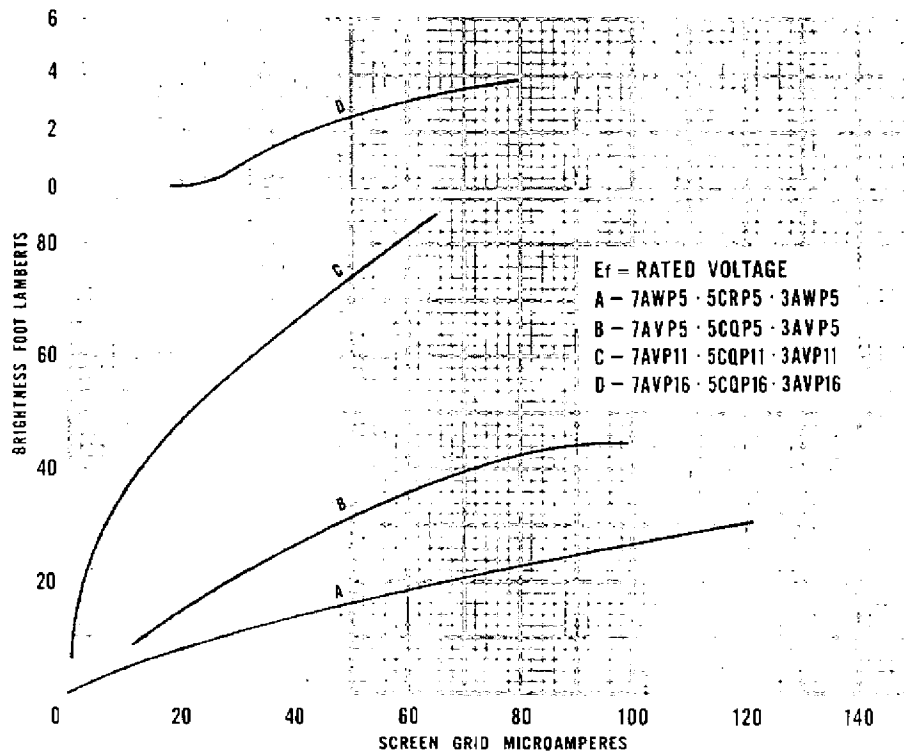
### RESOLUTION:

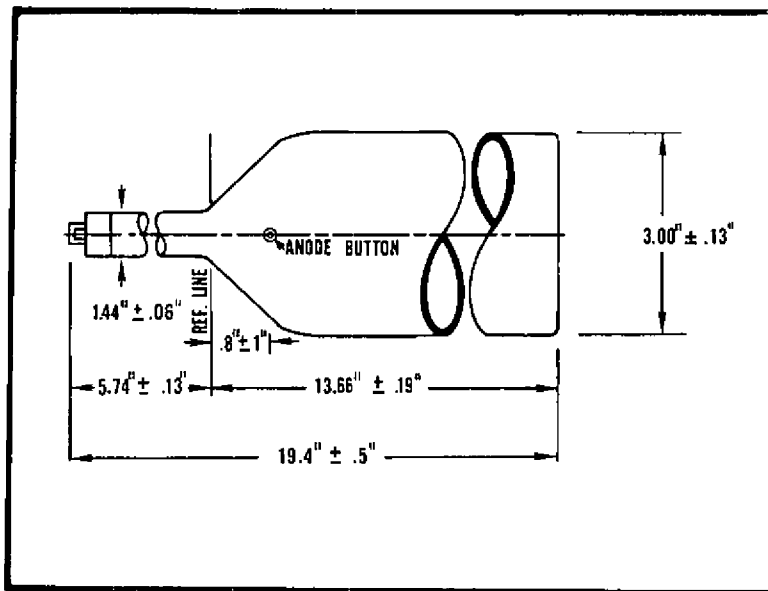
The resolution is measured by the compressed raster test pattern which has a 500 line resolution wedge. The contrast ratio of the wedge lines at extinction will vary from 2 to 5% at maximum resolution. Various other methods of determining resolution are in use, however the compressed raster test pattern offers simplicity and is generally understood.

## TRANSFER CHARACTERISTICS



## BRIGHTNESS VERSUS SCREEN CURRENT



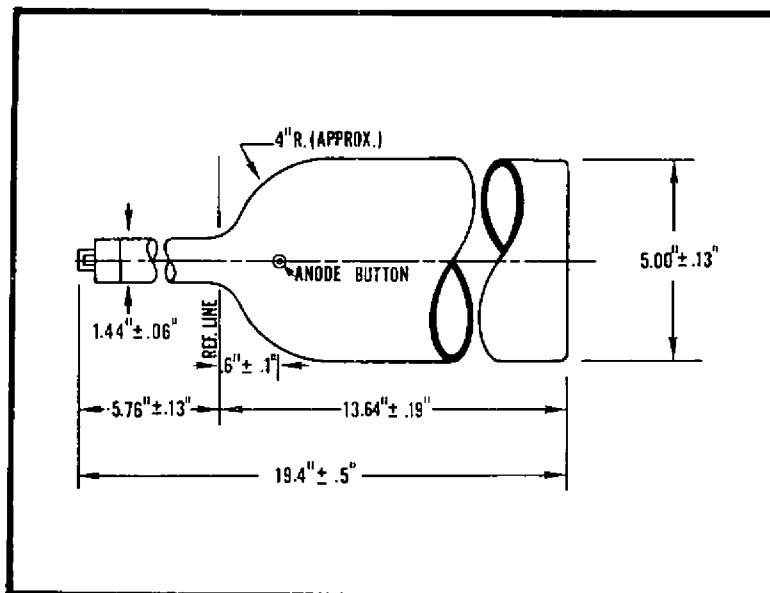


**3AVP5**

**3AWP5**

**3AVP11**

**3AVP16**

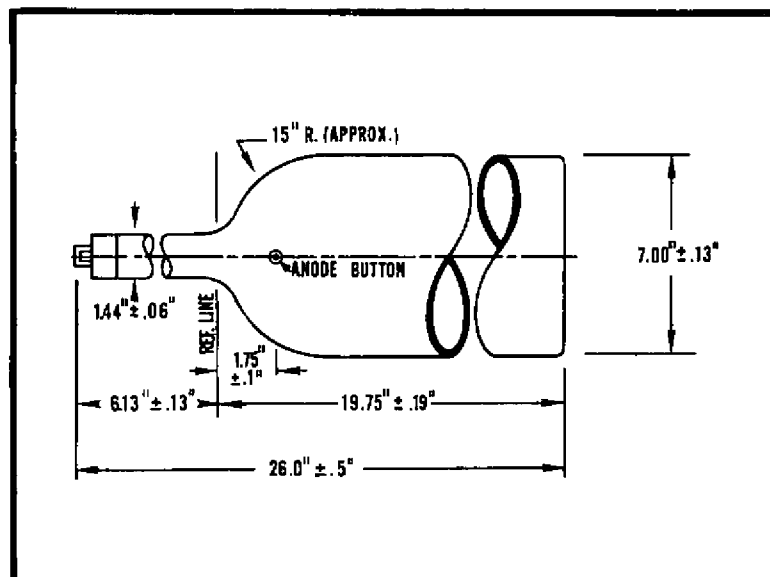


**5CQP5**

**5CRP5**

**5CQP11**

**5CQP16**



**7AVP5**

**7AWP5**

**7AVP11**

**7AVP16**

# ENGINEERING DATA

**CBS-HYTRON**

TUBES AND SEMICONDUCTORS

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

## CBS 3D21A-3D21B

### BLOCKING OSCILLATOR AND PULSE MODULATOR

The 3D21A and 3D21B are for high-vacuum blocking oscillator and pulse modulator service. Satisfactory pulse operation is assured by many tests including the following performed on every tube: pulse grid, screen, and plate characteristics, high voltage pulse operation and high voltage plate current cutoff. These tubes are small in diameter and light in weight and use a regular octal socket.

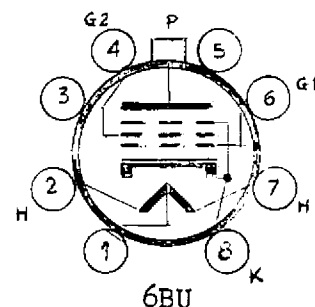
The 3D21A and 3D21B are recommended as the pulse modulator in applications requiring as high as 20kw power in the pulse. They are also suitable for use as deflection amplifiers, regulators and/or passing tubes in high-voltage power supplies.

### MECHANICAL DATA

|                        | 3D21A                           | 3D21B   |        |
|------------------------|---------------------------------|---------|--------|
| Bulb                   | ST-14                           | T-12    |        |
| Maximum diameter       | 1 13/16                         | 1 9/16  | inches |
| Maximum overall length | 4 13/16                         | 4 19/32 | inches |
| Maximum seated height  | 4 1/4                           | 4 1/16  | inches |
| Basing                 | 6BU                             |         |        |
| Base                   | Medium shell octal 8-pin, B8-11 |         |        |
| Cap                    | Skirted miniature, C1-2         |         |        |
| Mounting position      | Any                             |         |        |

### PIN CONNECTIONS

|       |                   |
|-------|-------------------|
| Pin 1 | Heater Center Tap |
| Pin 2 | Heater            |
| Pin 3 | No Connection     |
| Pin 4 | Grid 2            |
| Pin 5 | No Connection     |
| Pin 6 | Grid 1            |
| Pin 7 | Heater            |
| Pin 8 | Cathode           |
| Cap   | Plate             |



# ELECTRICAL DATA

## HEATER CHARACTERISTICS

|                                   | Parallel | Series          |       |
|-----------------------------------|----------|-----------------|-------|
| Heater voltage, a-c or d-c        | 6.3      | 12.6 $\pm 10\%$ | volts |
| Heater current                    | 1.7      | 0.85            | amp   |
| Peak heater-cathode voltage, max. | 150      | ---             | volts |
| Cathode preheating, min.          | 30       | 30              | sec   |

## MAXIMUM RATINGS (Absolute Maximum Values)\*

|                                                     |      |       |
|-----------------------------------------------------|------|-------|
| Plate voltage <del>/</del>                          | 3500 | volts |
| Peak plate voltage including transient <del>/</del> | 5000 | volts |
| Grid 2 voltage <del>/</del>                         | 850  | volts |
| Negative grid 1 voltage, instantaneous <del>/</del> | -500 | volts |
| Positive grid 1 voltage                             | +220 | volts |
| Plate dissipation                                   | 15   | watts |
| Grid 2 dissipation                                  | 3    | watts |
| Grid 1 dissipation                                  | 0.5  | watt  |

## CHARACTERISTICS

|                  |      |       |
|------------------|------|-------|
| Plate voltage    | 600  | volts |
| Grid 2 voltage   | 300  | volts |
| Grid 1 voltage   | -30  | volts |
| Plate current    | 30   | ma    |
| Grid 2 current   | 2.5  | ma    |
| Transconductance | 5500 | umhos |

## TYPICAL OPERATION

|                                    |      |      |      |       |
|------------------------------------|------|------|------|-------|
| Plate voltage                      | 3500 | 2500 | 1500 | volts |
| Grid 2 voltage                     | 800  | 800  | 800  | volts |
| Grid 1 voltage                     | -150 | -150 | -150 | volts |
| Signal voltage (peak above ground) | 150  | 150  | 150  | volts |
| Load resistance                    | 450  | 305  | 160  | ohms  |
| Power output (approx.)             | 21   | 14   | 7    | kw    |

## NOTES:

\* Pulse lengths of 10 usec. Total pulse length in any 240 usec period shall not exceed 12 usec.

~~/~~ Series resistance must be inserted in the power supply sufficient to limit the short-circuit current to less than 0.5 ampere.

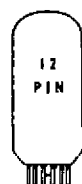
~~/~~ With a screen potential not exceeding 400 Vdc and when no instantaneous voltage due to transient is present (essentially resistance plate load) a maximum plate potential of 4500Vdc may be used.

(TENTATIVE)

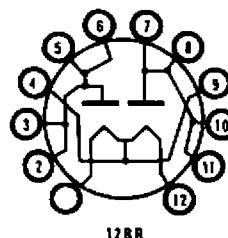
# engineering data for



BULLETIN E-424A  
5-61



**5AZ3**



CBS type 5AZ3 is a high-vacuum full-wave power rectifier which is designed for greater reliability and longer life. This tube employs a 12-pin button stem for better thermal efficiency. Internally generated heat flows easily through the double pins to the outside for radiation without the interference of undependable base-pin solder. In addition, the filament is center tapped for the d-c current connection so that the d-c component of filament current is equalized.

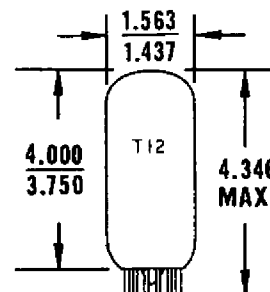
Electrically the 5AZ3 is identical to the 5U4GB and may be used for the same applications.

## MECHANICAL DATA

|                          |             |
|--------------------------|-------------|
| Cathode, coated filament |             |
| Bulb                     | T-12        |
| Overall height           | 4.346" max. |
| Seated height            | 4.000" max. |
| Base                     | E12-74      |
| Basing                   | 12 BR       |
| Mounting position        | Any         |
| Outline                  | EIA12-62    |

## PIN CONNECTIONS

|         |                                     |
|---------|-------------------------------------|
| Pin 1:  | Filament 2                          |
| Pin 2:  | Plate 2 (I.C. to pins 3, 5 & 6)     |
| Pin 3:  | Plate 2 (I.C. to pins 2, 5 & 6)     |
| Pin 4:  | Filament center tap (I.C. to pin 9) |
| Pin 5:  | Plate 2 (I.C. to pins 2, 3 & 6)     |
| Pin 6:  | Plate 2 (I.C. to pins 2, 3 & 5)     |
| Pin 7:  | Plate 1 (I.C. to pins 8, 10 & 11)   |
| Pin 8:  | Plate 1 (I.C. to pins 7, 10 & 11)   |
| Pin 9:  | Filament center tap (I.C. to pin 4) |
| Pin 10: | Plate 1 (I.C. to pins 7, 8 & 11)    |
| Pin 11: | Plate 1 (I.C. to pins 7, 8 & 10)    |
| Pin 12: | Filament 1                          |



from JEDEC release #3230A, June 12, 1961

## ELECTRICAL DATA

### FILAMENT CHARACTERISTICS

|                     |                     |
|---------------------|---------------------|
| Voltage, a-c or d-c | 5.0 $\pm$ 10% volts |
| Current             | 3.0 amp             |

### MAXIMUM RATINGS (Design maximum values)

#### Rectifier Service †

|                                                               |      |       |
|---------------------------------------------------------------|------|-------|
| Plate voltage, peak inverse                                   | 1700 | volts |
| Plate supply voltage, rms (Rating Chart I)                    | 600  | volts |
| D-c output current (Rating Chart I)                           |      |       |
| Steady-state peak plate current, each plate (Rating Chart II) | 1.0  | amp   |
| Transient peak plate current, each plate (Rating Chart III)   | 5.0  | amp   |

### AVERAGE CHARACTERISTICS

|                                     |    |       |
|-------------------------------------|----|-------|
| Tube conducting 225 ma (each plate) | 44 | volts |
| 275 ma (each plate)                 | 50 | volts |
| 300 ma (each plate)                 | 54 | volts |

### TYPICAL OPERATION

#### Full-Wave Rectifier (Capacitor Input Filter)

|                                         |     |     |         |
|-----------------------------------------|-----|-----|---------|
| Plate supply voltage, rms (each plate)‡ | 300 | 450 | volts   |
| Plate supply resistance (each plate)    | 21  | 67  | ohms    |
| Filter input capacitor                  | 40  | 40  | $\mu$ f |
| Output current, d-c                     | 300 | 275 | ma      |
| Output voltage at filter input, d-c     | 290 | 460 | volts   |

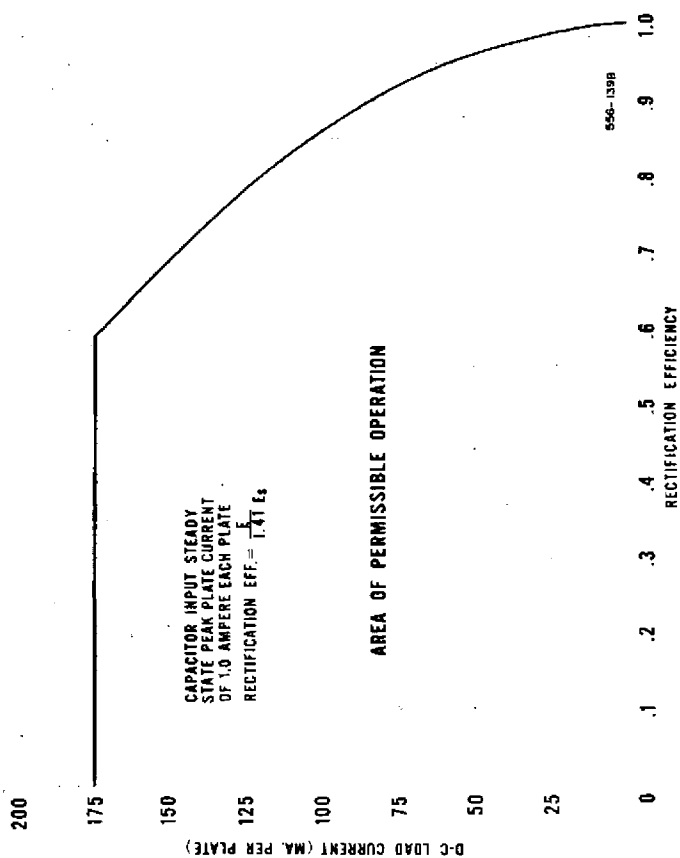
#### Full-Wave Rectifier (Choke Input Filter)

|                                         |     |        |
|-----------------------------------------|-----|--------|
| Plate supply voltage, rms (each plate)‡ | 550 | volts  |
| Filter input choke                      | 10  | henrys |
| Output current, d-c                     | 275 | ma     |
| Output voltage at filter input, d-c     | 420 | volts  |

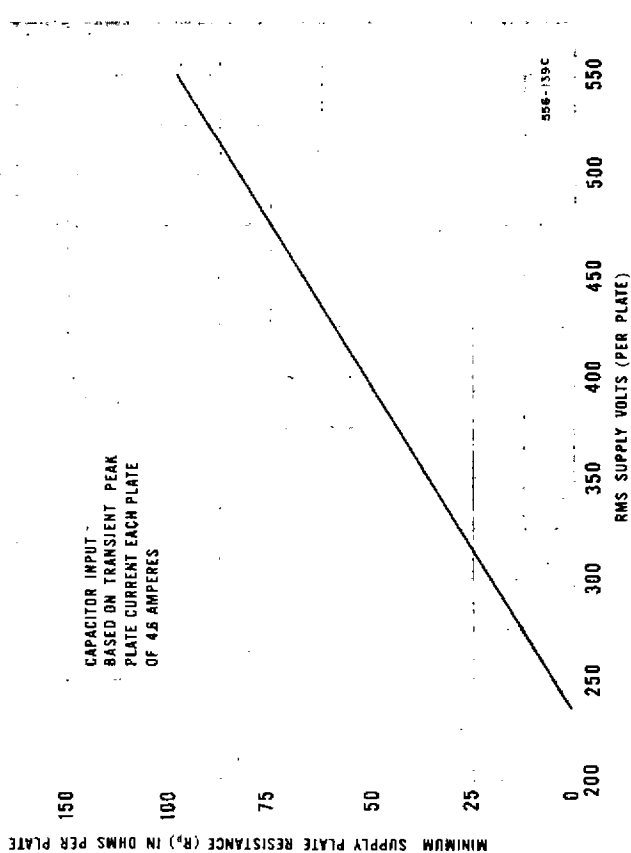
† For use with sinusoidal supply voltages within the frequency range of 25 to 1000 c.p.s.

‡ The indicated a-c supply voltage is measured without load.

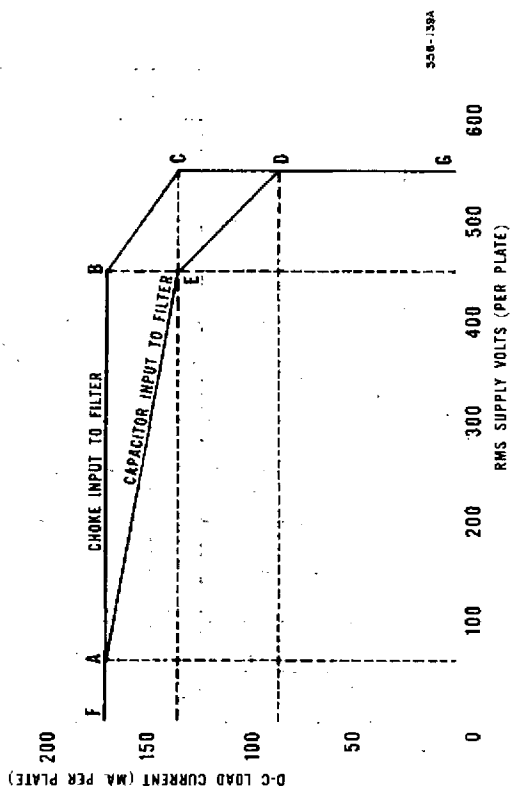
# RATING CHART II



# RATING CHART III



# RATING CHART I



**ENGINEERING DATA****CBS-HYTRON**

TUBES AND SEMICONDUCTORS

A Division of Columbia Broadcasting System, Inc.  
 Danvers, Massachusetts

**CBS TYPE 5BYP5**

**FIVE INCH ULTRA - HIGH RESOLUTION  
 PHOTOGRAPHIC CATHODE-RAY TUBE**

The CBS 5BYP5 is a five inch ultra-high resolution tube having a symmetrical clipped spot with a dimension of 0.7 mils (.0007") by 0.7 mils. This resolution figure is uniform throughout the screen area. This tube is especially designed for highly detailed precision photographic reproduction use. It will provide a minimum of 6000 TV lines at full scan conditions (a 4 1/2" line).

The P5 screen employed in the 5BYP5 is blue in color and of short persistence selected for photographic recording.

An optical flat non-browning glass is used for the faceplate to produce a distortionless flat screen. By using circuit correction, extreme accuracy of deflection linearity up to 0.1% can be achieved. Uncorrected linearity accuracy up to 1% is possible at optimum adjustment.

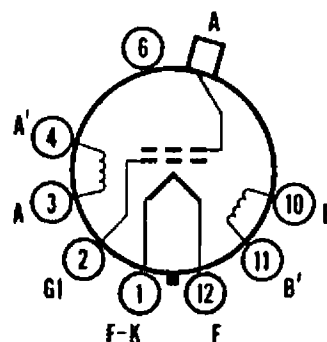
Special focus and deflection components are available from CBS-Hytron for use with the ultra-high resolution cathode-ray tube. Stock items are for side looking strip radar applications at 1000 c.p.s. scanning frequency. Other special scanning components such as raster types, are made to order.

**MECHANICAL DATA**

|                                                                             |                            |
|-----------------------------------------------------------------------------|----------------------------|
| Overall length                                                              | 18 3/4 ± 3/8 inch          |
| Greatest diameter of bulb                                                   | 5 1/8 inch                 |
| Maximum useful screen diameter                                              | 4 1/2 inch                 |
| Neck length                                                                 | 5 ± 1/4 inch               |
| Bulb contact, recessed small cavity                                         | J1-21                      |
| Base, small shell duodecal 7 pin                                            | <del>B7-51</del> B8-210    |
| Bulb contact alignment                                                      | In line with key lug ± 20° |
| Key lug aligns with major axis                                              |                            |
| Weight of tube only                                                         | 5.5 lbs                    |
| Total weight of display package: tube deflection<br>and focusing components | 40.5 lbs                   |

## PIN CONNECTIONS

Pin 1. Filament and cathode  
 Pin 2. Grid 1  
 Pin 3. Alignment A control  
 Pin 4. Alignment A' control  
 Pin 6. No connection  
 Pin 10. Alignment B control  
 Pin 11. Alignment B' control  
 Pin 12. Filament  
 Top Cap - Anode



## OPTICAL DATA

|                   |                                   |
|-------------------|-----------------------------------|
| Phosphor number   | P5                                |
| Fluorescent color | blue                              |
| Phosphorescence   | blue                              |
| Persistence       | $10^{-5}$ sec. approx.            |
| Resolution        | 1250 TV lines/inch                |
| Faceplate         | Optical flat, non-browning, glass |

## ELECTRICAL DATA

|                                                                                                                          |             |
|--------------------------------------------------------------------------------------------------------------------------|-------------|
| Focusing method                                                                                                          | magnetic*   |
| Deflecting method                                                                                                        | magnetic    |
| Deflection angle, diagonal                                                                                               | 30° approx. |
| Beam alignment voltage, 6.3 volts a-c or d-c (between pins 3 and 4, 10 and 11) variable, max. current requirement 1 amp. |             |
| * 14 inch long solenoid provides axial field.                                                                            |             |

### Direct Interelectrode Capacitances, ( Approx. )

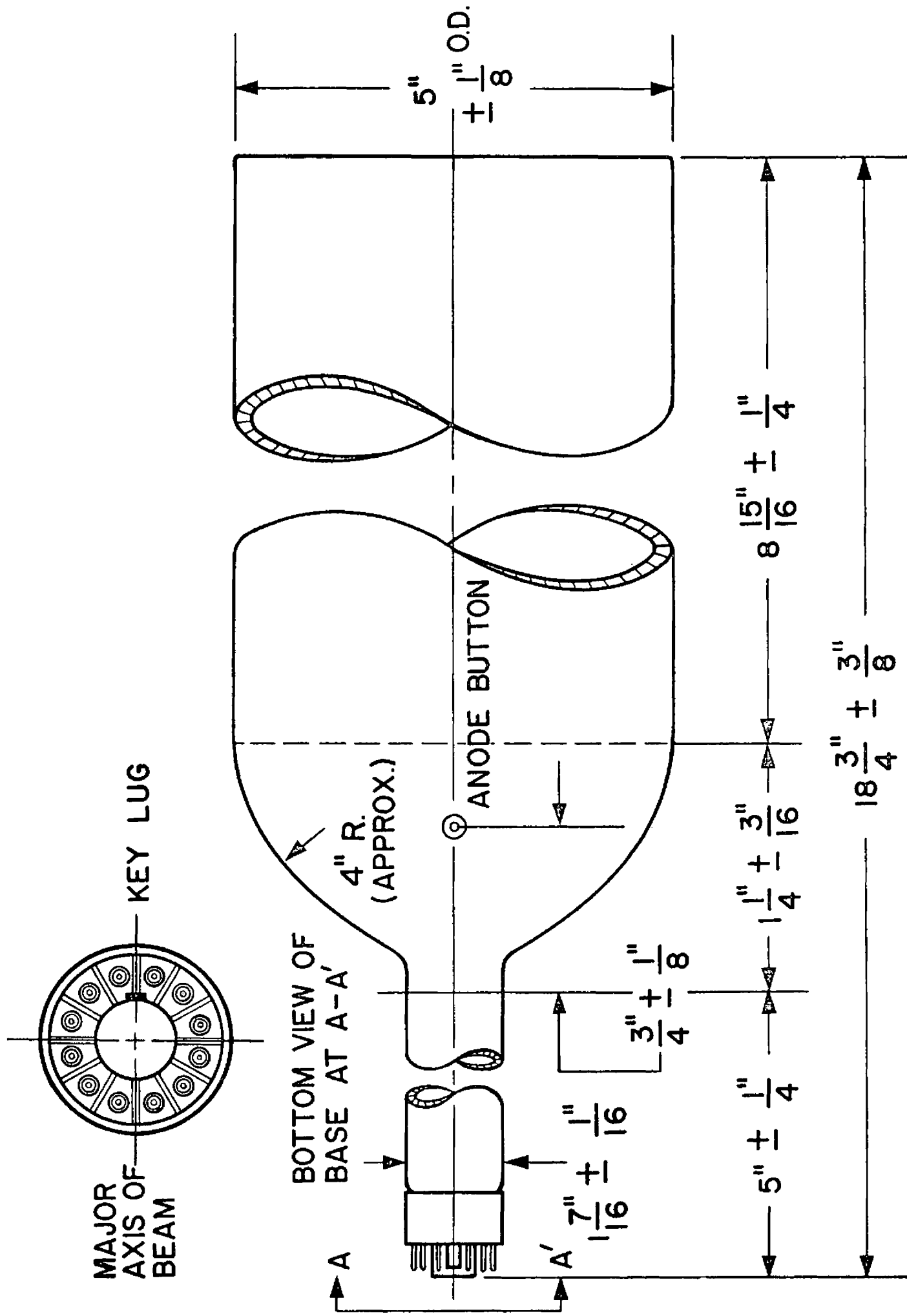
|                                             |                |
|---------------------------------------------|----------------|
| Grid 1 to all other electrodes              | 5 $\mu$ f max. |
| Filamentary cathode to all other electrodes | 4 $\mu$ f max. |

### Heater Characteristics

|                         |            |
|-------------------------|------------|
| Voltage, d-c $\pm$ 20 % | 0.9 volts  |
| Current                 | 0.160 amps |

### Maximum Ratings (Absolute maximum system)

|                     |           |
|---------------------|-----------|
| Anode voltage       | 18 KV     |
| Grid voltage        |           |
| Negative bias value | -50 volts |
| Positive bias value | 0 volts   |
| Positive peak value | +2 volts  |



COMPLETE TUBE & EXTERIOR DIMENSIONS

### Typical Operation

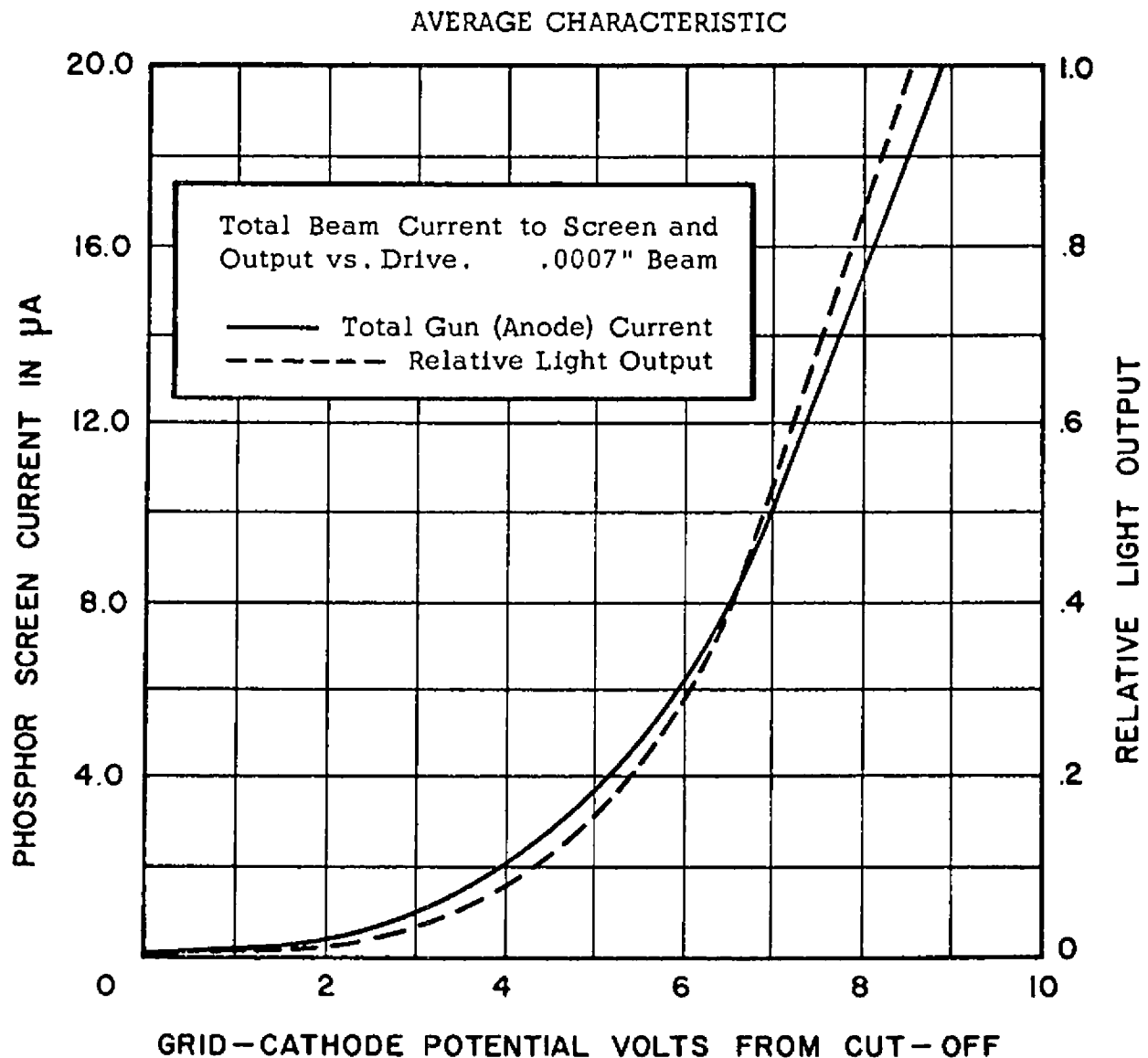
|                             |             |
|-----------------------------|-------------|
| Anode voltage               | 14 to 16 KV |
| Anode current, peak         | 500 $\mu$ a |
| Screen current, peak        | 25 $\mu$ a  |
| Signal grid cut-off voltage | - 10 volts  |

### Maximum Circuit Value

|                           |            |
|---------------------------|------------|
| Grid 1 circuit resistance | 1.0 megohm |
|---------------------------|------------|

### Caution

Shielding for X-rays is recommended for personal protection at close range if this tube is operated in excess of 16,000 volts or over Maximum Rated Anode Voltage, whichever is less. Safety glass covering tube's faceplate is usually sufficient.





# Engineering Data

Bulletin E-162  
Page 1 of 2 pages

October 5, 1950

## HYTRON TYPE 600L

### MECHANICAL DATA

|                        |                                      |             |
|------------------------|--------------------------------------|-------------|
| Coated filament        |                                      |             |
| Outline drawing        |                                      | Bulb T-9    |
| Base                   | B5-10 Intermediate shell octal 5-pin |             |
| Maximum diameter       |                                      | 1.5/16"     |
| Maximum overall length |                                      | 1.1/16"     |
| Maximum seated height  |                                      |             |
| Pin connections        |                                      | Basing 5T   |
| Pin 1 - No connection  | Pin 6 - No connection                |             |
| Pin 2 - Filament       | Pin 8 - Filament                     |             |
| Pin 4 - No connection  | Cap Plate                            |             |
|                        | Cap Plate                            |             |
| Cap                    |                                      | See drawing |
| Mounting position      |                                      | Vertical    |

\* Horizontal operation permitted if pins #2 and #4 are in vertical plane.

### ELECTRICAL DATA

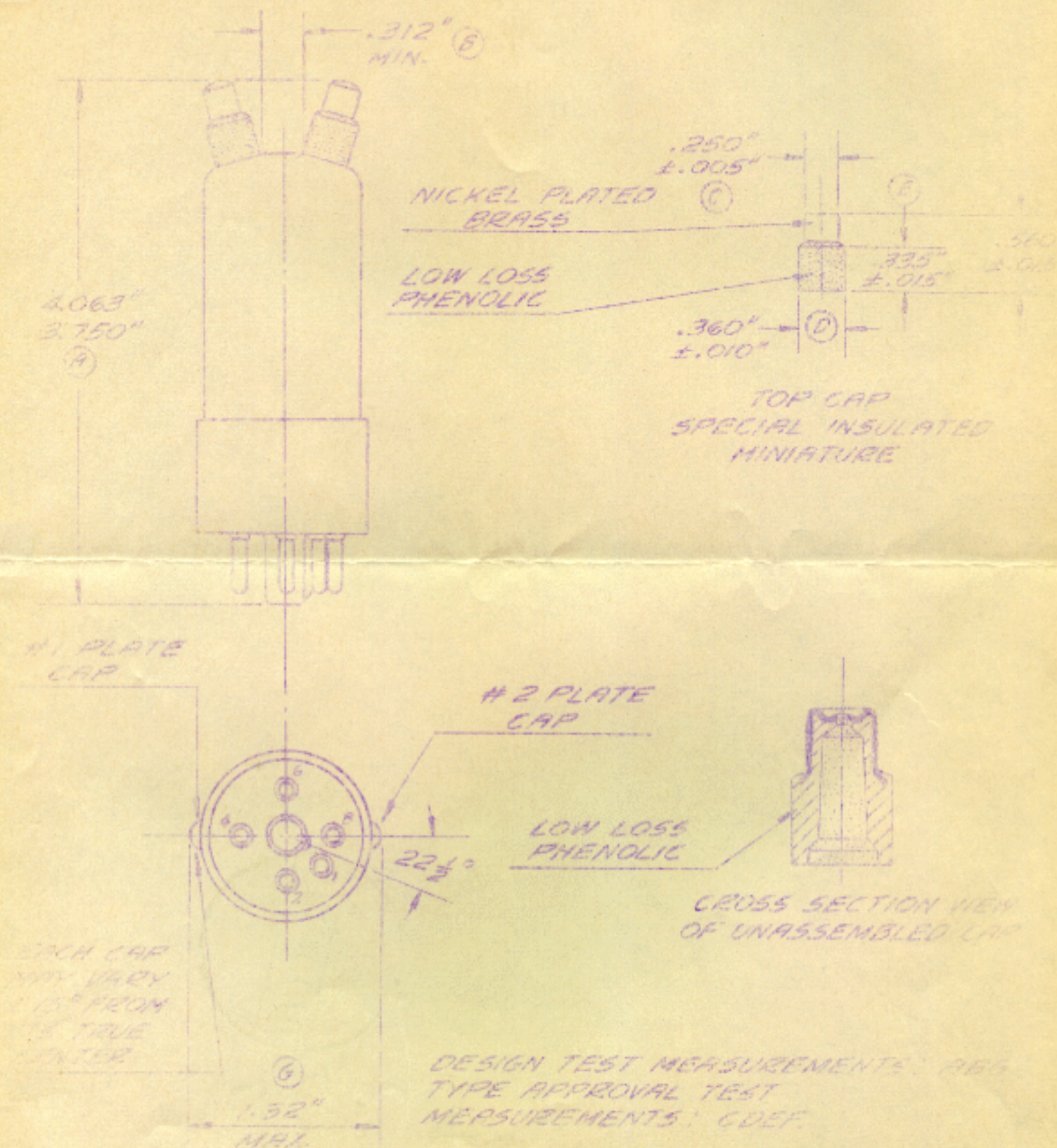
#### Ratings

|                                                                        |      |         |
|------------------------------------------------------------------------|------|---------|
| Filament voltage (ac or dc)                                            | 5.0  | volts   |
| Maximum peak inverse voltage                                           | 1200 | volts   |
| Maximum steady state peak plate current each plate                     | 375  | ma      |
| Maximum transient peak plate current each plate                        | 1.0  | amperes |
| Tube voltage drop (measured with tube conducting<br>145 ma each plate) | 50   | volts   |

#### Typical operation (Full Wave Rectifier)

#### Capacitor Input

|                                             |     |         |
|---------------------------------------------|-----|---------|
| Filament voltage                            | 5.0 | volts   |
| Filament current                            | 2.0 | amperes |
| AC plate supply voltage each plate          | 375 | volts   |
| Input condenser                             | 4   | uf      |
| Effective plate supply impedance each plate | 60  | ohms    |
| DC output current                           | 120 | ma      |
| DC output voltage                           | 360 | volts   |



# ELECTRON TUBE TYPE 6626

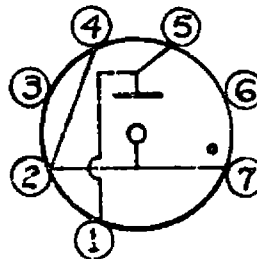
The 6626 is a two electrode inert gas filled cold cathode tube for use in voltage regulator and voltage reference applications where dependable performance under conditions of shock, vibration, high ambient temperatures and absence of external radiation is essential.

## Mechanical Data

Cathode-----Cold  
 Max. overall length-----2 5/8 inches  
 Max. seated length-----2 3/8 inches  
 Max. diameter-----3/4 inches  
 Mounting position-----Any  
 Envelope-----T5 1/2 (6-5)  
 Base-----Miniature glass button 7 pin E7-1

## Basing Diagram

Pin 1: Anode  
 Pin 2: Cathode  
 Pin 3: Internal Connection  
 Do not use  
 Pin 4: Cathode



Pin 5: Anode  
 Pin 6: Internal Connection.  
 Do not use  
 Pin 7: Cathode

5B0

## Electrical Data

### For Voltage Regulator Applications:

Maximum ratings, absolute values;

|                                         |                   |        |
|-----------------------------------------|-------------------|--------|
| Average starting current (Note 8).....  | 75                | ma     |
| D.C. cathode current.....               | 30 max.<br>5 min. | ma     |
| Ambient temperature, minimum.....       | -55               | °C     |
| Bulb temperature, maximum (Note 9)..... | +150              | °C     |
| Altitude.....                           | 120,000           | Ft.    |
| Frequency.....                          | 0                 | C.P.S. |

from JETEC release #1433, March 14, 1955, with changes  
 from JETEC release #1433A, Sept. 12, 1955 inserted.  
 sponsor: CBS-Hytron

# CHARACTERISTIC RANGE FOR EQUIPMENT DESIGN

| Voltage Regulator Service                                     | Min. | Avg. | Max. |       |
|---------------------------------------------------------------|------|------|------|-------|
| Anode supply voltage (d-c) <sup>(3)</sup>                     | 165  |      |      | volts |
| Anode breakdown voltage (total darkness)                      |      | 160  | 165  | volts |
| Anode breakdown voltage (normal ambient light) <sup>(4)</sup> |      | 155  | 165  | volts |
| Anode voltage drop                                            | 144  | 148  | 153  | volts |
| Regulation (5-30 ma) <sup>(5)</sup>                           |      | 2.0  | 5.0  | volts |
| Avg. change anode voltage drop during lifetime                |      | 1    | 3    | %     |

## For Voltage Reference Applications:

Maximum ratings, absolute values;

|                                 |              |     |
|---------------------------------|--------------|-----|
| F.C. cathode current.....       | 10 max.      | ma  |
|                                 | 6 min.       | ma  |
| Ambient temperature limits..... | -55° to +150 | °C  |
| Altitude.....                   | 120,000      | Ft. |

# CHARACTERISTIC RANGE FOR EQUIPMENT DESIGN

| Voltage Reference Service                      | Min. | Avg. | Max. |       |
|------------------------------------------------|------|------|------|-------|
| Anode supply voltage (d-c) <sup>(3)</sup>      | 165  |      |      | volts |
| Anode breakdown voltage (total darkness)       |      | 160  | 165  | volts |
| Anode breakdown voltage (normal ambient light) |      | 155  | 165  | volts |
| Voltage repeatability <sup>(8)</sup>           |      | 0.1  | .6   | volt  |

## Typical Operating Characteristics:

|                                                  |         |       |
|--------------------------------------------------|---------|-------|
| Anode voltage drop (Note 2).....                 | 148     | volts |
| Regulation (6-10 ma) (Note 2).....               | 0.5     | volts |
| Stability (Note 6).....                          | 0.2     | volts |
| Temperature sensitivity, anode voltage drop..... | ± 0.005 | v/°C  |
| Voltage jumps (Note 7).....                      | 0.1     | volts |

Special Ratings and Performance Data:

Shock rating;

Impact acceleration.....450 max. g

Reference MIL-E-IB specification  
paragraph 4.9.20.5

Fatigue rating;

Vibrational acceleration.....5.0 max. g

Reference MIL-E-IB specification  
paragraph 4.9.20.6

Elevated bulb temperature rating

Maximum bulb operation temperature.....+150° C

Tubes are tested under intermittent  
life test conditions at a minimum  
bulb temperature of 150° C for 1000  
hours. Reference MIL-E-IB paragraph  
4.11.5.

Shelf stability of electrical characteristics

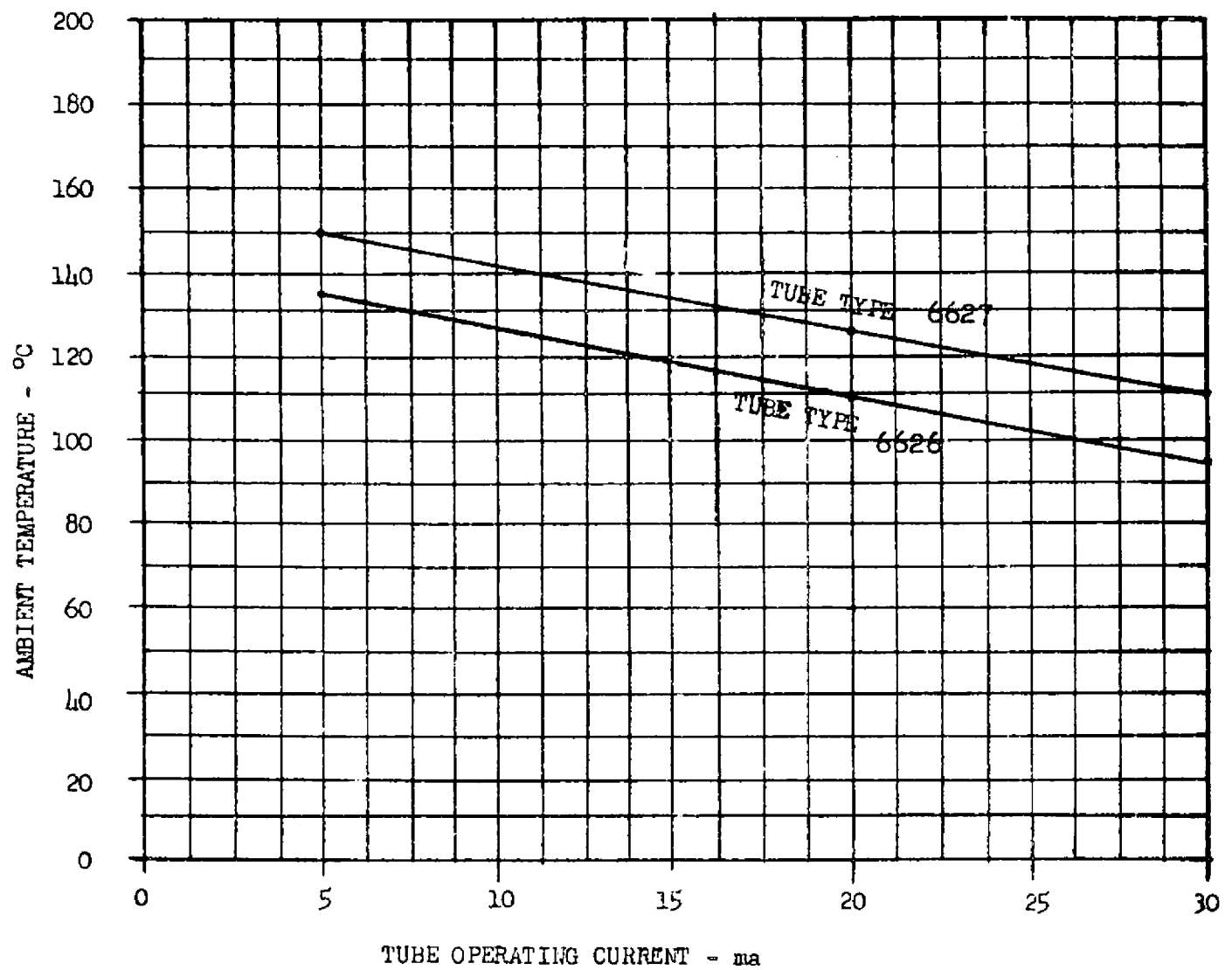
Tubes are tested for release after  
undergoing a minimum 1000 hour non-  
operating holding period.

Notes

- Note 1: The D.C. anode supply voltage is the minimum value necessary to assure ionization in the tube throughout life under conditions of either total darkness or normal illumination.
- Note 2: Maximum, minimum and average tube values during life.
- Note 3: If this value of shunt capacitance is exceeded in the associated circuit the tube may oscillate resulting in unstable performance.
- Note 4. Five to fifty foot candles of ambient light.

- Note 5: Defined as the maximum shift in tube voltage drop between successive firings of the tube operating at one value of current and temperature within its ratings.
- Note 6: Defined as the average shift in tube voltage drop over an 8 hour period when the tube is operated at one value of current and temperature within its ratings.
- Note 7: Defined as the instantaneous change in tube anode voltage drop as the tube current is varied slowly within the specified operating current range.
- Note 8: When equipment utilizing this tube is placed in operation a starting current in the tube in excess of the average operating current is permissible as indicated under maximum ratings. This current should not be allowed to continue for more than 5 seconds. When the tube is subjected to such high starting currents some time may be required for the tube to stabilize at its normal operating voltage. This "memory characteristic" is typical of glow discharge voltage regulator tubes. Similarly when a tube is operated for extended periods at a given current point within its operating range and then switched to a different operating current some time may be required for the tube to stabilize at the new point.
- Note 9: The maximum bulb temperature will vary both with ambient temperature and tube operating current. In an attached appendix sheet is shown the correlation between  $+150^{\circ}\text{C}$  maximum bulb temperature, ambient temperature and tube operating current.
- Note 10: Regulation is defined as the maximum allowable difference in tube voltage drop measured between any two current points within the specified current rating range (5-30 mA dc). The two current points are to be selected which indicate the largest value of regulation.

CONVERSION CURVE - AMBIENT TEMPERATURE VS TUBE OPERATION CURRENT  
TO PRODUCE MAXIMUM BULB OPERATING TEMPERATURE OF 150°C.



# ELECTRON TUBE TYPE 6627

The 6627 is a two electrode inert gas filled cold cathode tube for use in voltage regulator and voltage reference applications where dependable performance under conditions of shock, vibration, high ambient temperatures and absence of external radiation is essential.

## Mechanical Data

Cathode-----Cold  
 Max. overall length-----2 5/8 inches  
 Max. seated length-----2 3/8 inches  
 Max. diameter-----3/4 inches  
 Mounting position-----Any  
 Envelope-----T5 $\frac{1}{2}$  (6-5)  
 Base-----Miniature glass button 7 pin E7-1

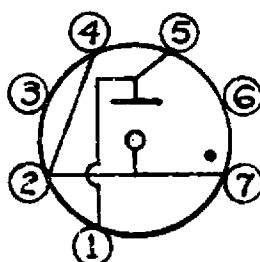
## Basing Diagram

Pin 1: Anode

Pin 2: Cathode

Pin 3: Internal Connection  
 Do not use

Pin 4: Cathode



Pin 5: Anode

Pin 6: Internal Connection.  
 Do not use

Pin 7: Cathode

5B0

## Electrical Data

### For Voltage Regulator Applications:

Maximum ratings, absolute values;

|                                         |                   |        |
|-----------------------------------------|-------------------|--------|
| Average starting current (Note 8).....  | 75                | ma     |
| D.C. cathode current.....               | 30 max.<br>5 min. | ma     |
| Ambient temperature, minimum.....       | -55               | °C     |
| Bulb temperature, maximum (Note 9)..... | +150              | °C     |
| Altitude.....                           | 120,000           | Ft.    |
| Frequency.....                          | 0                 | C.P.S. |

from JETEC release #1433, March 14, 1955, with changes  
 from JETEC release #1433A, Sept. 12, 1955 inserted.  
 sponsor: CBS-Hytron

# CHARACTERISTIC RANGE FOR EQUIPMENT DESIGN

| Voltage Regulator Service                                     | Min. | Avg. | Max. |       |
|---------------------------------------------------------------|------|------|------|-------|
| Anode supply voltage (d-c) <sup>(3)</sup>                     | 130  |      |      | volts |
| Anode breakdown voltage (total darkness)                      |      | 125  | 130  | volts |
| Anode breakdown voltage (normal ambient light) <sup>(4)</sup> |      | 120  | 130  | volts |
| Anode voltage drop                                            | 105  | 108  | 111  | volts |
| Regulation (5-30 ma) <sup>(5)</sup>                           |      | 1.5  | 2.5  | volts |
| Avg. change anode voltage drop during lifetime                |      | 2    | 4    | %     |

## For Voltage Reference Applications:

Maximum ratings, absolute values;

|                                 |              |     |
|---------------------------------|--------------|-----|
| D.C. cathode current.....       | 10 max.      | ma  |
|                                 | 6 min.       | ma  |
| Ambient temperature limits..... | -55° to +150 | °C  |
| Altitude.....                   | 120,000      | Ft. |

# CHARACTERISTIC RANGE FOR EQUIPMENT DESIGN

| Voltage Reference Service                      | Min. | Avg. | Max. |       |
|------------------------------------------------|------|------|------|-------|
| Anode supply voltage (d-c) <sup>(3)</sup>      | 130  |      |      | volts |
| Anode breakdown voltage (total darkness)       |      | 125  | 130  | volts |
| Anode breakdown voltage (normal ambient light) |      | 120  | 130  | volts |
| Voltage repeatability <sup>(8)</sup>           |      | 0.05 | 0.4  | volt  |

## Typical Operating Characteristics:

|                                                 |       |       |
|-------------------------------------------------|-------|-------|
| Anode voltage drop (Note 2).....                | 107   | volts |
| Regulation (6-10 ma) (Note 2).....              | 0.2   | volts |
| Stability (Note 6)...;                          | 0.2   | volts |
| Temperature sensitivity, anode voltage drop...± | 0.005 | v/°C  |
| Voltage jumps (Note 7).....                     | 0.05  | volts |

Special Ratings and Performance Data:

Shock rating;

Impact acceleration.....450 max. g

Reference MIL-E-IB specification  
paragraph 4.9.20.5

Fatigue rating;

Vibrational acceleration.....5.0 max. g

Reference MIL-E-IB specification  
paragraph 4.9.20.6

Elevated bulb temperature rating

Maximum bulb operation temperature.....+150° C

Tubes are tested under intermittent  
life test conditions at a minimum  
bulb temperature of 150° C for 1000  
hours. Reference MIL-E-IB paragraph  
4.11.5.

Shelf stability of electrical characteristics

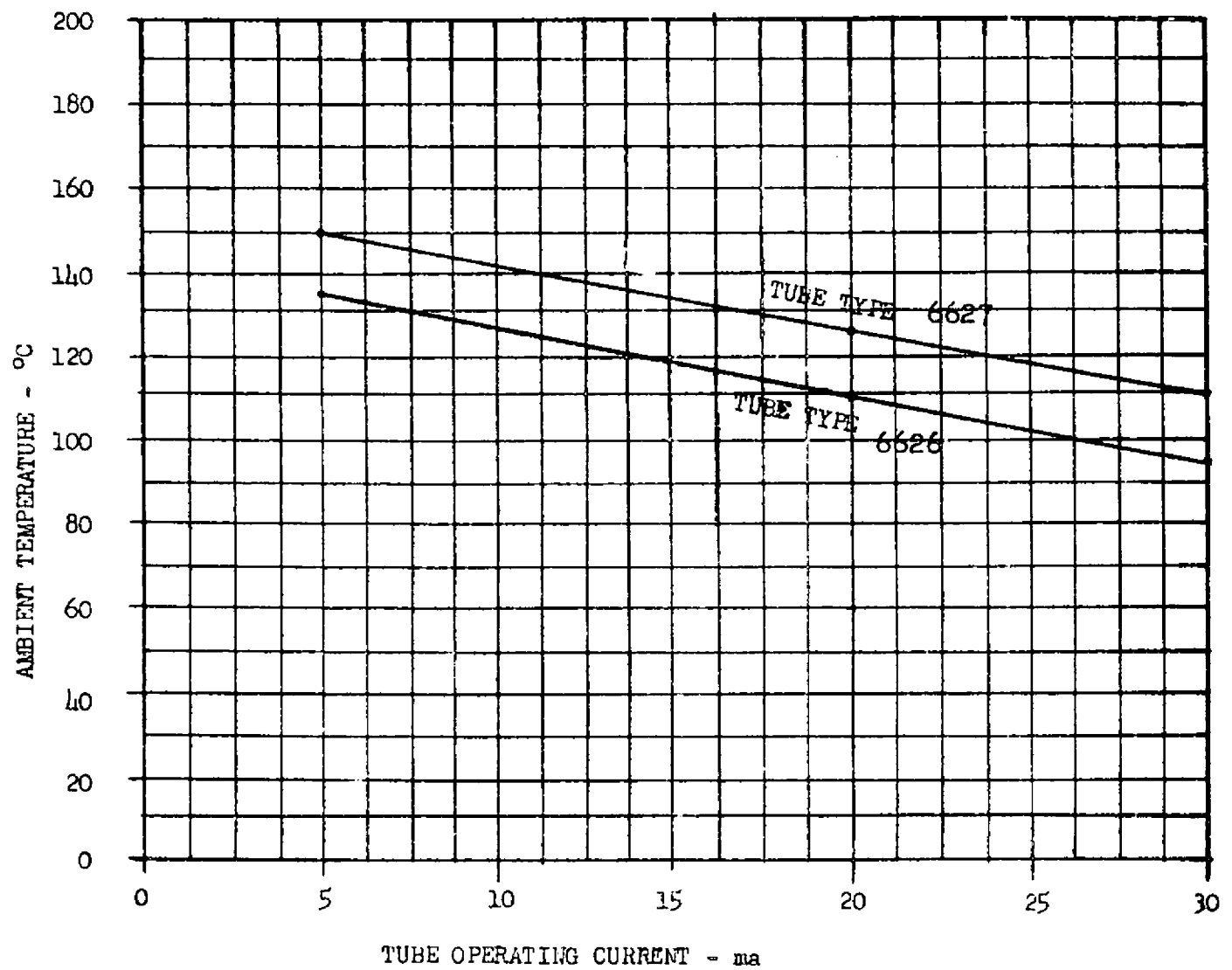
Tubes are tested for release after  
undergoing a minimum 1000 hour non-  
operating holding period.

Notes

- Note 1: The D.C. anode supply voltage is the minimum value necessary to assure ionization in the tube throughout life under conditions of either total darkness or normal illumination.
- Note 2: Maximum, minimum and average tube values during life.
- Note 3: If this value of shunt capacitance is exceeded in the associated circuit the tube may oscillate resulting in unstable performance.
- Note 4. Five to fifty foot candles of ambient light.

- Note 5: Defined as the maximum shift in tube voltage drop between successive firings of the tube operating at one value of current and temperature within its ratings.
- Note 6: Defined as the average shift in tube voltage drop over an 8 hour period when the tube is operated at one value of current and temperature within its ratings.
- Note 7: Defined as the instantaneous change in tube anode voltage drop as the tube current is varied slowly within the specified operating current range.
- Note 8: When equipment utilizing this tube is placed in operation a starting current in the tube in excess of the average operating current is permissible as indicated under maximum ratings. This current should not be allowed to continue for more than 5 seconds. When the tube is subjected to such high starting currents some time may be required for the tube to stabilize at its normal operating voltage. This "memory characteristic" is typical of glow discharge voltage regulator tubes. Similarly when a tube is operated for extended periods at a given current point within its operating range and then switched to a different operating current some time may be required for the tube to stabilize at the new point.
- Note 9: The maximum bulb temperature will vary both with ambient temperature and tube operating current. In an attached appendix sheet is shown the correlation between  $+150^{\circ}\text{C}$  maximum bulb temperature, ambient temperature and tube operating current.
- Note 10: Regulation is defined as the maximum allowable difference in tube voltage drop measured between any two current points within the specified current rating range (5-30 mA dc). The two current points are to be selected which indicate the largest value of regulation.

CONVERSION CURVE - AMBIENT TEMPERATURE VS TUBE OPERATION CURRENT  
TO PRODUCE MAXIMUM BULB OPERATING TEMPERATURE OF 150°C.



# ENGINEERING DATA

**CBS-HYTRON**

TUBES AND SEMICONDUCTORS

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

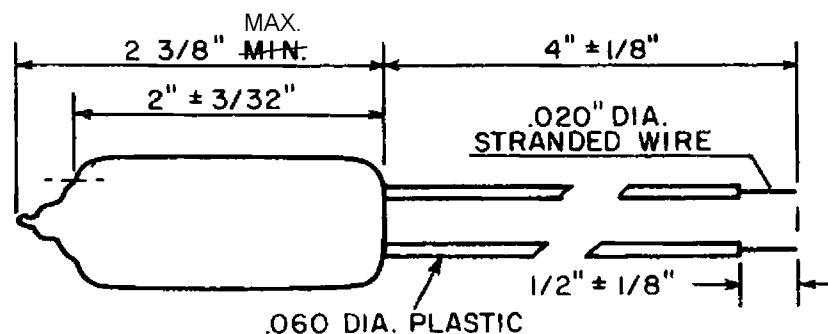
## CBS 6830 - 6831

### GASEOUS VOLTAGE REGULATORS

Constructed with flying leads which eliminate the need for a socket, the CBS types 6830 and 6831 are gaseous voltage regulators that can be used where wired-in terminals are desired. Encased in miniature envelopes, these units are especially suitable for packaging where compactness and light weight are prime objectives.

### MECHANICAL DATA

|                         |                                          |
|-------------------------|------------------------------------------|
| Cathode                 | Cold                                     |
| Maximum diameter        | 3/4 inch                                 |
| Maximum over-all length | 6 1/2 inches                             |
| Maximum bulb length     | 2 3/8 inches                             |
| Bulb                    | T-5 1/2                                  |
| Base                    | Miniature glass button with flying leads |
| Basing                  | 2AV                                      |
| Mounting position       | Any                                      |
| Terminals               |                                          |
| Lead 1, red code        | Anode                                    |
| Lead 2, black code      | Cathode                                  |



## ELECTRICAL DATA

### MAXIMUM RATINGS (Absolute Values)

#### Voltage Regulator Service

|                              |    |    |
|------------------------------|----|----|
| Cathode current maximum, d-c | 30 | ma |
| Cathode current minimum, d-c | 5  | ma |

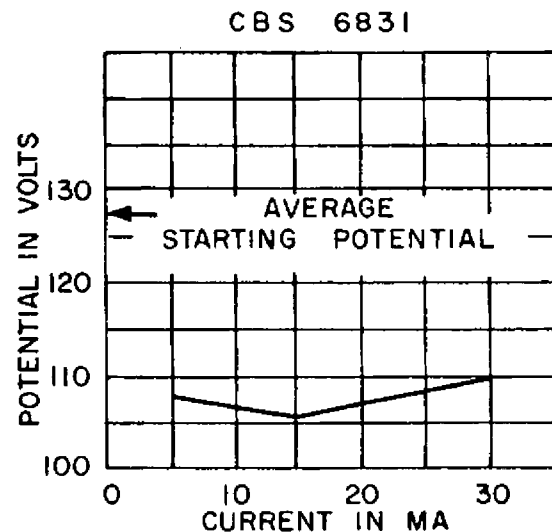
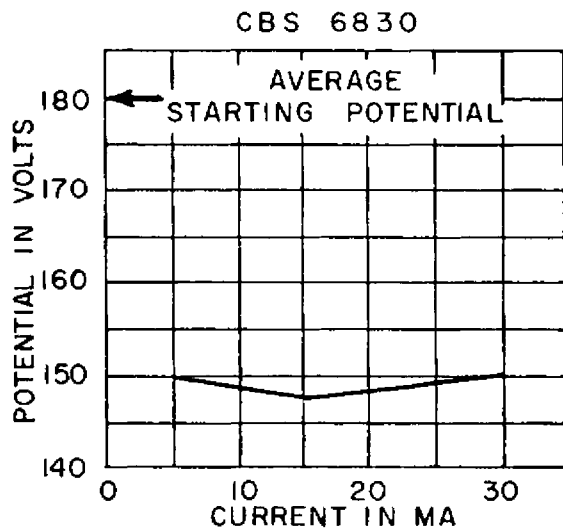
### CHARACTERISTICS AND TYPICAL OPERATION

#### Voltage Regulator Service

|                                                     | <u>6830</u> | <u>6831</u> |       |
|-----------------------------------------------------|-------------|-------------|-------|
| Anode supply voltage minimum, d-c                   | 185         | 133         | volts |
| Anode breakdown voltage (normal ambient light) max. | 185         | 133         | volts |
| Operating voltage, avg.                             | 150         | 108         | volts |
| Regulation (5-30 ma)* avg.                          | 2.0         | 1.0         | volts |

\*Regulation is defined as the maximum allowable difference in tube voltage drop measured between the two current points within the tube's current rating range (5-30 ma) which indicate the largest difference in tube drops.

## TYPICAL OPERATION CHARACTERISTICS



# ENGINEERING DATA

## CBS-HYTRON

TUBES AND SEMICONDUCTORS

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

# CBS 6955

## MEDIUM-MU DUOTRIODE FOR SQUARE-WAVE MODULATOR, BLOCKING OSCILLATOR, MULTIVIBRATOR, AND GENERAL-PURPOSE USAGE

The CBS 6955 is a medium-mu duotriode designed for pulse circuits, and in particular for high peak power blocking oscillators. It features high reliability in pulsed emission providing 2 amperes up to 10  $\mu$ s without slump, fast warm-up time to 80% stabilized plate current in 10 seconds, operation over the ambient temperature range of  $-62^{\circ}\text{C}$  to  $100^{\circ}\text{C}$ , and is specially tested for resonance vibration at frequencies up to 500 c.p.s.

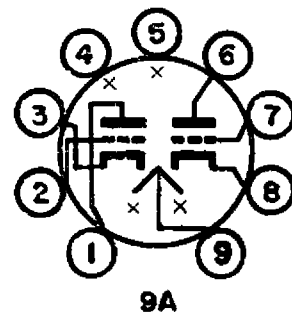
### MECHANICAL DATA

Cathode, coated unipotential  
Bulb  
Outline  
Maximum over-all height  
Maximum seated height  
Maximum diameter  
Base  
Basing  
Mounting position

T-6 1/2  
RETMA 6-2  
2 3/16 inches  
1 15/16 inches  
7/8 inch  
(E9-1)  
9A  
Any

### PIN CONNECTIONS

Pin 1 Plate (Section 2)  
Pin 2 Grid (Section 2)  
Pin 3 Cathode (Section 2)  
Pin 4 Heater  
Pin 5 Heater  
Pin 6 Plate (Section 1)  
Pin 7 Grid (Section 1)  
Pin 8 Cathode (Section 1)  
Pin 9 Heater (Center tap)



# HEATER CHARACTERISTICS

|                                   | Series         | Parallel      |       |
|-----------------------------------|----------------|---------------|-------|
| Voltage, a-c                      | 12.6 $\pm$ 12% | 6.3 $\pm$ 12% | volts |
| Current                           | 175            | 350           | ma    |
| Peak heater-cathode voltage, max. |                |               |       |
| Heater negative to cathode        | 90             | 90            | volts |
| Heater positive to cathode        | 90             | 90            | volts |

## ELECTRICAL DATA

### DIRECT INTERELECTRODE CAPACITANCES, No Shield

|                             | Section I | Section II |          |
|-----------------------------|-----------|------------|----------|
| Grid to plate: g1 to p      | 1.4       | 1.4        | $\mu$ pf |
| Input: g1 to k+h            | 1.5       | 1.5        | $\mu$ pf |
| Output: p to k+h            | 0.5       | 0.4        | $\mu$ uf |
| Coupling plate 1 to plate 2 |           | 0.8        | $\mu$ pf |

### MAXIMUM RATINGS (Continuous Commercial Service Values)

#### Pulse Modulator †

|                                  |      |       |
|----------------------------------|------|-------|
| Plate supply voltage, d-c        | 400  | volts |
| Control grid supply voltage, d-c | 250  | volts |
| Peak positive grid voltage, d-c  | 200  | volts |
| Peak grid current                | 0.9  | amp   |
| Peak plate current               | 1.25 | amp   |
| Peak cathode current             | 2.2  | amp   |
| Grid dissipation                 | 0.60 | watts |
| Plate dissipation                | 1.35 | watts |

### MAXIMUM RATINGS (Design Center Values)

#### Class A Amplifier

|                                 |      |       |
|---------------------------------|------|-------|
| Plate voltage                   | 300  | volts |
| Plate dissipation               | 2.75 | watts |
| Cathode current                 | 20   | ma    |
| Control-grid circuit resistance |      |       |
| Fixed bias                      | .25  | meg   |
| Self bias                       | 1.0  | meg   |

# CHARACTERISTICS AND TYPICAL OPERATION

## Pulse Modulator

|                                      |      |       |
|--------------------------------------|------|-------|
| Plate supply voltage, d-c            | 300  | volts |
| Grid supply voltage, d-c             | -25  | volts |
| Peak positive grid voltage           | 150  | volts |
| Peak plate current                   | 0.9  | amp   |
| Peak grid current                    | 0.7  | amp   |
| Plate load resistance (noninductive) | 75   | ohms  |
| Grid resistance (noninductive)       | 2400 | ohms  |
| Minimum cathode preheating           | 10   | sec   |

## Class A Amplifier

|                                                            |      |      |           |
|------------------------------------------------------------|------|------|-----------|
| Plate voltage                                              | 100  | 250  | volts     |
| Control-grid voltage                                       | 0    | -8.5 | volts     |
| Plate resistance (approx.)                                 | 5800 | 7000 | ohms      |
| Transconductance                                           | 3500 | 2350 | $\mu$ hos |
| Amplification factor                                       | 21.3 | 16.5 |           |
| Plate current                                              | 13.0 | 11.5 | ma        |
| Control-grid voltage (approx.)<br>for $I_b = 10 \mu a$     |      | -22  | volts     |
| Control-grid voltage (approx.)<br>for $g_m = 2350 \mu$ hos |      | 8.5  | volts     |

## NOTES:

† Duty Factor = .0035; pulse width = 1.5 microseconds; pulse repetition rate = 2300 pps.

# ENGINEERING DATA

E-265 2-13-56

**CBS-HYTRON**

TUBES AND SEMICONDUCTORS

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

## CBS 6BU4

### TRIODE HV REGULATOR TUBE

CBS 6BU4 is a high-voltage, low-current, sharp-cutoff beam triode designed for voltage regulation of the anode and focus supplies of color television receivers. This tube will provide voltage control over the wide range of 5,000 to 25,000 volts.

The CBS 6BU4 will give excellent voltage stabilization with small values of signal voltage because of its efficient electron-gun type structure that results in a high amplification factor of 1515 at 25 kv anode voltage.

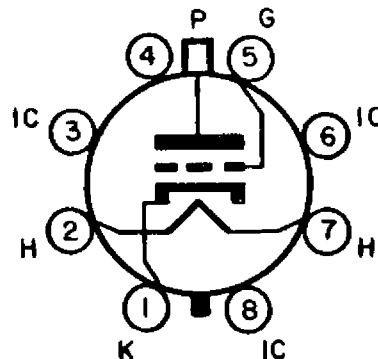
### MECHANICAL DATA

Cathode, coated unipotential  
Bulb  
Base, short medium shell octal 8-pin  
Maximum over-all length  
Seated height  
Maximum diameter  
Cap  
Mounting position

T-12  
B8-118  
5 1/16 inches  
4 11/32 ± 3/16 inches  
1 23/32 inches  
(Cl-1) small  
Any

### BASING DIAGRAM

Pin 1: Cathode  
Pin 2: Heater  
Pin 3: I.C., do not use  
Pin 4: N. C.  
Pin 5: Grid  
Pin 6: I.C., do not use  
Pin 7: Heater  
Pin 8: I.C., do not use  
Top Cap: Anode



86C

## ELECTRICAL DATA

### HEATER CHARACTERISTICS

|                                              |      |       |
|----------------------------------------------|------|-------|
| Heater voltage (a-c)                         | 6.3  | volts |
| Heater current                               | 0.45 | amp   |
| Peak heater-cathode voltage, max.            |      |       |
| Heater negative to cathode                   | 225  | volts |
| (Heater positive to cathode not recommended) |      |       |

### DIRECT INTERELECTRODE CAPACITANCES

|                         |     |          |
|-------------------------|-----|----------|
| Control grid to plate   | .03 | $\mu$ pf |
| Control grid to cathode | 2.0 | $\mu$ pf |
| Plate to cathode        | 8.0 | $\mu$ pf |

### MAXIMUM RATINGS (Design Center Values)

|                         |      |       |
|-------------------------|------|-------|
| Anode voltage           | 25   | kv    |
| Unregulated d-c supply  | 55   | kv    |
| Grid voltage            | -125 | volts |
| Cathode current         | 10   | ma    |
| Anode dissipation       | 25   | watts |
| Grid circuit resistance | 3.0  | meg   |

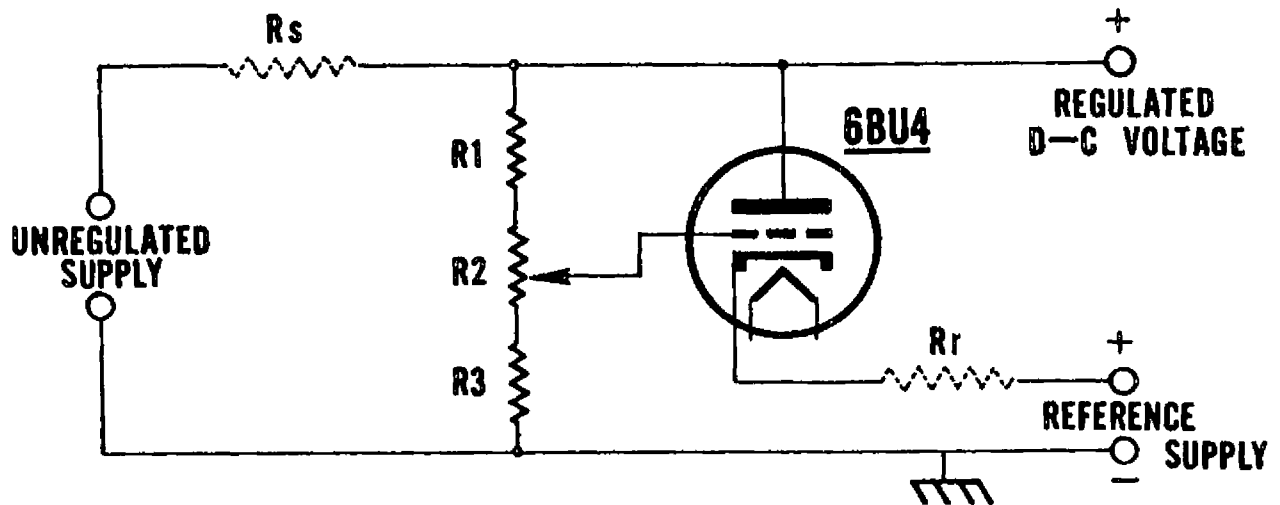
### CHARACTERISTICS

|                            |      |            |
|----------------------------|------|------------|
| Anode voltage              | 25   | kv         |
| Grid voltage               | -8.4 | volts      |
| Anode current              | 1.0  | ma         |
| Plate resistance           | 8.2  | meg        |
| Transconductance (approx.) | 185  | $\mu$ mhos |
| Amplification factor       | 1515 |            |

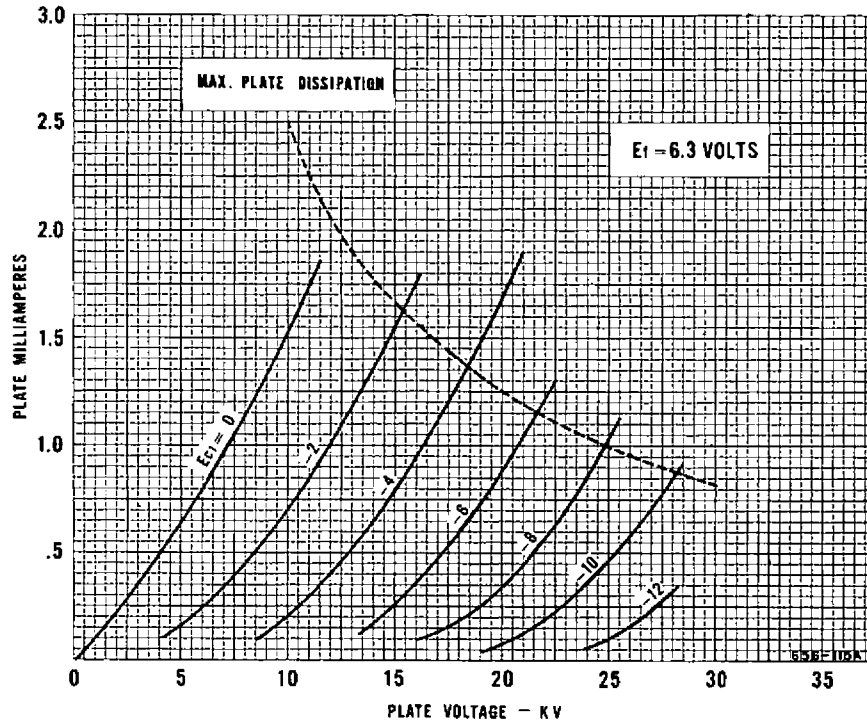
# TYPICAL OPERATION

## Shunt Regulator Service for Circuit Shown

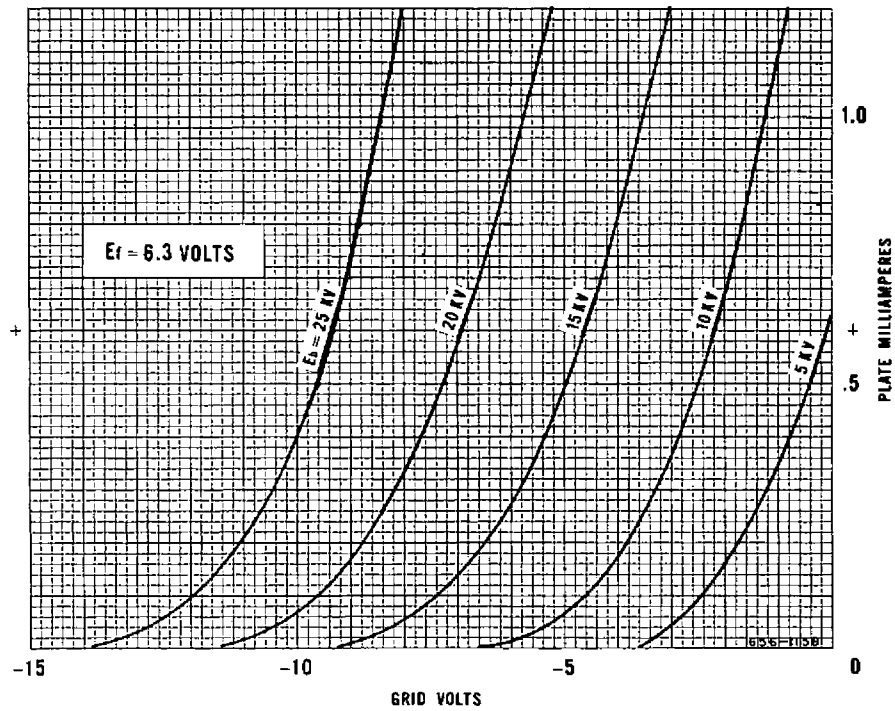
|                                           |      |            |
|-------------------------------------------|------|------------|
| Unregulated supply voltage, d-c (approx.) | 37   | kv         |
| Equivalent resistance, $R_s$              | 10   | meg        |
| Reference supply voltage, d-c             | 200  | volts      |
| Equivalent resistance, $R_r$              | 1000 | ohms       |
| Transconductance, effective $g_l$ to $p$  | 200  | $\mu$ mhos |
| Voltage divider resistances               |      |            |
| $R_1$ , 5w (10, 1/2w units in series)     | 220  | meg        |
| $R_2$ , 2w potentiometer                  | 2.0  | meg        |
| $R_3$ , 1/2w                              | 2.7  | meg        |
| Plate current, d-c                        |      |            |
| Load current = 0 ma                       | 1    | ma         |
| Load current = 1 ma                       | 50   | $\mu$ a    |
| Output voltage, regulated, d-c            |      |            |
| Load current = 0 ma                       | 25   | kv         |
| Load current = 1 ma                       | 24.5 | kv         |



# PLATE CHARACTERISTICS



# TRANSFER CHARACTERISTICS



# ENGINEERING DATA

**CBS-HYTRON**

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

E-284 3-17-58

TUBES AND SEMICONDUCTORS

## CBS TYPE 7205

### COLD - CATHODE TRIGGER TUBE

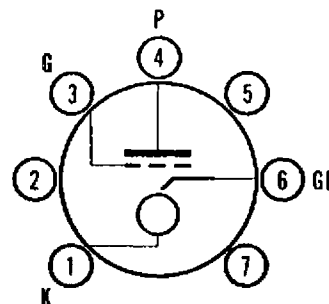
The 7205 is a cold-cathode miniature trigger and timer tube used in applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Because of its special construction the 7205 will withstand a wide ambient temperature range, impact shocks with 100g peaks, and severe vibrational stresses. Because of its dark-start design characteristic, the 7205 will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

### MECHANICAL DATA

|                                        |                                    |
|----------------------------------------|------------------------------------|
| Cathode                                | cold                               |
| Bulb                                   | T5 1/2                             |
| Base                                   | Min. button 7 pin, 2" flying leads |
| Mounting Position                      | Any                                |
| Overall Height ( not including leads ) | 1 3/4 inch                         |
| Maximum Diameter                       | 3/4 inch                           |

### LEAD CONNECTIONS

- Pin 1. Cathode
- Pin 2. Omitted
- Pin 3. Grid
- Pin 4. Anode
- Pin 5. Omitted
- Pin 6. Glow Pin
- Pin 7. Omitted



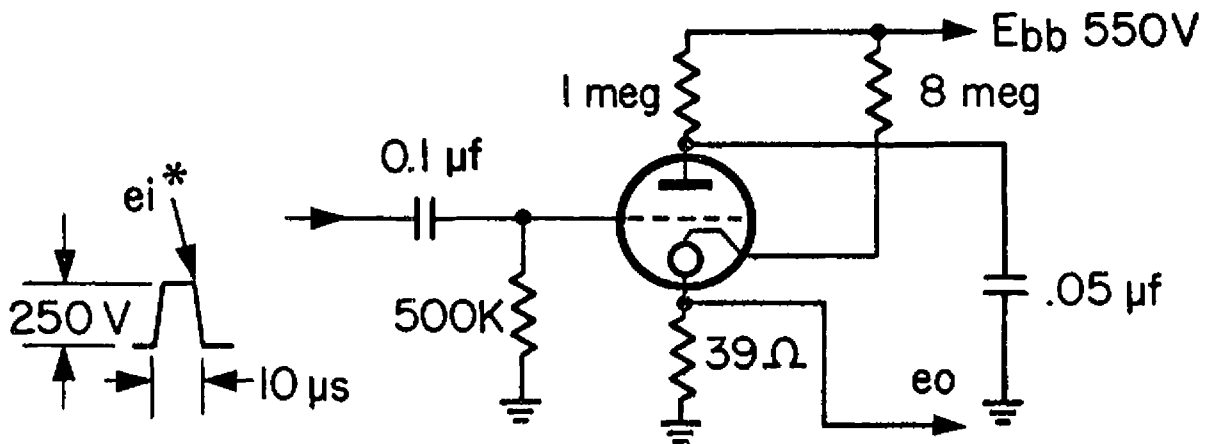
## ELECTRICAL DATA

### Maximum Ratings (Absolute Maximum Values)

|                            |                |
|----------------------------|----------------|
| Anode Operating Voltage    | 1000 volts     |
| Hold-off Voltage           | 2000 volts     |
| Cathode Current Peak       | 500 amp        |
| Glow Current               | 100 $\mu$ A    |
| Grid Resistor              | 2.0 meg        |
| Discharge Capacitor        | 0.5 $\mu$ f    |
| Power Input                | 1.0 W          |
| Grid Bias                  | $\pm$ 80 volts |
| Grid Pulse Current         | 40 $\mu$ A     |
| Output Pulse Duration      | 10 $\mu$ s     |
| Ambient Temperature Range  | -55 to + 85 °C |
| Anode Delay Time           | 4.0 $\mu$ s    |
| Anode Delay Time Variation | 0.4 $\mu$ s    |
| Pulse Repetition Rate      | 20 ppm         |

### Typical Operation (For circuit below)

|                      |            |
|----------------------|------------|
| Anode Supply Voltage | 550 volts  |
| Grid Voltage         | 0 volts    |
| Glow Current         | 50 $\mu$ A |



\* May be triggered manually by applying d-c momentarily to grid.

### Minimum Conditions

|                              |            |
|------------------------------|------------|
| Anode Operating Voltage, d-c | 500 volts  |
| Cathode Current Peak         | 10 amp     |
| Glow Current                 | 30 $\mu$ A |
| Grid Resistor                | 0.25 meg   |
| Grid Pulse Duration          | 10 $\mu$ s |
| Grid Pulse Amplitude         | 230 volts  |



E-287B 7-22-58

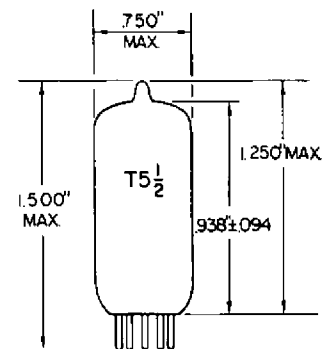
technical information

**CBS-HYTRON***A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts***7229****Cold-Cathode Trigger Tube**

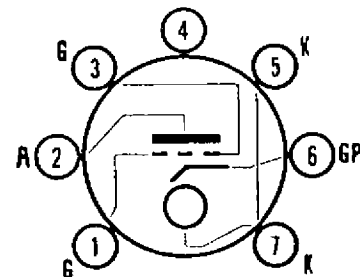
The 7229 is a cold-cathode miniature trigger and timer tube used in trigger applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Special construction enables the 7229 to operate over an ambient temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and withstand vibrational stresses. Dark-start design characteristic, is such that it will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

**MECHANICAL DATA**

|                         |           |
|-------------------------|-----------|
| Cathode                 | cold      |
| Bulb, JETEC 5-1         | T5 1/2    |
| Base, min. button 7-pin | (E7-1)    |
| Mounting position       | Any       |
| Maximum overall height  | 1.5 inch  |
| Maximum diameter        | 0.75 inch |

**PIN CONNECTIONS**

- Pin 1. Grid
- Pin 2. Anode
- Pin 3. Grid
- Pin 4. No connection
- Pin 5. Cathode
- Pin 6. Glow pin
- Pin 7. Cathode



## ELECTRICAL DATA

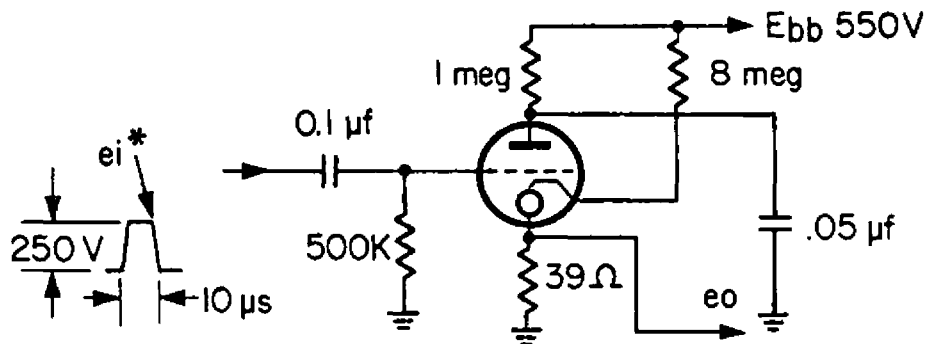
### Maximum Ratings (Absolute Maximum Values)

|                                             |                |
|---------------------------------------------|----------------|
| Anode operating voltage                     | 1000 volts     |
| Hold-off voltage                            | 2000 volts     |
| Cathode current, peak                       | 500 amp        |
| Glow current                                | 100 $\mu$ A    |
| Grid resistor                               | 2.0 meg        |
| Discharge capacitor                         | 0.5 $\mu$ f    |
| Power input                                 | 1.0 W          |
| Grid bias                                   | $\pm$ 80 volts |
| Grid pulse current                          | 40 $\mu$ A     |
| Output pulse duration                       | 10 $\mu$ s     |
| Ambient temperature range                   | -55 to +85° C  |
| Anode delay time                            | 4.0 $\mu$ s    |
| Anode delay time variation                  | 0.4 $\mu$ s    |
| Pulse repetition rate **                    | 20 ppm         |
| Potting temperature (not to exceed 2 hours) | 125° C         |

\*\*Pulse repetition rate is governed by the relation  $W = 1/2 CV^2f$ , where C = discharge capacitor; V = anode potential in kilovolts; W = power input, and f = repetition frequency.

### Typical Operation (For circuit below)

|                      |            |
|----------------------|------------|
| Anode supply voltage | 550 volts  |
| Grid voltage         | 0 volts    |
| Glow current         | 50 $\mu$ A |



\*May be triggered manually by applying d-c momentarily to grid.

### Minimum Conditions

|                              |            |
|------------------------------|------------|
| Anode operating voltage, d-c | 500 volts  |
| Cathode current, peak        | 10 amp     |
| Glow current                 | 30 $\mu$ A |
| Grid resistor                | 0.25 meg   |
| Grid pulse duration          | 10 $\mu$ s |
| Grid pulse amplitude         | 230 volts  |



# technical information

## CBS-HYTRON

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

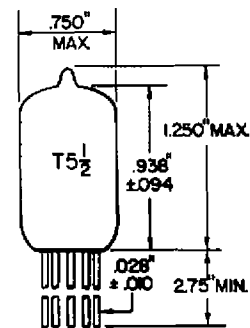
### 7230

#### Reliable Cold-Cathode Trigger Tube

The 7230 is a cold-cathode miniature trigger and timer tube used in critical applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Special construction enables the 7230 to operate over an ambient temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , withstand impact shocks with 100g peaks, and severe vibrational stresses. Dark-start design characteristic, is such that it will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

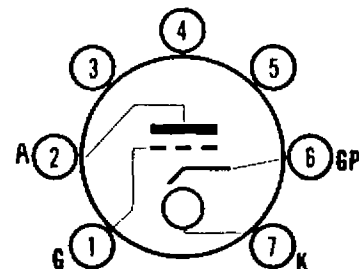
#### MECHANICAL DATA

|                                       |                      |
|---------------------------------------|----------------------|
| Cathode                               | cold                 |
| Bulb                                  | T5-1/2               |
| Base, min. button 7-lead              | flexible leads       |
| Lead length, minimum                  | 2.75 inches          |
| Lead diameter                         | $.028 \pm .010$ inch |
| Mounting position                     | Any                  |
| Max. overall ht. (leads not included) | 1.250 inch           |
| Maximum diameter                      | 0.75 inch            |



#### LEAD CONNECTIONS

- Lead 1. Grid
- Lead 2. Anode
- Lead 3. Omitted
- Lead 4. Omitted
- Lead 5. Omitted
- Lead 6. Glow pin
- Lead 7. Cathode



## ELECTRICAL DATA

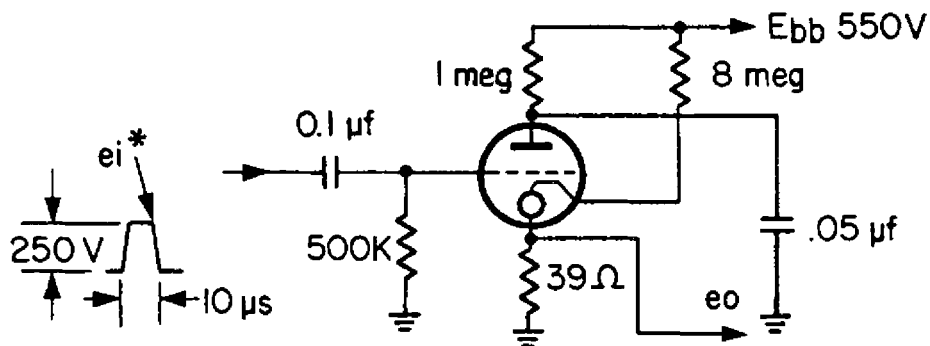
### Maximum Ratings (Absolute Maximum Values)

|                                             |                |
|---------------------------------------------|----------------|
| Anode operating voltage                     | 1000 volts     |
| Hold-off voltage                            | 3000 volts     |
| Cathode current peak                        | 500 amp        |
| Glow current                                | 100 $\mu$ A    |
| Grid resistor                               | 2.0 meg        |
| Discharge capacitor                         | 0.5 $\mu$ f    |
| Power input                                 | 1.0 W          |
| Grid bias                                   | $\pm$ 80 volts |
| Grid pulse current                          | 10 $\mu$ a     |
| Output pulse duration                       | 10 $\mu$ s     |
| Ambient temperature range                   | -55 to +85° C  |
| Anode delay time                            | 2.0 $\mu$ s    |
| Anode delay time variation                  | 0.2 $\mu$ s    |
| Pulse repetition rate**                     | 20 ppm         |
| Potting temperature (not to exceed 2 hours) | 125° C         |

\*\*Pulse repetition rate is governed by the relation  $W = 1/2 CV^2f$ , where C = discharge capacitor; V = anode potential in kilovolts; W = power input, and f = repetition frequency.

### Typical Operation (For circuit below)

|                      |            |
|----------------------|------------|
| Anode supply voltage | 550 volts  |
| Grid voltage         | 0 volts    |
| Glow current         | 50 $\mu$ a |



\*May be triggered manually by applying d-c momentarily to grid.

### Minimum Conditions

|                              |            |
|------------------------------|------------|
| Anode operating voltage, d-c | 500 volts  |
| Cathode current peak         | 10 amp     |
| Glow current                 | 30 $\mu$ A |
| Grid resistor                | 0.25 meg   |
| Grid pulse duration          | 10 $\mu$ s |
| Grid pulse amplitude         | 230 volts  |

## SPECIAL TESTS AND RATINGS

Operation tests for: d-c trigger current, d-c trigger voltage, pulse trigger voltage, emission, anode delay time, anode delay time variation, keep alive starting characteristic.

Conditions for tests:

Over temperature of -55 to +85°C

Temperature cycles under Mil-E-1C, 4.9.10

After impact shock of 100g

After vibration test of 10-500 cps cycling up to 10g for 4.5 hours  
in 3 planes of vibration.



E-287D 7-22-58

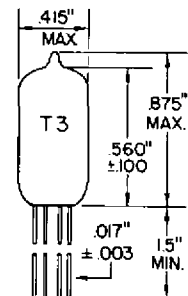
## 7231

### Subminiature Cold-Cathode Trigger Tube

The 7231 is a cold-cathode trigger and timer tube used in trigger applications where high hold-off voltage, short anode delay variation and high pulse currents are required. Its specifications are to commercial levels. Special construction enables the 7231 to operate over an ambient temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and withstand vibrational stresses. Dark-start design characteristic is such that it will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

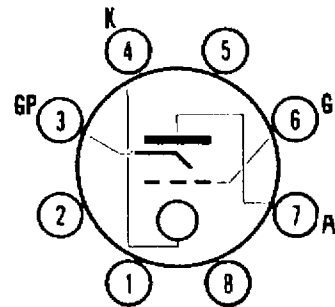
#### MECHANICAL DATA

|                                       |                      |
|---------------------------------------|----------------------|
| Cathode                               | cold                 |
| Bulb                                  | T3                   |
| Base, submin. button 8-lead           | flexible leads       |
| Lead length, minimum                  | 1.5 inch             |
| Lead diameter                         | $.017 \pm .003$ inch |
| Mounting position                     | Any                  |
| Max. overall ht. (leads not included) | 0.875 inch           |
| Maximum diameter                      | 0.415 inch           |



#### LEAD CONNECTIONS

|         |          |
|---------|----------|
| Lead 1. | Omitted  |
| Lead 2. | Omitted  |
| Lead 3. | Glow pin |
| Lead 4. | Cathode  |
| Lead 5. | Omitted  |
| Lead 6. | Grid     |
| Lead 7. | Anode    |
| Lead 8. | Omitted  |



## ELECTRICAL DATA

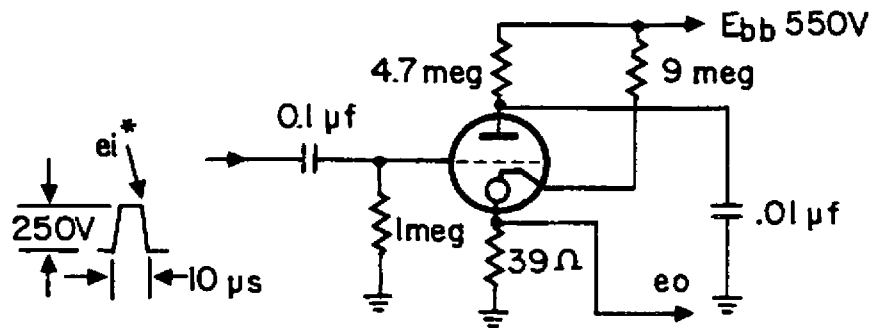
### Maximum Ratings (Absolute Maximum Values)

|                            |                |
|----------------------------|----------------|
| Anode operating voltage    | 700 volts      |
| Hold-off voltage           | 1500 volts     |
| Glow current               | 100 $\mu$ A    |
| Grid resistor              | 2.0 meg        |
| Discharge capacitor        | 0.2 $\mu$ f    |
| Power input                | 0.1 W          |
| Grid bias                  | $\pm$ 45 volts |
| Grid pulse current         | 20 $\mu$ a     |
| Output pulse duration      | 10 $\mu$ s     |
| Ambient temperature range  | -55 to +85°C   |
| Anode delay time           | 4.0 $\mu$ s    |
| Anode delay time variation | 0.4 $\mu$ s    |
| Pulse repetition rate *    |                |

\*Pulse repetition rate is governed by the relation  $W = 1/2 CV^2f$ , where C = discharge capacitor; V = anode potential in kilovolts; W = power input, and f = repetition frequency.

### Typical Operation (For circuit below)

|                      |            |
|----------------------|------------|
| Anode supply voltage | 550 volts  |
| Grid voltage         | 0 volts    |
| Glow current         | 50 $\mu$ a |



\*\*May be triggered manually by applying d-c momentarily to grid.

### Minimum Conditions

|                              |            |
|------------------------------|------------|
| Anode operating voltage, d-c | 500 volts  |
| Cathode current peak         | 10 amp     |
| Glow current                 | 30 $\mu$ A |
| Grid resistor                | 0.25 meg   |
| Grid pulse duration          | 10 $\mu$ s |
| Grid pulse amplitude         | 230 volts  |



E-287E 7-22-58

tes

**CBS-HYTRON**

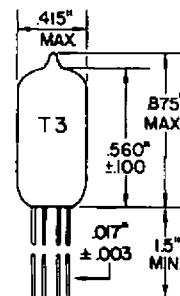
*A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts*

**7232****Reliable Subminiature Cold-Cathode Trigger Tube**

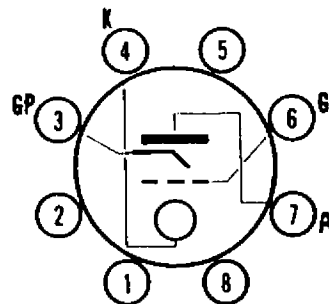
The 7232 is a cold-cathode trigger and timer tube used in strenuous trigger applications where high hold-off voltage, short anode delay variation and high pulse currents are required. Its specifications are intended for severe environmental service in critical applications. Special construction enables the 7232 to operate over an ambient temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and withstand impact shocks of over 2000 g peaks, and severe vibrational stresses. Dark-start design characteristic is such that it will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

**MECHANICAL DATA**

|                                       |                      |
|---------------------------------------|----------------------|
| Cathode                               | cold                 |
| Bulb                                  | T3                   |
| Base, submin. button 8-lead           | flexible leads       |
| Lead length, minimum                  | 1.5 inch             |
| Lead diameter                         | $.017 \pm .003$ inch |
| Mounting position                     | Any                  |
| Max. overall ht. (leads not included) | 0.875 inch           |
| Maximum diameter                      | 0.415 inch           |

**LEAD CONNECTIONS**

- Lead 1. Omitted
- Lead 2. Omitted
- Lead 3. Glow pin
- Lead 4. Cathode
- Lead 5. Omitted
- Lead 6. Grid
- Lead 7. Anode
- Lead 8. Omitted



## ELECTRICAL DATA

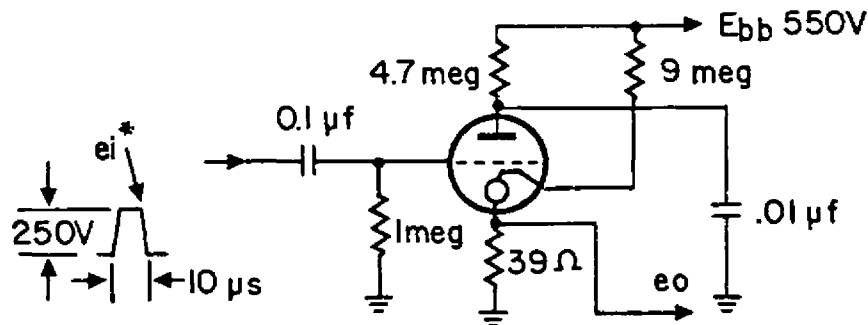
### Maximum Ratings (Absolute Maximum Values)

|                            |                |
|----------------------------|----------------|
| Anode operating voltage    | 1,000 volts    |
| Hold-off voltage           | 1,500 volts    |
| Glow current               | 100 $\mu$ A    |
| Grid resistor              | 2.0 meg        |
| Discharge capacitor        | 0.2 $\mu$ f    |
| Power input                | 0.1 W          |
| Grid bias                  | $\pm$ 45 volts |
| Grid pulse current         | 20 $\mu$ a     |
| Output pulse duration      | 10 $\mu$ s     |
| Ambient temperature range  | -55 to +85° C  |
| Anode delay time           | 1.60 $\mu$ s   |
| Anode delay time variation | 0.4 $\mu$ s    |
| Pulse repetition rate *    |                |

\*Pulse repetition rate is governed by the relation  $W = 1/2 CV^2f$ , where C = discharge capacitor; V = anode potential in kilovolts; W = power input, and f = repetition frequency.

### Typical Operation (For circuit below)

|                      |            |
|----------------------|------------|
| Anode supply voltage | 550 volts  |
| Grid voltage         | 0 volts    |
| Glow current         | 50 $\mu$ a |



\*\*May be triggered manually by applying d-c momentarily to grid.

### Minimum Conditions

|                              |            |
|------------------------------|------------|
| Anode operating voltage, d-c | 500 volts  |
| Cathode current peak         | 10 amp     |
| Glow current                 | 30 $\mu$ A |
| Grid resistor                | 0.25 meg   |
| Grid pulse duration          | 10 $\mu$ s |
| Grid pulse amplitude         | 230 volts  |

## SPECIAL TESTS AND RATINGS

Operation tests for: d-c trigger current, d-c trigger voltage, pulse trigger voltage, emission, anode delay time, anode delay time variation, keep alive starting characteristic.

### Conditions for tests:

Over temperature of -55 to +85°C

Temperature cycles under Mil-E-1C 4.9.10

After impact shock of 2000g

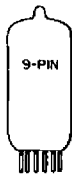
After vibration test of 10-500 cps cycling up to 10g for 4.5 hours  
in 3 planes of vibration.



## DUOTRIODE PULSE AMPLIFIER

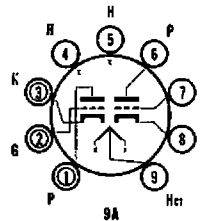
### 7318

Reliable pulse tube with extremely fast  
cathode warm-up



#### HEATER CHARACTERISTICS

|                                   | Series   | Parallel |       |
|-----------------------------------|----------|----------|-------|
| Voltage, a-c                      | 12.6±12% | 6.3±12%  | volts |
| Current                           | 175      | 350      | ma    |
| Peak heater-cathode voltage, max. |          |          |       |
| Heater negative to cathode        | 100      | 100      | volts |
| Heater positive to cathode        | 100      | 100      | volts |



#### ELECTRICAL DATA

##### DIRECT INTERELECTRODE CAPACITANCES, No Shield

|                              | Section 1 | Section 2 |     |
|------------------------------|-----------|-----------|-----|
| Grid to plate: g1 to p       | 1.4       | 1.4       | μmf |
| Input: g1 to k + h           | 1.5       | 1.5       | μmf |
| Output: p to k + h           | 0.5       | 0.5       | μmf |
| Coupling: plate 1 to plate 2 |           | 0.8       | μmf |

##### MAXIMUM RATINGS (Absolute Maximum Values)+

###### Pulse Modulator\*

|                                 |        |       |
|---------------------------------|--------|-------|
| Plate supply voltage, d-c       | 400    | volts |
| Grid 1 voltage, negative d-c    | -50    | volts |
| Grid 1 voltage, positive d-c    | 0      | volts |
| Peak positive grid voltage, d-c | 200    | volts |
| Peak grid current               | 0.9    | amp   |
| Peak plate current              | 1.25   | amp   |
| Peak cathode current            | 2.2    | amp   |
| Grid dissipation                | 0.60   | watts |
| Plate dissipation               | 1.35   | watts |
| Altitude                        | 60,000 | feet  |

##### MAXIMUM RATINGS (Absolute Maximum Values)+

###### Class A Amplifier

|                                 |        |       |
|---------------------------------|--------|-------|
| Plate voltage                   | 330    | volts |
| Plate dissipation               | 3.0    | watts |
| Cathode current                 | 22     | ma    |
| Control-grid circuit resistance |        |       |
| Fixed bias                      | 0.5    | meg   |
| Self bias                       | 1.0    | meg   |
| Bulb temperature                | 165    | °C    |
| Altitude                        | 60,000 | feet  |

##### CHARACTERISTICS AND TYPICAL OPERATION†

###### Pulse Modulator

|                                      |      |       |
|--------------------------------------|------|-------|
| Plate supply voltage, d-c            | 300  | volts |
| Grid supply voltage, d-c             | -25  | volts |
| Peak positive grid voltage           | 150  | volts |
| Peak plate current                   | 0.9  | amp   |
| Peak grid current                    | 0.7  | amp   |
| Plate load resistance (noninductive) | 75   | ohms  |
| Grid resistance (noninductive)       | 2400 | ohms  |
| Minimum cathode preheating           | 10   | sec   |

##### NOTES:

\*Duty factor = .0035; pulse width = 1.5 microseconds; pulse repetition rate = 2300 pps.

†Each section.

#### ENGINEERING DESIGN DATA

### 7318

SEPTEMBER 18, 1958

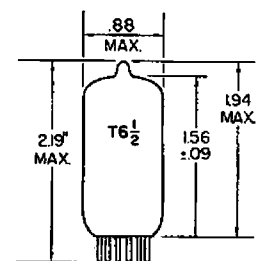
Pulse duotriode

#### CHARACTERISTIC CURVES

|                        |       |
|------------------------|-------|
| Plate                  | 2004A |
| Plate; Peak Ib & Ic    | 2004B |
| Transfer; Ib           | 2004C |
| Characteristics; Gm, μ | 2004D |

#### MECHANICAL DATA

|                              |             |
|------------------------------|-------------|
| Cathode, coated unipotential |             |
| Bulb                         | T-6½        |
| Outline                      | JETEC 6-2   |
| Maximum over-all-height      | 2.19 inches |
| Maximum seated height        | 1.94 inches |
| Maximum diameter             | .88 inch    |
| Base                         | (E9-1)      |
| Basing                       | 9A          |
| Mounting position            | Any         |



#### PIN CONNECTIONS

|       |                     |
|-------|---------------------|
| Pin 1 | Plate (Section 2)   |
| Pin 2 | Grid (Section 2)    |
| Pin 3 | Cathode (Section 2) |
| Pin 4 | Heater              |
| Pin 5 | Heater              |
| Pin 6 | Plate (Section 1)   |
| Pin 7 | Grid (Section 1)    |
| Pin 8 | Cathode (Section 1) |
| Pin 9 | Heater (Center tap) |

CBS-HYTRON, Danvers, Massachusetts  
A Division of Columbia Broadcasting System, Inc.

## APPLICATION

The CBS-Hytron 7318 is a medium- $\mu$  duotriode reliable pulse-tube with an extremely fast cathode warm-up time capable of providing 80% emission in 10 seconds. It is designed in particular for high peak-pulse blocking oscillators, square-wave modulators, multivibrators and other uses requiring a substantial plate current. Reliability and high cathode current, being of prime importance, are ensured by testing for vibration, fatigue, and pulse emission. Reliability under unfavorable environmental conditions is also enhanced by the 7318's ambient temperature operating range of  $-60^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$ .

This tube contains a cathode-heater assembly that is designed and processed to give the high emission required for pulse service. It will furnish rectangular pulses up to 55 microseconds width.

Life tests for the 7318 include environmental and pulse evaluation. They are on-off cycled for 12 minute periods with a 500 hour "on" time and pulse life tested for 500 hours for not more than 20% change in pulse emission.

## Class A Amplifier

|                                                           |      |      |                  |
|-----------------------------------------------------------|------|------|------------------|
| Plate voltage                                             | 100  | 250  | volts            |
| Control-grid voltage                                      | 0    | -8.5 | volts            |
| Plate resistance (approx.)                                | 5800 | 7000 | ohms             |
| Transconductance                                          | 3500 | 2350 | $\mu\text{mhos}$ |
| Amplification factor                                      | 21.3 | 16.5 |                  |
| Plate current                                             | 13.0 | 11.5 | ma               |
| Control-grid voltage (approx.) for $I_b = 10 \mu\text{a}$ |      | -22  | volts            |

## SPECIAL RATINGS AND PERFORMANCE DATA

### Interelectrode Leakage Resistance Each section

|                                                  |             |
|--------------------------------------------------|-------------|
| $E_r = 12.6/6.3 \text{ Vrms}$                    |             |
| Grid to all other elements with 100 Vdc applied  | 500 meg min |
| Plate to all other elements with 300 Vdc applied | 500 meg min |

### Heater to Cathode Leakage Current, Sections tied together

|                                                               |                        |
|---------------------------------------------------------------|------------------------|
| $E_r = 12.6/6.3 \text{ Vrms}$ ,<br>$E_{b1} = 100 \text{ Vdc}$ |                        |
| Heater positive with respect to cathode                       | 10 $\mu\text{Adc max}$ |
| Heater negative with respect to cathode                       | 10 $\mu\text{Adc max}$ |

### Transconductance at Low Heater Voltage Each section with other section grounded

|                                                                               |                           |
|-------------------------------------------------------------------------------|---------------------------|
| $E_r = 11/5.5 \text{ Vrms}$ , $E_b = 100 \text{ Vdc}$ , $E_c = 0 \text{ Vdc}$ | 2500 $\mu\text{mhos min}$ |
|-------------------------------------------------------------------------------|---------------------------|

### Cathode Warm-up Rating Each section with heater in parallel

|                                                                     |            |
|---------------------------------------------------------------------|------------|
| $E_b = 250 \text{ V}$ , $E_c = -8.5 \text{ V}$ (Instantaneous test) |            |
| 80% of stabilized plate current                                     | 10 sec max |

### Pulse Emission Slump Each section

|                                                                                                                                                                                                                                                        |         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| $E_r = 12.6 \text{ V}$ , $E_{b1} = 300 \text{ Vdc}$ , $R_L = 75 \Omega$ , $t_p = 10 \mu\text{sec}$ , $prr = 200 \text{ pps}$ , $E_{gr}/I_b = 1.8 \text{ amp min}$ , $E_c = -25 \text{ Vdc}$ , $R_k = 1 \Omega$ , Limit of $E_{gr} = 200 \text{ v max}$ |         |
| Ratio of trailing edge to leading edge                                                                                                                                                                                                                 | 80% min |

## ENVIRONMENTAL TESTS AND RATINGS

### Ambient Temperature Range

|                            |                                         |
|----------------------------|-----------------------------------------|
| (Operation within ratings) | $-60^{\circ}$ to $+100^{\circ}\text{C}$ |
|----------------------------|-----------------------------------------|

### Shock Rating

|                                                                   |           |
|-------------------------------------------------------------------|-----------|
| (1) Impact acceleration for .001 sec. duration (MIL-E-1D4.9.20.5) | 450 g max |
| (2) Impact acceleration for .011 sec. duration (Drawing JAN S-44) | 150 g max |

### Fatigue Rating (MIL-E-1D 4.9.20.6)

|                                  |       |
|----------------------------------|-------|
| Acceleration at 25 cps vibration | 2.5 g |
|----------------------------------|-------|

### Resonance Frequency Vibration Sections tied together

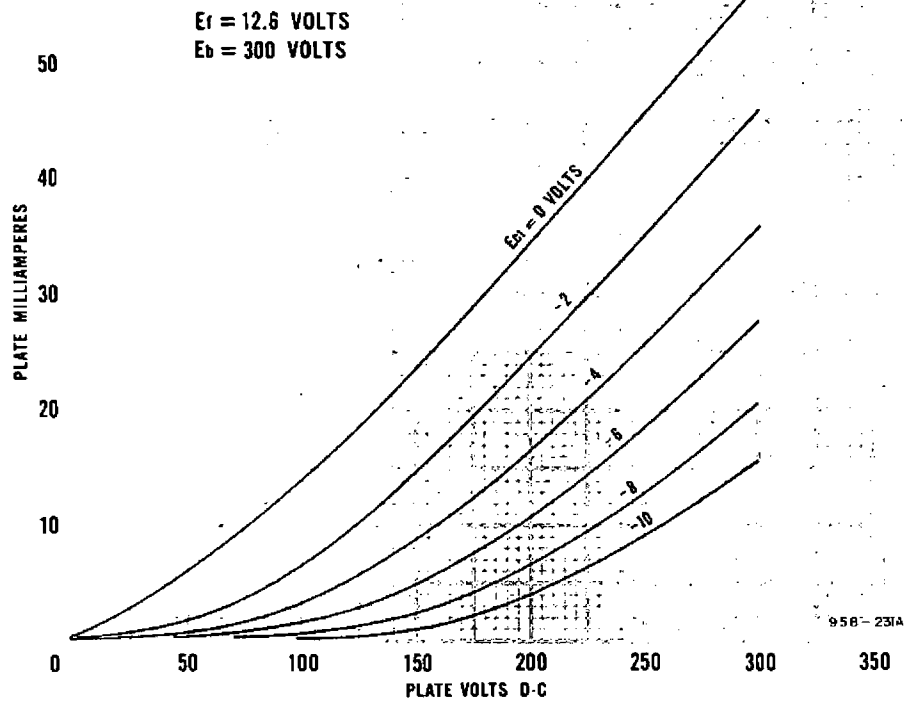
|                                                                                                        |              |
|--------------------------------------------------------------------------------------------------------|--------------|
| $E_r = 12.6 \text{ Vdc}$ , $E_b = 250 \text{ Vdc}$ , $E_c = -8.5 \text{ Vdc}$ ,<br>acceleration = 10 g |              |
| Noise output at 60 cps (peak)                                                                          | 80 mVac max  |
| Noise output at 370 cps (peak)                                                                         | 100 mVac max |
| High Frequency Fatigue Sections tied together                                                          |              |
| Constant acceleration at 10 to 500 cps (two hours in each of 3 mutually perpendicular positions)       | 10 g max     |

### Test End Points (Post shock and fatigue)

|                                                                                                                                                                                                |                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Pulse emission change                                                                                                                                                                          | 20% max                  |
| Heater to cathode leakage current                                                                                                                                                              |                          |
| Heater positive with respect to cathode                                                                                                                                                        | 30 $\mu\text{Adc max}$   |
| Heater negative with respect to cathode                                                                                                                                                        | 30 $\mu\text{Adc max}$   |
| Grid 1 current                                                                                                                                                                                 | -1.5 $\mu\text{Adc max}$ |
| Vibration Noise output voltage, (peak) (conditions of shock rating test (1) and (2), fatigue rating test (MIL-E-1D 4.9.20.6) and high frequency fatigue test, initially and until completion). | 150 mVac                 |
| Linear acceleration, 5 seconds in any plane (must meet shock and fatigue test end points after completion of test).                                                                            | 200 g                    |

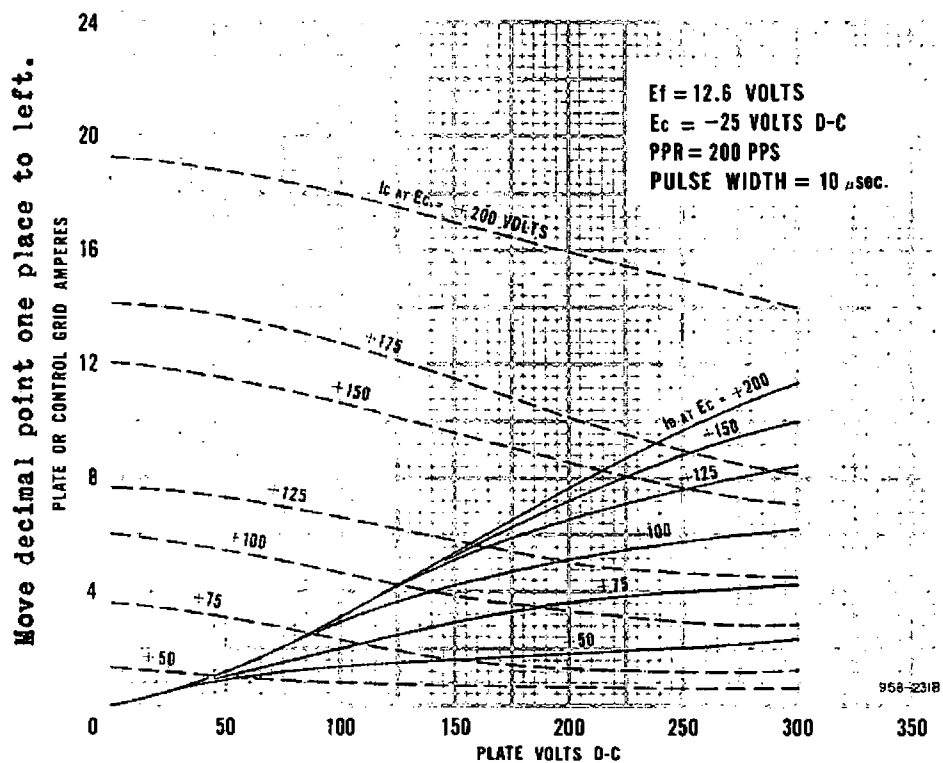
## AVERAGE PLATE CHARACTERISTICS

2004A

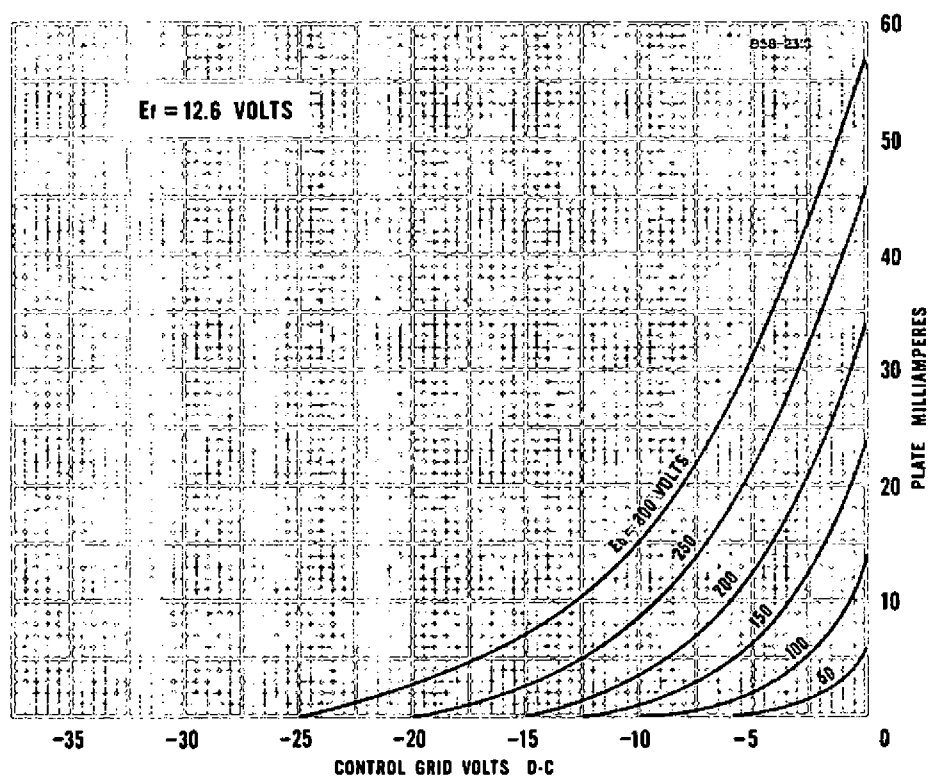


## AVERAGE PLATE CHARACTERISTICS

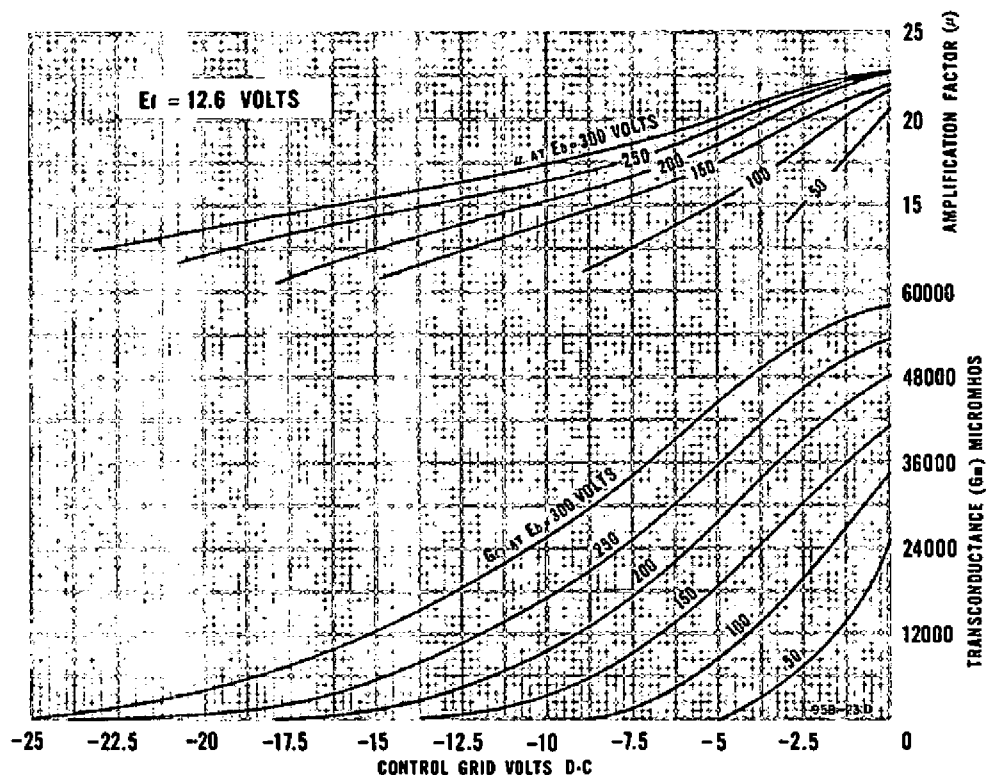
2004B



## AVERAGE TRANSFER CHARACTERISTICS



## AVERAGE CHARACTERISTICS



## "KRYTRON" TRIGGER TUBES

**RELIABLE** 7230 • 7441  
**COMMERCIAL** 7229 • 7439 • 7440

### ENGINEERING DESIGN DATA

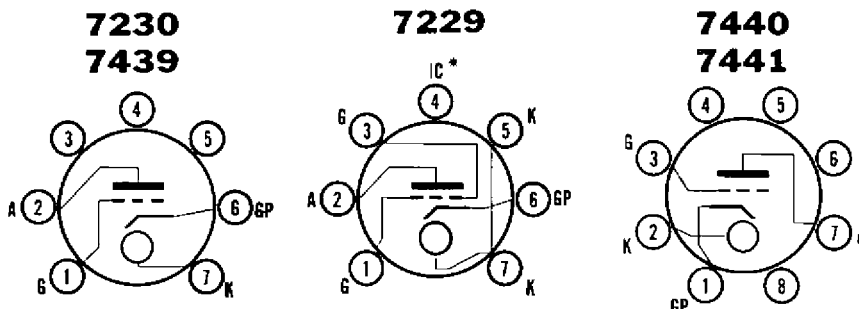
### KRYTRONS

MARCH 1, 1959

**Cold-cathode  
trigger tubes**

**7229**

### BASING DIAGRAMS



### MECHANICAL DATA

Cathode, cold  
Bulb T-5½  
Base, miniature button 7-pin (E7-1)  
Mounting position Any

### PIN CONNECTIONS

Pin 1 Grid  
Pin 2 Anode  
Pin 3 Grid  
Pin 4 I.C.\*  
Pin 5 Cathode  
Pin 6 Glow pin  
Pin 7 Cathode  
\*Do not use

**7230 7439**

### MECHANICAL DATA

Cathode, cold  
Bulb T-5½  
Base, miniature button with 7 flexible leads  
Mounting position Any

### LEAD CONNECTIONS

Lead 1 Grid  
Lead 2 Anode  
Lead 3 Omitted  
Lead 4 Omitted  
Lead 5 Omitted  
Lead 6 Glow pin  
Lead 7 Cathode

**7440 7441**

### MECHANICAL DATA

Cathode, cold  
Bulb T-3  
Base, subminiature button 8 flexible leads  
Mounting position Any

### LEAD CONNECTIONS

Lead 1 Glow pin†  
Lead 2 Cathode  
Lead 3 Grid  
Lead 4 Omitted  
Lead 5 Omitted  
Lead 6 Omitted  
Lead 7 Anode  
Lead 8 Omitted  
†Glow pin marked by red dot.

### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

Heater voltages None required

#### MAXIMUM RATINGS (Absolute Maximum values)

|                                             | 7229<br>7439 | 7230       | 7440 | 7441 |
|---------------------------------------------|--------------|------------|------|------|
| Anode operating voltage                     | 1000         | 1000       | 700  | 1000 |
| Hold-off voltage                            | 2000         | 3000       | 1500 | 1500 |
| Cathode current peak                        | 500          | 500        | —    | —    |
| Glow current                                | 100          | 100        | 100  | 100  |
| Grid resistor                               | 2.0          | 2.0        | 2.0  | 2.0  |
| Discharge capacitor                         | 0.5          | 0.5        | 0.2  | 0.2  |
| Power input                                 | 1.0          | 1.0        | 0.1  | 0.1  |
| Grid bias                                   | ±80          | ±80        | ±45  | ±45  |
| Grid pulse current                          | 40           | 10         | 20   | 20   |
| Output pulse duration                       | 10           | 10         | 10   | 10   |
| Ambient temperature range                   | —            | —55 to +85 | —    | —    |
| Anode delay time                            | 4.0          | 2.0        | 4.0  | 1.60 |
| Anode delay time variation                  | 0.4          | 0.2        | 0.4  | 0.4  |
| Pulse repetition rate                       | 20†          | 20†        | †    | †    |
| Potting temperature (not to exceed 2 hours) | —            | 125        | —    | —    |

#### ENVIRONMENTAL TESTS FOR TYPES 7230 & 7441

##### Operation tests (Performed under special conditions)

D-c trigger current, d-c trigger voltage, pulse trigger voltage.  
Anode delay time, anode delay time variation.  
Keep-alive starting characteristic.

##### Conditions for tests

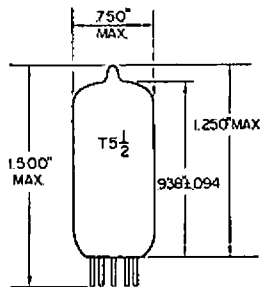
Oven temperature range of -55°C to +85°C  
Temperature cycles under MIL-E-10 4.9.10  
7441: After impact shock of 2000g  
7230: After impact shock of 100g  
After vibration test of 10-500 cps up to 10g for 4.5 hours in 3 planes.

**CBS-HYTRON**, Danvers, Massachusetts  
A Division of Columbia Broadcasting System, Inc.

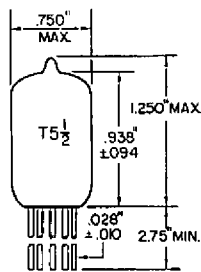
# APPLICATION

"Krytrons" are cold-cathode miniature trigger and timer tubes used in applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Because of their special construction they will withstand wide ambient temperature range, high impact shocks, and severe vibrational stresses. They will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

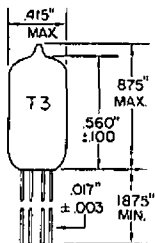
## 7229



## 7230 7439



## 7440 7441



# TYPICAL OPERATION FOR CIRCUIT SHOWN (All Types)

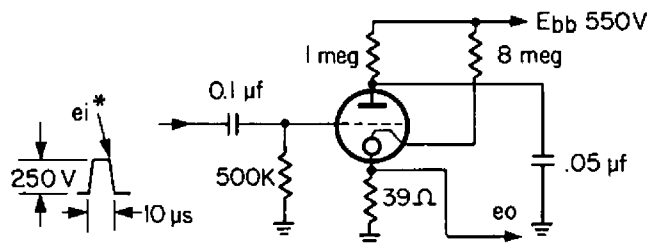
|                         |            |
|-------------------------|------------|
| Anode operating voltage | 550 volts  |
| Grid voltage            | 0 volts    |
| Glow current            | 50 $\mu$ a |

# MINIMUM CONDITIONS

|                              |              |
|------------------------------|--------------|
| Anode operating voltage, d-c | 400 volts    |
| Cathode current peak         | 10 amp       |
| Glow current                 | 30 $\mu$ A   |
| Grid resistor                | 250,000 ohms |
| Grid pulse duration          | 10 $\mu$ sec |
| Grid pulse amplitude         | 230 volts    |

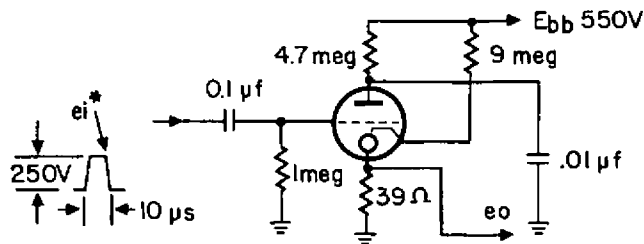
† Pulse repetition rate is governed by the relationship  $W = \frac{1}{2} CV^2 f$ , where C = discharge capacitor; V = Anode potential in kilovolts; W = power input, and f = repetition frequency.

## 7229 7230 7439



\* May be triggered manually by applying d-c momentarily to grid.

## 7440 7441



\* May be triggered manually by applying d-c momentarily to grid.

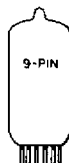
Reliable tubes through  
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# engineering data for

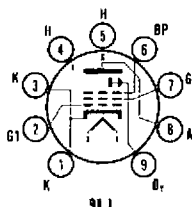
BULLETIN E393B  
4-61

## SECONDARY EMISSION HEXODE

### 7548



Miniature hexode for fast pulse generator and pulse amplifier service. High fast pulse wavefronts are obtainable from this tube because of the secondary emission current multiplication.



## ENGINEERING DATA

### 7548

## SECONDARY EMISSION HEXODE

### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                |           |
|----------------|-----------|
| Heater voltage | 6.3 volts |
| Heater current | 700 ma    |

#### DIRECT INTERELECTRODE CAPACITANCES

|                  |         |
|------------------|---------|
| Input            | 8.0 pf  |
| Output, anode    | 3.1 pf  |
| Output, dynode   | 4.4 pf  |
| Grid 1 to plate  | .027 pf |
| Grid 1 to dynode | .110 pf |

#### MAXIMUM RATINGS (Design maximum values)

|                                                                     |            |
|---------------------------------------------------------------------|------------|
| Anode Voltage (E <sub>bb</sub> )                                    | 1000 volts |
| Dynode Voltage (E <sub>dy</sub> )                                   | 400 volts  |
| Grid 2 Voltage (E <sub>c2</sub> )                                   | 300 volts  |
| Anode — Dynode Gradient (E <sub>bb</sub> -E <sub>dy</sub> )         | 600 volts  |
| Beam Rod Voltage (E <sub>BR</sub> ) $\phi$                          | 500 volts  |
| Anode Dissipation (E <sub>b</sub> -E <sub>dy</sub> ) I <sub>b</sub> | 3.5 watts  |
| Dynode Dissipation (E <sub>dy</sub> I <sub>dy</sub> )               | 4.0 watts  |
| Grid 2 Dissipation (E <sub>c2</sub> I <sub>c2</sub> )               | 1.5 watts  |
| Grid 1 Dissipation                                                  | 1 watt     |

#### CHARACTERISTICS AND TYPICAL OPERATING CONDITIONS

##### Class A Voltage Amplifier

|                                           |                   |
|-------------------------------------------|-------------------|
| Anode Voltage                             | 300 volts         |
| Dynode Voltage                            | 150 volts         |
| Grid 2 Voltage                            | 250 volts         |
| Anode Current                             | 23 ma             |
| Dynode Current                            | -15* ma           |
| Grid 2 Current                            | 2.5 ma            |
| Transconductance (E <sub>c1</sub> = -1.5) | 26,000 $\mu$ mhos |

#### PULSE AMPLIFIER SERVICE

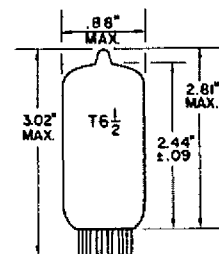
|                                |     |     |           |
|--------------------------------|-----|-----|-----------|
| Anode Voltage                  | 350 | 500 | 900 volts |
| Dynode Voltage                 | 150 | 200 | 400 volts |
| Screen Voltage                 | 250 | 250 | 250 volts |
| Pulse Anode Current            | .6  | .9  | > 1 amp   |
| Max. instantaneous anode power | —   | —   | 1 kw      |

\*The dynode current is negative relative to the plate current. Since it draws "negative" current from the positive terminal of the power supply, a bleeder resistor must be used to prevent supply instability.

$\phi$  In certain applications, it is permissible to operate the beam forming rods at positive potentials. Normally beam forming rods are grounded or tied to cathode.

### MECHANICAL DATA

Cathode, coated unipotential  
Bulb ..... T-6 1/2  
Outline ..... 6-4  
Base, 9-pin miniature .. JEDEC E9-1  
Basing ..... 9LJ  
Mounting position ..... Any



### PIN CONNECTIONS

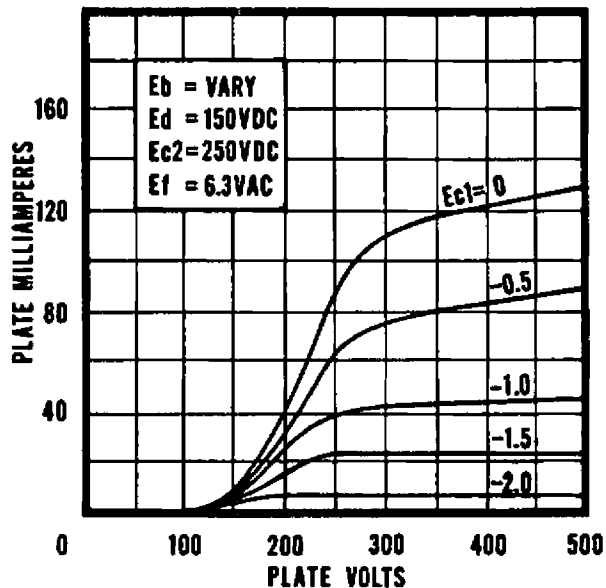
|       |                                       |
|-------|---------------------------------------|
| Pin 1 | Cathode                               |
| Pin 2 | Grid 1                                |
| Pin 3 | Cathode                               |
| Pin 4 | Heater                                |
| Pin 5 | Heater                                |
| Pin 6 | Beam Forming Rods                     |
| Pin 7 | Grid 2                                |
| Pin 8 | Anode                                 |
| Pin 9 | Dynode (Secondary Emission Electrode) |

**CBS ELECTRONICS**, Receiving Tube Operations, Danvers, Mass.  
A Division of Columbia Broadcasting System, Inc.

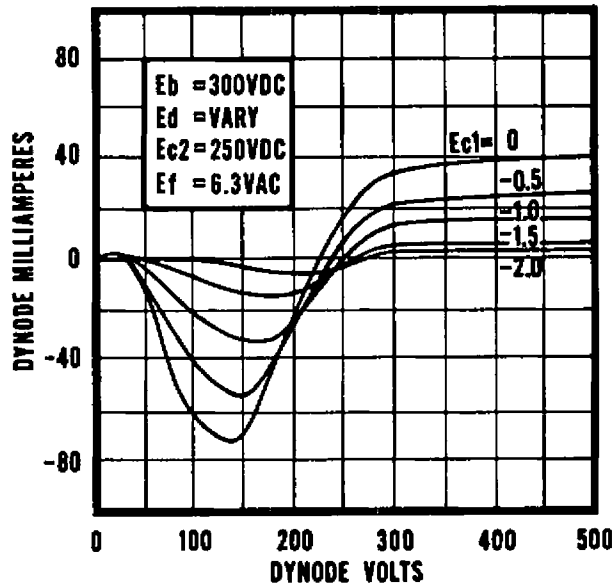
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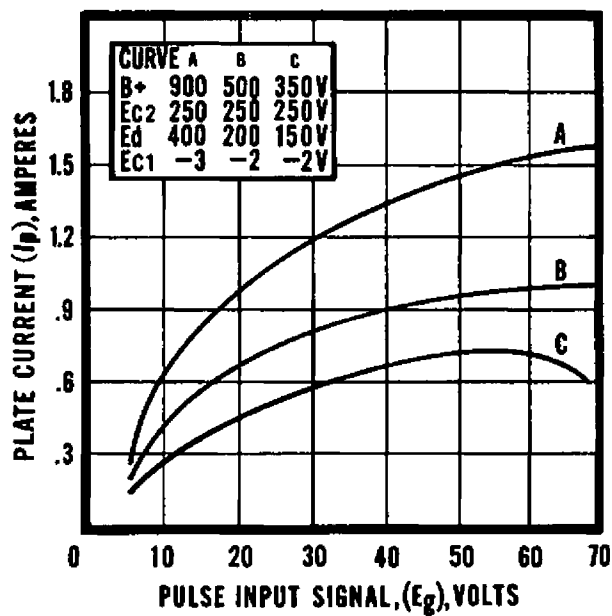
## AVERAGE PLATE CHARACTERISTICS



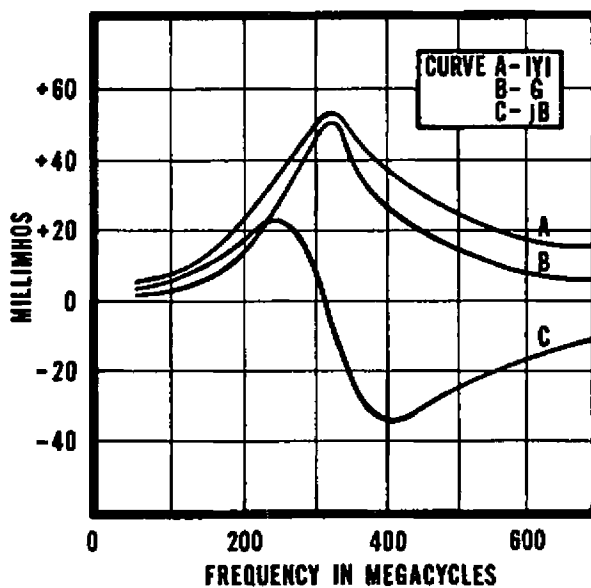
## AVERAGE DYNODE CHARACTERISTICS



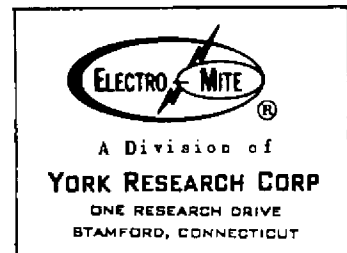
## POSITIVE GRID CHARACTERISTICS



## HOT INPUT ADMITTANCE CHARACTERISTICS



## Technical Information



# SECONDARY EMISSION HEXODE 7548

The EM 7548\* is an important new secondary emission vacuum tube. Featuring high-current, fast rise-time pulse generation characteristics, a wideband performance capability, and a stable life-expectancy of over 2000 hours, the 7548 surpasses other secondary emission tubes in performance and reliability. Its reliability features include standardized outline and basing dimensions, coiled heater, cathodes free from interface impedance and refractory dynode surfaces. The

EM 7548 is designed for volume production and exhibits a uniformity of electrical and mechanical parameters required by today's critical military and commercial markets.

### PRINCIPLES OF OPERATION

The EM 7548 follows conventional vacuum tube design concepts in developing, controlling, accelerating and shaping the primary electron stream. Departure from conventional design occurs in the 7548 in its dynode-anode region. Here a secondary-emission dynode structure is located in relation to the anode, for the efficient development of high secondary-to-primary electron ratios. Secondary electrons emitted from the dynode surface as a result of primary electron impingement are collected by the anode. The result in the EM 7548 is a primary electron multiplication factor of 3.

The use of secondary emission in the EM 7548 design provides several advantages unavailable with conventional high gain or pulse application tubes. These are:

- (1) Dynode output currents which produce dynode resistive load signals that remain in phase with the grid input signals. Regenerative circuits can thus be developed by applying feedback from the dynode to the control grid.
- (2) Anode currents greater than cathode currents (occurring as the result of secondary emission electron multiplication) allow the application of positive feedback from the anode to the cathode.
- (3) Two amplified outputs are developed by the tube, one of which is in phase with and the other out of phase with the input signal.
- (4) Faster recovery times at higher pulse currents than conventional gas filled or solid state pulse devices. (In the 7548, pulse recovery times are limited only by low values of interelectrode capacitances.
- (5) Noncritical electrode spacings which effectively reduce the probability of intermittent short circuits and other defects. The EM 7548 obtains high  $g_m$  values with secondary emission electron multiplication rather than with closely spaced tube elements.
- (6) Low output impedance characteristics. The plate resistance of the 7548 is determined by the plate current and plate to dynode voltage parameters. As the plate voltage approaches dynode potential, plate resistance decreases to values as low as 50 ohms.

\* REDESIGNATED AS EM7548 AND NOW  
MANUFACTURED EXCLUSIVELY BY:  
ELECTRO-MITE DIVISION OF YORK  
RESEARCH CORP., STAMFORD, CONN.

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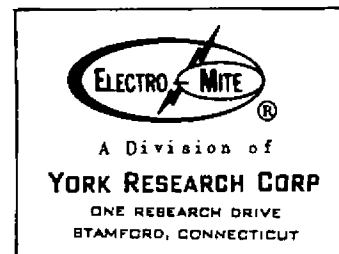
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## Application Notes

# SECONDARY EMISSION HEXODE

## 7548

1. In operation, the tube may exhibit a pale blue glow. This is a normal phenomenon in the tube and does not indicate a gaseous condition.
2. Efficient secondary electron collection is achieved when the potential difference between dynode and anode is greater than 150 volts.
3. Recommended maximum anode to dynode voltage is 600 volts. Field emission may produce arcing if these two electrodes are operated at voltage differences greater than this value. At voltage differentials greater than 600 volts secondary electron collection may decrease.
4. Since the dynode is an electron emitter, it is possible for the instantaneous dynode voltage to be greater than the dynode supply voltage. A bleeder resistor shunting the supply must be used to maintain a proper net positive current from the power supply and prevent supply instability.
5. In order to extend tube life, it is recommended that a B+ voltage delay be utilized. This recommended delay is mandatory if anode-dynode voltage differentials exceed 400 volts.
6. Recommended heater supply voltage regulation is  $\pm 5\%$ .
7. Since dynode transconductance is approximately  $2/3$  the value of anode transconductance, equal voltage outputs may be obtained when the dynode load resistance is made  $1\frac{1}{2}$  times the anode load resistance.
8. In fast pulse circuits with low load resistance, output coupling capacitances must be selected to produce time constants with a value at least 10 times greater than pulse width to prevent pulse degradation.
9. To achieve maximum performance with the EM 7548, stray circuit capacitances and inductances must be minimized.
10. The recommended maximum grid resistance is 100 K ohms.
11. In certain high current pulse applications, internal primary electron beam defocusing may occur due to the presence of large electron space currents. This effect may be neutralized by operating the beam forming rods at d-c potentials similar to those appearing on the screen and dynode. The beam rods should always be operated at a-c ground.

### EM 7548 APPLICATIONS

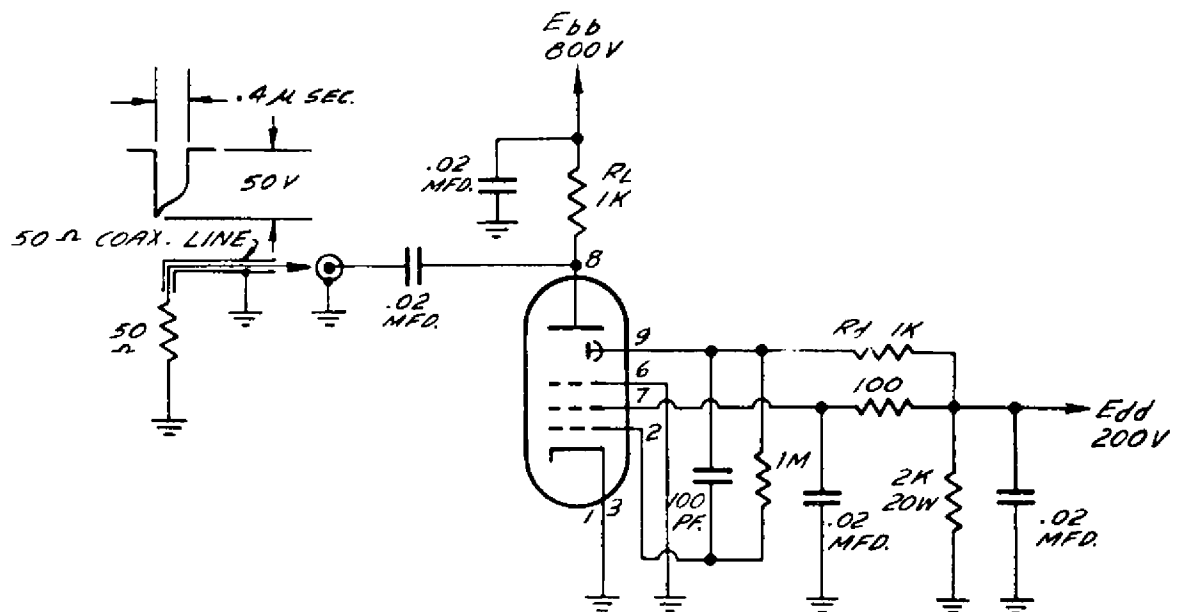
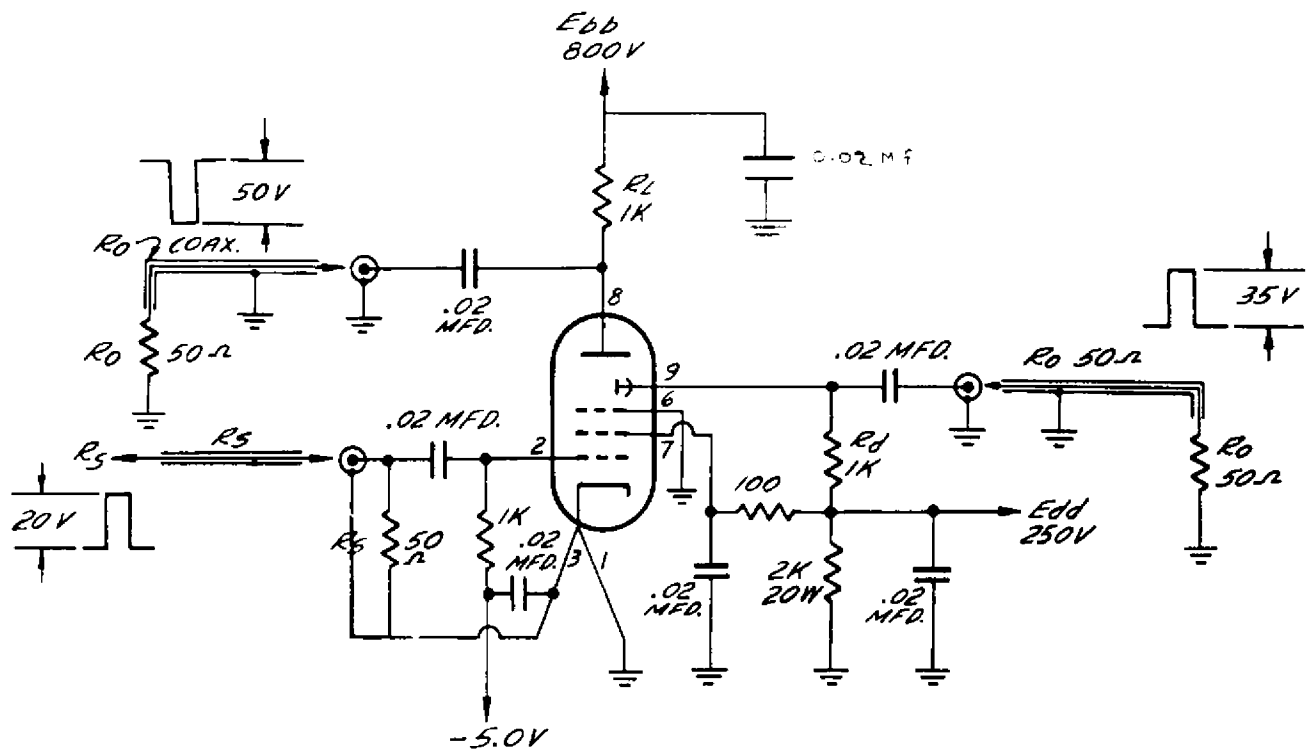
The 7548 operates efficiently in pulse circuits with switching times below 5 nanoseconds. It will furnish pulse-rise times of less than 3 nanoseconds for peak currents of over 1 ampere into low impedance loads (e. g. 50-ohm load) at high repetition frequencies. Life tests under high current pulse conditions are in operation using the EM 7548 and have logged over 2000 hours.

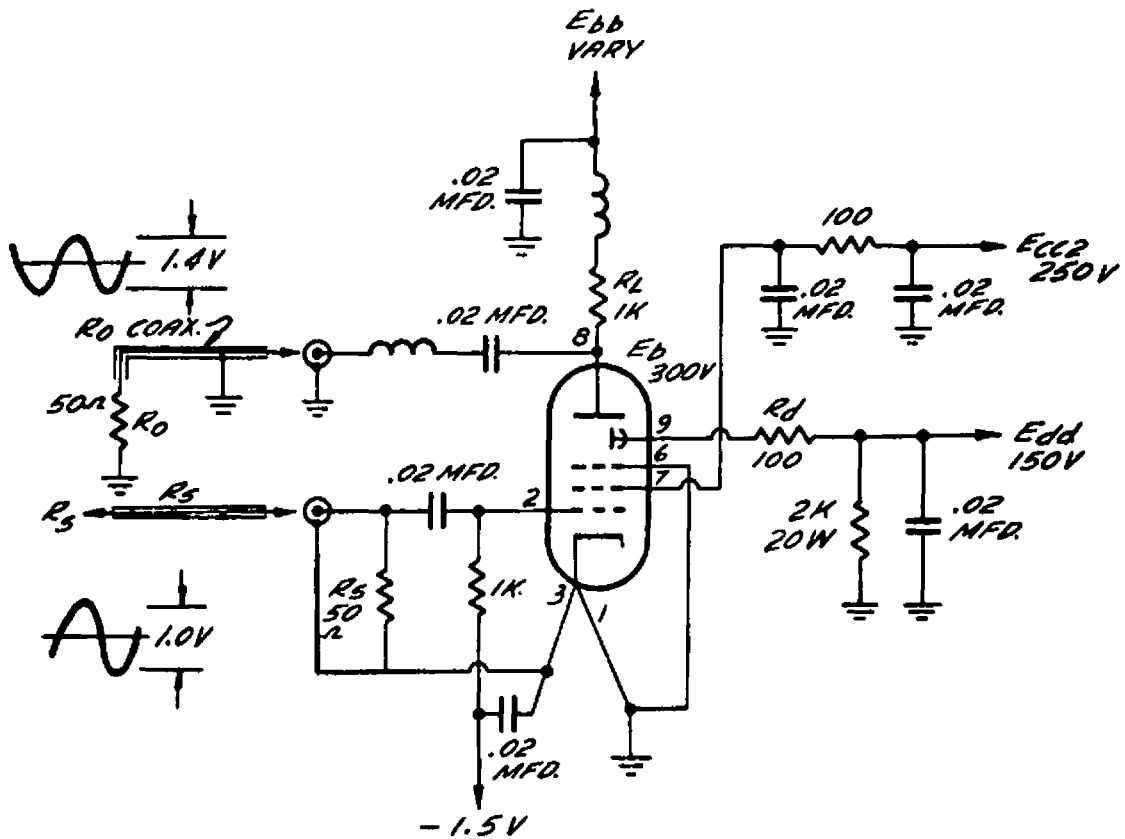
Examples of single stage pulse circuits employing the 7548 appear on following pages. These circuits illustrate the capabilities of the tube in fast rise-time free-running or driven pulse generators. In the univibrator (free-running) circuit the rise time is less than 3 ns and in driven circuits pulse rise times of less than 2 ns have been measured. These performance characteristics suggest the use of the EM 7548 in advanced flip-flop, trigger sweep and switching circuits.

The enclosed bibliography lists literature discussing the application of secondary emission tubes, similar to the EM 7548, in many technical areas such as nuclear particle counting, Kerr cell studies, fast oscillography, and image tube studies.

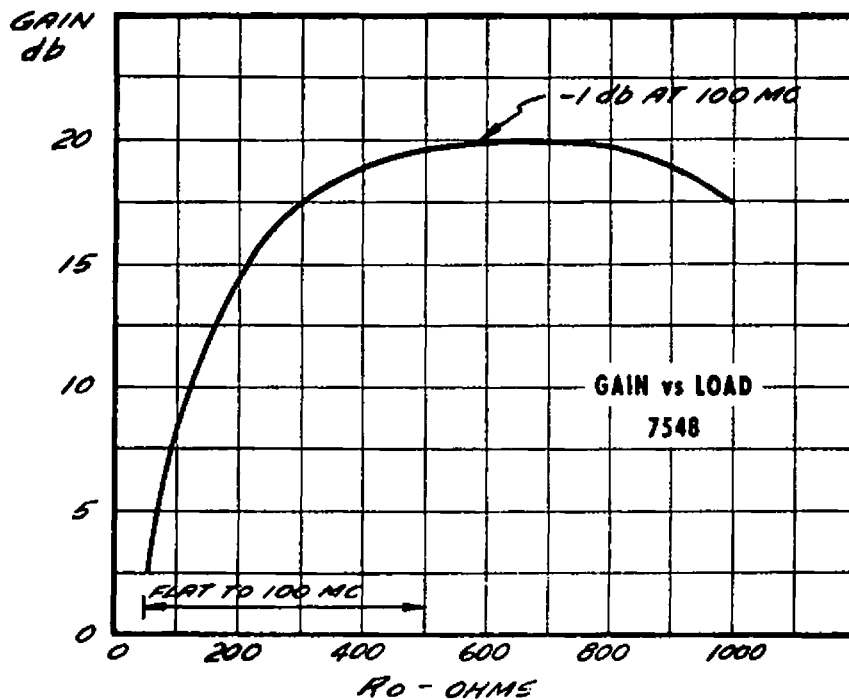
The EM 7548 design has a class A transconductance of 26,000 micromhos and a gain-bandwidth figure of merit of 350 mc/s. High conductivity gold-plated base pins and double cathode connections minimize inductive effects. These characteristics offer a flexibility in wideband circuit design unobtainable with conventional tubes. With a  $gm/I_b$  ratio of 1500: this tube delivers class A amplifier gains of 1.4 into low impedance loads. Circuit economies can be realized since the high transconductance of the EM 7548 can effectively reduce the number of stages required in high gain amplifiers. These features indicate the important advantages accruing from the use of this tube in such applications as wideband distributed amplifiers, video amplifiers and wide band-pass amplifiers. A single stage Class A amplifier circuit is illustrated on a following page, while the bibliography suggests other wideband circuit application literature.

The enclosed data sheet describes important mechanical and electrical parameters of the EM 7548. Anode and dynode dynamic characteristics are shown on the attached curve sheets.





**WIDEBAND CLASS "A" AMPLIFIER**



**WIDEBAND CLASS "A" AMPLIFIER**

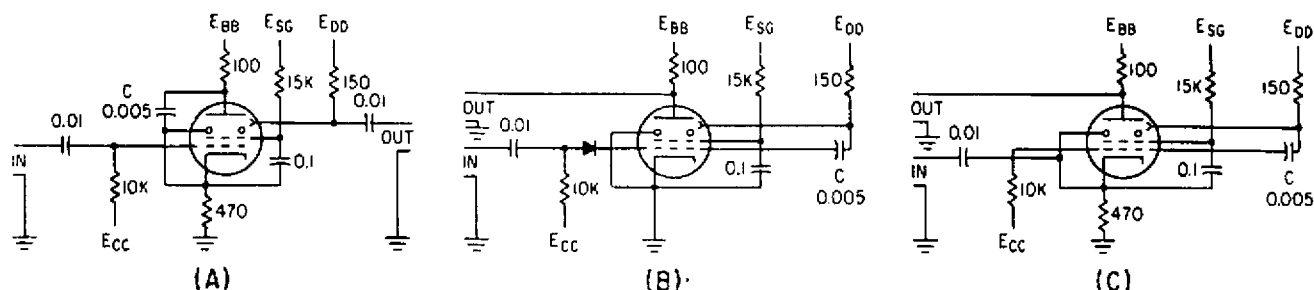


FIG. 1—Secondary-emission pentode trigger circuits: with positive feedback from plate to cathode (A); with positive feedback from dynode to grid (B); and for triggering with negative pulses (C)

# How to Use the Secondary-Emission Pentode

*Unique properties of the secondary-emission pentode,  
important in high-speed, short-duration pulse work, make  
this tube potentially useful in solving vacuum tube circuit problems*

By E. J. MARTIN, JR., Midwest Research Institute, Kansas City, Missouri

SECONDARY-EMISSION pentodes represent an important contribution to nanosecond pulse techniques.<sup>1</sup>

Although many persons who have a working knowledge of millimicrosecond pulse circuits might find it difficult to justify the designation of this or any other device as the most important, the secondary-emission pentode has done much to advance the state-of-the-art in high-speed, short-duration pulse work. The tube has made possible triggering circuits that have shorter starting delays, better repeatability and shorter recovery times than gas-discharge tube circuits used for similar purposes. In addition, the secondary-emission pentode makes it convenient to use regenerative feedback for generating fast-rise pulses at extremely fast repetition rates. Finally, the secondary-emission pentode can produce signal amplification without phase inversion, and thus can be used in some unique, balanced, distributed amplifier circuits.

Three types of secondary-emission pentodes are available commercially—the Philips EFP-60; the E.M.I. Z-319; and the recently announced EM type 7548.

We do not discuss or compare specific characteristics of these different tube types here, but deal with the general properties of the secondary-emission pentode class of vacuum tubes and demonstrate some unique properties by considering a few circuits which are frequently used for pulse generation, triggering and pulse amplification.

Engineers not engaged in the development and/or application of millimicrosecond pulse techniques should become acquainted with the secondary-emission pentode. Its general capabilities make it a potentially useful tool in the solution of some specific electronic circuit problems.

The secondary-emission pentode comprises a high-vacuum, r-f pentode modified by a secondary-emission cathode, or dynode, situated

between the suppressor and the plate. This dynode is operated at a potential intermediate between cathode and plate potentials. Its location is such that primary electrons which traverse the first part of the pentode structure (from cathode through suppressor) impinge upon the dynode rather than traveling directly to the plate.<sup>2</sup> The dynode is made of, or sensitized with, a material that has a high secondary-emission ratio,<sup>3</sup> usually in the range between four and seven. Since the plate is at a higher potential than the dynode while the suppressor is at cathode potential, the secondary electrons from the dynode are collected by the plate.

This arrangement greatly increases the overall transconductance of the tube without introducing relatively large interelectrode capacitances. The secondary-emission pentode may show an effective transconductance in excess of 20,000 micromhos with input and output capacitances of only 10 pf and

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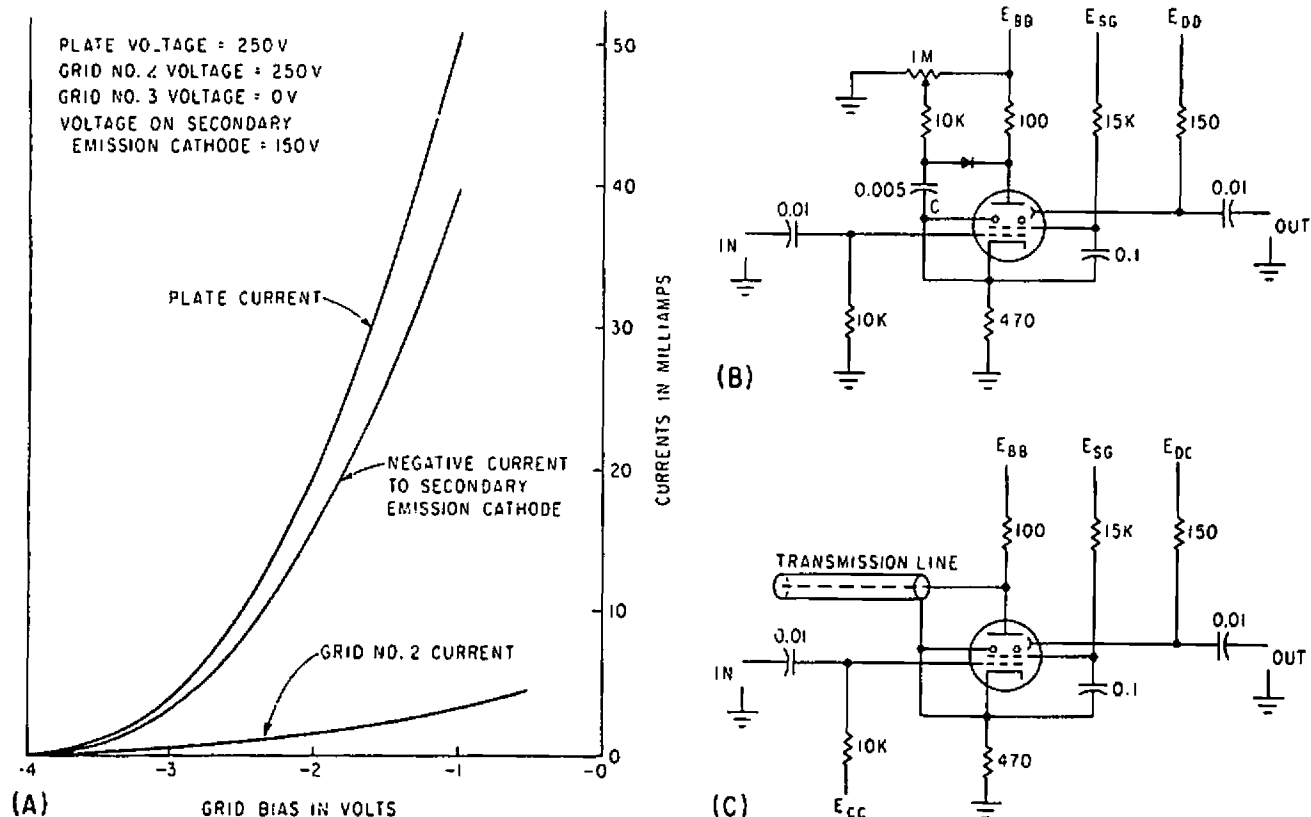


FIG. 2—Transfer characteristics of the EFP-60 (A); trigger circuit or pulse height discriminator (B); and a variation of the feedback circuit in a secondary-emission pentode trigger (C)

5 pf, and a grid-to-plate capacitance approximately three orders of magnitude smaller. Thus, in the design of cascaded, class-A amplifier stages, the secondary-emission pentode is of interest since it has a gain-risetime factor that compares favorably with those of other high-frequency pentodes.

Another feature arising from the novel arrangement is that since the dynode emits electrons at a greater rate than it receives them, there is an effective positive current flow out of the dynode. Except for the slight delay due to electron transit time, this dynode current is in phase with the grid signal. Consequently, an amplified, in-phase voltage will appear across a load impedance in the external dynode circuit. Besides amplification without phase inversion, this positive dynode current, along with the fact that both the dynode and plate currents are several times larger than the cathode current, leads to the possibility of using positive feedback to generate

fast-rise pulses.

The ways in which the properties of the secondary-emission pentode can be employed to advantage are most easily explained by considering a few typical secondary-emission pentode circuits.

Consider triggering and pulse generating circuits.<sup>4,5,6</sup> A regenerative, secondary-emission pentode trigger circuit is shown in Fig. 1A on p 60.

In the quiescent state, the control grid potential is adjusted to a value that is sufficiently negative to just maintain the tube cutoff. The cathode is at ground potential, the plate is at some potential  $E_{nn}$  volts above ground and the dynode is at an intermediate potential  $E_{nd}$ . Since the tube is just cutoff, even a small positive-going signal on the grid will liberate some cathode electrons. When these electrons impinge on the dynode, secondary emission occurs and the plate collects an electron current several times larger than that which origi-

nally left the cathode. Because it is emitting electrons, the dynode rises slightly above  $E_{nd}$ ; the plate potential drops slightly below  $E_{nn}$  when it collects the electrons. The drop in plate potential is fed back to the cathode through coupling capacitor C. Since the plate current is several times larger than the cathode current, the signal fed back to the cathode can be made of sufficient magnitude to overcome the cathode rise resulting from the flow of cathode current and to drive the cathode negative. This lowering of the cathode potential corresponds to an increase in grid potential. Consequently, more electrons are released from the cathode. Thus, even if the initiating pulse on the control grid should end during the cycle, feedback will keep repeating until the conduction of the tube has built up to a saturation level. Saturation is reached when the plate and dynode potentials have become substantially equal so that the plate can no longer collect all of the secondary

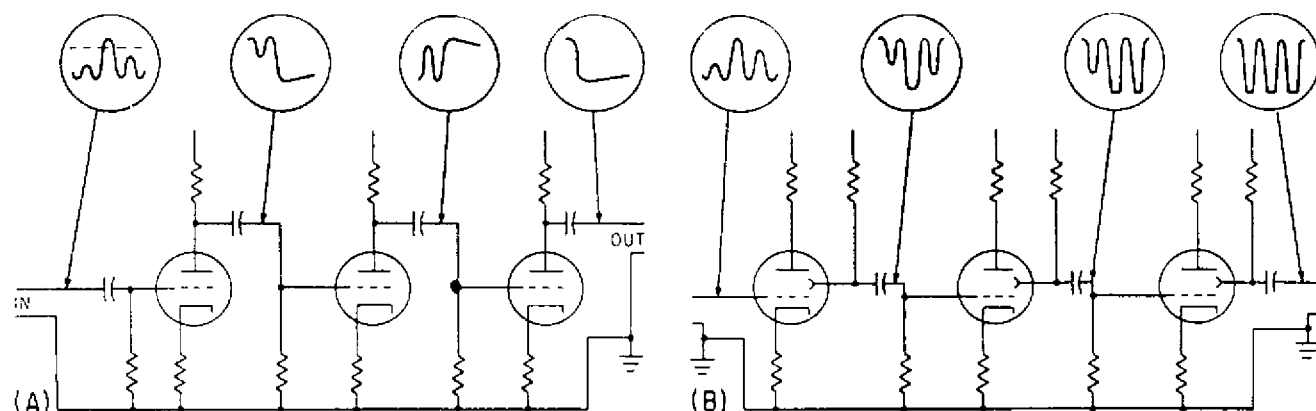


FIG. 3—Amplification by conventional cascade (A) and by cascaded secondary-emission pentodes (B)

electrons from the dynode.

With the tube in the heavily conducting state, the cathode begins to rise from its highly negative potential as the charge on the feedback capacitor is equalized through the cathode resistor to ground. This relatively slow rise of cathode potential has little effect on either the dynode or plate potentials so long as the supply of primary electrons from the cathode is large enough to maintain a rate of secondary emission at the dynode equal to or greater than the rate at which electrons can be collected by the plate. However, once the cathode potential rises to where liberation of primary electrons becomes small enough to result in a rate of production of secondary electrons at the dynode less than the rate at which the plate can collect electrons, the plate current will decrease slightly. The rise in plate potential is fed back to the cathode to further decrease the supply of primary and consequently secondary electrons. The tube is driven rapidly into cutoff and remains cutoff until another positive grid pulse is applied.

The circuit shown in Fig. 1A produces a positive output pulse across the dynode load each time it is triggered by a positive grid pulse. In Fig. 1B, a similar arrangement is shown for the production of a negative output pulse across the plate load. Feedback is from dynode to control grid, rather than from plate to cathode. The diode in the grid circuit in Fig. 1B insures that the feedback pulse is not impressed on any other circuit that might be connected to the input terminals

and also to make the feedback nearly independent of the impedance of the input generator. This second consideration is important when the positive trigger input is derived from a relatively low-impedance source that might make the development of the feedback signal difficult. An alternate form of this circuit, which can be used when a negative trigger pulse is available, is shown in Fig. 1C. The diode is not necessary in the input circuit since feedback is from dynode to control grid while the negative trigger pulse is impressed on the cathode.

In the trigger circuits of Fig 1A through 1C, it is necessary that the grid be biased beyond cutoff because whenever cathode current flows in any of these circuits, regeneration takes place. With a grid that is not biased to cutoff, any of these circuits will free-run. That is, another cycle of regeneration will begin each time the circuit recovers from the previous cycle. Then the circuit is no longer a trigger circuit, but rather a pulse train generator.

The EFP-60 transfer characteristics shown in Fig. 2A are typical of secondary-emission pentode transfer characteristics. They show there is a disadvantage to the operation associated with the circuits of Figs. 1A through 1C. Each regeneration cycle must begin from cutoff where the tube transconductance, and consequently the circuit gain, is relatively low. The circuit shown in Fig. 2B obviates operating the tube at or beyond cutoff in the quiescent state, and makes it possible to obtain an output pulse with a some-

what shorter overall rise time. In the circuit of Fig. 2B, regeneration is prevented by the biased diode in the feedback circuit. No feedback can occur until a negative-going pulse, which has an amplitude greater than the bias on the diode, appears at the plate. Adjustment of the diode bias allows the sensitivity of this circuit to be varied; the circuit may therefore be used as a pulse-height discriminator as well as a trigger circuit.

A variation of the trigger circuits can be obtained by replacing the feedback capacitor with an open-circuited section of transmission line. Figure 2C shows such an adaptation applied to the regenerative circuit in Fig. 1A. Upon application of a positive grid pulse to this circuit, the progress of the tube into the metastable, saturation-conduction state proceeds as described. The negative-going voltage step on the plate is transmitted down the length of transmission line in the feedback path. In-phase reflection of this voltage step at the open-circuited end of the line causes the potential difference between the two conductors to double as the reflected step is transmitted back up the line. Since the plate is drawing saturation current, its potential with respect to ground cannot change when the reflected step reaches the tube end of the line. Consequently, the reflected step voltage is developed as a positive-going voltage on the cathode. The result is a sharp decrease in primary electron flow that causes a sharp decrease in secondary electron flow to the plate and the tube is driven rapidly into cut-

off. Since the duration of the high-conduction state is dependent upon the length of the section of transmission line in the feedback path, the duration of the output pulse taken across the dynode load is adjusted by varying the length of this transmission line.

The secondary-emission pentode can be used for voltage amplification without phase inversion of the signal<sup>1, 2, 3</sup>.

This feature leads to the possibility of applications that would be difficult or impossible using more conventional tubes. One application is the trigger amplifier, shown in Fig. 3A. This amplifier might be used with one of the trigger circuits.

Suppose that it is desired to trigger a regenerative circuit similar to the one discussed in Fig. 2B, with each one of the pulses in the pulse train pictured at the input of Fig. 3A. Suppose, further, that the lowest diode bias level at which the trigger circuit can be operated with insured stability corresponds to an input pulse height indicated by the dashed line. The pulse train must be amplified if each one of the pulses is to produce triggering. However, the use of a conventional cascaded amplifier (Fig. 3A) may be precluded because the larger pulses will be amplified to the point where they cause grid current to be drawn in the latter stages of the amplifier string before the smaller pulses have amplified sufficiently to result in triggering of the regenerative circuit. The amplifier circuit shown in Fig. 3B presents a solution. The positive pulses in the train are amplified and converted to negative pulses by the first stage in the conventional manner. In subsequent

stages, the negative pulses are amplified without phase inversion by taking the outputs of the second and successive stages from the dynodes rather than the plates. As the amplification proceeds stage by stage, there is no possibility of any stage being made temporarily insensitive by grid conduction. On the contrary, as amplification proceeds down the cascaded stages, the amplitudes of the larger pulses are limited to a value determined by the grid biasing on the stages. Thus the output of the amplifier string can be a train of pulses, all of which have the same amplitude. The requirement that the pulses be positive to trigger the regenerative stage is satisfied by taking the output of the final stage from the plate rather than from the dynode. Amplitude is limited without clipper stages.

Another example of how the secondary-emission pentode can be applied to advantage is shown in Fig. 4—a distributed amplifier from which balanced push-pull outputs can be obtained. With conventional pentodes, two separate amplifier strings would be required to achieve comparable results.

Up to this point, the discussion has been concerned with a representative coverage of what might be called conventional secondary-emission pentode circuit applications, although here the conventional is somewhat unconventional when compared with ordinary vacuum-tube circuits.

As a final example of the uses that can be made of secondary-emission pentode properties, consider the cathode-follower circuit shown in Fig. 5<sup>4</sup>.

Figure 5 shows that the circuit is an ordinary cathode-follower

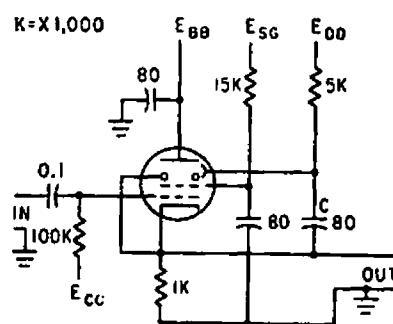


FIG. 5—This cathode follower circuit is useful for matching high-impedance sources with low-impedance loads

enhanced by the connection of the dynode back to the cathode. This circuit uses degenerative feedback, in much the same way that the trigger circuits use regenerative feedback, to achieve high-performance impedance transformation. This takes advantage of the high effective transconductance of the secondary-emission pentode in the cathode-follower circuit, even though the cathode current is only a small fraction of the plate or dynode current. This circuit can be applied when it is necessary to match a high-impedance source and a low-impedance load.<sup>11</sup>

## REFERENCES

- (1) I. A. D. Lewis and F. H. Welles, "Millimicrosecond Pulse Techniques," McGraw-Hill Book Co., p. 115, New York, 1955.
- (2) J. A. Narud, The Secondary Emission Pulse Circuit, Its Analysis and Application, Tech. Report No. 245, p. 2, Crut. Laboratory, Harvard Univ., Cambridge, Mass., 1967.
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- (7) *Ibid*, p. 141.
- (8) N. F. Moody, G. J. R. MacLusky and M. O. Deighton, Millimicrosecond Pulse Techniques, *Electronic Engr.*, 24, p. 214, May 1952.
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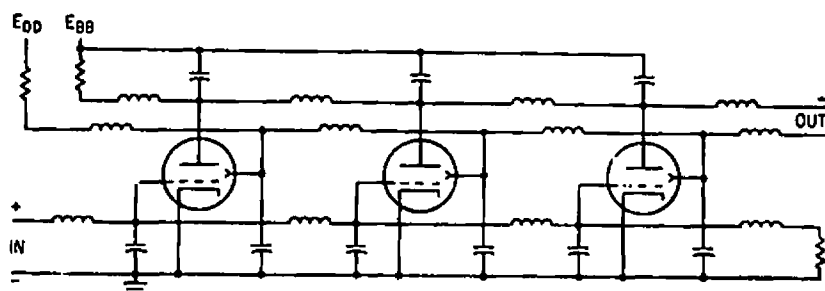


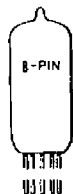
FIG. 4—Secondary-emission pentodes in a distributed amplifier from which balanced push-pull outputs can be obtained

## KRYTRON TRIGGER TUBES

7440 7595 7597

7441 7596 7598

Subminiature "Krytron" gaseous trigger tubes



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

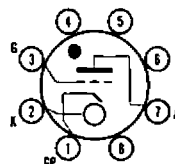
Heater voltages ..... None required

#### MAXIMUM RATINGS (Absolute maximum ratings)

|                            | 7595      | 7596        | 7597        | 7598        |       |
|----------------------------|-----------|-------------|-------------|-------------|-------|
| Anode operating voltage    | 350 min.  | 400 to 1500 | 400 to 1500 | 500 to 2500 | volts |
| Anode hold-off voltage     | 3         | 5           | 5           | 4           | Kv    |
| Anode current, peak        | 400       | 100         | 100         | 500         | amp   |
| Anode input                | 0.2       | 0.5         | 0.5         | 1           | watt  |
| Glow current               | 30 to 100 | 30 to 150   | 30 to 150   | 30 to 100   | μamp  |
| Grid firing voltage        | 85 to 250 | 30 to 150   | 30 to 150   | 130 min.    | volts |
| Grid firing pulse duration | 2 to dc   | 2 to dc     | 2 to dc     | 2 to dc     | μsec  |
| Grid firing current        | 8         | 15          | 15          | 15          | μamp  |
| Grid resistor to ground    | 2.0       | 1.0         | 1.0         | 1.0         | meg   |
| Anode delay time           |           |             |             |             |       |
| Temperature normal         | 1.0       | —           | —           | 1.0         | μsec  |
| Temperature extremes       | 1.0       | —           | —           | 1.0         | μsec  |
| Anode delay time variation |           |             |             |             |       |
| Temperature Normal         | 0.15      | —           | —           | 0.15        | μsec  |
| Temperature extremes       | 0.15      | —           | —           | 0.15        | μsec  |

#### MAXIMUM RATINGS (Absolute maximum values)

|                                             | 7440       | 7441 |       |
|---------------------------------------------|------------|------|-------|
| Anode operating voltage                     | 700        | 1000 | volts |
| Hold-off voltage                            | 1500       | 1500 | volts |
| Glow current                                | 100        | 100  | μA    |
| Grid resistor                               | 2.0        | 2.0  | meg   |
| Discharge capacitor                         | 0.2        | 0.2  | μf    |
| Power input                                 | 0.1        | 0.1  | watt  |
| Grid bias                                   | ±45        | ±45  | volts |
| Grid pulse current                          | 20         | 20   | μa    |
| Output pulse duration                       | 10         | 10   | μs    |
| Ambient temperature range                   | —55 to +85 |      | °C    |
| Anode delay time                            | 4.0        | 1.60 | μs    |
| Anode delay time variation                  | 0.4        | 0.4  | μs    |
| Pulse repetition rate                       | f          | f    | ppm   |
| Potting temperature (not to exceed 2 hours) | —          | —    | °C    |



## ENGINEERING DESIGN DATA

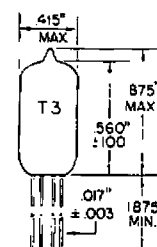
7440 7441  
7595 7596  
7597 7598

NOVEMBER 16, 1959.

### Cold cathode trigger tubes

#### MECHANICAL DATA

Cathode, cold  
Bulb ..... T-3  
Base, subminiature button  
8 flexible leads  
Mounting position ..... Any



#### LEAD CONNECTIONS

Lead 1 ..... Glow pin\*  
Lead 2 ..... Cathode  
Lead 3 ..... Grid  
Lead 4 ..... Omitted  
Lead 5 ..... Omitted  
Lead 6 ..... Omitted  
Lead 7 ..... Anode  
Lead 8 ..... Omitted  
\*Glow pin marked by red dot

#### APPLICATION

"Krytrons" are cold-cathode miniature trigger and timer tubes used in applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Because of their special construction they will withstand wide ambient temperature range, high impact shocks, and severe vibrational stresses. They will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

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## ENVIRONMENTAL TESTS FOR TYPES

7441

7595

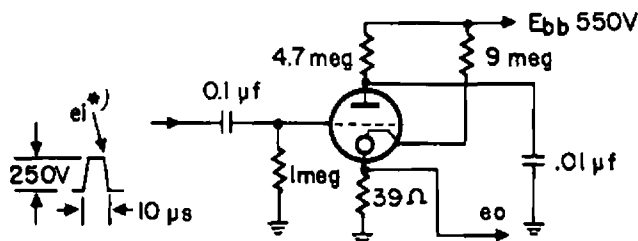
7597

### OPERATION TESTS (Performed under special conditions)

D-c trigger current, d-c trigger voltage, pulse trigger voltage  
Anode delay time, anode delay time variation  
Keep-alive starting characteristic

### CONDITIONS FOR TESTS

Oven temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
Temperature cycles under MIL-E-1D 4.9.10  
After impact shock of 2000g  
After vibration test of 10-500 cps up to 10g for 4.5 hours in 3 planes



\* May be triggered manually by applying d-c momentarily to grid.

### TYPICAL OPERATION FOR CIRCUIT SHOWN (All Types)

|                         |                  |
|-------------------------|------------------|
| Anode operating voltage | 550 volts        |
| Grid voltage            | 0 volts          |
| Glow current            | 50 $\mu\text{A}$ |

### MINIMUM CONDITIONS

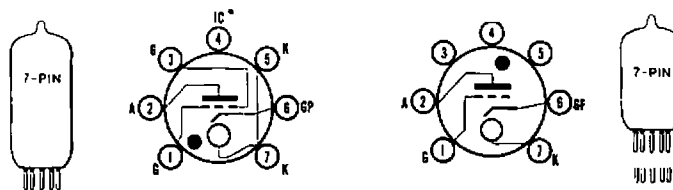
|                              |                    |
|------------------------------|--------------------|
| Anode operating voltage, d-c | 400 volts          |
| Cathode current peak         | 10 amp             |
| Glow current                 | 30 $\mu\text{A}$   |
| Grid resistor                | 250,000 ohms       |
| Grid pulse duration          | 10 $\mu\text{sec}$ |
| Grid pulse amplitude         | 230 volts          |

† Pulse repetition rate is governed by the relationship  $W = \frac{1}{2} CV^2 f$ , where C = discharge capacitor; V = Anode potential in kilovolts; W = power input, and f = repetition frequency.

\* Hold-off voltage given is the highest voltage to which the tube may be safely subjected under any condition. Provision should be made that the circuitry, tube base and socket will withstand this voltage. This may be accomplished by wider spacing, insulation coating, pressurizing, reduction of moisture, etc.

## KRYTRON TRIGGER TUBES

7229 7439 7600  
7230 7599 7602



7229 7600 7230 7439  
7599 7602

Miniature "Krytron" gaseous trigger tubes

### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

Heater voltages . . . . . None required

#### MAXIMUM RATINGS (Absolute maximum values)

|                             | 7599        | 7600 7602 |       |
|-----------------------------|-------------|-----------|-------|
| Anode operating voltage     | 300 to 1500 |           | volts |
| Anode hold-off voltage *    | 6           |           | Kv    |
| Anode current, peak         | 500         |           | amp   |
| Anode input                 | 2           |           | watts |
| Glow current                | 30 to 150   |           | μamp  |
| Grid firing voltage         | 120 to 250  |           | volts |
| Grid firing pulse duration  | 2 to dc     |           | μsec  |
| Grid firing current         | 7           |           | μamp  |
| Grid resistor to ground     | 2.0         |           | meg   |
| Anode delay time            |             |           |       |
| Temperature normal          | 1.5         |           | μsec  |
| Temperature extremes        | 1.5         |           | μsec  |
| Anode delay time variations | 0.2         |           |       |
| Temperature normal          | 0.2         |           | μsec  |
| Temperature extremes        | 0.2         |           | μsec  |

#### MAXIMUM RATINGS (Absolute maximum ratings)

|                                             | 7229       | 7439 | 7230 |       |
|---------------------------------------------|------------|------|------|-------|
| Anode operating voltage                     | 1000       |      | 1000 | volts |
| Hold-off voltage *                          | 2000       |      | 3000 | volts |
| Cathode current peak                        | 500        |      | 500  | amp   |
| Glow current                                | 100        |      | 100  | μA    |
| Grid resistor                               | 2.0        |      | 2.0  | meg   |
| Discharge capacitor                         | 0.5        |      | 0.5  | μf    |
| Power input                                 | 1.0        |      | 1.0  | watt  |
| Grid bias                                   | ±80        |      | ±80  | volts |
| Grid pulse current                          | 40         |      | 10   | μA    |
| Output pulse duration                       | 10         |      | 10   | μs    |
| Ambient temperature range                   | -55 to +85 |      |      | C     |
| Anode delay time                            | 4.0        |      | 2.0  | μs    |
| Anode delay time variation                  | 0.4        |      | 0.2  | μs    |
| Pulse repetition rate                       | 20         |      | 20   | ppm   |
| Potting temperature (not to exceed 2 hours) | —          |      | 125  | C     |

### ENGINEERING DESIGN DATA

7229 7230  
7439 7599  
7600 7602

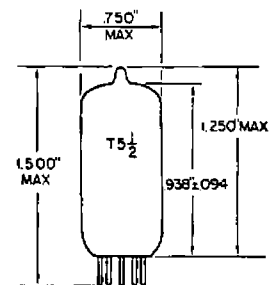
NOVEMBER 16, 1959

Cold cathode trigger tubes

7229 7600

#### MECHANICAL DATA

Cathode, cold  
Bulb T-5½  
Base, miniature button  
7-pin (E7-1)  
Mounting position . . . . . Any



#### PIN CONNECTIONS

|       |          |
|-------|----------|
| Pin 1 | Grid     |
| Pin 2 | Anode    |
| Pin 3 | Grid     |
| Pin 4 | I.C. *   |
| Pin 5 | Cathode  |
| Pin 6 | Glow pin |
| Pin 7 | Cathode  |

\*Do not use

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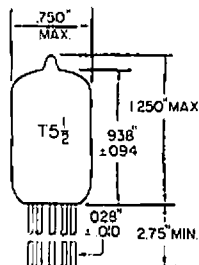
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Printed in U.S.A.

## 7230 7439 7599 7602

### MECHANICAL DATA

Cathode, cold  
Bulb T-5½  
Base, miniature button with  
7 flexible leads  
Mounting position Any



### LEAD CONNECTIONS

|        |          |
|--------|----------|
| Lead 1 | Grid     |
| Lead 2 | Anode    |
| Lead 3 | Omitted  |
| Lead 4 | Omitted  |
| Lead 5 | Omitted  |
| Lead 6 | Glow pin |
| Lead 7 | Cathode  |

### APPLICATION

"Krytons" are cold-cathode miniature trigger and timer tubes used in applications where high hold-off voltage, short anode delay times, minimum anode delay variation and high pulse currents are required. Because of their special construction they will withstand wide ambient temperature range, high impact shocks, and severe vibrational stresses. They will operate in sealed enclosures and after storage periods without requiring incident light or other extraneous energies to initiate the glow discharge.

## ENVIRONMENTAL TESTS FOR TYPES

7230

7602

### OPERATION TESTS (Performed under special conditions)

D-c trigger current d-c trigger voltage, pulse trigger voltage  
Anode delay time, anode delay time variation  
Keep-alive starting characteristics

### CONDITIONS FOR TESTS

Oven temperature range of  $-55^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
Temperature cycles under MIL-E-10 4.9.10  
After impact shock of 100g  
After vibration test of 10-500 cps up to 10g for 4.5 hours in 3 planes

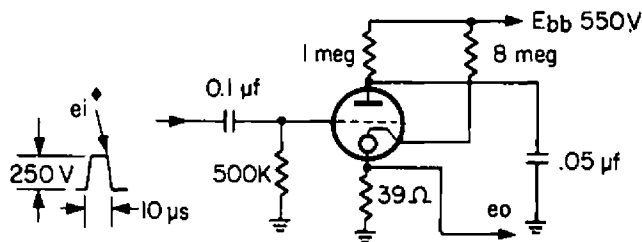
### TYPICAL OPERATION FOR CIRCUIT SHOWN All Types

|                         |                  |
|-------------------------|------------------|
| Anode operating voltage | 550 volts        |
| Grid voltage            | 0 volts          |
| Glow current            | 50 $\mu\text{A}$ |

### MINIMUM CONDITIONS

|                              |                    |
|------------------------------|--------------------|
| Anode operating voltage, d-c | 400 volts          |
| Cathode current peak         | 10 amp             |
| Glow current                 | 30 $\mu\text{A}$   |
| Grid resistor                | 250,000 ohms       |
| Grid pulse duration          | 10 $\mu\text{sec}$ |
| Grid pulse amplitude         | 230 volts          |

Pulse repetition rate is governed by the relationship  $W = \frac{1}{2} CV^2 f$ , where  $C$  = discharge capacitor;  $V$  = Anode potential in kilovolts;  $W$  = power input, and  $f$  = repetition frequency.



♦ May be triggered manually by applying d-c momentarily to grid.

\* Hold-off voltage given is the highest voltage to which the tube may be safely subjected under any condition. Provision should be made that the circuitry, tube base and socket will withstand this voltage. This may be accomplished by wider spacing, insulation coating, pressurizing, reduction of moisture, etc.

# engineering data for



BULLETIN  
T-1042

## MEDIUM-MU TRIPLE TRIODE

### 7688

#### TENTATIVE DATA

CBS Type 7688 is a compact, 12-pin medium-mu triple triode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. Each section is electrically equivalent to one section of a 12AU7.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a special 1000-hour life test, and a 5000-hour informational life test.

Additional mechanical features offered by CBS type 7688 include: gold plated base pins which prevent oxidation and improve base pin contact and precisely made and fitted parts in stronger structures.

#### MECHANICAL DATA

|                                |              |
|--------------------------------|--------------|
| Cathode, coated unipotential   |              |
| Bulb                           | T-7 1/2      |
| Maximum overall height         | 2.35 inches  |
| Maximum diameter               | 1.030 inches |
| Outline, JEDEC                 | 7-3          |
| Base, miniature button, 12-pin | E12-66       |
| Basing                         | 12BA         |
| Mounting position              | any          |

#### PIN CONNECTIONS

|        |                     |         |                   |
|--------|---------------------|---------|-------------------|
| Pin 1: | Cathode (Section 3) | Pin 7:  | Heater            |
| Pin 2: | Grid (Section 3)    | Pin 8:  | Plate (Section 1) |
| Pin 3: | Cathode (Section 2) | Pin 9:  | Grid (Section 2)  |
| Pin 4: | Grid (Section 1)    | Pin 10: | Plate (Section 2) |
| Pin 5: | Cathode (Section 1) | Pin 11: | N.C.              |
| Pin 6: | Heater              | Pin 12: | Plate (Section 3) |

## ELECTRICAL DATA

### HEATER CHARACTERISTICS

|                             |     |       |
|-----------------------------|-----|-------|
| Voltage, a-c or d-c         | 6.3 | volts |
| Current                     | 450 | ma    |
| Peak heater-cathode voltage |     |       |
| Heater negative to cathode  | 200 | volts |
| Heater positive to cathode* | 200 | volts |

\* D-c component 100 volts maximum

### MAXIMUM RATINGS (Design maximum values)

#### Class A Amplifier

|                                  |      |
|----------------------------------|------|
| Plate voltage, d-c               | 330  |
| Plate dissipation (each section) | 3.0  |
| Cathode current, average         | 20   |
| Cathode-grid circuit resistance  |      |
| Fixed bias                       | 0.25 |
| Cathode bias                     | 1.0  |

### CHARACTERISTICS AND TYPICAL OPERATION

#### Class A Amplifier

|                                              |      |      |            |
|----------------------------------------------|------|------|------------|
| Plate voltage                                | 100  | 250  | volts      |
| Control grid voltage                         | 0    | -8.5 | volts      |
| Plate resistance (approx.)                   | 6500 | 7700 | ohms       |
| Transconductance                             | 3100 | 2200 | $\mu$ mhos |
| Amplification factor                         | 20   | 17   |            |
| Plate current                                | 11.8 | 10.5 | ma         |
| Grid 1 voltage (approx.) for $I_b = 10\mu a$ |      | -24  |            |

# engineering data for

BULLETIN  
T-1043

## HIGH-MU TRIPLE TRIODE 7689

### TENTATIVE DATA

CBS Type 7689 is a compact, 12-pin high-mu triple triode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. Each section is electrically equivalent to one section of a 12AX7.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a special 1000-hour life test, and a 5000-hour informational life test.

Additional mechanical features offered by CBS type 7689 include: gold plated base pins which prevent oxidation and improve base pin contact and precisely made and fitted parts in stronger structures.

### MECHANICAL DATA

|                                |              |
|--------------------------------|--------------|
| Cathode, coated unipotential   |              |
| Bulb                           | T-7 1/2      |
| Maximum overall height         | 2.35 inches  |
| Maximum diameter               | 1.030 inches |
| Outline, JEDEC                 | 7-3          |
| Base, miniature button, 12-pin | E12-66       |
| Basing                         | 12BA         |
| Mounting position              | any          |

### PIN CONNECTIONS

|        |                     |         |                   |
|--------|---------------------|---------|-------------------|
| Pin 1: | Cathode (Section 3) | Pin 7:  | Heater            |
| Pin 2: | Grid (Section 3)    | Pin 8:  | Plate (Section 1) |
| Pin 3: | Cathode (Section 2) | Pin 9:  | Grid (Section 2)  |
| Pin 4: | Grid (Section 1)    | Pin 10: | Plate (Section 2) |
| Pin 5: | Cathode (Section 1) | Pin 11: | N.C.              |
| Pin 6: | Heater              | Pin 12: | Plate (Section 3) |

## ELECTRICAL DATA

### HEATER CHARACTERISTICS

|                                      |     |       |
|--------------------------------------|-----|-------|
| Voltage, a-c or d-c                  | 6.3 | volts |
| Current                              | 450 | ma    |
| Peak heater-cathode voltage, maximum |     |       |
| Heater negative to cathode           | 200 | volts |
| Heater positive to cathode*          | 200 | volts |

\* D-c component 100 volts maximum

### MAXIMUM RATINGS (Design maximum values)

#### Each Section

|                                    |     |       |
|------------------------------------|-----|-------|
| Plate voltage                      | 330 | volts |
| Control-grid voltage, negative d-c | 55  | volts |
| Control-grid voltage, positive d-c | 0   | volts |
| Plate dissipation                  | 1.1 | watt  |

### CHARACTERISTICS AND TYPICAL OPERATION

#### Class A Amplifier (Each Section)

|                            |        |        |       |
|----------------------------|--------|--------|-------|
| Plate voltage              | 100    | 250    | volts |
| Control-grid voltage       | -1     | -2     | volts |
| Plate resistance (approx.) | 80,000 | 62,500 | ohms  |
| Transconductance           | 1250   | 1600   | μmhos |
| Amplification factor       | 100    | 100    |       |
| Plate current              | 0.5    | 1.2    | ma    |

## MEDIUM-MU TRIPLE TRIODE 7690

### TENTATIVE DATA

CBS Type 7690 is a compact, 12-pin medium-mu triple triode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. Each section is electrically equivalent to one section of a 12AT7.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a special 1000-hour life test, and a 5000-hour informational life test.

Additional mechanical features offered by CBS type 7690 include: gold plated base pins which prevent oxidation and improve base pin contact and precisely made and fitted parts in stronger structures.

### MECHANICAL DATA

|                                |              |
|--------------------------------|--------------|
| Cathode, coated unipotential   |              |
| Bulb                           | T-7 1/2      |
| Maximum overall height         | 2.35 inches  |
| Maximum diameter               | 1.030 inches |
| Outline, JEDEC                 | 7-3          |
| Base, miniature button, 12-pin | E12-66       |
| Basing                         | 12BA         |
| Mounting position              | any          |

### PIN CONNECTIONS

|        |                     |         |                   |
|--------|---------------------|---------|-------------------|
| Pin 1: | Cathode (Section 3) | Pin 7:  | Heater            |
| Pin 2: | Grid (Section 3)    | Pin 8:  | Plate (Section 1) |
| Pin 3: | Cathode (Section 2) | Pin 9:  | Grid (Section 2)  |
| Pin 4: | Grid (Section 1)    | Pin 10: | Plate (Section 2) |
| Pin 5: | Cathode (Section 1) | Pin 11: | N.C.              |
| Pin 6: | Heater              | Pin 12: | Plate (Section 3) |

## ELECTRICAL DATA

### HEATER CHARACTERISTICS

|                                      |     |       |
|--------------------------------------|-----|-------|
| Voltage, a-c or d-c                  | 6.3 | volts |
| Current                              | 450 | ma    |
| Peak heater-cathode voltage, maximum |     |       |
| Heater negative to cathode           | 200 | volts |
| Heater positive to cathode*          | 200 | volts |

\* D-c component 100 volts maximum

### MAXIMUM RATINGS (Design maximum values)

#### Each Section

|                   |     |       |
|-------------------|-----|-------|
| Plate voltage     | 330 | volts |
| Plate dissipation | 2.8 | watts |

### CHARACTERISTICS AND TYPICAL OPERATION

#### Class A Amplifier (Each Section)

|                                                  |        |        |            |
|--------------------------------------------------|--------|--------|------------|
| Plate voltage                                    | 100    | 250    | volts      |
| Control-grid voltage                             | -1.0   | -2.0   | volts      |
| Cathode-bias resistor                            | 270    | 200    | ohms       |
| Plate resistance (approx.)                       | 15,000 | 10,900 | ohms       |
| Transconductance                                 | 4000   | 5500   | $\mu$ mhos |
| Amplification factor                             | 60     | 60     |            |
| Plate current                                    | 3.7    | 10.0   | ma         |
| Control-grid voltage (approx.) for $I_b=10\mu a$ | -5     | -12    | volts      |



# technical information

## CBS ELECTRONICS

*A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts*

7721 (D3a)

### Wideband Pentode Amplifier

Wideband pentode amplifier with extremely high transconductance in a miniature envelope and 9-pin base.

### MECHANICAL DATA

|                                      |                        |
|--------------------------------------|------------------------|
| Cathode                              | coated unipotential    |
| Bulb                                 | T6 1/2                 |
| Base                                 | 9-pin miniature button |
| Basing                               | 9EQ                    |
| Maximum overall height               | 2.43 inches            |
| Maximum seated height                | 2.15 inches            |
| Maximum height from base to shoulder | 1.88 inches            |
| Maximum diameter                     | .875 inch              |
| Mounting position                    | any                    |

### PIN CONNECTIONS

|                |                             |
|----------------|-----------------------------|
| Pin 1: Cathode | Pin 6: Internal connection* |
| Pin 2: Grid 1  | Pin 7: Plate                |
| Pin 3: Cathode | Pin 8: Grid 3 and shield    |
| Pin 4: Heater  | Pin 9: Grid 2               |
| Pin 5: Heater  |                             |

\* Do not use.

### ELECTRICAL DATA

#### Heater Characteristics

|                                   |     |       |
|-----------------------------------|-----|-------|
| Heater voltage, a-c or d-c        | 6.3 | volts |
| Heater current                    | 320 | ma    |
| Peak heater-cathode voltage, max. | 60  | volts |

#### Direct Interelectrode Capacitances

|                 |      |               |
|-----------------|------|---------------|
| Input           | 10   | $\mu\text{f}$ |
| Output          | 2    | $\mu\text{f}$ |
| Grid 1 to plate | .035 | $\mu\text{f}$ |

# MAXIMUM RATINGS (Absolute maximum values)

|                                      |       |       |
|--------------------------------------|-------|-------|
| Plate voltage, peak*                 | 400   | volts |
| Grid 2 voltage, peak*                | 400   | volts |
| Plate voltage, d-c                   | 220   | volts |
| Grid 2 voltage, d-c                  | 180   | volts |
| Grid 3 voltage, d-c                  | 0     | volts |
| Grid 1 voltage, positive             | 0     | volts |
| Grid 1 voltage, negative             | 10    | volts |
| Plate dissipation                    | 4.0   | watts |
| Grid 2 dissipation                   | 0.9   | watts |
| Cathode current                      | 29    | ma    |
| Maximum grid 1 circuit resistance†   | 0.5   | meg   |
| Maximum heater to cathode resistance | 20000 | ohms  |
| Bulb temperature                     | 170   | °C    |

\* Intermittent operation

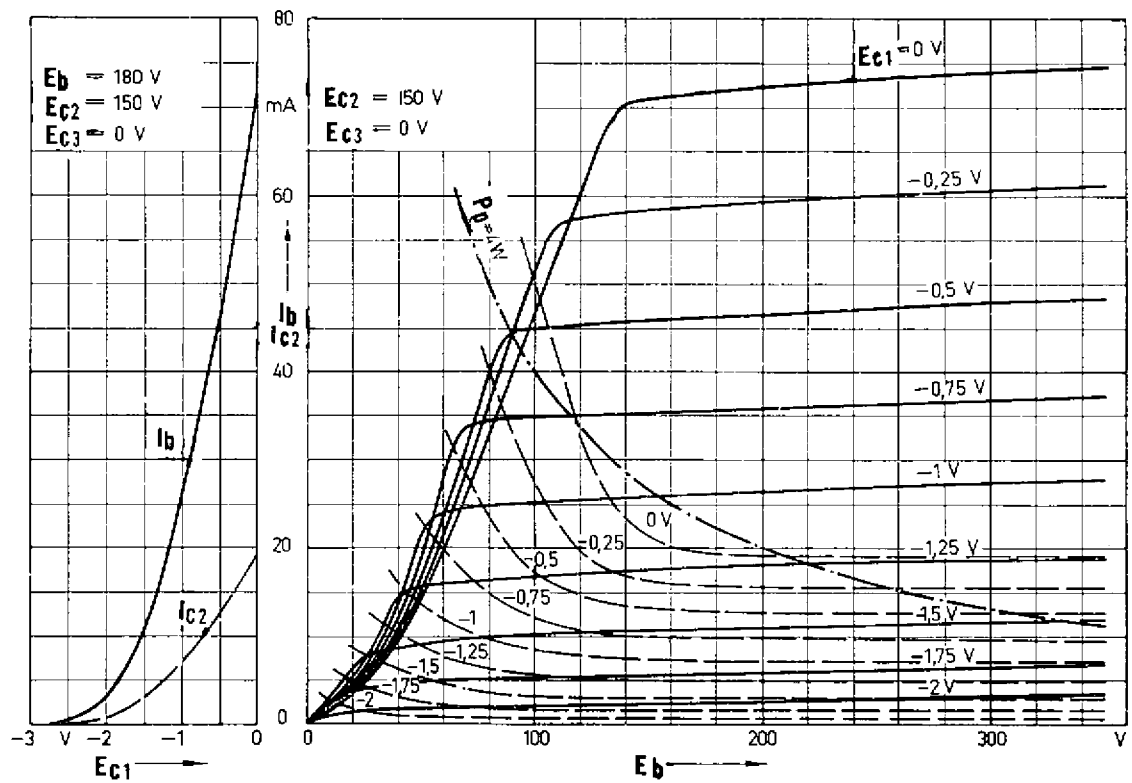
## CHARACTERISTICS

|                                      |       |       |
|--------------------------------------|-------|-------|
| Plate voltage, supply                | 190   | volts |
| Grid 3 voltage, supply               | 0     | volts |
| Grid 2 voltage, supply               | 160   | volts |
| Grid 1 voltage, supply†              | 10    | volts |
| Cathode resistor                     | 400   | ohms  |
| Plate current                        | 22    | ma    |
| Grid 2 current                       | 6.0   | ma    |
| Transconductance                     | 35000 | μmhos |
| Plate resistance                     | 0.12  | meg   |
| Grid 2 to plate amplification factor | 85    |       |
| Input resistance, 100 mc             | 1000  | ohms  |
| Bandwidth factor                     | 465   |       |
| Equivalent noise resistor            | 50    | ohms  |

† Values for automatic control grid bias arrangement.

# TRANSFER CHARACTERISTICS

# PLATE CHARACTERISTICS





# technical information

**CBS ELECTRONICS**

*A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts*

E280F/7722

## Wideband Pentode Amplifier

Wideband pentode amplifier with very high transconductance in a miniature envelope and 9-pin base.

### MECHANICAL DATA

|                                      |                        |
|--------------------------------------|------------------------|
| Cathode, coated unipotential         |                        |
| Bulb                                 | T-6 1/2                |
| Base                                 | 9-pin miniature button |
| Basing                               | 9EQ                    |
| Maximum overall height               | 2.43 inches            |
| Maximum seated height                | 2.15 inches            |
| Maximum height from base to shoulder | 1.88 inches            |
| Maximum diameter                     | .875 inches            |
| Mounting position                    | Any                    |

### PIN CONNECTIONS

|                |                            |
|----------------|----------------------------|
| Pin 1: Cathode | Pin 6: Internal Connection |
| Pin 2: Grid 1  | Pin 7: Plate               |
| Pin 3: Cathode | Pin 8: Grid 3 and shield   |
| Pin 4: Heater  | Pin 9: Grid 2              |
| Pin 5: Heater  |                            |

### ELECTRICAL DATA

#### Heater Characteristics

|                                   |     |       |
|-----------------------------------|-----|-------|
| Heater voltage                    | 6.3 | volts |
| Heater current                    | 320 | ma    |
| Peak heater-cathode voltage, max. |     |       |
| Heater negative to cathode        | 60  | volts |
| Heater positive to cathode        | 120 | volts |

#### Direct Interelectrode Capacitances

|                 |      |               |
|-----------------|------|---------------|
| Input           | 9.3  | $\mu\text{f}$ |
| Output          | 2.1  | $\mu\text{f}$ |
| Grid 1 to plate | .035 | $\mu\text{f}$ |

### Maximum Ratings (Absolute maximum values)

|                                   |     |       |
|-----------------------------------|-----|-------|
| Plate supply voltage              | 400 | volts |
| Plate voltage, d-c                | 220 | volts |
| Grid 2 supply voltage             | 400 | volts |
| Grid 2 voltage, d-c               | 180 | volts |
| Grid 1 voltage, negative          | 50  | volts |
| Grid 1 voltage, positive†         | 0   | volts |
| Plate dissipation                 | 4.0 | watts |
| Grid 2 dissipation                | 1.1 | watts |
| Cathode current                   | 30  | ma    |
| Grid 1 circuit resistance‡        | 0.5 | meg   |
| Bulb temperature at hottest point | 170 | °C    |

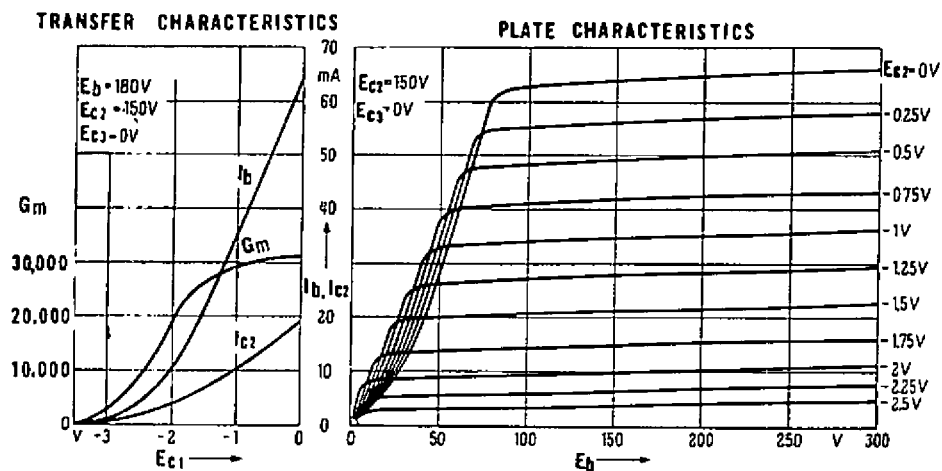
### Characteristics

|                               | Pentode | Triode |       |
|-------------------------------|---------|--------|-------|
| Plate supply voltage          | 190     | 160    | volts |
| Grid 3 voltage                | 0       | 0      | volts |
| Grid 2 supply voltage         | 160     | 160    | volts |
| Grid 1 supply voltage ‡       | +8      | +8     | volts |
| Cathode resistor              | 370     | 400    | ohms  |
| Plate current                 | 20      | 24.5   | ma    |
| Grid 2 current                | 6       |        | ma    |
| Transconductance              | 26,000  | 33,000 | μmhos |
| Amplification factor          |         | 60     |       |
| Input resistance, 100 mc *    | 1400    |        | ohms  |
| Plate resistance, approximate | 100k    | 1800   | ohms  |

† Grid 1 current must not exceed 0.5 μa, to prevent damage to tube.

‡ Values for automatic control grid bias arrangement.

\* Both cathode leads connected together.





## MEDIUM-MU TWIN TRIODE 7728

CBS Type 7728 is a miniature medium-mu twin triode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. The 7728 is a replacement for type 12AT7 and superior performance is assured because of its improved construction, special tests, and tight minimum-maximum limits.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life and resistance against the formation of interface impedance are a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

Additional mechanical features offered by CBS type 7728 include: gold plated base pins which prevent oxidation and improve base pin contact; precisely made and fitted parts in stronger structures for lower noise and microphonism; and electrical features include: initial plate current balance, life tested plate current balance, grid current test, and reverse grid current test.

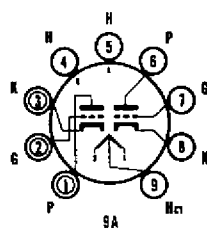
### MECHANICAL DATA

Cathode, coated unipotential

|                   |                        |
|-------------------|------------------------|
| Bulb              | T-6 1/2                |
| Outline           | JEDEC 6-2              |
| Base              | Miniature 9-pin (E9-1) |
| Basing            | 9A                     |
| Mounting position | Any                    |

### PIN CONNECTIONS

Pin 1: Plate (Section 2)  
Pin 2: Grid 1 (Section 2)  
Pin 3: Cathode (Section 2)  
Pin 4: Heater  
Pin 5: Heater  
Pin 6: Plate (Section 1)  
Pin 7: Grid (Section 1)  
Pin 8: Cathode (Section 1)  
Pin 9: Heater Center Tap



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                                   | Series   | Parallel |       |
|-----------------------------------|----------|----------|-------|
| Voltage, a-c or d-c               | 12.6±10% | 6.3±10%  | volts |
| Current                           | 150      | 300      | ma    |
| Peak heater-cathode voltage, max. |          |          |       |
| Heater negative to cathode        | 200      | 200      | volts |
| Heater positive to cathode*       | 200      | 200      | volts |

\*D-c component must not exceed 100 volts

#### DIRECT INTERELECTRODE CAPACITANCES

|                                        | Section 1 | Section 2 |     |
|----------------------------------------|-----------|-----------|-----|
| Grid to plate: g to p                  | 1.5       | 1.5       | uuf |
| Input: g to k+h                        | 2.2       | 2.2       | uuf |
| Output: p to k+h                       | 0.5       | 0.4       | uuf |
| Heater to cathode                      | 2.4       | 2.4       | uuf |
| Coupling                               |           |           |     |
| Grid (Section 1) to grid (Section 2)   | .005      |           | uuf |
| Plate (Section 1) to plate (Section 2) | 0.4       |           | uuf |

#### MAXIMUM RATINGS (Design maximum values)

##### Each Section

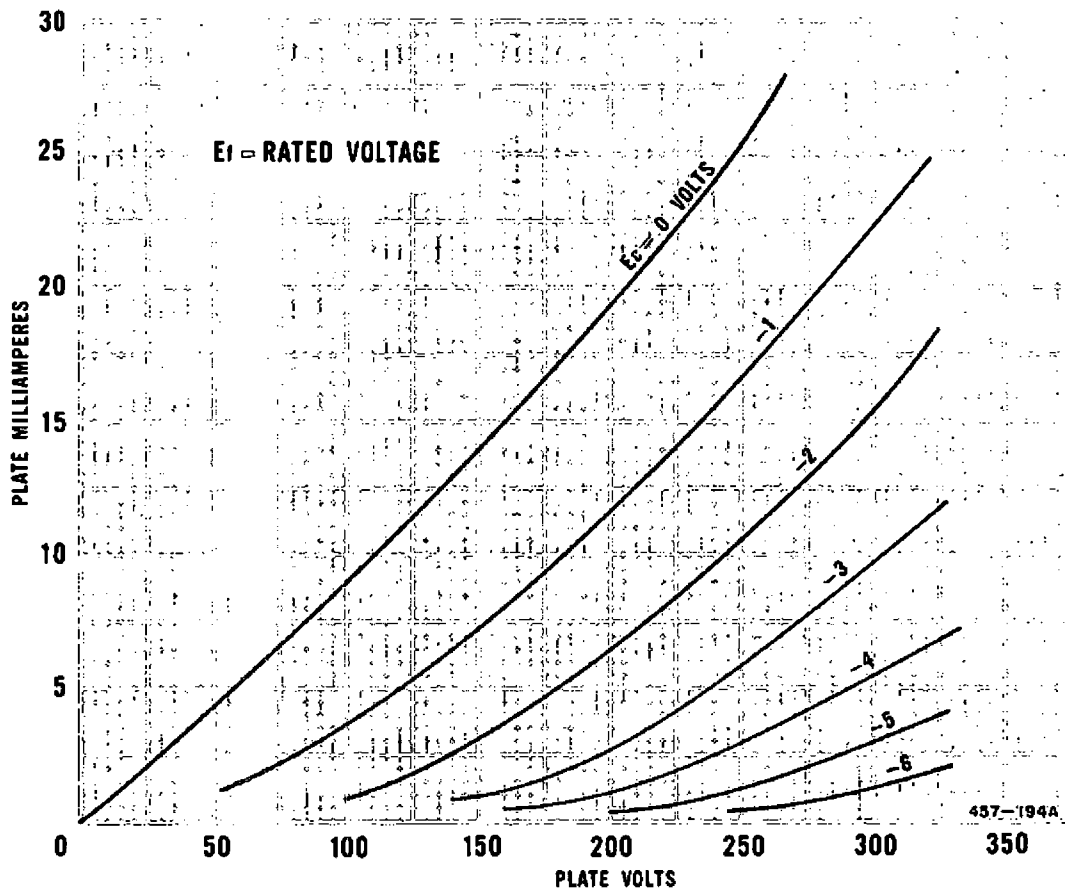
|                   |     |       |
|-------------------|-----|-------|
| Plate voltage     | 330 | volts |
| Plate dissipation | 2.8 | watts |
| Bulb temperature  | 165 | C     |

#### CHARACTERISTICS AND TYPICAL OPERATION

##### Class A Amplifier - Each Section

|                                                  |       |       |       |
|--------------------------------------------------|-------|-------|-------|
| Plate voltage                                    | 100   | 250   | volts |
| Control grid voltage                             | -1.0  | -2.0  | volts |
| Cathode bias resistor                            | 270   | 200   | ohms  |
| Plate resistance (approx.)                       | 15000 | 10900 | ohms  |
| Transconductance                                 | 4000  | 5500  | umhos |
| Amplification factor                             | 60    | 60    |       |
| Plate current                                    | 3.7   | 10.0  | ma    |
| Control grid voltage (approx.)<br>for Ib = 10 uA | -5    | -12   | volts |

## AVERAGE PLATE CHARACTERISTICS





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

12.6 series connection or 6.3 parallel connection  
Eb = 250 Vdc  
Ec = -2 Vdc

| Reference<br>Note 2 | AQL<br>Note 1     | Test                       | Conditions                                                                             | Sym.                                                  | Min.                              | Max.                             | Unit                                                     |
|---------------------|-------------------|----------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------|-----------------------------------|----------------------------------|----------------------------------------------------------|
| 4.7.5               | 0.4               | Continuity & Short         |                                                                                        | ---                                                   | ---                               | ---                              | ---                                                      |
| 4.10.8              | 2.5*              | Heater Current             | Ef = 12.6<br>Ef = 6.3                                                                  | If<br>If                                              | 138<br>275                        | 162<br>325                       | mA<br>mA                                                 |
| 4.10.15             | 1.0               | Heater Cathode Leakage     | Ehk = +200 Vdc<br>Ehk = -200 Vdc                                                       | Ihk<br>Ihk                                            | 0<br>0                            | 5.0<br>5.0                       | $\mu$ Adc<br>$\mu$ Adc                                   |
| 4.10.6.1            | 1.0               | Grid Current (1)           | Rg = 0.5 meg<br>Note 4                                                                 | Ic(1)                                                 | ---                               | -0.5                             | $\mu$ Adc                                                |
| ---                 | 2.5<br>[REDACTED] | Grid Block (2)             | Eb = 120 Vdc<br>Ec = 0; Note 6, 3                                                      | E1C1                                                  | 0                                 | -1.5                             | Vdc                                                      |
| 4.10.4.1            | 2.5<br>[REDACTED] | Plate Current (1)          | Ec = -15 Vdc, Note 3                                                                   | Ib(1)                                                 | ---                               | 50                               | $\mu$ Adc                                                |
| 4.10.4.1            | 1.0               | Plate Current (2)          | Note 3                                                                                 | Ib(2)                                                 | 7.0                               | 14.0                             | mA                                                       |
| 4.10.4.1            | 1.0               | Plate Current Differential | Notes 3, 12                                                                            | $\Delta$ Ib(3)                                        | ---                               | 15                               | %                                                        |
| 4.10.9              | 2.5               | Transconductance (1)       | Note 3                                                                                 | Sm(1)                                                 | 4500                              | 6700                             | umhos                                                    |
| 4.10.9              | 2.5               | Transconductance (2)       | Ef=5.7 or 11.4; Note 3                                                                 | $\Delta$ Sm                                           | ---                               | 15                               | %                                                        |
| ---                 | 1.0               | Pulse Emission             | Eb=250 Vdc, Ec= -30 Vdc<br>Rk=1.0 ohm; Notes 3, 5                                      | Isp                                                   | 200                               |                                  | mA                                                       |
| 4.10.3.4            | 2.5               | Noise & Microphonics       | Ebb=300Vdc, Rk=200 $\Omega$<br>Rp=10K, Ck=1000uf, Rg=250K<br>Ecal=100mVac; Notes 4, 13 | M                                                     | ---                               | ---                              | ---                                                      |
| ---                 | 2.5               | Contact Potential          | Eb=150Vdc, Ec1=0, Rg/g=2.2meg<br>Notes 3, 11                                           | Ecp                                                   | 0                                 | -1.0                             | Vdc                                                      |
| 4.8                 | 2.5               | Insulation of Electrodes   | E(g1-all)=100Vdc, g1 Negative<br>E(p-all)=300Vdc, p Negative<br>Note 3                 | R(g-all)<br>R(p-all)                                  | 1000<br>1000                      | ---                              | meg<br>meg                                               |
| 4.10.14             | 2.5*              | Capacitance                | Without Shield<br>Note 3                                                               | Cgp<br>Cin<br>Cout(1)<br>Cout(2)<br>[REDACTED]<br>Cpp | 1.3<br>2.0<br>0.2<br>0.16<br>0.15 | 1.9<br>3.0<br>0.7<br>0.6<br>0.33 | $\mu$ uf<br>$\mu$ uf<br>$\mu$ uf<br>$\mu$ uf<br>$\mu$ uf |

## LIFE TESTS

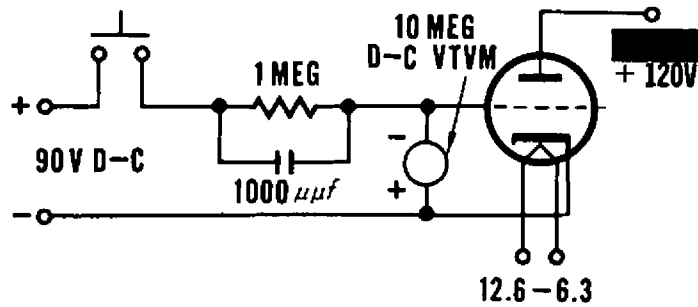
|     |                  |                              |                                                                            |     |     |     |     |
|-----|------------------|------------------------------|----------------------------------------------------------------------------|-----|-----|-----|-----|
| --- | 1.0<br>Code<br>K | Early Life Assurance<br>Test | Ef=6.3V or 12.6V<br>Eb=250 Vdc<br>Rk=200 $\Omega$<br>Ehk= -200 Vdc, Note 7 | --- | --- | --- | --- |
|-----|------------------|------------------------------|----------------------------------------------------------------------------|-----|-----|-----|-----|

| <u>Reference</u> | <u>AQL</u> | <u>Test</u>                                            | <u>Conditions</u>                                                        | <u>Sym.</u>            | <u>Min.</u> | <u>Max.</u> | <u>Unit</u>  |
|------------------|------------|--------------------------------------------------------|--------------------------------------------------------------------------|------------------------|-------------|-------------|--------------|
| ---              | ---        | Early Life Assurance<br>Test End Points                | Shorts and Continuity                                                    | ---                    | ---         | ---         | ---          |
|                  |            |                                                        | Change in Plate Current (2)<br>of Individual tubes                       | $\Delta \frac{I_b}{t}$ | ---         | 20          | %            |
|                  |            |                                                        | Plate Current (3) Differential<br>Note 12                                | $\Delta I_b(3)$        |             | 20          | %            |
| 4.11.5           | ---        | Intermittent Life Test<br>(1) 1000 Hours               | Early Life Assurance Test<br>Conditions, Note 8                          | ---                    | ---         | ---         | ---          |
| 4.11.4           | ---        | Intermittent Life Test<br>(1) End Points<br>1000 Hours | Inoperatives                                                             | ---                    | ---         | ---         | ---          |
|                  |            |                                                        | Grid Current(1)                                                          | $I_c(1)$               | 0           | -1.0        | $\mu A_{dc}$ |
|                  |            |                                                        | Change in Plate Current (2)<br>of Individual Tubes                       | $\Delta \frac{I_b}{t}$ | ---         | 20          | %            |
|                  |            |                                                        | Plate Current (3) Differential<br>Note 12                                | $\Delta I_b(3)$        |             | 25          | %            |
|                  |            |                                                        | Heater Cathode Leakage<br>Ehk= +200 Vdc                                  | $I_{hk}$               | ---         | 20          | $\mu A_{dc}$ |
|                  |            |                                                        | Ehk= -200 Vdc                                                            | $I_{hk}$               | ---         | 20          | $\mu A_{dc}$ |
|                  |            |                                                        | Insulation of Electrodes<br>E(g-all)                                     | $R_{g-all}$            | 1000        | ---         | meg          |
|                  |            |                                                        | E(p-all)                                                                 | $R_{p-all}$            | 1000        | ---         | meg          |
| 4.11.5           | ---        | Intermittent Life Test(2)<br>1000 Hours                | Ef=6.3V or 12.6V<br>Eb = 250 Vdc<br>Ec= -50Vdc, Note 9                   | ---                    | ---         | ---         | ---          |
| 4.11.4           | ---        | Intermittent Life Test<br>(2) End Points<br>1000 Hours | Interface<br>Resistance<br>Note 10                                       | $R_i$                  | ---         | 100         | ohms         |
| 4.11.7           | ---        | Heater Cycling Life Test                               | Ef=7.0 or 13.8V<br>Ehk= -200 Vdc<br>Cycle<br>1.0 min. on<br>4.0 min. off | ---                    | ---         | 48          | hours        |
| 4.11.4           | ---        | Heater Cycling Life<br>Test End Points                 | Shorts and Continuity                                                    | ---                    | ---         | ---         | ---          |
|                  |            |                                                        | Heater Cathode Leakage<br>Ehk = +200 Vdc                                 | $I_{hk}$               | ---         | 15          | $\mu A_{dc}$ |
|                  |            |                                                        | Ehk = -200 Vdc                                                           | $I_{hk}$               | ---         | 15          | $\mu A_{dc}$ |

#### TEST NOTES

- Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics having similar AQL's shall be combined for sampling purposes with the exception of control test. Control tests are indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4.1.
- Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.
- Note 3: Test each section separately. The section not under test shall be grounded.
- Note 4: Connect both sections in parallel.
- Note 5: The grid is driven with a pulse voltage as follows:  $e_{gk} = +30V$ ;  $P_r = 1000$ ;  $T_p = 10 \mu s$ ;  $T_r < 1 \mu s$ ;  $T_f = < 1 \mu s$  ( $e_{gk}$  shall be defined as the instantaneous peak voltage between the grid and the negative end of the cathode resistor). Peak cathode current shall be measured by means of a high impedance oscilloscope, or equivalent, device connected across a cathode resistor of 1.0 ohm. Preheat for 5 minutes at rated heater voltage; no other voltages applied.

Note 6: The grid blocking test shall be performed using circuit shown below or equivalent.



Apply 90 Vdc to grid momentarily. Upon removal of voltage VTVM shall not go positive nor shall it go more negative than -1.5 volts.

Note 7: Early Life Assurance Test

- a. Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- b. Serially mark all tubes of the sample.
- c. Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- d. The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours ( $\pm 4$  hours) with the intermediate down period reading point at 20 hours ( $\pm 4$  hours) and 2 hours ( $\pm 30$  minutes). Intermittent or continuous operation may be employed.
- e. A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

Note 8: 1000 Hour Intermittent Life Test

- a. The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test end point characteristic.
- b. Record the reference characteristic.
- c. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test shall be part of the 1000 hours.
- d. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- e. Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

Note 9: Intermittent Life Test (2)

- a. Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test end point characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- b. Sample size shall be 10 tubes.
- c. Record the reference characteristics.
- d. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours.
- e. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.

Note 10:  $R_i$  (Interface Resistance) shall be measured using the equivalent diode resistance 2 frequency method.

Note 11: Use 10 megohm input resistance DC VTVM. Read voltage developed across  $R_g$ .

Note 12: Difference in Plate Current ( $I_{b3}$ ) between each section.

Note 13: The rejection level shall be set at the VU meter reading obtained during calibration.



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This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life is a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

Additional mechanical features offered by CBS type 7729 include: gold plated base pins which prevent oxidation and improve base pin contact; precisely made and fitted parts in stronger structures for lower noise and microphonism; and electrical features include: initial plate current balance, life tested plate current balance, grid current test, and reverse grid current test.

### MECHANICAL DATA

Cathode, coated unipotential

Bulb

T-6 1/2

Outline

JEDEC 6-2

Base

Miniature 9-pin (E9-1)

Basing

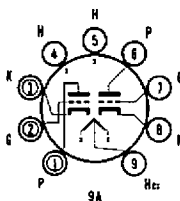
9A

Mounting position

Any

### PIN CONNECTIONS

- Pin 1: Plate (Section 2)
- Pin 2: Grid 1 (Section 2)
- Pin 3: Cathode (Section 2)
- Pin 4: Heater
- Pin 5: Heater
- Pin 6: Plate (Section 1)
- Pin 7: Grid (Section 1)
- Pin 8: Cathode (Section 1)
- Pin 9: Heater Center Tap



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                                   | Series         | Parallel      |       |
|-----------------------------------|----------------|---------------|-------|
| Voltage, a-c or d-c               | 12.6 $\pm$ 10% | 6.3 $\pm$ 10% | volts |
| Current                           | 150            | 300           | ma    |
| Peak heater-cathode voltage, max. |                |               |       |
| Heater negative to cathode        | 200            | 200           | volts |
| Heater positive to cathode*       | 200            | 200           | volts |

\*D-c component must not exceed 100 volts

#### DIRECT INTERELECTRODE CAPACITANCES

|                        | Section 1 | Section 2 |     |
|------------------------|-----------|-----------|-----|
| Grid to plate: g1 to p | 1.7       | 1.7       | uuf |
| Input: g1 to k+h       | 1.6       | 1.6       | uuf |
| Output: p to k+h       | 0.46      | 0.34      | uuf |

#### MAXIMUM RATINGS (Design maximum values)

##### Each Section

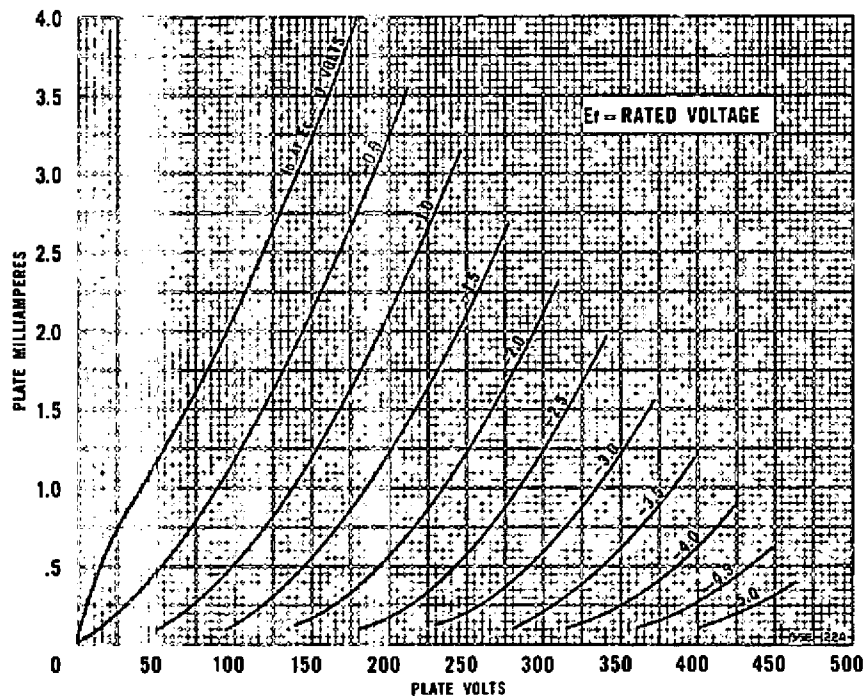
|                                    |     |       |
|------------------------------------|-----|-------|
| Plate voltage                      | 330 | volts |
| Plate dissipation                  | 1.1 | watts |
| Cathode current                    | 20  | ma    |
| Control grid voltage, negative d-c | 55  | volts |
| Control grid voltage, positive d-c | 0   | volts |
| Bulb temperature                   | 165 | °C    |

#### CHARACTERISTICS AND TYPICAL OPERATION

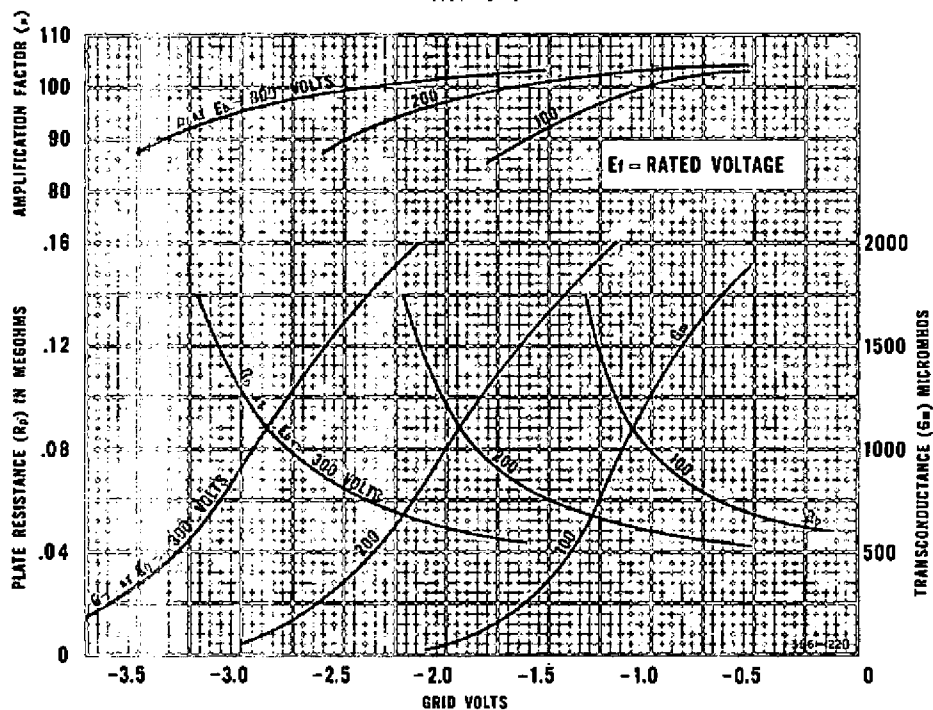
##### Class A Amplifier - Each Section

|                            |       |       |       |
|----------------------------|-------|-------|-------|
| Plate voltage              | 100   | 250   | volts |
| Control grid voltage       | -1.0  | -2.0  | volts |
| Plate resistance (approx.) | 80000 | 62500 | ohms  |
| Transconductance           | 1250  | 1600  | umhos |
| Amplification factor       | 100   | 100   |       |
| Plate current              | 0.5   | 1.2   | ma    |

## AVERAGE PLATE CHARACTERISTICS



## AVERAGE TRANSFER CHARACTERISTICS EACH UNIT





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

12.6 series connection or 6.3 parallel connection     $E_b = 250 \text{ Vdc}$   
 $E_c = -2 \text{ Vdc}$

| Reference<br>Note 2 | AQL<br>Note 1 | Test                       | Conditions                                                                                                                                         | Sym.                                         | Min.         | Max.       | Unit                               |
|---------------------|---------------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|--------------|------------|------------------------------------|
| 4.7.5               | 0.4           | Continuity & Short         |                                                                                                                                                    | ---                                          | ---          | ---        | ---                                |
| 4.10.8              | 2.5*          | Heater Current             | $E_f = 12.6 \text{ V}$<br>$E_f = 6.3 \text{ V}$                                                                                                    | $I_f$<br>$I_f$                               | 138<br>275   | 162<br>325 | mA<br>mA                           |
| 4.10.15             | 1.0           | Heater Cathode Leakage     | $E_{hk} = +200 \text{ Vdc}$<br>$E_{hk} = -200 \text{ Vdc}$                                                                                         | $I_{hk}$<br>$I_{hk}$                         | 0<br>0       | 5.0<br>5.0 | $\mu\text{Adc}$<br>$\mu\text{Adc}$ |
| 4.10.6.1            | 1.0           | Grid Current (1)           | Note 4                                                                                                                                             | $I_{c(1)}$                                   | ---          | -0.5       | $\mu\text{Adc}$                    |
| ---                 | 2.5           | Grid Block (2)             | $E_b = 67.5 \text{ Vdc}$<br>$E_c = 0$ ; Note 6, 3                                                                                                  | $E_1 C_1$                                    | 0            | -1.5       | Vdc                                |
| 4.10.4.1            | 4.0           | Plate Current (1)          | $E_c = -5 \text{ Vdc}$<br>Note 3                                                                                                                   | $I_{b(1)}$                                   | ---          | 35         | $\mu\text{Adc}$                    |
| 4.10.4.1            | 1.0           | Plate Current (2)          | Note 3                                                                                                                                             | $I_{b(2)}$                                   | 0.75         | 1.75       | mAdc                               |
| 4.10.4.1            | 1.0           | Plate Current Differential | Note 12                                                                                                                                            | $\Delta I_{b(2)}$                            |              | 20         | %                                  |
| 4.10.9              | 2.5           | Transconductance (1)       | Note 3                                                                                                                                             | $S_{m(1)}$                                   | 1200         | 2000       | umhos                              |
| 4.10.9              | 2.5           | Transconductance (2)       | $E_f = 90\%$ of $E_f$ used in $S_{m(1)}$ test<br>Note 3                                                                                            | $\Delta S_m$                                 | ---          | 15         | %                                  |
| ---                 | 1.0           | Pulse Emission             | $E_b = 200 \text{ Vdc}$ , $E_{c1} = 25 \text{ Vdc}$<br>Notes 3, 5                                                                                  | $I_{sp}$                                     | 200          |            | mA                                 |
| 4.10.3.4            | 2.5           | Noise & Microphonics       | $R_p = 200 \text{ K}$ , $E_{bb} = 250 \text{ Vdc}$ , $E_{cc} = -2 \text{ Vdc}$ M<br>Note 4, 13, $R_g = 50 \text{ K}$ , $E_{cal} = 85 \text{ mVac}$ |                                              | ---          | ---        | ---                                |
| ---                 | 2.5           | Contact Potential          | $E_b = 150 \text{ Vdc}$ , $E_{c1} = 0$ , $R_g/g = 2.2 \text{ meg}$<br>Notes 3, 11                                                                  | $E_{cp}$                                     | 0            | -1.0       | Vdc                                |
| 4.8                 | 2.5           | Insulation of Electrodes   | $E_{(g_1\text{-all})} = 100 \text{ Vdc}$<br>$g_1$ Negative<br>$E_{(p\text{-all})} = 300 \text{ Vdc}$<br>$p$ Negative<br>Note 3                     | $R_{(g\text{-all})}$<br>$R_{(p\text{-all})}$ | 1000<br>1000 | ---        | meg<br>meg                         |

## LIFE TESTS

|     |                  |                                         |                                                                                                                                         |                        |     |     |     |
|-----|------------------|-----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------|-----|-----|-----|
| --- | 1.0<br>Code<br>K | Early Life Assurance<br>Test            | $E_f = 6.3 \text{ V}$ or $12.6 \text{ V}$<br>$E_b = 250 \text{ Vdc}$<br>$E_c = -2 \text{ Vdc}$<br>$E_{hk} = -200 \text{ Vdc}$<br>Note 7 | ---                    | --- | --- | --- |
| --- | ---              | Early Life Assurance<br>Test End Points | Shorts and Continuity                                                                                                                   | ---                    | --- | --- | --- |
|     |                  |                                         | Change in Plate Current (2) of<br>Individual tubes                                                                                      | $\Delta \frac{I_b}{t}$ | --- | 20  | %   |

| Reference | AQL | Test                                                   | Conditions                                                                                                       | Sym.                   | Min. | Max. | Unit            |
|-----------|-----|--------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|------------------------|------|------|-----------------|
| 4.11.5    | --- | Intermittent Life Test<br>(1) 1000 Hours               | Early Life, Assurance Test<br>Conditions, Note 8                                                                 | ---                    | ---  | ---  | ---             |
| 4.11.4    | --- | Intermittent Life Test<br>(1) End Points<br>1000 Hours | Inoperatives                                                                                                     | ---                    | ---  | ---  | ---             |
|           |     |                                                        | Grid Current (1)                                                                                                 | $I_{c(1)}$             | 0    | -1.0 | $\mu\text{Adc}$ |
|           |     |                                                        | Change in Plate Current (2)<br>of Individual Tubes                                                               | $\Delta \frac{I_b}{t}$ | ---  | 30   | %               |
|           |     |                                                        | Heater Cathode Leakage<br>$E_{hk} = +200 \text{ Vdc}$                                                            | $I_{hk}$               | ---  | 20   | $\mu\text{Adc}$ |
|           |     |                                                        | $E_{hk} = -200 \text{ Vdc}$                                                                                      | $I_{hk}$               | ---  | 20   | $\mu\text{Adc}$ |
|           |     |                                                        | Insulation of Electrodes<br>$E(g\text{-all})$                                                                    | $R_{g\text{-all}}$     | 1000 | ---  | meg             |
|           |     |                                                        | $E(p\text{-all})$                                                                                                | $R_{p\text{-all}}$     | 1000 | ---  | meg             |
| 4.11.5    | --- | Intermittent Life Test<br>(2) 1000 Hours               | $E_f = 6.3 \text{ V}$ or $12.6 \text{ V}$<br>$E_b = 250 \text{ Vdc}$ , $E_c = -25 \text{ Vdc}$<br>Note 9         | ---                    | ---  | ---  | ---             |
| 4.11.4    | --- | Intermittent Life Test<br>(2) End Points<br>1000 Hours | Interface<br>Resistance<br>Note 10                                                                               | $R_i$                  | ---  | 100  | ohms            |
| 4.11.7    | --- | Heater Cycling Life Test                               | $E_f = 7.0 \text{ V}$ or $13.8 \text{ V}$<br>$E_{hk} = -200 \text{ Vdc}$<br>Cycle<br>1.0 min. on<br>4.0 min. off | ---                    | ---  | 48   | hours           |
| 4.11.4    | --- | Heater Cycling Life<br>Test End Points                 | Shorts and Continuity                                                                                            | ---                    | ---  | ---  | ---             |
|           |     |                                                        | Heater Cathode Leakage<br>$E_{hk} = +200 \text{ Vdc}$                                                            | $I_{hk}$               | ---  | 15   | $\mu\text{Adc}$ |
|           |     |                                                        | $E_{hk} = -200 \text{ Vdc}$                                                                                      | $I_{hk}$               | ---  | 15   | $\mu\text{Adc}$ |

#### TEST NOTES

Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics having similar AQL's shall be combined for sampling purposes with the exception of control test. Control tests are indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4.1.

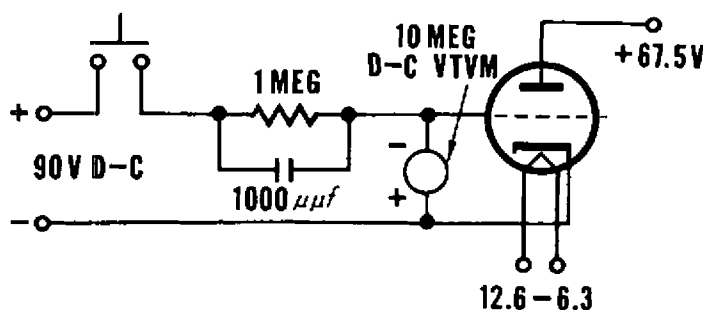
Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.

Note 3: Test each section separately. The section not under test shall be grounded.

Note 4: Connect both sections in parallel.

Note 5: Use pulse of ten microsecond duration,  $e_{gk} = +50 \text{ V}$ , at a 1% duty cycle. Read with scope across a 1.0 ohm cathode resistor.

Note 6: The grid blocking test shall be performed using circuit shown below or equivalent.



**Note 7: Early Life Assurance Test**

- a. Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- b. Serially mark all tubes of the sample.
- c. Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- d. The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours ( $\pm 4$  hours) with the intermediate down period reading point at 20 hours ( $\pm 4$  hours) and 2 hours ( $\pm 30$  minutes). Intermittent or continuous operation may be employed.
- e. A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

**Note 8: 1000 Hour Intermittent Life Test**

- a. The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test end point characteristic.
- b. Record the reference characteristic.
- c. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test shall be part of the 1000 hours.
- d. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- e. Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

**Note 9: Intermittent Life Test (2)**

- a. Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test end point characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- b. Sample size shall be 10 tubes.
- c. Record the reference characteristics.
- d. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours.
- e. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.

**Note 10:** Interface Resistance shall be measured using the equivalent diode resistance 2 frequency method.

**Note 11:** Use 10 megohm input resistance DC VTVM. Read voltage developed across  $R_g$ .

**Note 12:** Difference in Plate Current ( $I_{b(2)}$ ) between each section.

**Note 13:** The rejection level shall be set at the VU meter reading obtained during calibration.



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## MEDIUM-MU TWIN TRIODE 7730

CBS Type 7730 is a miniature medium-mu twin triode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. The 7730 is a replacement for type 12AU7 and superior performance is assured because of its improved construction, special tests, and tight minimum-maximum limits.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life and resistance against the formation of interface impedance are a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

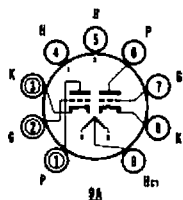
Additional mechanical features offered by CBS type 7730 include: gold plated base pins which prevent oxidation and improve base pin contact; precisely made and fitted parts in stronger structures for lower noise and microphonism; and electrical features include: initial plate current balance, life tested plate current balance, grid current test, and reverse grid current test.

### MECHANICAL DATA

|                              |                        |
|------------------------------|------------------------|
| Cathode, coated unipotential |                        |
| Bulb                         | T-6 1/2                |
| Outline                      | JEDEC 6-2              |
| Base                         | Miniature 9-pin (E9-1) |
| Basing                       | 9A                     |
| Mounting position            | Any                    |

### PIN CONNECTIONS

- Pin 1: Plate (Section 2)
- Pin 2: Grid (Section 2)
- Pin 3: Cathode (Section 2)
- Pin 4: Heater
- Pin 5: Heater
- Pin 6: Plate (Section 1)
- Pin 7: Grid (Section 1)
- Pin 8: Cathode (Section 1)
- Pin 9: Heater Center-Tap



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                                   | Series         | Parallel      |       |
|-----------------------------------|----------------|---------------|-------|
| Voltage, a-c or d-c               | 12.6 $\pm$ 10% | 6.3 $\pm$ 10% | volts |
| Current                           | 150            | 300           | ma    |
| Peak heater-cathode voltage, max. |                |               |       |
| Heater negative to cathode        | 200            | 200           | volts |
| Heater positive to cathode*       | 200            | 200           | volts |

\*D-c component must not exceed 100 volts

#### DIRECT INTERELECTRODE CAPACITANCES

|                        | No Shield | Shield * |     |
|------------------------|-----------|----------|-----|
| Grid to plate: g1 to p | 1.5       | 1.5      | uuf |
| Input: g1 to k+h       | 1.6       | 1.8      | uuf |
| Output: p to k+h       |           |          |     |
| Section 1              | 0.40      | 2.0      | uuf |
| Section 2              | 0.32      | 2.0      | uuf |

\*JETEC shield 315 connected to cathode.

#### MAXIMUM RATINGS (Design maximum values)

##### Each Section

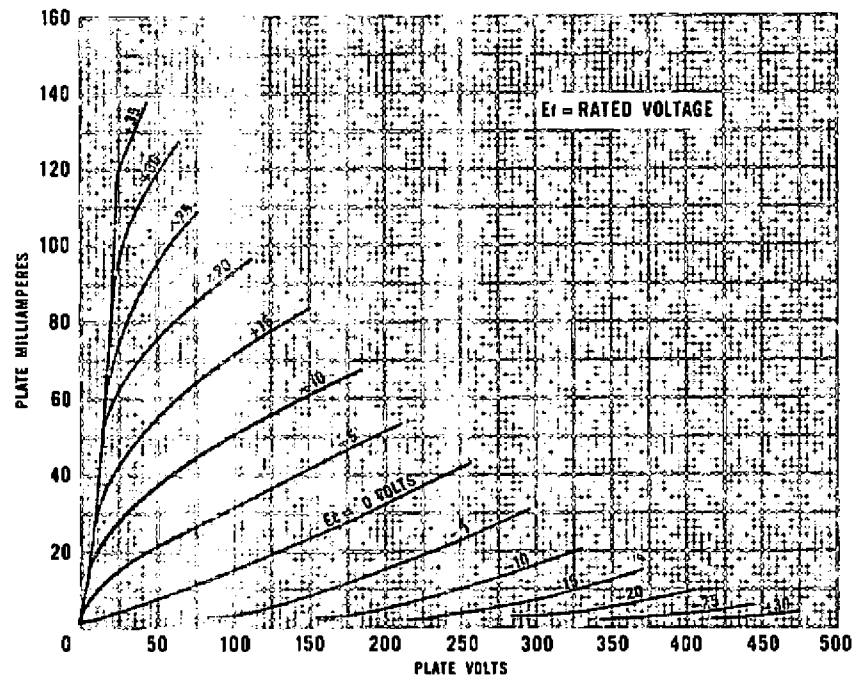
|                                |     |       |
|--------------------------------|-----|-------|
| Plate voltage                  | 330 | volts |
| Plate dissipation (each plate) | 3.0 | watts |
| Cathode current                | 20  | ma    |
| Bulb temperature               | 165 | °C    |

#### CHARACTERISTICS AND TYPICAL OPERATION

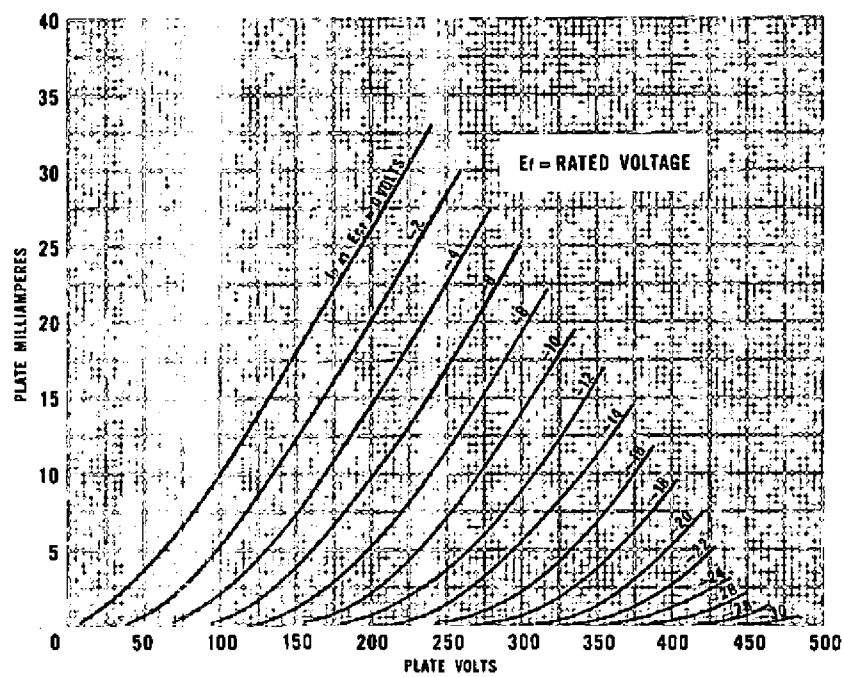
##### Class A Amplifier - Each Section

|                                            |      |      |       |
|--------------------------------------------|------|------|-------|
| Plate voltage                              | 100  | 250  | volts |
| Control grid voltage                       | 0    | -8.5 | volts |
| Plate resistance (approx.)                 | 6500 | 7700 | ohms  |
| Transconductance                           | 3100 | 2200 | umhos |
| Amplification factor                       | 20   | 17   |       |
| Plate current                              | 11.8 | 10.5 | ma    |
| Grid 1 voltage (approx.)<br>for Ib = 10 ua |      | -24  | volts |

## AVERAGE PLATE CHARACTERISTICS



## AVERAGE PLATE CHARACTERISTICS





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

12.6 series connection or 6.3 parallel connection Eb = 120 Vdc  
Ec = 0 Vdc

| Reference<br>Note 2 | AQL<br>Note 1 | Test                       | Conditions                                                                                                | Sym.                                     | Min.                               | Max.                               | Unit                            |
|---------------------|---------------|----------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------|------------------------------------|------------------------------------|---------------------------------|
| 4.7.5               | 0.4           | Continuity & Short         |                                                                                                           | ---                                      | ---                                | ---                                | ---                             |
| 4.10.8              | 2.5*          | Heater Current             | Ef = 6.3<br>Ef = 12.6                                                                                     | If<br>If                                 | 275<br>138                         | 325<br>162                         | mA                              |
| 4.10.15             | 1.0           | Heater Cathode Leakage     | Ehk = +200 Vdc<br>Ehk = -200 Vdc                                                                          | Ihk<br>Ihk                               | 0<br>0                             | 5.0<br>5.0                         | uAdc                            |
| 4.10.6.1            | 1.0           | Grid Current (1)           | Ebb = 250 Vdc<br>Ecc = -9Vdc, Rg/g=0.5meg<br>Rp=2K, Note 4                                                | Ic(1)                                    | ---                                | -.5                                | uAdc                            |
| ---                 | 2.5           | Grid Block (2)             | Ebb = 67.5 Vdc<br>Ec=0; Notes 3, 6                                                                        | E <sub>1</sub> C <sub>1</sub>            | 0                                  | -1.5                               | Vdc                             |
| 4.10.4.1            | 2.5           | Plate Current (1)          | Ecc = -15 Vdc<br>Rp=2K; Note 3                                                                            | Ib(1)                                    | ---                                | 50                                 | uAdc                            |
| 4.10.4.1            | 1.0           | Plate Current (2)          | Rp = 2K; Note 3                                                                                           | Ib(2)                                    | 8                                  | 16                                 | mAdc                            |
| 4.10.4.1            | 1.0           | Plate Current Differential | Ebb=250Vdc, Ecc= -9.0Vdc<br>Rg/g=0.5meg, Rp=2K<br>Notes 3, 7, 13                                          | Δ Ib(3)                                  | ---                                | 15                                 | %                               |
| 4.10.9              | 2.5           | Transconductance(1)        | Ebb=100Vdc; Note 3                                                                                        | Sm(1)                                    | 3000                               | 4200                               | umhos                           |
| 4.10.9              | 2.5           | Transconductance(2)        | Ef=90% of Ef used in Sm(1)<br>test, Eb= 100Vdc; Note 3                                                    | Δ Sm                                     | ---                                | 15                                 | %                               |
| ---                 | ---           | Cathode Current            | Eb=22V, Rg-p=300K; Note 3                                                                                 | Ik                                       | 1.2                                | ---                                | mA                              |
| ---                 | 1.0           | Pulse Emission             | Eb=200, Ec= -30, egk= +50V<br>Notes 5, 3                                                                  | Isp                                      | 175                                | ---                                | mAdc                            |
| 4.10.3.4            | 2.5           | Noise & Microphonics       | Ebb=275Vdc; Ec=0, Rk=1500 ohms<br>Ck=1000 uuf, Rp=50000 ohms<br>Rg=50000 ohms, Ecal=50mVac<br>Notes 4, 14 | M                                        | ---                                | ---                                | ---                             |
| ---                 | 2.5           | Contact Potential          | Ebb=120Vdc, Ec <sub>1</sub> =0, Rg/g=2.2meg<br>Notes 12, 3                                                | Ecp                                      | 0                                  | -1.0                               | Vdc                             |
| 4.8                 | 2.5           | Insulation of Electrodes   | E(g <sub>1</sub> -all)=100Vdc, g <sub>1</sub> Negative<br>E(p-all)=300Vdc, p Negative<br>Note 3           | R(g-all)<br>R(p-all)                     | 1000<br>1000                       | ---                                | meg<br>meg                      |
| 4.10.14             | 2.5*          | Capacitances               | Without Shield, Note 3                                                                                    | Cgp<br>Cin<br>Cout 1<br>Cout 2<br>Clg-2g | 1.2<br>1.2<br>0.35<br>0.24<br>0.01 | 1.8<br>2.0<br>0.65<br>0.46<br>0.01 | uuf<br>uuf<br>uuf<br>uuf<br>uuf |

| <u>Reference</u> | <u>AQL</u>    | <u>Test</u>                                         | <u>Conditions</u>                                                           | <u>Sym.</u>            | <u>Min.</u> | <u>Max.</u> | <u>Unit</u> |
|------------------|---------------|-----------------------------------------------------|-----------------------------------------------------------------------------|------------------------|-------------|-------------|-------------|
| LIFE TESTS       |               |                                                     |                                                                             |                        |             |             |             |
| ---              | 1.0<br>Code K | Early Life Assurance Test                           | Ef=12.6V or 6.3V<br>Eb=250Vdc<br>Ecc= -9Vdc, Rg/g=47ohms<br>Note 8          | ---                    | ---         | ---         | ---         |
| ---              | ---           | Early Life Assurance<br>Test End Points             | Shorts and Continuity                                                       | ---                    | ---         | ---         | ---         |
|                  |               |                                                     | Change in Plate Current (2)<br>of Individual tubes                          | $\Delta \frac{I_b}{t}$ | ---         | 20          | %           |
|                  |               |                                                     | Plate Current (3) Differential<br>Note 13                                   | $\Delta I_b(3)$        | ---         | 20          | %           |
| 4.11.5           | ---           | Intermittent Life Test<br>(1) 1000 Hours            | Early Life Assurance Test<br>Conditions, Note 9                             | ---                    | ---         | ---         | ---         |
| 4.11.4           | ---           | Intermittent Life Test<br>(1) End Points 1000 Hours | Inoperatives<br>Grid Current (1)                                            | ---                    | ---         | ---         | ---         |
|                  |               |                                                     | Change in Plate Current (2)<br>of Individual Tubes                          | $\Delta \frac{I_b}{t}$ | ---         | 20          | %           |
|                  |               |                                                     | Plate Current (3) Differential<br>Note 13                                   | $\Delta I_b(3)$        | ---         | 25          | %           |
|                  |               |                                                     | Heater Cathode Leakage<br>Ehk= +200Vdc                                      | Ihk                    | ---         | 20          | uAdc        |
|                  |               |                                                     | Ehk= -200Vdc                                                                | Ihk                    | ---         | 20          | uAdc        |
|                  |               |                                                     | Insulation of Electrodes<br>E(g-all)                                        | Rg-all                 | 1000        | ---         | meg         |
|                  |               |                                                     | E(p-all)                                                                    | Rp-all                 | 1000        | ---         | meg         |
| 4.11.5           | ---           | Intermittent Life Test(2)<br>1000 hours             | Ef=12.6V or 6.3V<br>Eb = 250 Vdc<br>Ecc= -50Vdc, Rg/g=47000 ohms<br>Note 10 | ---                    | ---         | ---         | ---         |
| 4.11.4           | ---           | Intermittent Life Test<br>(2) End Points 1000 Hours | Interface Resistance                                                        | Ri                     | ---         | 100         | ohms        |
| 4.11.7           | ---           | Heater Cycling Life Test                            | Ef=13.8V or 7.0V<br>Ehk= -200V;Cycle<br>1.0 min. on<br>4.0 min. off         | ---                    | ---         | 48          | hours       |
| 4.11.4           | ---           | Heater Cycling Life<br>Test End Points              | Shorts and Continuity                                                       | ---                    | ---         | ---         | ---         |
|                  |               |                                                     | Heater Cathode Leakage<br>Ehk= +200Vdc                                      | Ihk                    | ---         | 15          | uAdc        |
|                  |               |                                                     | Ehk= -200Vdc                                                                | Ihk                    | ---         | 15          | uAdc        |

#### TEST NOTES

Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics having similar AQL's shall be combined for sampling purposes with the exception of control test. Control tests are indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4.1.

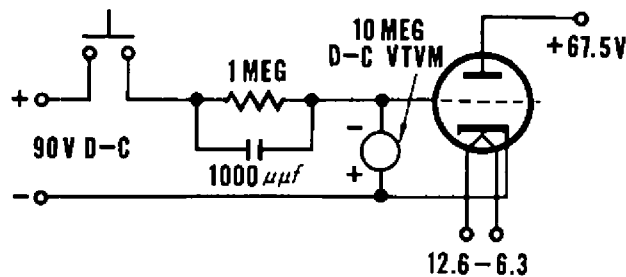
Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.

Note 3: Unless otherwise specified herein, the following test conditions shall apply: Each unit will be tested separately. A unit not under test shall be grounded.

Note 4: Connect both sections in parallel.

Note 5: Use a pulse of one microsecond duration at a 1% duty cycle. Read with scope across a 1.0 cathode resistor.

Note 6: The grid current test shall be performed using circuit shown below or equivalent.



Apply 90 Vdc to grid momentarily. Upon removal of voltage VTVM shall not go positive nor shall it go more negative than -1.5 volts.

Note 7: Each tube shall not have greater than 15% unbalance between sections and at end of life shall not be out of balance by 25%

Note 8: Early Life Assurance Test

- Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- Serially mark all tubes of the sample.
- Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours ( $\pm 4$  hours) with the intermediate down period reading point at 20 hours ( $\pm 4$  hours) and 2 hours ( $\pm 30$  minutes). Intermittent or continuous operation may be employed.
- A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

Note 9: 1000 Hour Intermittent Life Test

- The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test end point characteristic.
- Record the reference characteristic.
- Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test shall be part of the 1000 hours.
- Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

Note 10: Intermittent Life Test (2)

- Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test end point characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- Sample size shall be 10 tubes.
- Record the reference characteristics.
- Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours.
- Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.

- Note 11: RI (Interface Resistance) shall be measured using the equivalent diode resistance 2 frequency method.
- Note 12: Use 10 meg input resistance DC VTVM. Read voltage developed across  $R_g$ .
- Note 13: Difference in plate current between sections.
- Note 14: The rejection level shall be set at the VU meter reading obtained during calibration.



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## MEDIUM MU TRIODE-SHARP CUTOFF PENTODE

### 7731

CBS Type 7731 is a miniature medium-mu triode and sharp-cutoff pentode which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. The 7731 is a replacement for type 6U8 and superior performance is assured because of its improved construction, special tests, and tight minimum-maximum limits.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life is a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

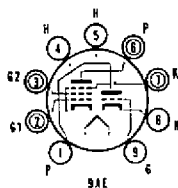
Additional mechanical features offered by CBS type 7731 include: gold plated base pins which prevent oxidation and improve base pin contact; precisely made and fitted parts in stronger structures for lower noise and microphonism; and electrical features include: life tested transconductance, low heater voltage transconductance test, and grid current test.

### MECHANICAL DATA

|                              |                        |
|------------------------------|------------------------|
| Cathode, coated unipotential |                        |
| Bulb                         | T-6 1/2                |
| Outline                      | JEDEC 6-2              |
| Base                         | Miniature 9-pin (E9-1) |
| Basing                       | 9AE                    |
| Mounting position            | Any                    |

### PIN CONNECTIONS

|                                          |
|------------------------------------------|
| Pin 1: Triode Plate                      |
| Pin 2: Pentode Grid 1                    |
| Pin 3: Pentode Grid 2                    |
| Pin 4: Heater                            |
| Pin 5: Heater                            |
| Pin 6: Pentode Plate                     |
| Pin 7: Pentode Cathode,<br>Grid 3, I. S. |
| Pin 8: Triode Cathode                    |
| Pin 9: Triode Grid                       |



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                                  |         |       |
|----------------------------------|---------|-------|
| Voltage, a-c or d-c              | 6.3±10% | volts |
| Current                          | 450     | ma    |
| Peak heater-cathode voltage, max |         |       |
| Heater negative to cathode       | 200     | volts |
| Heater positive to cathode*      | 200     | volts |

\*D-c component must not exceed 100 volts

#### DIRECT INTERELECTRODE CAPACITANCES

##### Triode Section

|                           | No Shield | Shield♦ |     |
|---------------------------|-----------|---------|-----|
| Grid to plate: g1 to p    | 1.8       | 1.8     | uuf |
| Input: g1 to k+h          | 2.5       | 2.5     | uuf |
| Output: p to k+h          | 0.4       | 1.0     | uuf |
| Heater to cathode: h to k | 3.0       | 3.0     | uuf |

##### Pentode Section

|                             |      |       |     |
|-----------------------------|------|-------|-----|
| Grid to plate: g1 to p, max | 0.01 | 0.006 | uuf |
| Input: g1 to k+h+g2+g3      | 5.0  | 5.0   | uuf |
| Output: p to k+h+g2+g3      | 2.6  | 3.5   | uuf |
| Heater to cathode: h to k   | 3.0  | 3.0   | uuf |

#### MAXIMUM RATINGS (Design maximum values)

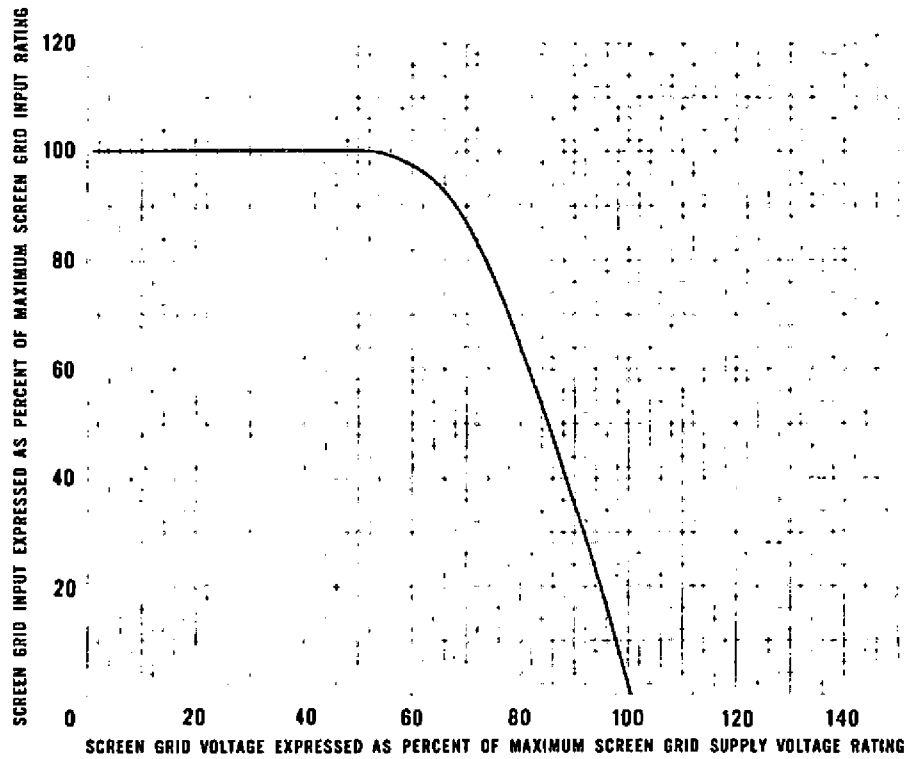
|                              | Triode | Pentode      |       |
|------------------------------|--------|--------------|-------|
| Plate voltage                | 330    | 330          | volts |
| Grid 2 voltage, pentode      |        | Rating Chart |       |
| Grid 2 supply voltage        |        | 330          | volts |
| Grid 1 voltage, positive d-c | 0      | 0            | volts |
| Plate dissipation            | 3.0    | 3.0          | watts |
| Grid 2 dissipation           |        | 0.6          | watts |
| Bulb Temperature             |        | 165          | ° C   |

#### CHARACTERISTICS AND TYPICAL OPERATION

|                                           | Triode | Pentode |       |
|-------------------------------------------|--------|---------|-------|
| Plate voltage                             | 150    | 250     | volts |
| Grid 2 (screen) voltage                   |        | 110     | volts |
| Cathode bias resistor                     | 56     | 68      | ohms  |
| Plate resistance (approx.)                | 5000   | 400000  | ohms  |
| Transconductance                          | 8500   | 5200    | umhos |
| Amplification factor                      | 40     |         |       |
| Plate current                             | 18     | 10      | ma    |
| Grid 2 current                            |        | 3.5     | ma    |
| Grid 1 voltage (approx.)<br>for Ib = 10ua | -12    | -10     | volts |

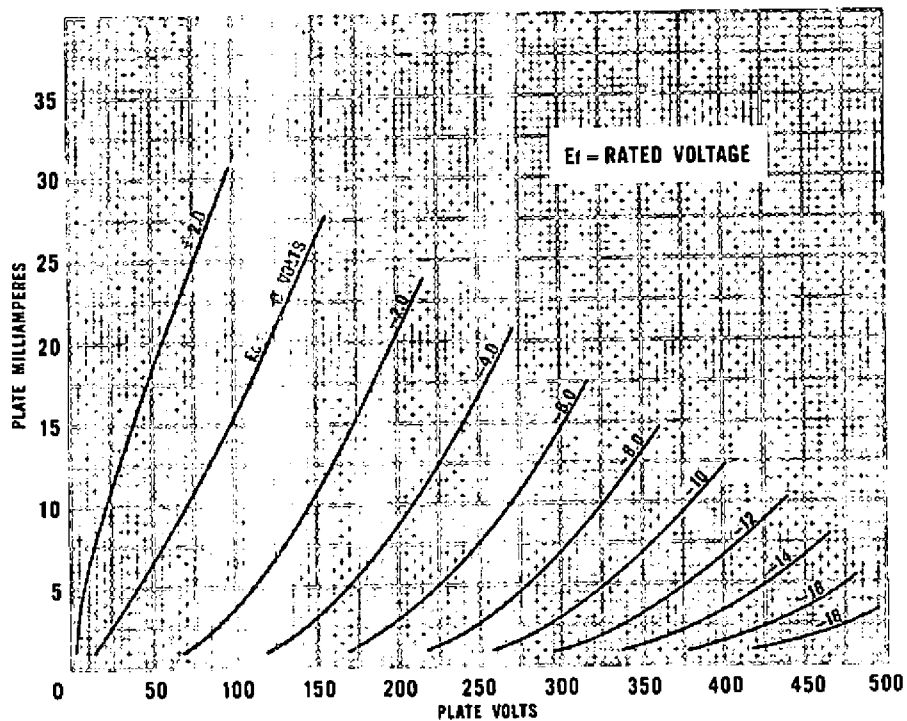
♦ JEDEC shield 315 connected to cathode.

## SCREEN GRID RATING



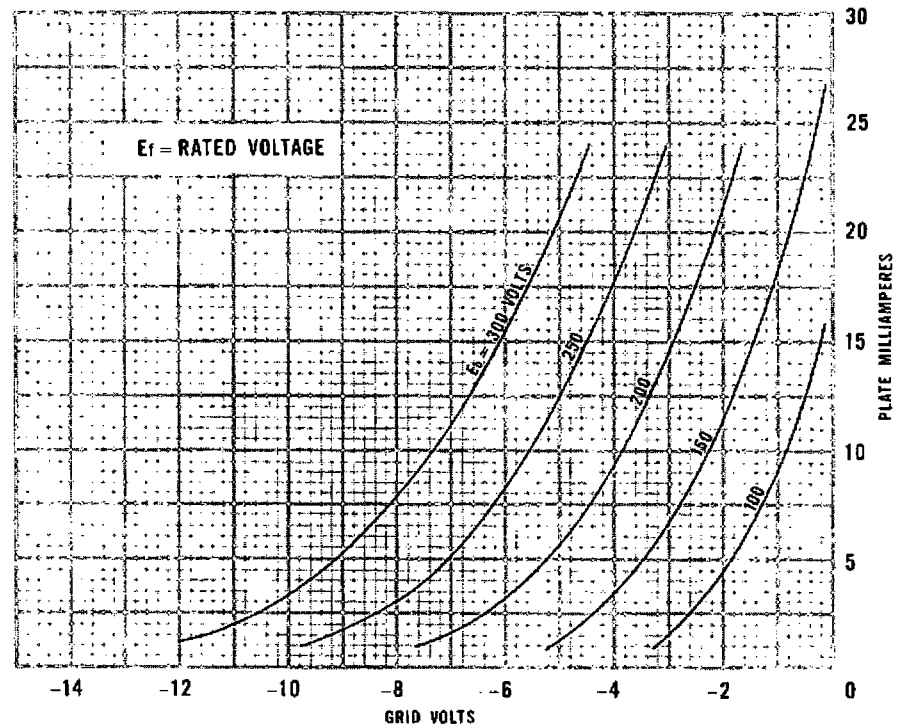
## AVERAGE PLATE CHARACTERISTICS

TRIODE SECTION



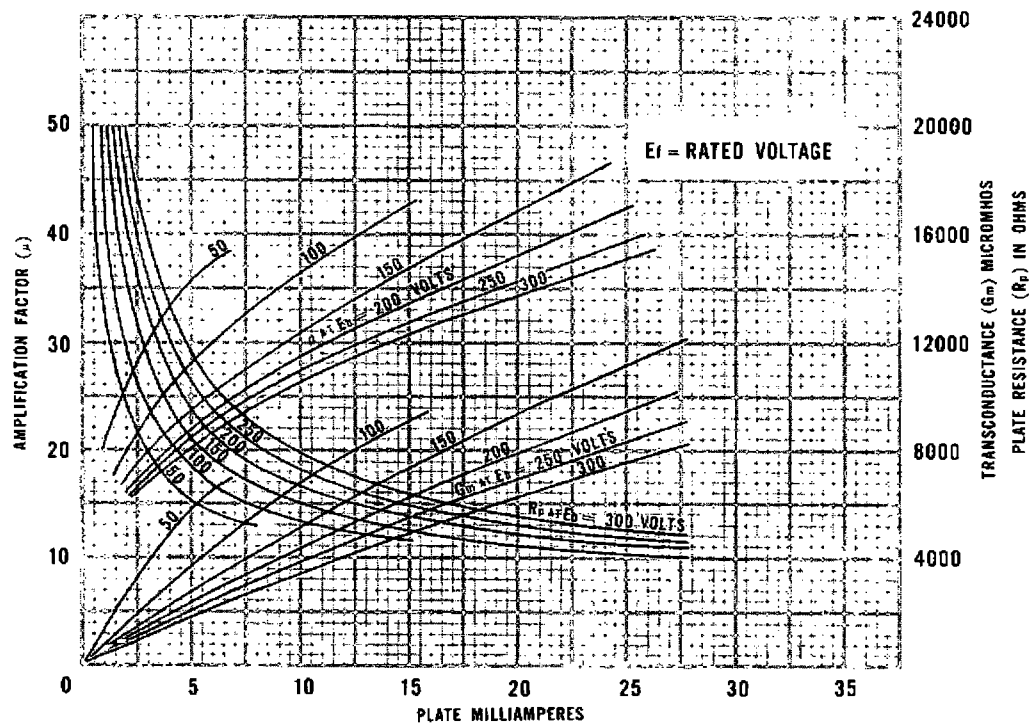
# AVERAGE TRANSFER CHARACTERISTICS

## TRIODE SECTION



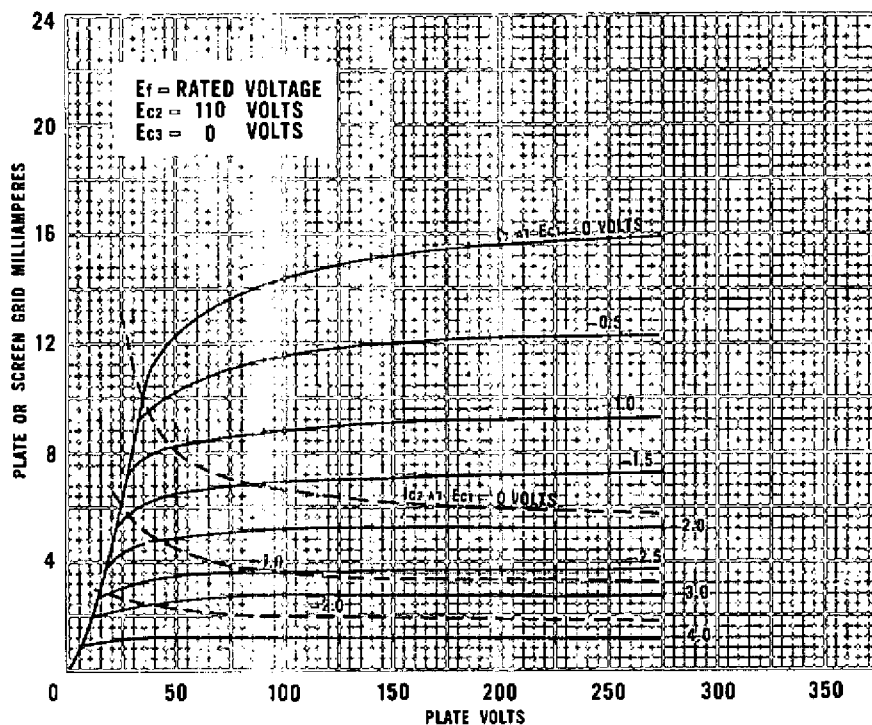
# AVERAGE CHARACTERISTICS

## TRIODE SECTION



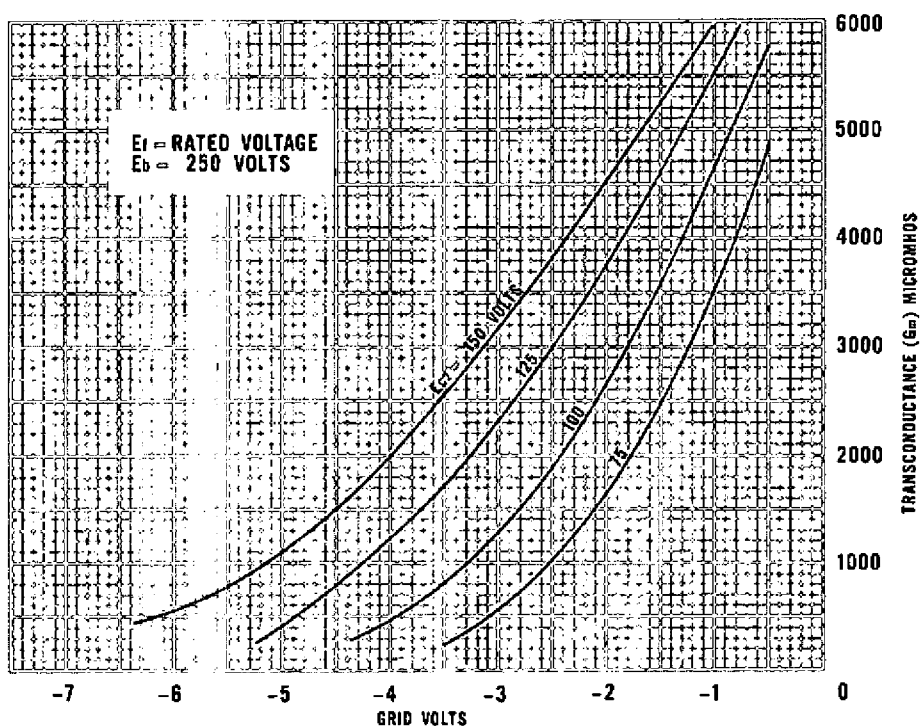
## AVERAGE PLATE CHARACTERISTICS

PENTODE SECTION



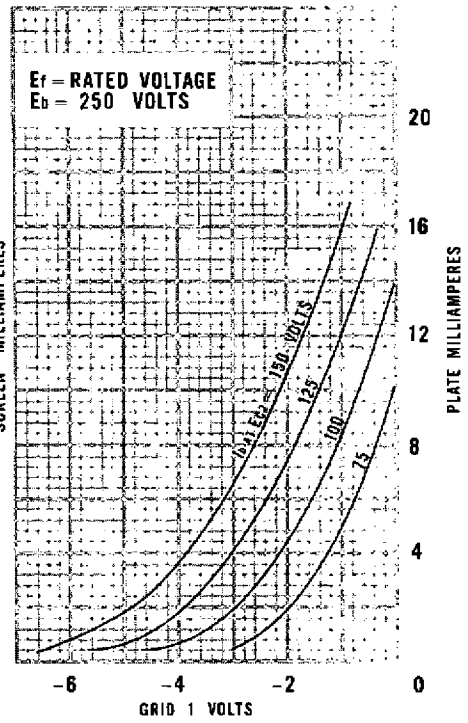
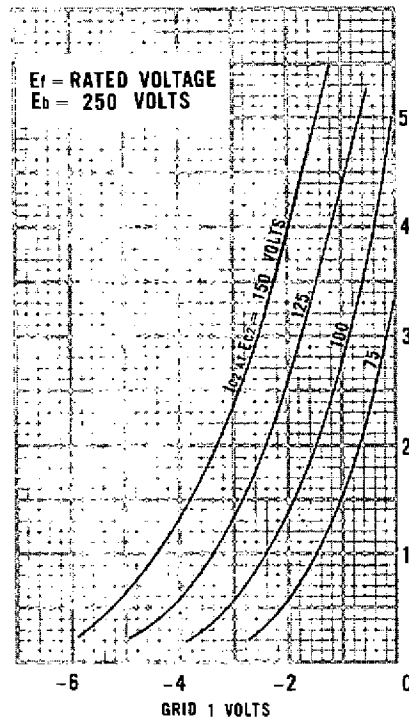
## AVERAGE TRANSFER CHARACTERISTICS

PENTODE SECTION



# AVERAGE TRANSFER CHARACTERISTICS

## PENTODE SECTION





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

Eh=6.3V; Ebt=150Vdc; Eclt=0Vdc  
Rkt=56ohms; Ebp=250Vdc; Eclp=0Vdc  
Ec2p=110Vdc; Rkp=68ohms; Ehk=±200Vdc

| Reference<br>Note 2 | AQL<br>Note 1 | Test                             | Conditions                              | Sym.                    | Min.              | Max.              | Unit              |
|---------------------|---------------|----------------------------------|-----------------------------------------|-------------------------|-------------------|-------------------|-------------------|
| 4.7.5               | 0.4           | Continuity & Shorts              |                                         | ---                     | ---               | ---               | ---               |
| 4.10.8              | 2.5*          | Heater Current                   |                                         | Ih                      | 425               | 475               | mA                |
| 4.10.4.1            | 1.0<br>2.5    | Plate Current Pent.              |                                         | Ibp                     | 6.0               | 13.0              | mA <sub>dc</sub>  |
| 4.10.4.3            |               | Screen Current Pent.             |                                         | Ic2p                    | 2.0               | 5.0               | mA <sub>dc</sub>  |
| 4.10.6.1            | 1.0<br>2.5    | Grid Current Pent.               | Ecl = 0.5V                              | Ic1p                    | ---               | -0.7              | uA <sub>dc</sub>  |
| 4.10.9              |               | Transconductance Pent.           | Note 3                                  | Smp                     | 4000              | 6400              | umho              |
| 4.10.4.1            | 1.0           | Plate Current CO Pent.           | Ecl= -13Vdc, Rk=0                       | I2bp                    | ---               | 50                | uA <sub>dc</sub>  |
| 4.10.15             | 1.0           | H-K Leakage Pent.                | Ehk = ±200 Vdc                          | Ihkp                    | ---               | 10                | uA <sub>dc</sub>  |
| 4.10.14             | 2.5*          | Capacitance Pent.                |                                         | Cgpp<br>Cout p<br>Cin p | ---               | .02<br>3.8<br>6.0 | uuf<br>uuf<br>uuf |
| 4.10.4.1            | 1.0           | Plate Current Triode             |                                         | Ibt                     | 12                | 25.0              | mA <sub>dc</sub>  |
| 4.10.6.1            | 1.0           | Grid Current Triode              | Ecl = -.5V                              | Ic1t                    | ---               | 0.7               | uA <sub>dc</sub>  |
| 4.10.9              | 2.5           | Transconductance Triode          | Note 3                                  | Smt                     | 6000              | 11000             | umho              |
| 4.10.4.1            | 1.0           | Plate Current CO Triode          | Ecl= -15Vdc, Rk = 0                     | Ibt(2)                  | ---               | 50                | uA <sub>dc</sub>  |
| 4.10.15             | 1.0           | Heater Cathode Leakage Triode    | Ehk = ± 200 Vdc                         | Ihkt                    | ---               | 10                | uA <sub>dc</sub>  |
| 4.10.9              | 2.5*          | Transconductance Pent.           | Ef=5.7V, Note 3                         | Δ Smp                   | ---               | 15                | %                 |
| 4.10.9              | 2.5*          | Transconductance Triode          | Ef=5.7V, Note 3                         | Δ Smt                   | ---               | 15                | %                 |
| 4.10.6.1            | 2.5*          | Grid Current (2) Pentode         | Ef=7.0V, Rg1=100K<br>Note 6             | Icp(2)                  | ---               | 1.0               | uA <sub>dc</sub>  |
| 4.10.6.1            | 2.5*          | Grid Current (2) Triode          | Ef=7.0, Rg1=.5 meg<br>Note 6            | Ict(2)                  | ---               | 1.0               | uA <sub>dc</sub>  |
| 4.8                 | 2.5*          | Insulation of Electrodes Triode  | E(g-all)= -100Vdc<br>E(p-all)= -100Vdc  | R(g1-all)<br>R(p-all)   | 100<br>100        | ---               | meg<br>meg        |
| 4.8                 | 2.5*          | Insulation of Electrodes Pentode | E(g1-all)= -100Vdc<br>E(p-all)= -100Vdc | R(g1-all)<br>R(p-all)   | 100<br>100        | ---               | meg<br>meg        |
| 4.10.14             | 2.5*          | Capacitances Triode              | Without Shield                          | Cgp<br>Cin<br>Cout      | 1.5<br>1.5<br>0.2 | 2.1<br>3.5<br>0.8 | uuf<br>uuf<br>uuf |

| <u>Reference</u> | <u>AQL</u>     | <u>Test</u>                                        | <u>Conditions</u>                                                                                                                                  | <u>Sym.</u>               | <u>Min.</u> | <u>Max.</u> | <u>Unit</u> |
|------------------|----------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|-------------|-------------|-------------|
| 4. 10. 3. 1      | 2. 5           | RF Noise                                           | Note 7                                                                                                                                             | RFN                       | ---         | ---         | ---         |
| 4. 10. 3. 4      | 2. 5           | Noise and Microphonics<br>Pentode                  | Eb=Ecc <sub>2</sub> =110Vdc, Rb=10K<br>Rk=0, Ecc <sub>1</sub> = -2Vdc<br>Ecal=30mV. Rg <sub>1</sub> =50K                                           | M                         | ---         | ---         | ---         |
|                  |                | Noise & Microphonics<br>Triode                     | Note 9<br>Ebb=150Vdc, Rb=10K<br>Rk=0, Ecc <sub>1</sub> = -1.0Vdc<br>Rg <sub>1</sub> =50K, Ecal=30mV                                                | M                         |             |             |             |
| LIFE TESTS       |                |                                                    |                                                                                                                                                    |                           |             |             |             |
| ---              | 1. 0<br>Code K | Early Life Assurance<br>Test                       | Ef=6. 3V, Ebp=250Vdc<br>Ec <sub>2</sub> =110Vdc, Ebt=150Vdc<br>Rg/t=100K, Rg/p=100K<br>Rkp=68Ω, Rkt=56Ω,<br>Ehkt= -200Vdc, Ehkp= -200Vdc<br>Note 4 | ---                       | ---         | ---         | ---         |
| ---              | ---            | Early Life Assurance<br>Test End Points            | Shorts & Continuity<br>Change in Transconductance<br>(pentode) of Individual tubes                                                                 | ---                       | ---         | ---         | ---         |
|                  |                |                                                    | $\Delta \frac{S_{mp}}{t}$                                                                                                                          |                           |             | 10          | %           |
|                  |                |                                                    | Change in Transconductance<br>(triode) of Individual tubes                                                                                         | $\Delta \frac{S_{mt}}{t}$ |             | 10          | %           |
| 4. 11. 5         | ---            | Intermittent Life Test<br>End Points 1000 Hours    | Early Life Assurance Conditions<br>Note 5                                                                                                          |                           |             |             |             |
| 4. 11. 4         | ---            | Intermittent Life Test<br>End Points<br>1000 Hours | Inoperatives                                                                                                                                       | ---                       | ---         | ---         | ---         |
|                  |                |                                                    | Change in Transconductance<br>(pentode) of Individual Tubes                                                                                        | $\Delta \frac{S_{mt}}{t}$ |             | 20          | %           |
|                  |                |                                                    | Change in Transconductance<br>(triode) of Individual Tubes                                                                                         | $\Delta \frac{S_{mt}}{t}$ |             | 20          | %           |
|                  |                |                                                    | Grid Current Pent.                                                                                                                                 | Ic(1)p                    | ---         | -1. 0       | uAdc        |
|                  |                |                                                    | Grid Current Triode                                                                                                                                | Ic(1)t                    | ---         | -1. 0       | uAdc        |
|                  |                |                                                    | Heater Cathode Leakage Pentode                                                                                                                     | Ihk                       | ---         | 20          | uAdc        |
|                  |                |                                                    | Insulation Resistance Triode                                                                                                                       | R                         | 50          | ---         | meg         |
|                  |                |                                                    | Insulation Resistance Pentode                                                                                                                      | R                         | 50          | ---         | meg         |
| 4. 11. 7         | 1. 0           | Heater Cycling<br>Life Test                        | Ef=7. 0V, Ehkp= -200Vdc<br>Ehk <sub>t</sub> = -200Vdc, Cycle<br>1. 0 min. on<br>4. 0 min. off                                                      | ---                       | ---         | 48          | hours       |
| 4. 11. 4         | ---            | Heater Cycling Life<br>Test End Points             | Inoperatives                                                                                                                                       | ---                       | ---         | ---         | ---         |
|                  |                |                                                    | Heater Cathode Leakage Pentode                                                                                                                     | Ihk <sub>p</sub>          | ---         | 15          | uAdc        |
|                  |                |                                                    | Heater Cathode Leakage Triode                                                                                                                      | Ihk <sub>t</sub>          | ---         | 15          | uAdc        |

#### TEST NOTES

Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics, having similar AQL's shall be combined for sampling purposes with the exception of control test. Control test is indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4. 1.

Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.

Note 3: The cathode resistor shall be shunted with capacitive reactance not exceeding three (3) ohms 60 cycles.

**Note 4: Early Life Assurance Test**

- a. Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- b. Serially mark all tubes of the sample.
- c. Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- d. The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours ( $\pm 4$  hours) with the intermediate down period reading point at 20 hours ( $\pm 4$  hours) and 2 hours ( $\pm 30$  minutes). Intermittent or continuous operation may be employed.
- e. A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

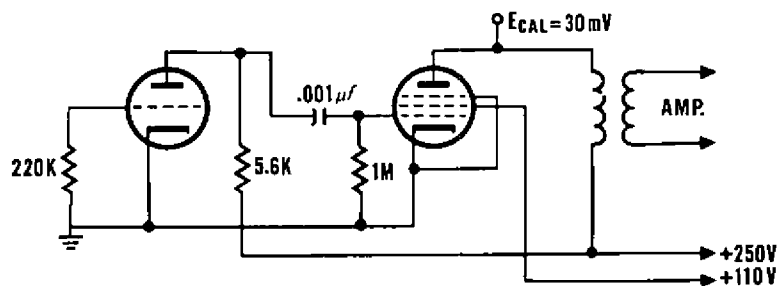
**Note 5: 1000 Hour Intermittent Life Test**

- a. The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test endpoint characteristic.
- b. Record the reference characteristic.
- c. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test shall be part of the 1000 hours.
- d. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- e. Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

**Note 6: Prior to this test, tubes to be preheated five (5) minutes at conditions indicated below. Test immediately after preheating.**

|          | Eh<br>V | Ec1<br>Vdc | Rk<br>ohms | Rg1    | Eb<br>Vdc | Ec2<br>Vdc |
|----------|---------|------------|------------|--------|-----------|------------|
| Pentode: | 7.0     | 0          | 68         | 100K   | 250       | 110        |
| Triode:  | 7.0     | 0          | 56         | .5 meg | 150       | ---        |

**Note 7:**



**Note 8: Test each section separately.**

**Note 9: The rejection level shall be set at the VU meter reading obtained during calibration.**

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Printed in U.S.A.

## SHARP CUTOFF PENTODE 7732

CBS Type 7732 is a miniature sharp cutoff pentode which is especially designed and tested for high input impedance applications in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. The 7732 is a replacement for type 6CB6 and superior performance is assured because of its improved construction, special tests, and tight minimum-maximum limits.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life is a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

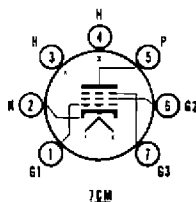
Additional mechanical features offered by CBS type 7732 include: gold plated base pins which prevent oxidation and improve base pin contact, precisely made and fitted parts in stronger structures for lower noise and microphonism. Electrical features include: grid current test, low heater voltage transconductance test, and life tested transconductance.

### MECHANICAL DATA

|                              |                                     |
|------------------------------|-------------------------------------|
| Cathode, coated unipotential |                                     |
| Bulb                         | T-5 1/2                             |
| Outline                      | JEDEC 5-2                           |
| Base                         | Miniature button 7-pin (JEDEC E7-1) |
| Basing                       | 7CM                                 |
| Mounting position            | Any                                 |

### PIN CONNECTIONS

|                      |
|----------------------|
| Pin 1: Grid 1        |
| Pin 2: Cathode       |
| Pin 3: Heater        |
| Pin 4: Heater        |
| Pin 5: Plate         |
| Pin 6: Grid 2        |
| Pin 7: Grid 3, I. S. |



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                                  |               |       |
|----------------------------------|---------------|-------|
| Voltage, a-c or d-c              | 6.3 $\pm$ 10% | volts |
| Current                          | 300           | ma    |
| Peak heater-cathode voltage, max |               |       |
| Heater negative to cathode       | 200           | volts |
| Heater positive to cathode*      | 200           | volts |

\*D-c component must not exceed 100 volts

#### DIRECT INTERELECTRODE CAPACITANCES

|                              | No Shield | Shield ♦ |     |
|------------------------------|-----------|----------|-----|
| Grid to plate: g1 to p, max  | 0.025     | 0.15     | uuf |
| Input: g1 to k+h+g2+g3+i. s. | 6.5       | 6.5      | uuf |
| Output: p to k+h+g2+g3+i. s. | 2.0       | 3.0      | uuf |

♦ JEDEC shield 316 connected to cathode

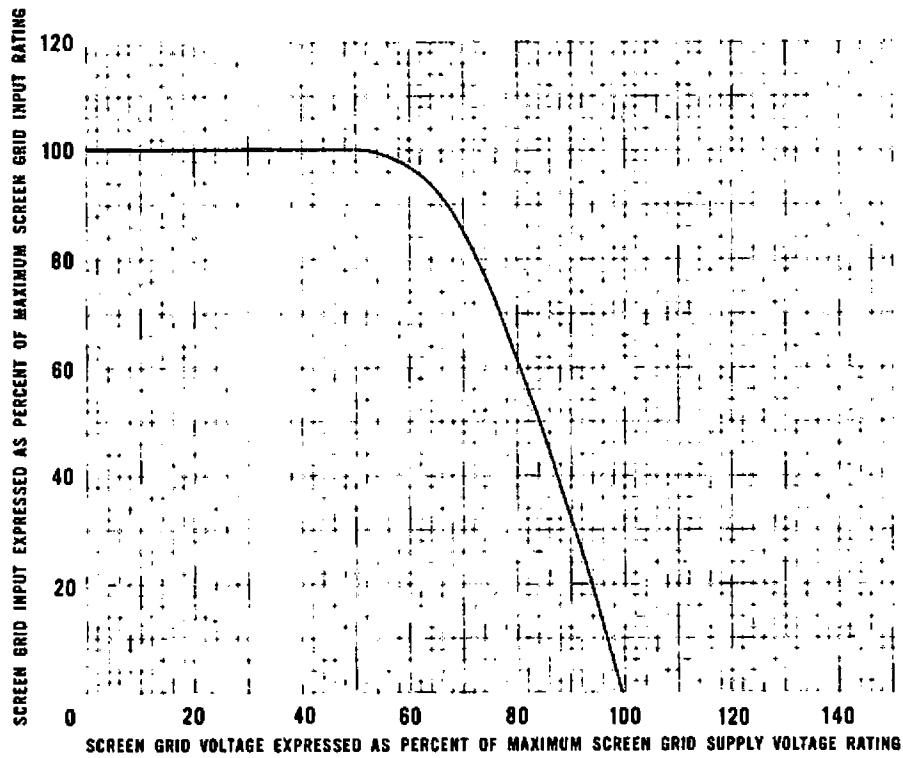
#### MAXIMUM RATINGS (Design maximum values)

|                              |              |       |
|------------------------------|--------------|-------|
| Plate voltage                | 330          | volts |
| Grid 2 voltage               | Rating Chart |       |
| Grid 2 supply voltage        | 330          | volts |
| Grid 1 voltage, positive d-c | 0            | volts |
| Plate dissipation            | 2.3          | watts |
| Grid 2 dissipation           | .55          | watts |
| Bulb temperature             | 165          | °C    |

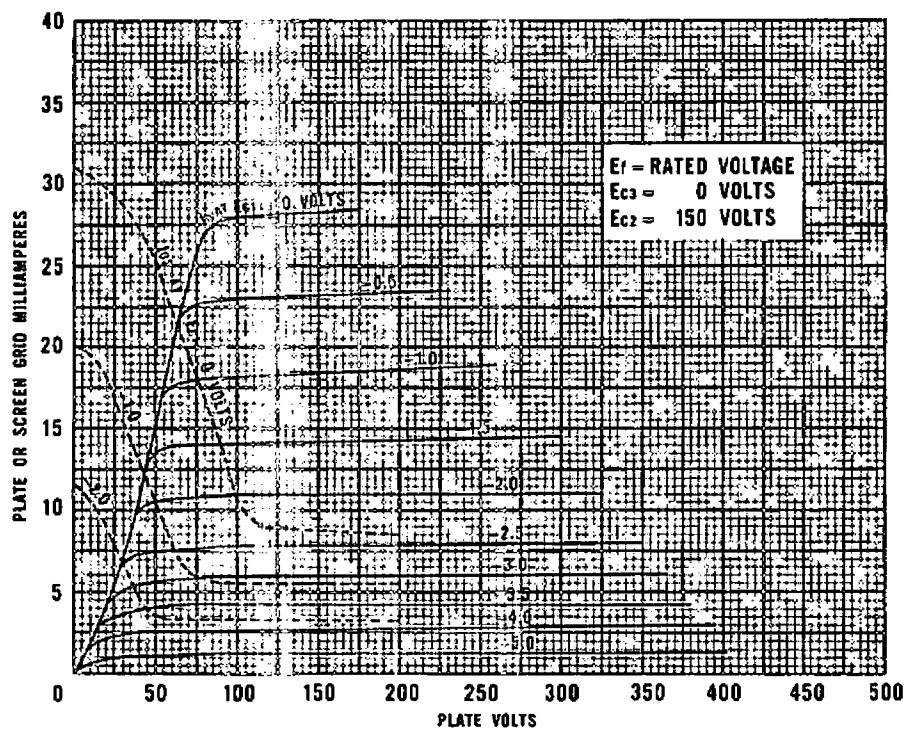
#### CHARACTERISTICS AND TYPICAL OPERATION

|                                                    |      |       |
|----------------------------------------------------|------|-------|
| Plate voltage                                      | 250  | volts |
| Grid 3 (suppressor) connected to cathode at socket |      |       |
| Grid 2 (screen) voltage                            | 150  | volts |
| Cathode bias resistor                              | 200  | ohms  |
| Plate resistance (approx.)                         | 0.6  | meg   |
| Transconductance                                   | 6000 | umhos |
| Plate current                                      | 8.5  | ma    |
| Grid 2 current                                     | 2.5  | ma    |
| Grid 1 voltage (approx) for Ib=20ua                | -8.0 | volts |

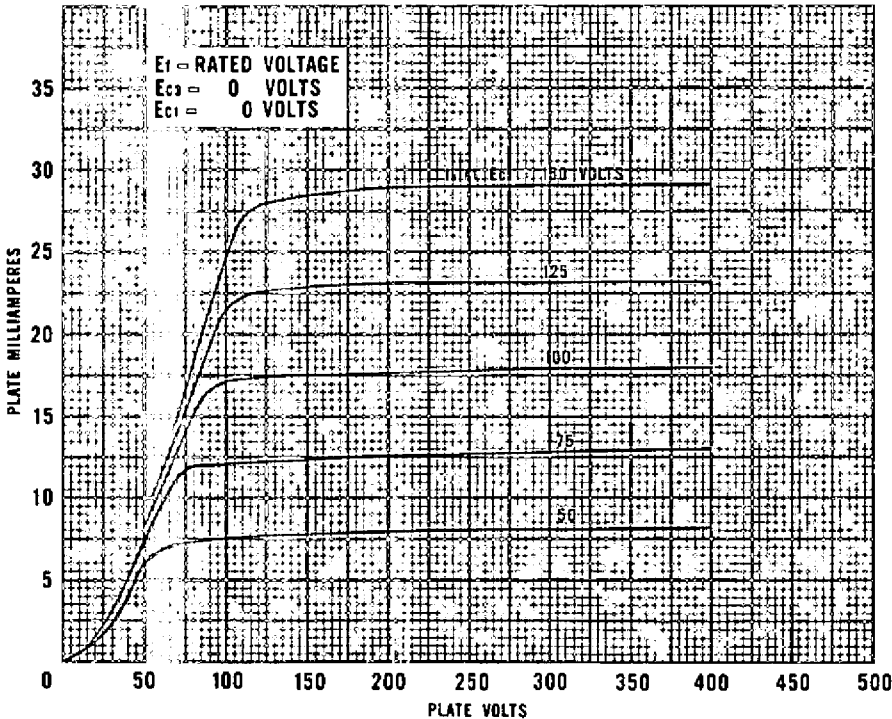
## SCREEN GRID RATING



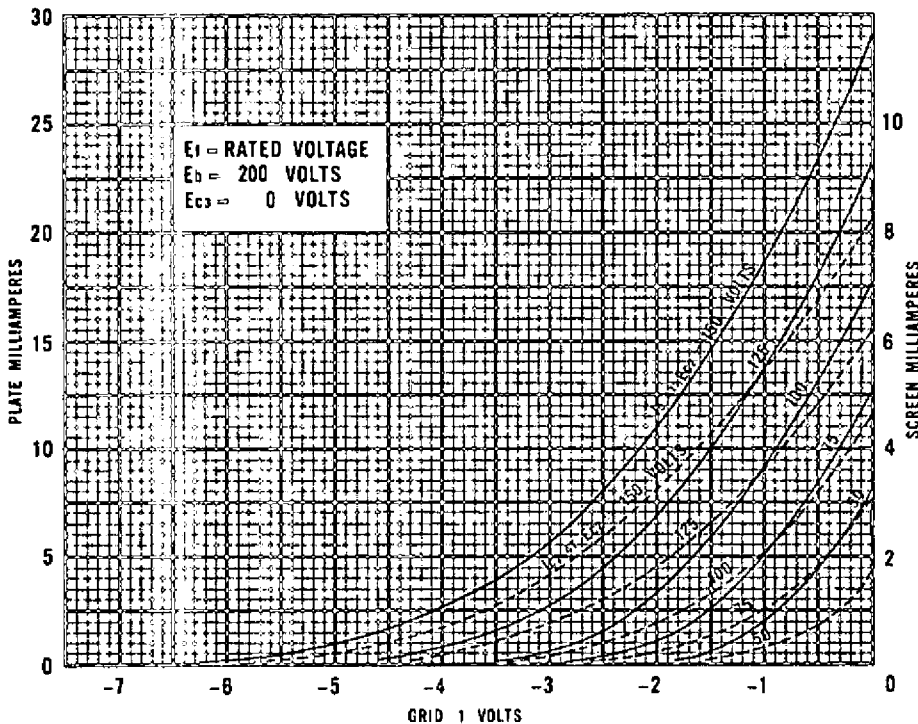
## AVERAGE PLATE CHARACTERISTICS



### AVERAGE PLATE CHARACTERISTICS



### AVERAGE TRANSFER CHARACTERISTICS





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

Ef=6.3V; Eb=250Vdc  
Ec1=0Vdc; Ec2=150Vdc; Rk=200ohms

| Reference | AQL    | Test                     | Conditions                                                                                                       | Sym.                  | Min.              | Max.               | Unit              |
|-----------|--------|--------------------------|------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------|--------------------|-------------------|
| Note 2    | Note 1 |                          |                                                                                                                  |                       |                   |                    |                   |
| 4.7.5     | 0.4    | Continuity & Short       |                                                                                                                  | ---                   | ---               | ---                | ---               |
| 4.10.8    | 2.5*   | Heater Current           |                                                                                                                  | If                    | 275               | 325                | mA                |
| 4.10.15   | 1.0    | Heater Cathode Leakage   | Ehk = +200Vdc<br>Ehk = -200Vdc                                                                                   | Ihk<br>Ihk            | ---<br>---        | 10<br>10           | uAdc<br>uAdc      |
| 4.10.6.1  | 1.0    | Grid Current (1)         |                                                                                                                  | Ic(1)                 | 0                 | -0.3               | uAdc              |
| 4.10.4.1  | 2.5    | Plate Current (1)        |                                                                                                                  | Ib(1)                 | 6.0               | 12.0               | mA                |
| 4.10.4.3  | 2.5    | Screen Grid Current      |                                                                                                                  | Ic(2)                 | 1.5               | 3.5                | mA                |
| 4.10.9    | 1.0    | Transconductance(1)      |                                                                                                                  | Sm(1)                 | 5000              | 7400               | umhos             |
| 4.8       | 2.5    | Insulation of Electrodes | E(g1-all)=100Vdc, g1 Negative<br>E(p-all)=300Vdc, p Negative                                                     | R(g1-all)<br>R(p-all) | 500<br>5000       | ---                | Meg<br>Meg        |
| 4.10.4.1  | 2.5    | Plate Current (2)        | Rk=0; Ec1= -12Vdc                                                                                                | Ib(2)                 | ---               | 100                | uAdc              |
| 4.10.9    | 2.5    | Transconductance (2)     | Ef=5.7V                                                                                                          | $\Delta$ Sm           | ---               | 15                 | %                 |
| 4.10.6.1  | 2.5    | Grid Current (2)         | Ef=7.0V; Rg1=0.1Meg, Note 3                                                                                      | Ic(2)                 | 0                 | -0.4               | uAdc              |
| 4.10.3.1  | 2.5    | RF Noise                 | Ec1= -2Vdc; Ec2=15.0 mVac;<br>Note 4                                                                             | ---                   | ---               | ---                | ---               |
| 4.10.3.4  | 2.5    | Noise and Microphonics   | Ef=6.3Vac; Ehk=0; Ebb=300Vdc<br>Ecc=150Vdc; Rp=0.01Meg<br>Rk=200 ohms; Rg1=50,000 ohms<br>Ec2=50mVac; Notes 5, 8 | M                     | ---               | ---                | ---               |
| 4.9.19.1  | 2.5*   | Vibration                | Rp=2000 ohms                                                                                                     | Ep                    | ---               | 100                | mVac              |
| 4.10.14   | 2.5*   | Capacitance              | No Shield<br>No Shield<br>No Shield                                                                              | Cgp<br>Cin<br>Cout    | ---<br>5.2<br>1.3 | .025<br>7.8<br>2.3 | uuf<br>uuf<br>uuf |

## LIFE TESTS

|        |               |                                      |                                                                                     |                        |     |     |     |
|--------|---------------|--------------------------------------|-------------------------------------------------------------------------------------|------------------------|-----|-----|-----|
| ---    | 1.0<br>Code K | Early Life Assurance Test            | Ef=6.3V; Eb=250Vdc; Ec2=150Vdc<br>Rk=200 ohms; Ehk= +200Vdc<br>Rg1 = 1.0Meg; Note 6 | ---                    | --- | --- | --- |
| ---    | ---           | Early Life Assurance Test End Points | Shorts and Continuity                                                               | ---                    | --- | --- | --- |
|        |               |                                      | Change in transconductance of individual tubes                                      | $\frac{\Delta S_m}{t}$ | --- | 10  | %   |
| 4.11.5 | ---           | Intermittent Life Test 1000 Hours    | Early Life Assurance Test Conditions, Note 7                                        | ---                    | --- | --- | --- |

| <u>Reference</u> | <u>AQL</u> | <u>Test</u>                                       | <u>Conditions</u>                                                                     | <u>Sym.</u>                           | <u>Min.</u>              | <u>Max.</u>            | <u>Unit</u>                |
|------------------|------------|---------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------|--------------------------|------------------------|----------------------------|
| 4.11.4           | ---        | Intermittent Life Test<br>End Points - 1000 hours | Inoperatives Grid Current (1)<br>Change in Transconductance(1)<br>of individual tubes | ---<br>lc(1)<br>$\Delta \frac{Sm}{t}$ | ---<br>0<br>0            | ---<br>-0.5<br>20      | ---<br>uAdc<br>%           |
|                  |            |                                                   | Transconductance(2)                                                                   | $\Delta Sm$                           | 0                        | 20                     | %                          |
|                  |            |                                                   | Heater Cathode Leakage<br>Ehk= +200Vdc<br>Ehk= -200Vdc                                | Ihk<br>Ihk                            | 0<br>0                   | 25<br>25               | uAdc<br>uAdc               |
|                  |            |                                                   | Insulation of Electrodes<br>E(g1-all)<br>E(pl-all)                                    | R(g1-all)<br>R(p-all)                 | 50<br>500                | ---<br>---             | Meg<br>Meg                 |
| 4.11.7           | ---        | Heater Cycling Life Test                          | Ef=7.5V<br>Ehk= -200Vdc<br>Cycle<br>1.0 min. on<br>4.0 min. off                       | ---                                   | ---                      | 48                     | hours                      |
| 4.11.4           | ---        | Heater Cycling Life Test<br>End Points            | Shorts & Opens<br>Heater Cathode Leakage<br>Ehk= +200Vdc<br>Ehk= -200Vdc              | ---<br>---<br>Ihk<br>Ihk              | ---<br>---<br>---<br>--- | ---<br>---<br>15<br>15 | ---<br>---<br>uAdc<br>uAdc |

#### TEST NOTES

Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics, having similar AQL's shall be combined for sampling purposes with the exception of control test. Control test is indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4.1.

Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.

Note 3: Prior to this test, tubes to be preheated five (5) minutes at conditions indicated below. Test immediately after pre-heating:

|     |     |      |      |     |     |
|-----|-----|------|------|-----|-----|
| Ef  | Ec1 | Rk   | Rg1  | Eb  | Ec2 |
| V   | Vdc | ohms | Meg  | Vdc | Vdc |
| 7.0 | 0   | 200  | 0.25 | 250 | 150 |

Note 4: The output indicator shall be a "VU" meter. The three (3) milliwatt point shall be determined as a meter deflection of 25 percent of the calibration point.

Note 5: The cathode resistor shall be shunted with capacitive reactance not exceeding three (3) ohms 60 cycles.

Note 6: Early Life Assurance Test

- Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- Serially mark all tubes of the sample.
- Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours ( $\pm 4$  hours) with the intermediate down period reading point at 20 hours ( $\pm 4$  hours) and 2 hours  $\pm 30$  minutes. Intermittent or continuous operation may be employed.
- A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

Note 7: 1000 Hour Intermittent Life Test

- a. The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test endpoint characteristic.
- b. Record the reference characteristic.
- c. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test shall be part of the 1000 hours.
- d. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- e. Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

Note 8: The rejection label shall be set at the VU meter reading obtained during calibration.



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## WIDEBAND PENTODE AMPLIFIER 7733

CBS Type 7733 is a wideband pentode amplifier which is especially designed and tested for use in measurement test equipment, instrumentation, and other applications where extreme reliability, stable characteristics, and long life are required. The 7733 is a replacement for types 12BY7 and 12BY7A. Superior performance is assured because of its improved construction, special tests, and tight minimum-maximum limits.

This electron tube has a continuous-wound coil heater which is superior to ordinary heaters both electrically and mechanically. Burn-outs are virtually eliminated, heater-cathode leakage is lower, and hum is lower. Further insurance of quality is provided by heater cycle testing.

Stable characteristics throughout life is a result of meticulous processing and selection of cathode sleeve material. Also each tube is subjected to a 48 hour burn-in period to obtain a more uniform level of performance when they are put into operational service.

An elaborate testing procedure is carried out on these tubes for confidence in their ultimate operation. There is a 100-hour early life assurance test, a special 1000-hour life test, and a 5000-hour informational life test.

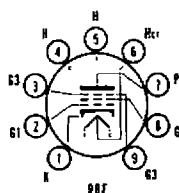
Additional mechanical features offered by CBS type 7733 include: gold plated base pins which prevent oxidation and improve base pin contact; precisely made and fitted parts in stronger structures for lower noise and microphonism; and electrical features include: grid current test, knee test, reduced heater voltage plate current test, and life tested plate current.

### MECHANICAL DATA

|                              |                        |
|------------------------------|------------------------|
| Cathode, coated unipotential |                        |
| Bulb                         | T-6 1/2                |
| Outline                      | JEDEC 6-3              |
| Base                         | Miniature 9-pin (E9-1) |
| Basing                       | 9BF                    |
| Mounting position            | Any                    |

### PIN CONNECTIONS

|                          |
|--------------------------|
| Pin 1: Cathode           |
| Pin 2: Grid 1            |
| Pin 3: Grid 3, I.S.      |
| Pin 4: Heater            |
| Pin 5: Heater            |
| Pin 6: Heater Center Tap |
| Pin 7: Plate             |
| Pin 8: Grid 2            |
| Pin 9: Grid 3, I.S.      |



### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                             |                |       |
|-----------------------------|----------------|-------|
| Voltage, a-c or d-c         | 12. 6/6. 3±10% | volts |
| Current                     | 300/600        | ma    |
| Peak heater-cathode voltage |                |       |
| Heater negative to cathode  | 200            | volts |
| Heater positive to cathode* | 200            | volts |

\*D-c component must not exceed 100 volts.

#### DIRECT INTERELECTRODE CAPACITANCES

|                              |      |     |
|------------------------------|------|-----|
| Grid to plate: g1 to p, max. | .063 | uuf |
| Input: g1 to k+h+g2+g3+i. s. | 10.7 | uuf |
| Output: p to k+h+g2+g3+i. s. | 4.0  | uuf |

#### MAXIMUM RATINGS (Design maximum values)

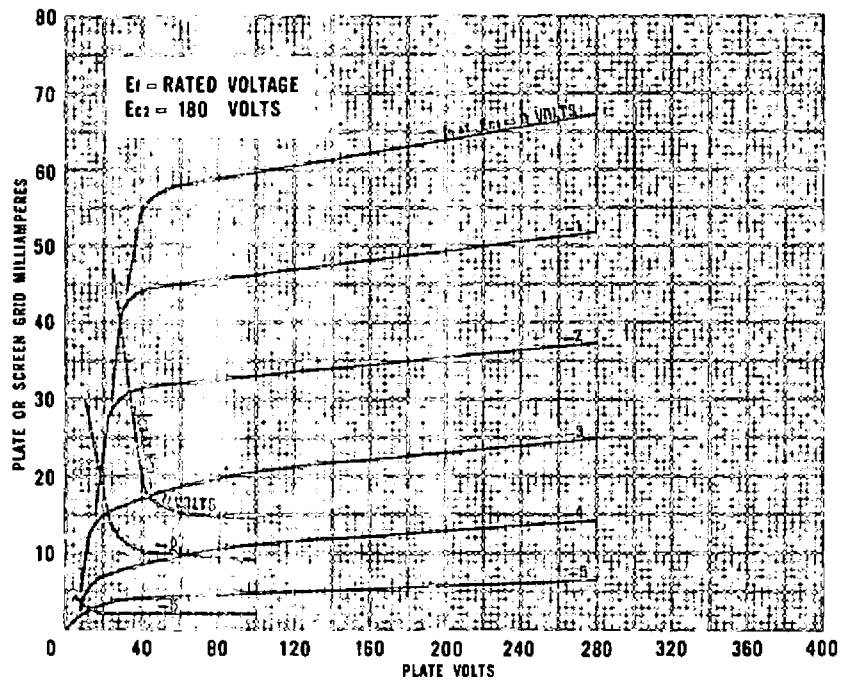
|                              |      |       |
|------------------------------|------|-------|
| Plate voltage                | 330  | volts |
| Grid 2 voltage               | 190  | volts |
| Grid 1 voltage, negative d-c | -55  | volts |
| Grid 1 voltage, positive d-c | 0    | volts |
| Plate dissipation            | 6.5  | watts |
| Grid 2 dissipation           | 1.2  | watts |
| Grid 1 circuit resistance    |      |       |
| Fixed bias                   | 0.25 | meg   |
| Self bias                    | 1.0  | meg   |
| Bulb temperature             | 165  | °C    |

#### CHARACTERISTICS AND TYPICAL OPERATION

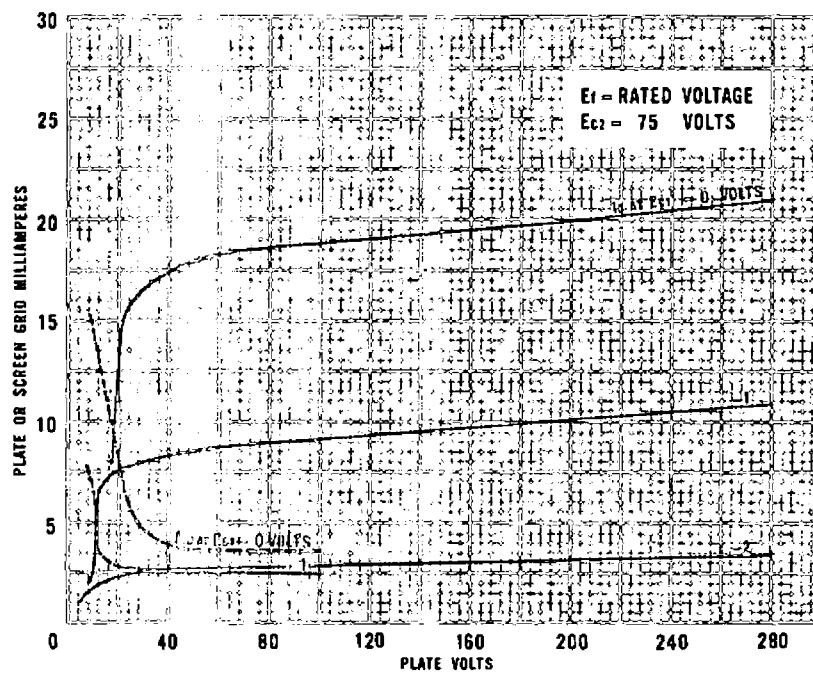
##### Class A Amplifier

|                                                    |       |       |
|----------------------------------------------------|-------|-------|
| Plate voltage                                      | 250   | volts |
| Grid 3 (suppressor) connected to cathode at socket |       |       |
| Grid 2 (screen voltage)                            | 180   | volts |
| Cathode bias resistor                              | 100   | ohms  |
| Plate resistance (approx. )                        | 90000 | ohms  |
| Transconductance                                   | 12000 | umhos |
| Plate current                                      | 24    | ma    |
| Grid 2 current                                     | 5.0   | ma    |
| Grid 1 voltage (approx. ) for Ib=20ua              | -8    | volts |
| Amplification factor (g1 to g2)                    | 31.5  |       |

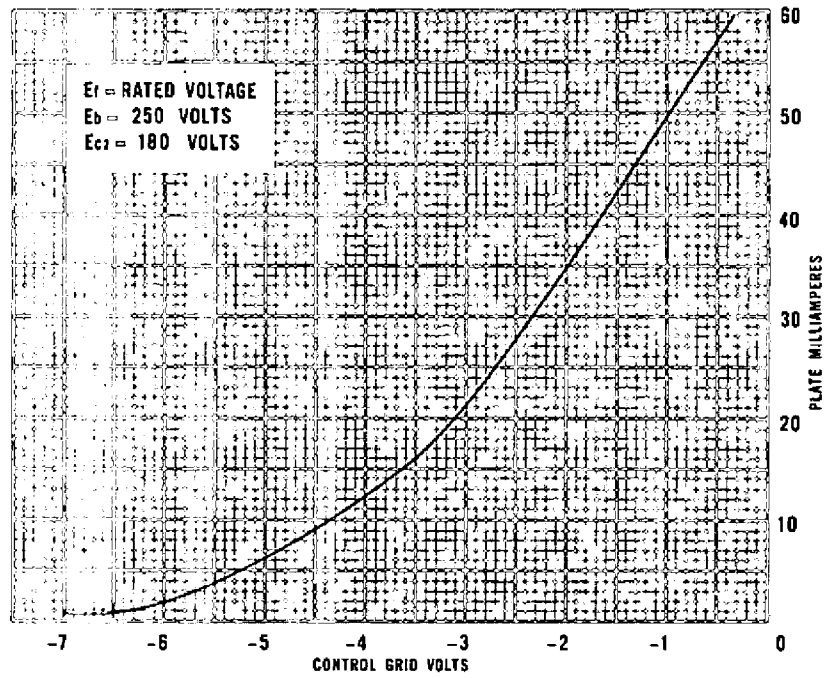
## AVERAGE PLATE CHARACTERISTICS



## AVERAGE PLATE CHARACTERISTICS



## AVERAGE TRANSFER CHARACTERISTICS





# CUSTOMER ACCEPTANCE SPECIFICATION

## Test Conditions

12.6 series connection or 6.3 parallel connection

$E_b = 250 \text{ Vdc}$ ,  $E_{c2} = 180 \text{ Vdc}$   
 $E_{c1} = 0 \text{ Vdc}$ ,  $R_k = 100 \text{ ohms}$

| Reference<br>Note 2 | AQL<br>Note 1 | Test                     | Conditions                                                                                                                                                                  | Sym.                              | Min.       | Max.                 | Unit                                               |
|---------------------|---------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------|----------------------|----------------------------------------------------|
| 4.7.5               | 0.4           | Continuity & Short       |                                                                                                                                                                             | ---                               | ---        | ---                  | ---                                                |
| 4.10.8              | 2.5*          | Heater Current           | $E_f = 12.6 \text{ V}$<br>$E_f = 6.3 \text{ V}$                                                                                                                             | $I_f$<br>$I_f$                    | 275<br>570 | 325<br>630           | $\text{mA}$<br>$\text{mA}$                         |
| 4.10.15             | 1.0           | Heater Cathode Leakage   | $E_{hk} = +200 \text{ Vdc}$<br>$E_{hk} = -200 \text{ Vdc}$                                                                                                                  | $I_{hk}$<br>$I_{hk}$              | ---        | 10<br>10             | $\mu\text{A}$<br>$\mu\text{A}$                     |
| 4.10.6.1            | 1.0           | Grid Current (1)         |                                                                                                                                                                             | $I_{c(1)}$                        | 0          | -0.5                 | $\mu\text{A}$                                      |
| 4.10.4.1            | 1.0           | Plate Current (1)        |                                                                                                                                                                             | $I_{b(1)}$                        | 19         | 31                   | $\text{mA}$                                        |
| 4.10.4.3            | 2.5           | Screen Grid Current      |                                                                                                                                                                             | $I_{c2}$                          | 3.5        | 8.5                  | $\text{mA}$                                        |
| 4.10.9              | 2.5           | Transconductance (1)     |                                                                                                                                                                             | $S_m(1)$                          | 8500       | 13500                | $\mu\text{mhos}$                                   |
| ---                 | 2.5           | Knee Determination       | $E_{bb}$ vary, $E_{cc2}=150 \text{ Vdc}$<br>$R_{g1}=2.2 \text{ meg}$ , $E_{cc1}=0$                                                                                          | $K_n$                             | ---        | 50                   | $\text{Vdc}$                                       |
| 4.8                 | 2.5           | Insulation of Electrodes | $E_{(g1-all)}=100 \text{ Vdc}$ , $g1$ negative<br>$E_{(p-all)}=300 \text{ Vdc}$ , $p$ Negative                                                                              | $R_{(g1-all)}$<br>$R_{(p-all)}$   | 100<br>100 | ---                  | $\text{Meg}$<br>$\text{Meg}$                       |
| 4.10.4.1            | 2.5           | Plate Current (2)        | $R_k=0$ , $E_{c1} = -16 \text{ Vdc}$                                                                                                                                        | $I_{b(2)}$                        | ---        | 40                   | $\mu\text{A}$                                      |
| 4.10.9              | 2.5           | Plate Current (2)        | $E_f = 5.7 \text{ V}$ or $11.4$                                                                                                                                             | $\Delta I_b$                      | ---        | 15                   | %                                                  |
| 4.10.6.1            | 2.5           | Grid Current (2)         | $E_f=7.0 \text{ V}$ or $13.8$ , $R_{g1}=0.1 \text{ Meg}$<br>Note 3                                                                                                          | $I_{c(2)}$                        | 0          | -1.5                 | $\mu\text{A}$                                      |
| 4.10.3.4            | 2.5           | Noise & Microphonics     | $R_{g1}=50 \text{ K}$ , $E_{bb}=300 \text{ V}$ , $R_p=10 \text{ K}$<br>$E_{cc2}=180 \text{ Vdc}$ , $R_k=0$ ; $E_{cc} = -5 \text{ V}$<br>$E_{cal}=30 \text{ mVac}$ , Notes 4 | $M$                               | ---        | ---                  | ---                                                |
| 4.10.4.1            | 2.5*          | Plate Current (3)        | $E_b=65 \text{ Vdc}$ , $E_{c2}=150 \text{ Vdc}$<br>$E_{c1}=0$ ; $R_k=0$ , Note 7                                                                                            | $I_{b(3)}$                        | 30         | 70                   | $\text{mA}$                                        |
| 4.9.19.1            | 2.5*          | Vibration                | $R_p=2000 \text{ ohms}$                                                                                                                                                     | $E_p$                             | ---        | 100                  | $\text{mVac}$                                      |
| 4.10.14             | 2.5*          | Capacitance              | No Shield<br>No Shield<br>No Shield                                                                                                                                         | $C_{gp}$<br>$C_{in}$<br>$C_{out}$ | ---        | 0.063<br>12.4<br>4.5 | $\mu\text{uf}$<br>$\mu\text{uf}$<br>$\mu\text{uf}$ |

## LIFE TESTS

|     |                  |                              |                                                                                                                                                                                             |     |     |     |     |
|-----|------------------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|
| --- | 1.0<br>Code<br>K | Early Life Assurance<br>Test | $E_f=6.3 \text{ V}$ or $12.6 \text{ V}$<br>$E_b=250 \text{ Vdc}$<br>$E_{c2}=180 \text{ Vdc}$<br>$R_k=100 \text{ ohms}$ , $E_{hk} = -200 \text{ Vdc}$ ,<br>$R_{g1}=1.0 \text{ Meg}$ , Note 5 | --- | --- | --- | --- |
|-----|------------------|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|-----|

| <u>Reference</u> | <u>AQL</u> | <u>Test</u>                                    | <u>Conditions</u>                                                      | <u>Sym.</u>               | <u>Min.</u> | <u>Max.</u> | <u>Unit</u> |
|------------------|------------|------------------------------------------------|------------------------------------------------------------------------|---------------------------|-------------|-------------|-------------|
| ---              | ---        | Early Life Assurance Test End Points           | Shorts and Continuity                                                  | ---                       | ---         | ---         | ---         |
|                  |            |                                                | Change in Plate Current of Individual Tubes                            | $\Delta \frac{I_b}{t}$    | ---         | 10          | %           |
| 4.11.5           | ---        | Intermittent Life Test 1000 Hours              | Early Life Assurance Test Conditions, Note 6                           | ---                       | ---         | ---         | ---         |
| 4.11.4           | ---        | Intermittent Life Test End Points - 1000 hours | Inoperatives                                                           | ---                       | ---         | ---         | ---         |
|                  |            |                                                | Grid Current (1)                                                       | Ic(1)                     | 0           | -1.5        | uAdc        |
|                  |            |                                                | Change in Plate Current (1) of individual tubes                        | $\Delta \frac{I_b(1)}{t}$ | 0           | 20          | %           |
|                  |            |                                                | Heater Cathode Leakage                                                 |                           |             |             |             |
|                  |            |                                                | Ehk= +200Vdc                                                           | Ihk                       | 0           | 20          | uAdc        |
|                  |            |                                                | Ehk= -200 Vdc                                                          | Ihk                       | 0           | 20          | uAdc        |
|                  |            |                                                | Insulation of Electrodes                                               |                           |             |             |             |
|                  |            |                                                | E(gl-all)                                                              | R(gl-all)                 | 50          | ---         | Meg         |
|                  |            |                                                | E(pl-all)                                                              | R(P-all)                  | 50          | ---         | Meg         |
| 4.11.7           | ---        | Heater Cycling Life Test                       | Ef=7.0V or 13.8V<br>Ehk= -200V<br>Cycle<br>1.0 Min. on<br>4.0 Min. off | ---                       | ---         | 48          | hours       |
| 4.11.4           | ---        | Heater Cycling Life Test End Points            | Shorts & Opens Heater Cathode Leakage                                  | ---                       | ---         | ---         | ---         |
|                  |            |                                                | Ehk = +200 Vdc                                                         | Ihk                       | ---         | 15          | uAdc        |
|                  |            |                                                | Ehk = -200 Vdc                                                         | Ihk                       | ---         | 15          | uAdc        |

#### TEST NOTES

Note 1: Lots of CBS Electronics tubes may be sampled using MIL-STD-105A sampling tables for the specified AQL. All characteristics, having similar AQL's, shall be combined for sampling purposes with the exception of control test. Control test is indicated by an asterisk (\*). The term AQL, as used on the specification, is defined in MIL-STD-105A, paragraph 4.1.

Note 2: References are paragraphs in MIL-E-1D specification, dated 31 March 1958.

Note 3: Prior to this test, tubes to be preheated five (5) minutes at conditions indicated below. Test immediately after preheating:

| Ef   | Ecl | Rk   | Rgl | Eb  | Ec2 |
|------|-----|------|-----|-----|-----|
| V    | Vdc | ohms | Meg | Vdc | Vdc |
| 7.0  | 0   | 100  | 0.1 | 250 | 180 |
| or   |     |      |     |     |     |
| 13.8 |     |      |     |     |     |

Note 4: Rejection point shall be VU reading obtained during calibration.

Note 5: Early Life Assurance Test

- Life test samples shall be selected from a lot at random in such a manner as to be representative of the lot. If such selection results in a sample containing tubes which are outside the initial specification limits for the relevant life test endpoint characteristics, such tubes shall be replaced by randomly selected acceptable tubes.
- Serially mark all tubes of the sample.
- Record reference characteristic measurements on the entire sample after a maximum operation of 15 minutes under specified voltage and current conditions.
- The Early Life Assurance Test sample shall be operated at specified conditions or equivalent for 100 hours (+ 4 hours) with the intermediate down period reading point at 20 hours (+ 4 hours) and 2 hours + 30 minutes. Intermittent or continuous operation may be employed.

- e. A defective shall be defined as a tube having failed the shorts and continuity test or a tube having a change in referenced characteristic greater than that specified.

Note 6: 1000 Hour Intermittent Life Test

- a. The sample size shall be 10 tubes and shall be selected from the first 10 lowest number tubes which have successfully passed the Early Life Assurance Test and meet the initial test endpoint characteristic.
- b. Record the reference characteristic.
- c. Place the sample on life test with the specified operating conditions for 1000 hours with the intermediate down period reading points at  $250 \pm 24$  hours,  $500 \pm 24$  hours and  $750 \pm 24$  hours. The 100 hours of Early Life Assurance Test — shall be part of the 1000 hours.
- d. Acceptance criteria - The sample is acceptable if it has earned a total of 9000 tube hours. The total number of tube hours is the sum of the successful operating hours of each tube.
- e. Quarterly, the life test sample shall be continued to 5000 hours with interim reading points at each 1000 hours. This test will be run to determine long life capabilities.

Note 7: Plate current  $I_b(3)$  reading shall be an instantaneous reading.

Note 8: The rejection level shall be set at the VU meter reading obtained during calibration.



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Melrose Park, Ill., 1990 N. Mannheim Road, EStebrook 9-2100 • Atlanta, Georgia, Cary Chapman and Co., 672 Whitehall St., SW., JAckson 4-7388  
Minneapolis, Minn., The Helmann Co., 1711 Hawthorne Avenue, FEderal 2-5457 • Los Angeles, Calif., 2120 S. Garfield Avenue, RAymond 3-9081

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# technical information

## CBS ELECTRONICS

A Division of Columbia Broadcasting System, Inc.  
Danvers, Massachusetts

### TENTATIVE DATA

E235L/7751

The E235L is a reliable beam power pentode with long life (over 10,000 hours). Its characteristics are held to narrow limits and the cathode is free from interface formation.

This tube has low internal resistance at zero grid bias, and it is especially designed as a switching tube for pulsed equipment, as a pass tube in regulated power supplies, and other power tube applications (especially for low anode and screen grid voltages).

### MECHANICAL DATA

|                              |             |
|------------------------------|-------------|
| Cathode, coated unipotential |             |
| Base                         | Octal       |
| Maximum overall height       | 4.14 inches |
| Maximum seated height        | 3.38 inches |
| Maximum diameter             | 1.3 inches  |
| Mounting position            | Any         |

### PIN CONNECTIONS 7AC

|        |        |        |                 |
|--------|--------|--------|-----------------|
| Pin 1: | N.C.   | Pin 5: | Grid 1          |
| Pin 2: | Heater | Pin 6: | N.C.            |
| Pin 3: | Plate  | Pin 7: | Heater          |
| Pin 4: | Grid 2 | Pin 8: | Cathode, Grid 3 |

### ELECTRICAL DATA

#### HEATER CHARACTERISTICS

|                             |     |       |
|-----------------------------|-----|-------|
| Heater voltage              | 6.3 | volts |
| Heater current              | 1.2 | amps  |
| Peak heater-cathode voltage |     |       |
| Heater negative to cathode  | 200 | volts |
| Heater positive to cathode  | 250 | volts |

## DIRECT INTERELECTRODE CAPACITANCES

|                       |      |               |
|-----------------------|------|---------------|
| Input                 | 17.5 | $\mu\text{f}$ |
| Output                | 9.0  | $\mu\text{f}$ |
| Grid 1 to plate, max. | 1.3  | $\mu\text{f}$ |

## MAXIMUM RATINGS (Absolute maximum values)

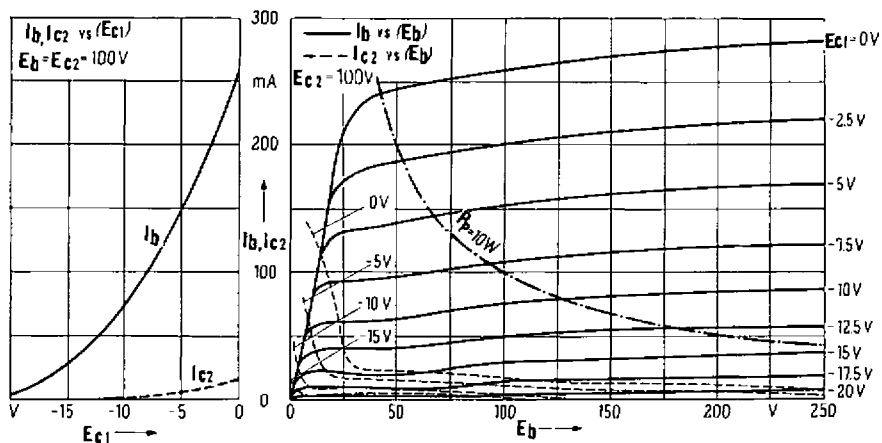
|                                          |        |                    |
|------------------------------------------|--------|--------------------|
| Plate supply voltage, zero plate current | 550    | volts              |
| Plate voltage, d-c                       | 250    | volts              |
| Grid 2 supply voltage, zero grid current | 550    | volts              |
| Grid 2 voltage, d-c                      | 250    | volts              |
| Plate dissipation                        | 10     | watts              |
| Grid 2 dissipation                       | 5      | watts              |
| Plate and grid 2 total dissipation       | 13     | watts              |
| Cathode current                          | 200    | ma                 |
| Grid 1 circuit resistance                | 0.5    | meg                |
| Heater-Cathode external resistance       | 20,000 | ohms               |
| Bulb temperature                         | 220    | $^{\circ}\text{C}$ |

## CHARACTERISTICS

|                                                 |        |                  |
|-------------------------------------------------|--------|------------------|
| Plate supply voltage                            | 100    | volts            |
| Grid 2 voltage, zero signal                     | 100    | volts            |
| Grid 1 voltage                                  | -8.2   | volts            |
| Plate current                                   | 100    | ma               |
| Grid 2 current                                  | 7.0    | ma               |
| Transconductance                                | 14,000 | $\mu\text{mhos}$ |
| Plate resistance                                | 5,000  | ohms             |
| Grid 2 amplification factor                     | 5.6    | ---              |
| Internal resistance, zero grid bias             | 100    | ohms             |
| Plate current, $E_{c1} = -35\text{V}$ (approx.) | 0.1    | ma               |

# TRANSFER CHARACTERISTICS

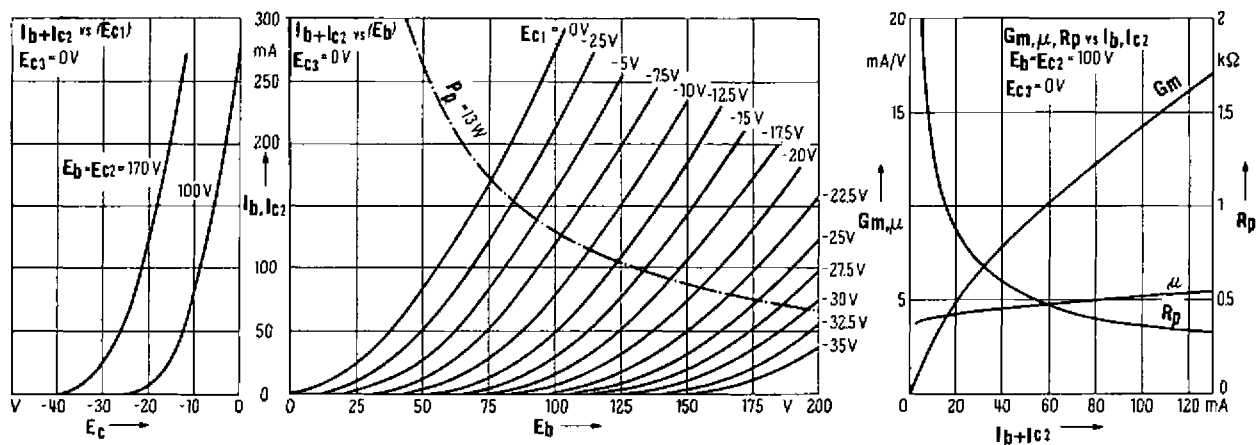
# PLATE CHARACTERISTICS



# \*TRANSFER CHARACTERISTICS

# \*PLATE CHARACTERISTICS

# \*CHARACTERISTICS



# \*TRIODE CONNECTED

AUGUST 1960

**7817**

# PHOTOMULTIPLIER



The CBS Type 7817 supersedes and is a direct replacement for CBS Type CL-1002. Type 7817 is a 10-stage, 2 inch diameter, end-on photomultiplier sensitive to the blue region of the spectrum. The faceplate is plano-concave with the photocathode deposited on the curved surface. This design insures excellent uniformity of response across the face of the tube. Use of the curved photocathode in conjunction with the linear multiplier structure provides short transit time spread. The tube utilizes silver magnesium dynodes. Type 7817 is intended for use in scintillation counting, spectroscopy, photometry and flying spot scanner applications.

## GENERAL DATA

|                                                                |                                                                       |
|----------------------------------------------------------------|-----------------------------------------------------------------------|
| Spectral Response                                              | S-11                                                                  |
| Photocathode                                                   | Semi-transparent                                                      |
| Photocathode Window                                            | Circular end-on type                                                  |
| Window Diameter                                                | 1.745 inches (min.)                                                   |
| Window Index of Refraction                                     | 1.51                                                                  |
| Tube Diameter                                                  | 2±1/16 inches                                                         |
| Overall Length                                                 | 5-5/8±1/8 inches                                                      |
| Seated Height to Center of Window                              | 4-7/8±1/8 inches                                                      |
| Mounting Position                                              | Any                                                                   |
| Weight (approximate)                                           | 179 gm.                                                               |
| Base                                                           | Medium shell diheptal<br>14 pin (JETEC No. B14-38)<br>Non-Hygroscopic |
| Wavelength at Maximum Response                                 | 4400±500 angstroms                                                    |
| Wavelength at 10% of Maximum Response on Long Wavelength Side  | 6125±275 angstroms                                                    |
| Wavelength at 10% of Maximum Response on Short Wavelength Side | 3250±250 angstroms                                                    |

## MAXIMUM RATINGS

|                                                                                                                                                                                                                        | Units      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Supply Voltage (DC or peak AC) between Anode and Cathode                                                                                                                                                               | 2000 volts |
| Supply Voltage (DC or peak AC) between Last Dynode and Anode                                                                                                                                                           | 250 volts  |
| Supply Voltage (DC or peak AC) between Cathode and First Dynode                                                                                                                                                        | 400 volts  |
| Supply Voltage (DC or peak AC) between Cathode and Focusing Electrode (See Note 5)                                                                                                                                     | 400 volts  |
| Average Anode Current (See Note 6)                                                                                                                                                                                     | 5 ma       |
| Average Anode Dissipation (See Note 6)                                                                                                                                                                                 | 1 watt     |
| Environmental Conditions (Non-operating):<br>Ambient Storage Temperature +75 °C<br>Shock: 40 g, 11 ms. duration (See Note 7)<br>Vibration: 0.35" double amplitude displacement:<br>0-25 cycles<br>10 g: 25-2000 cycles |            |

(See Notes 7, 8)



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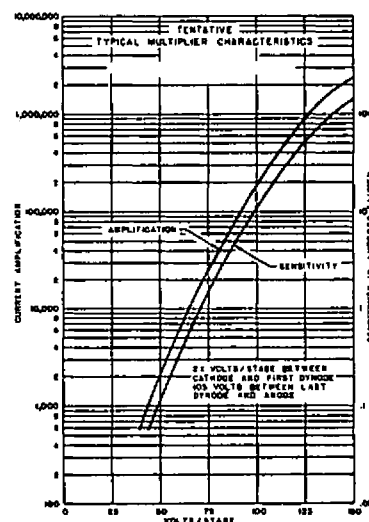
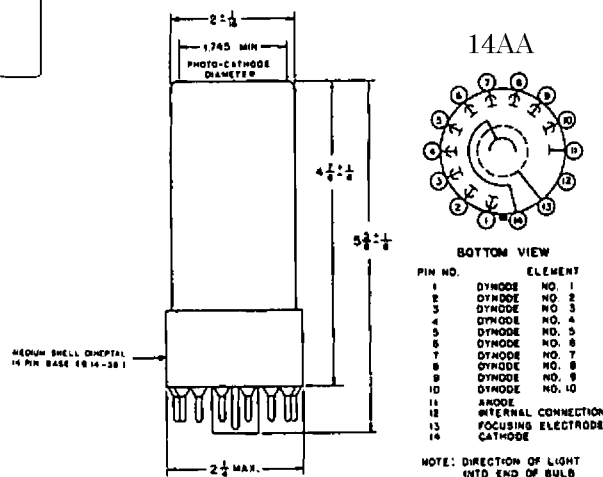
TYPE  
7817

# CHARACTERISTIC ELECTRICAL DATA

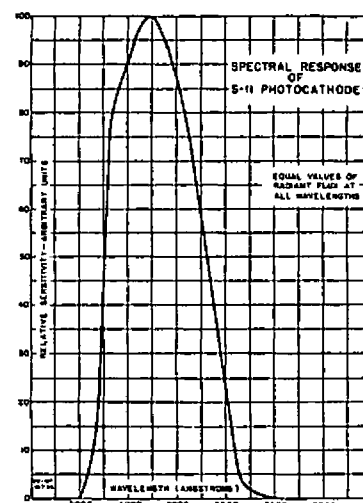
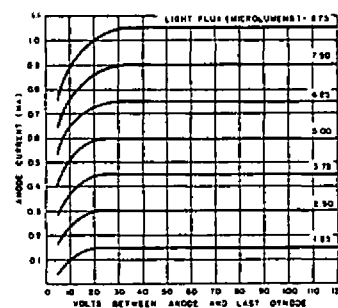
|                                                                                        | Min.                | Avg.                  | Max. | Units     |
|----------------------------------------------------------------------------------------|---------------------|-----------------------|------|-----------|
| Cathode Radiant Sensitivity at 4400 Å                                                  |                     | .056                  |      | μa/μw     |
| Cathode Luminous Sensitivity                                                           | 50                  | 80                    |      | μa/lumen  |
| Anode Radiant Sensitivity at 4400 Å, 1250 volts between cathode and anode (See Note 3) |                     | $1.26 \times 10^{-2}$ |      | amp/μw    |
| Anode Luminous Sensitivity 1250 volts between cathode and anode                        | 4                   | 13.5                  |      | amp/lumen |
| 1750 volts between cathode and anode                                                   | 30                  | 120                   |      | amp/lumen |
| (See Notes 1, 3, 5)                                                                    |                     |                       |      |           |
| Last Dynode Luminous Sensitivity 1250 volts between cathode and anode                  |                     | 9                     |      | amp/lumen |
| 1750 volts between cathode and anode                                                   |                     | 90                    |      | amp/lumen |
| (See Notes 1, 3)                                                                       |                     |                       |      |           |
| Current Amplification 1250 volts between cathode and anode                             |                     | 170,000               |      |           |
| 1750 volts between cathode and anode                                                   |                     | 2,000,000             |      |           |
| (See Notes 3, 5)                                                                       |                     |                       |      |           |
| Equivalent Anode Dark Current Input                                                    | $2 \times 10^{-10}$ | $2 \times 10^{-9}$    |      | lumen     |
| (See Notes 1, 4)                                                                       |                     |                       |      |           |
| Interelectrode Capacitances                                                            |                     |                       |      |           |
| a) Anode to all other electrodes                                                       | 3.2                 |                       |      | μmf       |
| b) Anode to last dynode                                                                | 2.8                 |                       |      | μmf       |
| Time Jitter over Full Cathode (See Note 9)                                             | 3                   |                       |      | mμs       |
| Anode Pulse Rise Time                                                                  |                     |                       |      |           |
| With 1 mm diam. illuminated on tube face                                               | 2.5                 |                       |      | mμs       |
| With full cathode illuminated                                                          | 4                   |                       |      | mμs       |
| (See Note 10)                                                                          |                     |                       |      |           |

## NOTES

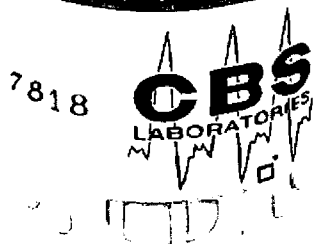
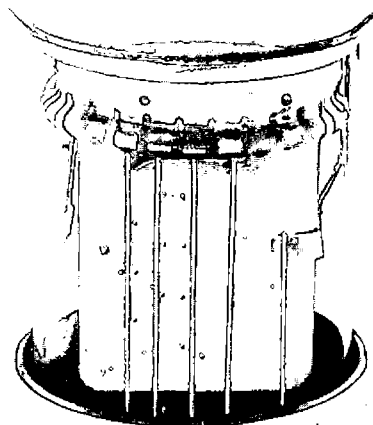
- Note 1: The light source is a tungsten filament lamp operated at a color temperature of 2870°K.
- Note 2: Measured at 0 cps with 210 volts applied between cathode and all other electrodes connected together.
- Note 3: The applied voltage, V, is distributed in the following manner: 1/6 of V between cathode and dynode 1, 1/12 of V between succeeding dynodes, 1/12 of V between dynode 10 and anode. Improved pulse energy resolution and gain stability can be obtained if voltage between cathode and dynode 1 is set at four times that between succeeding stages; this mode of operation is recommended for all scintillation spectrometry work.
- Note 4: Measured at 25°C with supply voltage adjusted to give an anode luminous sensitivity of 20 amperes per lumen.
- Note 5: The focusing electrode should be varied between photocathode and dynode 1 potentials for optimum photoelectron collection efficiency. Best gain and pulse energy resolution are usually obtained with shield potential above cathode 80% of cathode - dynode 1 potential.
- Note 6: Average over a 30 second interval maximum.
- Note 7: Test performed, with no voltage applied, in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.
- Note 8: Test performed, with no voltage applied, through three complete cycles at three minutes per cycle in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.
- Note 9: Jitter is greatest delay between anode pulses due to position from which electrons are simultaneously released within a circle on tube face of specified diameter.
- Note 10: Measured between 10% and 90% of anode pulse height.



TENTATIVE AVERAGE ANODE CHARACTERISTIC  
VOLTS / STAGE = 100



SEPTEMBER 1960


**7818**

# PHOTOMULTIPLIER

The CBS Type 7818 supersedes and is a direct replacement for CBS Type CL-1003. Type 7818 is a 10-stage, 3-inch diameter, end-on photomultiplier sensitive to the blue region of the spectrum. The faceplate is plano-concave with the photocathode deposited on the curved surface. This design insures very good uniformity of response across the face of the tube. Use of the curved photocathode in conjunction with the linear multiplier structure provides short transit time spread. Silver-magnesium dynodes are used.

Type 7818 is particularly applicable in scintillation counting when large crystals are to be used. Other applications include flying spot scanners and photometric instruments.

## GENERAL DATA

|                                                                |                                                                       |
|----------------------------------------------------------------|-----------------------------------------------------------------------|
| Spectral Response                                              | S-11                                                                  |
| Photocathode                                                   | Semi-transparent                                                      |
| Photocathode Window                                            | Circular end-on type                                                  |
| Window Diameter                                                | 2.703 inches (min.)                                                   |
| Window Index of Refraction                                     | 1.51                                                                  |
| Tube Diameter                                                  | $3 \pm 3/32$ inches                                                   |
| Overall Length                                                 | $6-1/8 \pm 1/8$ inches                                                |
| Seated Height to Center of Window                              | $5-3/8 \pm 1/8$ inches                                                |
| Mounting Position                                              | Any                                                                   |
| Weight (approximate)                                           | 245 gm.                                                               |
| Base                                                           | Medium shell diheptal<br>14 pin (JEDEC No. B14-38)<br>Non-Hygroscopic |
| Wavelength at Maximum Response                                 | $4400 \pm 500$ angstroms                                              |
| Wavelength at 10% of Maximum Response on Long Wavelength Side  | $6125 \pm 275$ angstroms                                              |
| Wavelength at 10% of Maximum Response on Short Wavelength Side | $3250 \pm 250$ angstroms                                              |

## MAXIMUM RATINGS

|                                                                                                                                                                                                                | Units                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Supply Voltage (DC or peak AC) between Anode and Cathode                                                                                                                                                       | 2000 volts                          |
| Supply Voltage (DC or peak AC) between Last Dynode and Anode                                                                                                                                                   | 250 volts                           |
| Supply Voltage (DC or peak AC) between Cathode and First Dynode                                                                                                                                                | 400 volts                           |
| Supply Voltage (DC or peak AC) between Cathode and Focusing Electrode (See Note 5)                                                                                                                             | 400 volts                           |
| Average Anode Current (See Note 6)                                                                                                                                                                             | 5 ma                                |
| Average Anode Dissipation (See Note 6)                                                                                                                                                                         | 1 watt                              |
| Environmental Conditions (Non-operating):<br>Ambient Storage Temperature $+75^{\circ}\text{C}$<br>Shock: 40 g, 11 ms. duration (See Note 7)<br>Vibration: 0.35" double amplitude displacement:<br>(See Note 8) | 0-25 cycles<br>10 g: 25-2000 cycles |

from JEDEC release #3006, Oct. 24, 1960

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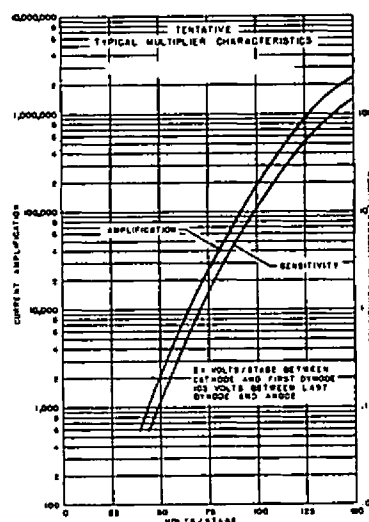
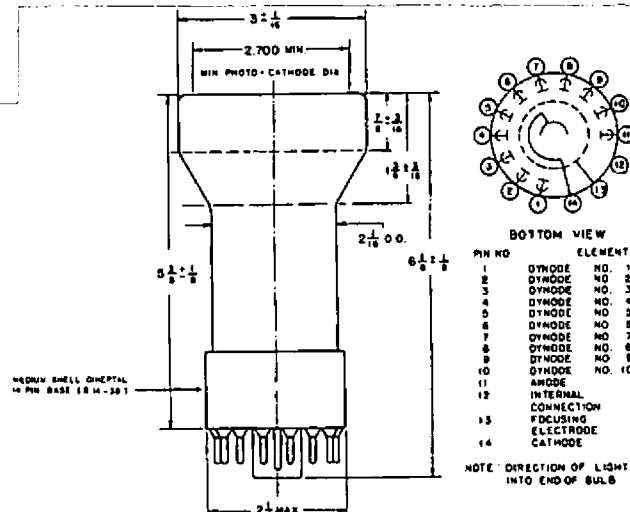
**TYPE  
7818**

**CHARACTERISTIC  
ELECTRICAL DATA**

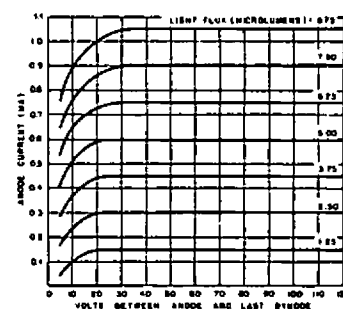
|                                                                                        | Min. | Avg.                 | Max.               | Units                      |
|----------------------------------------------------------------------------------------|------|----------------------|--------------------|----------------------------|
| Cathode Radiant Sensitivity at 4400 Å                                                  |      | .060                 |                    | $\mu\text{A}/\mu\text{W}$  |
| Cathode Luminous Sensitivity                                                           | 50   | 70                   |                    | $\mu\text{A}/\text{lumen}$ |
| Variation in Cathode Luminous Sensitivity over entire cathode (See Note 5)             |      | $\pm 20$             |                    | %                          |
| Anode Radiant Sensitivity at 4400 Å, 1250 volts between cathode and anode (See Note 3) |      | $1.2 \times 10^{-2}$ |                    | $\text{amp}/\mu\text{W}$   |
| Anode Luminous Sensitivity 1250 volts between cathode and anode                        | 4    | 13.5                 |                    | $\text{amp}/\text{lumen}$  |
| 1750 volts between cathode and anode (See Notes 1, 3, 5)                               | 30   | 120                  |                    | $\text{amp}/\text{lumen}$  |
| Last Dynode Luminous Sensitivity 1250 volts between cathode and anode                  |      | 9                    |                    | $\text{amp}/\text{lumen}$  |
| 1750 volts between cathode and anode (See Notes 1, 3)                                  |      | 90                   |                    | $\text{amp}/\text{lumen}$  |
| Current Amplification 1250 volts between cathode and anode                             |      | 190,000              |                    |                            |
| 1750 volts between cathode and anode (See Notes 3, 5)                                  |      | 2,000,000            |                    |                            |
| Equivalent Anode Dark Current Input (See Notes 1, 4)                                   |      | $2 \times 10^{-10}$  | $2 \times 10^{-9}$ | lumen                      |
| Inter-electrode Capacitances a) Anode to all other electrodes                          |      | 3.2                  |                    | $\mu\text{f}$              |
| b) Anode to last dynode                                                                |      | 2.8                  |                    | $\mu\text{f}$              |
| Time Jitter over Central 2.5 inches (See Note 9)                                       |      | 9                    |                    | $\text{m}\mu\text{s}$      |
| Anode Pulse Rise Time With 1 mm diam. illuminated on tube face (See Note 10)           |      | 3                    |                    | $\text{m}\mu\text{s}$      |

**NOTES**

- Note 1: The light source is a tungsten filament lamp operated at a color temperature of 2870°K.
- Note 2: Measured at 0 cps with 210 volts applied between cathode and all other electrodes connected together.
- Note 3: The applied voltage, V, is distributed in the following manner: 1/6 of V between cathode and dynode 1, 1/12 of V between succeeding dynodes, 1/12 of V between dynode 10 and anode. Improved pulse energy resolution and gain stability can be obtained if voltage between cathode and dynode 1 is set at four times that between succeeding stages; this mode of operation is recommended for all scintillation spectrometry work.
- Note 4: Measured at 25°C with supply voltage adjusted to give an anode luminous sensitivity of 20 amperes per lumen.
- Note 5: The focusing electrode should be varied between photocathode and dynode 1 potentials for optimum photoelectron collection efficiency. Best gain and pulse energy resolution are usually obtained with shield potential above cathode 80% of cathode - dynode 1 potential.
- Note 6: Average over a 30 second interval maximum.
- Note 7: Test performed, with no voltage applied, in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.
- Note 8: Test performed, with no voltage applied, through three complete cycles at three minutes per cycle in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.
- Note 9: Jitter is greatest delay between anode pulses due to position from which electrons are simultaneously released within a circle on tube face of specified diameter.
- Note 10: Measured between 10% and 90% of anode pulse height.



**TENTATIVE AVERAGE ANODE CHARACTERISTIC**  
VOLTS / STAGE - 103



SEPTEMBER 1960

**7819**

# PHOTOMULTIPLIER

The CBS Type 7819 supersedes and is a direct replacement for CBS Type CL-1015. Type 7819 is a 10-stage, 5-inch diameter, end-on photomultiplier sensitive to the blue region of the spectrum. The faceplate is plano-concave with the photocathode deposited on the curved surface. This design insures good collection efficiency across the face of the tube. This tube utilizes a linear dynode structure with silver-magnesium dynodes.

Type 7819 is particularly well suited for use in scintillation counting when large crystals or large volumes of liquid scintillators are to be used. Other applications include use in flying spot scanners and photometric instruments.



## GENERAL DATA

## MAXIMUM RATINGS

|                                                                |                                                                       |
|----------------------------------------------------------------|-----------------------------------------------------------------------|
| Spectral Response                                              | S-11                                                                  |
| Photocathode                                                   | Semi-transparent                                                      |
| Photocathode Window                                            | Circular end-on type                                                  |
| Window Diameter                                                | 4.250 inches (min.)                                                   |
| Window Index of Refraction                                     | 1.51                                                                  |
| Tube Diameter                                                  | 5-1/4±3/16 inches                                                     |
| Overall Length                                                 | 7-3/4±1/8 inches                                                      |
| Seated Height to Center of Window                              | 7±1/8 inches                                                          |
| Mounting Position                                              | Any                                                                   |
| Base                                                           | Medium shell diheptal<br>14 pin (JETEC No. B14-38)<br>Non-Hygroscopic |
| Wavelength at Maximum Response                                 | 4400±500 angstroms                                                    |
| Wavelength at 10% of Maximum Response on Long Wavelength Side  | 6125±275 angstroms                                                    |
| Wavelength at 10% of Maximum Response on Short Wavelength Side | 3250±250 angstroms                                                    |

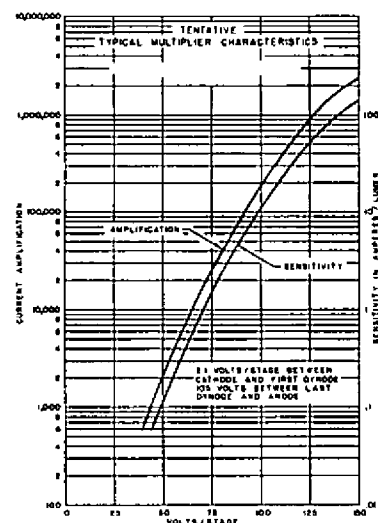
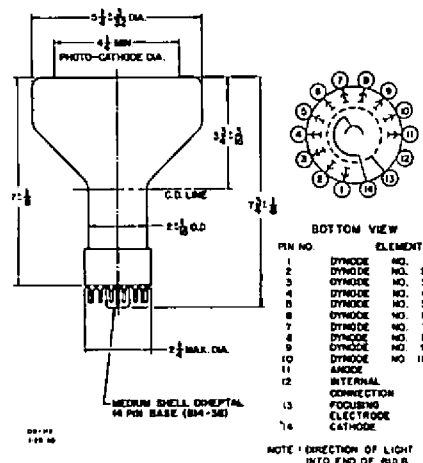
|                                                                                    | Units      |
|------------------------------------------------------------------------------------|------------|
| Supply Voltage (DC or peak AC) between Anode and Cathode                           | 2000 volts |
| Supply Voltage (DC or peak AC) between Last Dynode and Anode                       | 250 volts  |
| Supply Voltage (DC or peak AC) between Cathode and First Dynode                    | 400 volts  |
| Supply Voltage (DC or peak AC) between Cathode and Focusing Electrode (See Note 5) | 400 volts  |
| Average Anode Current (See Note 6)                                                 | 5 ma       |
| Average Anode Dissipation (See Note 6)                                             | 1 watt     |
| Environmental Conditions (Non-operating):                                          |            |
| Ambient Storage Temperature +75 °C                                                 |            |
| Shock: 40 g, 11 ms. duration (See Note 7)                                          |            |
| Vibration: 0.35" double amplitude displacement: 0-25 cycles (See Note 8)           |            |
| 10 g: 25-2000 cycles                                                               |            |

### CHARACTERISTIC ELECTRICAL DATA

|                                                                                        | Min. | Avg.                 | Max.               | Units                      |
|----------------------------------------------------------------------------------------|------|----------------------|--------------------|----------------------------|
| Cathode Radiant Sensitivity at 4400 Å                                                  |      | .060                 |                    | $\mu\text{a}/\mu\text{w}$  |
| Cathode Luminous Sensitivity                                                           | 50   | 70                   |                    | $\mu\text{a}/\text{lumen}$ |
| Variation in Cathode Luminous Sensitivity over entire cathode (See Note 5)             |      | $\pm 20$             |                    | %                          |
| Anode Radiant Sensitivity at 4400 Å, 1250 volts between cathode and anode (See Note 3) |      | $1.2 \times 10^{-2}$ |                    | $\text{amp}/\mu\text{w}$   |
| Anode Luminous Sensitivity 1250 volts between cathode and anode                        | 4    | 13.5                 |                    | $\text{amp}/\text{lumen}$  |
| 1750 volts between cathode and anode (See Notes 1, 3, 5)                               | 30   | 120                  |                    | $\text{amp}/\text{lumen}$  |
| Last Dynode Luminous Sensitivity 1250 volts between cathode and anode                  |      | 9                    |                    | $\text{amp}/\text{lumen}$  |
| 1750 volts between cathode and anode (See Notes 1, 3)                                  |      | 90                   |                    | $\text{amp}/\text{lumen}$  |
| Current Amplification 1250 volts between cathode and anode                             |      | 190,000              |                    |                            |
| 1750 volts between cathode and anode (See Notes 3, 5)                                  |      | 2,000,000            |                    |                            |
| Equivalent Anode Dark Current Input (See Notes 1, 4)                                   |      | $2 \times 10^{-10}$  | $2 \times 10^{-9}$ | lumen                      |
| Interelectrode Capacitances                                                            |      |                      |                    |                            |
| a) Anode to all other electrodes                                                       |      | 3.2                  |                    | $\mu\text{mf}$             |
| b) Anode to last dynode                                                                |      | 2.8                  |                    | $\mu\text{mf}$             |

## NOTES

- Note 1: The light source is a tungsten filament lamp operated at a color temperature of 2870°K.
- Note 2: Measured at 0 cps with 210 volts applied between cathode and all other electrodes connected together.
- Note 3: The applied voltage, V, is distributed in the following manner: 1/6 of V between cathode and dynode 1, 1/12 of V between succeeding dynodes, 1/12 of V between dynode 10 and anode. Improved pulse energy resolution and gain stability can be obtained if voltage between cathode and dynode 1 is set at three to four times that between succeeding stages.
- Note 4: Measured at 25°C with supply voltage adjusted to give an anode luminous sensitivity of 20 amperes per lumen.
- Note 5: The focusing electrode should be varied between photocathode and dynode 1 potentials for optimum photoelectron collection efficiency. Best gain and pulse energy resolution are usually obtained with shield potential above cathode 20% of cathode — dynode 1 potential. Best uniformity of cathode response is usually obtained with shield at cathode potential.
- Note 6: Average over a 30 second interval maximum.
- Note 7: Test performed, with no voltage applied, in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.
- Note 8: Test performed, with no voltage applied, through three complete cycles at three minutes per cycle in each of three orthogonal axes. Reference axis is through Pins 2 and 9 on tube base.



TENTATIVE AVERAGE ANODE CHARACTERISTIC

