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THE TELEVISION PICTURE TUBE

Electronic TUBES

Techni-talk on AM, FM, TV Servicing

PHOSPHORS FOR CATHODE RAY TUBES

PHOSPHOR Desig-nation	COLOR		*PERSISTENCE	DESCRIPTION
	Fluorescence	Phosphor-escence		
P1	Green	Green	Medium	PHOSPHOR P1 is a zinc silicate phosphor which produces a brilliant fluorescent spot of green color and medium persistence. CR tubes employing this phosphor are particularly useful for general oscillograph applications in which recurrent wave phenomena must be observed.
P2	Blue-Green	Green	Long	PHOSPHOR P2 is a zinc sulphide phosphor with a blue-green fluorescence and a green phosphorescent color with long persistence. The blue-green fluorescence is of short persistence, however, making this type of screen suitable for use where visual perception is important. This type of screen is generally used in oscillographs and in some radar or sonar indicator applications.
P3	Green-Yellow	Green-Yellow	Medium	PHOSPHOR P3 is a zinc beryllium silicate phosphor having a yellow fluorescence and a yellow phosphorescence with a medium short persistence. Although this type of phosphor is nearing obsolescence, it continues to find uses in oscillograph and indicator applications.
P4 Sulfide	White	White	Short	PHOSPHOR P4 is available in three types. The all-sulfide type consists of two components, zinc sulfide which fluoresces blue and zinc cadmium sulfide which fluoresces yellow. The mixture of the two provides a highly effective screen of white fluorescence with short persistence which finds general application in monochrome direct-view television tubes.
P4 Silicate	White	Blue	Medium	The all-silicate type also consists of two components, a blue-fluorescing calcium magnesium silicate and a yellow-fluorescing zinc beryllium silicate. The mixture produces a white fluorescence and a blue phosphorescence with a medium persistence and is especially useful for monochrome picture tubes for projection television systems.
P4 Silicate-sulfide	White	Yellow	Medium	A combination silicate-sulfide type is also available but does not enjoy extensive use.
P5	Violet-Blue	Violet-Blue	Very Short	PHOSPHOR P5 is a calcium tungstate phosphor which presents a highly actinic spot of bluish fluorescence with very short persistence. This type of phosphor is of particular value in cathode-ray tubes employed in high speed photographic applications.
P6	White	White	Short	PHOSPHOR P6 is a white phosphor developed primarily for color television applications.
P7	Blue-White	Green-Yellow	Long	PHOSPHOR P7 is a two-layer (cascade) screen of long persistence consisting of a layer of zinc sulfide on top of a layer of zinc cadmium sulfide. When excited by an electronic beam, this type of phosphor will produce a bluish fluorescence of short persistence. Following excitation, the screen will exhibit a greenish-yellow phosphorescence lasting for several minutes. CR tubes employing this phosphor are found most often in radar or sonar applications, where extremely low-speed recurrent phenomena or medium-speed non-recurrent phenomena are to be observed.
P8	(Obsolete)			
P9	(Obsolete)			
P10	Dark Trace	Color depends on absorption characteristics and type of illumination	Very Long	PHOSPHOR P10 is a very long persistence phosphor of the potassium chloride type which turns dark purple under the influence of an electron beam. An outside source of light is used for observation of the "dark trace." The persistence of this trace depends on temperature and may vary from a few seconds to several months. This type of screen finds application in some memory devices but is not in general use.
P11	Blue	Blue	Short	PHOSPHOR P11 is a zinc sulfide phosphor which presents a highly actinic spot of brilliant bluish fluorescence having sufficiently short persistence to make its use practicable in most moving film photographic applications without blurring. Exceptions are those instances where the film is driven at a high rate of speed. The characteristic brilliance of this phosphor makes it also valuable in those applications requiring visual observation. The persistence of P-11 phosphor is approximately 100 times as long as the P-5 phosphor.
P12	Orange	Orange	Medium Long	PHOSPHOR P12 is a zinc magnesium fluoride phosphor having an orange fluorescence and a phosphorescence of similar color and medium-long persistence. This phosphor was developed primarily for radar applications and enjoys the advantage of possessing an afterglow of the same color possessed by the fluorescence.
P13	(Obsolete)			
P14	Purple	Yellow-Orange	Medium Long	PHOSPHOR P14 is a two-layer (cascade) screen consisting of a zinc sulphide and a zinc cadmium sulphide, and having a purple fluorescence with an orange phosphorescence. Although the persistence of this phosphor is slightly less than that of the P-7 phosphor, its orange phosphorescence is better suited to the dark-adapted eye and may be observed with less fatigue.
P15	Blue-Green	Blue-Green	Extremely Short	PHOSPHOR P15 is a zinc oxide phosphor with an extremely short persistence and produces a fluorescent spot of both blue-green and near-ultraviolet color. The latter color has a persistence even shorter than the blue-green fluorescence, a feature that makes this phosphor particularly well-suited to the high speed scanning requirements of a flying spot signal generator.
P16	Violet and Near-Ultraviolet	Violet and Near-Ultraviolet	Extremely Short	PHOSPHOR P16 is an extremely short persistence calcium magnesium silicate phosphor having small grain size, and providing a color peaking at the near ultraviolet at 3700 angstrom units. It is of particular value in flying spot generator applications where a minimum of blurring or trailing of the signal is a requirement.
P17	Greenish-Yellow	Yellow	One Comp't: Extremely Short Other Comp't: Long	PHOSPHOR P17 is a two-layer (cascade) screen having a fluorescence of greenish-yellow color and a phosphorescence of a yellow color. The initial fluorescence is of extremely short persistence, but the phosphorescence is of long persistence. This type of phosphor is most often used in simultaneous dual applications. Its short persistence component consists essentially of the P-15 phosphor and its long persistence component is the same as the P-7 phosphor.
P18	—	—	Short	PHOSPHOR P18 is a zinc cadmium sulphide phosphor having a short persistence identical to that of the P-11 phosphor, and a fluorescence peaking at a wavelength of 5505 angstrom units. It is of particular use in high voltage image tube applications.

*The following is only an approximate definition of the terms used for qualitative description of persistence. Space limitation does not permit the publication of Persistence Characteristic curves for each phosphor designation.

Long: Visible for more than 1 second.
Medium Long: Luminance below 10 per cent of initial within 250 millseconds or less.
Very Long: Long variable persistence dependent on temperature, amount of illumination, and electron-energy density of bombardment.
Medium: Luminance below 10 per cent of initial within 30 milliseconds or less.
Short: Luminance below 10 per cent of initial within 3 milliseconds or less.
Very Short: Luminance below 10 per cent of initial within 30 microseconds or less.
Extremely Short: Luminance below 10 per cent of initial within 5 microseconds or less.

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R. G. KEMPTON—Editor

THE TELEVISION PICTURE TUBE

The television picture tube is the most important part of any television receiver. This is true not only because it is one of the most expensive parts in the receiver but primarily because it represents the result and purpose of all the other elements in the receiver. It is the picture tube which presents the principal difference to the set owner between a television receiver and a radio. The operation of this tube is a mystery to practically every owner of a TV receiver, and in many instances not thoroughly understood by some service technicians. An attempt will be made in this article to present a complete story of *how and why* a picture tube operates, as well as how to recognize and check for defects which develop in picture tubes. Information on the elimination of a number of typical defects will also be given throughout the article.

THE GLASS BOTTLE

The TV picture tube is composed primarily of a glass bottle similar in some respects to a milk bottle. These "bottles," as they are commonly called, are supplied by glass manufacturers and are made to exacting specifications agreed upon by the tube and glass manufacturers. The faceplate like the bottom of the milk bottle is made of heavier glass than the sides and must be optically clear and free of blemishes. The faceplate of practically all picture tubes manufactured at the present time is made of a glass which is tinted to provide a greater degree of contrast. The inside of the faceplate is coated with a phosphor which emits light when bombarded by a stream of electrons. It might be well at this point to consider the phosphors used on all cathode-ray tubes.

THE PHOSPHOR SCREEN

Phosphors or luminescent materials are solids which possess the property of emitting light upon receiving radiation of one or more different types. In considering phosphors for use in cathode-ray tubes, two materials having entirely different properties are of importance. The first of these are known as fluorescent materials which "fluoresce" under direct radiation, emitting a form of light termed fluorescence. This conversion of invisible radiation into visible light occurs almost instantaneously and with little or no change in the temperature of the fluorescent materials. The second are phosphorescent materials which possess the property of storing energy for a period of time, the phosphorescence radiating visible light for some time after receiving initial excitation. The length of time during which this condition exists depends upon the decay characteristics of the particular phosphor used.

By combining fluorescent materials with phosphorescent materials, phosphors are created which may be suitable for various purposes. The variation in nature and quantity of these combined materials provide phosphors which possess the property of converting various types of radiation into visible light, and of maintaining the radiation of visible light for various periods of time.

Phosphors, as used for the screens of cathode-ray tubes, have two important characteristics: COLOR and PERSISTENCE. These characteristics can be used to define the phosphor. Descriptions of phosphors which have been used in the manufacture of television picture tubes as well as all cathode-ray tubes are listed in the table shown on page 1. These phosphors are identified by the designations P1, P2, P3, etc, as assigned by the RTMA Data Bureau. All cathode-ray tubes are so numbered that the first number indicates the diameter of the faceplate, the first letter is an arbitrary letter assigned to tubes which have different electrical or physical properties, the letter P stands for phosphor and the number following indicates the type of phosphor used on the faceplate. For example, a type 5CP1 has a faceplate five inches in diameter which is coated with a P1 phosphor and is used principally in oscilloscopes. A type 10BP4 has a faceplate ten inches in diameter which is coated with a P4 phosphor and is used principally in TV receivers.

THE INSIDE COATINGS

After the phosphor coating is applied to the faceplate, the inside of the bell and neck area is coated with a conductive graphite coating called "aquadag." This coating starts about two inches in back of the faceplate and extends part way down the neck of the tube as can be seen in Fig. 1 which is a photograph of a type 17BP4-A picture tube. This coating is connected electrically to the HV anode button, and also carries the high-voltage to the HV anode in the gun structure. In General Electric Aluminized Picture tubes, an additional thin layer of metal is used to cover the phosphor on the faceplate. This layer of metal also covers the inside area of the bell portion of the picture tube and is

(Continued on page 5)

Fig. 1. General Electric Type 17BP4-A picture tube showing clear glass area between the faceplate and the aquadag coatings.

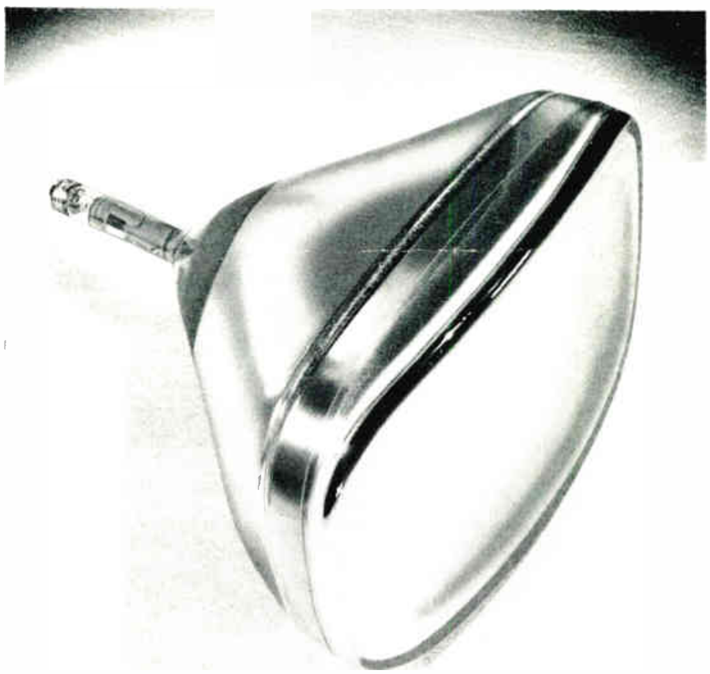

Fig. 2. General Electric Type 21EP4-B picture tube showing the inside aluminized coating on the edge of the faceplate and the bell area.

(*Continued from page 2*)
connected electrically to the anode button. The aquadag coating in aluminized tubes extends only from the point where the metal coating ends to about two inches from the base. The metal coating on the bell of the picture tube as well as the aquadag coating on the neck can be seen in Fig. 2 which is a photograph of a type 21EP4-B picture tube.

This layer of metal acts as a mirror to reflect the light produced by the phosphor. Picture tubes which do not have the aluminized coating have a clear glass area between the phosphor on the faceplate and the graphite coating. This area is clearly shown in Fig. 2 and can be used as a window to see the inside of the faceplate. If you look through this "window" at a time when a picture is being produced on the screen, you will notice that the picture looks clearer and considerably brighter. A portion of this bright clear picture is lost in the ordinary tube because some of the brightness is reflected back and scattered by the inside graphite coating resulting in deterioration of picture quality. Through the addition of a reflective metal coating, none of the brightness is lost on the inside of the tube, and it is all reflected through the faceplate resulting in a considerable increase in brightness.

The inside graphite coating, as previously mentioned, is electrically connected to the HV anode contact and represents a part of the second or HV anode. The effect of this HV on the electron beam will be discussed in detail later. Most picture tubes also have a graphite coating on part of the exterior portion of the bell. This coating does not make contact with the anode button and is usually separated from it by a circular area of clear glass. The conductive coating on the outside of the bell and the conductive coating on the inside of the bell separated by glass, form a capacitor which is used as part of the HV power supply filter network. The area which is covered by the exterior portion determines the capacitance. Most of the larger size picture tubes have a coating which covers a smaller portion of the outside bell area than that covered on smaller tubes. The reason for this is to limit the capacitance and, therefore, the charge which if accidentally discharged, could be a safety hazard. This outside coating covers most of the bell on the seventeen-inch tube in Fig. 1. but only about a two-inch band back toward the neck of the twenty-one inch tube in Fig. 2.

IMPLOSIONS

After the interior coatings are applied, the electron gun assembly is flame-sealed into the glass bottle. The air is removed by attaching high vacuum pumps to the tubulation at the center of the base and baking the bulb at 750 degrees Fahrenheit for a prolonged period. When as much air as possible has been removed, the tubulation is sealed off. This tubulation is just inside the key projection on the bakelite base of the picture tube. Due to the vacuum created by the removal of practically all air from the inside of the tube, a tremendous pressure is exerted on the outside area just by the normal atmospheric pressure. As an example a ten-inch picture tube has a total glass area of about 375 square inches. Assuming an atmospheric pressure of 15 pounds per square inch. the total pressure in pounds would be 375 x 15 or 5625 lb. If this is converted to tons it equals 2.81 or almost three tons. Since the total pressure is in direct ratio to the glass area, the total pressure becomes greater as the size of the picture tube is increased. Inasmuch as this pressure is from the outside, a fracture of the envelope will cause the glass to be driven inward. A picture tube is, therefore, said to *implode* rather than explode. Every precaution should obviously be taken in handling picture tubes to prevent the possibility of scratching or chipping any surface which could result in an *implosion*.

Although only a very few injuries from picture tube implosions have been reported, the danger is ever present. As an example. the photographs shown in Figs. 3 and 4 illustrate the effect of a picture tube implosion. In this case the implosion, fortunately, occurred at a time when the chassis was in the cabinet. Notice the size of the pieces of glass remaining from a twenty-one inch picture tube. Most of the small tubes which were not protected were broken and the aluminum shield cans were dented. As a precaution ALWAYS wear safety glasses whenever handling an exposed picture tube. Another hazard is also present after a picture tube implosion and that is the danger of cuts from the glass splinters or pieces. Since there is always a danger of infection from any cut or scratch, be sure to wear heavy gloves if it is ever necessary to touch or remove fragments of an imploded picture tube. Considerable care will be required in removing all of the glass splinters and fragments from the chassis and cabinet. This should be done in order to eliminate the possibility of anyone's receiving a cut during either this or some future servicing operation. Some care should also be exercised in disposing of the glass fragments. One suggestion would be to use an old cardboard box and either tape or tie it closed. A heavy paper bag may also be used but it should be completely lined with several layers of newspaper.

In the next issue the electron gun will be described. Defects which develop in the cathode as well as information on how to observe an enlarged image of the cathode as it can be made to appear on any picture tube screen will be included. How to eliminate some defects such as shorts, opens and contaminated cathode surfaces will appear in subsequent issues.

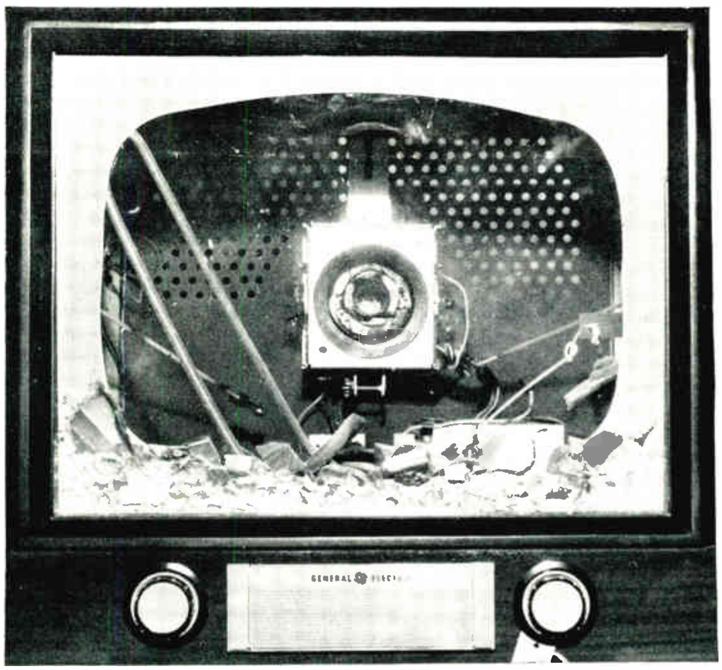

Fig. 3. Front view of a TV receiver in which the picture tube imploded.

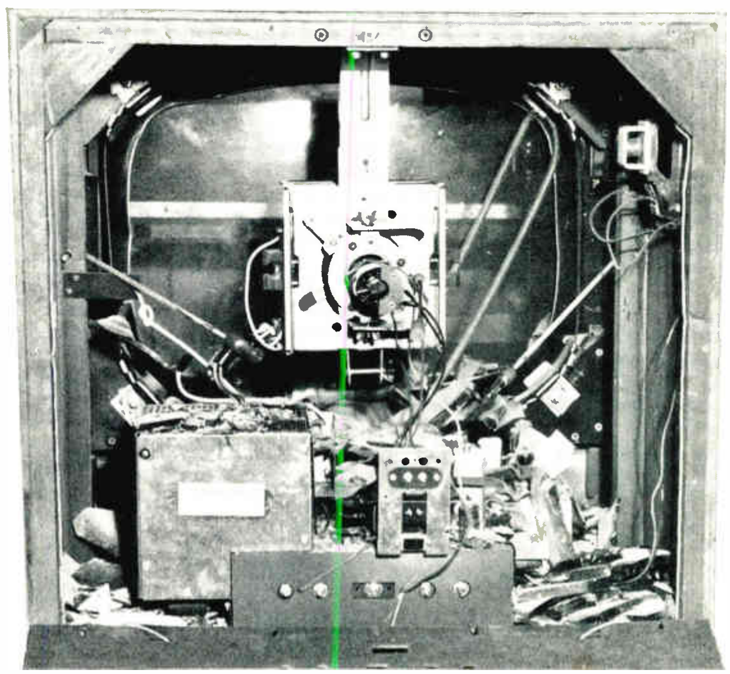

Fig. 4. Rear view of the same receiver shown in Fig. 3.

BENCH NOTES

Contributions to this column are solicited. For each question, short-cut or chronic-trouble note selected for publication, you will receive $10.00 worth of electronic tubes. In the event of duplicate or similar items, selection will be made by the editor and his decision will be final. The Company shall have the right without obligation beyond the above to publish and use any suggestion submitted to this column. Send contributions to The Editor, Techni-talk, Tube Department, General Electric Company, Schenectady 5, New York.

15.75 KC WHISTLE

The following TV trouble was encountered in a set a few weeks ago. The complaint was an excessively loud 15.75 kc whistle emanating from somewhere in the receiver. I tried small bits of paper or rubber between the two halves of the horizontal output transformer core as I had done before but this time it did not work. I finally found the trouble to be a fairly loose width coil *core* which was being electromagnetically vibrated against the fiber coil form by the 15.75 kc pulse flowing through the width coil. I remedied this condition by sliding a thin strip of fish paper between the core and the inner wall of the coil form.

Nicholas DiPrimo
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NEW USE FOR HAIRDRYER

Here is a suggestion to help locate trouble in television sets. Quite often I run across sets which give trouble only after they have had time to get hot. When the chassis is removed and turned up to work on, it does not get hot enough for the trouble to show up. Heat lamps have been used for this, but I found a HAIR-DRYER of the type used in the home to be more effective. Heat can be applied to a single capacitor or other part one at a time. The part may also be cooled again as a double check. Faulty condensers, for example, will show with heat applied only about forty seconds.

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TELE-TONE TROUBLES

Two chronic troubles on Tele-Tone Model TV249 can give technicians not familiar with this model a big headache.

POOR VERTICAL LINEARITY WITH INSUFFICIENT HEIGHT. A new 6SN7-GT vertical oscillator does not help and the voltages check about normal. This condition is usually caused by the 1.5M resistor which is in series with height control in the oscillator plate circuit increasing in value to about four or five megohms. Replace with new 1.5M resistor.

POOR HORIZONTAL AND IN SOME CASES ALSO VERTICAL SYNC. The horizontal weaves or tears in extreme cases. The 100 mmfd. condenser coupling the plate of the 6SN7-GT sync separator to 6AL5 diode limiter develops a high resistance leakage (50-100 megohms). Replace with good mica 100 mmfd. condenser.

Samuel M. Pearlman
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NOISE CHECK WITH SCOPE

The use of the oscilloscope in servicing power supplies may be new to some. Here is a specific example in its favor.

All are familiar with the sound of a failing choke, field coil or a bleeder resistor. When these components start to fail the "crashes" are of such short time duration the damping action of a standard 20,000 ohms per volt meter will not localize this trouble.

Such a condition was evident in Stromberg-Carlson model 1121. This large set is of the AM-FM-SW type with 5U4-G, dual "pi-type" filter and bleeder resistor. A signal tracer detected (and amplified) the frying noise at various points in the B+ circuit. However, as soon as a scope was used by placing the vertical input to various points throughout the filter and bleeder circuit, they appeared "clean as a whistle" and at different amplitudes. The greatest amplitude appeared at the plate of the 6SQ7 tube. The trouble was a 100 mmfd mica capacitor which was connected between the plate terminal and ground.

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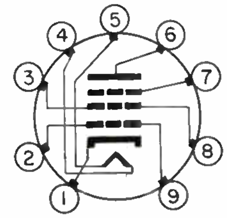
Houston 24, Texas

What's new!

6CL6

The 6CL6 is a 9-pin miniature power pentode especially designed for use in the final video stage of television receivers. It is capable of supplying 132 volts peak to peak output across a load resistor of 3900 ohms.

Heater Voltage (A-c or D-c)	6.3 volts
Heater Current	0.65 ampere
Typical Operation in 4-mc Bandwidth Video Amplifier	
Plate Supply Voltage	300 volts
Grid—No. 3	Connected to Cathode at Socket
Grid—No. 2 Supply Voltage	300 volts
Grid—No. 1 Bias Voltage	−2 volts
Grid—No. 1 Signal Voltage (Peak to Peak)	3 volts
Grid—No. 2 Resistor	24000 ohms
Grid—No. 1 Resistor	0.1 megohm
Load Resistor	3900 ohms
Zero-signal Plate Current	30 ma
Zero-signal Grid—No. 2 Current	7.0 ma
Voltage Output (Peak to Peak)	132 volts



6AH4-GT

The type 6AH4-GT is a high perveance triode designed for use as a vertical deflection amplifier in television receivers.

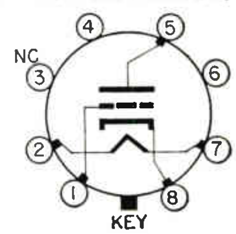
Heater Voltage (Ac or Dc)	6.3 Volts
Heater Current	0.75 Amps

CHARACTERISTICS

Conditions:

Heater Voltage	6.3	6.3 volts
Plate Voltage (D-c)	250	250 volts
Grid Voltage (D-c)	—33	—23 volts
Plate Current	5.0	30 ma
Transconductance		4500 μmhos
Amplification Factor		8.0
Plate Resistance		1780 ohms
Grid Voltage for 0.5 ma plate-current (approx.)		—40 volts
Maximum Plate Dissipation*		7.5 watts

* An adequate bias resistor or other means is required to protect the tube in the absence of excitation.



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