

TECHNICAL INFORMATION

TONOTRON (MAGNETIC) TYPE NO. 7033

5-INCH DIRECT-DISPLAY HALF-TONE STORAGE TUBE

DESCRIPTION

The Tonotron direct-display, cathode-ray storage tube features: (1) storage of half-tones, (2) sufficient brightness for use in high ambient-light levels, (3) controllable persistence, (4) minimum over-all length, (5) high resolution writing gun, (6) precision collimating lens system, (7) aluminum-backed phosphor. Black*, white, and intermediate shades of grey can be stored for periods of the order of minutes. ** Erasure can be either "instantaneous" or gradual.

Figure 1 illustrates the essential components of the tube: the writing gun, the flood gun, the storage-target assembly, and the viewing screen. The storage section assembly consists of a collector mesh, a storage mesh with dielectric material applied to its surface, and a viewing screen. In the unwritten state, the dielectric surface of the storage mesh is charged negatively, approximately 6 volts, thus repelling the low-energy flood electrons back to the collector. Where the high-velocity writing beam has charged the dielectric in a positive direction by secondary emission, flood electrons can penetrate the storage mesh and are then post-accelerated to the viewing screen. The amount the writing beam charges this dielectric, controls the number of flood electrons penetrating the mesh and thus the brightness of the screen. Figure 5 plots a typical storage characteristic of brightness versus dielectric surface potential. All of the voltages shown are referred to the flood-gun cathode potential. The figure shows the half-tone range and the cutoff potential.

The flood beam is used for erasure of written information. This erasure mode depends on two factors: (1) there is a high capacitive coupling between the dielectric surface and the storage mesh, (2) low-energy electrons strike the dielectric and charge it in a negative direction, since the secondary ratio is less than one. This means that when the storage mesh is elevated by an amount equal to the cutoff potential, i. e., 5.8 volts in the characteristic of Fig. 2, the storage surface will follow by capacitive coupling. All parts of the dielectric previously at operating range potentials will then be slightly positive and flood electrons can strike the surface, charging it down to flood-cathode potential. When the storage mesh is then returned to its normal voltage, the surface is carried capacitively to the negative cutoff potential. This process can be accomplished in one pulse or in many pulses, depending on the application. When one pulse erasure is used, the erase time is about 125 milliseconds. When a pulse train of low duty cycle is used, erasure time can be prolonged and the written information will fade down with an arbitrary time constant controlled by the duty cycle of the erase pulse. Additional discussion of erase performance will be found under the section, "Contrast Ratio" page 13.

* The use of "Black" and "White" refer to the unwritten and fully written states.

** See Section "Extending Storage Time" for method of extending the storage time.

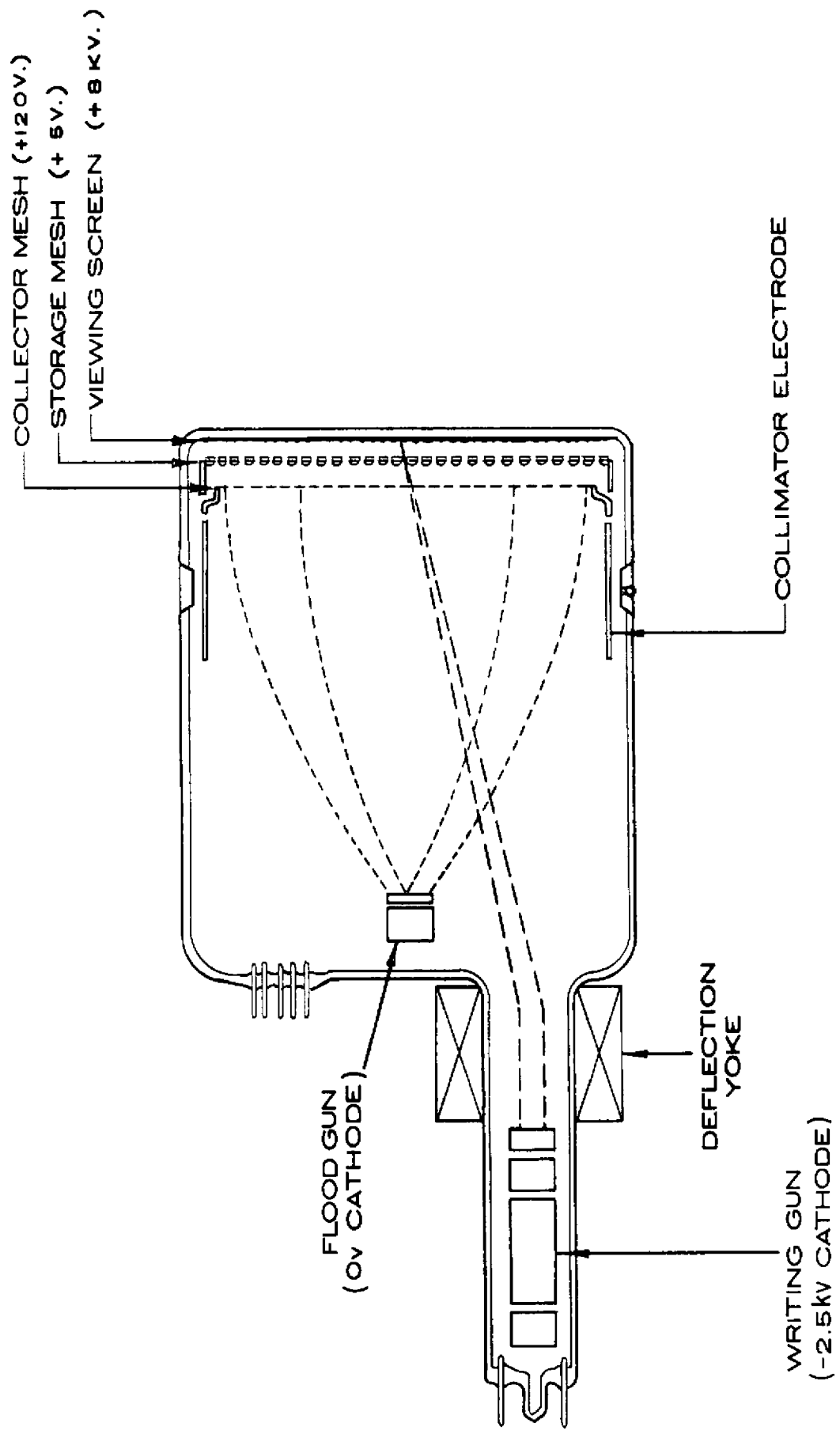


FIG. 1 --- SCHEMATIC DIAGRAM

Except for ion currents and insulator leakage, the stored pattern could exist indefinitely. Leakage is negligible at normal tube operating conditions so that most tubes will store patterns for many days if all operating voltages are removed. With voltages applied, however, storage is limited by ions generated from the residual gases left in the tube as well as from other sources. Ions will generally limit the useful storage time to about 60 seconds.

ELECTRICAL DATA

Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angle, approximate	
Horizontal	18 Degrees
Vertical	26 Degrees
Direct Interelectrode Capacitances, Approximately	
Writing Gun Cathode to all other electrodes	7.7 uuf
Writing Gun Grid #1 to all other electrodes	8.6 uuf
Writing Gun Cathode to Writing Gun Grid #1	5.5 uuf
Writing Gun Heater to Writing Gun Cathode	5.5 uuf
View Screen to all other electrodes	34.8 uuf
Storage Mesh to all other electrodes	76.1 uuf
Collector Mesh to all other electrodes	64.9 uuf

OPTICAL DATA

Phosphor Number	P20*
	Aluminized
Fluorescent Color	Yellow
Phosphorescent Color	Yellow
Face Plate Transmission	83-92% over the visible range.

MECHANICAL DATA

Over-all length	11-1/8" \pm 3/8"
Greatest Diameter of Bulb	5-3/8"
Minimum Useful Screen Diameter	4"
Neck Length	4-7/8" \pm 1/4"
Mounting Position.	Any. Shock mounting is required for operation under conditions of excessive vibration.
Bases, writing gun	JETEC E8-11, requires standard vidicon socket, Cinch Mfg. Corp. No. 54A18088.
Flood Gun	JETEC E7-1, requires standard 7-pin miniature socket.
Ambient Temperature	Operation or exposure is not recommended outside the range -40° to +180°F.

* Other phosphors available on special order.

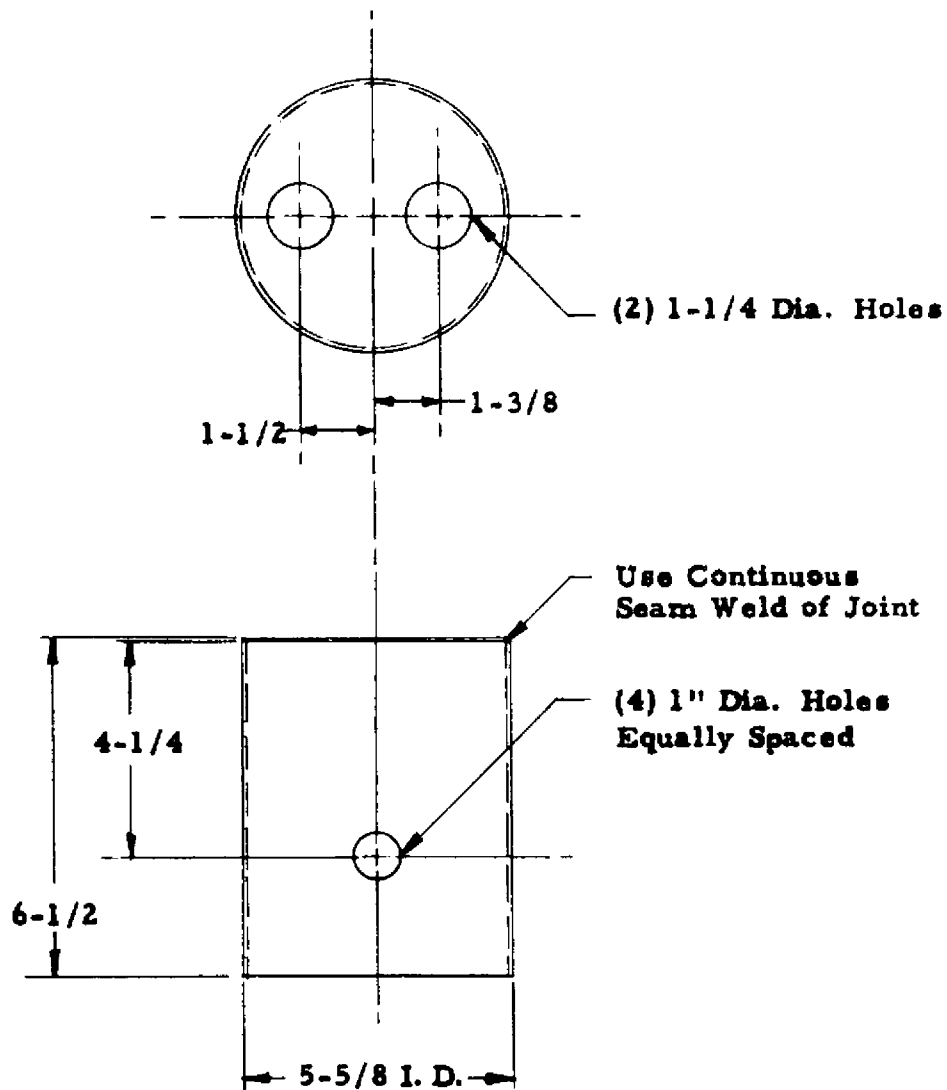
RATINGS

(All ratings are max. max. unless otherwise shown. Values presented herein should not be exceeded under any circumstances). All voltages are given with respect to flood gun cathode unless otherwise shown.

Heaters (two), for Unipotential Cathodes

Voltage	6.3 \pm 10% AC or DC volts
Current (each Heater)	0.6 amp
Viewing-screen voltage	10,000 volts
Viewing-screen dissipation	10 watts
Storage-mesh voltage	-25 volts, + 200 volts
Collector-mesh voltage	300 volts
Third-anode voltage (collimating electrode)	300 volts
Second-anode voltage	200 volts
First-anode (flood gun) voltage	200 volts
Cathode (writing gun) voltage	-3000 volts
First-anode (writing gun) voltage (focusing electrode)	-3000 volts
Grid No. 1 Voltage (flood gun) Negative - Bias Value	125 volts
Positive - Bias Value	0 volts
Positive - Peak Value	2 volts
Grid No. 1 Voltage (writing gun) with respect to writing gun cathode Negative - Bias Value	125 volts
Positive - Bias Value	0 volts
Positive - Peak Value	2 volts
Peak-Heater-Cathode Voltage (flood gun) Heater negative with respect to cathode during warm-up period not to exceed 15 sec.	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to cathode	180 volts
Peak-Heater - Cathode Voltage (writing gun) with respect to writing gun cathode Heater negative with respect to cathode during warm-up period not to exceed 15 sec.	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to cathode	180 volts

**PROPOSED TONOTRON
ELECTRON TUBE
MAGNETIC SHIELD**



MAT'L:

.020 to .040 Mumetal
Or *Fernetic Conetic

*TM-Perfection Mica Co-Magnetic Shield Div.

FIG. 3

TYPICAL OPERATING CONDITIONS*

Voltages and Currents

Viewing-screen voltage	4000 to 8000 volts
Storage-mesh voltage	5 volts
Collector-mesh voltage	120 volts
Third-anode voltage (adjust for optimum collimation)	20 to 40 volts
Second-anode voltage	6 volts
First-anode (flood gun) voltage	80 volts
Control-grid (flood gun) operating bias (adjust for full coverage of viewing screen; cutoff value is approximately -90 volts)	0 to -30 volts
Cathode(flood gun) voltage	0 volts
Cathode (writing gun) voltage	-2500 volts
Control-grid (writing gun) (voltage for visual extinction of focused spot)*	-70 volts
First-anode (writing gun) voltage for focus*	350 to 750 volts
First-anode (writing gun) current for focus	less than 1 microampere
Viewing screen current	0 to 500 ua
Storage-mesh current	-15 to +75 ua
Collector-mesh, Third-anode, Second-anode Currents, each	less than 2 ma
Cathode (flood gun) current	0 to 2 ma
Cathode (writing gun) current	0 to 1500 ua

MECHANICAL

MOUNTING

The type 7033 Tonotron Storage Tube may be mounted in any position required for viewing. Where use under conditions of extreme shock or excessive vibration is contemplated, the use of shock mounting is recommended to prevent the possibility of damage to the storage surface.

TEMPERATURE

The designer is cautioned not to exceed the ambient temperature limitations as set forth under Mechanical Data, page 3. Forced air cooling may be used under extreme high temperature conditions with satisfactory results.

MAGNETIC SHIELDING

Magnetic shielding is required for both the writing gun and the flood gun. Low intensity magnetic fields (viz, the earth's magnetic field) can deflect the flood electrons sufficiently to destroy collimation. (See page 13). Stray magnetic fields from the deflection yoke may also divert the flood beam and the writing beam within the guns, and may therefore modulate the beam current as it passes through the limiting apertures.

*All voltages are given with respect to the flood-gun cathode, except those starred, which are given with respect to the writing-gun cathode.

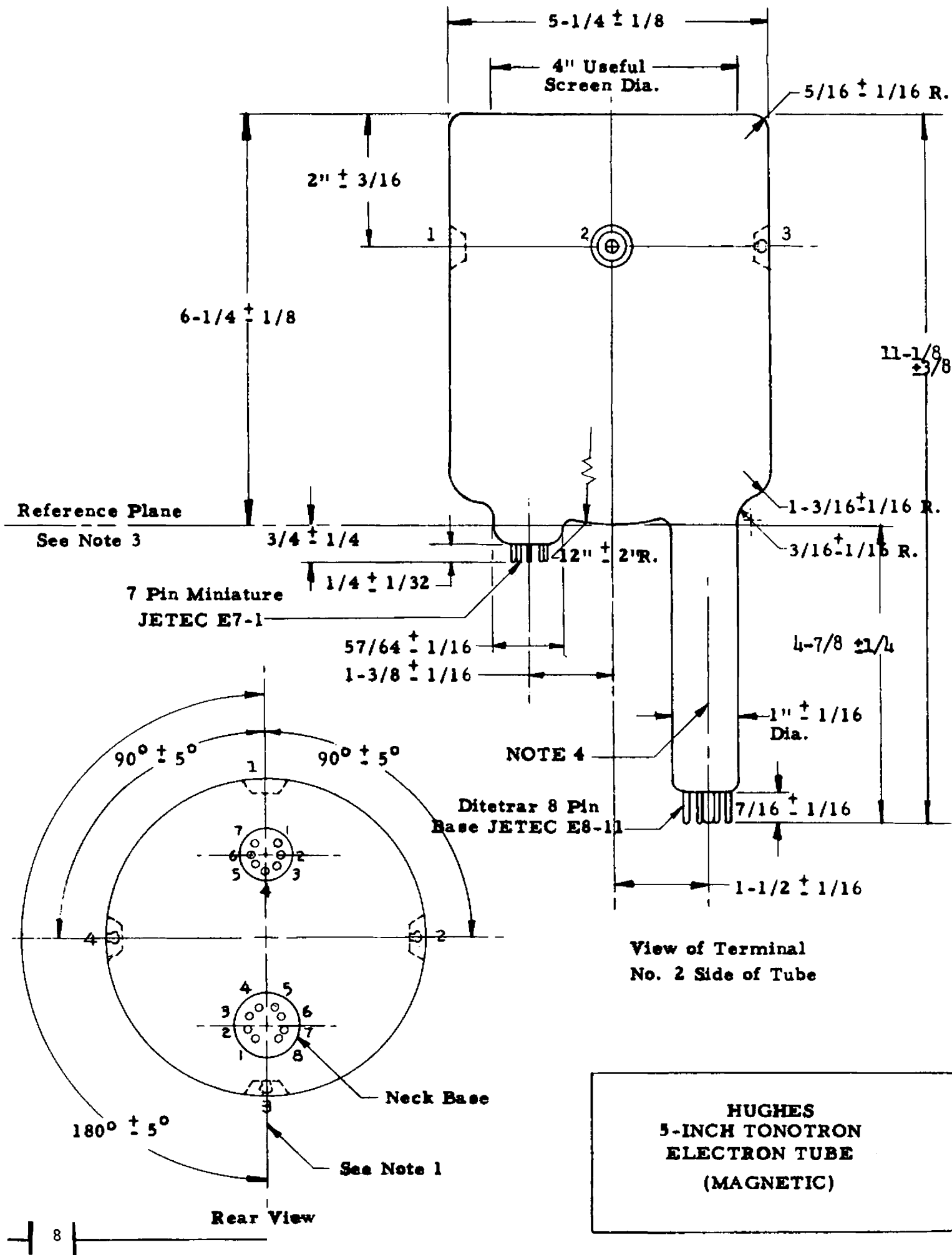


FIG. 4 OUTLINE DRAWING

MAGNETIC SHIELDING (continued)

A close-fitting shield extending from the front edge of the tube to the reference line (see outline drawing) and then formed about the back of the front end is recommended.

Further improvement in operation may be achieved by using magnetic shielding material for the outer cup of the deflecting yoke.

CIRCUITRY

The circuits required to operate the Tonotron Storage Tube fall into five categories: erase circuits, video circuits, deflection circuits, static-voltage supplies, and protective circuits. Figure 2 is a diagram of a typical circuit for application to a Plan-Position Indicating Display:

1. **ERASE CIRCUITS.** Two types of erase circuits are commonly used with the Tonotron tube. One is merely a battery, potentiometer, and microswitch arrangement to manually elevate the storage mesh potential for "instantaneous" erasure; the other is a pulse-train generator, with variable amplitude and duty cycle. The amplitude is 0 to 10 volts; duty cycle is adjustable between 0.5 percent and 20 percent; optimum pulse repetition rate varies between 1 and 3 KC, depending upon the desired erase rate.
2. **VIDEO CIRCUITS.** A video signal of approximately 20 volts is required to drive the writing gun, which is a standard cathode-ray gun with electrostatic focus and magnetic deflection. In those displays featuring re-trace blanking, the blanking requirements are more stringent because of the ability of the tube to integrate weak repetitive signals to full highlight brightness.
3. **DEFLECTION CIRCUITS.** Deflection circuitry, for the 2.5 kv beam, is conventional. In the design of the deflection yoke, the centering device, and the writing gun magnetic shield, if used, careful consideration should be given to deflection field uniformity and to the prevention of the deflection field from affecting the writing beam inside the gun. For Plan-Position Indicating displays best results are obtained with a mechanically rotated yoke.

Since the writing gun is located off center in the vertical plane, either a permanent magnet or a DC yoke bias is required to center the writing beam.

A change in the relationship of writing beam current with writing time will cause shifts in both output brightness and image persistence. Therefore, in displays such as PPI or sector scan where the writing speed is not constant, correcting measures are required in order to maintain uniformity of brightness and persistence. These measures usually assume the form of ramp correcting voltages applied to the video signal. The exact nature of these voltages will vary depending upon the type of display. The circuit of Figure "2" includes such a correcting circuit.

TYPICAL STORAGE CHARACTERISTIC

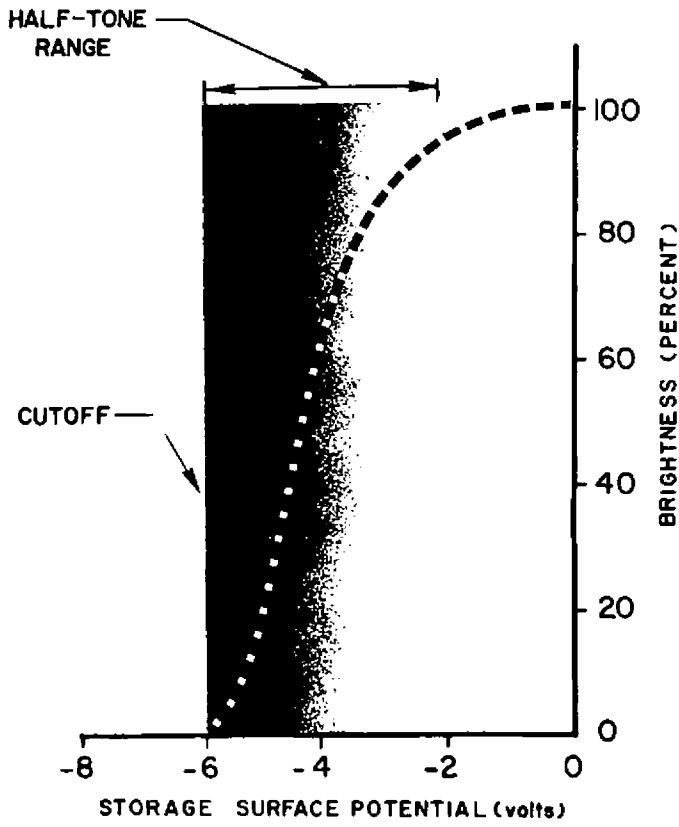


FIG. 5

TRANSFER CHARACTERISTIC FOR FLOOD GUN

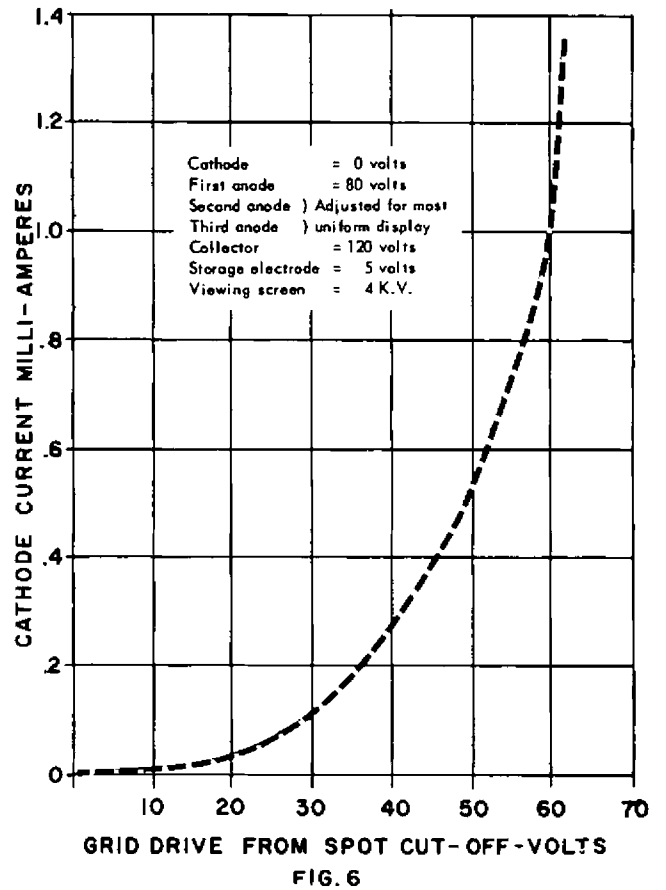


FIG. 6

TRANSFER CHARACTERISTICS FOR WRITING GUN

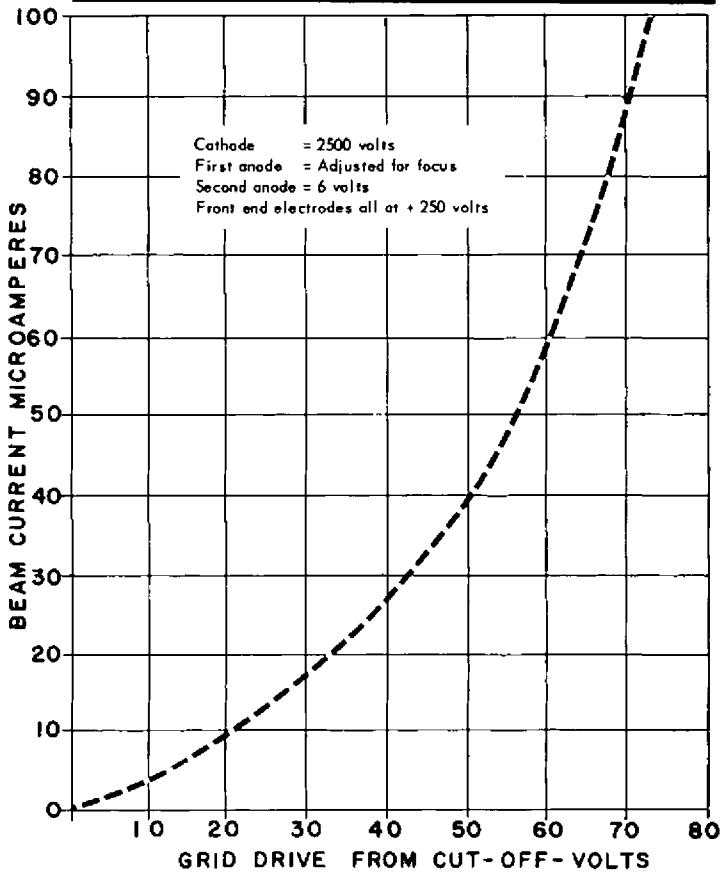


FIG. 7

AVERAGE LIGHT OUTPUT

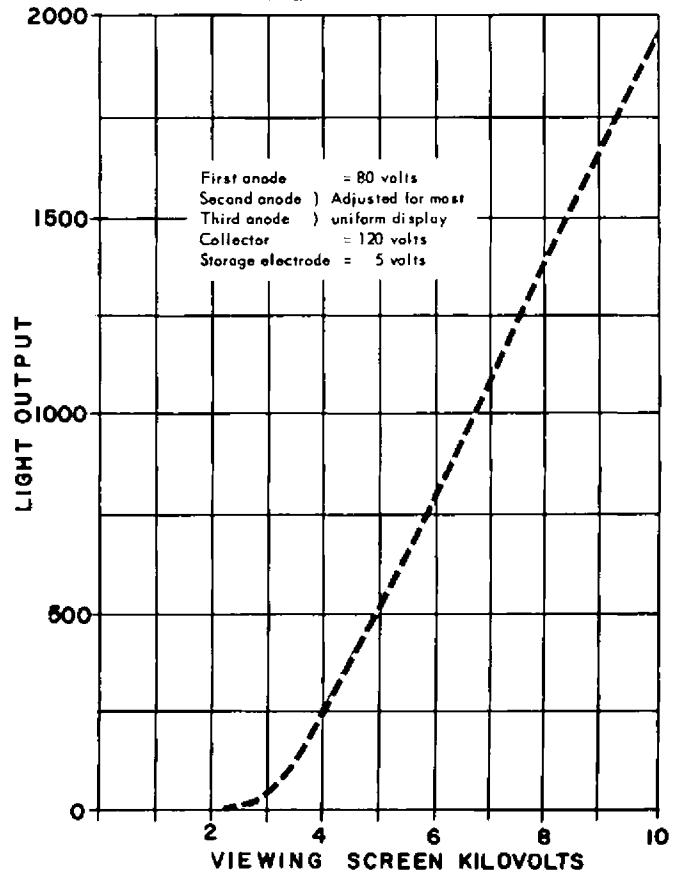


FIG. 8

4. **STATIC VOLTAGE SUPPLIES.** Conventional power supplies are used to furnish the static voltage requirements as listed on page 7 : Typical Operating Conditions. Provision should be made for adjustment of: (a) the third-anode voltage, to collimate the flood beam, (b) the flood-gun control-grid voltage, to adjust the size of the flood beam, (c) the writing-gun first-anode voltage, for focus and (d) the storage-mesh voltage, for adjustment of storage over the range of desired conditions. Since the writing-gun cathode voltage is not operated at ground potential, either the control-grid driving circuits must be referenced to the cathode, or the cathode potential must be well regulated. The electrostatic focusing is proportional, and care must be exercised to preserve the focusing ratio so as to maintain a good spot. This requires either a proportional focus voltage, or well-regulated cathode and focus voltages. RF supplies are satisfactory for the high voltage.

5. **PROTECTIVE CIRCUITS.** Due to the high internal voltage gradient between the storage mesh and the viewing screen, it is advisable to provide protection against excessive surge currents. A limited-energy type power supply for the viewing screen with 1 ma maximum short circuit current is suggested. In any event, a protective resistor of at least one megohm should be used in series with the viewing-screen lead. Damage to the storage surface may result from operation of the writing beam on any part of the screen not covered by the flood beam. If it is necessary or desirable to operate the writing gun with the flood beam cut off, the collector mesh voltage must be lowered to storage mesh potential to prevent runaway charges from breaking down the dielectric coating on the storage mesh.

PERFORMANCE

WRITTEN RESOLUTION

65 Lines/Inch

Measured by the shrinking raster method at full brightness, 30 ua beam current and single pulse erasure. Characteristic range is from 50 lines/inch to 85 lines/inch. Resolution can be increased by using less beam current, e. g. , changing from 60 ua to 30 ua will increase the resolution by 25%.

BRIGHTNESS (See Fig. 8)

1750 Foot Lamberts

At 9 KV the characteristic range is 1000 Ft. L. to 2000 Ft. L. Further brightness can be obtained by increasing the collector mesh voltage. Readjustment of the collimation is required. (See page 13 collimation). This procedure, however, is not recommended when critical half-tone

rendition is required. A 50% increase in brightness is gained by increasing the collector voltage 50%.

ERASE TIME (Single pulse erasure, pulse amplitude equal to target
cutoff) 125 milliseconds.

Characteristic range is 50 milliseconds to 250 milliseconds. The single pulse erase time may be decreased by increasing the pulse amplitude. Increasing pulse amplitude one volt will lower erase time 75%.

Continuous erasure uses an erase pulse train. By varying pulse amplitude, frequency and duty cycle, the persistence, contrast, integrating properties and degree of flicker can be controlled. The persistence time is approximately:

$$P = \frac{K}{FD}$$

where P is the persistence in seconds of full brightness areas,

F is the erase pulse frequency

D is the erase pulse duration in seconds

K is the minimum erase time in seconds for a single pulse of the amplitude being used.

Pulse amplitude varies between 0 and 5 volts. For critical half-tone reproduction, the amplitude should be adjusted to a value just sufficient to cut off the flood beam. Frequency and duty cycle are then adjusted for the persistence desired. This condition is also necessary to achieve maximum writing speed. Where half-tone reproduction is of secondary importance, a higher pulse amplitude will suppress noise and accentuate the desired signal.

Pulse shape influences the decay characteristic. Using a square wave form, brighter areas persist longer than dim areas since flood electrons will then bombard all portions of the storage layer for the same length of time. However, when a positive sawtooth or a triangular waveform is employed, differing intensity areas will tend to persist, for the same length of time since flood electrons will then bombard the more positive areas for a longer period of time.

If the pulses applied are insufficient to produce complete erasure of a trace before subsequent re-writing, the integrating properties of the storage surface can cause "blooming" (over-writing) of a heavily written trace. If desired, however, this property can be used to allow a weak signal to be integrated to visibility.

CONTRAST RATIO

at 3-second persistence
approximately 100:1

The contrast ratio is roughly proportional to the persistence time for short duration persistences. The relatively long "instantaneous" erase pulse causes the entire screen to assume full highlight brightness (unless the viewing screen voltage is simultaneously dropped). Similarly, with gradual erasure, each individual pulse of the erase train causes the entire screen to assume full highlight brightness for its duration so that the average "unwritten" brightness is increased. Thus, the contrast is proportional to the persistence time for short persistence, although the effect is negligible for long persistence.

NUMBER OF HALF-TONES

5 Minimum

Characteristic is measured by applying a vertical bar of six different intensities (3db difference) to the writing gun control grid and sweeping vertically at a frequency of 1/4 cycle per second. The intensity of the weakest bar is adjusted so that the written information is barely discernible. The number of contrasting intensity bars visible is then defined as the number of half-tones.

COLLIMATION ADJUSTMENT

In making the collimation adjustment, the potential in an electrostatic lens gap is varied until the flood electrons approach the storage mesh orthogonally over the entire area. (The collimation adjustment is critical for half-tones; it is most critical in the vicinity of the storage-mesh cutoff value.) Therefore, the most precise collimation adjustment can be obtained when the entire screen is in a half-tone state near cutoff. Collimation voltages should be regulated to 1% for satisfactory half-tone reproduction. After viewing-screen, storage-mesh, collector, and flood-gun voltages are applied to the tube, the flood-gun bias should be reduced to the exact point where full coverage of the target is obtained. Then the target should be erased (using either a single long pulse, or a pulse train), by slowly increasing the pulse amplitude until, in the absence of the pulse, the screen brightness has acquired a low half-tone level. There will then be a period of the order of 30 seconds, before ion effects become important, in which to adjust the collimation. This is accomplished by adjusting the third-anode potential (in the vicinity of 30 v) to obtain uniformity over the largest obtainable circle. After a reasonable value seems to have been attained, it is wise to re-erase the target and check the result again. In some instances it may be possible to improve the collimation by also adjusting the second-anode (in the range of 5 to 30 volts).

PIN ORIENTATION

BODY BASE CONNECTIONS

(7-pin miniature JETEC E7-1)

- Pin No. 1 First Anode (flood gun)
- Pin No. 2 Control Grid (flood gun)
- Pin No. 3 Heater, (flood gun)
- Pin No. 4 Heater, (flood gun)
- Pin No. 5 Internal Connection - Do Not Use
- Pin No. 6 Second-Anode (writing and flood guns)
- Pin No. 7 Cathode (flood gun)

NECK BASE CONNECTIONS

(Small Button ditetrar 8-pin JETEC E8-11)

- Pin No. 1 Control Grid (writing gun)
- Pin No. 2 Heater (writing gun)
- Pin No. 3 Heater (writing gun)
- Pin No. 4 Internal Connection - Do Not use
- Pin No. 5 Cathode (writing gun)
- Pin No. 6 Internal Connection - Do Not Use
- Pin No. 7 No Connection
- Pin No. 8 First-Anode (writing gun)

BULB TERMINAL CONNECTIONS

- Cap No. 1 Viewing Screen
(Recessed small cavity cap, JETEC No. J1-21)
- Cap No. 2 Collector Mesh
(Recessed small ball cap, JETEC No. J1-22)
- Cap No. 3 Third-Anode
(Recessed small ball cap, JETEC No. J1-22)
- Cap No. 4 Storage Mesh
(Recessed small ball cap, JETEC No. J1-22)

EXTENDING STORAGE TIME

Through pulsing techniques it is possible to increase the storage time from about one minute to more than five minutes. Image deterioration in the Tonotron Tube is caused by positive ions (produced by the collision of flood electrons with gas molecules) landing on the storage surface where they neutralize some of the negative charge. If the flood gun is cut off half the time, approximately half the ions are produced and thus storage time is doubled. A sacrifice in brightness proportional to the increase in storage time is implicit in this technique.

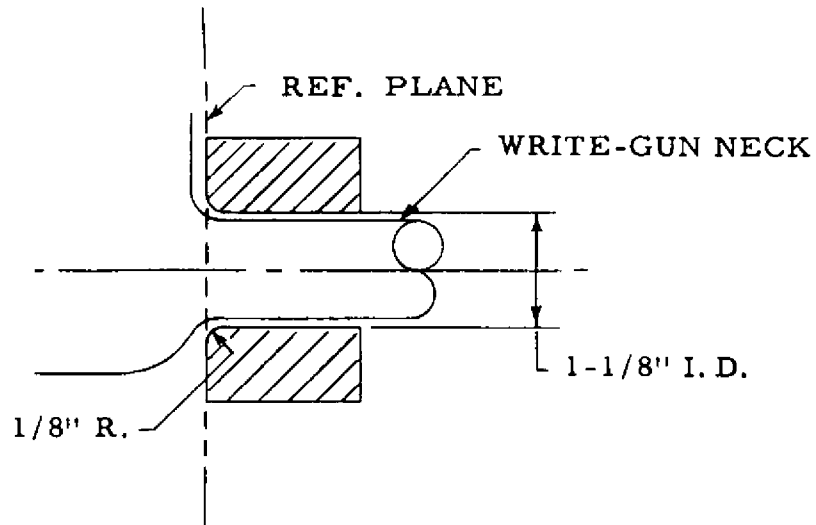
A multivibrator of variable duty cycle can be used to pulse the flood gun grid On-and-Off. The repetition rate of this multivibrator should be such as to avoid visual "beating" effects between the intensity modulation of the erasing pulse and that of the flood gun grid pulse. Flood gun pulsing deflects the writing gun beam approximately 0.040" and therefore requires corrective compensation in the sweep circuits to maintain spot size.

SCHEMATIC INFORMATION

(Drawing on Page 8).

Notes:

1. Plane through centers of neck and floodgun base coincides with plane through tube axis and bulb terminal 1 and 3 within $\pm 10^\circ$
2. Dimensions without tolerances are design centers
3. The reference plane is determined by means of a gauge as shown in the following sketch:



4. Maximum angle between centerline of writing gun neck and centerline of tube is $1/2^\circ$.

Please address inquiries for further technical information to:

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