ITT ELECTRON TUBE DEPARTMENT ■ COMPONENTS DIVISION
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, CLIFTON, NEW JERSEY

## IATRON TUBES - CONDENSED LISTING

| Type | Nominal Diameter In. | Write Gun Data | | | Phosphor Voltage | Light Output Ft. Lamberts |
|---|---|---|---|---|---|---|
| | | Location | Deflection | Voltage | | |
| 7172 | 2.5 | Coaxial | ES | -450 | 6.0 KV | 5000 |
| 7173 | 4 | Off Set | EM | -450 | 7.0 KV | 2800 |
| 7174 | 4 | Off Set | EM | -450 | 15.0 KV | 15000 |
| 7423 | 5 | Off Set | ES | -750 | 8.5 KV | 4000 |
| D-3001 | 5 | Off Set | ES | -750 | 8.5 KV | 2000 |
| FW 202<br>FW-204 | 5 | Coaxial | EM | -2500 | 10.0 KV | 2500 |
| FW-208 | 7.5 | Off Set | EM | -2500 | 10.0 KV | 1250 |
| FW-211 | 2.5 | Coaxial | ES | -900 | 8.5 KV | 4000 |
| FW-212 | 5 | Coaxial | ES | -1500 | 10.0 KV | 2500 |
| FW-223 | 5 | Coaxial | EM | -1000 | 10.0 KV | 2500 |
| FW-227 * | 4 | Off Set | ES | -1000 | 4.0 KV | 200 |
| FW 231<br>FW 232<br>FW-235 | 4 | Off Set | ES | -600 | 8.5 KV | 2000 |

EM - Electromagnetic

ES - Electrostatic

* - Two Write Guns; P11 Phosphor

# OPERATING PRINCIPLES OF IATRON* STORAGE TUBES

The Iatron Storage Tube is a cathode ray device which produces a bright visual display for direct viewing of electrically stored information. The tube consists of a CRT type writing gun for the electrical signal input, an insulator mesh for storage of the writing beam charge, a flooding gun to illuminate the storage mesh, and an aluminized phosphor viewing screen for visual output. The large undeflected flood beam continuously excites the phosphor after passing through the insulator mesh. The insulator mesh acts as a grid and modulates in cross section, the flooding beam. This modulation is in accordance with the charge placed on the insulator mesh by the writing beam. To erase stored information the metallic backing mesh which supports the insulator is pulsed, and by capacitive action the charged areas are erased. The rate of erasing, or persistance, can be controlled by adjusting the frequency, width, and amplitude of the erase pulses.

Viewing time in the range of milliseconds to several minutes may be obtained.

## Electrode Functions

There are three basic sections in an Iatron tube; these are the writing, flooding, and imaging sections. The functions of the backing electrode and viewing screen have been previously discussed and henceforth will be considered as part of the flooding section.

The writing section contains only the writing gun, which is of a type commonly used in cathode ray tubes and is operated in the same fashion. Complete operating data is given under the Operating Values and Typical Characteristics Sections for the particular tube type.

In the flooding section, a special diode gun produces a high current divergent beam. Conductive coatings on the inside of the glass bulb serve as anodes, whose purpose is to collimate the flooding beam. The flood gun anodes and the collector mesh all affect collimation but only the voltages on two or three anodes need be adjustable to achieve optimum collimation, when the other electrodes are operated at the specified operating voltages.

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## Flooding Beam Collimation

The tube must be operated in a magnetic shield to prevent deflection of the flood beam by magnetic field. Failure to provide adequate shielding will cause non-uniform light output across the tube face.

To collimate the flood beam, apply typical operating voltages as specified under Operating Values and Typical Performance Characteristics. Bias the writing gun to cutoff and turn off the erase pulses. Allow the tube to ion write to full brightness, (this may take several minutes), then adjust the collimating anode voltages so that the flood beam produces uniform light output over the entire screen.

Do not permit the tube to operate in this maximum brightness condition any longer than necessary to make the collimation adjustments. Operating at full brightness for periods up to 5 minutes is permissible for making the collimation adjustments but operation for prolonged periods at this high brightness will result in damage to the tube. Apply the erase pulses to the tube to reduce light output.

## Flooding

As its name implies, the flood gun simultaneously floods the entire storage surface with a low velocity high current electron beam. The beam is not deflected and is of uniform current density in cross section. As the beam passes through the meshes of the storage surface, the individual rays of the beam defined by the meshes are modulated by the potentials stored on the surface surrounding each mesh opening.

The value of the most positive potential stored on the storage surface is negative with respect to the flooding gun cathode. Consequently, flooding current cannot strike the surface but can penetrate the openings in the meshes if the potential level there is as high or higher than the cathode voltage. The cathode is normally operated at zero voltage and the backing electrode at +10 volts. The combined effect of the backing electrode and the storage surface voltages is to establish a potential level greater than zero in the mesh openings when the storage surface voltage is more positive than approximately -4 volts. Within the control range of -4 to 0 volts, flood current penetrates the mesh openings in proportion to the storage surface potential, continues on to strike the phosphor, and produces visible light output. As noted above, flooding beam cutoff occurs at a storage surface potential of approximately -4 volts and, as will be explained, zero voltage corresponds to maximum light output.

Writing

The writing gun produces a low current high density electron beam, which is either electrostatically or magnetically focused and deflected. The writing spot is modulated and deflected in the usual manner for cathode ray tubes. Before striking the phosphor the writing beam passes in sequence through two fine mesh metal screens, the collector and the backing electrode, which are mounted close behind the phosphor. The two mesh assemblies intercept about one-half of the electrons passing through them.

The backing electrode, located immediately behing the phosphor, derives its name from its primary purpose in the tube, which is to support the storage (insulator) surface. This storage surface consists of a thin layer of insulator material coated on one side of the mesh, the side facing the electron guns.

The portion of the writing beam, which is intercepted by the storage surface causes secondary electron emission, and the collector mesh, by virtue of its proximity to the storage surface, assures uniform collection of the secondary electrons. Since the secondary emission ratio is greater than unity for primary electrons with the velocity of the writing beam electrons the net result is that a net positive charge is stored on the insulator mesh wherever the writing beam impinges upon it.

Wherever charges are stored during writing, the potential of the storage surface is shifted in the positive direction according to the relationship $dv = dq/_{c}$. The voltage shift, dv, or the capacity, C, of the elemented area encompassed on the storage surface by the writing spot is proportioned to the stored writing charge, dq. In this way a potential distribution, corresponding to the beam modulating voltage and position with respect to the unwritten areas is established on the areas of the storage surface, which are written upon. The storage surface, therefore, acts as a grid for the flood gun and modulates the flood beam.

The storage surface potential can increase in the positive directions during writing until a peak value, positive with respect to the flooding gun cathode, may be reached after prolonged writing. However, it cannot be stored at that level but is automatically and continuously erased by the flooding beam to cathode potential after writing has ceased.

Erasing

Positive ions resulting from collision of the flood electrons with residual gas molecules land uniformly on the storage surface causing it to charge slowly in the positive direction. This is frequently termed ion writing. In less than one minute it can write the tube from cutoff to full light output, if no erase pulses are applied to the tube.

Erasing (Cont'd)

The ion writing can never cause the storage surface to go more positive than flood gun cathode potential because further increase in potential is checked by the landing of flood beam electrons on the storage surface should it become positive. Unlike the high energy writing beam, the flooding beam has insufficient energy to cause appreciable secondary emission; therefore, its effect in landing is to charge the storage surface in the negative direction to cathode potential, zero voltage.

The process of using the flood beam to charge the storage surface in the negative direction is termed erasing. In order to erase, the storage surface potential must first exceed zero volts and this condition is met by momentarily increasing the voltage of the backing electrode. A change in the backing electrode voltage induces a like change on the storage surface. The electrical circuit is completed by the beam in the tube, when the storage surface potential increases above zero volts and erasing begins.

The normal operating voltage of the backing electrode is +10 volts and the storage surface potentials are assumed distributed in the control range of 0 to -4 volts. If the backing electrode is suddenly raised to +14 volts, the storage surface potentials are likewise raised 4 volts to the range 0 to +4 volts. Flooding electrons will land on the storage surface charging it to zero volts. Next, restoring the backing electrode voltage to +10 volts reduces the storage surface to -4 volts and flood beam cutoff.

Viewing Time

Iatron tubes write bright traces on a dark background. The dark bachground is established and maintained by erasing with a continuous train of positive going voltage pulses applied to the backing electrode. To maintain a dark background, it is necessary to prevent ion writing, which, as already stated, can cause the viewing screen brightness to increase to maximum in a period of less than one minute. Assuming an ion writing time of 40 seconds, this rate referred to the storage surface is about 4/40 volts per second = .1 volt per second. If the rate of erasing, which causes brightness to decrease, is greater than the rate of ion writing, then the net change will be in the direction of decreasing brightness. Thus the effect of ion writing is overcome and an increase in background brightness is prevented. Since the maximum rate of erasing is about 4/.02 or 1000 volts per second (about 10,000 times greater than that required to counteract ion writing) this objective can be readily obtained.

The average rate of erasing is adjustable by pulse width, frequency, or both and provides a means of adjusting viewing time. Viewing time is the time required to erase from maximum brightness to cutoff. When the rate of erase is set so that it is just sufficient to overcome ion writing, the time to erase to cutoff is maximum and viewing time is maximum.

Black Level

It will be obvious from the discussion of erasing that the potential level to which the storage surface is erased depends to some extent on the amplitude of the erase pulses. The correct combination of erase duty cycle and amplitude should erase the tube to cutoff but not beyond cutoff. If there is insufficient erase the background will not be dark and if there is too much erase, writing must commence from a point beyond cutoff and writing speed capabilities will be reduced. Therefore, the erase pulse conditions must be correctly adjusted for optimum tube performance.

The correct amount of erase may be determined experimentally. With the tube collimated and writing gun biased off, slowly increase the amount of erase to some level which causes the light output of the tube to just dim uniformly. Next, turn off the erase pulses and observe the tube face. If the tube is still illuminated the tube is above cutoff. Go back and increase the erase slightly and repeat the procedure. Continue in this manner until the minimum amount of erase, which will just cause the face of the tube to go completely dark is found. These increments of erase increase must be very small as cutoff is approached because if cutoff is exceeded the tube will require considerable time operating with no erase to ion write back-up to above cutoff. As discussed previously, erase in excess of that required for cutoff will result in viewing times less than the full capabilities of the tube.

Power Supply Requirements

The writing gun voltages are all negative with respect to the flood gun cathode, which is normally operated at ground potential. The writing gun voltages may be obtained from a voltage divider circuit across the writing gun power supply in the usual manner for cathode ray tube guns.

Any voltage variations of the backing electrode are capacitively coupled to the storage surface which acts as a control grid for the flood beam. Therefore, the same precautions as regards ripple and shielding should be taken in operating the backing electrode as would be taken in operating any vacuum tube control grid. Although the backing electrode does not intercept current directly it does conduct all storage surface charging currents and therefore the impedance of the associated DC and pulse circuitry should not exceed 10,000 ohms.

The regulation of the viewing screen high voltage is not critical. Changes in phosphor voltages less than 10% do not cause a significant change in any of the electrode currents or tube characteristics. A series current limiting resistor of at least 1 megohm should be used and the power supply designed so that with no current through the current limiting resistor the voltage at the tube does not exceed the maximum ratings.

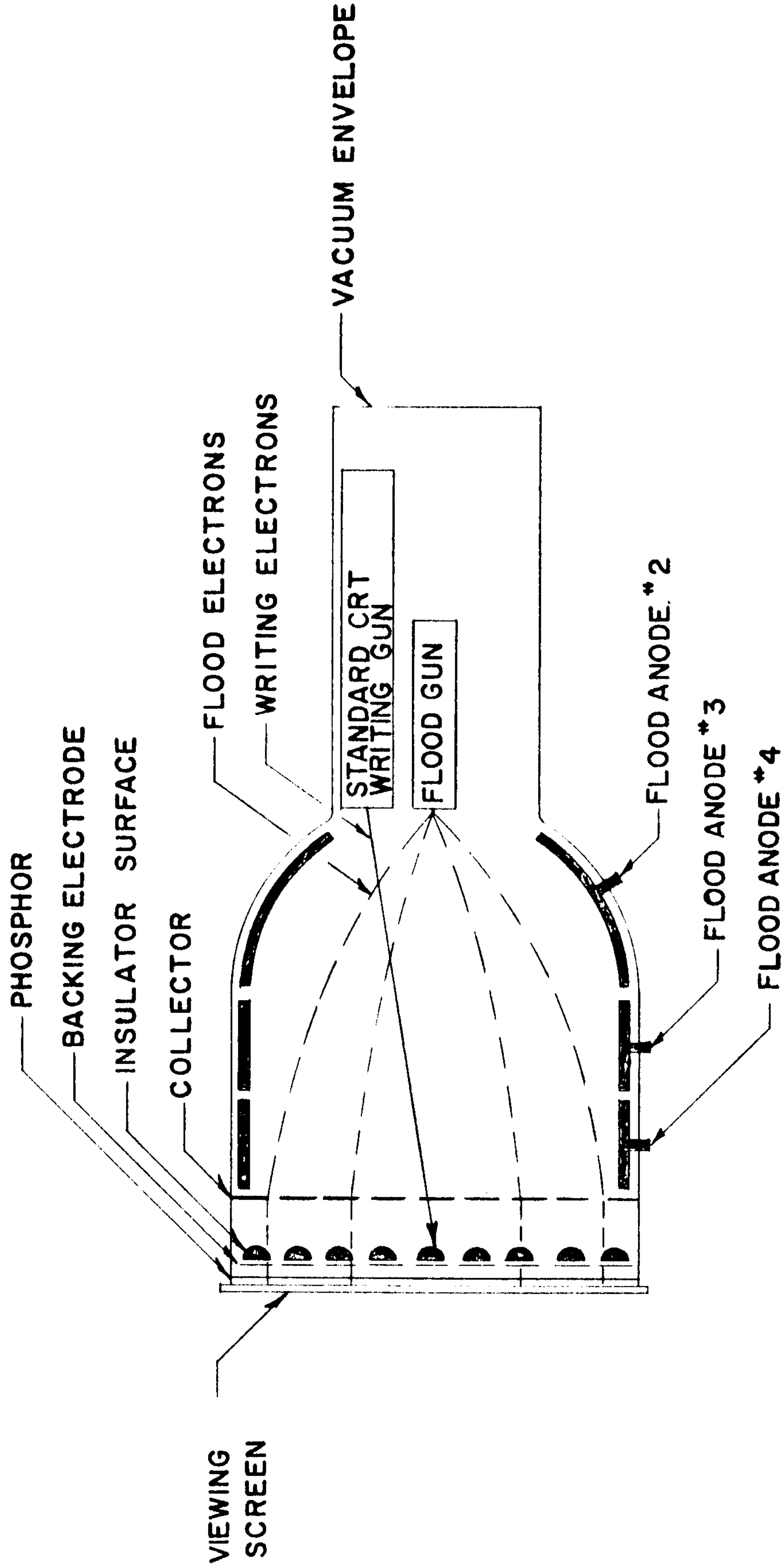
Special Precautions

Observe maximum ratings to avoid possible damage to the tube. In particular, the viewing screen voltage should be limited so as to never exceed the maximum rated value.

The full voltage should never be applied to the viewing screen instantaneously. An ordinary RC filter at the output of the power supply will provide adequate assurance that the voltage build up will not be too abrupt.

Repeated bombardment with the high current focused writing beam on a small area of the storage surface can burn and damage the storage surface. This will result in the burned area having different persistance characteristics causing the burned area to be visible when the writing beam is scanned across the area. The burned area may remain for several hours or even permanently. Therefore, deflection voltages should be applied before operating the writing beam. It should be noted that the burning is on the storage surface and not the phosphor, so that the tube may be damaged while there is no phosphor voltage applied to the tube and consequently no visual light output.

Attention is again called to the fact that the storage surface can be erased to far below cutoff by a high amplitude pulse applied to the backing electrode. A large transient voltage on this electrode can prevent normal writing for several minutes.




**PICTORIAL VIEW**
**IATRON TUBE**