5.5 IMAGE DISSECTOR (NONSTORAGE) TUBE

5.501 Principle of Operation. The image dissector operates on the principle of an electron-collecting aperture which is scanned by an electron image from a photo-emitting surface upon which an optical image is focused. The aperture collects the

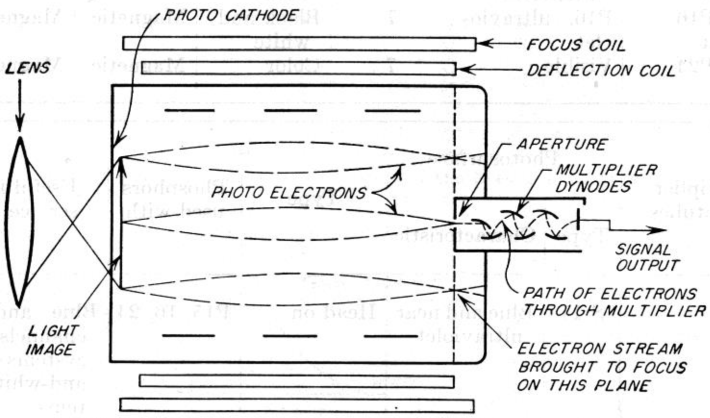

FIG. 5-51. Operating principles of the image dissector.

electrons emitted by the photosensitive material of the photocathode. The electron streams forming the electron image from the photocathode are caused to move past the aperture by externally applied magnetic deflection fields. The electrons collected by the aperture are introduced into the first stage of an electron multiplier and subsequently amplified by secondary multiplication to a sufficiently high level to develop a signal appreciably higher than the noise generated in the following (conventional) video amplifier stage.

The streams of electrons emitted by the photocathode of the image dissector are brought to a focus on a plane passing through the multiplier aperture and perpendicular to the axis of the tube. This is accomplished by the action of an axial magnetic focusing field and the electrical field produced by the accelerator rings. Therefore, as the entire raster is deflected across the multiplier aperture, the aperture intercepts the sharply focused stream of electrons produced by each illuminated area, and translates the light image into a stream of electrons forming the video signal information. This is illustrated by Fig. 5-51. Figure 5-52 illustrates the external appearance of an image dissector tube.

5.502 Optical Input Arrangement and Parameters. The useful area of the commercial image-dissector photocathode is a circle of $2\frac{3}{4}$ in. diameter, permitting the use of a scanned area of 2.2 by 1.65 in. The light from the scene to be televised is focused directly on the photocathode, which is deposited directly on the inside of the faceplate of the image dissector. The lens should be designed to cover this area, since the resolution varies directly with the size of the image used on the photosurface.

The photocathode of the image dissector (which is usually custom-made) is of the cesium-silver oxide or the cesium-antimony type. These two types of surfaces are different in spectral response and efficiency. The cesium-silver oxide surface as shown on Fig. 5-34 has its highest response in the red region while the cesium-antimony surface has its highest response in the blue region and is nearly equivalent to the S-9 response of a phototube. These photosurfaces are relatively insensitive to radiation outside the visible spectrum, except the silver-cesium oxide surface which has some infrared response. This is a desirable feature in some industrial applications.

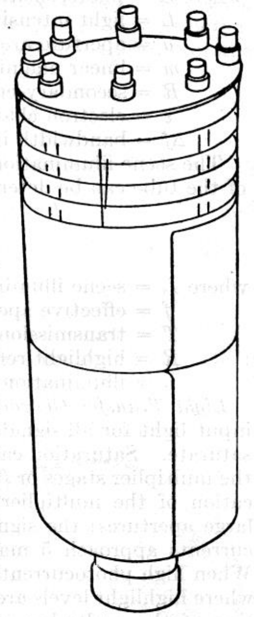

FIG. 5-52. Image dissector.

5.503 Electrical Arrangements and Performance Characteristics. *Resolution.* The resolution of the image dissector is determined by the aperture size of the collector and the magnification of the image from the photocathode to the plane on which the image is focused. The curves of Fig. 5-53 give the resolution of the tube as a function of the aperture size (square aperture) for an image magnification of 1. For different magnifications the line numbers are multiplied by the magnification ratio. This curve gives the response of the tube to a square-wave test pattern in terms of peak signal amplitude and television line number.

Image dissectors are made to the specifications of the customer with respect to the size of the aperture which ultimately controls the sensitivity and the resolving capabilities. The signal-to-noise ratio of the reproduced picture with a given illumination varies as the square root of the aperture area or directly with the aperture width. The resolution varies inversely as the width of the collecting aperture.

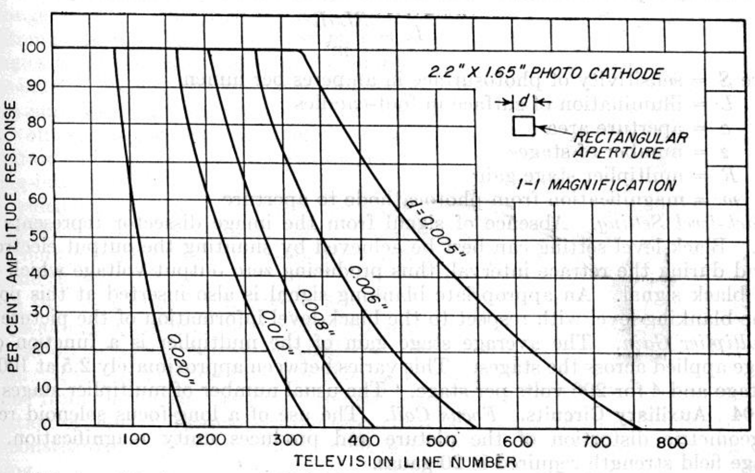

FIG. 5-53. Amplitude response of the image dissector as a function of aperture size.

The signal-to-noise ratio of the signal developed can be expressed as

$$\frac{\text{Peak signal}}{\text{R-m-s noise current}} = \left[\frac{SLa(R-1)}{2Rm^2e\Delta f}\right]^{1/2} \tag{5.10}$$

where S = photosensitivity of photosurfaces in amperes per lumen
L = light intensity in foot-candles (on photosurface)
a = aperture area in square feet
m = linear magnification of image within tube
R = secondary-emission ratio of first multiplier dynode
e = electron charge
Δf = bandwidth in cycles per second

The scene illumination necessary to produce this illumination on the photocathode of the tube can be determined by the following relationship

$$I_s = \frac{4f^2L}{TR} \tag{5.11}$$

where I_s = scene illumination in foot-candles
f = effective aperture of lens
T = transmission factor of lens
R = highlight reflectance of scene
L = illumination of photocathode

Light Transfer Characteristics. The signal output is directly proportional to the input light for all signal levels below the point where the final stages of the multiplier saturate. Saturation can be guarded against by the use of (1) variable potentials on the multiplier stages or (2) a controlled multiplier stage to control the over-all amplification of the multiplier. For low-resolution systems (that is, systems employing large apertures) the signal output will be linear up to the point where peak signal currents approach 5 ma, at which point the last dynode stage tends to saturate. When high photocurrents are drawn from the photocathode, in high-resolution tubes where highlight levels are necessary to achieve the proper signal-to-noise ratio, saturation of the multiplier or lack of conductivity of the photosurface may distort the picture and alter the light transfer characteristics.

Output Impedance. The multiplier of the image dissector can be considered to be a constant current generator with a very high value of shunt impedance. The capacity to ground of the multiplier itself is 10 $\mu\mu$f. Sufficient gain is obtained in the multiplier to permit the use of a low value of load impedance. Therefore, the signal need not be corrected by a peaking stage. The output signal can be determined by

$$I_o = \frac{SLaR^z}{m^2} \tag{5.12}$$

where S = sensitivity of photosurface in amperes per lumen
L = illumination of surface in foot-candles
a = aperture area
z = number of stages
R = multiplier stage gain
m = magnification from photocathode to aperture

Black-level Setting. Absence of signal from the image dissector represents black level. Black-level setting can best be achieved by shunting the output electrode to ground during the retrace interval, thus producing zero output voltage which represents black signal. An appropriate blanking signal is also inserted at this point to fix the blanking level with respect to the black-level information of the picture.

Multiplier Gain. The average stage gain of the multiplier is a function of the voltage applied across the stages. This varies between approximately 2.5 at 100 volts per stage and 4 for 200 volts per stage. The usual number of multiplier stages is 11.

5.504 Auxiliary Circuits. *Focus Coil.* The use of a long-focus solenoid reduces the geometric distortion of the picture and produces unity magnification. The average field strength required is 20 gauss.

Deflection Coils. The deflection coils located adjacent to the tube and under the focus coil produce a cross component of deflection field in the order of 4 gauss for full deflection.

Focusing Electrodes. Focusing electrodes consisting of a series of rings along the path of the electron image produce a uniform accelerating field for the electron image. Connection to these electrodes is made through terminals on the periphery of the faceplate. Each of these rings is maintained approximately 100 volts positive with respect to the preceding one. The anode of the tube is maintained at ground potential and the photocathode at approximately −2,000 volts, while the aperture of the multiplier is maintained at approximately −1,400 volts.

References Secs. 5.501–5.504

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43. N. Schaetti, An Image Dissector Without Storage for Film Scanner, *Bull. assoc. suisse élec.*, vol. 40, no. 17, pp. 569–570, 1949.
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