Farnsworth

IMAGE DISSECTOR

ENGINEERING BULLETIN No. 1

JANUARY, 1940

FARNSWORTH TELEVISION & RADIO CORP.

FORT WAYNE, INDIANA

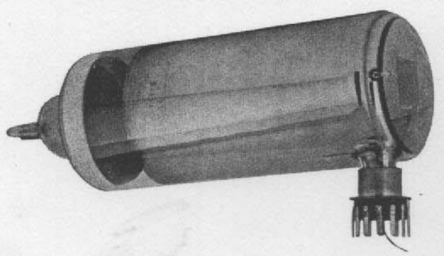
MANUFACTURERS OF ELECTRONIC PRODUCTS

FARNSWORTH IMAGE DISSECTOR

The Farnsworth Image Dissector is a simple and easily controlled pickup tube for use in a television camera. It is capable of producing an undistorted brilliant image which is rich in detail and strong in contrast. This electronic device is especially suited for use in telecine projectors, and also for direct pickup where the average subject brightness is not less than 150-250 candles per square foot when used in conjunction with a f/2.5 lens. In telecine operation it is customary to use a light source in the projector to provide about 200 foot candles on the cathode of the tube. This can readily be accomplished by means of an incandescent projection lamp. It has been successfully used in Europe and America for televising motion-picture film and for direct pickup demonstrations.

Its primary function is to convert the light energy from a televised subject into corresponding video frequency pulses which may be received so as to modulate the scanning beam of a cathode-ray tube upon whose fluorescent screen the image is reproduced. The pulses are transmitted either as a part of the modulation of a carrier from a radio transmitter or by suitable cable to the receiver.

FIG. 1, FARNSWORTH IMAGE DISSECTOR FOR TELECINE OPERATION



Simple In Construction

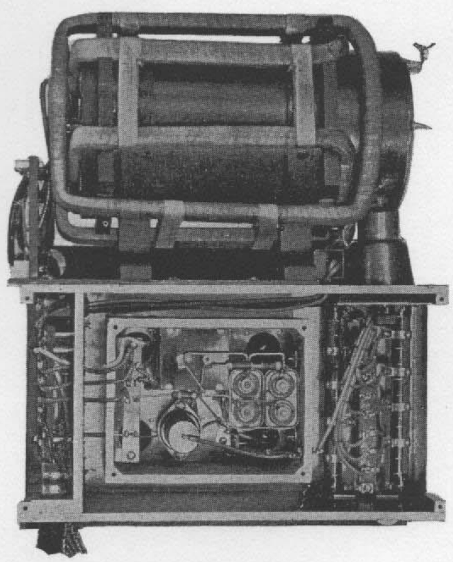
The tube's simplicity of construction is illustrated in Fig. 1, where it is seen to consist of an evacuated glass cylinder, closed at both ends. Its internal parts are a photo-sensitive cathode, an anode for accelerating the electrons emitted therefrom, and a shielded target containing a small aperture and an electron-multiplier. Its external accessories are a focusing coil, a high-frequency horizontal scanning coil and a low-frequency vertical scanning coil.

The cathode is a spun silver cup with a flat bottom on whose inner surface a caesium-silver oxide film has been formed; it occupies one end of the glass cylinder. The other end is a plane glass surface. The anode is a conducting nickel coating on the inner surface of the cylinder. The target is placed close to the plane glass end. The entire cylinder fits into the focusing coil by which an axial magnetic field is established throughout the length of the cylinder. The coil and tube are placed within a supporting frame-work consisting of the horizontal and vertical scanning coils, as shown in Fig. 2.

Operating Simplicity

The Dissector is operated by focusing an optical image from a lens through the plane glass end on to the photo-sensitive cathode at the other end. This causes the emission of photo-electrons from each point of the image in numbers proportional to the intensity of the light thereon.

FIG. 2, IMAGE DISSECTOR TUBE IN COIL SYSTEM MOUNTED ON HEAD AMPLIFIER



These electrons are accelerated from the cathode toward the target by means of a positive potential of several hundred volts on the anode and, by means of the axial magnetic field from the focusing coil, are sharply focused as an electron image in the plane of the aperture in the target. The number of electrons per unit area in this electron image corresponds to the brightness of the corresponding areas in the optical image focused on the cathode.

This electron image is deflected both horizontally and vertically by means of transverse magnetic fields from the two pairs of deflecting coils in the surrounding frame-work. These coils are supplied with L.F. and H.F. linear sawtooth currents whose combined action cause the electron image to traverse the aperture in a series of 441 interlaced lines repeated thirty times per second. This motion results in a progressive selection of image areas, and in a succession of electronic bombardments of the target. These successive bombardments correspond to respective areas of the optical image. This constitutes the process of image dissection, whence the name of the tube is derived. The fluctuations in the electron flow through the aperture correspond to the variations in the light and shade of the optical image.

The electronic current is then amplified by the electron-multiplier, whose operation depends upon static voltage conditions between successive stages. Each photo-electron coming through the aperture is a primary electron striking a secondary emission surface. The emitted secondary electrons are electrostatically focused on a succeeding stage where each acts as a primary in causing further secondary emission. Eleven stages of such action give a tremendous gain, as indicated in the figures for the sensitivity.

The operating currents are few in number. High-voltage DC is necessary to maintain the potential difference between cathode and anode, and between the stages of the electron multiplier. A lower voltage DC is required for the magnetic focusing coil. Low-frequency and high-frequency sawtooth currents are used for the two scanning coils.

Sensitivity

The cathode of a Dissector tube has a sensitivity of 30-45 microamperes per lumen. Its caesiated surface has a spectral response which peaks at about 7500 Angstroms. If a tungsten lamp at normal brilliancy be used as the source of light, the combination of the two spectral distribution curves results in "best focus" being obtained at about 8000 Angstroms. With 10 lumens in the high lights, (200-foot candles when the optical area is 2¼ x 3 in.) a Dissector having a sensitivity of 35 microamperes per lumen provides a calculated current of 1.3×10^{-9} amperes through the aperture.

Assuming a constant secondary emission ratio for each multiplier surface, the output current is given by the equation $i = i_o s^n$ where i_o is the initial photocurrent, s is the secondary emission ratio, and n is the number of stages. With 100-volts per stage, s is approximately 2.6. With 11-stages, 1.3×10^{-9} amperes is thus amplified to 50 microamperes. Across a 4000-ohm resistor this gives a 0.2 volt signal when the resistance is calculated for a video cut-off frequency of 3.5 m.c. This relatively high voltage output makes possible the use of only one stage in the head amplifier of a television camera.

Resolution

Assuming that the optical image on the cathode is 3 x 2¼ in. and that the ratio of the optical image to the electron image area is 1 : 1, a 441-line theoretical resolution with a 4 to 3 aspect ratio can be obtained from a scanning aperture 0.005 in. square. This aperture size divides the image into 270,000 picture elements. A larger electron image permits the use of a larger aperture to obtain the same resolution, since the resolution is a function of the ratio of the aperture size to the size of the electron image. An aperture .009 x .012 in. has been found to be effective in giving a good signal-to-noise ratio for the 441-line resolution.

Freedom From Shading Effects

An outstanding advantage that the dissector tube enjoys is that its output signal is entirely free from shading effects and contains complete background information. Both of these advantages are due to the fact that its output is effectively the photoelectric current from the light-sensitive cathode. There are no secondary electrons near the cathode to rain back and reduce the contrast or otherwise introduce undesirable shading signals. Consequently, there is no need for complex shading controls nor for an expert operator to handle them.

Complete Background Information

Since the photoelectric current is the only source of the output current, the DC output is directly proportional to the picture background. This information may be utilized in several simple ways to provide the proper background level for transmitter modulation. These eliminate the necessity for a separate photocell, and its associated direct coupled amplifier, to pick up background information.

Absence of Retrace Surge

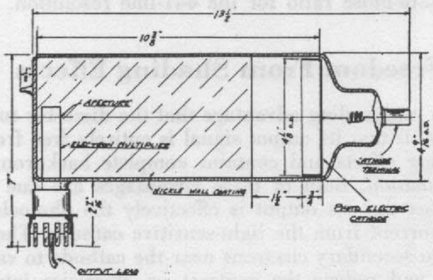
A third advantage is the absence of the spurious signal, known as "retrace surge," which originates during the retrace interval due to the redistribution of the charge on the mosaic of some storage type tubes. The characteristics of these tubes cannot be utilized until the signal is blanked out and the extra amplitude blanking pulse is limited. This spurious signal is not found in the dissector output.

Because of the inclusion of an electron multiplier as an integral part of the image dissector, the tube has a relatively high level of output. This enables the use of but one stage in the head amplifier and greatly simplifies the design and operation of the video amplifier chain. There is thus a minimum of phase distortion to be corrected.

No Keystone Distortion

Finally, to this list of advantages, whereby the image dissector requires few and simple auxiliary circuits, should be added the fact that it produces no keystone distortion, which otherwise has to be corrected. Minimization of circuits means greater stability of operation. More complete information regarding the tube may be found in October, 1939 "electronics" in an article by C. C. Larson and B. C. Gardner.

FIG. 3, OUTLINE DIMENSIONS OF IMAGE DISSECTOR FOR TELECINE USE



Two Sizes of Tubes

Image Dissectors are made in two standard sizes, a long tube for telecine use and a short tube for direct pickup of various scenes. The long tube has a cylinder length of 10⅜" and a diameter of 4½"; its target is placed off center. The short tube has a length of 7⅜" for the same diameter, and requires special focusing and scanning coils; the target is in the center, near the plane glass end. The figures on operating characteristics are for the long tube.

Typical Operating Characteristics

Amount of light for good pictures: 1-20 lumens.
Standard Defining Aperture: .009 by .012 in.
Dissector voltage: collector O v, cathode—1500 v.
Dissector current: 0.2 M.A.
Focusing Coil Current: 20 M.A. D.C.
H.F. Deflecting Coil Current: 250 M.A.
L.F. Deflecting Coil Current: 16 M.A.

Multiplier Voltage—

1st stage	1100 v.	7th stage	500 v.
2nd stage	1000 v.	8th stage	400 v.
3rd stage	900 v.	9th stage	300 v.
4th stage	800 v.	10th stage	200 v.
5th stage	700 v.	11th stage	100 v.
6th stage	600 v.		