**Writing to the eyelet.**

Description and simulations of writing bivalued information to the eyelet.

A graph of a wave

Description automatically generated

Eyelet current as a function of the eyelet’s electrostatic potential. Positive currents are due to secondary electron production. This curve is important to understanding how the writing process works. This curve is modeled after Figure 6, USPatent 2,635,201 and Figure 8, reference 2. The zero crossing at V0 is at a slightly negative potential (~-1V) given the thermal distribution of the electrons emitted from a cathode at 0V. The model curve is qualitatively similar to references 1, 2 and is used in the following LtSpice simulations.

*1.* US Patent 2,635,201

*2. Jan Rajchman, The Selective Electrostatic Storage Tube, RCA Review, Volume XII, No. 1, pp 53 - 97, March, 1951*

3. LtSpice: https://www.analog.com/en/index.html

Inspecting the I-V curve for the eyelet, there are two stable potentials: V0 and VC. Recall that the eyelet is floating, i.e. not connected to any external circuit. Assume, first, that the eyelet is near V0. If for some reason the potential increases (e.g. to 10V) the increased negative current will tend to reduce the potential back to 0. If, on the other hand, the potential on the eyelet is near VC, and the potential increases for some reason (e.g. during the write process), the negative current will return the potential to VC. If the potential drifts below VC, as may happen with leakage currents, the increased positive current (secondary electron production) will raise the potential back to VC. These two points are stable because the slope of the I-V curve is negative at these points. The point VA is not stable. If the eyelet finds itself at VA, any perturbation in potential will tend to raise the potential beyond VA and settle at VC.

**Writing methods**

In all methods, the write plate is used to change the potential of an selected eyelet via displacement current. Since the eyelets are also capacitively coupled to the collector, there is also a displacement current to the collector. In the absence of any other current, the eyelet will rise by ½ the write plate potential (assuming the plate starts at zero). To make any changes, the potential of the eyelet must be brough past the potential VA. The minimum Vwrite is twice the difference (VC-VA). For a collector at 180V, VA is about 50V, so the absolute minimum is 260V. A value of 360V is recommended in both references.

1. The write plate is made to rapidly rise from 0V to 360V followed by a sufficiently long plateau to allow an eyelet originally at 180V, brought to 180+360/2 = 360 V, to decay back to 180V. An eyelet originally at 0V will be at 0+ 360/2 = 180V. At the end of the plateau, the eyelet will be at 180V, independent of the initial potential and the write plate is slowly lowered to 0V over a time equal to the plateau time. If positive registry in the eyelet is desired (V=180V = digital bit=1), nothing else is done. If a bit=0 (V=0V) is desired, the current to the eyelet is keyed off just before the beginning of the write decay. With no external current to the eyelet, its potential will fall to near zero; 180 – 360/2 = 0V. Once the write procedure is completed, quiescent current is returned to all eyelets. This method was described in the original patent, USPatent 2,635,201 **and is the approach taken in the present application.**
2. In this method, the electron beam is not keyed. The write plate is made to rise rapidly to 360V as before. If the bit is to be 1 (180V), the write pulse decays slowly to cause the displacement current to be smaller than the net positive incoming electron current (see I-V) curve. This will effectively charge the element positively. If the bit is to be 0 (0V), the write plate is kept positive 360 for a sufficient time to allow an element at twice collector to decay to 180V (negative current portion of the I-V curve). Then the write plate is made to drop as rapidly as it rose resulting in a negative displacement current.

**Method 1**. Write pulse rapid rise, with a linear decay back to zero. Key current with selector bars.

**LtSpice Simulations**

The electron beam source to the eyelet is modeled in LtSpice using an arbitrary function current source (element “bi”). The function used is that which produces the IV curve above, given here:

I={if((time<10u)|(time>15u),

453.345u\*exp(-0.000399261\*(-114.956+V(eyelet))\*\*2)

-124.818u\*exp(-0.00186908\*(-31.0809+V(eyelet))\*\*2)

-388.297u/(1+exp(-0.0622775\*(-155.076+V(eyelet))))

,0)}

The function is parsed to make it more readable. The “if” statement is used to key off the current as needed. The LtSpice model

A diagram of a circuit

Description automatically generated

When writing a 0, current is keyed off before beginning of write plate decay. Starting with bit = 1 is the most extreme example. When the write pulse is initially applied, it must remain constant for an irreducible time to allow the eye to collect sufficient (negative) current to reduce the potential to the VC equilibrium point. This time is on the order of 0.5 to 1 uS

dt = C dV / I

C = 1pF, dV = 200V, I = 400uA

A screen shot of a computer

Description automatically generated

Writing a 1. Current is not keyed off.

Starting from a 0

A screen shot of a computer

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Starting from a 1.

A screen shot of a computer

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