Storage Tubes and Their Basic Principles, pp. 93 - 96

<u>Description</u> (Fig. 26). This device employs a large number of short parallel beams of electrons emitted from elongated flat cathodes which lie side by side in a single plane. Between the cathodes and parallel to them in the same plane are selecting bars. In an adjacent plane is another set of selecting bars perpendicular to the first set so that a series of windows is formed with an element of the cathode inside each window through which an electron beam may flow. By means of a series of external leads the potentials of the individual selecting bars can be controlled. Parallel to the planes of the cathode and the selecting bars are three successive perforated metal plates: a collector plate, a writing plate, and a reading plate. The holes of each plate coincide with the windows formed by the selecting bars. In each hole of the writing plate is an insulated metal eyelet which serves as a storage element. Beyond the reading plate is a Faraday cage formed by two additional perforated plates whose holes coincide with those of the other plates. Between the plates of the Faraday cage are reading output wires parallel to the plates but spaced between the holes. External to the Faraday cage, placed against its outer plate, is a glass sheet coated with phosphor on the side facing the cathode.

The <u>input</u> <u>signal</u> (yes-no information) is applied by allowing primary current to flow through a particular window, applying a voltage pulse to the writing plate, and then cutting off the current through the window either <u>during</u> or at the end of the pulse, depending on the information to be stored by the primary current at the eyelet. The <u>output</u> <u>signal</u> is obtained by determining the presence or absence of a voltage pulse

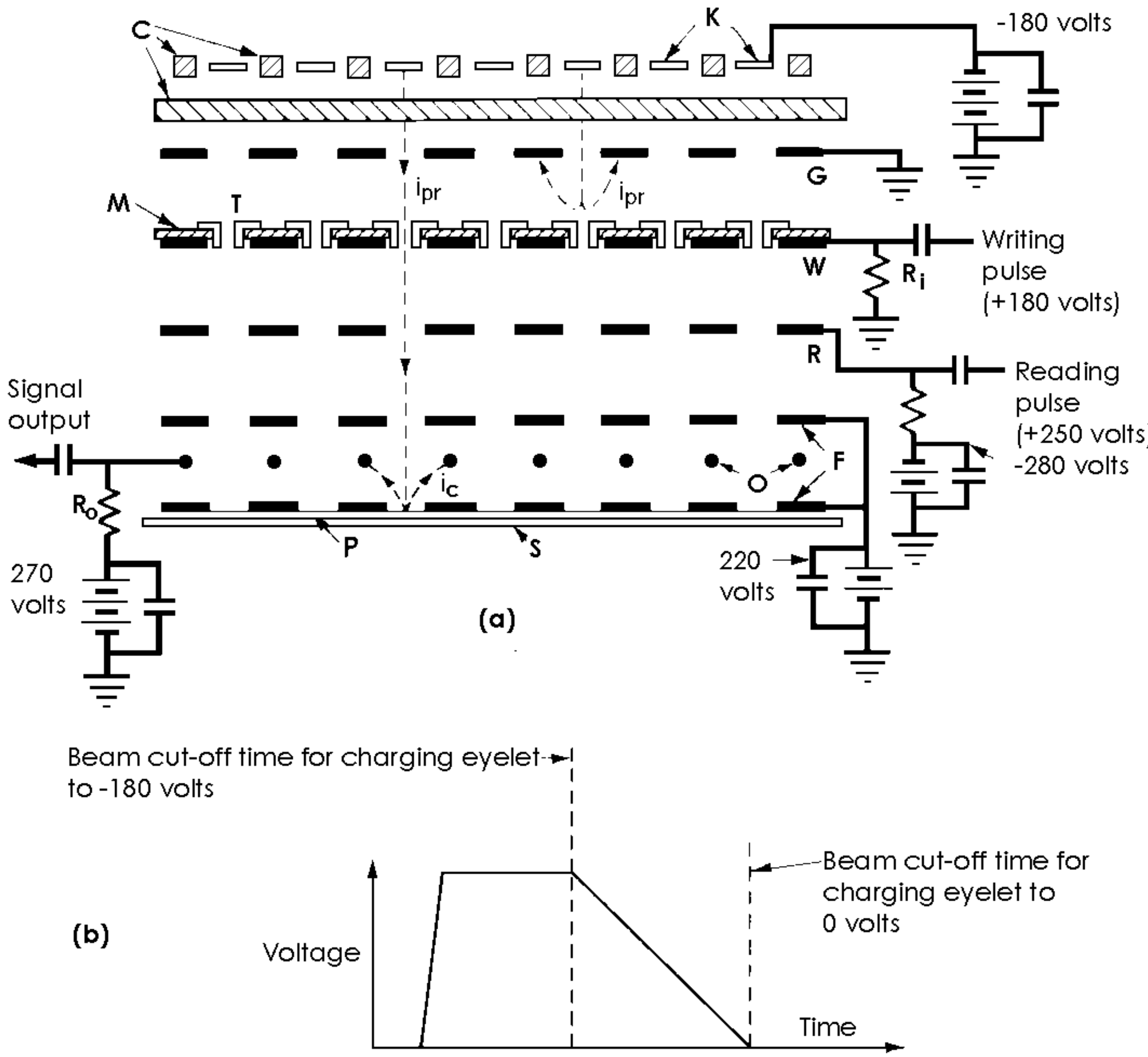


Fig. 26. Computer storage tube (Rajchman).
(a) electrode system; (b). pulse applied to writing plate.

**C**, selecting bars; **F**, Faraday cage; **G**., collector plate; **$i_c$**, collected secondary current from phosphor; **$i_{pr}$**, unreflected primary current (eyelet at 0 volts); **$i'_{pr}$**, reflected primary current (eyelet at -180 volts); **K**, cathode; **M**, insulating sheet; **0**, reading (output) wires; **P**, phosphor surface; **R**, reading-pulse plate; **$R_i$**, input resistor; **$R_o$**, output resistor: **S**, glass plate; **T**, metal storage eyelets; **W**, writing plate.

across the output resistor $R_0$ connected to the reading-output wires when a particular window is allowed to pass electrons and a voltage pulse is applied to the reading plate. Output signals are also obtained visually as light spots on the phosphor elements external to the Faraday cage.

Writing. The process of writing consists of charging each insulated writing-plate eyelet either to the potential of the cathode (-180 volts) or approximately the potential of the collector (0 volts). Since the first crossover potential $V_{crl}$ of the metal eyelets is assumed to be less than 180 volts, the eyelets will tend to acquire either the cathode potential or approximately the collector potential at equilibrium (see Figs. 3 and 4). Although writing can be accomplished in several ways, a typical method is described below.

The primary current passing through all the windows except one is first cut off by pulsing all the selecting bars to a potential of -250 volts with respect to the cathode except the four bars associated with the particular window, which are allowed to remain at cathode potential. (Current will only flow through a window when all four bars associated with it are at cathode potential, thus preventing the flow of current through windows adjacent to the desired one.)

While current is flowing through the window a positive pulse is next applied to the writing plate, capacitively raising the potential of the eyelets approximately 180 volts. The shape of this pulse is such that it has a rapid rise time, a flat portion of constant amplitude, and a long decay time (see Fig. 26b). If the insulated eyelet was at cathode potential initially, it will suddenly be shifted to a value close to the collector potential. During the flat portion of the pulse, primary electrons striking the eyelet will tend to shift it to the equilibrium potential $V_{eq}$ slightly positive with respect to the collector (or maintain it at $V_{eq}$ if it has already reached that potential), since the eyelet will be bombarded under the condition $\delta e > 1$. If the eyelet was at collector potential initially, the pulse will shift it approximately 180 volts positive with respect to the collector. The eyelet will now shift negative during the flat portion of the pulse until it reaches the equilibrium potential Veq. In either case, at the end of the flat portion of the pulse the eyelet will be at approximately the collector potential.

Depending on the desired final potential of the eyelet after writing, the primary current passing through the window is either (a) suddenly cut off at the end of the flat portion of the writing-plate pulse, or (b) allowed to remain on during the time of the slow decay of the pulse. If the primary current is suddenly cut off, the eyelet will merely be lowered from approximately collector potential to the cathode potential (-180 volts) by capacitive action as the pulse decays. If, however, the primary current is allowed to remain on, the eyelet will be maintained continuously at approximately collector potential by secondary-emission action as the pulse decays (assuming sufficient primary current), so that, at the end of the pulse, the eyelet will be at approximately collector potential. In a similar manner, by successively opening the other windows, each storage eyelet can be charged to either cathode or collector potential.

In order to prevent an output signal from appearing during writing, the reading plate is maintained at a potential of 280 volts, 100 volts negative with respect to the cathode, so that no electrons can reach the output circuit.

The writing access time, i.e., the time required for circuit switching and charging a particular element, is about 7 microseconds for the above type of writing. By means of an-other form of writing (see Ref. 65) the writing-access time can be reduced to 5 microseconds.

Reading. Reading is accomplished by allowing the primary current to flow through a particular window and observing whether a pulse is produced in the output across $R_0$ when a 150-volt positive pulse is applied to the reading plate. If the eyelet corresponding to this window was left at cathode potential as a result of previous writing, primary electrons would reach it with essentially zero energy and no current would pass through the holes. If the eyelet was left at collector potential, primary electrons would reach it with an energy corresponding to approximately 180 volts and a portion of the electrons reaching it would pass through the hole. The eyelet thus acts as a control grid whose potential determines whether or not electrons pass through it.

Since the pulse applied to the reading plate carries it to a potential 50 volts positive with respect to the cathode, primary current, if it passes through the eyelet, will also pass through the reading plate and continue through the Faraday cage whose potential is 220 volts. These primary electrons will finally strike the phosphor surface outside the cage, producing secondary electrons which will be attracted to the reading output wires whose potential, 270 volts, is 50 volts greater than that of the Faraday cage. As a result, a negative pulse will be produced across the common output resistor $R_0$, and a visual spot will be produced at the phosphor surface where it is bombarded.

In the same manner, the potential of each eyelet can be individually determined by allowing primary current to flow through the corresponding window and applying a positive pulse to the reading plate. Since the action of the primary current tends to maintain the eyelets at the equilibrium potentials established in writing, any shift in the eyelet potentials due to leakage or gas ions will be compensated by the reading action.

In practical operation the minimum access time for read-mg, i.e., the time required for switching and obtaining the output signals, is about 3 microseconds.

Erasing. Since, as indicated in the writing process, the potentials of the individual eyelets can be shifted either to the cathode or the collector potential regardless of their previous potentials, no separate erasing action is required before the writing of new information.

Polarity and Halftones. The output of this device is such that if the current through a window is cut off in writing after the decay of the writing-plate pulse, a negative output pulse will be produced in reading. If the current through a window is cut off before the decay of the writing-plate pulse, no output pulse will be observed in reading.

Since the process of writing involves shifting the eyelet potentials to only two possible values (yes-no operation) no halftones can be produced in the output.

Additional Considerations. For monitoring purposes, the potentials of all the storage eyelets can be determined by biasing the reading plate positive with respect to the cathode and allowing current to flow through all the windows simultaneously. In this case, a pattern of bright dots will be observed on the phosphor surface, corresponding to the eyelets which are at collector potential.

In typical tubes the decay time for the insulated eyelets is about 20 milliseconds. In operation, therefore, after each writing and reading action, all the windows are maintained open, since the primary current tends to maintain by a "holding" action of each of the eyelets at the equilibrium potential established in writing. This technique provides an indefinite number of readings regardless of leakage or ion discharge.

Since all the four selecting bars associated with a particular window must be at cathode potential for current to flow through the window, it is possible to connect the selecting bars internally in groups, thus reducing the number of external leads required, although still allowing control of one window at a time. In this device, which employs 256 windows, only 18 external leads are required for separate control of each window. In general, by such a method of grouping the selecting bars, the number of windows individually controlled can be made proportionate to the fourth power of the number of external leads.

Excerpt from STORAGE TUBES and Their Basic Principles

By Max Knoll and Benjamin Kazan