A DIGITIZING DEVICE FOR FILMLESS VISUAL DETECTORS

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ABSTRACT

We describe a device for eliminating film as data storage for visual detectors. The device is particularly suited for streamer chambers.

I. INTRODUCTION

Fast cycling visual detectors have a very high operational cost. Assume 20 pulses per second and 5¢/event (probably a fair estimate of developed film cost), one reaches $\$10^5$/day of operation. Wire chamber systems claim that these rates and higher are well within reach and magnetic tape cost is negligible. I would like to propose a digitizer which will make the streamer chamber (or conventional visual spark-chamber array) filmless.

II. GENERAL DESCRIPTION OF THE DEVICE

I shall describe first the hardware available at present for a streamer-chamber digitizer. With some variations, one could use the same hardware on conventional optical spark chambers, probably on fast-cycling bubble chambers, or on high-resolution hodoscopes (like the one proposed by Hofstadter in the present summer study).

The image from a streamer chamber is focused on a photocathode, and a microchannel plate (Refs. 1-3) amplifies the electron signal several thousand times. The microchannel plate is essentially a large number of electron multipliers arranged in an array (typically a few millimeters thick); each electron multiplier is a small tube, whose inner surface is a good secondary emitter (Figs. 1 and 2). The microchannel plate in Fig. 2 has 40μ diameter holes, a thickness of 2.4 mm, an open area of 62% and a maximum amplification of 10^7 (in the so-called pulse saturation mode). Plates up to 6-in. diameter have been operated. Unfortunately the high-resolution plates (below 40μ hole size) are classified. My guess for a reasonable limit hole size is 5μ. The fundamental advantages of this amplifier are the absence of distortions coupled with high gain and resolution, besides its compact size and cost (1-in. square ~ $500).

The amplified electron image is then stored by a digitizing memory. There are two promising devices for the memory. The first is a (modified) silicon target vidicon, the second a self-scanned solid-state image sensor.

III. THE SILICON TARGET VIDICON (STV)

Usually vidicons have a uniform photosensitive target where the free charge produced by light (or by electrons) is read by a flying electron beam; the position of the electron beam spot on the target is determined by measuring the voltage (or current) in both horizontal and vertical deflection optics. The target of a STV (Refs. 4 and 5) is made by forming a large number of diodes (like 670,000 in a square 12×12 mm^2) on an insulating support, and the position of the beam in the x direction can be determined by counting the number of diodes hit by the beam. The position of the beam in the y direction will be determined by a series of wires sensing the beam position and feeding back the information to the vertical deflection coil.

Presently available STV have a diode spacing (or least count) of 15μ, with a diode size of 8μ diameter. The reading rate is 1/30 of a second for ~680,000 diodes, or 20 Mc. Higher reading rates and higher resolution are feasible (Ref. 6).

IV. THE SELF-SCANNED SOLID-STATE IMAGE SENSOR (SIS)

P. K. Weimer and collaborators have developed a very interesting approach to image sensing (Refs. 7 and 8). They built a matrix of 360×360 photodiodes, 25μ in size, with a vertical and horizontal scanner deposited on the same plate. The output of the SIS is the horizontal and vertical coordinate of each diode hit by light (or electrons) in 9-bits binary form. The reading time of the sensor is ~1/20 sec or 2.5 Mc.

Work is in progress at RCA to build a $1,000 \times 1,000$ element matrix. Higher resolutions seem unlikely at present by using the same thin film evaporation technique. Both STV and SIS have been developed mainly for general purpose TV applications, where the density of information must be uniform; the sensing elements arrangement can be changed to fit our requirements just by changing the masks used to form diodes on the STV or SIS.

V. SOME MORE DETAILS

The two memory devices described are capable of reaching 10^6 positions, in a fairly compact size of several square inches; these 10^6 elements can be divided in 100 rows each with 10^4 positions. In Fig. 3 is schematically shown a possible arrangement of the complete digitizer. The image from the streamer chamber is focused on a photocathode (through a ~f:8 lens), amplified by the microchannel plate (5-10μ hole size) and stored on an STV (with ~15μ diode spacing). With a demagnification of 20 from real space to the STV plate, and with 15-cm wide plate one sees a

3-m wide area with a least count of 0.3 mm in space. The spacing in the direction perpendicular to the 100 rows will be ~ 3 mm on the STV plate. The electron beam will be guided by feedback from the two metallic strips in front of the diode rows (by requiring, for example, equal beam current going out from the two strips). A much simpler arrangement can be made replacing the STV by a SIS, probably at the cost of some resolution and reading speed, but with the advantage of a complete insensitivity to stray magnetic fields.

VI. CONCLUSIONS

A digitizing device capable of "converting" the streamer chamber in a "wire-chamber like" mode has been described. The digitizer seems to be well within present technology capability and will allow substantial savings in film cost.

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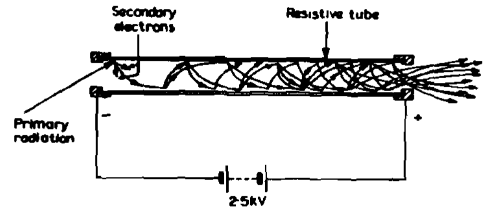

Fig. 1. Channel electron multiplier.

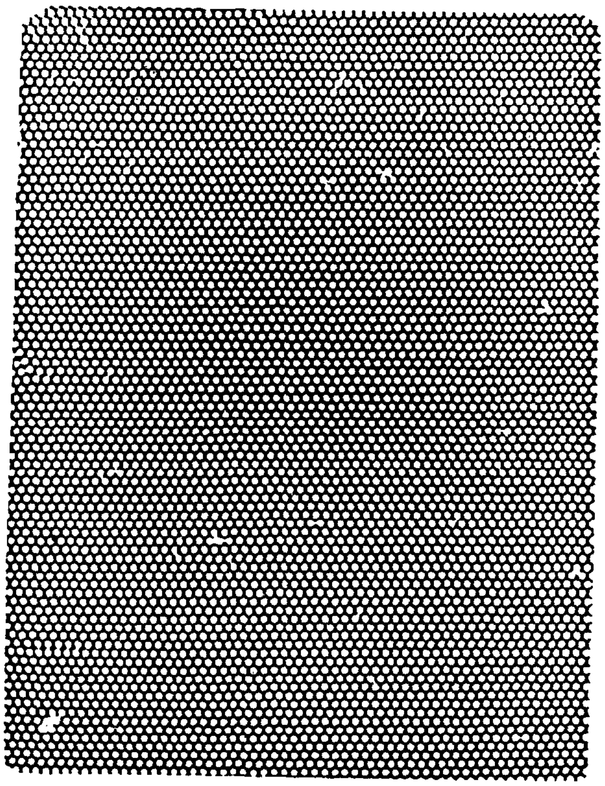

Fig. 2. Microscopic enlargement of part of channel plate composed of 40 m channels.

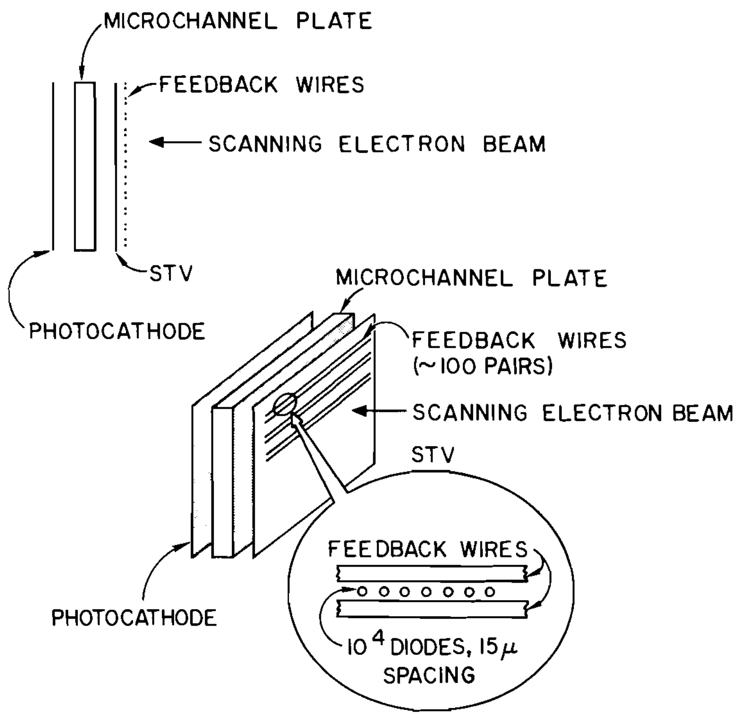

Fig. 3. Proposed digitizing system: the electron image from the photocathode, amplified by the channel-plate secondary-emission multiplier, produces a charge image on the STV which is read out by a scanning beam.