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Publication Date

1964-01-28

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UCRL-11146

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

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Abstract

A vidicon camera tube furnishes an ideal means for directly viewing spark-chamber events. By digitizing spark locations initially, one can perform the subsequent circuit logic by digital-circuit techniques. Information stored on magnetic tape can be presented in a format suitable for immediate analysis by a computer. A recent system for scanning two views of 12 spark-chamber gaps is described along with plans for future developments.

Introduction

Spark chambers can recycle in intervals of milliseconds, and therefore accumulate vast quantities of data during a single experiment. It is thus desirable that the acquisition, calculation, and interpretation of the information be made in an appropriately short time. A direct-view vidicon scanning system has been developed recently at this Laboratory to meet this need. Spark locations stored in parallel analogue form on the vidicon target are converted into serial analogue signals by scanning, thence digitized and within microseconds transferred to a buffer core store. Supplementary counter information related to each event is also collected, and after 10 events fill the store, its entire contents are recorded on magnetic tape in computer format.

Direct-view scanning and digitizing has several advantages over photographic recording:

a. Spark-track information is available for immediate entry into a computer. The system also allows both immediate and playback viewing of the digitized events at a remote location.

b. One can electronically select particular areas of the chamber for storage or rejection of each event.

c. An electronic system is capable of higher ultimate speeds than a mechanical camera.

d. All fixed or variable parameters from any source for a given nuclear event are easily assembled into one location on magnetic tape.

e. Magnetic tape is less expensive than film and is reusable.

f. When more than one view is required several vidicon cameras can be employed to view one or more chambers to simplify the optics.

In addition the system can readily be adapted to scan spark-chamber photographs. If a vidicon has sufficient sensitivity, it is preferred to an orthicon since it is more compact, less expensive, and does not have the electrostatic lens of the orthicon, which could be distorted by the spark-chamber electrostatic field.

Certain disadvantages should also be pointed out for a system of this type:

a. Good circuit reliability is required since all data are lost if the electronics fail.

b. A large memory is necessary if complicated events are stored.

System Requirements

Initial design requirements were for a vidicon system to digitize one particle track per event in spark chambers located at the entrance and exit of a momentum-analyzing spectrometer. The system should accept several events during an accelerator beam burst, and the resolution in the camera should be limited to that attainable from currently available vidicons and deflection yokes. It is imperative that the unit operate in an environment of spark-chamber and accelerator electrical noise.

A block diagram of the first system constructed is shown in Fig. 1, and the general operating specifications outlined in Table I. The arrangement of mirrors and lenses which projects the spark images onto the vidicon camera provides a format in which the two views of the spark chamber appear next to each other and with the plates parallel. This allows scanning by a single camera.

Vidicon Digitizing Camera

Input information is temporarily stored as a potential map on the semiconductor target of the vidicon. Scanning by the electron beam generates a video signal as the beam encounters the variously charged regions of the target, partially erasing the stored image. The short-term analogue storage of the vidicon is an essential property of the system and depends on the persistence of charge on the semiconductor target after the light flash has disappeared. An orthicon possesses storage properties also and could be used, although it is inherently more complicated. An image-dissector tube does not store, and hence can not be used for the present purpose.

The camera must operate remotely in stray electric and magnetic fields from the spark chamber, bending and steering magnets, and the accelerator. A camera design aimed at these requirements consists of an optical lens mount, a video preamplifier, and the vidicon with its

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deflection circuitry, enclosed in a tubular housing. The remaining circuitry and all controls are rack-mounted at the control area, communicating with the camera via a single cable. Shielding for a 100-gauss stray magnetic field and a 10-kV/meter pulsed electric field is an integral part of the system.

TABLE I

SPECIFICATIONS OF INITIAL SCANNING SYSTEM

Maximum spark-chamber gaps	12
Views	2
Maximum number of sparks per gap	2
Vidicon scans per gap	2
Digitizing time for one scan line	50 μsec
Quantizing error in digitizing	1/1024
Time to digitize and store one event	12 msec
Information in one event	504 bits
Dead time to erase event	36 msec
Maximum events per second	20
Number of events stored in buffer before transferring to magnetic tape	10

The chamber fiducial arrangement consists of illuminated slits on both sides of the spark chamber in each view. One view is sketched in Fig. 2. The left-hand slits are stopped down so that the top of these slits mark the central region of the spark gap. As the sweep proceeds in the slow vertical-sweep direction, the first video signal from a left-hand slit sets the digitizing logic so that on the following fast sweep, digitization starts. Fast scanning is done parallel to the spark-chamber plates. If a spark is present, a scaler is turned on when the sweep passes over the spark, and off when the sweep passes the slit at the right-hand side of the chamber. For calibration the scaler is gated on when the sweep passes the left-hand fiducial, and off by the one on the right. The two scalers available for this measurement may be used either to digitize two sparks per gap, or one spark per gap and the total gap length, i. e., the distance between left- and right-hand fiducials. To improve resolution, the digitizing is repeated two times in each gap, and the average of these two sweeps is delivered to the buffer store. The scalers count in binary, thus it is convenient to obtain the average of any two sweeps by shifting the readout of the scalers one place. A 20-Mc digitizing rate is employed and the total scanning time for one event is 12 msec. With an RCA 7263A vidicon, the video signal level will be down to about 40% at the end of the full scan.

Once an event is digitized, the vidicon target must be completely erased (recharged). Three 12-msec sweeps of the vidicon target are made immediately after an event has been digitized, and thereafter periodic recharging scans are made between accelerator beam bursts.

Each spark is identified by a gap number, view, and the particular sector counter that triggered the chamber. But because of the fixed event-data format (see Fig. 3), it is not necessary to store the view and gap numbers. Therefore the data are compressed by eliminating unnecessary information. The digitized information is first sent to a data combiner, then temporarily stored in a 6144-bit magnetic-core buffer, and finally transferred onto magnetic tape for subsequent processing by a 7094 computer.

Event Sequence

The data combiner controls the sequence of operations during storage of events. When the counter electronics signals that an event has occurred, the data combiner first inhibits further collection of data and then transfers 24 bits of data from the current event into the core memory. This block contains the event serial number, identification of counter(s) detecting the event, and miscellaneous bits. Next, the data combiner signals the vidicon digitizer to begin digitizing the addresses of sparks in the chamber, and simultaneously connects the output of the digitizer to the input of the buffer store. The digitizer then issues the twenty-four 12-bit words containing the spark addresses and erases the vidicon screen. When finished, the digitizer signals the data combiner. The data combiner then resets its data registers, advances the event-serial-number register by one, and removes the inhibit condition on the counter electronics. At this point the counter electronics is ready to accept another event.

Data-Record Sequence

When the buffer store is filled to capacity by the data from 10 events, it issues a "store-full" signal; this starts the IBM 729V tape transport. After an appropriate delay, the transport begins requesting data from the buffer store at a rate of 60, 000 characters per second (7 bits per character). When emptied, the buffer signals the tape control. The tape control then generates the longitudinal-parity-check character and stops the tape transport. During the 29 msec required to transfer the data, the data combiner inhibits further acquisition of data.

Checking and Monitoring

The magnetic tape can be read within 4 msec after writing. The tape control has the necessary electronics for checking the parity of the information read from the tape and issuing an alarm if errors are discovered. Thus one can be assured that the data are being properly recorded.

The visual-readout block is a device for monitoring data either from the data combiner (one 36-bit word can be displayed) or from the magnetic tape (three 36-bit words can be displayed from a pre-chosen area of the record). The data are displayed on three banks of 36 incandescent lamps each. Using the visual readout, one can compare data received from the data combiner with that read from tape.

An analogue cathode-ray-tube monitor connected to the signal output of the vidicon allows the operator to observe the entire spark-chamber array. All sparks and illuminated fiducial marks are visible on this display. In addition the raster display can be intensified to indicate particular areas of interest, e. g., the actual lines scanned or the areas where digitizing is permitted.

A second digital display unit can show the digitized addresses of sparks or fiducials both at the time of occurrence and during a playback of the magnetic tape. Since the present system has a storage capacity of only two sparks or fiducials per gap, the display portrays only these data. Any additional sparks are ignored. The display reconstructs the original event with the correct spatial orientation, although the aspect ratio of the display may be distorted. The spark-chamber gaps are displayed as the ordinate, while the spark distance from the left side of the chamber is plotted as the abscissa. To display an entire event takes 1333 μsec.

System Operating Results

Because the first operation of the system in an experiment is scheduled for February 1964, only preliminary operational results are reported. Figure 4 shows a digital display of a cosmic-ray track that was stored by the unit and subsequently replayed from the magnetic tape.

The vidicon camera resolution was measured to be one part in 2000. This was checked by measuring the scanning time between two fiducials located in the plane of the spark chamber with a time-to-height converter connected to a pulse-height analyzer. Spark addresses are recorded in a 10-bit register; thus, the maximum quantizing error is one part in 1024. This figure can be improved by increasing the register and buffer capacity.

Future Plans

A number of refinements are planned after the initial operation of the system. Decreasing the quantizing error and improving the vidicon camera resolution would make the system useful where more precise track measurement is required. A larger buffer store would allow the system to be used on chambers with a greater number of gaps or multiple-chamber experiments.

Since the vidicon camera is relatively inexpensive, in some experiments the use of several cameras may be more economical than than the construction of a large mirror array.

Ultimately it is expected that the buffer will be connected directly to an on-line computer. By employing the computer-interrupt feature, other computations can be made when spark-chamber data are not being generated.

Acknowledgments

We appreciate the encouragement and support of the Moyer-Helmholz experimental-physics group, who will be the first users of the equipment. Many members of the Nuclear Instrumentation Groups have contributed to the development and construction of the overall system. Lloyd Robinson designed the buffer store.

This work was done under the auspices of the U. S. Atomic Energy Commission.

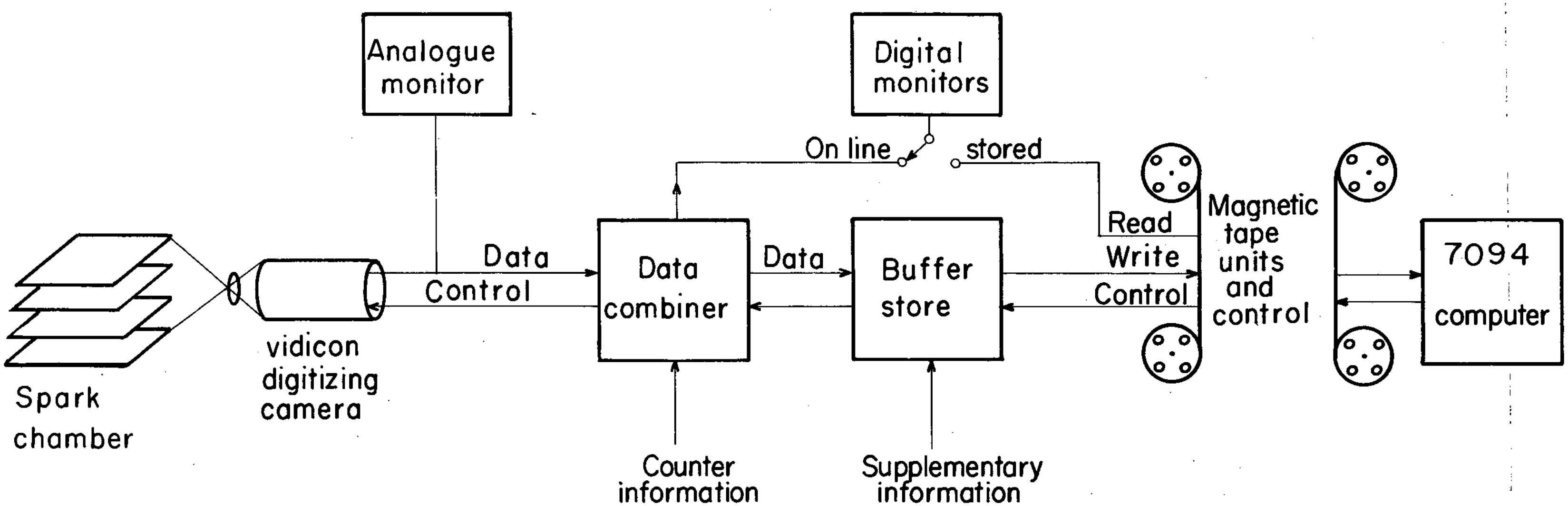
Figure captions

Fig. 1-- Block diagram of vidicon scanning system.

Fig. 2--Spark-chamber scanning sequence.

Fig. 3-- Computer word format for one event.

Fig. 4-- Digitized display of cosmic-ray track replayed from magnetic tape.



MUB-2385

Fig. 1

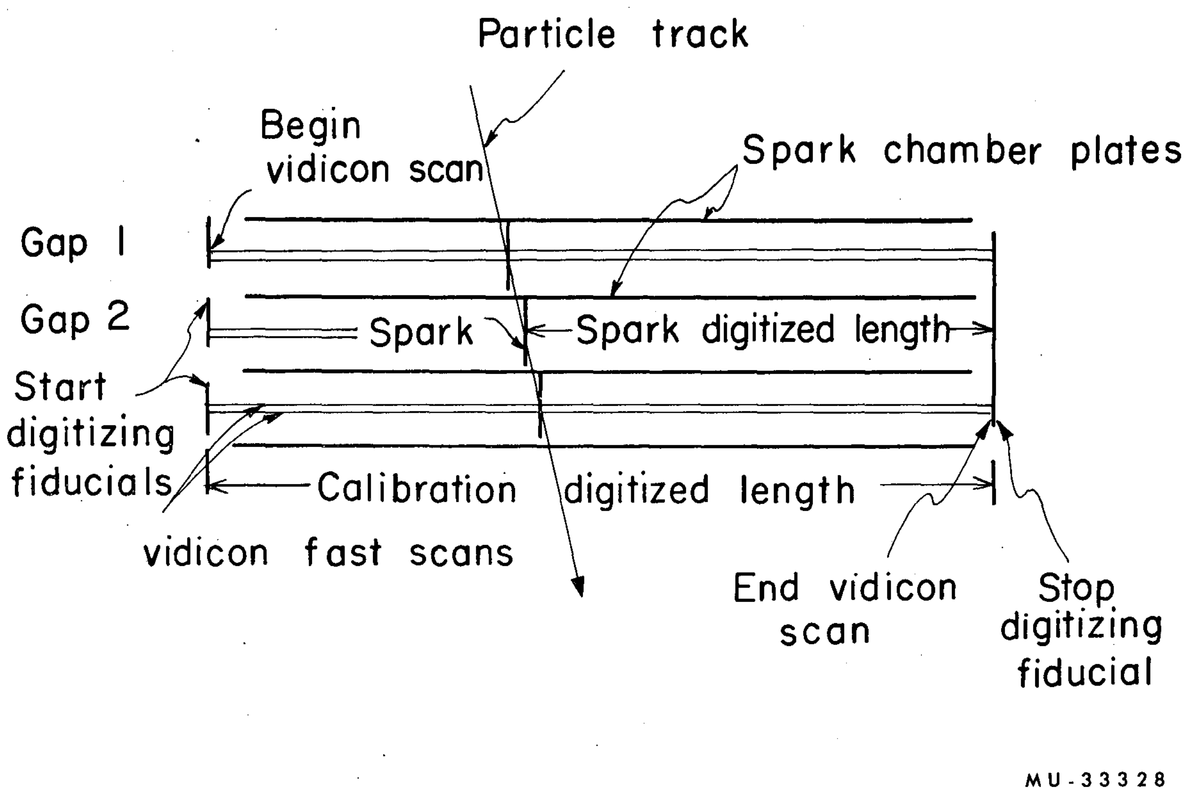

Particle track
Begin vidicon scan
Spark chamber plates
Gap 1
Gap 2
Spark
Spark digitized length
Start digitizing fiducials
Calibration digitized length
vidicon fast scans
End vidicon scan
Stop digitizing fiducial
MU-33328

Fig. 2

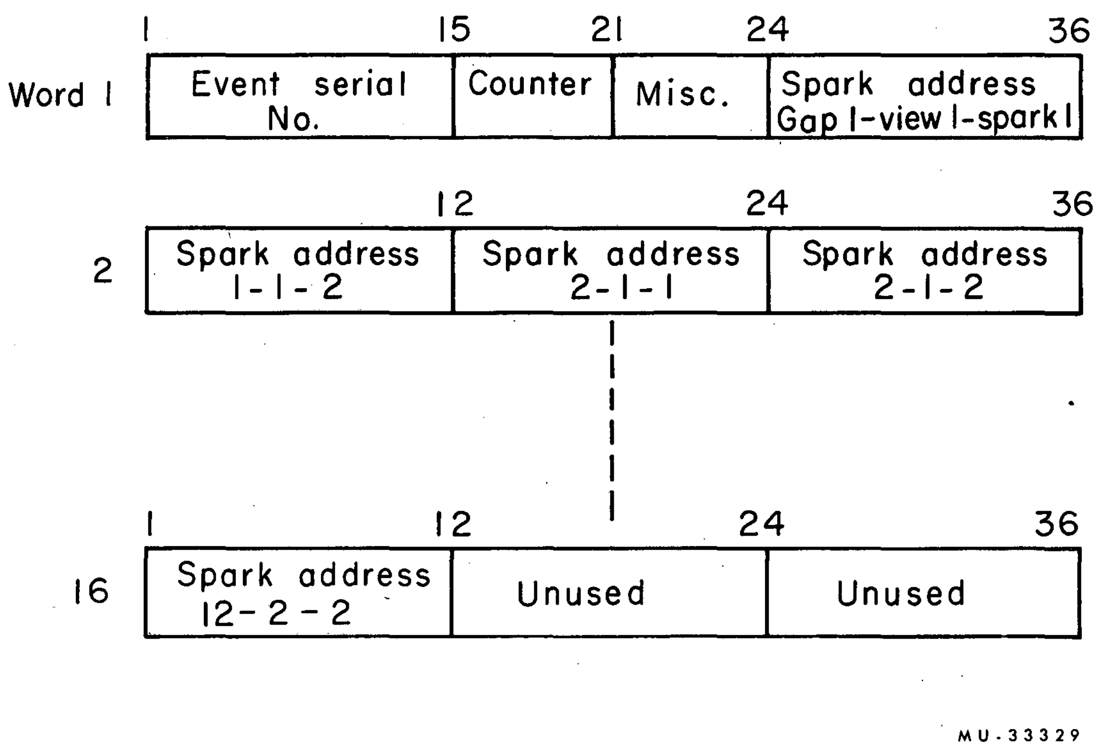

1
15
21
24
36
Word 1
Event serial No.
Counter
Misc.
Spark address Gap 1-view 1-spark 1
12
24
36
2
Spark address 1-1-2
Spark address 2-1-1
Spark address 2-1-2
1
12
24
36
16
Spark address 12-2-2
Unused
Unused
MU-33329

Fig. 3

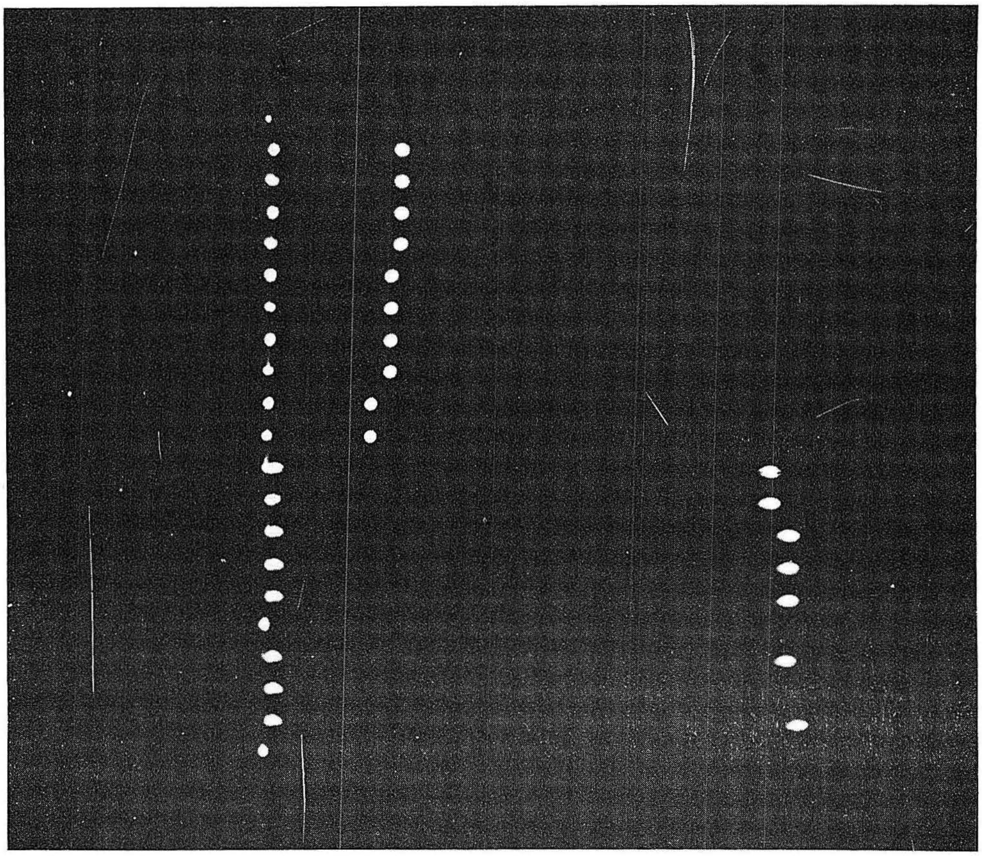


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Fig. 4