Title
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DISCLAIMER

DIGITIZED MEASURING PROJECTOR FOR THE ANALYSIS OF SPARK-CHAMBER PHOTOGRAPHS†

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As the number of pictures recorded in spark-chamber experiments over the past two years has increased from a few tens of thousands to several hundreds of thousands in each experiment, the need for semiautomatic data-recording devices for analyzing spark chambers has become apparent. There have been a number of proposals for rather exotic schemes for automatically and quickly converting spark-chamber photographs to digital information that can be directly processed by a computing machine, without the need of a human scanner. These schemes became almost mandatory for experiments where the number of pictures or events exceeds a million. However, such devices will be expensive and the development time required to bring them into operation considerable. While they will be exceedingly useful when available, the most realistic estimate predicts that it will be several years before they are in operation. The immediate problem of the present experiments requires some device that can be used now rather than two years from now. In this vein we have built a measuring projector, for use with spark chambers, which does not dispense with the scanner but makes his work much less painstaking and eliminates some of the transcription errors that a scanner is prone to make.

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From the standpoint of measuring the automatically recording the measurements of tracks, there is one striking difference between spark-chamber photographs and bubble-chamber tracks. In a spark chamber the spark itself is generally not parallel to the direction of motion of the particle. The direction and position of the path of the particle are given by a series of points usually taken as the center points of the sparks. In fact, many spark-chamber tracks, when examined closely, appear in the form of a staircase. For this reason a track-following device such as is commonly used with bubble-chamber analysis does not seem particularly applicable to spark-chamber pictures. Because of this we have adopted the philosophy that the most expedient approach is to have the scanner make a best fit of a straight line to the spark centers along the track. This is, of course, applicable only to chambers with no magnetic field applied directly to the field of view. A natural coordinate system for this purpose is the direction or angle the line makes with respect to some fiducial angle, and one x,y coordinate somewhere on the line. With these considerations in mind we built a scanning device which presents to the scanner a ruled line which he can adjust in position and direction until it coincides with the spark. An x,y coordinate of the line and its direction are then automatically recorded on punched paper tape.

Several different physical configurations of the projecting machine were considered. A very obvious and appealing approach is one of using an ordinary drafting machine on a projection table and digitizing the position of the drafting machine and the angular setting of the drafting machine. The scanner then would line up the rule of the drafting machine with the track and then punch correctly an x,y coordinate and a direction. This sort of device, however, demands that the optical system used to project the film onto the scanning table be free of distortions. Although this is a soluble problem, we felt that it would be easier over a long period of time to keep the machine free of errors if we could eliminate the effect of distortion in the projection optics. Therefore, we decided to measure the x,y coordinate directly on the film. The angular measurement, however, can be made on the projection surface, since it is relatively easy to maintain an optical system free of rotational aberrations. A schematic drawing of the projection machine is shown in Fig. 1. The stage that carries the film and thus measures the x,y coordinates is a microscope stage designed for nuclear emulsion analysis. It has motion in both the x and y directions and is driven by screws with a 1-mm pitch. The film runs over a flat glass plate on the stage and is clamped by another vacuum-operated glass plate. The stage position is then digitized by using Datex CG-703 geared encoders manufactured by Datex Corporation of Monrovia, California. These encoders read a shaft rotation with a least count of one-thousandth of a turn and a full count of 10^5 counts. Thus the least count corresponds to 1μ on the film. The events are presented for the scanner by projecting the film through the projection lens and mirror above the projector onto a translucent screen. The screen rotates in an accurately aligned mounting and has scribed on it a line with which the scanner can align the track of sparks. A Datex CG-703 geared encoder is also used to record the rotation of the screen. The encoder is geared to the projection screen such that a least count corresponds to one ten-thousandth of a revolution, or approximately 1/30 deg. Since it is frequently desirable to be able to scan the spark-chamber pictures under relatively low magnification — where the entire picture can be easily seen — and then to make the measurements on a particular part of the picture under higher magnification, we have provided a lens turret which allows the scanner to select either of two magnifications. The scanner can select a magnification of the films on the screen of either 10 or 60.

In addition to the information from the encoders, a set of parameter information set up by the scanner on switches is recorded on the paper tape. This information can be either decimal or binary in character. The decimal information is used for recording such things as run number, frame number, etc. The binary information is used for answering "yes", "no" questions such as, "Did the track interact in the spark chamber?", "Did the track stop in the spark chamber?", "Did the track scatter in the spark chamber?", etc. The electronics to transfer all this information onto the paper tape was also supplied by the Datex Corporation. This system is designed in such a way that the format of the information as it appears on the paper tape and the number of decimal or binary characters is completely under our control by use of a plug-board. Thus we have been able to make the machine quite flexible and able to cope with the completely different geometries that occur from one experiment to the next. Parameter information is set up on switches presented to the scanner on a large board. This board can be rebuilt from one experiment to another to contain only those switches needed for a particular experiment, and could be laid out in such a way as to have some mnemonic representation to facilitate use by the scanner.

The projection machine has started to operate on a regular scanning schedule. The least count of both the x,y coordinates and the angular measurement contribute smaller errors than those arising from the reproducibility of setting. Thus the errors of the machine are smaller than the scanning errors. On preliminary measurements to date we believe that a scanner will reproducibly set on a given track of sparks with an rms deviation of approximately 10 μ in x and y and about 0.1 deg in angle. Measurement of a typical event can be carried out in 2 or 3 min by the average scanner; this involves the measurement of five tracks, five stereo images, and six fiducial lines. Although this time is only slightly faster than that in which the scanner could measure the event on a scanning table with a hand-held protractor, the fatigue of the scanner is much less, recording errors are avoided, and the accuracy is substantially greater.

The paper tape produced by the machine is converted to magnetic tape by using an IBM 1401 computer with a 1011 paper-tape reader attached. The magnetic tape may then be processed with either an IBM 709 or IBM 7090 for actual kinematic analysis of the event.

FIGURE CAPTION

Fig. 1. Schematic elevation view of the spark-chamber measuring projector.