SYSTEM FOR THE DIRECT DIGITIZATION OF ELECTRON IMAGES FROM A TEM

Richard E. Hartman, Harold Alsberg, Roberta S. Hartman,
Robert Nathan, and Pierrre Wendell*.

The Jet Propulsion Laboratory of The California Institute of Technology,

During the past several years we have been developing a system which recovers information from electron images in the transmission electron microscope and which transforms this information into a form suitable for digital image processing and analysis utilizing the VICAR image processing system developed at the Image Processing Laboratory. This system uses an IBM 360/44 computer.

The information normally recovered in a transmission electron micrograph consists of a two-dimensional field of data in which each datum is, ideally, proportional to the number of electrons received by a finite elemental area during a finite interval of time. The ideal sensor for an electron image would be a two dimensional array of electron counters which would have the following properties: (1) Each counter would have the sensitivity required to detect single electrons. (2) Their apertures would be of equal size and dimensionally small. (3) The counters would be spaced so that the limiting resolution of the microscope could be utilized at its available maximum magnification. (4) Each would be capable of storing all electrons regardless of the counting interval. (5) Their capacity would be sufficient to provide a large dynamic range. (6) The counters would be able to utilize high energy electrons (100 kv) with no significant deterioration. In addition, the system used to read the array should be destructive, i. e. the stored information should be removed when read.

A reasonable approximation to this ideal sensor is provided by a silicon diode vidicon when it is used for the direct sensing of electron images. We have designed and built a demountable system which places such a vidicon in the vacuum system of the Hitachi HV-1 high vacuum electron microscope where it serves as a direct transducer of electron images. The vidicon is driven by a standard television camera at EIA-RS-170 rates(1).

Figure 1 is a block diagram of the system in its present state of development. The camera delivers a linear analogue signal organized into two 262 line fields which are interlaced to provide a 525 line frame at a frame rate of 30/sec. To reduce this data rate to one acceptable for input to the IBM 729 digital tape recorder the signal from the camera is delivered to a line selection system. This gates successive lines of successive fields to a digitizer which then digitizes the accepted line into 512 8-bit bytes. These are stored in a one line buffer which then delivers the information to the 729 tape recorder at a rate of approximately 60kHz. This process is completed before the time of the selection of the next line from the camera data stream. The process is repeated until a complete digitized frame is recorded. This digital record can then be delivered to the IBM 360/44 computer for analysis, processing, and ultimately for the production of hard copy electron micrographs.

The system, in its present state, has a number of deficiencies: (1) The fact that the digital record recovers only one line per field from the information delivered by the primary electron beam to the sensor results in a loss of 99.6% of the information extracted from the specimen. Particularly with biological specimens, which are our major interest, the specimen deterioration which results from specimen beam interaction makes this loss unacceptable. (2) The most serious problem related to the characteristics of the silicon diode targets is the result of their rather limited dynamic range. As shown elsewhere(2), saturation of these targets occurs at about 50 electrons per picture element with 50kv electrons. In order to obtain satisfactory signal to noise ratios from such images with specimens producing low modulation of the primary beam (low contrast in biological specimens), many images must be recorded and subsequently summed by computer. Although this is possible, it rapidly becomes infeasible because of the high cost in effort and computer time.

EIGHTH INTERNATIONAL CONGRESS ON ELECTRON MICROSCOPY, CANBERRA, 1974, VOL I.

This system has proved to be extremely useful by providing the opportunity for preliminary evaluation of the performance of silicon diode arrays as sensors in the electron microscope, by defining a number of problems which must be overcome in future deveopments, and by providing considerable experience in the digital processing of electron micrographs. Preliminary tests of further modifications of the system, which cannot be discussed here because of space limitations, indicate that these problems can be overcome.

* Current Address: The Institute of Physics, Strasbourg, France.

(1) Electronic Industries Association, EIA-RS-170 "Television Standards Specifications."

(2) Hartman, Roberta S., et al. These Proceedings.

Supported by NASA Contract NAS 7-100 and NIH Grants GM18619 and RR00443.

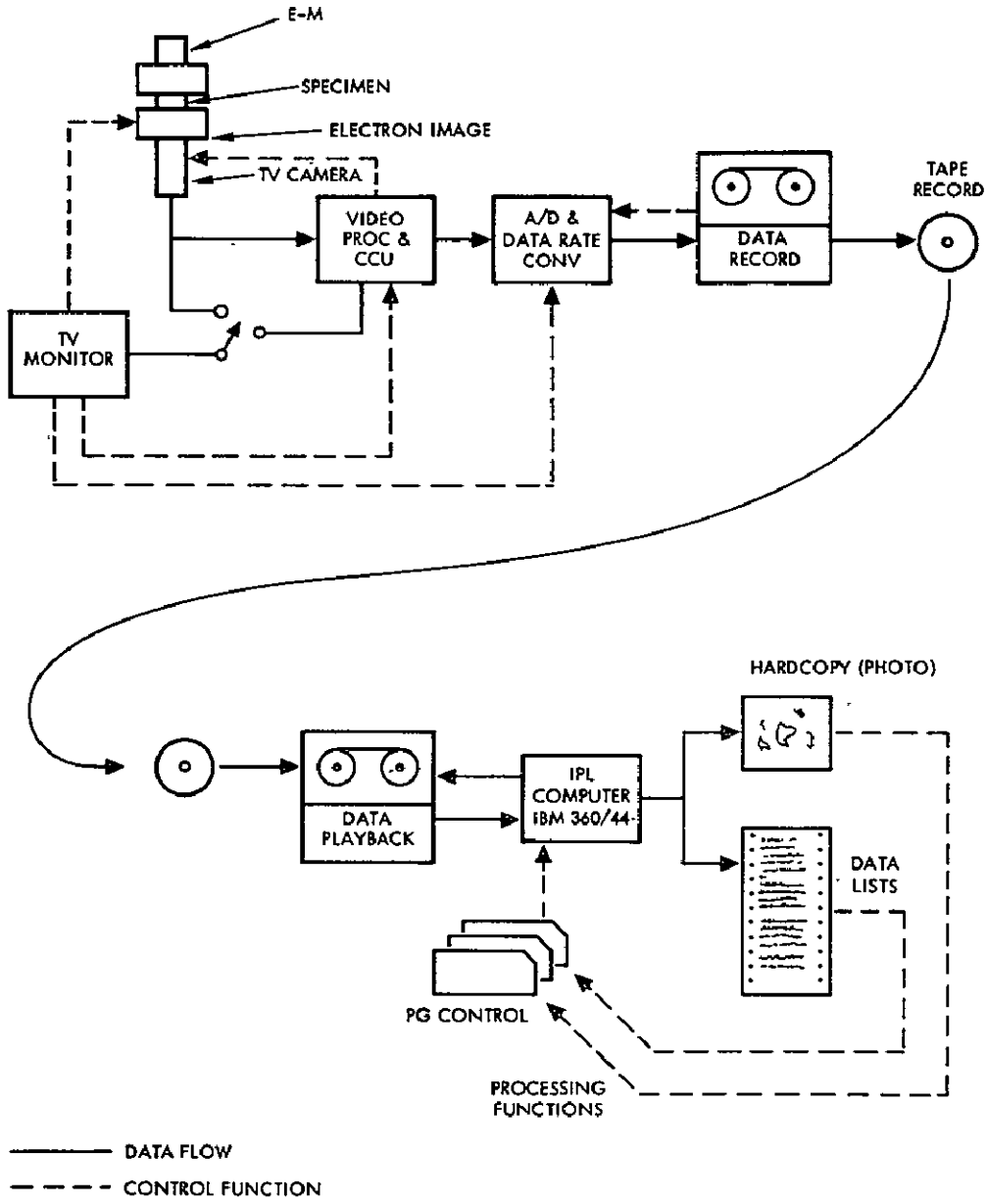

Figure 1. Electron Microscope/Computer Interface System