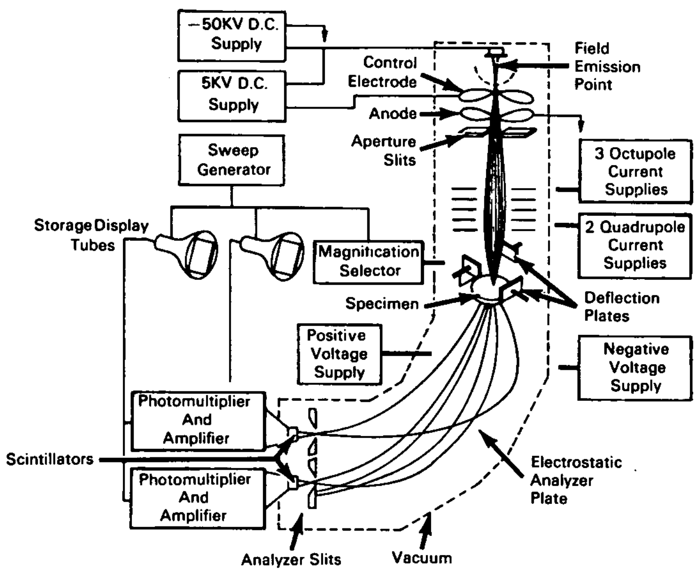
AEC-NASA TECH BRIEF

New Electron Microscope Employs New Video Display Technique



The problem:

To design, for a scanning electron microscope, a video display system which will provide advantages in visual observation over conventional display systems. The desired features include: (1) a color gradient technique generated within the display system, (2) the ability to change the apparent specimen position without necessitating fine adjustment of the specimen location, (3) good resolution for viewing portions of the specimen where selected energy regions contribute relatively few electrons, (4) the ability to change the magnification range without refocusing, and (5) the ability to permit leisurely viewing over extended observation periods without using photographic techniques, and without continuous and excessive bombardment of the specimen.

Electron microscopes employing high-magnification electron imaging depend upon "fast-scan" techniques and require visual control of specimen positioning, adjustment of the magnification range, and image refocusing when magnification is changed. Conventional electron microscopes generally do not permit leisurely viewing over extended periods. Visual display with a standard oscilloscope requires either high electron microscope beam strength or the use of photographic techniques to avoid image flicker.

The solution:

Direct-view storage display tubes in an integral system which combines features found in scanning electron microscopes, electrostatic energy analyzers, and CRT display methods. This microscope display system provides (1) slow-scanning rates, used with the two direct-view storage display tubes, allowing the microscope electron beam to be continually focused sharply on the specimen while the image is slowly "written" on the display tubes; (2) a superimposed

(continued overleaf)

imaging and color gradient technique using precisely-adjusted mirrors for use with the dual (side-by-side) storage tube output; (3) change of apparent specimen location by applying dc biases to the microscope beam deflection plates; (4) a microscope beam strength of 1×10^{-9} amperes which, when used with slow scan, provides a sufficient number of events per picture element, including observations in energy regions containing few electrons; (5) a change in magnification by changing the amplitude of the sweep voltages applied to the microscope deflection plates; and (6) storage tubes which permit viewing periods of several hours, with the image persisting through shutdowns and power failures.

How it's done:

The integrated microscope system employs three basic functional units which are used for electron beam emission and control, specimen bombardment with subsequent electron beam focusing, and a photomultiplier output display system.

Electrons emitted from the beam control and field emission point pass through the specimen and enter the electrostatic energy analyzer (see Figure). The electrostatic energy analyzer plates refocus the electrons at the analyzer slits. Electrons that have traversed the specimen with little loss of energy are focused at the lower slit, while the upper slit is used to observe electrons that have suffered appreciable energy loss. Behind the slits are cesium iodide scintillators with quartz light pipes leading to the photomultiplier tubes; the outputs of the photomultipliers and amplifiers are then applied to the storage tubes. The two display patterns produced on the storage tubes simultaneously produce images of the specimen using two different electron energies.

An optical device permits the observation of the two displays by superimposing and viewing the images through separate color filters. A pair of mirrors, such as used in a periscope, produces an image of one display tube which appears to be located midway between the tubes. A second set of semisilvered mirrors, similarly arranged, is placed in the viewing path of the first set of mirrors. With the four mirrors adjusted exactly, the images are congruent, and exhibit no parallax problems or differences of magnification.

Since the eye has difficulty judging the relative illumination of nonadjacent areas in a nonuniform field, but may quite easily distinguish slight color changes in nearby areas, a set of color filters is used to observe contrast effects of the displays being presented at different electron energies. Although the illumination of the storage tubes normally appears yellow-green (P20 phosphor), illuminated areas of the first display tube, when used with a red filter, will appear bright pink, and areas of the second tube, viewed through a blue filter, appear bright green. In a display region where both images are contributing an appreciable portion of the light, a slight change in illumination from either display will produce substantial color variation. Thus neighboring areas of a specimen, varying slightly in the relative number of electrons being contributed to the two energy images, appear substantially different in hue. At the design strength of the microscope electron beam of 1×10^{-9} amperes, with slow scan, a photomultiplier output amplifier of moderate gain and bandwidth is adequate even for observations in energy regions where there are relatively few electrons, allowing good resolution for very faint specimens.

The extended storage time of the direct-view storage display tubes, as compared with phosphor decay times of standard oscilloscope tubes, permits visual observation of a single slowly scanned raster. Specimen examination may begin before a single scan is completed, with the presentation persisting for many seconds, even at high display intensities. In addition, successive "writes" may be partially added, permitting averaging and integration over long observation times without extremely slow initial scanning. Successive scans may be piled up until visual observation indicates that a good statistical integration has been achieved. A recording camera and/or the optical superposition device may be interposed leisurely while the displays are retained in storage.

Notes:

1. Magnification may be chosen by simple switching, and specimen position is also obtained electronically. The color optical system provides contrast without specimen "staining", and identification of specimen constituents is possible.
2. The factor causing the greatest degree of difficulty in the practical use of the system has been the relatively poor quality and characteristics of the available storage tubes. The lack of illumination uniformity over the 6×6 inch tube area, for electron beam intensities below saturation illumination, and the slight dynamic range of the tubes have contributed to a very high contrast display image.
3. Additional details are contained in *IEEE Transactions on Nuclear Science,* April 1965, p. 104–110.
4. Inquiries concerning this innovation may be directed to:

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   Reference: B67-10312
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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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