Video recording of low intensity CEMA images

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This note describes an inexpensive assembly of commercially available TV components that can be used to observe, record, and display low-light-level visual images. The resulting TV system has been in use in our laboratory for almost two years to analyze static field-ion and transient field-desorption images which appear on the fluorescent screen of a curved, Chevron Channel-electron-multiplier-array (CEMA) detector operating in ultra high vacuum. If the TV system is connected to the video input of a commercial image digitizer, CEMA images can be digitally stored and processed in real-time. Visual LEED and ESDIAD data can be easily analyzed in this manner.

After testing several TV cameras for their low-light-level imaging capability, a camera incorporating a 9.5 mm newvicon tube and an f0.7 TV lens was chosen. Each camera-newvicon (or vidicon)-lens combination was judged by its ability to observe the random, dark-current image spots which appear on the fluorescent screen of the CEMA detector at high gain (10^6). A brighter image of better quality was obtained by mounting a 4:1 conjugate, low distortion lens onto the TV camera in place of the TV lens. In this case, the 6.6 × 8.8 mm active area of the vidicon tube restricted the field-of-view of the camera to a 26 × 35 mm region of the CEMA screen.

The TV camera was connected to a commercial 19 mm cassette video recorder which in turn was connected to a high-resolution, flat-field TV monitor. To enhance image contrast, an image processor was usually connected between the TV camera and video recorder. Figures 1 and 2 show images obtained in this manner by photographing the TV monitor during the playback of a portion of a video tape. Since the vertical resolution of the 525-line standard TV system is approximately 343 lines, viewing the entire 73 mm diameter fluorescent screen of the CEMA detector (as in Figs. 1 and 2) provided an effective image resolution of only 343/73 = 4.7 lines/mm. This is approximately a factor of six poorer than the resolution which can be obtained from direct contact prints of the fluorescent screen, and about a factor of 20 worse than the resolution which can be obtained by photographing.

Fig. 1. A static helium-field-ion image of tungsten at 20 K and 1 × 10^-5 Torr helium, photographed from a video tape recording during playback.

Fig. 2. A dc field-desorption image of tungsten at 20 K and 8 × 10^-10 Torr, photographed from a video tape recording during playback. The dc evaporation rate of the tungsten lattice (recorded in real-time on the video tape) was approximately one (110) plane/s.
the fluorescent screen with Tri-X\textsuperscript{13} professional film. Using the 4:1 conjugate lens to view a circular area of the fluorescent screen 26 mm in diameter resulted in a TV image resolution of 343/26 \approx 13\text{ lines/mm}, an improvement in resolution by almost a factor of three.

The standard TV scan rate permitted a reasonably detailed, time-dependent history of CEMA images to be made, provided a single image of interest persisted for several video frames. Since the TV scan rate is 30 video frames per second, the scan time for one video frame is 1/30 \approx 30\text{ ms}, and consequently the image of a transient event lasting a shorter time will be incompletely recorded. To insure that the image of a transient event appears on several video frames, a fluorescent-screen phosphor with a decay time of the order of 100 ms should be used. As a result, only ten changes in a CEMA image per second will be accurately recorded.

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\textsuperscript{a}A U.S. Department of Energy Facility.
\textsuperscript{d}The Quantex Corporation, Sunnyvale, California (Model DS-20).
\textsuperscript{f}The Radio Corporation of America (RCA Model TC1005/NO2).
\textsuperscript{g}The Radio Corporation of America (RCA Newvicon Model 4905).
\textsuperscript{h}Cannon U.S.A., Inc., Optical Products Division, Lake Success, NY (TV-16, f0.78, 25 mm focal length).
\textsuperscript{i}The Farrand Optical Company, New York, NY (Super Farron, f0.87, 72 mm focal length).
\textsuperscript{j}U.S. JVC Corp., Maspeth, NY (JVC Model CB6060U).
\textsuperscript{k}Tektronix, Inc., Beaverton, Oregon (Model 634).
\textsuperscript{l}Microtime, Inc., Bloomfield, CT (Image-EX image processor).
\textsuperscript{n}A registered trademark of The Eastman Kodak Company, Rochester, NY.