Boresight Cameras

By K. L. WARTHMAN

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Motion picture cameras equipped with telephoto lenses were installed on the Project Echo transmitting and receiving antennas located at Holmdel, New Jersey. When the Echo satellite was visible, a camera obtained a photographic record of the pointing accuracy of the antenna. These data were then used to correlate variations of signal strength with deviations in antenna pointing angle.

I. INTRODUCTION

The conventional method of evaluating the tracking performance of radar antennas has been to provide a camera-lens system mounted on the antenna structure to provide an optical line-of-sight parallel to the radar beam. This permits the recording on motion picture film of the radar pointing error, whenever the object being tracked is capable of being photographed. Camera instrumentation of this type was provided for both Holmdel antennas, the 60-foot paraboloid transmitter and the 20-foot horn receiver.*

II. PHOTOGRAPHIC CONSIDERATIONS

The brightness of the Echo satellite was expected to be greater than that of a first-magnitude star. Experience in astronomical photography indicated that first-magnitude stars could be recorded on Tri-X negative film (Eastman Kodak No. 7233) with an exposure of $\frac{1}{30}$ second and a lens aperture of f3.5. Accordingly, it was decided to use a camera speed of four frames per second. This frame rate provides an exposure time of $\frac{1}{8}$ second and at the same time affords 16 minutes of continuous camera

* Although this equipment was designed by the Bell System as part of its research and development program, it was operated in connection with Project Echo under Contract NASW-110 for the National Aeronautics and Space Administration.

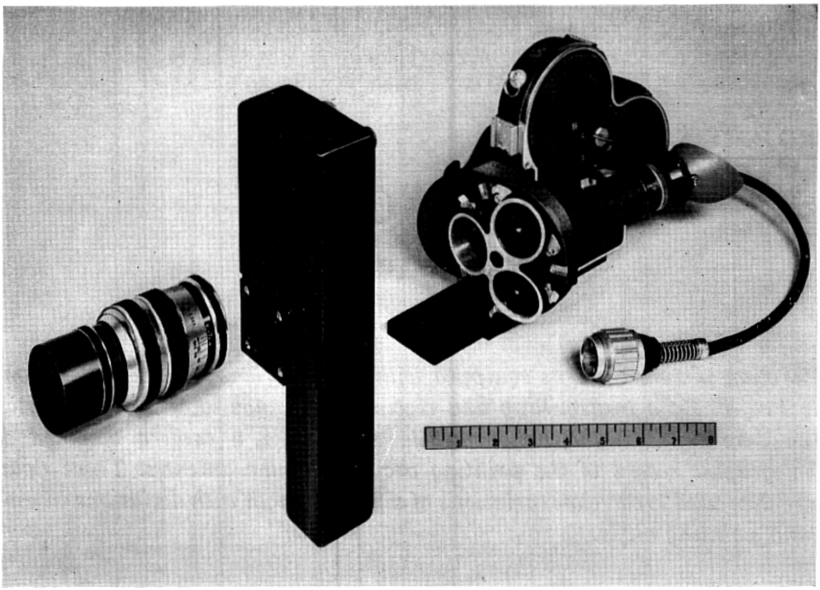

Fig. 1 — Tracking camera.

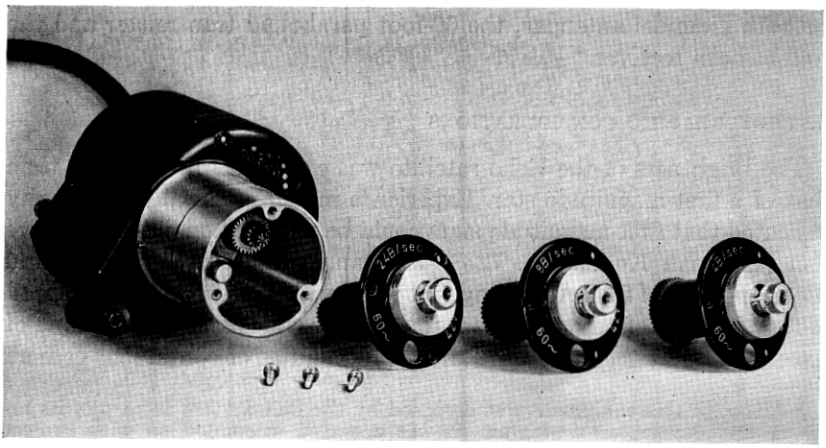

Fig. 2 — Synchronous motor with gear reductions for 24, 8, 4 frames per second.

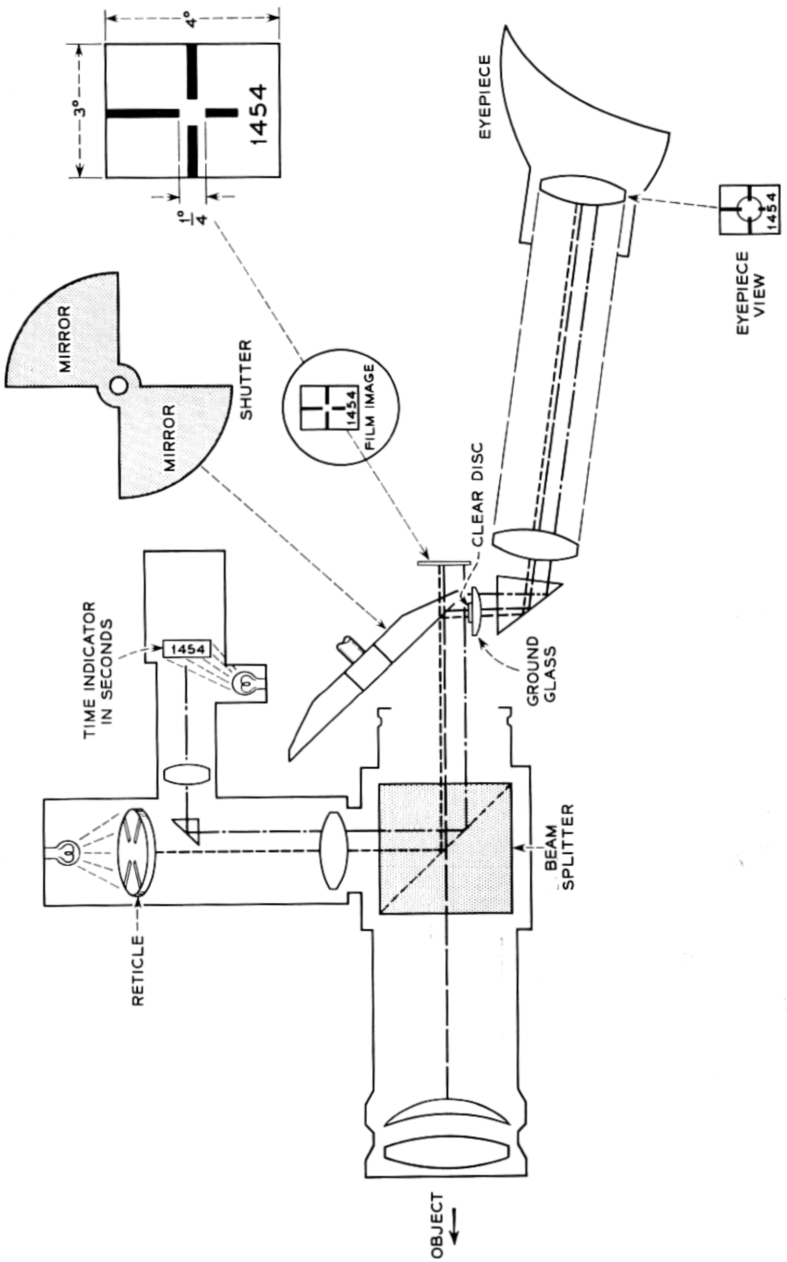

Fig. 3 — Optical schematic.

operation with the 100-foot film capacity of the camera. The 16-mm film was considered adequate for the photographic detail required and was selected in preference to 35-mm film in order to minimize film costs, processing charges, storage space, and equipment investment.

III. CAMERA

The Arriflex 16-mm camera (see Fig. 1) was selected for Project Echo because the feature of through-the-lens viewing was desired for alignment of the optical system with the transmitting and receiving antennas. Also, this camera could have been equipped with a 400-foot magazine if a faster frame rate or longer tracking time had been desired. A 24-frame-per-second synchronous motor was ordered with special gear reductions that could be easily interchanged to provide four or eight frames per second (see Fig. 2).

IV. LENS

The desired field of view of 3 degrees was obtained by using a 150-mm, f3.5 Kilfitt lens. This field of view was large enough to keep the satellite

Fig. 4 — Camera mounted on horn receiver.

image within the film frame during early tests when some tracking difficulties could be expected. The 150-mm lens gave enough magnification to permit reducing the data to the desired accuracy. The camera system was designed so that a 300-mm lens could be used without modification if desired in later tests.

V. RETICLE AND TIMING MARKS

A projected reticle was imaged on the film by using a beam splitter. The optical schematic is shown in Fig. 3. The time in seconds was recorded on the film by using a conventional telephone message register as a stepping counter. The reticle and message register were also visible through the eyepiece for optical alignment and time correlation. The necessary optics to project these images on the film were assembled in a housing which replaced the standard lens-to-camera adaptor.

Fig. 5 — Camera mounted on paraboloid transmitter.

VI. CAMERA MOUNTING

The cameras were mounted on the vertical center-line and just beyond the lower edge of the antenna apertures (Figs. 4 and 5). This location placed the cameras about 8 feet above ground level when the antennas were pointed at the horizon so that they could be loaded and checked for alignment from a small platform. A special dovetailed mount was pro-

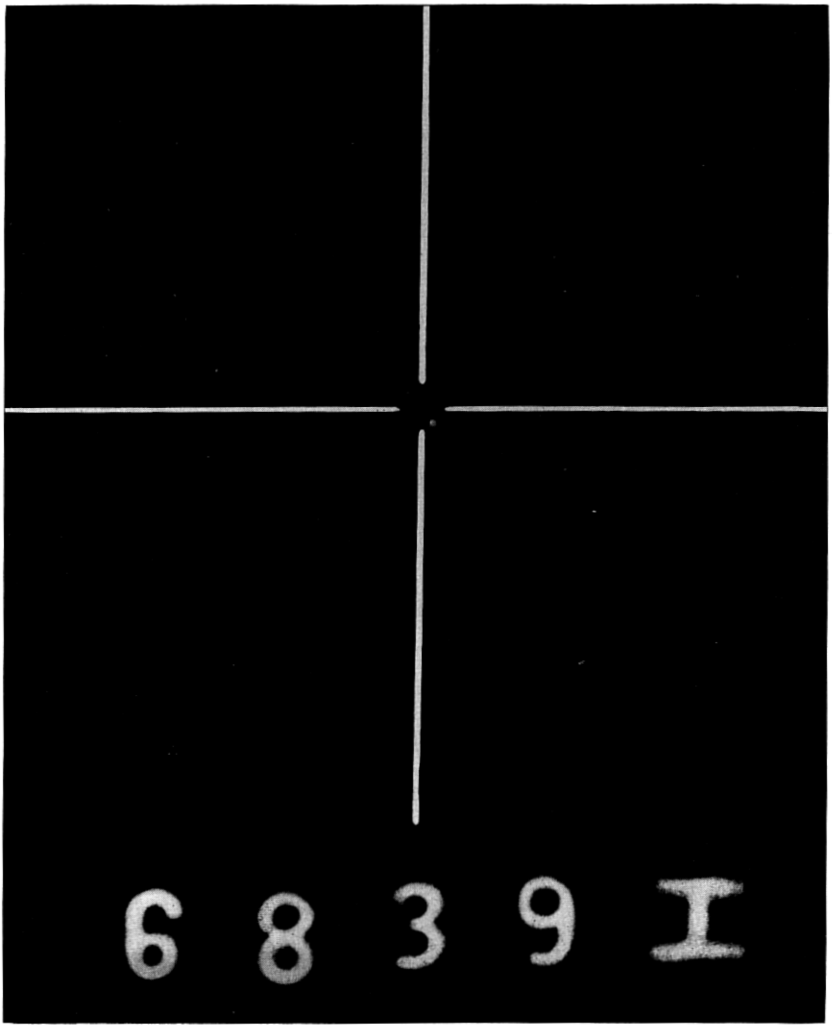

Fig. 6 — Typical single 16-mm frame (pass 70, August 18, 1960).

vided for the cameras to permit removal and replacement without disturbing the alignment. The base of this special mount was equipped with adjustments for alignment in elevation and azimuth. A weatherproof cover with a front opening was provided in the event that inclement weather was experienced during operation.

VII. POWER SUPPLY AND CAMERA CONTROL

Special 42-volt power supplies were used to operate the synchronous camera drive motors. These power supplies were mounted on the antennas adjacent to the cameras. The cameras could be operated at the antennas to facilitate loading of film and alignment, or could be operated remotely from the main control console.

VIII. RESULTS

The enlarged view of a single 16-mm frame of pass 70 shows the Echo satellite in the reticle opening (Fig. 6). The reticle opening is 0.15 degree, which is slightly less than the original design of $\frac{1}{4}$ degree. The letter H at the end of the message register number indicates that the film came from the camera mounted on the horn antenna. From August 12, 1960, to March 15, 1961, 6900 feet of film were exposed during 39 Echo satellite passes.