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EXPLORING IN AEROSPACE ROCKETRY
14. ROCKET LAUNCH PHOTOGRAPHY

by William A. Bowles
Lewis Research Center
Cleveland, Ohio

Presented to Lewis Aerospace Explorers
Cleveland, Ohio
1966-67

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION · WASHINGTON, D.C. · 1968

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14. ROCKET LAUNCH PHOTOGRAPHY

by William A. Bowles*

Ever since May 5, 1961, when astronaut Alan B. Shepard rode America's first manned spacecraft 302 miles down the Atlantic Missile Range, we have become accustomed to seeing dramatic photographs of space vehicles thrust spaceward by powerful rocket engines. These documentary pictures, however, represent only a minute part of the total role of photography in aerospace technology. Photography has long been recognized as a valuable and indispensable scientific tool. The human eye cannot review or recall the image of an object which it has previously seen, and neither can it prolong into minutes the split-second timing of an event. Conclusions drawn from the visual observation of a malfunction could be erroneous. On the other hand, photographic instrumentation enables engineers and scientists to make detailed and accurate analyses of problems, and it can show the reasons for the success or failure of a project.

The cameras used by aerospace scientists and engineers are highly specialized and unlike those used for home movies, snapshots, or news photography. Their capability of recording at high speed permits time to be frozen or to be extended to many times normal. This extension of time is accomplished by filming at rates of up to several thousand frames per second and then projecting (viewing) the film in single frames or at low frame rates. For example, if an occurrence is filmed at 24 frames per second and the film is projected at the same rate, the filmed sequence takes the same length of time as the actual occurrence. However, if the occurrence is filmed at 400 frames per second and the film is projected at 24 frames per second, the duration of the filmed sequence is $16\frac{2}{3}$ times as long as the duration of the actual occurrence. Filming at 5000 frames per second and projecting at 24 frames per second extends the duration of the filmed sequence to $208\frac{1}{3}$ times that of the actual occurrence.

Various types of cameras are used to record the trajectory, velocity, roll, pitch, and yaw of vehicles and to furnish statistical data at altitudes up to 40 or 50 miles. However, long before the vehicle is ready for flight, the testing of countless items, such as the umbilical-cord release, cooling-blanket removal, launcher release, nose-fairing separation for spacecraft ejection, etc., has benefited from photography.

Camera operating speed is not the only consideration in choosing photographic equipment to meet a particular requirement. Film sizes of 16, 35, or 70 millimeters may be

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*Assistant Chief, Photographic Branch.

used. The 16-millimeter film can be used at higher camera speeds than can the 35- and 70-millimeter films, but the latter two sizes provide better image quality. Therefore, the larger sizes are used when the need for superior image quality exceeds the demand for high frame rate (camera speed).

Telescopic lenses of extremely long focal lengths (up to 500 in.) are used to provide data on missiles at high altitudes. Such lenses have effective ranges up to 100 000 feet and are located approximately this same distance from the launch pad. This location provides a good elevation angle, if the lens is used for tracking, and a good overall view of the missile, if the lens is used for general observation. (The principles of good camera positioning are discussed in chapter 13.) The image size factor must also be considered in the selection of a camera location. For any given lens, the image completely fills the frame when the subject is at some specific distance from the camera. Therefore, if the camera is located too close to the subject, the image size becomes excessive.

In addition to photographing missiles at high altitudes, it is also necessary to film small areas of action on or near the vehicle during the critical lift-off period. For these requirements, lenses with much shorter focal lengths are used, and the cameras are mounted at the base of the vehicle and on the service and umbilical towers. Some requirements may involve the study of an area only 6 inches square, and the camera which is used to fulfill such a requirment may encounter temperatures in excess of 2500° F. The camera must be protected against these high temperatures by means of a special housing cooled by an inert gas (usually nitrogen). The gas is fed into the protective housing, and then, by means of exhaust ports, it is routed across the cover glass to minimize fogging or condensation. The inert-gas purge acts as a safety factor in preventing the ignition of the rocket-fuel vapors by the electrical system of the camera. The engineering value of photography can be increased considerably by using precise timing marks along the edge of the film. These marks enable the viewer to determine the exact timing of some particular occurrence.

The installation of 60 cameras is not an unusual requirement for a major launch. Each instrument is programmed to perform a special function. Some photographic requirements cannot be fulfilled by ground-based equipment. For example, studies of zero-gravity effects inside the fuel tanks or observation of the staging of the spacecraft necessitate the installation of photographic or television equipment within the vehicle.

The possibilities of optical and photographic instrumentation are practically unlimited. With its constant technological advances, space age photography should continue to be a valuable scientific tool.

Figures 14-1 to 14-12 were selected to illustrate the significant role of photography in rocket launch operations. The depth of detailed information to be derived from photography is obvious.

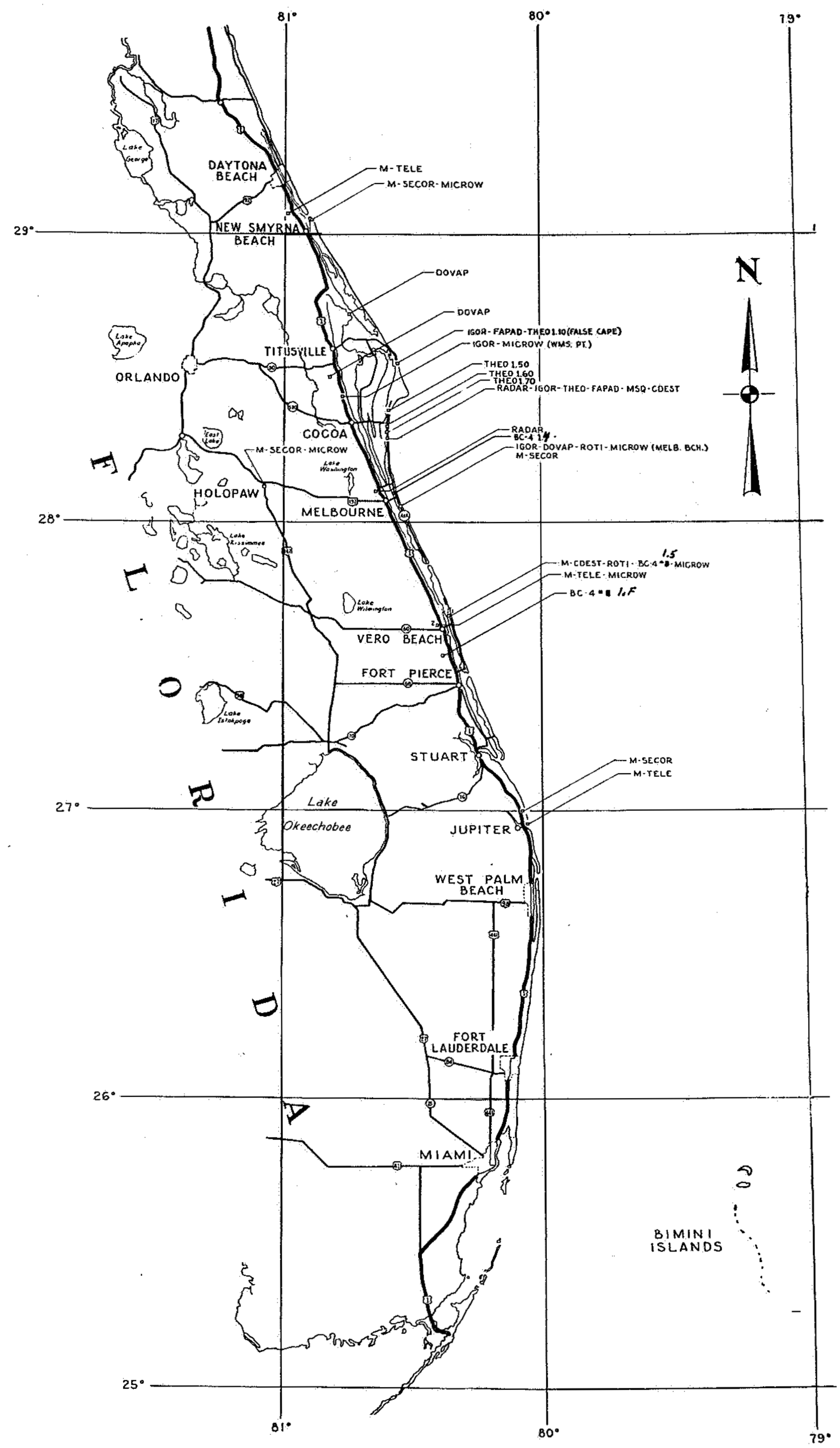

Figure 14-1. - Map of east coast of Florida showing locations of long-range cine-theodolite, Roti, and Igor tracking cameras. Extreme distances from launch sites required for triangulation and for image ratios with 350- to 500-inch lenses are also apparent.

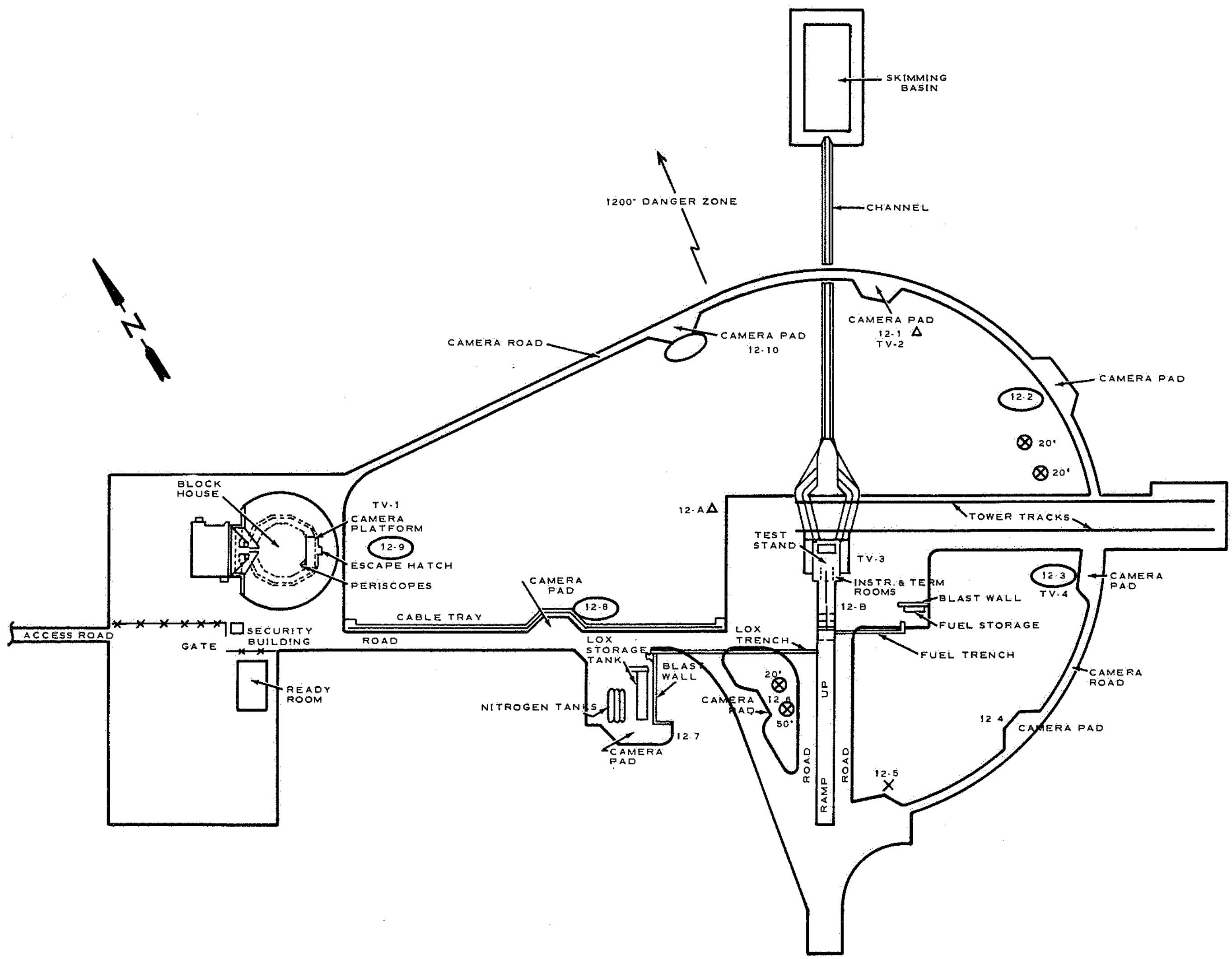

Figure 14-2. - Schematic drawing of typical launch complex (launch pad 12) at Cape Kennedy. Camera sites are indicated by complex number and camera locations clockwise around test stand. For example, 12-5 site is found at 5 o'clock from position North. Many of these sites have several cameras of various film sizes, frame rates, and focal length lenses. The actual camera installation depends upon particular vehicle requirements; 360°, or around-the-clock, coverage is necessary for evaluation of performance of any malfunction.

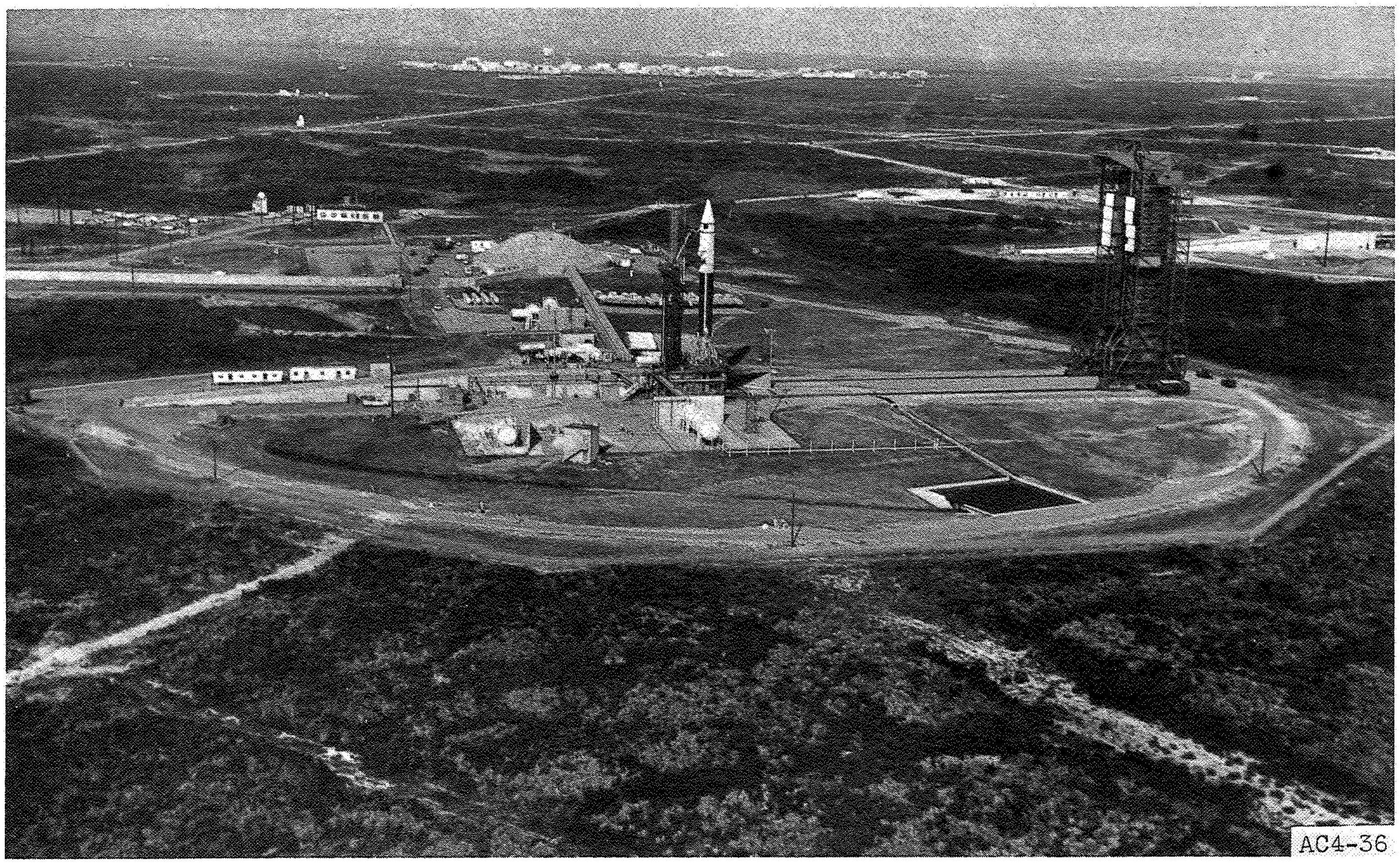

Figure 14-3. - Aerial view of Atlas-Centaur vehicle on launcher, with gantry, or service tower, rolled back. Camera positions around perimeter road can be distinguished.

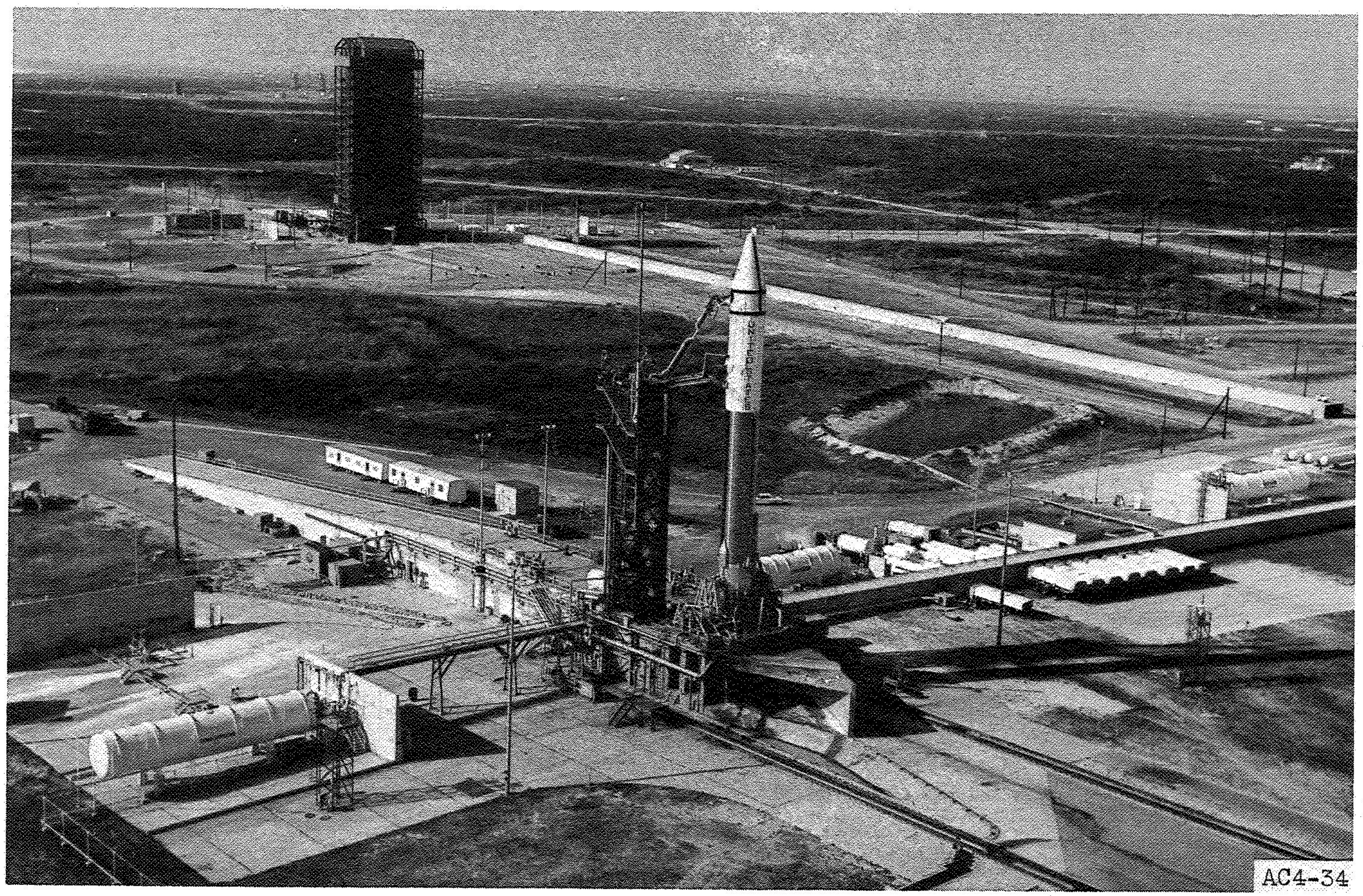

Figure 14-4. - Closeup aerial view of Atlas-Centaur vehicle and launch complex. Photographic instrumentation would provide data on launcher release action at base of vehicle, engine ignition, and umbilical-power disconnect action.

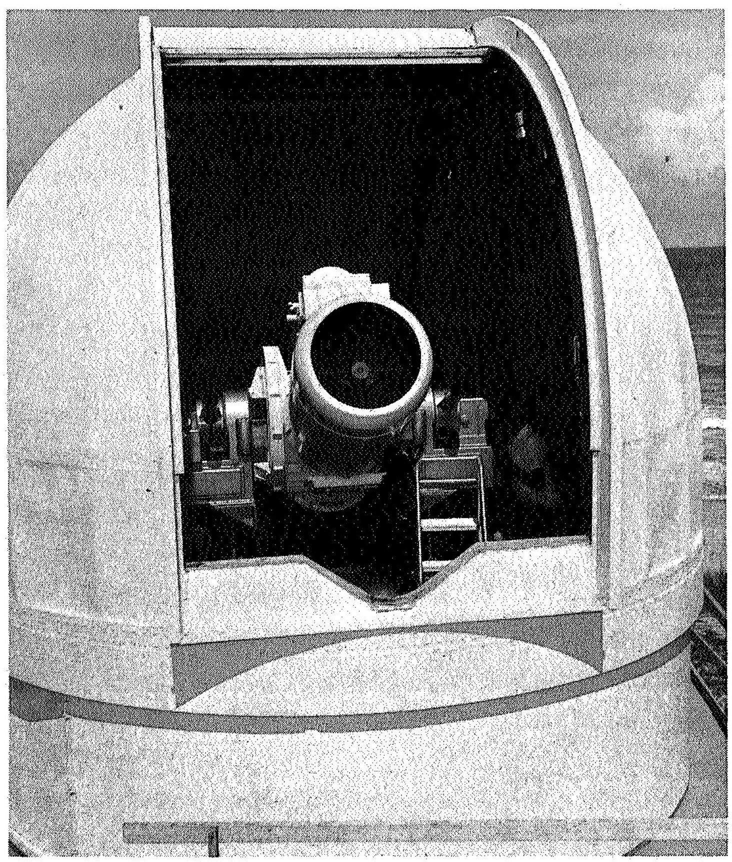

Figure 14-5. - Roti tracking camera with 500-inch lens. This camera is located at Melbourne Beach, over 20 miles from Cape Kennedy. Figure 14-7 was photographed by this camera when missile was at an altitude of 14 miles.

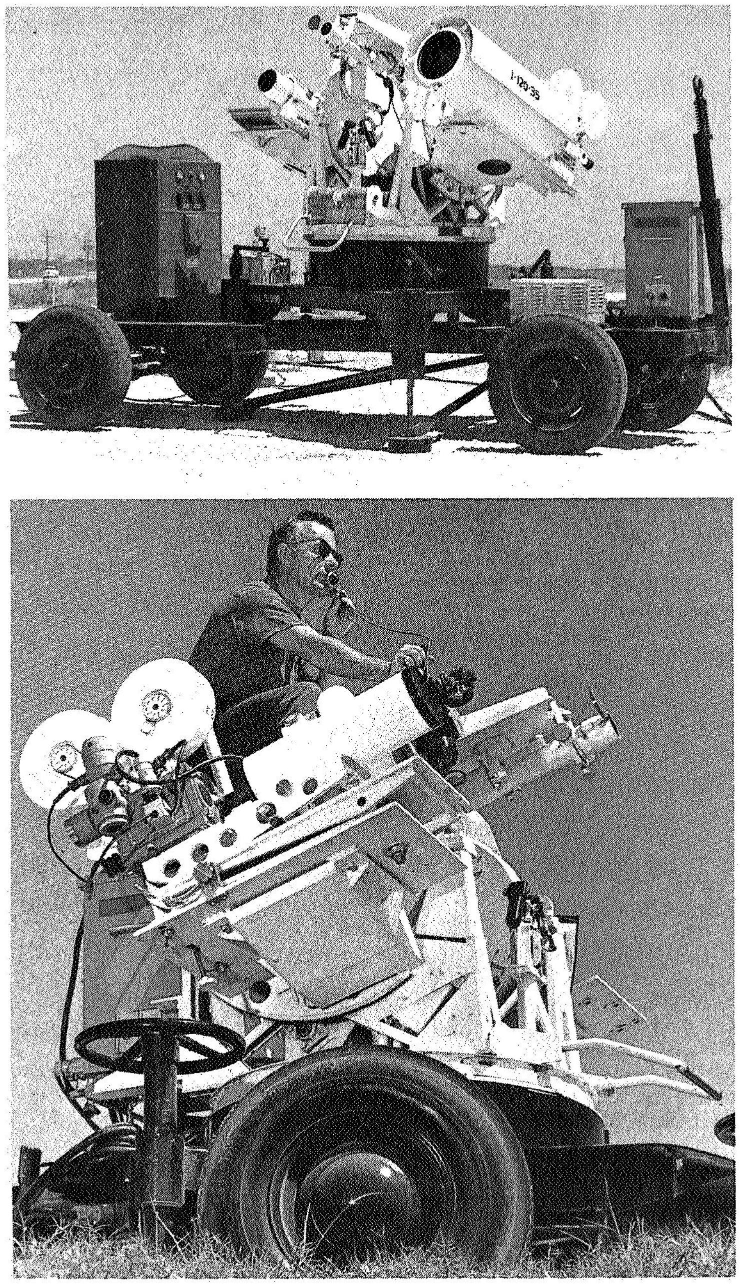

Figure 14-6. - Mobile optical trackers consisting of three to four cameras with lenses ranging in size from 20- to 120-inch focal length. These units are moved to suitable locations shown on Cape Kennedy map and operated by photographer seated on gimbal-mounted camera platform.

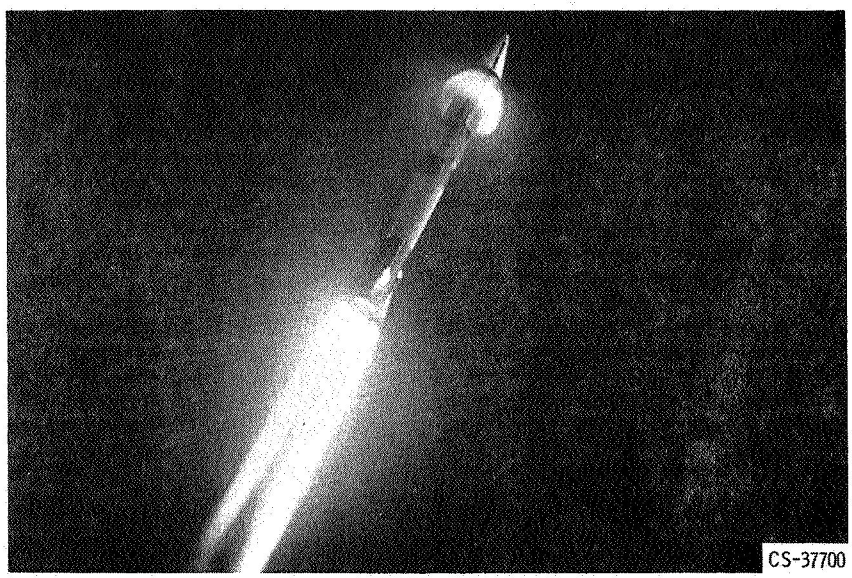

Figure 14-7. - Shock wave passing over nose cone of Atlas-Centaur vehicle. Photographed at altitude of 75 000 feet by Melbourne Beach Roti; lens, 500-inch focal length.

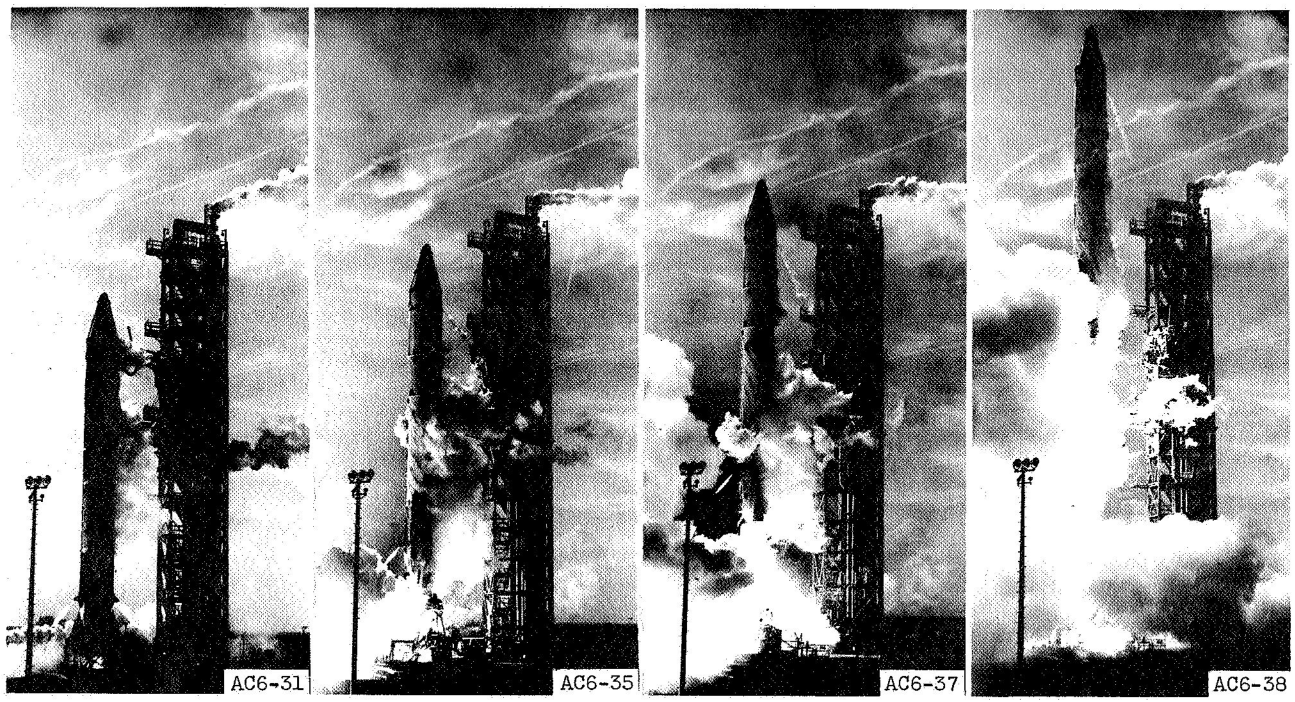

Figure 14-8. - Sequence of frames showing lift-off of Atlas-Centaur vehicle.

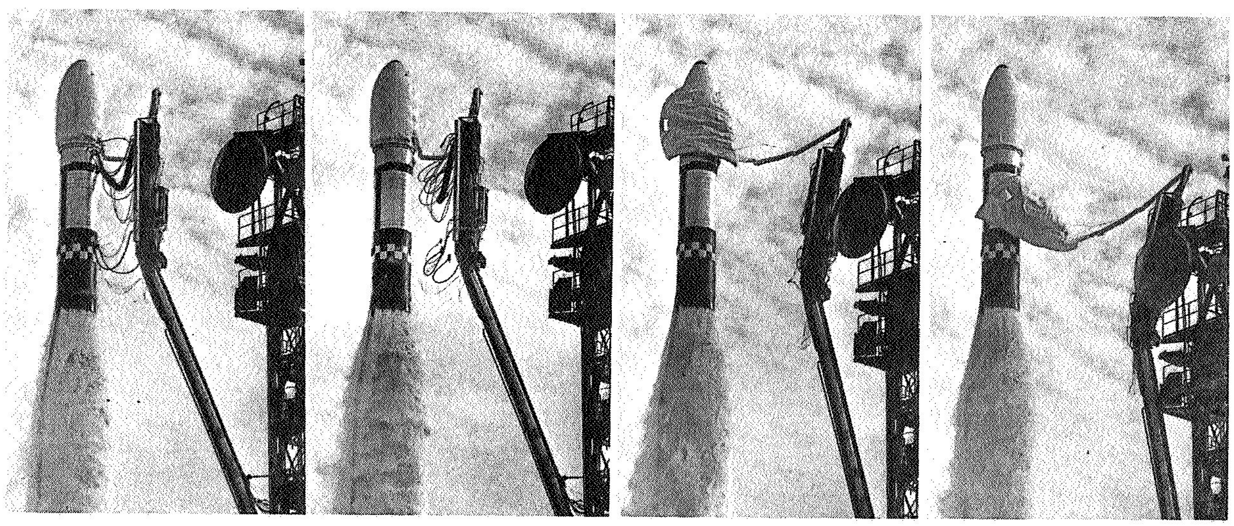

Figure 14-9. - Four frames from sequence showing general view of umbilical-cord and boom retraction. Notice removal of air-conditioning cooling blanket from around spacecraft. Installation of cameras is often required to study various small details included here. At times, camera concentration might be on one specific connector during release action.

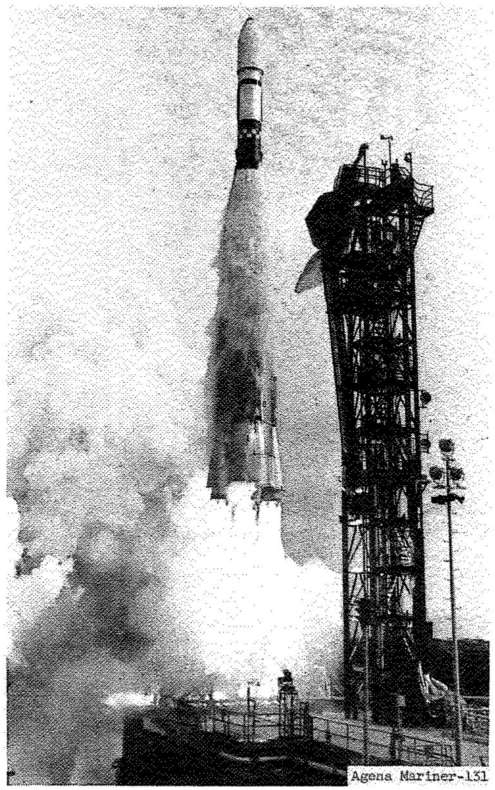

Figure 14-10. - Overall view of Atlas-Agena vehicle during launch of Mariner spacecraft. This is same vehicle shown in figure 14-9 after removal of cooling blanket.

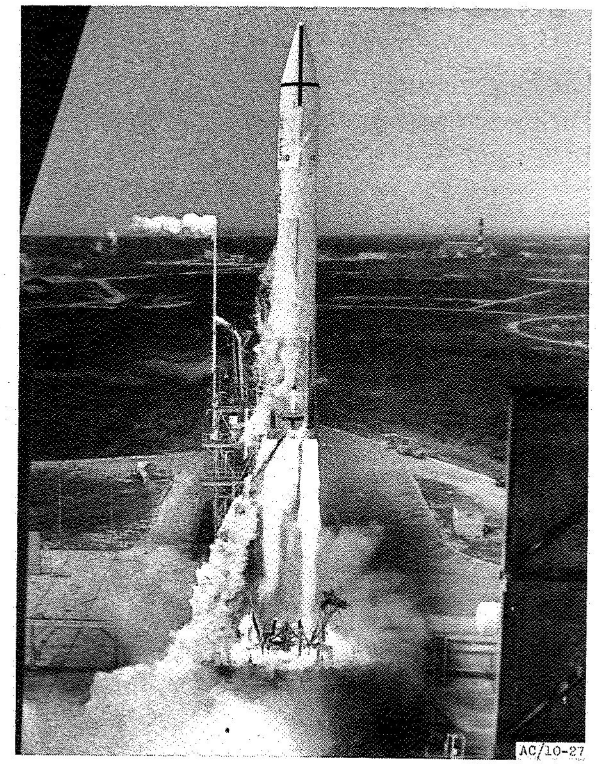

Figure 14-11. - Launch of Surveyor I as seen from top of service tower.

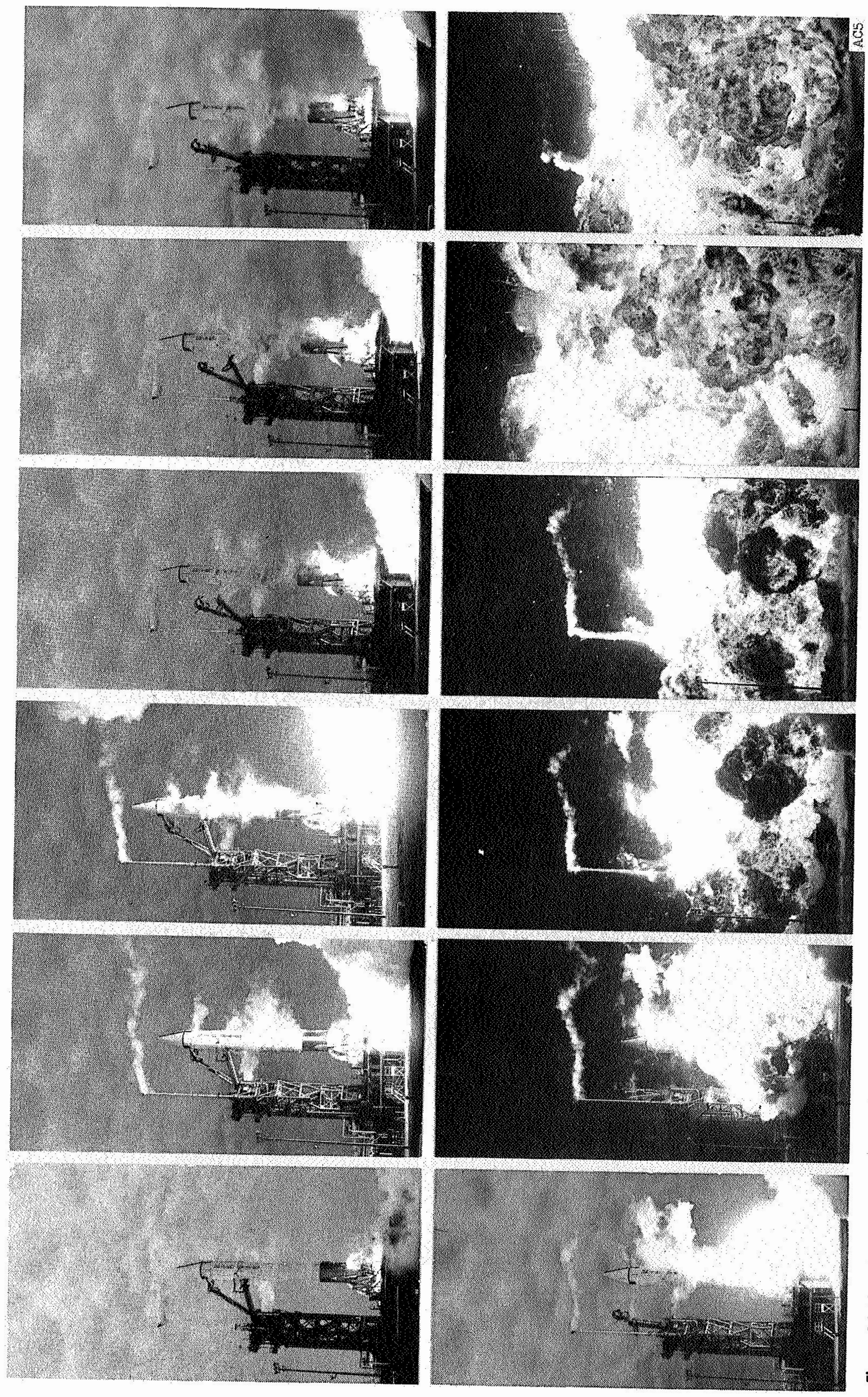

Figure 14-12. - Sequence showing explosion of vehicle on launch pad. In many instances, analysis of high-speed motion pictures is the only method of determining reasons for failure. Visual observations would not indicate that vehicle actually rose up 5 feet and then returned to launcher before explosion.

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