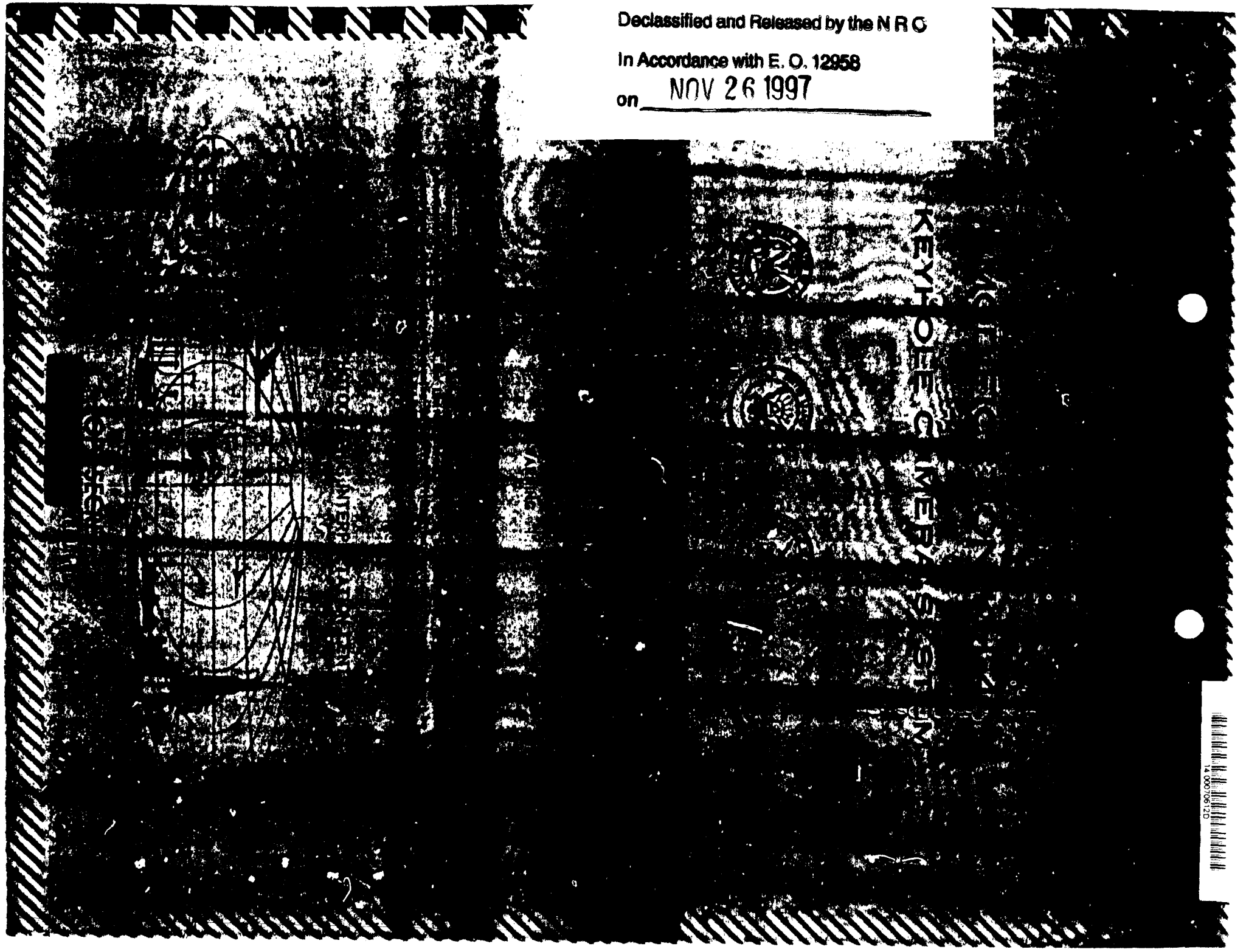

MODIFICATION KH-4, KEYHOLE CAMERA SYSTEM

This publication presents general technical information necessary for the reduction of quantitative data obtained from photography using Modification KH-4 of the KEYHOLE camera system.* The specific camera data -- operational focal lengths, lens distortion, depression angle of horizon cameras, image motion compensation (IMC) velocity, filter and exposure data, film data, resolution capabilities, and timing pulses -- will be published separately for each KEYHOLE mission.

KH-4 Configuration

The major modification comprising the KH-4 configuration will be the utilization of two KH-3 panoramic cameras mounted in a convergent manner to provide stereoscopic coverage (Figure 1). The cameras, to be mounted at angles of 15 degrees to the vertical axis of the carrying vehicle, will be canted toward each other, forming a 30-degree angle. The cameras are designated as follows: the forward-pointing camera is the "forward camera," and the aft-pointing camera is the "aft camera."

The vehicle is designed to fly with 1.5 degrees of positive pitch, i.e., nose up, which will affect the orientation of the camers to the nadir. The panoramic cameras will not be compensated for tis pitch

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*The initial KEYHOLE camera system and subsequent modifications are designated KH" with a numerical suffix. In the future, camera information pertaining to a particular KEYHOE mission will be identified both by mission number and by the appropriate camera designation.

In the KH-1 configuration (The initial system), image motion compensation (IMC) has constant velocity. This camera configuration was utilized in Mission 9009.

In the KH-2 configuration (the first modification of the camera system), the IMC chges continuously throughout each pass. This camera configuration was utilized in Missions 13, 9017, and 9019.

For a description of the KH-3 configuration, see NPIC publication, [redacted] Mification KH-3, KEYHOLE Camera System, Aug 61.

For a discussion of IMC, see CIA publication, [redacted] Explanation of Ige Motion Compensation Provided on KEYHOLE Camera Systems, May 61.

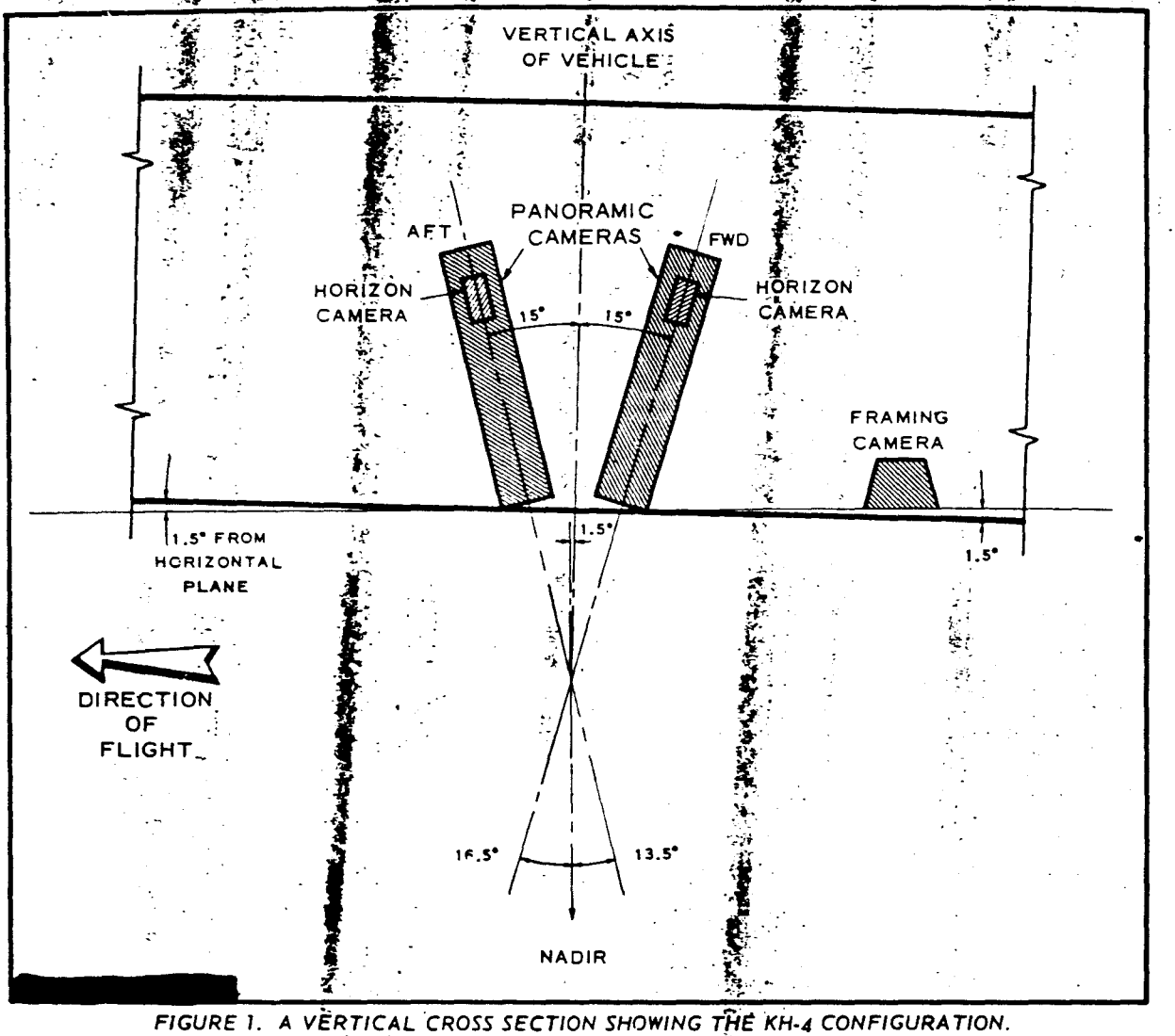


FIGURE 1. A VERTICAL CROSS SECTION SHOWING THE KH-4 CONFIGURATION.

angle. The forward camera will point forward 16.5 degrees from nadir and the aft camera will point 13.5 degrees from the nadir. The aft camera is oriented approximately the same as the camera in the KH-3 system. The forward camera will scan the ground from left to right and the aft camera will scan from right to left. The forward camera, because it faces in the opposite direction, requires a reversed image motion compensation (Figure 2). This change will show in the equation of the path of the principal point. The equation for this path in the forward

camera is Y = +8.1864 sin θ, whereas the equation for the path in the aft camera is Y = -8.1864 sin θ.

In the early missions of the KH-4 system both cameras will be operated by a common program which has been extended from 15 minutes to 30 minutes in duration, i.e., velocity/height (V/H) ratio program. However, the cameras are nonsynchronous. In a situation where one camera fails, the other will continue to operate.

Operations. The KH-4 system can operate on both ascending (south-to-north) passes and descending (north-to-south) passes and there may also be an operation where the camera is turned on during an ascending pass and left on into a descending pass. The capability of producing split passes has been improved. More than one "camera off-camera on" operation can be actuated within a pass, the only limitation being that the camera must remain on or off for a time period corresponding to three degrees of latitude.

Format. The size of the format of the panoramic cameras in the KH-4 system will be the same as the KH-3 format with the exception of the width of image which will be 2.187 inches. The KH-4 format will differ in the information imaged on the format edges, such as timing marks, binary time readout, and the titling (Figure 2). The titling will appear on the format edge containing the fiducial marks. On the film positive the forward camera frames will have the titling on the side opposite the flight direction and the aft camera frames will have the titling in the direction of flight. The titling will consist of operation ("A" for ascending, "D" for descending, "M" for both ascending and descending), pass number, frame number, camera designation ("FWD" for forward camera, "AFT" for aft camera), mission number, launch date, and classification.

Time Data. In the KH-4 system a new clock will be incorporated with an accuracy of ± 10 milliseconds with the readout imaged on the format edge (Figure 2). The readout will appear in binary form and will represent elapsed time. Provisions are made to correlate elapsed and real time. Frequency marks will be employed in this system as they were

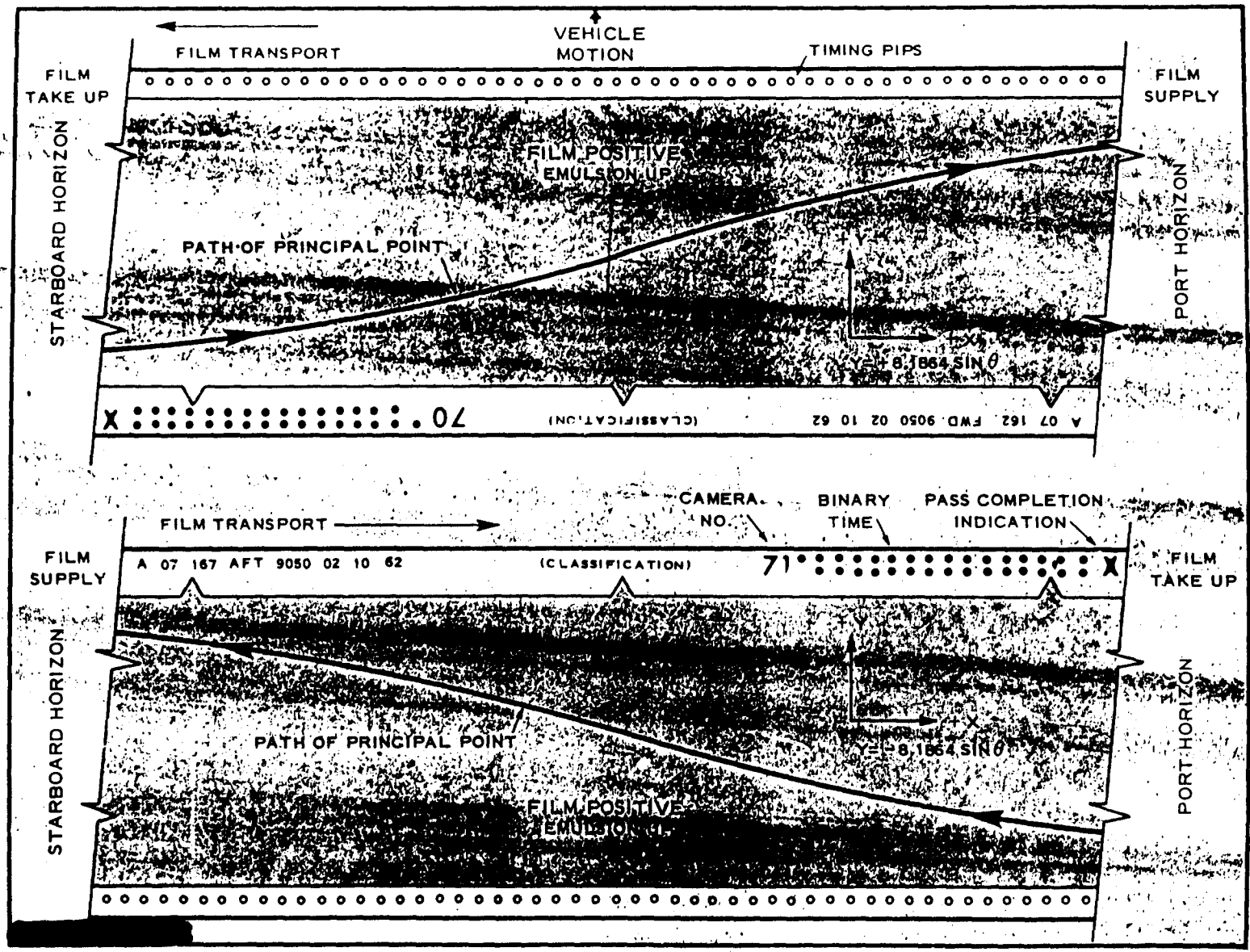


FIGURE 2. KH-4 FORMAT SHOWING TITLING AND PATH OF PRINCIPAL POINT. Drawing not to scale. (For dimensions, see figure in [redacted] Modification KH-3, KEYHOLE Camera System, Aug 61).

in the KH-2 system. The cycles per second (cps) will be stepped up from 160 cps to 200 cps. The frequency marks will appear on the edge opposite the fiducial marks. The marks will be smaller in size than those which appeared in the KH-1 and KH-2 systems.

Camera Features

The KH-4 configuration will include two KH-3 panoramic cameras and two pairs of horizon cameras and a framing camera for determining the attitude of the carrying vehicle.

KH-3 Panoramic Camera. The principal features of the KH-3 camera are as follows:

Lens:	Petzval f/3.5
Focal length:	24 inches
Scan angle:	70 degrees
Shutter:	focal plane
Shutter speeds:	interchangeable slit widths for exposures of 1/300 second, 1/500 second, and 1/1,000 second.
Film load:	70 mm x 7,600 feet (each unit)
Image motion compensation (IMC):	Proportional to velocity/height (V/H) ratio

Horizon Camera. As in the earlier KEYHOLE camera systems, the KH-4 system will utilize horizon cameras for determining the attitude of the carrying vehicle. As in the KH-3 system, which mounts a pair of horizon cameras on a panoramic camera, the KH-4 system will use two pairs of horizon cameras, mounting a pair on each of the panoramic cameras. The design depression angle of the horizon cameras will remain 15 degrees from the horizontal plane when the panoramic cameras are in the vertical position.

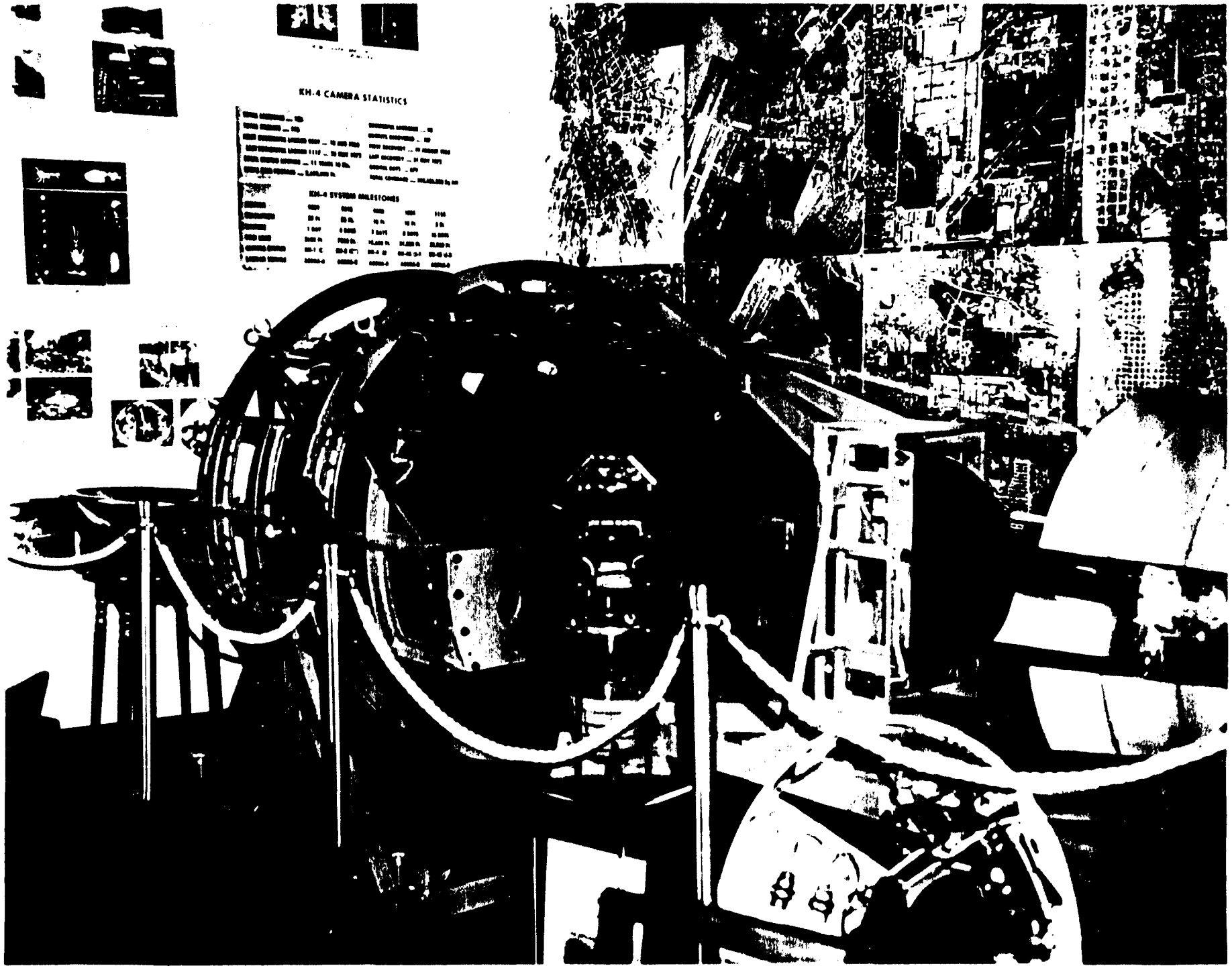
Framing Camera. The KH-4 system will employ for the first time a small framing camera to aid in determining attitude. The features of this camera are as follows:

Lens:	Zeiss Biagon f/4.5
Focal length:	38.10 mm
Field angle:	72 degrees x 72 degrees
Shutter:	Compur, rated at 80 percent efficiency
Shutter speeds:	1/125 second, 1/250 second, and 1/500 second
Average weighted area resolution:	90 L/mm
Format size:	2.25 inches x 2.25 inches (70 mm)
Grid:	The lens-camera system is equipped with a Reseau Grid made of evaporated nickel chromium on a one-millimeter borosilicate glass plate. The grid interval is 2.5 mm over the entire format.
Filter:	Wratten 21
Film load:	70 mm x 120 feet, approximately 400 frames with 1/8-inch separation between frames
Scale:	approximately 1:7,000,000

The framing camera will be controlled by the forward panoramic camera. The forward camera will be programed to trigger the framing camera once every predetermined number of frames. The framing camera will be triggered when the scan of the forward camera reaches the center of its format. The ratio of framing camera exposures to forward panoramic camera exposures can be set from 1:6 to 1:11. The probable choice will be between 1:6 and 1:8. The exposure time of the framing camera exposure will be recorded as an elongated frequency mark on the corresponding panoramic exposure. This mark will appear on the forward

format. The framing camera will be positioned 1.5 degrees counter to the positive pitch of the vehicle in order to produce vertical photography.

The titling of the framing camera will consist of frame number, mission number, date, and classification. Frames will be numbered consecutively throughout the entire mission.


KH-4 CAMERA STATISTICS
KH-4 SYSTEM MILESTONES