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May 1964

TECHNICAL PUBLICATION

THE 112-B CAMERA SYSTEM

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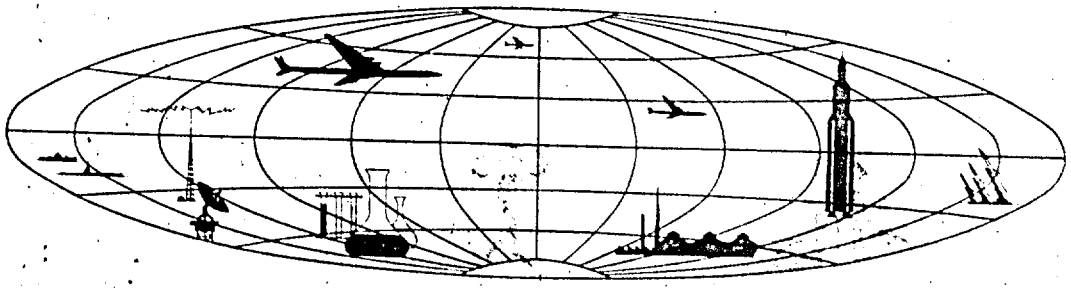

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PREFACE

This publication presents general technical information for early exploitation of photography obtained by the 112-B camera system.

The scales, tables and charts presented in the publication are for use by the photo interpreters in determining approximate size and scale of objects, and are not meant to take the place of more precise mensuration parameters.

Technical operational data such as scan rate, cycle periods, and focal lengths will be available for each mission.

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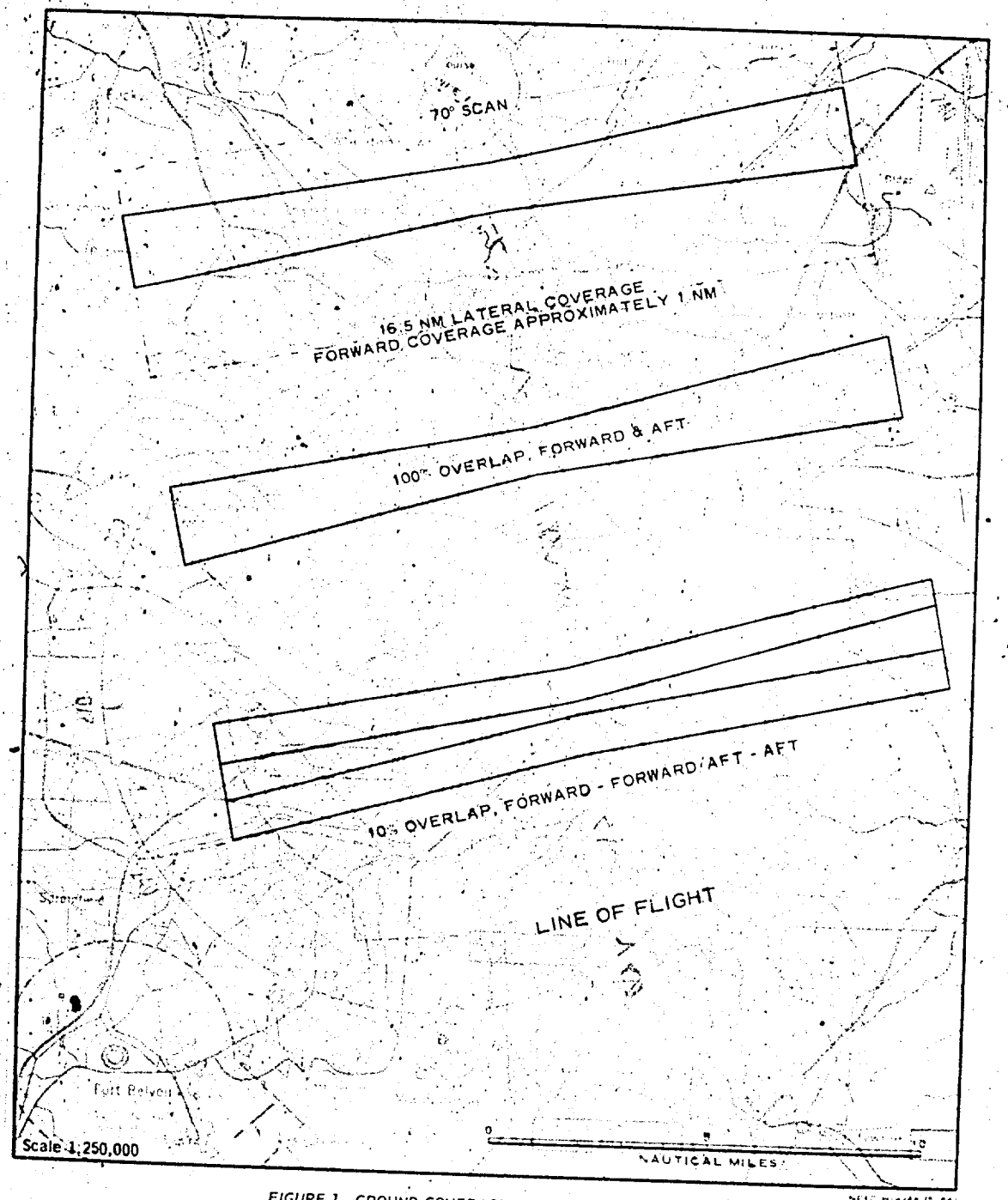

FIGURE 1. GROUND COVERAGE, ALTITUDE 70,000 FEET.

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INTRODUCTION

The 112-B camera system has been developed to provide 100 percent stereoscopic convergent photography for the collection of intelligence information from a high-altitude reconnaissance aircraft. The system consists of a pair of 24" focal length panoramic cameras and a 3" focal length panoramic tracker camera.

The two main cameras are pitched at a 26° convergent angle between the cameras to attain stereo coverage and a good base-height ratio. The forward-looking camera is pitched 13° forward of nadir and the aft-looking camera is pitched 13° aft of nadir. The panoramic cameras pan transverse to the flight line out to 35° left and 35° right for a total 70° scan angle (Figure 1).

The approximate scale of the photography at the center of the format is 1:36,000, with smaller scales in ascending order out to the end of the scan. Scales for different altitudes and positions are listed in Table 1.

Table 1 - Scales

Altitude Feet	Center of Format	Left or Right of Center of Format					
		5	10	15	20	25	[illegible]
60,000	30,780	30,900	31,260	31,900	32,750	33,[illegible]	35,[illegible]
62,000	31,800	31,930	32,300	32,960	33,870	34,[illegible]	36,[illegible]
64,000	32,830	32,960	33,340	34,020	34,960	36,[illegible]	37,[illegible]
66,000	33,850	33,990	34,380	35,080	36,050	37,180	38,[illegible]
68,000	34,880	35,020	35,420	36,150	37,140	38,310	40,[illegible]
70,000	35,910	36,050	36,470	37,210	38,240	39,440	41,[illegible]
72,000	36,930	37,080	37,500	38,280	39,330	40,500	42,[illegible]
74,000	37,960	38,110	38,550	39,340	40,420	41,600	43,[illegible]
76,000	38,990	39,140	39,600	40,400	41,520	42,830	45,[illegible]
78,000	40,010	40,160	40,630	41,470	42,610	43,940	46,[illegible]
80,000	41,040	41,190	41,680	42,530	43,700	45,070	47,41[illegible]

This camera configuration allows 100 percent stereoscopic coverage of an area 16.1 nautical miles (nm) wide and approximately 2,634 nm long for each mission. The optimum operating altitude is 70,000 feet with a nominal ground speed of 400 nm per hour.

Each camera uses a narrow-angle lens to produce high resolution. The total angular field of view is 5°13' of arc with 2°36' half angle. This produces a forward gain of approximately one nm for each photograph. Complete figures and width of frame and length of frames are shown in Table 2.

CAMERA OPERATION

Each main camera consists of a 24" focal length rotating lens, a slit-carrying scan arm, and the take-up and supply units.

The lens system rotates through a 360° angle during each cycle period, but the slit-carrying scan arm traverses only the 70° scan angle of

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the format. The scan arm is moved across the film with the lens system and is then reloaded into its start position while the lens is rotating around to the start of the next scan. The film take-up and supply motions are also completed during the transient rotation of the lens system. One member of the lens system (the field flattener) is attached to the scan arm near the focal plane in order to reduce chromatic aberration. The film paths of the two cameras are identical; however, the cameras are turned 180° from each other so that the forward camera film moves from right to left and the aft camera film moves from left to right. The film is held in the focal plane at the time of exposure by two rollers attached to the end of the scan arm. The film is held stationary throughout exposure by film clamps at each end of the rails. Film is metered by a metering roller on the take-up side of the camera. The camera film path illustration (Figure 2) shows these operations.

The 112-B camera system is capable of taking continuous photography over a range of approximately 2,634 miles, or may be operated in bursts over particular target areas for either short or long periods of time (Figure 3). Photographs can be taken for approximately seven hours of flying time during normal cycling operations and these may be taken continuously in one long flight line or taken in many short bursts. Complete details on operating times and coverage are listed in Table 2.

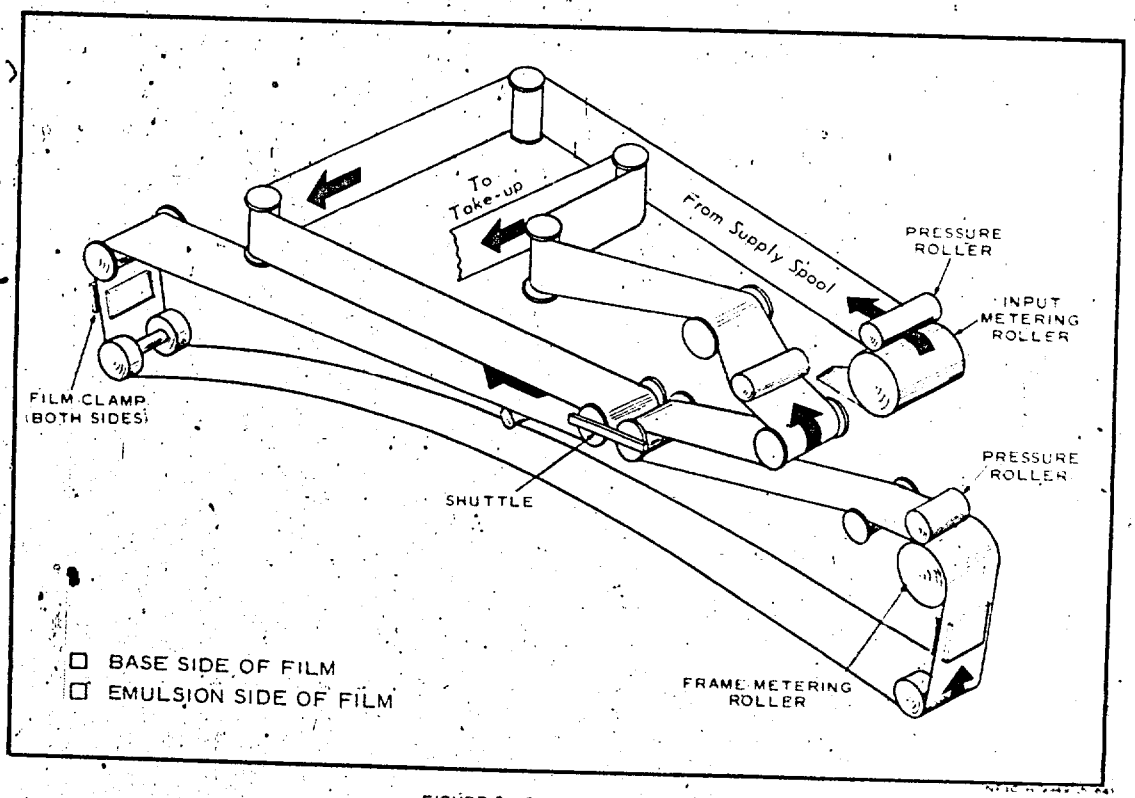

FIGURE 2. CAMERA FILM PATH.

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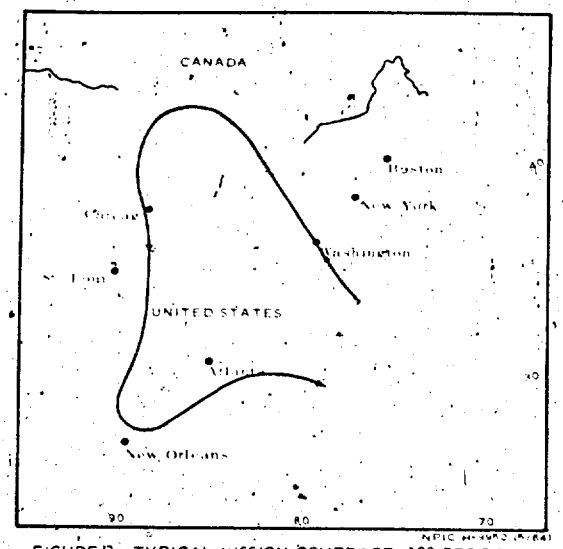

FIGURE 3. TYPICAL MISSION COVERAGE, 100 PERCENT STEREO.

PHYSICAL CHARACTERISTICS OF THE SYSTEM

General Data:

1. Camera type — Stereo Panoramic
2. Focal Length — 24"
3. Film Width — 70 mm
4. Format Size — 2.187" x 29.323"
5. Angular Coverage — 5 degrees, 13 min x 70 degrees
6. Film Load — 7,800 feet each camera
7. Lens Type — Petzval (5 elements)
8. Aperture — f/3.5
9. Operational Altitude — 70,000'
10. Stereo Angle — 26 degrees
11. Filter — Wratten 21
12. Shutter Width — see Table 3
13. Film Type — SO 132 or SO 206
14. Film Base — 3 Mil Estar Base

Table 2 System Coverage and Operating Modes

Altitude	Ground Velocity Knots	Cycle Rate CPS	Operating Mode	Total Number Frames 7800 ft.	Frames Per Minute	Total Operation Time Minutes	Forward Cov. Frame Wo. ol nm	Lateral Cov. per Frame nm	Total Forward Coverage nm	Area Cov. per Frame sq nm	Total Area Coverage sq nm
60,000	350-370	9.0	4	2910	6.66	437	0.885	13.85	2320	12.26	[illegible]
	371-390	8.0	2	2910	7.50	389	0.885	13.85	2320	12.26	31,332
	391-410	7.0	3	2910	8.57	340	0.885	13.85	2320	12.26	[illegible]
	411-430	7.0	3	2910	8.57	340	0.885	13.85	2320	12.26	31,332
65,000	350-370	9.0	1	2910	6.66	437	0.934	14.95	2447	13.96	36,382
	371-390	8.0	2	2910	7.50	389	0.934	14.95	2447	13.96	36,382
	391-410	7.0	3	2910	8.57	340	0.934	14.95	2447	13.96	36,382
	411-430	7.0	3	2910	8.57	340	0.934	14.95	2447	13.96	36,382
70,000	350-370	9.0	1	2910	6.66	437	1.00	16.10	2634	16.10	42,467
	371-390	9.0	1	2910	6.66	437	1.00	16.10	2634	16.10	42,467
	391-410	9.0	1	2910	6.66	437	1.00	16.10	2634	16.10	42,467
	411-430	8.0	2	2910	7.50	389	1.00	16.10	2634	16.10	42,467
75,000	350-370	9.0	1	2910	6.66	437	1.08	17.30	2823	18.68	48,818
	371-390	9.0	1	2910	6.66	437	1.08	17.30	2823	18.68	48,818
	391-410	9.0	1	2910	6.66	437	1.08	17.30	2823	18.68	48,818
	411-430	9.0	1	2910	6.66	437	1.08	17.30	2823	18.68	48,818

nm = Nautical Miles
sq nm = Square Nautical Miles
wo. ol = Without Overlap

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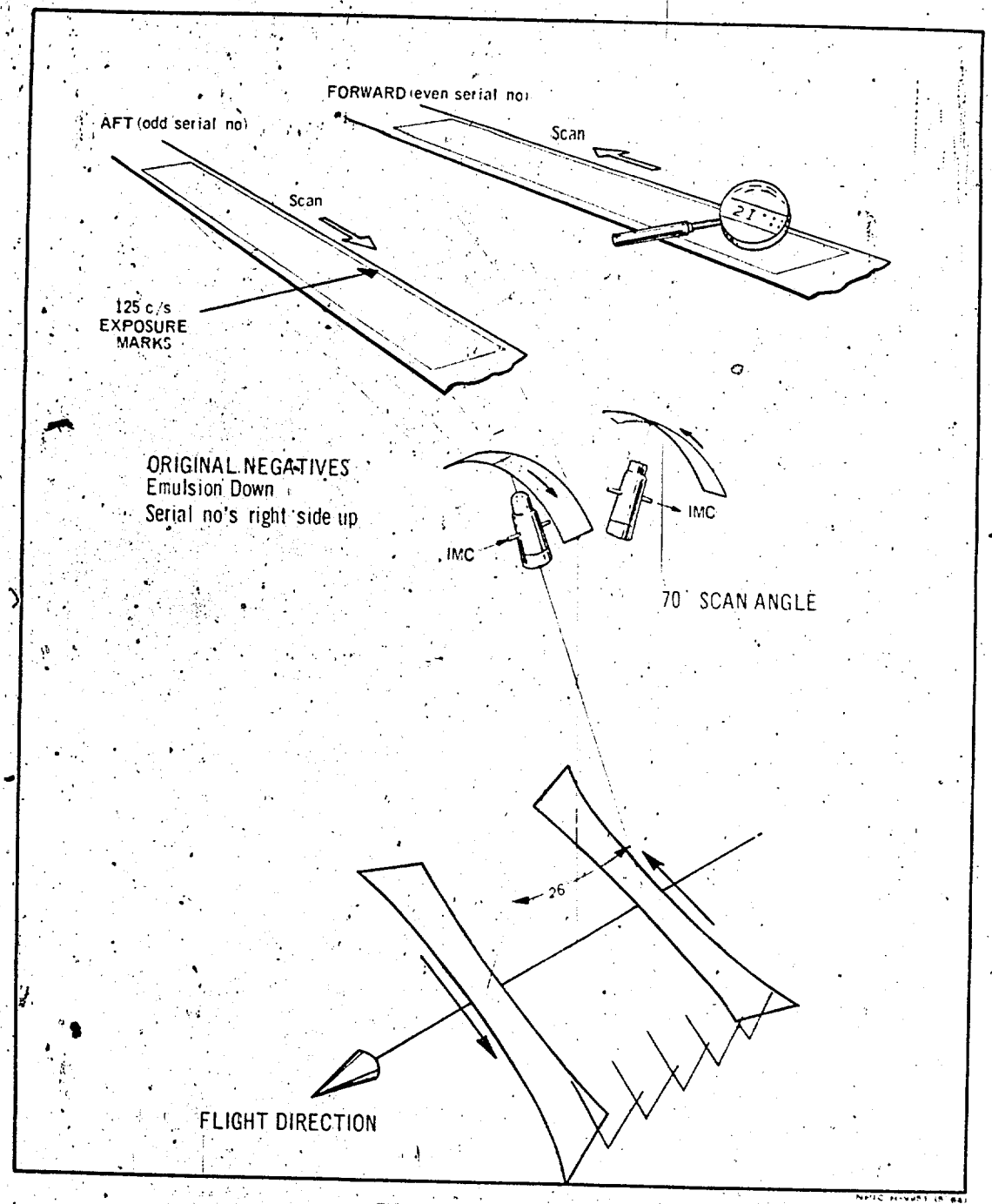

FIGURE 4. SCAN SCHEMATIC.

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Table 3 - Slit Width and Scan Rate Table (See Figure 4)

Part Number	Exposure Slit Width	Mode 3 7 Sec. Cycle	Mode 2 8 Sec. Cycle	Mode 1 9 Sec. Cycle
60152-1	0.189	1.115	1.100	1.090
2	0.151	1.140	1.125	1.110
3	0.121	1.180	1.155	1.140
4	0.095	1.230	1.200	1.175
5	0.076	1.285	1.250	1.220
6	0.064	1.333	1.295	1.265
7	0.049	1.435	1.385	1.345
8	0.039	1.555	1.475	1.455
9	0.031	1.715	1.625	1.525
10	0.025	1.830	1.770	1.665

Scan Rates	Mode 3 7 Sec. Cycle	Mode 2 8 Sec. Cycle	Mode 1 9 Sec. Cycle
Degrees/Second	51.428	45.000	40.000
Inches/Second	21.54	18.85	16.75
Radians/Second	.8976	.7854	.698

MODES OF OPERATION

The cameras normally operate steroscopically with the forward looking camera producing 10 percent forward lap photography at a preset cycle period of 7, 8 or 9 seconds. The aft-looking camera also produces 10 percent forward lap photography and stays within 2 percent of the same operating speed as the forward camera (Figure 5).

If one camera should stop operating for any reason during a mission, the remaining camera can be operated monoscopically to produce complete monoscopic coverage with 10 percent forward lap.

The camera can operate in 3 different modes. These are designated modes 1, 2 and 3 according to the cycle period and scan rate desired for proper camera operation.

The camera will always be operated at the cycle period that most nearly matches the velocity-height ratio at that point. Therefore, the cycle period should always be within 1 to 2 percent of Image Motion Compensation (IMC). The lens system rotation and sweep of the scan arm are very accurately controlled to allow precise IMC.

FORMAT AND TITLING

A. Format: The 112-B format dimensions are 2.187" by 29.323", which provides ground coverage of 1.10 nm by 16.10 nm at an altitude of 70,000'. The extreme ends of the format, the so called "bonus areas," are subject to distortion and poor focus. However, this condition is confined to approximately 0.50" of the scene width at each end of the format. The metering between individual frames measures 0.25". Slight variations may occur but seldom in excess of 0.05". The format borders, or edges, are approximately 0.27" wide. One edge contains the fiducials and provides space for the title block. The time 125 cps track is recorded on

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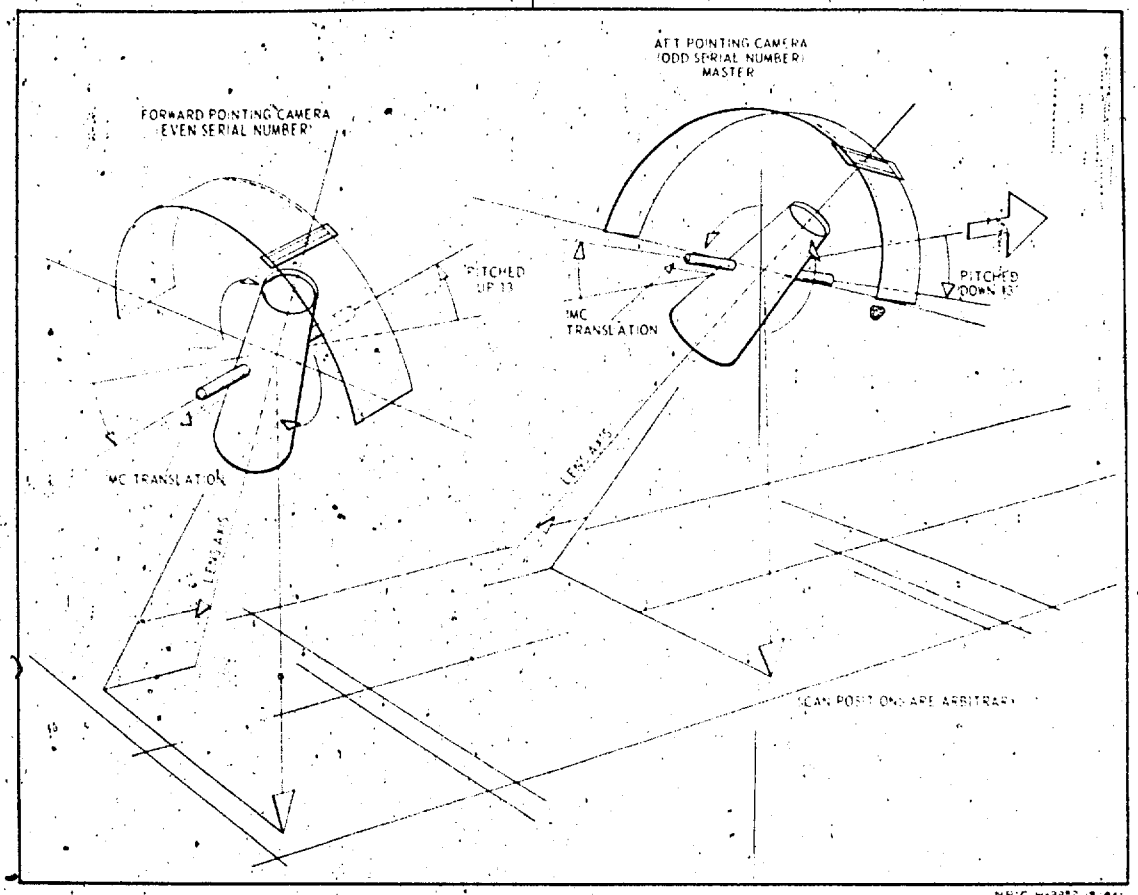

FIGURE 5. CAMERA OPERATION SCHEMATIC.

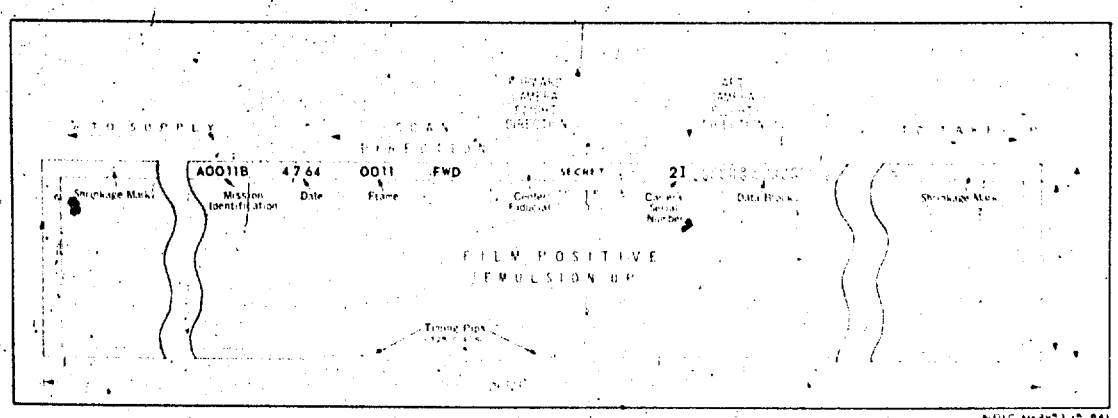

FIGURE 6. FORMAT DIAGRAM.

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the other edge. Inclusion of a frame counter and camera-off indicator is currently under consideration (Figure 6).

B. Titling: The title block, composed in 10-point type size, appears with each frame and provides the basic information pertinent to each frame. Individual components are separated by spaces sufficient to prevent confusion or erroneous interpretation of the titling. The information content and make-up are as follows:

1. Mission Identification: Missions are identified by letter-number combinations consisting of a letter prefix followed by four numerals and a letter suffix. Where four numbers are not required, the significant digits are preceded by zeros in order to maintain the integrity of the mission identification component. Examples: A0011B, A0111B.

2. Operational Date: The flight date is recorded numerically in day month year sequence, with the numerical components separated by single spaces. Example: 4 July 1964 is recorded as 4 7 64.

3. Camera Designation: The forward-looking and aft-looking cameras are distinguished by the designations FWD and AFT, respectively, and the camera serial numbers. The FWD camera serial number is an even number and the corresponding AFT camera number is odd.

4. Frame Numbers: The title frame numbers progress sequentially from the first to last frames of the mission. Space for four numbers is provided. Where the frame count does not require the application of four significant digits, zeros are prefixed in order to utilize the allotted spaces. Examples: 0011, 0111.

5. Material Classification: This includes the appropriate codeword if required, as well as the assigned classification of the material. When employed, the codeword follows the classification. In addition, the classification block indicates, when necessary, any restrictions that pertain to dissemination of the material.

The title components enumerated in the preceding paragraphs will not necessarily be recorded on the film in that order. However, regardless of the sequence employed, no difficulty should be encountered in recognizing the individual items. It should also be noted that the titling on the FWD camera material is oriented to the direction of flight. That is, on the film positive, the titled edge is the leading edge with regard to the direction of flight. The AFT camera material is oriented with the titling on the trailing edge.

TIME RECORDING FOR EACH EXPOSURE

There will be a data block on each exposure which will record time of exposure to 0.1 second accuracy. This will be recorded directly in Greenwich civil time from the clock in the aircraft. The clock reading is recorded in binary coded decimal. The representative values of the bits are shown in the Data Block Diagram (Figure 7).

Cycle periods may be measured to 0.1 second accuracy by subtracting successive frame times. On the edge of each frame 125 cps marks will be recorded and an indicator will be shown in this time track to show when the time recording was made. This indicator will be in the form of a blank in the 125 cps track.

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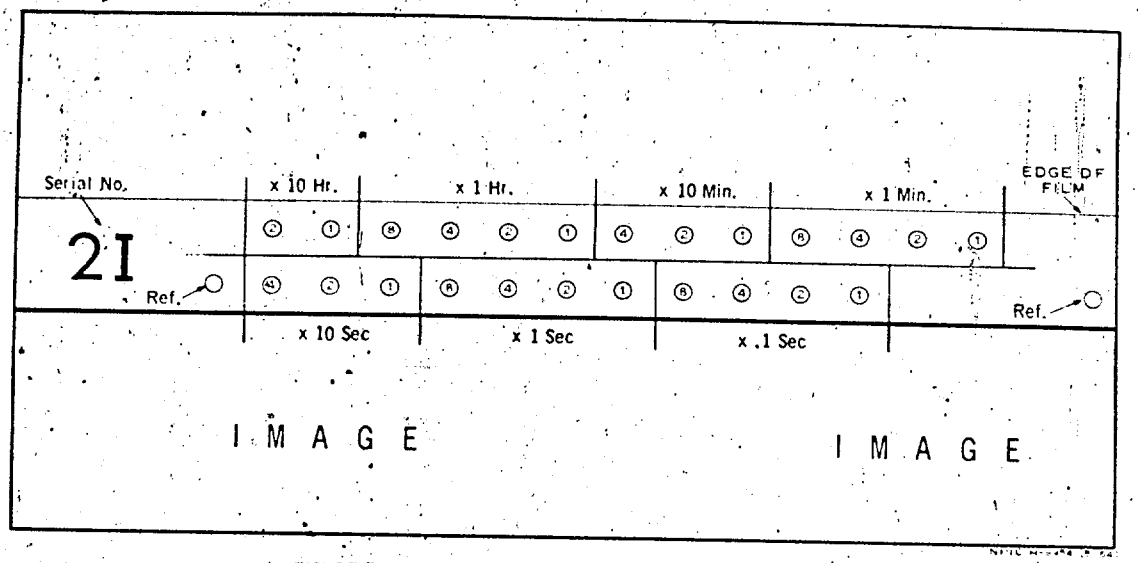

FIGURE 7. DATA BLOCK VIEW, FILM POSITIVE, EMULSION UP.

CYCLE PERIODS

The camera is capable of operating at cycle periods of 7, 8, and 9 seconds. These cycle periods change as a function of velocity-height (V/H) and are changed to produce proper IMC and proper forward lap (10 percent minimum).

The cycle period is the time between successive centers of format. Scan rates may be computed from the cycle period as well as IMC, and distortions due to improper IMC.

Scan rate is the speed of travel across the format by the slit and is usually given in radians/second; however, in Table 3 these are shown in degrees/second, inches/second, and radians/second.

$\frac{2\pi}{C.P.}$ = radians/second

$\frac{360°}{C.P.}$ = degrees/second

$\frac{29.323 \times 70}{360}$ / C.P. = inches/second

π = 3.1416

C.P. = Cycle Period

29.323 = Length of Film

70/360 = Degrees of Scan

IMAGE MOTION COMPENSATION

IMC is accomplished by translation of the lens in the Fore-Aft direction while the scan arm is traveling across the film. This will produce motionless images in the image plane when this motion exactly matches the V/H ratio of the moving aircraft. Since the amount of this motion is also a function of the speed of the scan arm, an IMC constant is produced by changing the scan arm speed for different V/H Ratios. This allows a constant IMC ratio to be established. For this system the IMC is y = .3209 Sin θ in inches or y = 8.1508 Sin θ in millimeters. Both

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cameras are operated by identical cams so that the IMC is the same for both cameras, however, the scan is in opposite directions therefore the sign changes from FWD to AFT cameras (Figure 4).

RESOLUTION

The system has a ground resolution capability of approximately 11 inches at the center of format. This resolution will decrease outward from the center of format to about 16 inches at the 25° position of the scan.

TRACKER CAMERA

The 3" focal length tracker camera is a 180° scan panoramic camera. The camera has a half angle of 21° or a full FWD-AFT coverage of 42° and scans to 90° left and right of the flight path

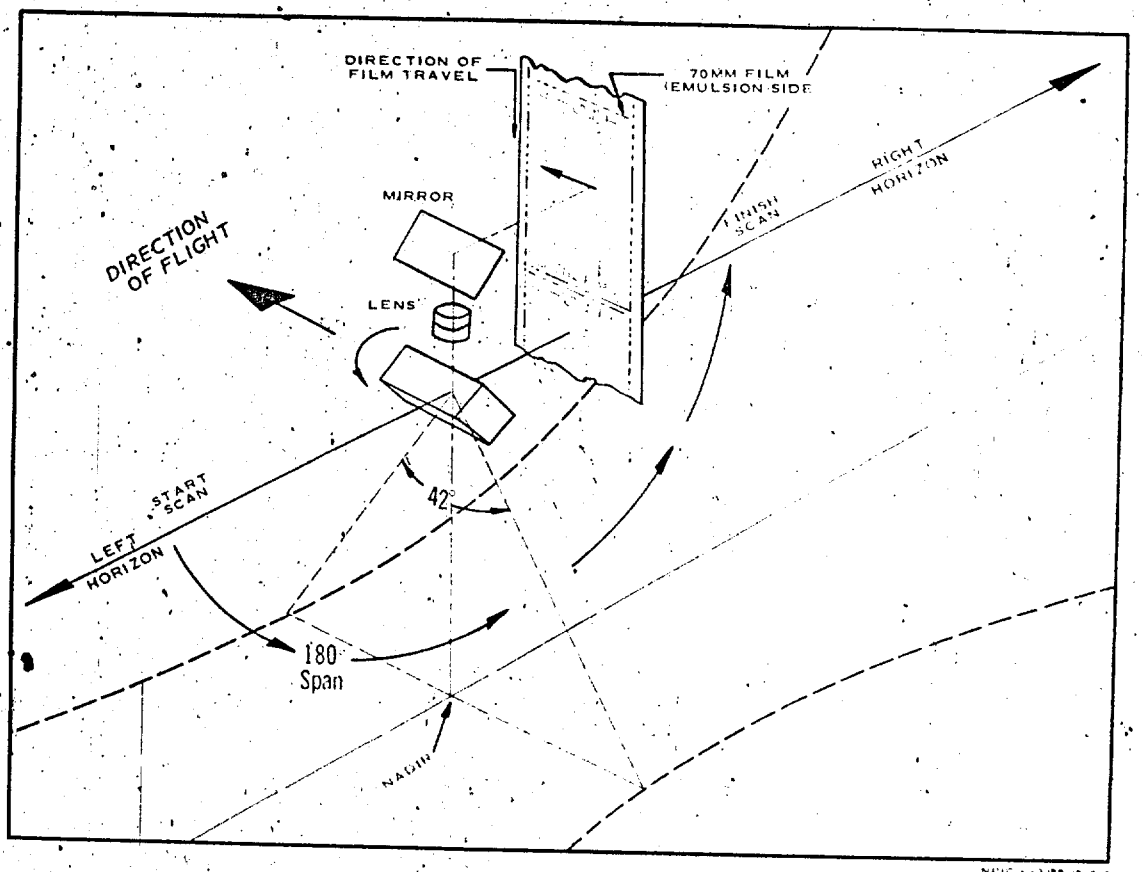

FIGURE 8. TRACKER CAMERA SCHEMATIC.

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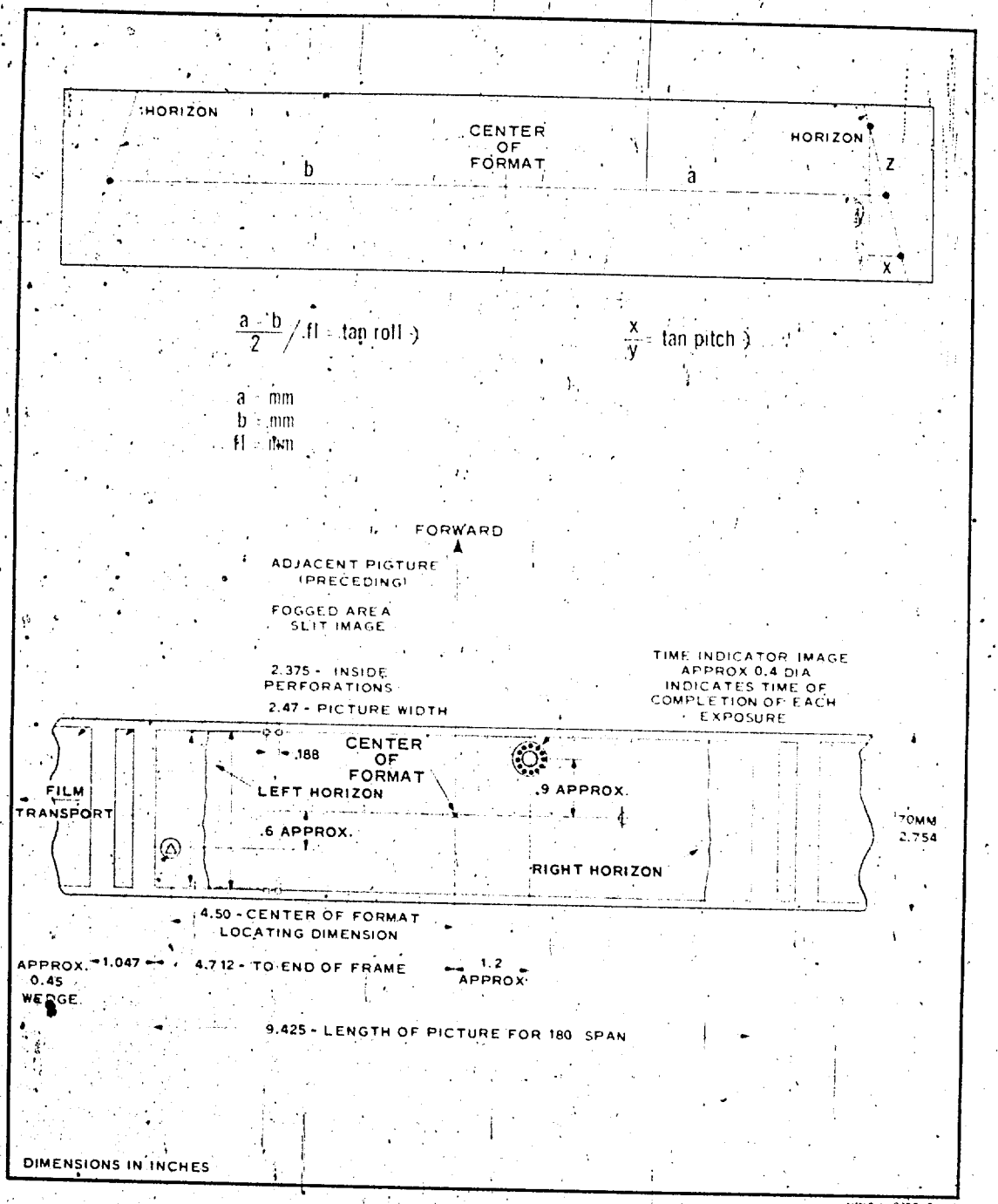

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FIGURE 9. FILM FORMAT, TRACKER CAMERA.

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to produce a horizon to horizon photograph.

The lens is a 3" focal length f/8 fixed focus orthometar type lens.

The film is moved in synchronization with rotation of a prism in front of the lens to produce motion free photography.

The camera loads 1,000 feet of 70mm Estar based film and produces photos that are 2.375 inches wide and 9.425 inches long.

A schematic of the operation of this camera is shown in Figure 8.

There is a clock superimposed on the tracker camera photography which reads in seconds.

This tracker camera is the only source of attitude for this system at this time; however, only gross measurements of pitch and roll conditions can be made from this camera.

Figure 9 depicts the geometry necessary for gross attitude determinations from the tracker camera. Points a and b are measured from the center of format of the photograph to the horizon as shown. One half the difference is the amount the wing is down or up in reference to a non-rolled position. When divided by the focal length this gives the tangent of the roll angle at that point.

To find the pitch of the vehicle, measured arcs from the center of the horizon must be marked at equal distance from the center as is shown by the Z in the diagram. Then the x-y measurement is made and when y is divided into x this becomes the tangent of the pitch and or the nose up-nose down condition of the aircraft.

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