HARVARD COLLEGE OBSERVATORY

APOLLO TELESCOPE MOUNT

HYDROGEN ALPHA TELESCOPE

FILM AND ATLAS GUIDE

HARVARD COLLEGE OBSERVATORY

ATM HYDROGEN ALPHA TELESCOPE

FILM AND ATLAS GUIDE

by

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1.0 Introduction

This document is a handbook to accompany the Atlas and provide an explanation of its use, a description of the Atlas, a description of the flight film and film processing, the location of the copies of the H-Alpha films and the Atlas, and a description of the H-Alpha 1 Telescope on ATM.

2.0 Atlas

2.1 Purpose of Atlas

The H-Alpha Atlas provides selected photographs of the sun, taken with the Hydrogen Alpha 1 Telescope aboard ATM Skylab during the manned portions of SL2, SL3, and SL4. The purpose of the Atlas is to provide readily accessible pointing information and solar feature identification to scientists evaluating the data of ATM experiments. The original flight film has been used to produce the Atlas to provide the greatest possible resolution. It is intended that the Atlas provide most of the need for prints from the original flight film, so that further handling of the flight film will be only rarely required.

2.2 Contents of Atlas

Each page of the main Atlas consists of a 16 by 16 arc minute portion of the solar disk enlarged to 8 by 8 inches, and a data section. The data section contains the ATM Fine Sun Sensor (FSS) coordinates, the SO82B Bias, the SO52 Pointing Error Sensor (PES) readings, SO55 mode information, day of year (DOY), time (GMT), sun remaining time (SRT), and day/night cycle number. In general the Atlas photographs are printed to show disk detail. However, where there are off-limb features, particularly when the reticle intersection is off the solar disc, another photograph is included which is printed to optimize the off-limb detail.

Each volume of the Atlas contains approximately 100 pages with about 5 prints per day/night cycle. This is close to 8% of the total number of pictures taken. (See 3.4)

The day/night cycle numbers included in each volume and the day of year of the first print are printed on the back binding of the volume.

The complete Atlas contains the following:

Approximately 50 volumes of prints of 100 pages each showing a 16 x 16 arc minute portion of the sun; approximately three volumes of prints showing the full solar disk enlarged to 8 inches in diameter, with one picture for each day; one copy of the "ATM Pointing Reference Handbook," TN74-27, prepared by Ball Brothers Research Corp., Boulder, Colorado; one copy of the "Roll Reference Determination Summary Report," TN74-14, also by Ball Brothers; and ten copies of this Atlas guide which includes the SO55 raster overlay and the roll angle overlay.

2.3 Description of Print

The scale on each main Atlas print (Fig. 1) is 2 arc minutes per inch and is 4 arc minutes per inch on the full disk prints. The reticle is always in the exact center and perpendicular to the edges. When the print is oriented with the data box on the left, solar North will be up (+Y) and East will be toward the data box (-X) when the ATM roll angle (GAM RR) is zero.

The prints are made on Kodak Polycontrast Rapid paper with an "N" surface. The equivalent contrast grade at which the paper was exposed is about 2.5. The photos were in general printed to a high density, which increased the dynamic range of the paper considerably. This added range can be brought out in the dark areas by back lighting the print.

The print included in this document is a sample page from the Atlas.

2.4 Description of Data Section

FSS

The GAM X and GAM Y values are the outputs from the Fine Sun Sensor deviation wedge position encoder in arc seconds.

The GAM RR value is the telemetered roll in arc minutes without any correction or updating factors.

Reference Coordinates

The reference coordinates located near the FSS values show the positive direction of each axis, which is the direction of motion of the reticle relative to a stationary sun.

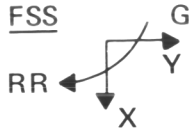
SO52

The values are the outputs of the Pointing Error Sensor in the White Light Coronagraph (SO52). A reading will occur only when sun centered, but not at all sun centered pointings.

SO82

The values are the current bias values for the Extreme Ultraviolet Spectroheliograph (SO82B). These values, when selected by the astronaut, bias the reading of the Fine Sun Sensor at the control console so that pointing of the SO82B slit can be achieved directly. Note that the reading is biased only at the control console and does not affect the Fine Sun Sensor readings given in the data section or in telemetry.

FSS



GAM	X	−324
	Y	−145
	RR	−8

SO52 PES X

Y

SO82 BIAS X 26

Y 55

SO 55 DETECTORS:

1	2	3	4	5	6	7
1	1	1	1	1	1	1

MODE: MIRROR RASTER

MIRROR: POS. X

POS. Y

GRATING: POS. 1

REF. OPTICAL

DOY 248 GMT 12:59:30 SRT 2 CYCLE 1758

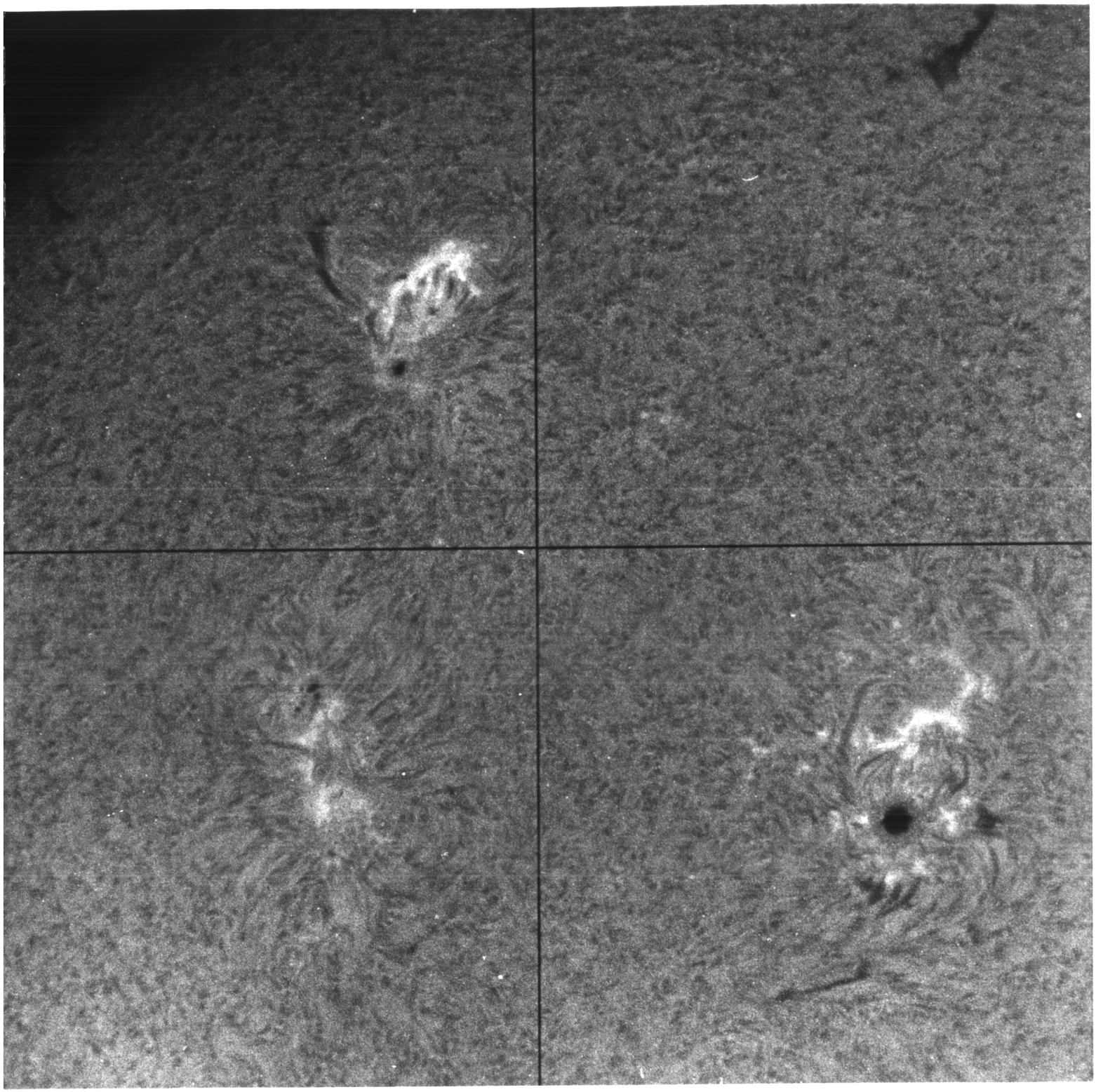


TABLE 1

MODE*	MIRROR	GRATING	PERTINENT DATA
STOP	STOP	STOP	MIRROR X & Y POSITION GRATING POSITION
MIRROR RASTER	3 RASTER (M3R) or AUTO RASTER (MAR)	STOP	GRATING POSITION
MIRROR LINE SCAN	SCAN (MLS)	STOP	MIRROR Y POSITION GRATING POSITION
GRATING SCAN	STOP	AUTO SCAN 3 SCAN	MIRROR X & Y POSITION
GRATING REFERENCE	STOP	REFERENCE	MIRROR X & Y POSITION
GRATING SINGLE STEP	STOP	SINGLE STEP	MIRROR X & Y POSITION

*Note that the mode selected may not have been initiated at the time of the photograph.

SO55

Detectors – The detectors which were on at the time the photograph was taken are indicated by a "1" in their numbered boxes.

Mode, Mirror, and Grating – One of six possible modes is listed. Table 1 gives the status of the mirror and grating for each of these modes.

DOY The day of year.

GMT Greenwich Mean Time from the ATM clock as recorded on the film in the H-Alpha Telescope.

SRT Sun Remaining Time in a particular orbit to a point 400 KM above the Earth's horizon.

CYCLE – The total number of day/night cycles of Skylab from the launch of the SL1 mission on 14 May 1973 are given. To convert these to the cycle numbers that were recycled at the beginning of each manned mission the following numbers must be subtracted.

SL2 subtract 167
SL3 subtract 1154
SL4 subtract 2870

2.5 **Criteria for Print Selection**

Prints were selected at the beginning and end of each orbit, at each significant pointing change, or, in the absence of a pointing change, at approximately 15 minute intervals.

The prints selected at the orbital extremes were at, or near, the 400 KM points. A significant pointing change is defined as a translation in X or Y of at least 5 arc seconds or a roll change of at least 10 arc minutes. Also, the pointing must have been stable for at least one minute before the corresponding print is selected for the Atlas.

2.6 **Distribution of the Atlas**

Copies of the H-Alpha Atlas are being distributed to the following:

Dr. R. MacQueen
High Altitude Observatory
P. O. Box 1470
Boulder, CO 80302

Mr. J. Hirmann
National Oceanic and Atmospheric Administration
R-43, Rm. 2010
325 South Broadway
Boulder, CO 80302

Dr. A. Krieger
American Science &
Engineering, Inc.
955 Massachusetts Avenue
Cambridge, MA 02139

Dr. A. DeLoach, S&E-SSL-T
NASA
Marshall Space Flight Center
Huntsville, AL 35812

Dr. E. Reeves
Harvard College Observatory
60 Garden Street
Cambridge, MA 02138

Dr. G. Vaiana
Harvard College Observatory
60 Garden Street
Cambridge, MA 02138

Dr. J. Underwood
Aerospace Corporation
P. O. Box 92957
Los Angeles, CA 90009

Dr. R. Tousey – 7140
Naval Research Laboratory
Washington, DC 20375

Mr. J. Johns
National Space Science Data
Center
Code 601
Goddard Space Flight Center
Greenbelt, MD 20771

3.0 Flight Film

3.1 Description

The flight film is 35mm Kodak SO101 on 1000 foot rolls. This film has the same emulsion as Kodak SO392 solar recording film but the base is changed from 0.005 inch thick estar to 0.0025 inch thick mylar on the SO101.

3.2 Flight Film Processing and Copying

The H-Alpha flight film was processed and copied at the Aerospace Corp., El Segundo, California.

The processing was done in a continuous Foulton processor. The development time was approximately 2 minutes in a solution of 1 part D-19 developer to 2 parts water at 70 F. This resulted in a gamma of about 2.5 with a 1.4 average image density.

During the processing of the flight film a densitometer was used in the processor to measure and record the density of each frame at the earliest possible time to assure consistent and proper development.

The copies consisted of one second generation master positive made from the flight film and 12 third generation negative copies. When making the master positive the images were individually reregistered to standardize the location of the reticle intersection relative to the sprocket holes, and convert the binary timing marks to numerical form.

Two types of third generation copies were made to individually optimize limb and disk details. This was done so that the disk copies could be made to a lower density than the original although retaining the original contrast to aid in making enlarged prints and in viewing. For the SL2 copies this was accomplished by two different exposures of each frame on the master positive and then printing alternate frames when making the third generation copies. With SL3 and SL4 one exposure of each frame was made on the master positive and then the exposure was changed on the third generation copies to separately bring out either the limb or disk.

3.3 Distribution of Film Copies

Copies of the film were sent to the following:

Mr. E. E. Franck
Harvard College Observatory
60 Garden Street
Cambridge, MA 02138

Mr. J. Hirmann
National Oceanic and Atmospheric Administration
R-43, Rm. 2010
325 South Broadway
Boulder, Colorado 80302

Mr. Joseph Johns
National Space Science
Data Center
Code 601
Goddard Space Flight
Center
Greenbelt, MD 20771

Mr. W. C. Keathley
SL/SE-ATM
NASA
Marshall Space Flight Center
Huntsville, Alabama 35812

Dr. A. Krieger
American Science &
Engineering
955 Massachusetts Avenue
Cambridge, MA 02139

Mr. J. Markey
Perkin Elmer
Main Avenue, Station 210
Norwalk, CT 06856

Dr. R. MacQueen
High Altitude Observatory
P. O. Box 1470
Boulder, Colorado 80302

Dr. E. Reeves
Harvard College Observatory
60 Garden Street
Cambridge, MA 02138

Dr. Alan Title
Lockheed Solar Observatory
P. O. Box 551
Burbank, California 91503

Dr. R. Tousey – 7140
Naval Research Laboratory
Washington, DC 20375

Dr. A. DeLoach
S & E-SSL-T
NASA
Marshall Space Flight Center
Huntsville, Alabama 35812

Dr. J. Underwood
Aerospace Corp.
P.O. Box 95085
Mail Station 120/1909
Los Angeles, CA 90045

3.4 H alpha coverage

There were a total of five H alpha film loads during the Skylab mission, one on SL2 and two each on SL3 and SL4. The coverage was as follows:

SL2		May 29 to June 18 (10,930 frames)
	DOY	149 to 169
	Hα Day*	15 to 35
SL3	Film Mag. 310-1	Aug 7 to Aug 22 (13,240 frames)
	DOY	219 to 234
	Hα Day	21 to 36
	Film Mag 308-2	Aug 24 to Sept 21 (15,330 frames)
	DOY	236 to 264
	Hα Day	38 to 2
SL4	Film Mag 310-2	Nov. 26 to Dec 25 (14,460 frames)
	DOY	330 to 359
	Hα Day	4 to 33
	Film Mag 310-3	Dec 26 to Feb 3 (9,312 frames)
	DOY	360 to 34
	Hα Day	34 to 9

Note that the number of frames were counted on the 3rd generation copies and in the case of the SL4 frames where the camera jammed the number given is the number of "usable" frames where the reticle intersection is not obscured by an overlapping image.

* The "Hα Day" is the day number from zero to 63 that is recorded in binary on the original Hα film and translated to numerical form on the 35mm copies.

4.0 Description of H Alpha Telescope

Two Hydrogen Alpha Telescopes were mounted on the ATM. The H Alpha 2 Telescope has a video camera only and was used by the crew as a pointing instrument. The H Alpha 1 Telescope has both a film and video camera and was used to provide a permanent record on film of ATM pointing, as well as a pointing instrument.

The H Alpha 1 Telescope (Fig. 2) has a 6¾ inch Cassagrain primary optical system forming a 2 inch image of the sun. The movable reticle, seen on the H Alpha photographs, is located at this initial focal plane. A series of lenses are located slightly forward of this focal plane to make the field rays parallel, eliminating wavelength variations across the field of the sun that would be caused by rays from different parts of the field of view going through the filter at different angles. The filter system consists of an 0.8Å narrow band interference filter and a 7Å interference blocking filter. A beamsplitter in back of the filter package reflects 90% of the light through a re-imaging zoom lens to a TV camera. The transmitted 10% is re-imaged by a fixed relay lens onto the film.

The H Alpha Telescopes, along with the narrow band filters, were built by the Perkin-Elmer Corp., Norwalk, CT. The blocking filter was made at Spectro-Film Corp., Winchester, Mass. Testing of the telescope and filter systems was done at the Lockheed Solar Observatory, Rye Canyon, California.

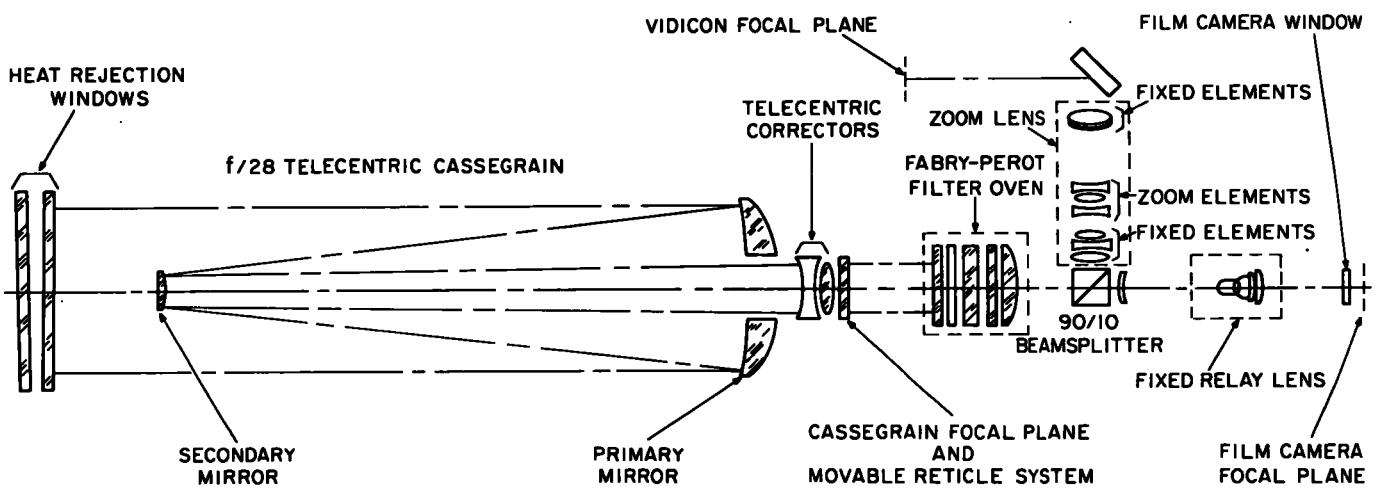


FIGURE 2: H-ALPHA 1 TELESCOPE

5.0 Overlays

Two different overlays are provided. The "SO55 Overlay" (Fig. 3) is used with the 2 arc minute per inch main atlas prints to locate the SO55 raster pattern or mirror position. The most probable alignment of the overlay relative to the H Alpha reticles is at line 9 and step 32 of the SO55 raster pattern. A mark (+) is put on the overlay at this point to be placed at the intersection of the reticle on the H Alpha print. To complete the alignment the extensions of this mark labeled +X and +Y are to be placed over the cross hairs on the +X and +Y directions on the print. The wide marks on the ends of the overlay show the range over which the position of the SO55 mirror changed relative to the H Alpha reticles during the co-alignments.

The "Roll Angle and SO55 Raster Overlay" (Fig. 4) serves the dual purpose of locating solar North from the roll angle on either scale atlas print, or of locating the SO55 raster pattern on the 4 arc minute per inch full disk prints.

6.0 Anomalies

6.1 Image Non-uniformity

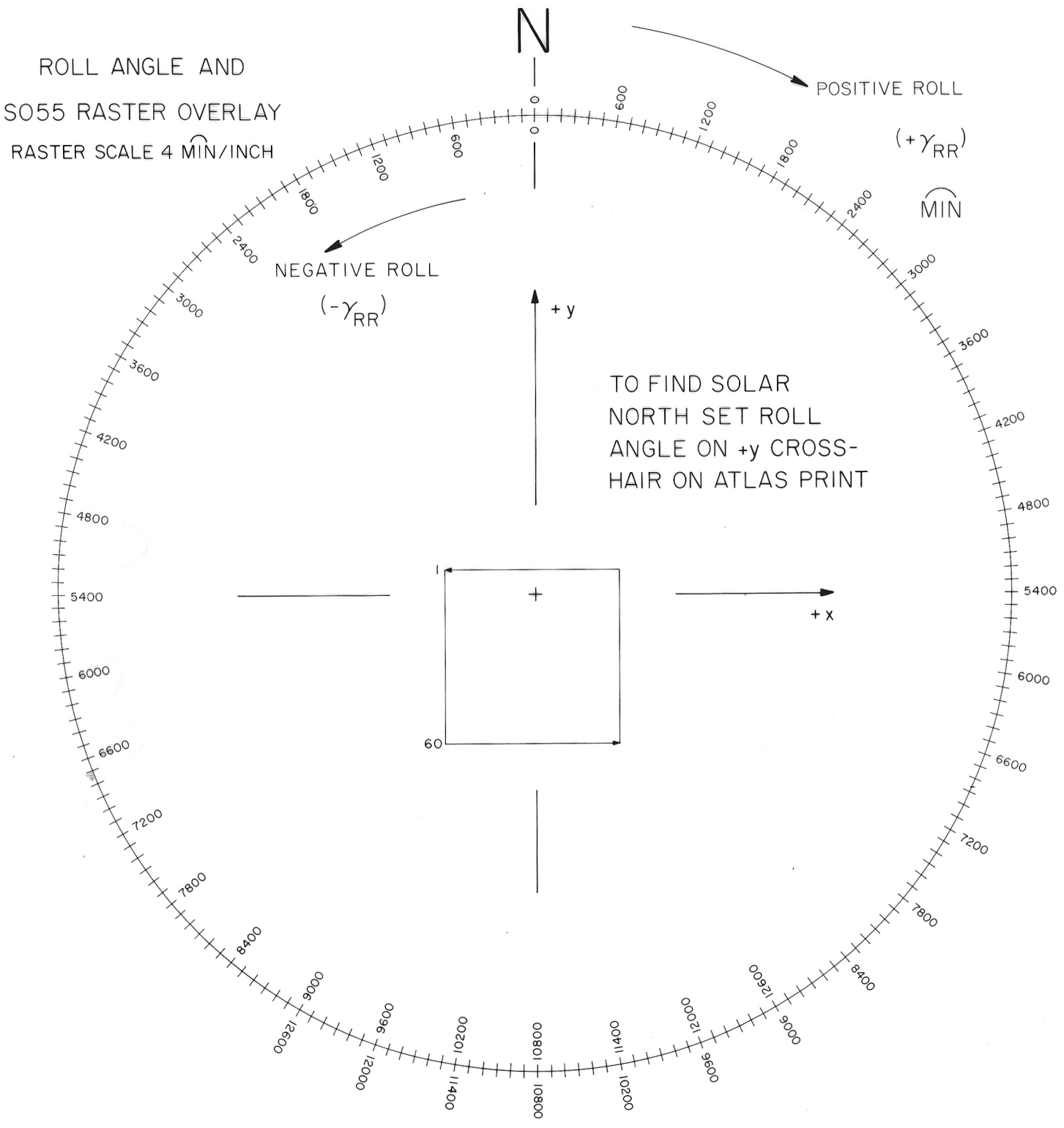
During the processing of the flight film the output of the processing densitometer showed a cyclical variation of image density of orbital frequency. The cause of the variation is possibly a combination of a temperature rise in the filter package caused by solar radiation, a doppler shift, or telescope contamination. These variations will be seen on the atlas prints as a nonuniformity when the SRT (sun remaining time) is large, and as a more uniform, but sometimes out of focus, image near the end of an orbit. This condition became progressively worse throughout the mission.

6.2 Film Camera Malfunction

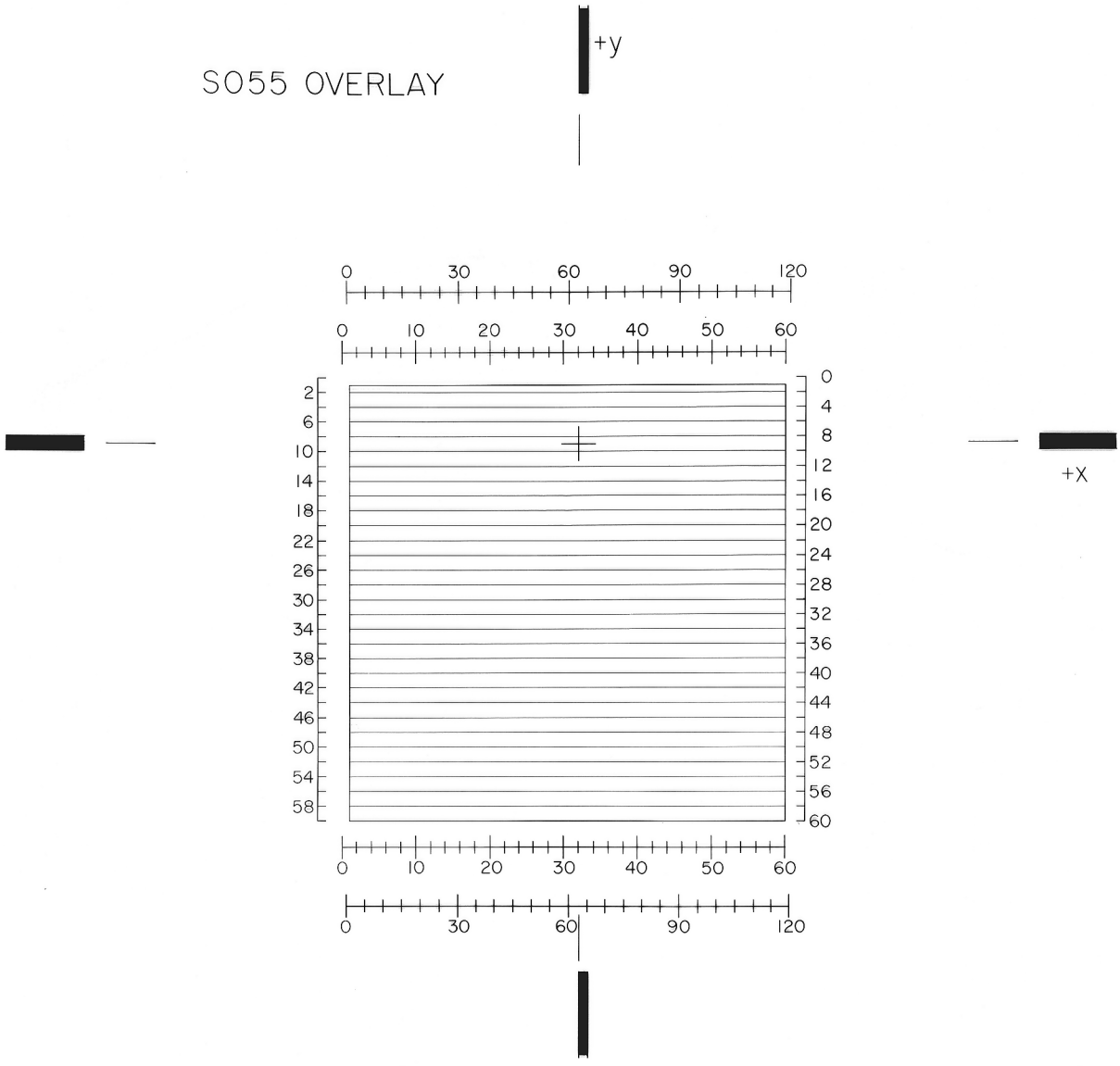
During the SL4 mission the film camera periodically jammed causing an overlapping of the solar images. A large number of exposures were ruined. Overlapping images were included in the atlas if the overlapping did not obscure the intersection of the H alpha reticle. Cycles for which no pictures were salvaged are 3799, 3817, 3818, 3819, 3820, 3845, 3846, 3847, 3875, 3876, and 3877.

6.3 Time Anomalies

In some cases the change in GMT time and SRT time from one page to another will be different. The reason for this is that the GMT time was always taken from the H Alpha film whereas the SRT time was taken from the CUT (Compressed User Tapes) data printouts. In most cases an H Alpha photo was found at the exact time of a data printout. However, in some instances, an H Alpha photo had to be selected at a slightly different time. In those cases the GMT time will correspond to the H Alpha picture and the SRT time will correspond to the data. Care was taken in selecting the picture to insure that the pointing information in the data was valid for the GMT time listed.


ROLL ANGLE AND
S055 RASTER OVERLAY
RASTER SCALE 4 MIN/INCH
N
POSITIVE ROLL
(+γRR)
MIN
NEGATIVE ROLL
(-γRR)
+y
+x
TO FIND SOLAR
NORTH SET ROLL
ANGLE ON +y CROSS-
HAIR ON ATLAS PRINT
1
60
0
600
1200
1800
2400
3000
3600
4200
4800
5400
6000
6600
7200
7800
8400
9000
9600
10200
10800
11400
12000
12600

S055 OVERLAY



ROLL ANGLE AND

S055 RASTER OVERLAY

RASTER SCALE 4 $\overset{\frown}{\text{MIN}}$/INCH