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STATUS REPORT NO. 4 - NGR-03-003-007  
January 1, 1970 thru June 30, 1970CASE FILE  
COPYPURPOSE OF GRANT

"To establish and operate a Planetary Patrol Program"

PERSONNEL

W. A. Baum, Principal Investigator (no salary)  
R. L. Millis, Co-Investigator and Program Manager (no salary)  
P. B. Boyce, Co-Investigator (no salary)  
J. L. Loven, Business Manager, part-time  
S. E. Jones, Chief Technician  
L. J. Martin, Film Analyst and Editor  
C. F. Capen, Jr., Film Analyst and Editor, from 1 April  
J. Smith, Film Editing Assistant, through 31 May  
B. Sollid-Nord, Darkroom Assistant  
K. L. Williams, Computing Assistant, from 27 March  
A. Zacharoudis, Film Editing Assistant, temporary from 27 May  
H. L. Giclas, Business Officer, one-quarter time  
H. J. Scheele, Bookkeeper, one-quarter time

On June 1, Smith began a three-month leave of absence. Her duties have been assumed by Zacharoudis, who has a temporary summer appointment. Capen, who is an experienced observer and a knowledgeable student of Mars, joined the staff in April, filling the vacancy left by the resignation of Fischbacher. Sollid-Nord was previously employed in an identical capacity under NASA Grant NGR-03-003-001.

In addition to the people listed above, many others of the Planetary Research Center staff have been directly involved in the Planetary Patrol Program. These people are organizationally associated with NASA Grant NGR-03-003-001, which provides the basic annual support for the Planetary Research Center. The planetary patrol is the largest current undertaking of the Center.

Observers at other patrol stations are all employees of their respective observatories, whose patrol operations are partially supported by the planetary patrol grant.

GENERAL DESCRIPTION AND HISTORY OF THE PROGRAM

The Planetary Patrol Program is a photographic study of Mars, Jupiter, and Venus based on continuous surveillance of these planets by a network of telescopes spaced in longitude around the Earth. The telescopes--all

of which have apertures near 24 inches--have been equipped with identical camera systems and have been modified where necessary to produce image scales near 4.5 arc-seconds per millimeter. The available planets are photographed hourly throughout the night by each of the patrol stations. A complete set of observations is comprised of fourteen-frame sequences of exposures through each of three filters--red, green, and blue. In addition, those stations using reflecting telescopes take a sequence through an ultraviolet filter. The exposed films are returned to the Planetary Research Center at the Lowell Observatory where they are developed, edited, copied, and catalogued. When the material from all stations is combined, the result is a very homogeneous photographic record which has unprecedented continuity in time. This continuity is clearly evident in Figure 1, which covers a complete rotation of Jupiter.

The Planetary Patrol Program was organized by the Planetary Research Center along the lines recommended by the Lunar and Planetary Missions Board and by the Space Sciences Board Panel on Earth-Based Planetary Astronomy. Actual observations began in April of 1969 with six observatories participating. During 1969 we received 7,379 usable fourteen-frame sequences of Mars images and 3,695 usable sequences of Jupiter images from the patrol stations. The average quality of these photographs is at least equal to that of the photographs in the Lowell Observatory historical collection, while the continuity is such that in 80 percent of the cases for a three-month interval around opposition the time interval from one set of Mars observations to the next in the same color is less than 70 minutes. For a more detailed description of the 1969 patrol, the reader is referred to Status Report Nos. 2 and 3.

The 1970 patrol observations began on January 5th with Jupiter. The observatories participating in the program this year are the same as those who participated in 1969, with the exception of the Magdalena Peak station of New Mexico State University, which was associated only temporarily with the network for a few months in 1969. During this report period the network has concentrated mainly on Jupiter. Photography of Venus in the ultraviolet was added to the schedule in June at those stations using reflecting telescopes. The purpose of the Venus observations is to check on the previously reported four-day retrograde circulation of features which are visible in the ultraviolet.

Although the 1970 patrol is still in progress, it is possible at this time to make certain comparisons between this year's effort and that of 1969. First of all, increased experience on the part of the observers, improved observing techniques, and improvements in the equipment have combined to give us a much higher yield. We estimate that on the average 85 percent of the film received this year has contained images of readable quality. The percentage of images classified as superior has also increased.

The ultimate value of the Planetary Patrol Program, of course, rests with the scientific results that can be derived from the material collected. To this end we have spent a great deal of effort in acquainting

the general scientific community with the available patrol photographs. Several thousand feet of copy film have been supplied to investigators around the country for use in their individual studies. In addition, analysis of the patrol films is being actively pursued by the staff of the Planetary Research Center. Since the most unique feature of the patrol photographs is their continuity, they lend themselves most readily to the analyses of short-term temporal changes in the atmospheric and surface features of the planets. Several studies of this type now under way at the Planetary Research Center are mentioned in the section titled ANALYSIS.

#### THE PLANETARY PATROL NETWORK DURING THE FIRST HALF OF 1970

During the current report period the following five observatories actively participated in the patrol program: the Lowell Observatory in Arizona, the Mauna Kea Observatory in Hawaii, the Mount Stromlo Observatory in eastern Australia, the Republic Observatory in South Africa, and the Cerro Tololo Inter-American Observatory in northern Chile. A detailed description of the equipment being used at these observatories is contained in Status Report No. 2. The present report will be confined to modifications and changes which have occurred during the present report period.

At the Lowell Observatory most of the 1970 Jupiter photographs were taken with the 24-inch Clark refractor. In order to carry out photography in the blue spectral region with this visually-corrected telescope, it was necessary to provide a color-correcting lens. A six-inch-diameter lens was designed by I. S. Bowen of the Hale Observatories and fabricated by Don Loomis in Tucson, Arizona. A mechanism for moving the lens in and out of the beam was designed by Busby and built in the Lowell shop. This mechanism (see Figure 2) was installed in the telescope in March. Improvements of the telescope control system were also made at that time. The 24-inch Morgan telescope was used for Jupiter photography during intervals when the refractor was disabled for modifications and also for the ultra-violet photography of Venus. The Lowell observers during the first half of 1970 were Leonard Martin, Bruce Faure, Don Thompson, and Charles Capen.

The performance of the patrol station at the Mauna Kea Observatory has been outstanding this year. The dust problem which severely hampered this station in 1969 was solved by adopting several precautionary measures. Phil Crump, P. Hendricks, and Harrison Ward skillfully handled the observing, while William Sinton and Robert Murphy supervised the program. The NASA-Hawaii 24-inch telescope performed well, although minor adjustment of the declination bearings was required.

The 26-inch Yale-Columbia refractor continued to be used for the patrol photography at the Mount Stromlo Observatory. After initial difficulties with focus and exposure were overcome, this station produced excellent photographs; but the quantity of material has been limited by

chronically poor weather conditions. The patrol observers at Mount Stromlo are Vic Williamson and Peter Scales. The program is supervised by Norman Stokes.

Patrol observations got off to a slow start this year at the Republic Observatory in South Africa. The summer monsoons prevented this station from taking significant numbers of photographs in January, February, and March; but many excellent photographs were received from South Africa during April, May, and June. The patrol equipment was shifted in late June from the 26-inch Innes refractor to a 20-inch Boller and Chivens reflector. This move was made so that ultraviolet photography of Venus could be carried out. The observing at the Republic Observatory was done by Gregory Roberts and J. Jannetta under the supervision of J. Hers.

The patrol station at Cerro Tololo Inter-American Observatory consistently produced planet photographs of excellent quality during the current report period. The patrol observers were Herman Rojas and Oscar Saá. The 24-inch Lowell-Tololo telescope has performed well.

Examples of the photographs from each of the 1970 patrol stations are shown in Figures 3 through 7. Each image is a composite made from seven or more original exposures.

In addition to the above five observatories, two other observatories have been making preparations for joining the patrol network in 1971.

At the Astrophysical Observatory in southern India work is under way on a 24-foot dome and a mounting for the 24-inch Cassegrain mirrors now on loan to that Observatory. All of the patrol equipment has arrived safely in India.

Negotiations with the Perth Observatory in western Australia were brought to a successful conclusion in May. An agreement was reached whereby a telescope will be loaned to the Perth Observatory for use in the patrol, and the Perth Observatory will construct at its own expense a suitable dome and housing for this telescope. An order for a 24-inch, F/75 reflecting telescope, similar to those previously installed in Chile and Hawaii, was placed with the Boller and Chivens Division of The Perkin-Elmer Corporation. The telescope is expected to be operational at Perth by late 1970. Construction of a planetary camera for use on this telescope was begun in the Lowell shops and, at the end of June, was approximately 50 percent completed. We believe that the addition of these two stations in India and western Australia will significantly strengthen the patrol network.

#### FILMS AND RECORDS

During the first half of 1970 the patrol network produced 147 rolls of exposed film. Each roll is 125 feet long and typically contains several

hundred usable Jupiter and Venus images. The contribution to the above total by each station is given in Table I.

TABLE I  
PATROL OUTPUT DURING THE FIRST HALF OF 1970

<u>Station</u>	<u>No. of Rolls</u>
Lowell Observatory	25
Mauna Kea Observatory	43
Mount Stromlo Observatory	33
Republic Observatory	14
Cerro Tololo Inter-American Observatory	32

Each roll of film received from the stations must be calibrated, developed, edited, copied, mounted, and catalogued. The procedures followed in accomplishing these tasks were largely developed last year and are described in Status Report No. 3. The processing of original film and production of copies are carried out by Cook, Bryant, and Sollid-Nord under the direction of Jones. Initial inspection and the grading of images are handled by Thompson, Faure, and Capen under the direction of Martin. Secondary editing and the mounting of copies are done by Smith and Zacharoudis. Cataloguing is the responsibility of Horstman.

It has been possible this year to process and edit each roll of film within a few days of its arrival at Lowell Observatory. As a result, camera malfunctions and observer errors are caught more quickly than was the case in 1969. If serious problems are evident, the station is contacted by telegram. Otherwise, a routine report describing the quality of the roll is filled out and returned to the station. We believe that this rapid feedback to the patrol stations has resulted in a significant improvement in the overall quality of the patrol photographs.

The production of copies of the patrol films has been the most time-consuming step in the film-handling process. During the peak of observing we were running about two months behind in this task. In order to alleviate the problem, bulk-film magazines have recently been adapted to our Trans-Flo processor so that it is now possible to develop 2,500 feet of film per run rather than 500 feet as had been the case in the past. The adapter for these magazines was designed by Busby and built in the Lowell instrument shop. We expect that this modification will greatly reduce the delay in the routine production of copies. During this report period 130 rolls of duplicate negatives were supplied to outside investigators, in addition to 185 rolls for mounting and for a roll "library" at the Center.

PUBLICATIONS AND PAPERS

During the period covered by this report, a paper entitled "The International Planetary Patrol Program" was submitted for publication to the journal Icarus by Baum, Millis, Jones, and Martin. Baum presented a paper describing the patrol at the January meeting of the Division of Planetary Sciences of the American Astronomical Society, and at the same meeting Boyce presented a paper concerning the use of patrol photographs for investigating the diurnal brightening of regions on Mars. Abstracts of both DPS papers are appearing in the Bulletin of the American Astronomical Society. Millis presented a paper on the planetary patrol at the Fiftieth Anniversary Meeting of the Southwestern and Rocky Mountain Division of the American Association for the Advancement of Science in April. Also in April, Martin presented a paper on new measurements of cloud motions on Mars at the meeting of the Arizona Academy of Science in Phoenix.

ANALYSIS

The 1969 Mars patrol photographs form the basis for three research programs currently in progress at the Planetary Research Center. Martin is mapping the motion of Martian clouds in an effort to determine cloud velocities and circulation patterns. Boyce and Faure have nearly completed a study of the diurnal photometric behavior of semi-permanent Martian clouds. Baum, Boyce, and Thompson are studying the dependence of "blue clearing" on phase and color.

The Jupiter patrol photographs are being used by Millis and Dr. Kenneth O'Dell of the Northern Arizona University physics department to study short-term fluctuations in the longitude of the Great Red Spot. Dr. Gary Layton of Northern Arizona University is studying vertical shear in the Jovian atmosphere by measuring the relative motion of features having the same latitude but different colors.

These programs of analysis are described in more detail in our current status report (No. 14, for January-June 1970) under the Planetary Center's sustaining grant, NGR-03-003-001.



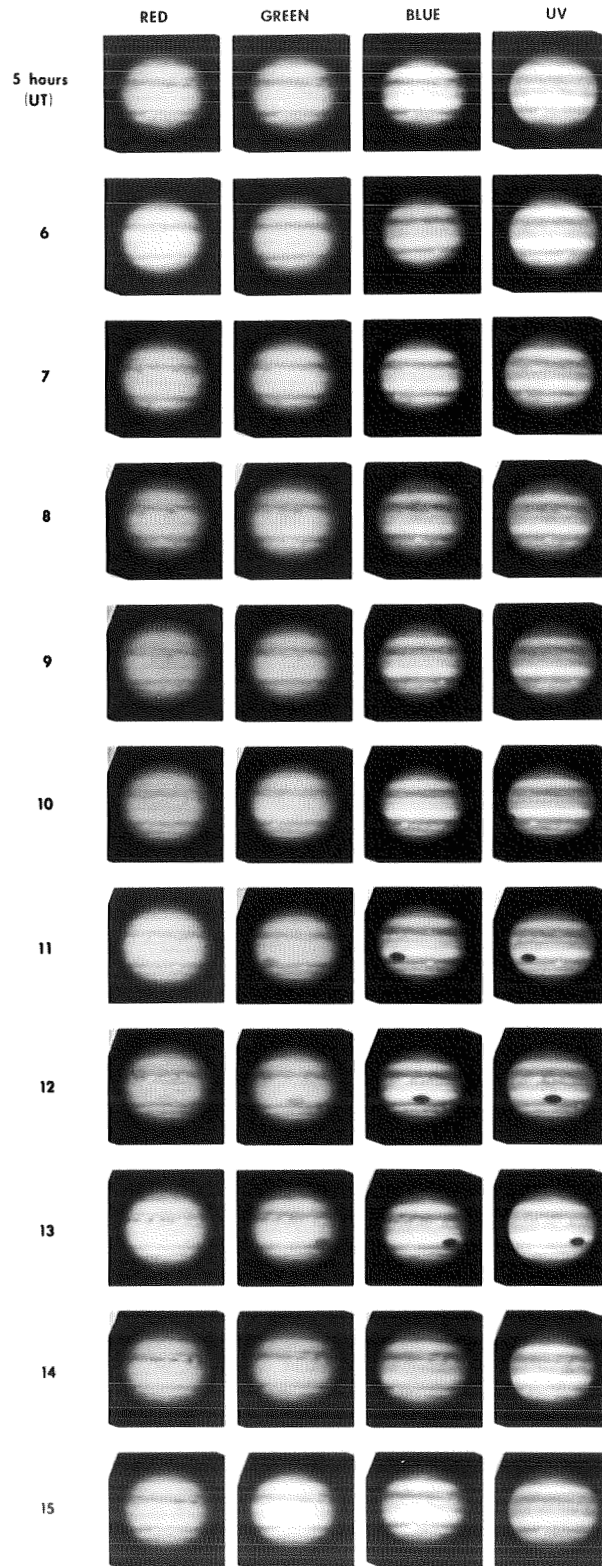
ROBERT L. MILLIS  
Program Manager



WILLIAM A. BAUM  
Principal Investigator

# JUPITER ROTATION SEQUENCES

30 MARCH, 1970

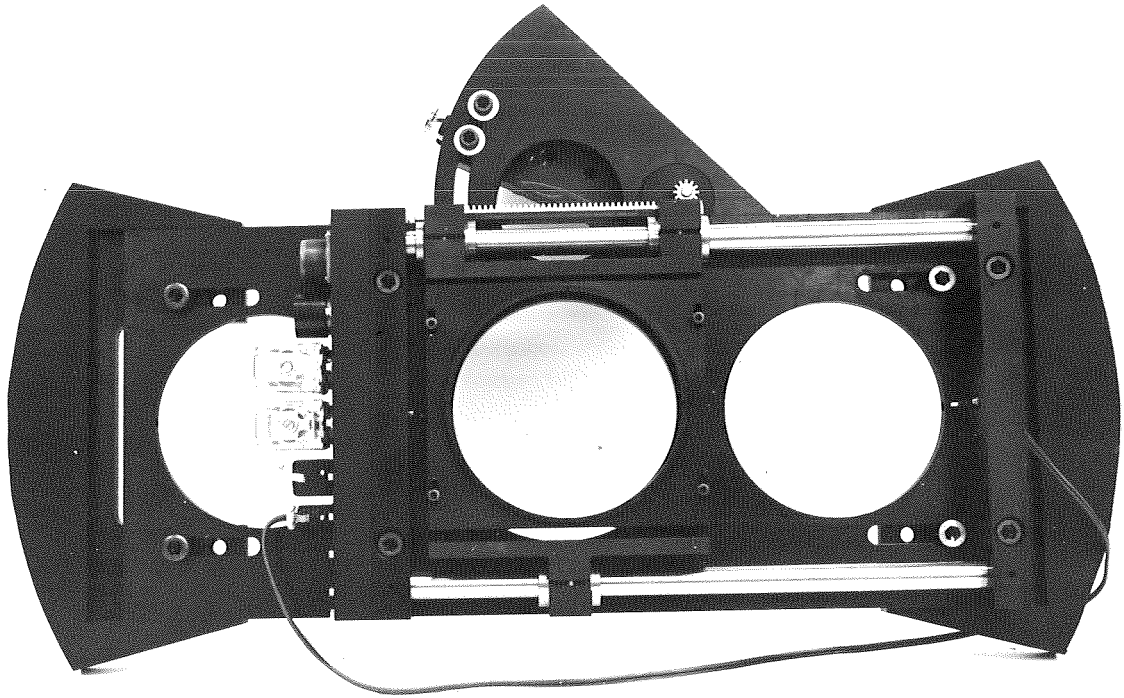


International Planetary Patrol Program

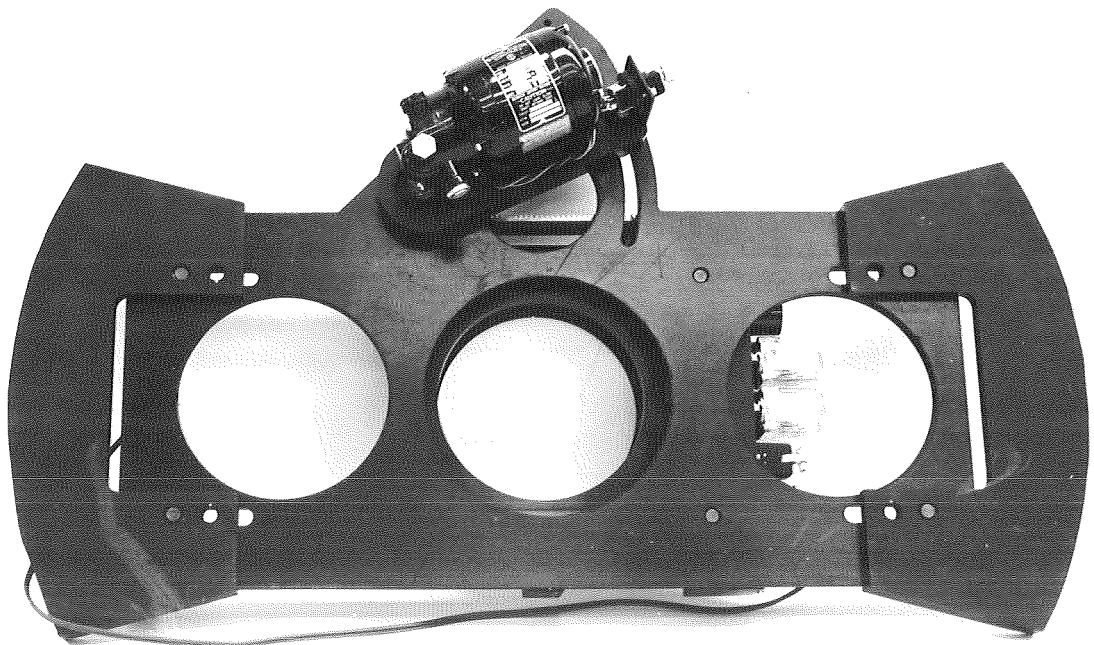
Lowell Observatory  
Flagstaff Arizona

Figure 1.

COLOR CORRECTOR  
MOUNTING ASSEMBLY



FRONT



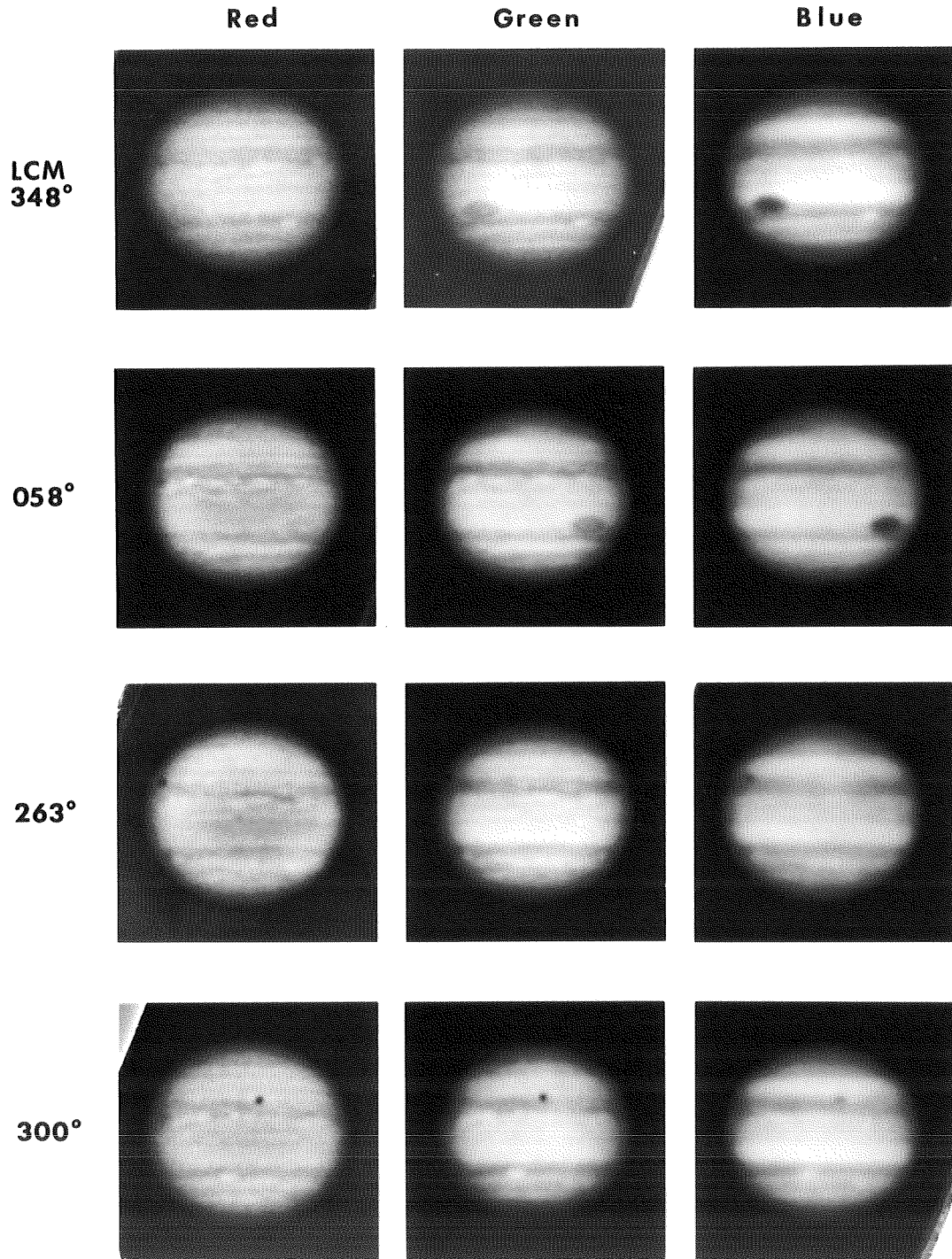
BACK

Figure 2 .



# JUPITER - 1970

Observations from Lowell Observatory, Flagstaff, Arizona

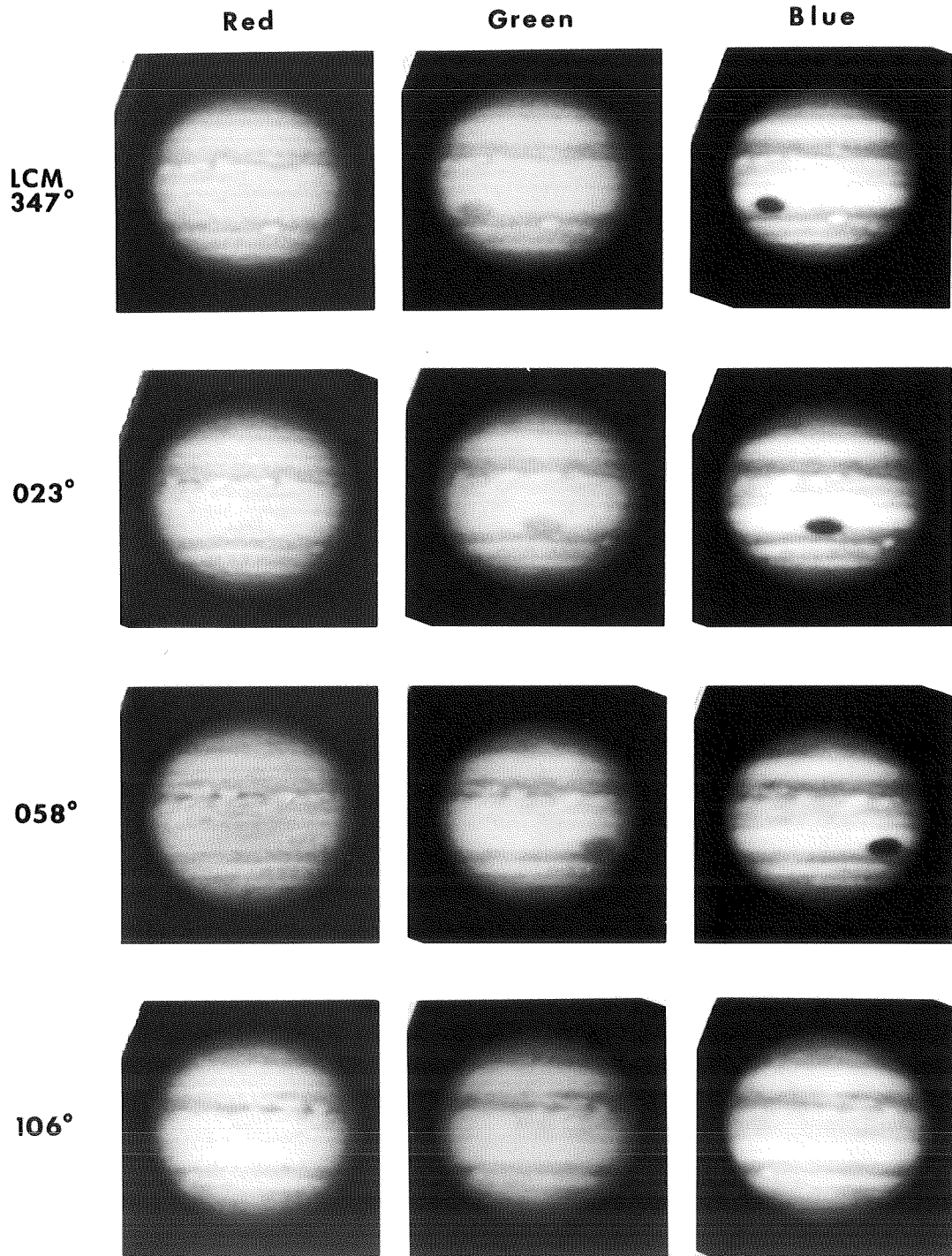


International Planetary Patrol Program  
Lowell Observatory  
Flagstaff, Arizona

Figure 3.

# JUPITER - 1970

Observations from Mauna Kea Observatory, Hawaii

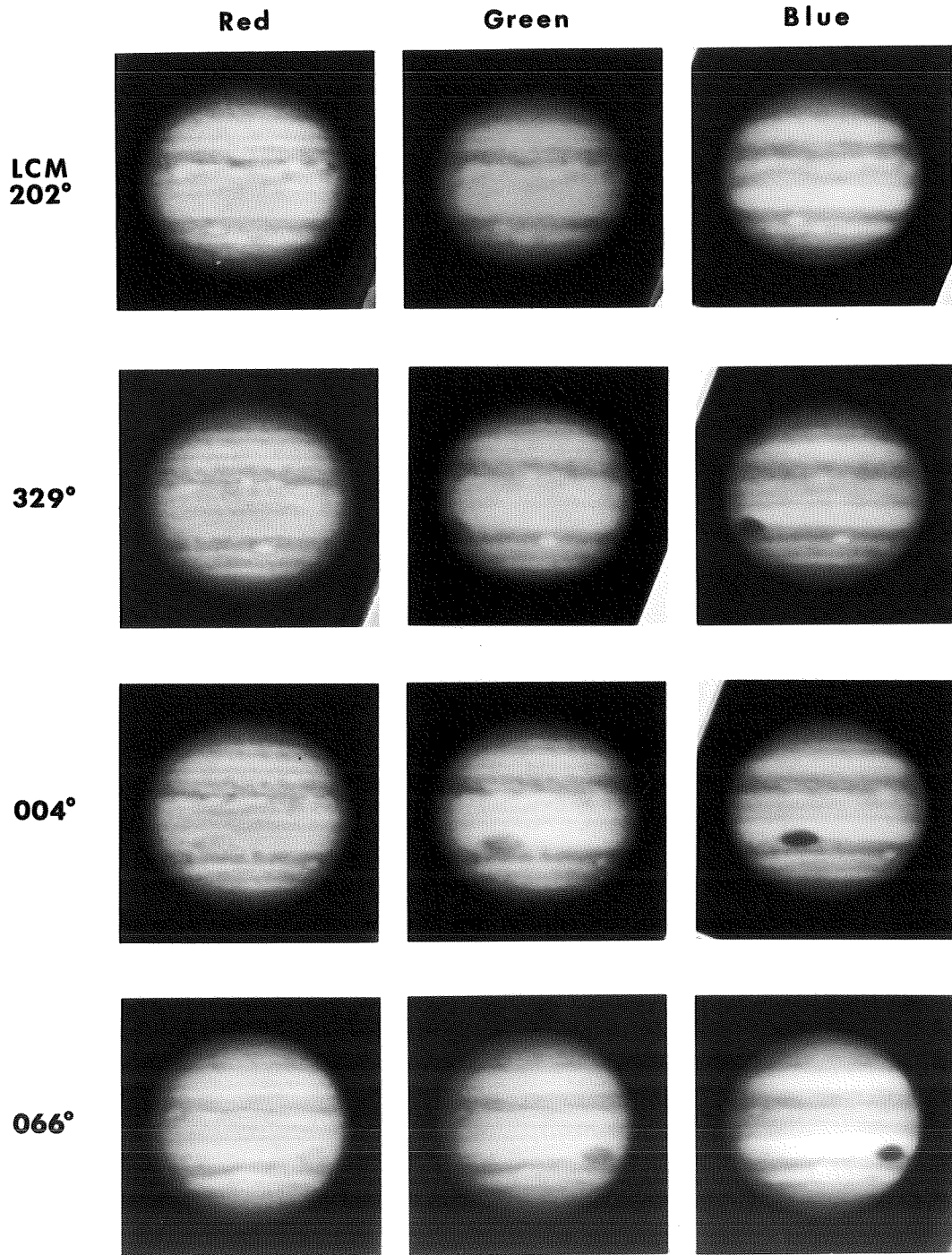


International Planetary Patrol Program  
Lowell Observatory  
Flagstaff, Arizona

Figure 4.

# JUPITER - 1970

Observations from Mt. Stromlo Observatory, Australia

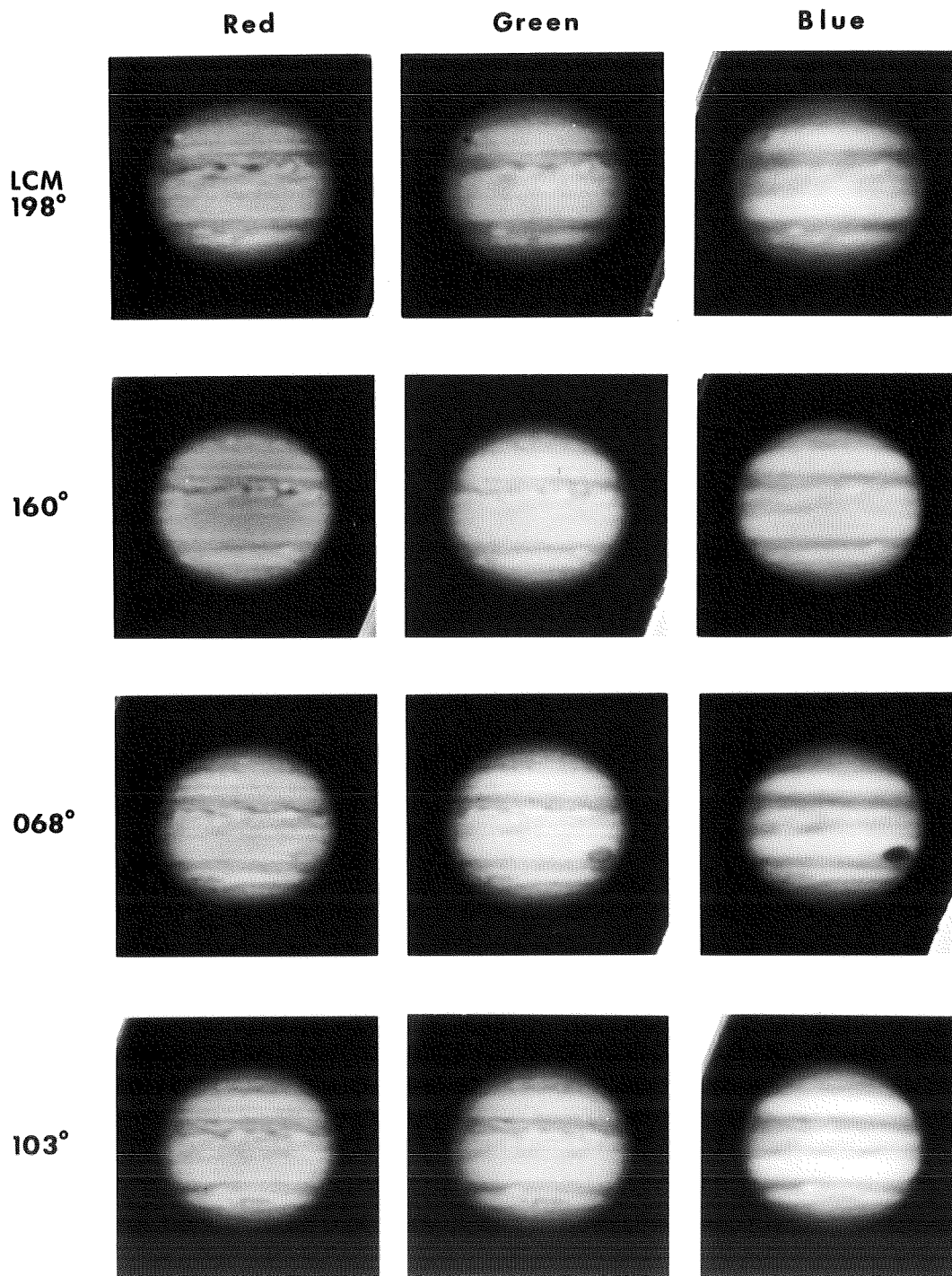


International Planetary Patrol Program  
Lowell Observatory  
Flagstaff, Arizona

Figure 5.

# JUPITER - 1970

Observations from Republic Observatory, South Africa

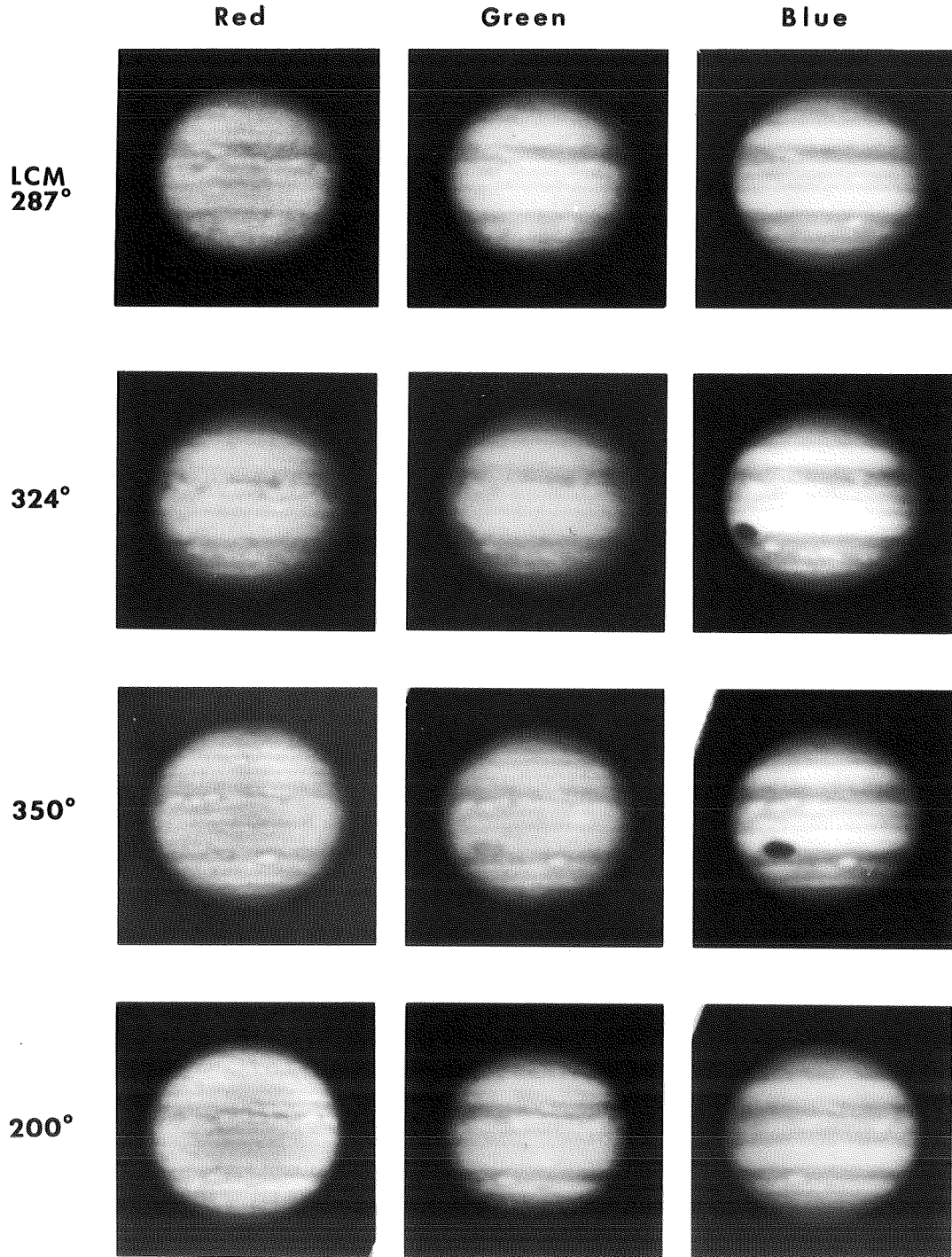


International Planetary Patrol Program  
Lowell Observatory  
Flagstaff, Arizona

Figure 6.

# JUPITER - 1970

Observations from Cerro Tololo Observatory, Chile



International Planetary Patrol Program

Lowell Observatory

Flagstaff, Arizona

Figure 7.