NEW MEXICO STATE UNIVERSITY
LAS CRUCES, NEW MEXICO 88001
AREA 505 646-2614

Observatory

JUPITER'S RED SPOT IN 1968-1969

E. J. Reese

The Observatory*

New Mexico State University

Las Cruces, New Mexico 88001

October 1969

*TN-701-70-31 Supported in part by NASA Grants NGL-32-003-001 and NGR-32-003-027

JUPITER'S RED SPOT IN 1968-1969

E. J. Reese

The Observatory
New Mexico State University
Las Cruces, New Mexico 88001

ABSTRACT

Photographic observations of Jupiter's Red Spot between 14 October 1968 and 24 August 1969 are reported. The Red Spot regained all of the darkness and area that it had exhibited from 1961 to early 1966. A 3-month oscillation in longitude was observed for the sixth consecutive apparition. A series of dark streaks apparently were emitted from the preceding tip of the Red Spot, and advanced from that feature at the rate of 17 m/sec. Two dark spots on the north edge of the South Temperate Belt encountered the Red Spot and underwent accelerations which were an order of magnitude greater than the greatest acceleration previously observed in the atmosphere of Jupiter.

INTRODUCTION

The Red Spot was very dark and well-defined during the apparition, having regained the darkness and area that it had exhibited from 1961 to early 1966 (Fig. 1). The latitude and longitude of the Red Spot were measured from photographic plates taken on 83 dates between 14 October 1968 and 24 August 1969. The results of this measuring program, as well as activity associated with the Red Spot, will be discussed.

METHOD

The procedure used for measuring the position of the Red Spot was basically the same as that described in previous reports (Reese and Solberg, 1966; Solberg, 1968). Six to nine images per plate were measured for longitude; four images for latitude. A first order correction for phase exaggeration of 0.08 times the phase angle* was applied to all longitude measurements. This correction has been determined by measuring the position of Satellite I near inferior geocentric conjunction (Smith and Reese, 1968).

All measurements were obtained from blue sensitive photographic plates, using a 61-cm Cassegrain reflector at its 46-m, all mirror focus. The average probable error was ±0°.10 for both longitude and latitude measurements; this is equivalent to a measuring error of about 9 microns on the Mann measuring machine.

POSITION OF THE RED SPOT

During 1968-69, the center of the Red Spot decreased irregularly in System II longitude from 25°.4 to 21°.2 as illustrated in Fig. 2. In Table I the drift in longitude has been divided into a number of essentially linear sections, from which rotation periods were calculated by the method of least squares.

The zenographic latitude of the center of the Red Spot oscillated slightly between -22°.0 and -22°.5 during the apparition (Fig. 3), and had a mean value of -22°.25 ±0°.03.

DIMENSIONS OF THE RED SPOT

The length of the Red Spot increased from about 22° to 25° during the early months of the apparition (Fig. 4), and had a mean

* The phase angle is considered positive before opposition, negative after opposition.

value of 24°.2 or 28,200 km. The width also increased during the early part of the apparition (Fig. 5), and had a mean value of 12°.24 ±0°.09 or 13,700 km. Table II summarizes the changing dimensions of the Red Spot during 1968-69. Between 1878 and 1888 when the maximum size of the Red Spot was attained, the length was 38,500 km., the width was 13,800 km., and the area was 417 million square kilometers.

THREE-MONTH OSCILLATION IN LONGITUDE

The three-month oscillation in the longitude of the Red Spot, which was discovered by Solberg (1968), was observed for the sixth consecutive apparition. A least squares analysis of all the data from 1963 to 1969 gives the oscillation a period of 89.9 ±0.2 days and an amplitude of 0°.8. Observed maxima and minima during that interval are given in Table III.

EMISSION OF DARK MATERIAL FROM THE RED SPOT

A series of dark streaks apparently were emitted from the preceding tip of the Red Spot at zenographic latitude -22°.6 (Fig. 6). These streaks moved away from the Red Spot in the direction of rotation at an average rate of -1°.27 of longitude per day or 17.0 m/sec (Fig. 7). As they moved away from the Red Spot, the streaks were diverted southward across the South Tropical Zone and finally formed a very delicate belt at latitude -24°.6 which was very near the north edge of the South Temperate Belt. This may be the first time that motion relative to the Red Spot has been observed in the dark belt-like appendage which is on rare occasions attached to the preceding tip of the Red Spot. The compatibility of this motion with the previously observed vortical nature of the perimeter of the Red Spot (Reese and Smith, 1968) poses an interesting problem.

DARK SPOTS ACCELERATED BY RED SPOT VORTEX

A number of rapidly moving dark spots were observed on the north edge of the South Temperate Belt during the apparition (Fig. 7). These spots formed in a region about 50° preceding the Red Spot and moved in the direction of rotation with a fairly constant rate of about -3°.93 of longitude per day or 51.5 m/sec relative to System II until reaching longitude (II) 100°. From then on the spots behaved quite independently of each other as they approached the following end of the Red Spot. Two of the better observed spots (numbers 2 and 4 in Figs. 7 and 8) acquired a constant deceleration of 1.13×10^{-5} m/sec^2 and slowed down to velocities of -26 and -14 m/sec respectively just before reaching the following end of the Red Spot vortex. As the spots entered the vortex, they underwent the greatest acceleration** that we have ever observed in a Jovian spot, and then proceeded across the south edge of the Red Spot with a velocity of 72.8 m/sec relative to System II or 72.6 m/sec relative to the center of the Red Spot. This agrees well with the velocity of 71.5 m/sec observed along the south edge of the Red Spot vortex in 1966 and 1967. However, unlike the dark spot A in January 1966 (Reese and Smith, 1968), the two recent spots left the edge of the Red Spot and continued along the north edge of the South Temperate Belt after passing the longitude of the preceding end of the Red Spot. The spots decelerated again to a velocity of about 36 m/sec and finally faded away about 40° preceding the Red Spot, near the longitude where they apparently had originated some 100 days previously.

** The actual value of this acceleration is dependent upon the time interval over which the change in velocity took place. It seems unlikely that the interval was much greater than one day, and it could have been considerably less. Assuming an interval of one day, the acceleration was 3.1×10^{-4} m/sec^2 for spot 2 and 7.4×10^{-4} m/sec^2 for spot 4.

A change in the velocity of a dark spot on the north edge of the South Temperate Belt was usually accompanied by a small change in the latitude of that spot. After passing longitude (II) 100°, spots 2 and 4 gradually drifted northward from -26°.4 to -25°.0 just before entering the Red Spot vortex. Spots 9 and 10, which underwent very little deceleration as they approached the following end of the Red Spot, remained fixed at latitude -26°.4 until they were lost shortly after entering the Red Spot vortex. The difference in behavior of the spots as they approached the Red Spot suggests widespread variations in the circulatory pattern of the Jovian atmosphere at this latitude.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to H. G. Solberg, Jr. for measuring many of the photographic plates. He is also indebted to R. L. Fritz and R. B. Minton for their excellent work in producing composite images of Jupiter, and to Mrs. E. M. Ingraham for her work in preparing some of the figures. The work reported here was supported by the National Aeronautics and Space Administration under Grants NGL-32-003-001 and NGR-32-003-027.

REFERENCES

Reese, E. J., and Solberg, H. G. (1966). Recent measures of the latitude and longitude of Jupiter's Red Spot. Icarus 5, 248-257.

Reese, E. J., and Smith, B. A. (1968). Evidence of vorticity in the great Red Spot of Jupiter. Icarus 9, 474-486.

Smith, B. A., and Reese, E. J. (1968). Observations of Io at inferior geocentric conjunction. Contributions of the Observatory, New Mexico State University, Vol. 1, No. 2, 66-69.

Solberg, H. G. (1969). A three-month oscillation in the longitude of Jupiter's Red Spot. Planet. Space Sci., 17, 1573-1580.

TABLE I

ROTATION RATES OF THE RED SPOT, 1968-69

	Limiting Dates	Limiting Longitudes	Drift °/day	Std. Dev.	Rotation Period 9^h55^m+	Std. Dev.	Number of Plates
1968	14 Oct - 27 Nov	25°.4 - 24°.0	-0°.0310	±0°.0250	$39^s.4$	$\pm1^s.0$	7
	27 Nov - 9 Jan	24.0 - 24.8	+0.0183	±0.0101	41.4	±0.4	9
1969	9 Jan - 4 Feb	24.8 - 22.7	-0.0790	±0.0227	37.4	±0.9	11
	4 Feb - 11 Apr	22.7 - 23.9	+0.0180	±0.0050	41.4	±0.2	21
	11 Apr - 6 May	23.9 - 21.9	-0.0773	±0.0159	37.5	±0.6	12
	6 May - 5 Jun	21.9 - 22.8	+0.0263	±0.0075	41.7	±0.3	9
	5 Jun - 24 Aug	22.8 - 21.2	-0.0192	±0.0023	39.8	±0.1	14
Mean During Apparition	14 Oct 68-24 Aug 69	25.4 - 21.2	-0.0132	±0.0020	40.1	±0.1	83
Mean Between Successive Oppositions	20 Feb 68-21 Mar 69	26.2 - 23.6	-0.0066		40.4		

TABLE II

DIMENSIONS OF THE RED SPOT, 1968-69

Months	Mean Length λ	Mean Length km	Mean Width β"	Mean Width km	Mean Area Square degrees	Mean Area Millions sq. kms.
Oct - Nov	22°.09	25,700	10°.87	12,100	188.6	245.20
Dec - Jan	22.88	26,700	11.52	12,900	207.0	269.14
Feb - Mar	24.84	28,900	12.45	13,900	242.9	315.79
Apr - May	24.74	28,800	12.48	13,900	242.5	315.29
Jun - Aug	24.61	28,700	12.40	13,800	239.7	311.61
Mean	24.22	28,200	12.24	13,700	232.8	302.72

TABLE III

MAXIMA AND MINIMA OF RED SPOT'S OSCILLATION IN LONGITUDE

(Add 2,400,000 to Julian Date)

Event Number	Calendar Date	Julian Date	$\Delta\lambda$
1	27 Sep 63	38300	-0°.8
2	24 Oct 63	38327	+0.6
3	24 Dec 63	38388	-1.1
4	1 Feb 64	38427	+0.6
8	1 Aug 64	38609	+0.4
9	28 Aug 64	38636	-0.4
10	15 Oct 64	38684	+0.4
11	1 Dec 64	38731	-0.5
12	22 Jan 65	38783	+0.6
13	27 Feb 65	38819	-0.7
16	6 Aug 65	38979	+0.9
17	10 Sep 65	39014	-0.8
18	23 Oct 65	39057	+0.2
19	30 Nov 65	39095	-0.9
20	24 Jan 66	39150	+0.7
21	2 Mar 66	39187	-0.6
22	12 Apr 66	39228	+0.9
26	24 Sep 66	39393	+0.9
27	30 Nov 66	39460	-0.6
28	7 Jan 67	39498	+1.3
29	5 Mar 67	39555	-1.2
30	22 Apr 67	39603	+1.2
34	31 Oct 67	39795	+0.4
35	26 Nov 67	39821	-1.0
36	13 Jan 68	39869	+2.5
37	21 Feb 68	39908	-1.2
38	17 Mar 68	39933	+1.0
39	24 May 68	40001	-0.9
43	21 Nov 68	40182	-0.4
44	13 Jan 69	40235	+0.6
45	11 Feb 69	40264	-0.9
46	8 Apr 69	40320	+0.8
47	8 May 69	40350	-0.5
48	15 Jun 69	40388	+0.4

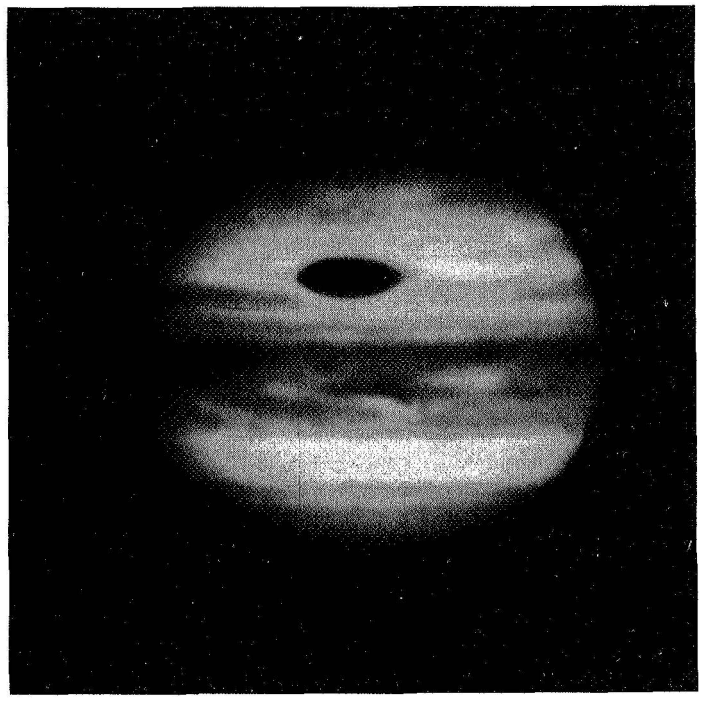

Fig. 1 Jupiter in blue light, 13 January 1969, 1216 UT, showing a dark belt-like appendage attached to the preceding tip of the Red Spot. This photograph was taken by R. B. Minton with the 61-cm. reflector at the NMSU Observatory. South at top.

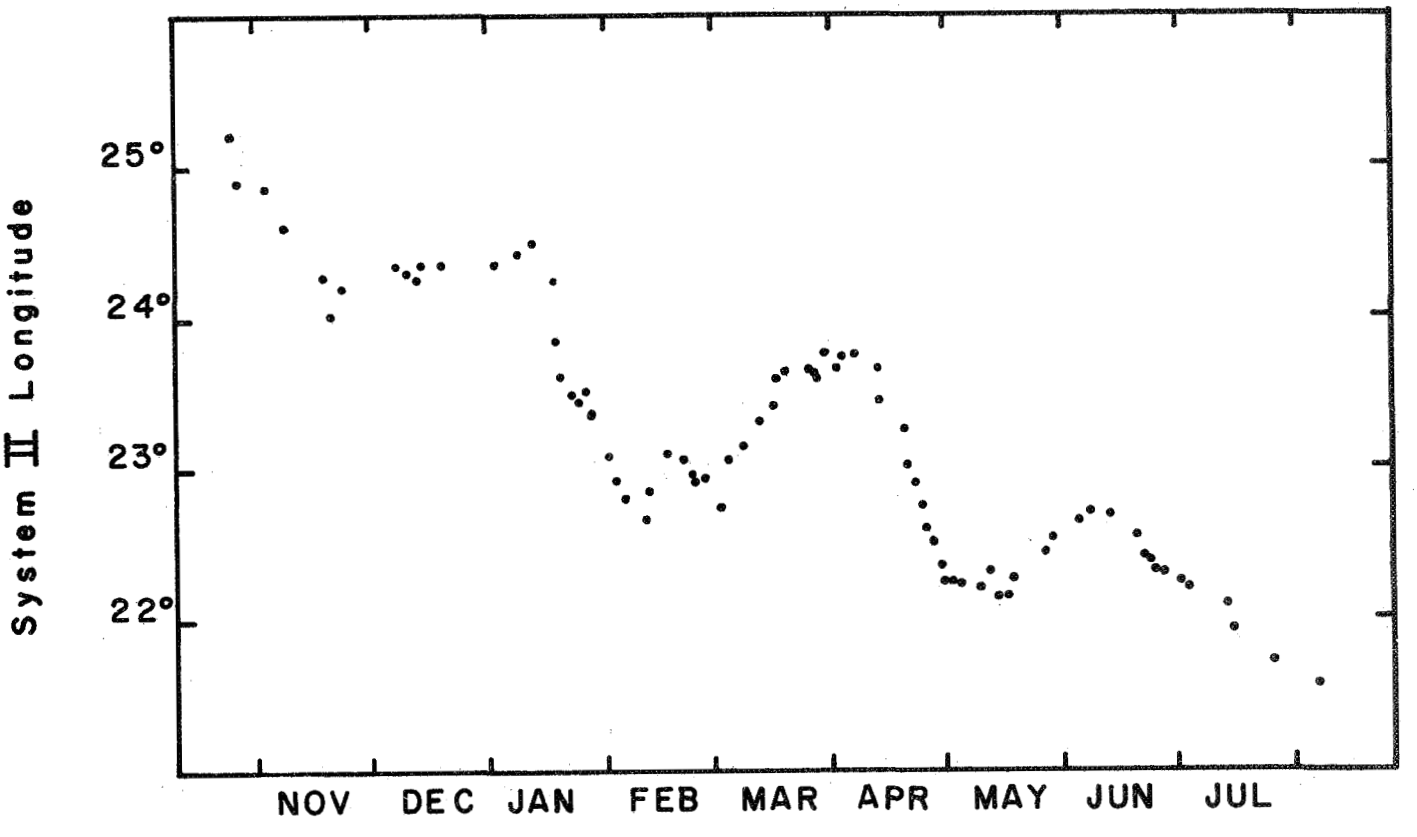

Fig. 2 Longitude of Red Spot, 1968-69; five-plate means.

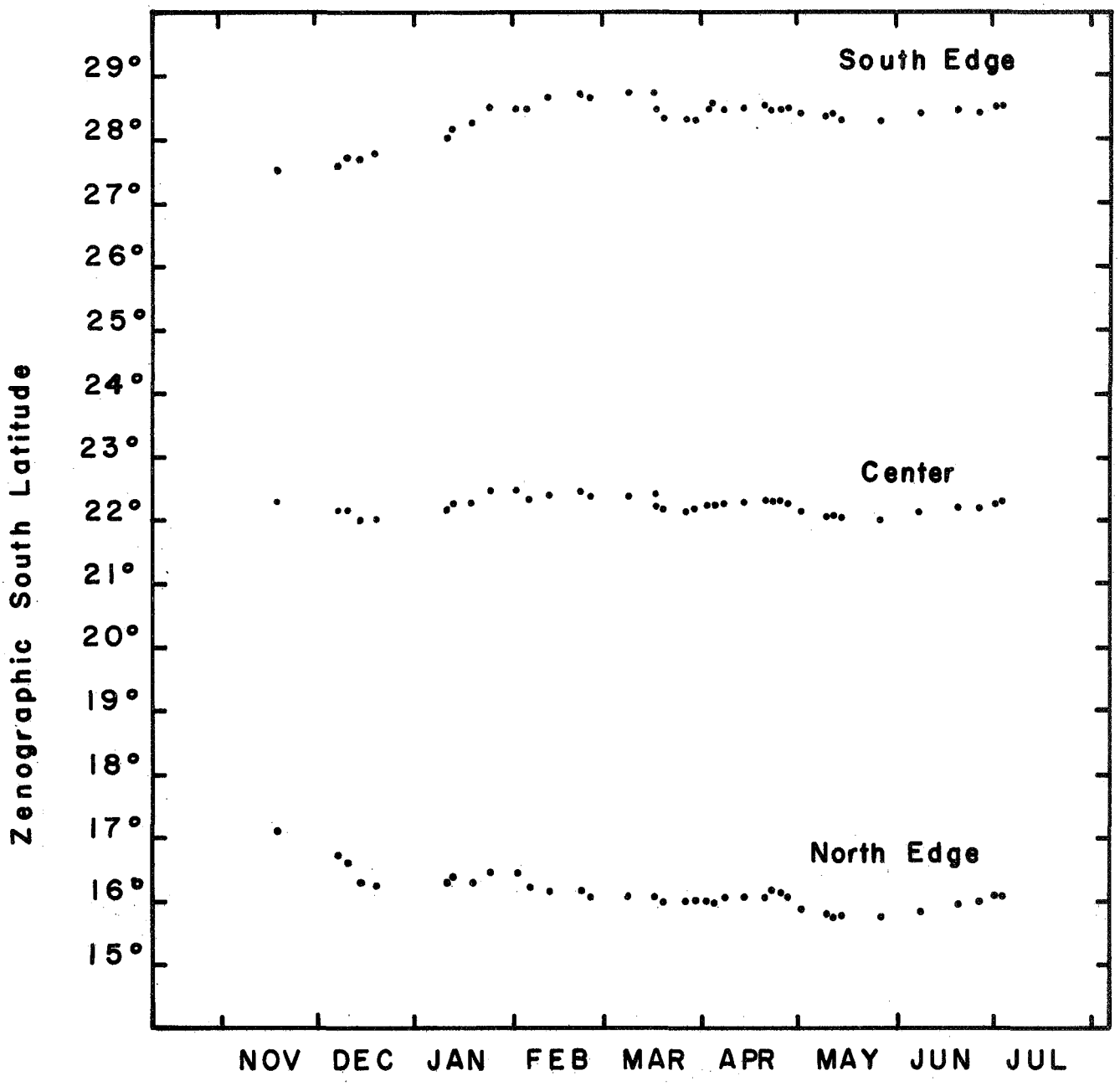

Fig. 3 Latitude of Red Spot, 1968-69; five-plate means.

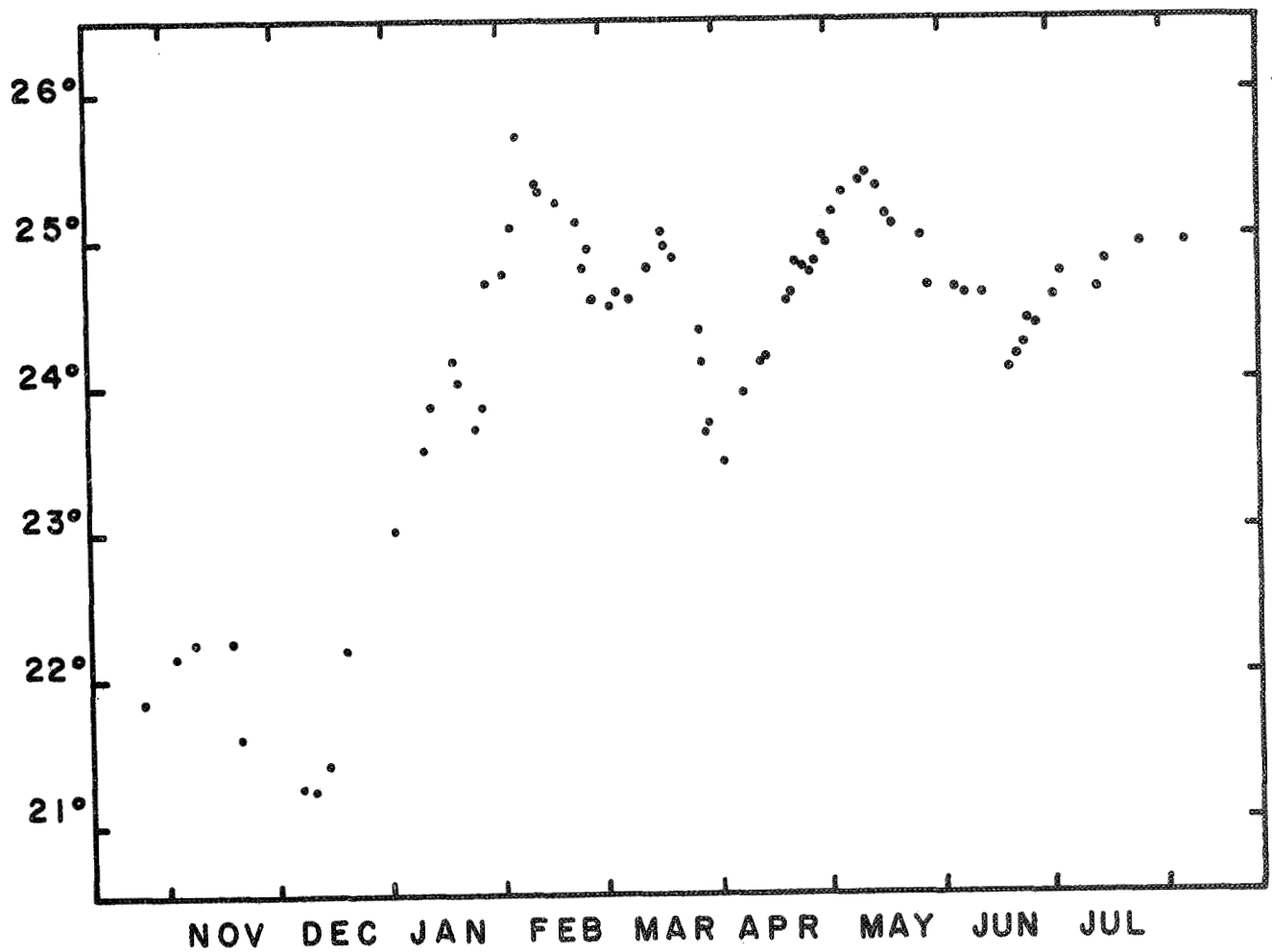

Fig. 4 Length of Red Spot, 1968-69; five-plate means.

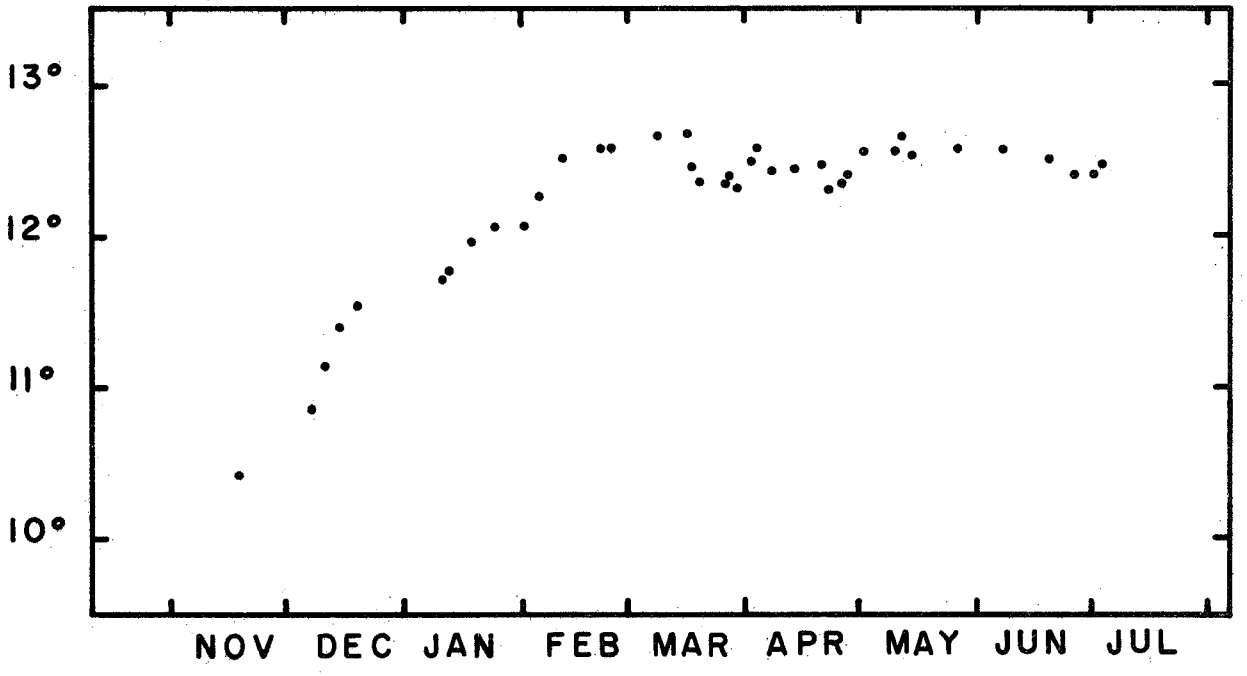

Fig. 5 Width of Red Spot, 1968-69; five-plate means.

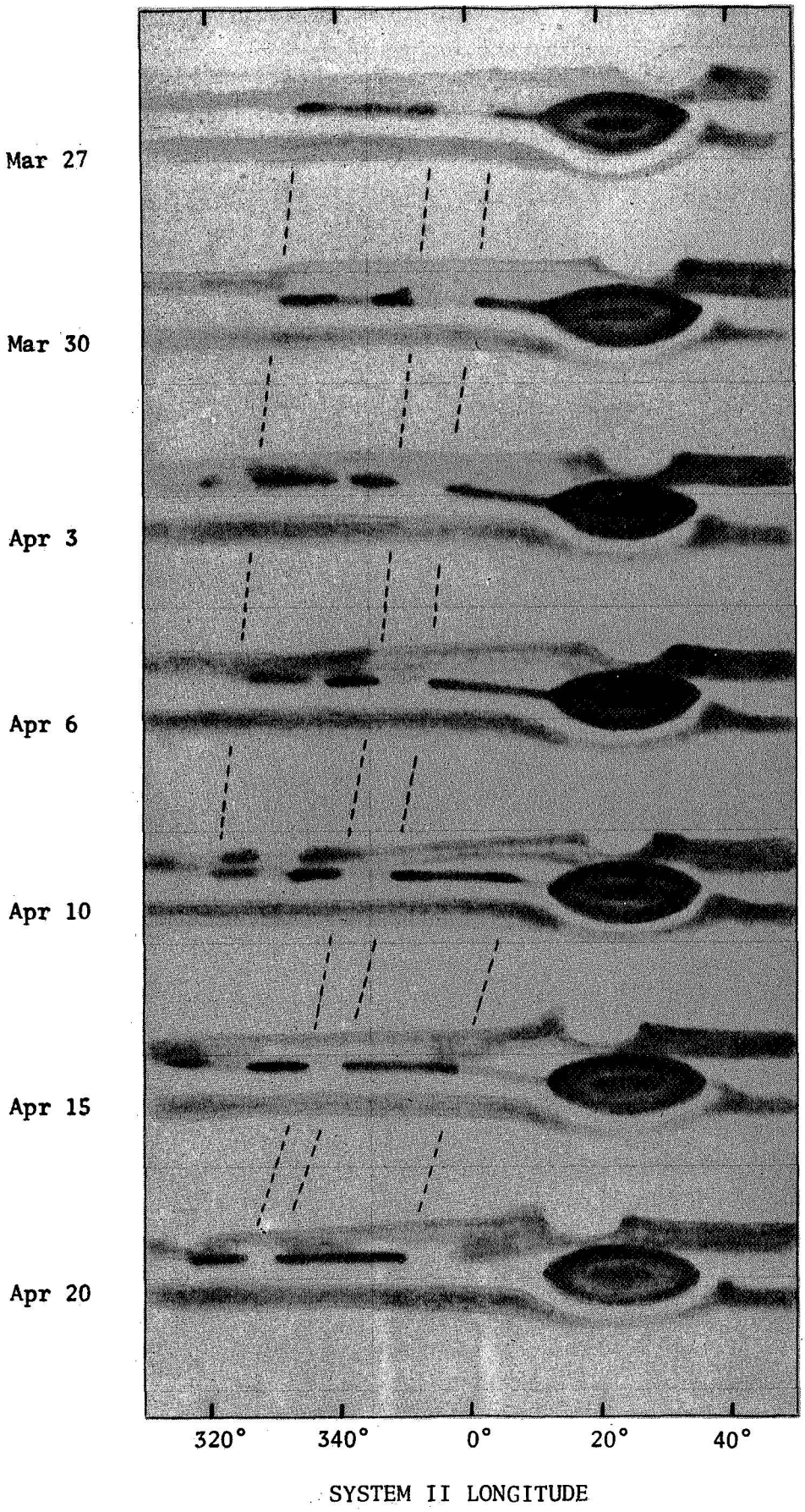

Fig. 6 Sketches of Jupiter's Red Spot and vicinity in 1969 made from photographs taken in blue light showing the apparent emergence of a dark streak from the preceding end of the Red Spot.

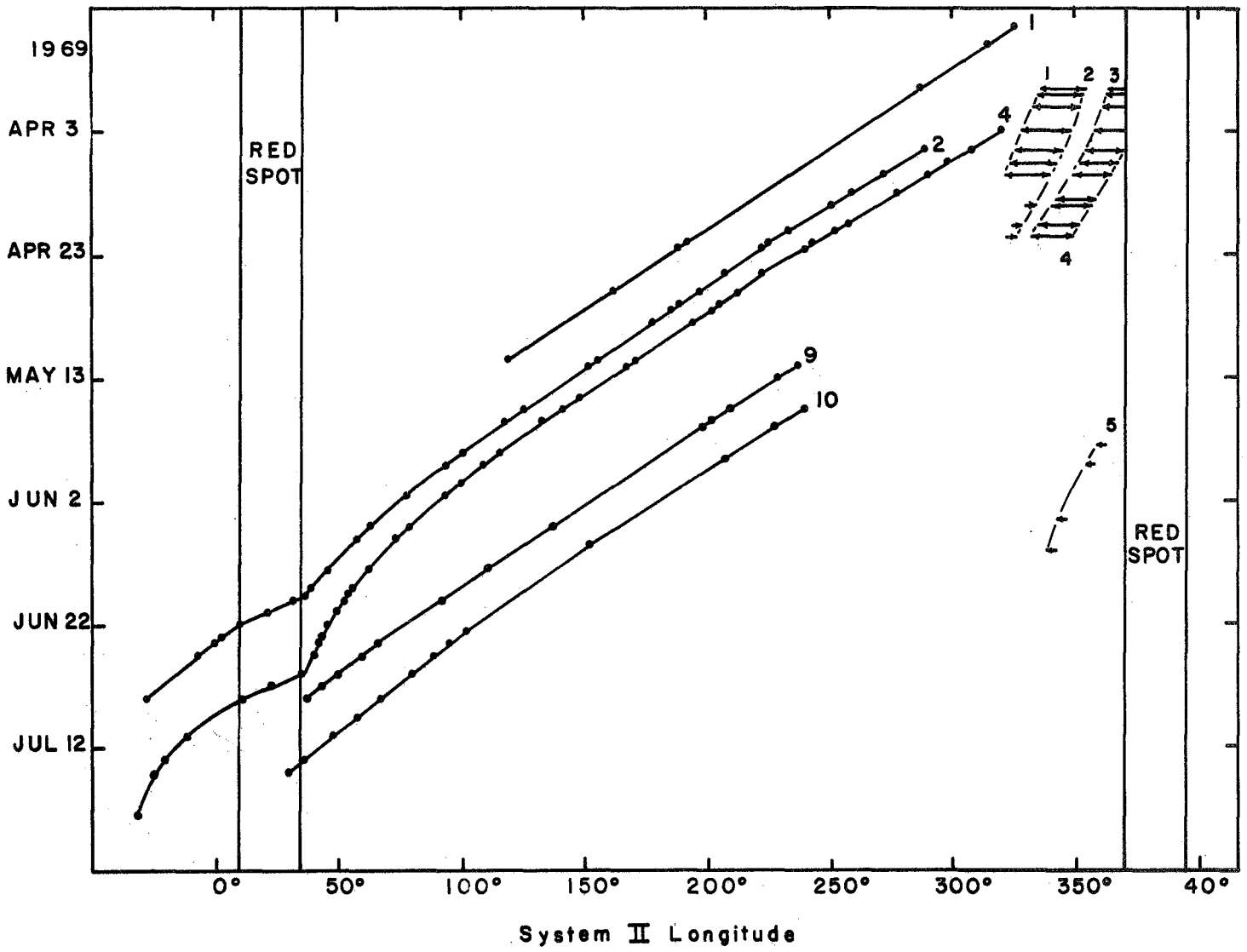

Fig. 7 Rapidly moving spots in Jupiter's South Tropical Zone, 1968-69. The round dots represent dark spots on the north edge of the South Temperate Belt, while the arrows represent dark streaks near the preceding end of the Red Spot.

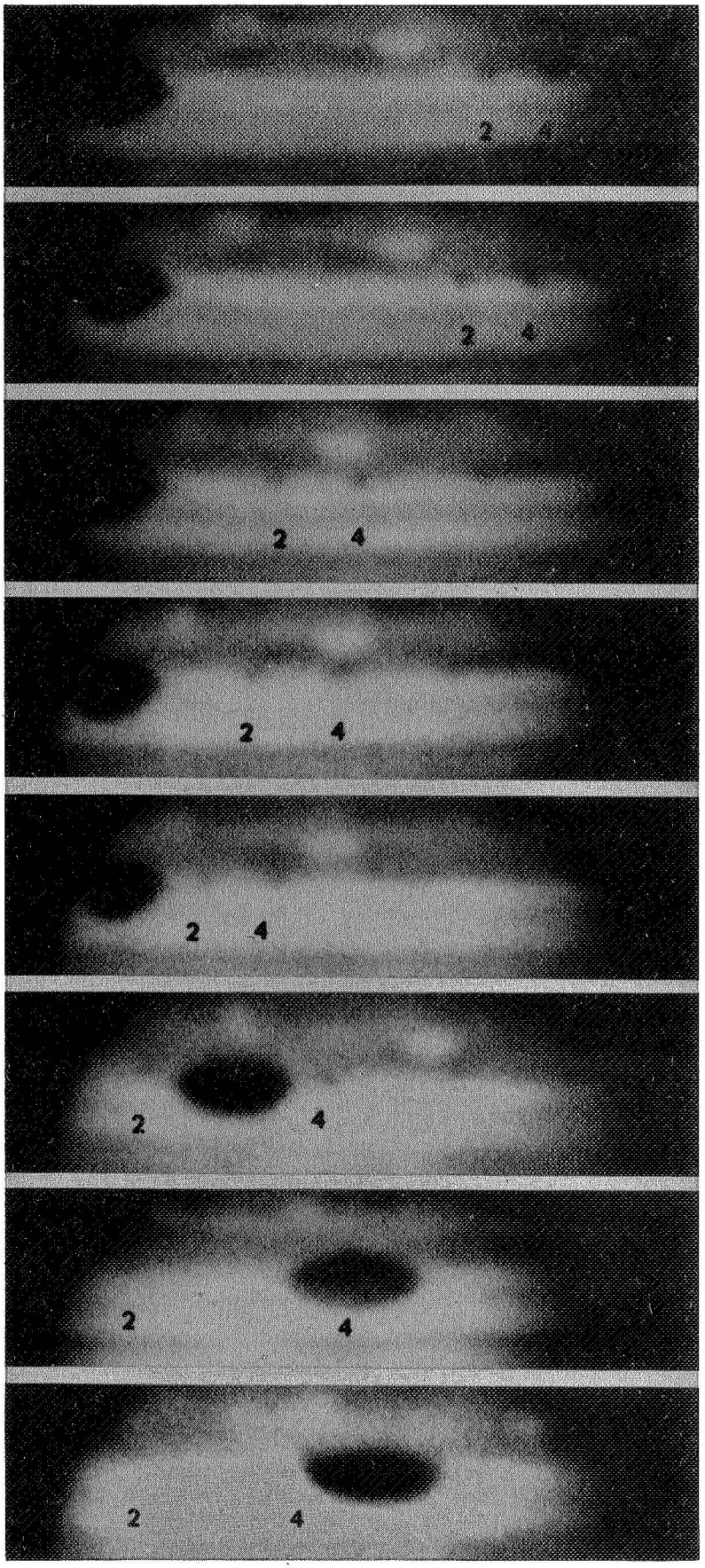

Fig. 8 Photographs of Jupiter in 1969 showing dark spots 2 and 4 on the north edge of the South Temperate Belt approaching and passing the Red Spot. These photographs were taken by R. B. Minton, C. F. Knuckles, and T. B. Kirby with the 61-cm. reflector at the NMSU Observatory.