SPACE SCIENCES LABORATORY

MAGNETIC FIELD VARIATIONS IN INTERPLANETARY SPACE

John M. Wilcox

Series 10, Issue 39
August 26, 1969

UNIVERSITY OF CALIFORNIA, BERKELEY

MAGNETIC FIELD VARIATIONS IN INTERPLANETARY SPACE

John M. Wilcox

Technical Report

ONR Contract Nonr 3656(26), Project NR 021 101,
NASA Grant NGR 05-003-230 and NSF Grant GA-1319

Magnetic Field Variations in Interplanetary Space*

John M. Wilcox

Space Sciences Laboratory

University of California

Berkeley, California

Abstract. Magnetic field variations and structures in interplanetary space are described and related to the sun. Discrete flare-related effects in the interplanetary medium occur within a large-scale interplanetary sector pattern related to a solar sector pattern that is ordered over a large extent in heliographic latitude and longitude. A random walk transport of photospheric field lines slightly modifies the over-all ordered pattern, but sector boundaries appear to resist the random walk process. There is a delay of approximately one solar rotation between appearance of an active region and its possible effect on the interplanetary sector pattern. A flare occurrence is most probable near a solar sector boundary.

In an earlier paper at this Symposium Hundhausen (1969) has already discussed the magnetic variations incident to interplanetary shock waves, so as to describe these structures completely in terms of both plasma and field variations. Solar wind disturbances associated with flares have also

*Invited paper delivered at Third ESLAB/ESRIN Symposium, Intercorrelated Satellite Observations Related to Solar Events, Noordwijk, Holland, September 1969.

recently been reviewed by Wilcox (1969). The present discussion therefore gives a broader view of the configuration of the interplanetary magnetic field and its relation to the sun.

We may first observe that the sector structure of the interplanetary magnetic field has persisted up to the most recent observations, as shown in Figure 1. For several consecutive days the interplanetary field will be varying about an average Archimedes spiral directed away from the sun. Then at a sector boundary there is an abrupt change of direction to an average spiral field directed toward the sun for the next several days. It is within this large-scale sector pattern that the specific solar flare-related effects occur.

A recent investigation of the solar origin of the interplanetary field has utilized observations at the Crimean Astrophysical Observatory by Severny (1969) of the mean photospheric magnetic field. In these observations Severny simply admits sunlight to the solar magnetograph and observes the resulting Zeeman splitting. In this observation each area of the visible solar disk has equal weight in proportion to its brightness. A comparison of this mean photospheric field with the direction of the interplanetary magnetic field is shown in Figure 2, after Wilcox et al. (1969). A very close correspondence between these two magnetic fields can be observed in Figure 2. The interplanetary observations have been adjusted to allow for an average 5-day transit time of solar wind plasma from sun to earth, as has been previously observed (Wilcox, 1968).

This agreement between solar and interplanetary fields could exist only if the solar source of the interplanetary magnetic field was part of a field pattern that was ordered over an appreciable portion of the solar disk. (If the solar pattern that was the source of the interplanetary field existed only over a small range of latitudes this pattern would contribute only a small part of Severny's observations, and would not control the time of polarity reversals.) Such a large-scale solar sector pattern has been proposed by Wilcox and Howard (1968) and by Schatten et al. (1969). Figure 3 shows the position of a solar sector boundary as a function of heliographic latitude observed by Schatten et al. (1969). The weak large-scale photospheric magnetic field has the same predominant polarity over a wide range of latitudes on both sides of the solar equator, and the predominant polarity changes at the sector boundary as shown in Figure 3.

The large-scale configuration in longitude of the solar sector magnetic field may be similar to that shown in Figure 4, after Wilcox (1968). The large-scale pattern of the solar field may be modified by a random walk process recently proposed by Jokipii and Parker (1969). Consider the bundle of magnetic field lines associated with a small element of solar wind plasma during its four or five day transit time from the sun to the earth. This bundle of field lines will not remain fixed on the sun in the small element of area from which this solar wind plasma left the sun, but rather the field lines will be dispersed in the photosphere by a random walk process associated with the supergranulation as first described by Leighton (1964). A schematic of this process is shown in Figure 5. During the transit time of an element of solar wind plasma from the sun to the earth the field lines that originally passed through this element in the photosphere will be dispersed in a Gaussian pattern having a 1/e width that corresponds to the amount of solar rotation in approximately two days. Fan et al. (1968) have observed the intensity of 0.6-13 Mev protons in the interplanetary medium near the earth. Often such protons are present in a stream lasting for several days as the interplanetary magnetic field pattern corotates with the sun past the earth. Figure 6 shows the intensity of one of these streams observed during April 1966. If we assume that these protons were accelerated in a localized active region, the agreement of these observations with the Gaussian curve having a 1/e width of 2.5 days is consistent with the mechanism proposed by Jokipii and Parker.

Figure 7 shows another of the Mev interplanetary proton streams observed by Fan _et al_. (1968). Notice that the ordinate in this figure is logarithmic, as compared with the linear ordinate shown in Figure 6. The spikes in the intensity of protons 13-70 Mev labeled (a)-(h) denote discrete flare and shock-wave events. The physical interpretation of Figure 7 (see also Wilcox and Schatten, 1969) is that the envelope of the proton stream observed at 0.6-13 Mev is caused by protons more or less continually accelerated at an active region by sub-flare processes that have followed interplanetary field lines dispersed by the Jokipii-Parker process into the wide longitudinal section of the interplanetary medium. Protons accelerated in the flares (a)-(h) at the active region were able to almost immediately reach the interplanetary medium near the earth by traveling along the field lines dispersed by the Jokipii-Parker process.

A magnetic sector boundary was observed on March 31, 1966. Notice that this appears to mark the division between two proton streams shown in Figure 7. Fan _et al_. (1968) conclude that an interplanetary magnetic sector may occupy most but not necessarily all of the region associated with the proton fluxes. Further evidence of the relation between a sector boundary and energetic proton fluxes is shown in Figure 8, which shows observations by McCracken _et al_. (1968) of the temporal dependence of the flux of 7.5-45 Mev interplanetary protons, of the azimuth of the interplanetary magnetic field, and of the cosmic-ray anisotropy. The marked change of cosmic-ray anisotropy at the sector boundary is evident. Notice that the flux of energetic protons has an abrupt decrease approximately $2\frac{1}{2}$ hours after the sector boundary has passed.

Lanzerotti (1969) has also observed changes in energetic proton fluxes related to a magnetic sector boundary.

It appears that a sector boundary may be an exception to the magnetic random walk process proposed by Jokipii and Parker. The persistence of a given sector boundary essentially unchanged for a year or more would not appear to be consistent with a diffusion of field lines caused by the random walk process. The energetic proton observations discussed above also indicate that the random walk process does not produce field lines crossing sector boundaries. The termination of energetic interplanetary proton streams near but not necessarily at sector boundaries remains an unexplained problem. Diffusion might cause some spilling over of protons across a sector boundary, but presumably would not yield a sharp termination near but not at a sector boundary.

It seems reasonably well established that there tends to be a delay of approximately one solar rotation between the appearance of a magnetic feature in the photosphere and a corresponding change in the interplanetary sector pattern. A summary of an investigation by Schatten et al. (1968) of the influence of a solar active region on the interplanetary magnetic field is shown in Figure 9. Each column represents a solar rotation and each row represents a particular observation. The top row represents a portion of a map in the ecliptic plane of the interplanetary magnetic field, showing in rotation 1500 the appearance of a loop pattern convected outward by the solar wind. In the following rotation a new interplanetary sector appears, which increases in size in subsequent rotations. Development of a bipolar photospheric magnetic region and of plage and sunspot activity is shown in the third and fourth rows of Figure 9. The important point for the present discussion is shown in the fifth row, in which one can see that almost all of the flares associated with the active region occurred before the change in the interplanetary field that gave rise to a new sector. In other words the shock waves and accelerated particles associated with a flare tend to be sent out into the pre-existing large scale pattern of the interplanetary magnetic field. This effect has also been observed on a statistical basis during nine solar rotations by Schatten et al. (1968)

Bumba and Obridko (1969) have shown that flare activity and especially proton-flare activity is concentrated in the neighborhood closest to the solar sector boundaries. Figure 10 is a histogram of frequency distribution of the time differences between the central meridian passage of spot groups and that of the interplanetary magnetic field sector boundaries for the case of groups with flares of importance of 1+ or greater and with the number of flares equal to or greater than 10. About one half of the proton-flare region developments were accompanied in the interplanetary magnetic structure by fast and short lived changes of polarity around the boundary of sectors.

In addition to the interplanetary shock wave events that have been discussed at this Symposium by Hundhausen (1969), interplanetary large-amplitude, aperiodic Alfvén waves propagating outward from the sun along the average magnetic field direction have been observed by Belcher et al. (1969). These waves appear to be present at least 30% of the time during five months of observations by Mariner 5 in 1967. Figure 11 shows plots of the radial component of the interplanetary magnetic field and of the solar wind velocity. A very detailed correlation of the nonsinusoidal fluctuations can be observed. Belcher et al. (1969) give a number of reasons for interpreting the observed fluctuations as Alfvén waves. In particular they observe a strong tendency for the fluctuations of the magnetic field to be normal to the average magnetic field. This is required for any superposition of Alfvén modes but not for the magneto-acoustic modes. Figure 12 shows the distribution of the angle between the field averaged over a 6 hour interval and the direction of minimum fluctuation of B during this interval, showing that the fluctuations are predominantly normal to the average field direction.

Power spectra of the interplanetary magnetic field have been obtained by Coleman (1966) with data from Mariner 2 in 1962, by Siscoe _et al_. (1968) with Mariner 4 data in 1964, and by Sari and Ness (1969) with Pioneer 6 data in 1966. The results are summarized in Figure 13. In the higher frequency range the spectral slope and magnitude are dominated by the presence of microstructural discontinuities on a scale less than 0.01 AU. The discrepancy between the various observations shown in Figure 13 is not understood, but could be related to a change with time (and with the solar cycle) of the microstructure of the interplanetary medium. The observed power spectra have been related to the theoretical determination of the cosmic ray diffusion coefficient by Jokipii (1966) and by Roelof (1966).

We may conclude by mentioning an interesting new technique for observing fluctuations in the interplanetary medium. Levy _et al_. (1969) have observed the Faraday rotation of the telemetry carrier signal from Pioneer 6 when it was occulted by the sun in the last half of November 1968. Figure 14 shows observations of polarization versus time when the line-of-sight distance from the sun was 6.2 solar radii. An increase in the electron content of the ionosphere could only cause an increase in polarization angle above 90°. In Figure 13 the base line is approximately 87°. The reason for this appears to be an increase in the steady-state plasma density and magnetic field as the line-of-sight approached the sun. These steady-state phenomena are now being analysed and compared with the interplanetary magnetic sector pattern.

The transient event is probably associated with a moving plasma concentration ejected by the sun. It appears to be associated with solar dekametric radio bursts. If this is correct the plasma velocity is of the order of several hundred km/sec.

In summary, it appears that discrete flare-related effects in the interplanetary medium occur within a large-scale interplanetary sector pattern related to a solar sector pattern that is ordered over a large extent in heliographic latitude and longitude. A random walk transport of photospheric field lines slightly modifies the over-all ordered pattern, but sector boundaries appear to resist the random walk process. There is a delay of approximately one solar rotation between appearance of an active region and its possible effect on the interplanetary sector pattern. A flare occurrence is most probable near a solar sector boundary.

Acknowledgement

This work was supported in part by the Office of Naval Research under Contract Nonr 3656(26), by the National Aeronautics and Space Administration under Grant NGR 05-003-230, and by the National Science Foundation under Grant GA-1319.

References

Belcher, J. W., Davis, L., Jr., and Smith, E. J.: 1969, J. Geophys. Res. 74, 2302.

Bumba, V. and Obridko, V. N.: 1969, Solar Phys. 6, 104.

Coleman, P. J., Jr.: 1966, J. Geophys. Res. 71, 5509.

Fan, C. Y., Pick, M., Pyle, R., Simpson, J. A. and Smith, D. R.: 1968, J. Geophys. Res. 73, 1555.

Hundhausen, A. J.: 1969, Third ESLAB/ESRIN Symposium, Intercorrelated Satellite Observations Related to Solar Events, Noordwijk, Holland.

Jokipii, J. R.: 1966, Astrophys. J. 146, 480.

Jokipii, J. R. and Parker, E. N.: 1969, Astrophys. J. 155, 777.

Lanzerotti, L. J.: 1969, J. Geophys. Res. 74, 2851.

Leighton, R. B.: 1964, Astrophys. J. 140, 1547.

Levy, G. S., Sato, T., Seidel, B. L., Stelzried, C. T., Ohlson, J. E. and Rusch, W. V. T.: 1969, submitted to Science.

McCracken, K. C., Rao, U. R. and Ness, N. F.: 1968, J. Geophys. Res. 73, 4159.

Roelof, E. C.: 1966, Ph.D. Thesis, University of California, Berkeley.

Sari, J. W. and Ness, N. F.: 1969, Solar Phys. 8, 155.

Schatten, K. H., Wilcox, J. M. and Ness, N. F.: 1968, Solar Phys. 5, 240.

Schatten, K. H., Wilcox, J. M. and Ness, N. F.: 1969, Solar Phys. 6, 442.

Severny, A.: 1969, Nature, in press.

Siscoe, G. L., Davis, L., Jr., Coleman, P. J., Jr., Smith, E. J., and Jones, D. E.: 1968, J. Geophys. Res. 73, 61.

Wilcox, J. M.: 1968, Space Sci. Rev. 8, 258.

Wilcox, J. M.: 1969, Solar Flares and Space Research, ed. by Z. Svestka and C. De Jager, North-Holland Publishing Co., Amsterdam.

Wilcox, J. M. and Colburn, D. S.: 1969, J. Geophys. Res. 74, 2388.

Wilcox, J. M. and Howard, R.: 1968, Solar Phys. 5, 564.

Wilcox, J. M., Severny, A. and Colburn, D. S.: 1969, submitted to Nature.

Wilcox, J. M. and Schatten, K. H.: 1969, J. Geophys. Res. 74, 2449.

Figure Captions

Figure 1. Observed sector structure of the interplanetary magnetic field, overlayed on the daily geomagnetic character index C9, as prepared by the Geophysikalisches Institut in Göttingen. Light shading indicates sectors with field predominantly away from the sun, and dark shading indicates sectors with field predominantly toward the sun. Diagonal bars indicate an assumed quasi-stationary structure during 1964 (Wilcox and Colburn, 1969).

Figure 2. (Top) Mean value of the solar magnetic field observed at the Crimean Astrophysical Observatory (dots) and polarity of the interplanetary magnetic field (bars), displaced to allow for a 5-day transit time for the solar wind plasma from the sun to the earth.

(Bottom) Contribution of sunspot magnetic fields to the mean solar field shown above. The polarity of the sunspot fields tends to be opposite to the polarity of the mean solar field and the interplanetary magnetic field. This suggests that sunspot fields are not directly related to the source of the interplanetary magnetic field (Wilcox et al., 1969).

Figure 3. The average position of a solar sector boundary during 1965 according to the analysis of Schatten et al. (1969). On each side of the boundary the weak photospheric magnetic field is predominantly of a single polarity in equatorial latitudes on both sides of the equator (Wilcox et al., 1969).

Figure 4. Plausible magnetic-field pattern and isothermal surfaces near a solar sector boundary (Wilcox, 1968).

Figure 5. Schematic illustration of the field-line random walk generated by the turbulent motions in the photosphere. A typical element of fluid moves a distance L at velocity V, and a cell lasts a time $\tau = L/V$. The field lines are convected out by the solar wind at velocity V_w, which is several times the Alfvén velocity (Jokipii and Parker, 1969).

Figure 6. Experimental points are the intensity of (0.6-13)-MeV protons in 1966 observed with Pioneer 6 by Fan et al. (1968). Solid line, Gaussian curve, intensity = $32 \times \exp\left[-(\Delta t/1.25)^2\right]$, where Δt is time for maximum intensity in days (Jokipii and Parker, 1969).

Figure 7. Thirty-minute averages of the counting rates of protons 13-70 and 0.6-13 MeV. The enhanced flux of 0.6- to 13-MeV protons during March 15-31 is attributed to solar region 8207. The first evidence of enhanced flux from the following region (8223) appears on March 31. A magnetic sector boundary occurs on March 31. Note at this time the abrupt change in the level of modulation at the Climax neutron monitor. (a)-(h) denote discrete flare and shock-wave events seen at 13-70 MeV (Fan et al., 1968).

Figure 8. The temporal dependence of the flux of 7.5- to 45-MeV protons, of the azimuth of the magnetic field, and of the cosmic-ray anisotropy, during the passage of a magnetic sector boundary past the Pioneer 6 spacecraft. Note the high degree of correlation between the changes in the magnetic and cosmic-ray azimuths (McCracken et al., 1968).

Figure 9. Chart showing the history of the active region associated with the interplanetary magnetic-loop event. Each column shows the development

of the feature during successive solar rotations. Each row describes different observations of the region. The figures are centered on the central meridian plage passage, with the Mount Wilson magnetograph observations and the Fraunhofer Institute maps extending over a scale of 40° in longitude and 20° in latitude. The first contour level on the Mount Wilson magnetogram for solar rotation 1502 has been omitted due to an increase in noise during that time period. The plage area is graphed on a scale of millionths of the solar disk (Schatten et al., 1968).

Figure 10. The histogram of frequency distribution of the time differences between the central meridian passage of spot groups and that of the interplanetary magnetic field sector boundary for the groups: (a) with flares of importance 1+ or greater; (b) with the number of flares equal or greater than ten (Bumba and Obridko, 1969).

Figure 11. Plots of the radial components of the interplanetary magnetic field, B_R, and of the solar wind velocity, V_R, observed with Mariner 5. Note the very good detailed correlation of the nonsinusoidal fluctuations (Belcher *et al.*, 1969).

Figure 12. Distribution of the angle between the field averaged over a 6-hour interval, and the direction of minimum fluctuation of the field during this interval. The ordinate is the ratio of the number observed to that expected for an isotropic distribution (Belcher *et al.*, 1969).

Figure 13. Comparison of power spectra of the interplanetary field obtained by Coleman (1966) with data from Mariner 2 in 1962, by Siscoe *et al.* (1968) with Mariner 4 data in 1964, and by Sari and Ness (1969) with data from Pioneer 6 in 1966. The noise levels T_{NL} are also indicated (Sari and Ness, 1969).

Figure 14. Faraday rotation of the telemetry carrier signal from Pioneer 6 near solar occultation when the line-of-sight distance from the sun was 6.2 solar radii (Levy *et al.*, 1969).

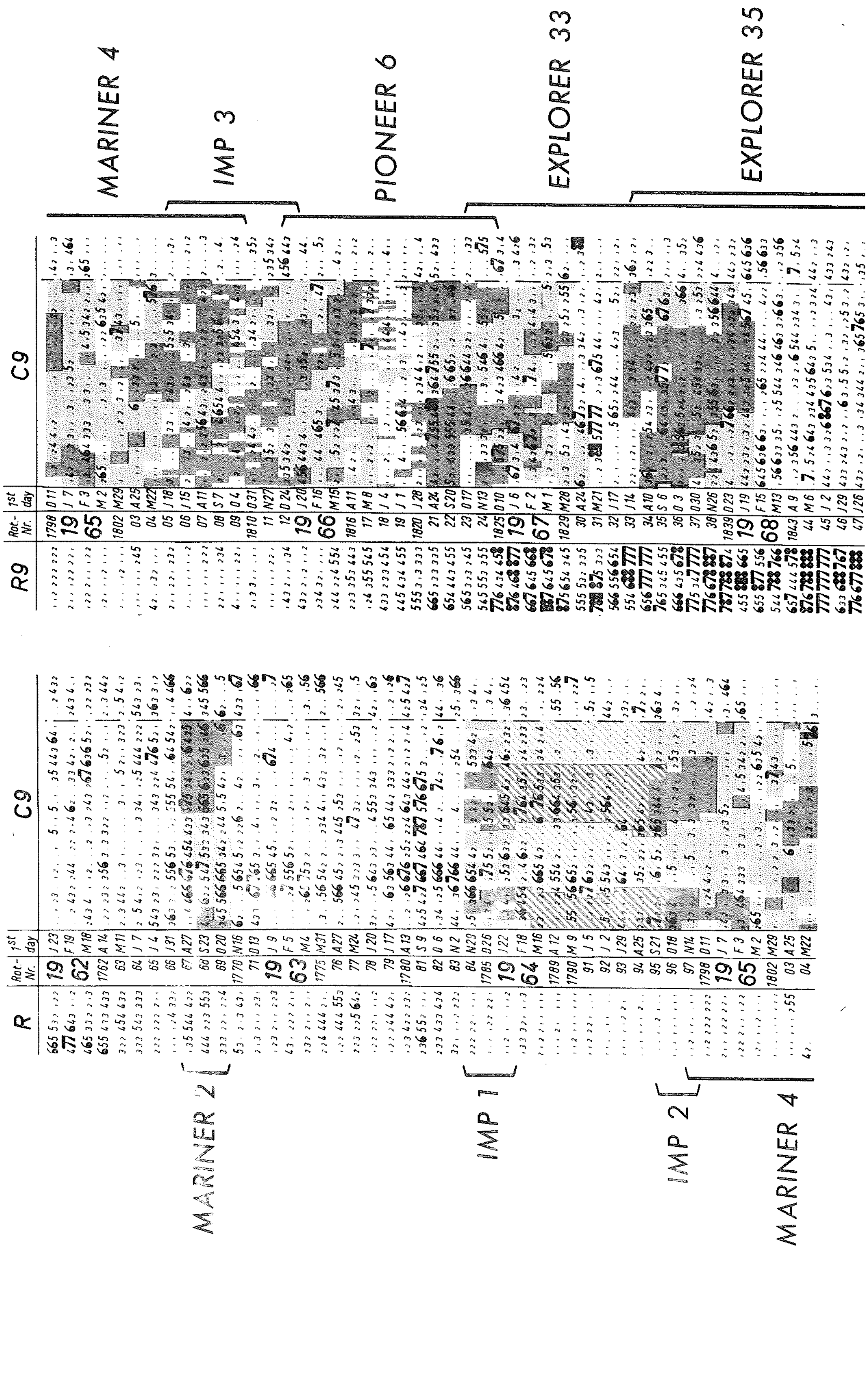
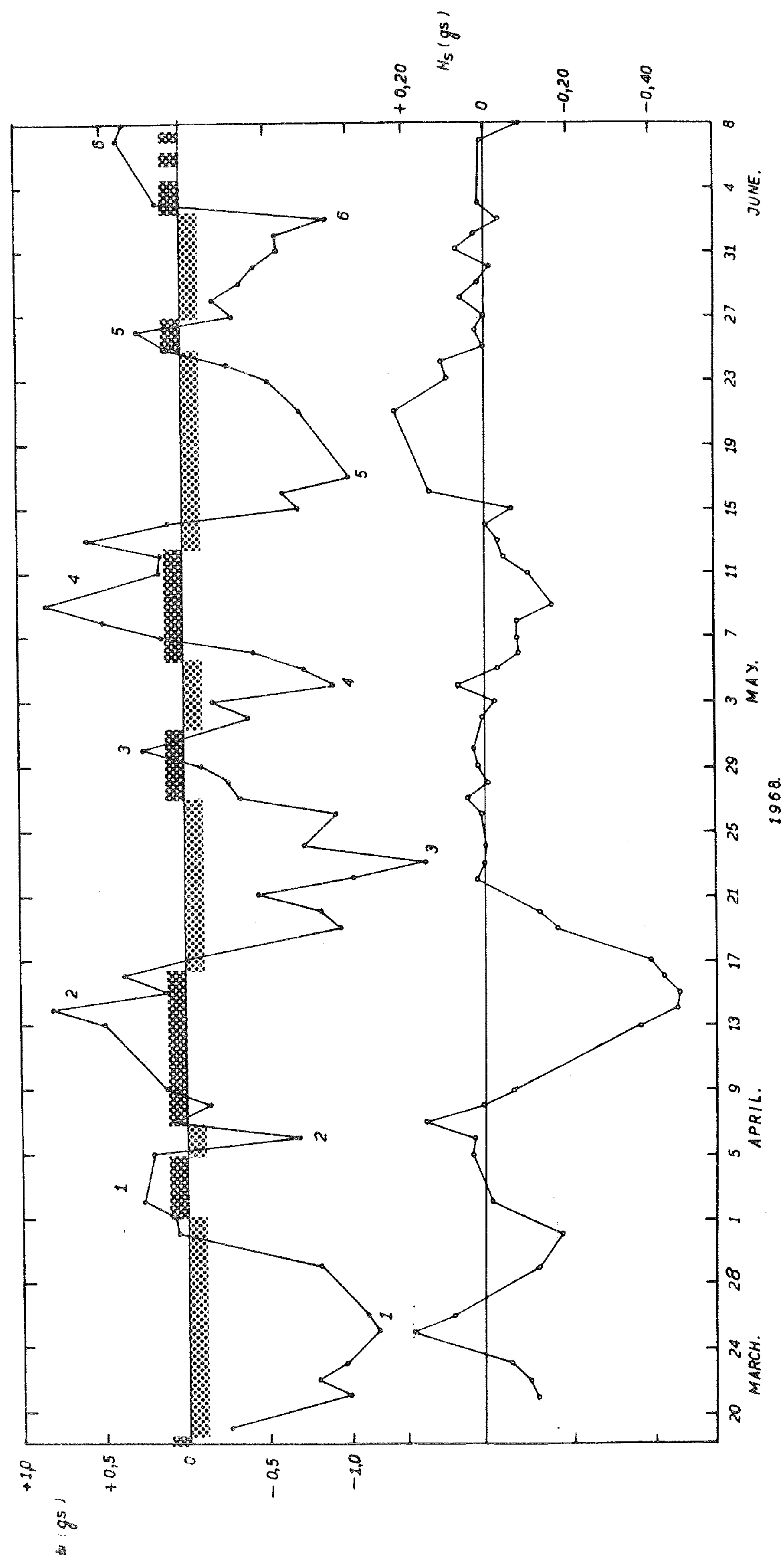

MARINER 2
IMP 1
IMP 2
MARINER 4
R
Rot.-Nr.
1st day
C9
R9
MARINER 4
IMP 3
PIONEER 6
EXPLORER 33
EXPLORER 35

Figure 1



Hw (gs)
+1,0
+0,5
0
−0,5
−1,0
Ms (gs)
+0,20
0
−0,20
−0,40
20
24
28
1
5
9
13
17
21
25
29
3
7
11
15
19
23
27
31
4
8
MARCH.
APRIL.
MAY.
JUNE.
1968.

Figure 2

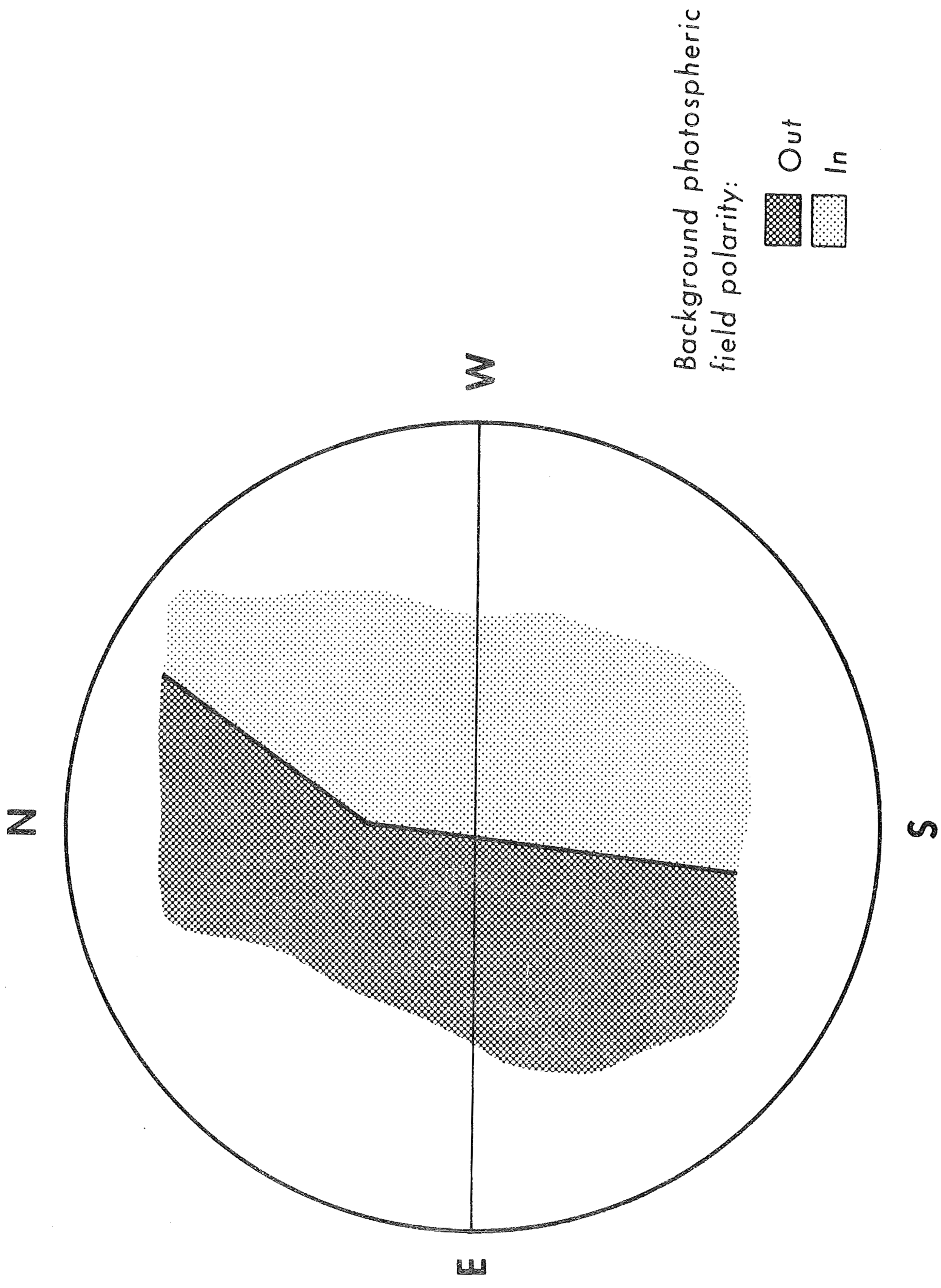


Figure 3

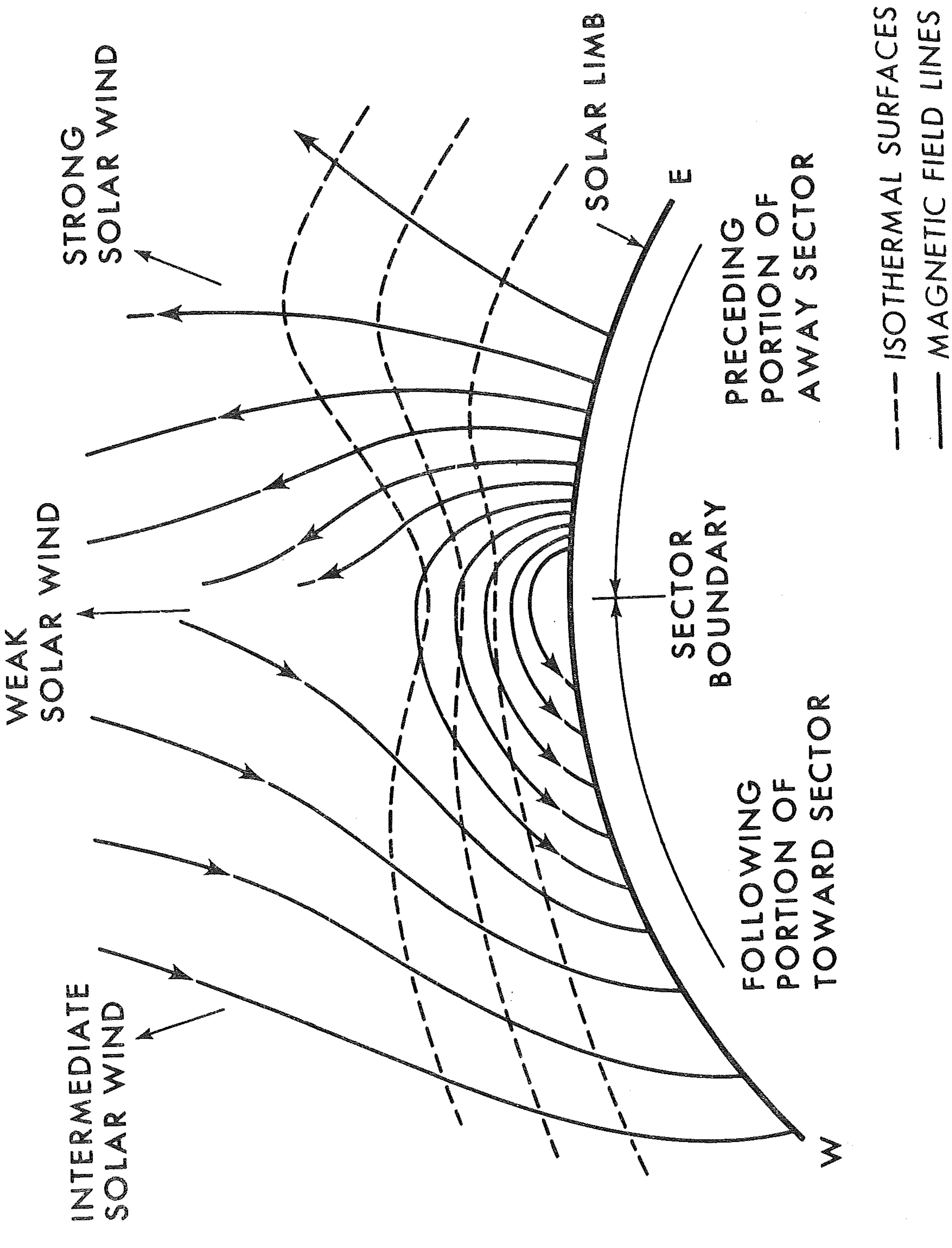
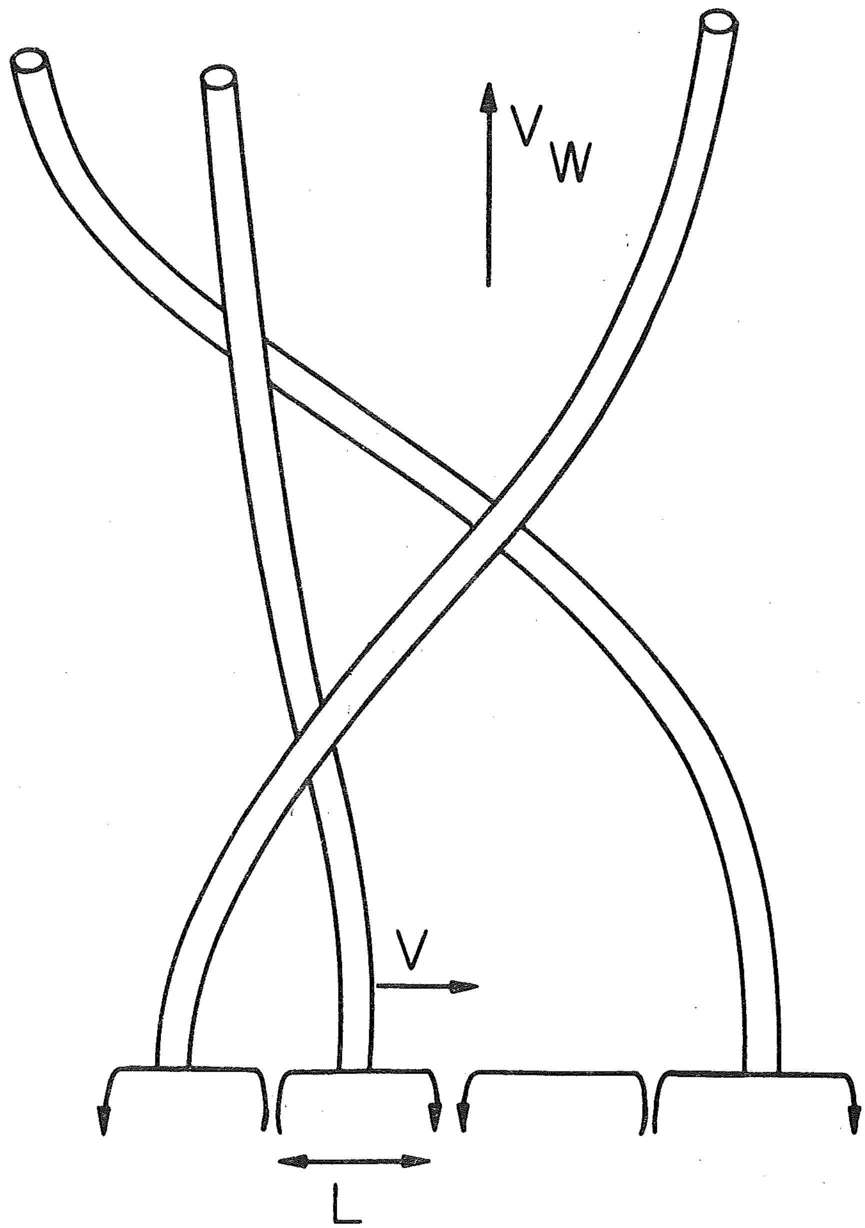
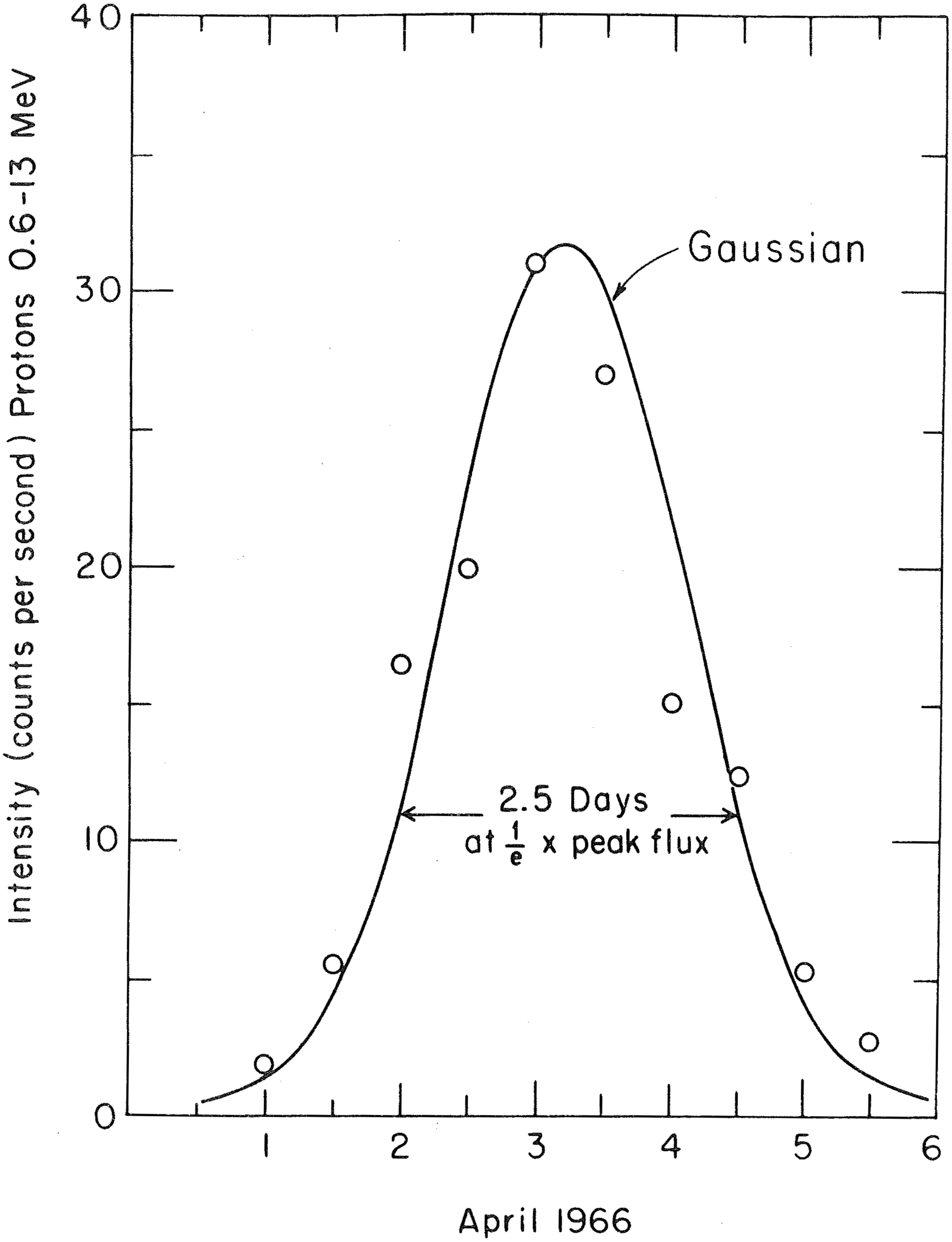

STRONG SOLAR WIND
SOLAR LIMB
E
PRECEDING PORTION OF AWAY SECTOR
WEAK SOLAR WIND
SECTOR BOUNDARY
FOLLOWING PORTION OF TOWARD SECTOR
INTERMEDIATE SOLAR WIND
W
ISOTHERMAL SURFACES
MAGNETIC FIELD LINES

Figure 4



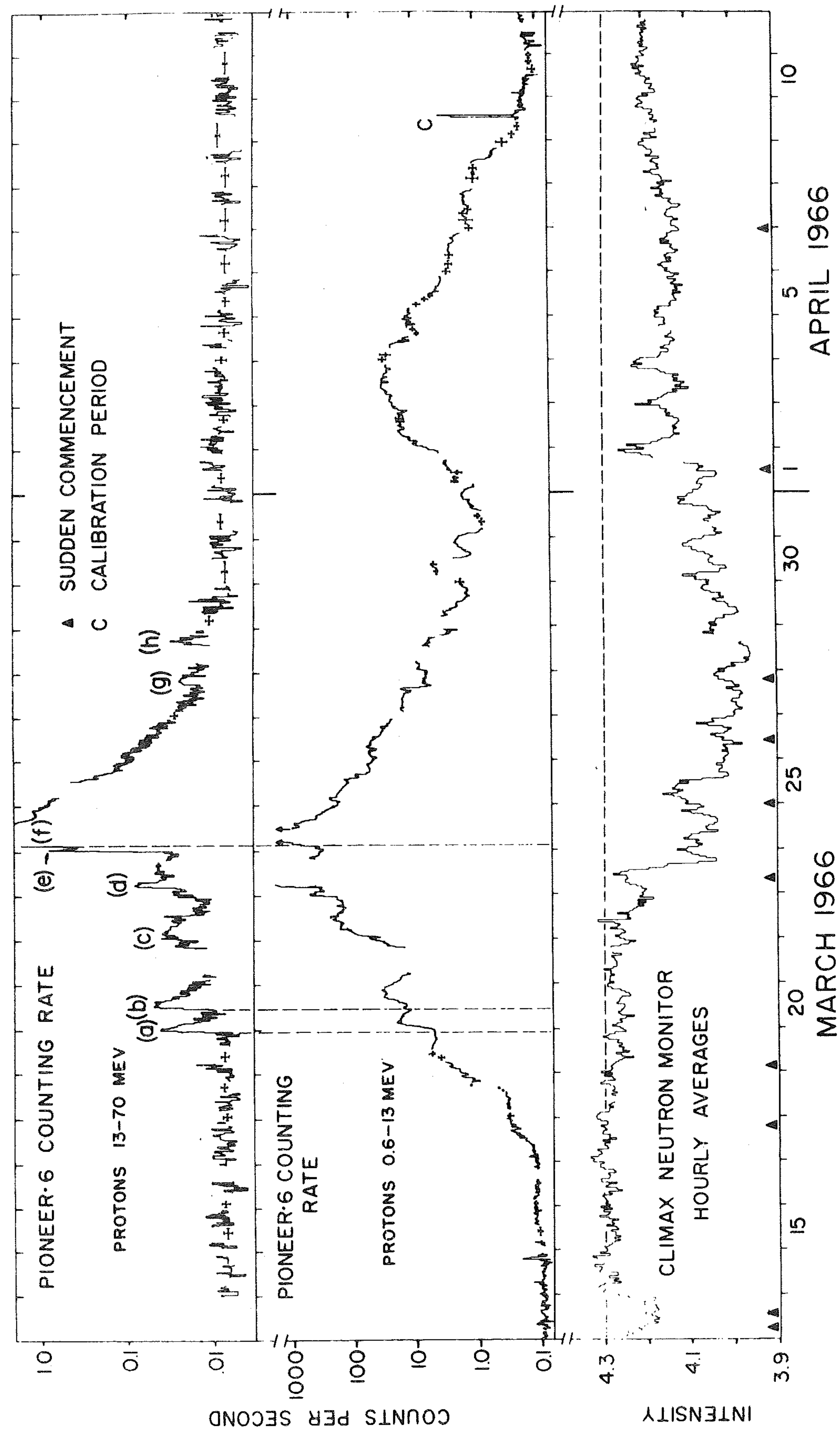
Photospheric Supergranulation Pattern

Figure 5



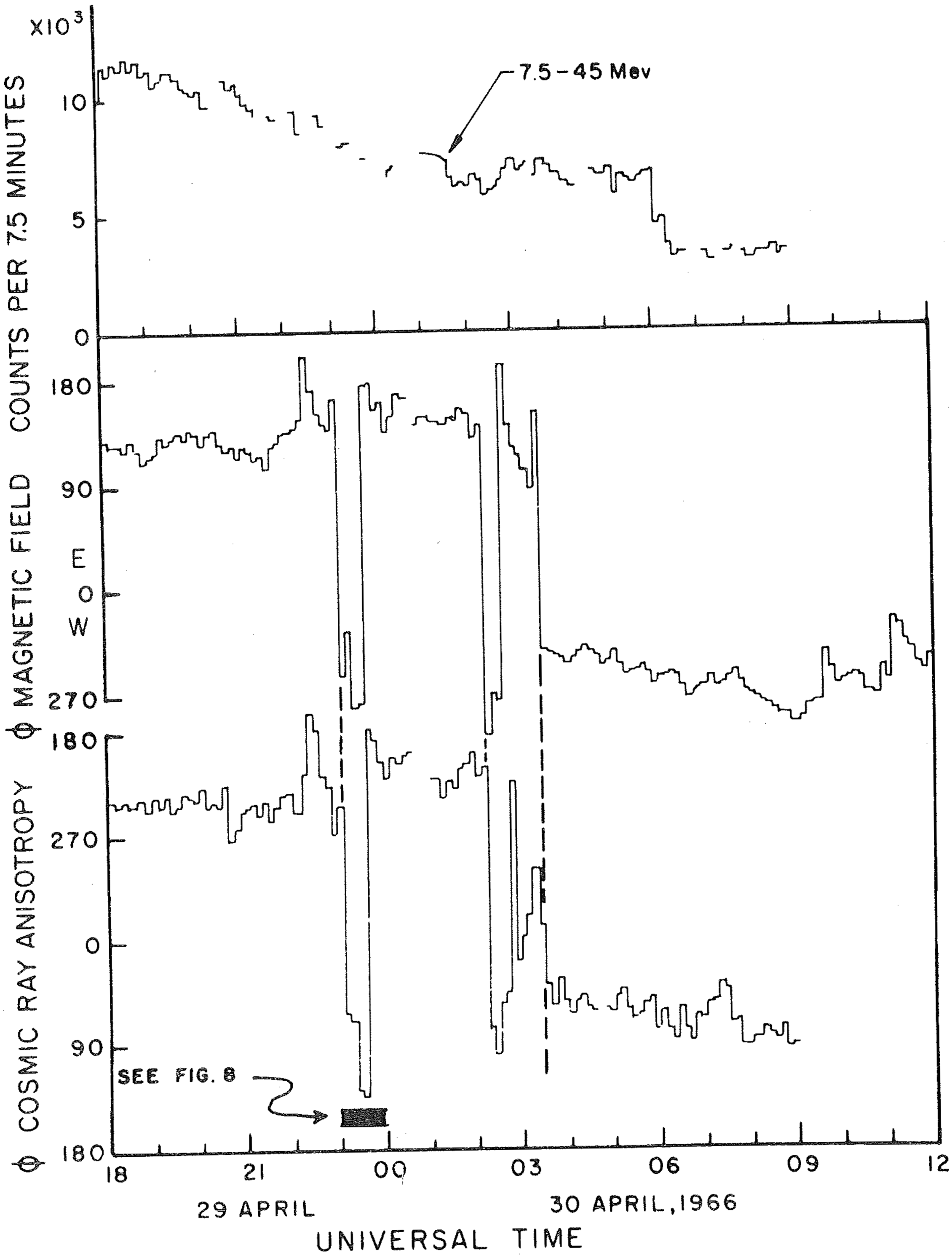
Intensity (counts per second) Protons 0.6-13 MeV
40
30
20
10
0
Gaussian
2.5 Days
at $\frac{1}{e}$ x peak flux
1
2
3
4
5
6
April 1966

Figure 6



PIONEER-6 COUNTING RATE
PROTONS 13-70 MEV
PIONEER-6 COUNTING RATE
PROTONS 0.6-13 MEV
CLIMAX NEUTRON MONITOR HOURLY AVERAGES
▲ SUDDEN COMMENCEMENT
C CALIBRATION PERIOD
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
C
COUNTS PER SECOND
INTENSITY
1.0
0.1
0.01
1000
100
10
1.0
0.1
4.3
4.1
3.9
15
20
25
30
1
5
10
MARCH 1966
APRIL 1966

Figure 7



X10³
COUNTS PER 7.5 MINUTES
10
5
0
7.5 - 45 Mev
ϕ MAGNETIC FIELD
180
90
E
0
W
270
ϕ COSMIC RAY ANISOTROPY
180
270
0
90
180
SEE FIG. 8
18
21
00
03
06
09
12
29 APRIL
30 APRIL, 1966
UNIVERSAL TIME

Figure 8

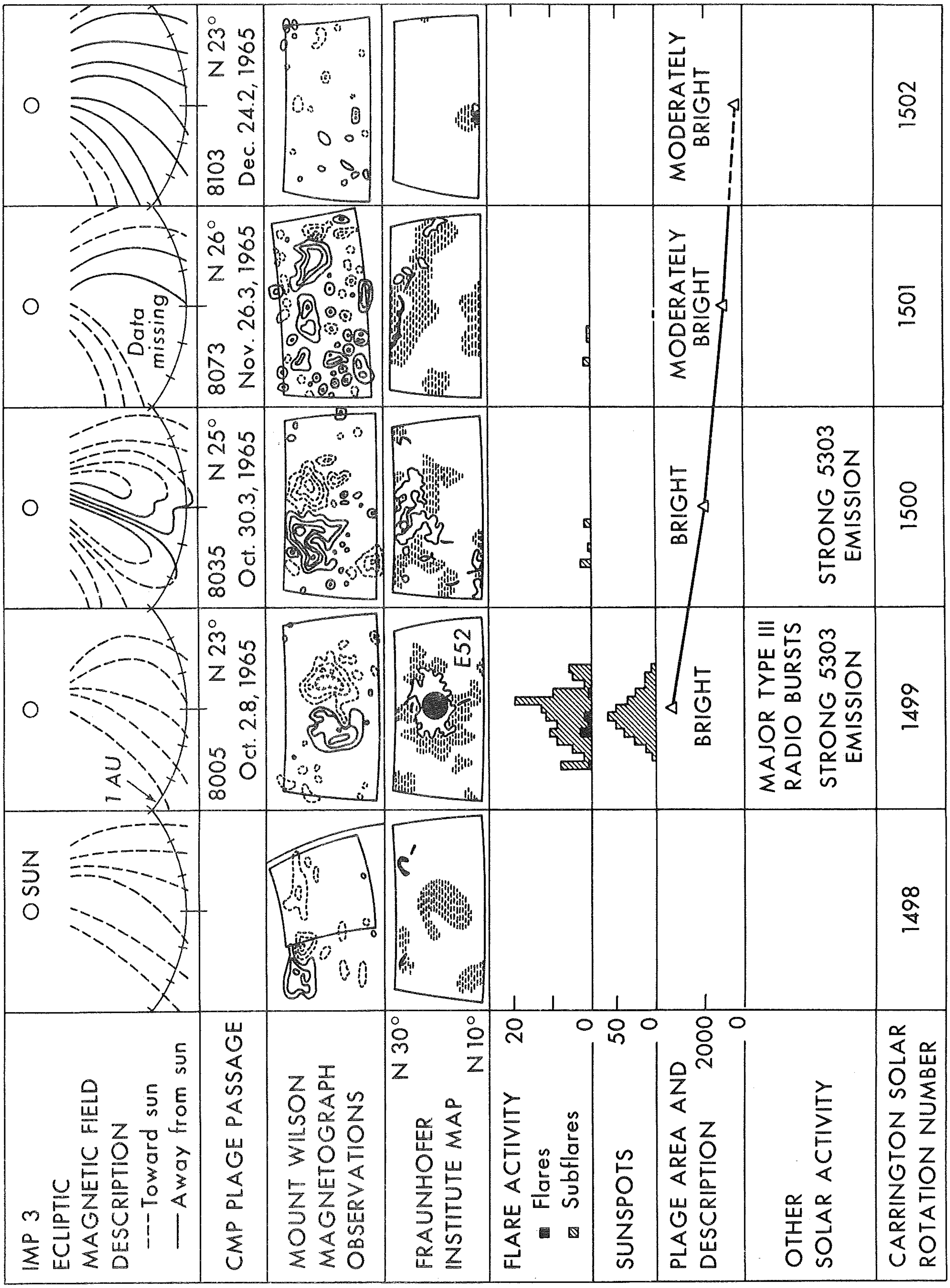

IMP 3
ECLIPTIC
MAGNETIC FIELD
DESCRIPTION
--- Toward sun
—— Away from sun
CMP PLAGE PASSAGE
MOUNT WILSON
MAGNETOGRAPH
OBSERVATIONS
FRAUNHOFER
INSTITUTE MAP
N 30°
N 10°
FLARE ACTIVITY
Flares
Subflares
20
0
SUNSPOTS
50
0
PLAGE AREA AND
DESCRIPTION
2000
0
OTHER
SOLAR ACTIVITY
CARRINGTON SOLAR
ROTATION NUMBER
O SUN
1498
1 AU
8005
Oct. 2.8, 1965
N 23°
E52
BRIGHT
MAJOR TYPE III
RADIO BURSTS
STRONG 5303
EMISSION
1499
8035
Oct. 30.3, 1965
N 25°
BRIGHT
STRONG 5303
EMISSION
1500
Data
missing
8073
Nov. 26.3, 1965
N 26°
MODERATELY
BRIGHT
1501
8103
Dec. 24.2, 1965
N 23°
MODERATELY
BRIGHT
1502

Figure 9

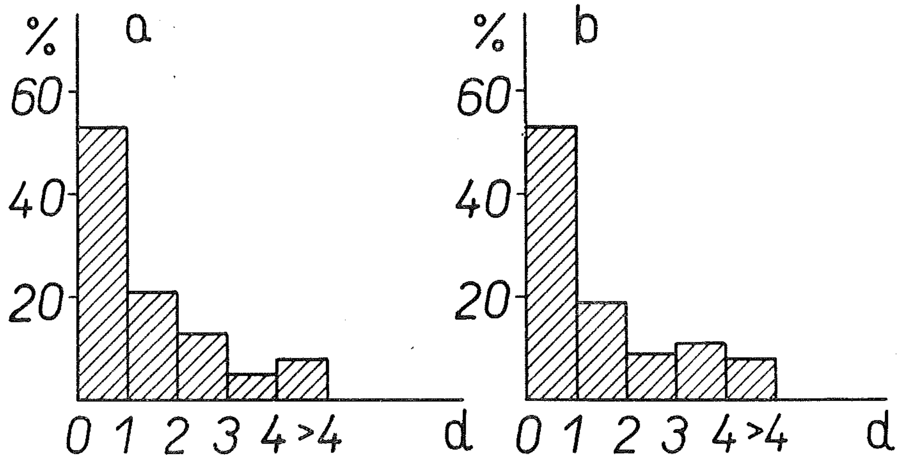
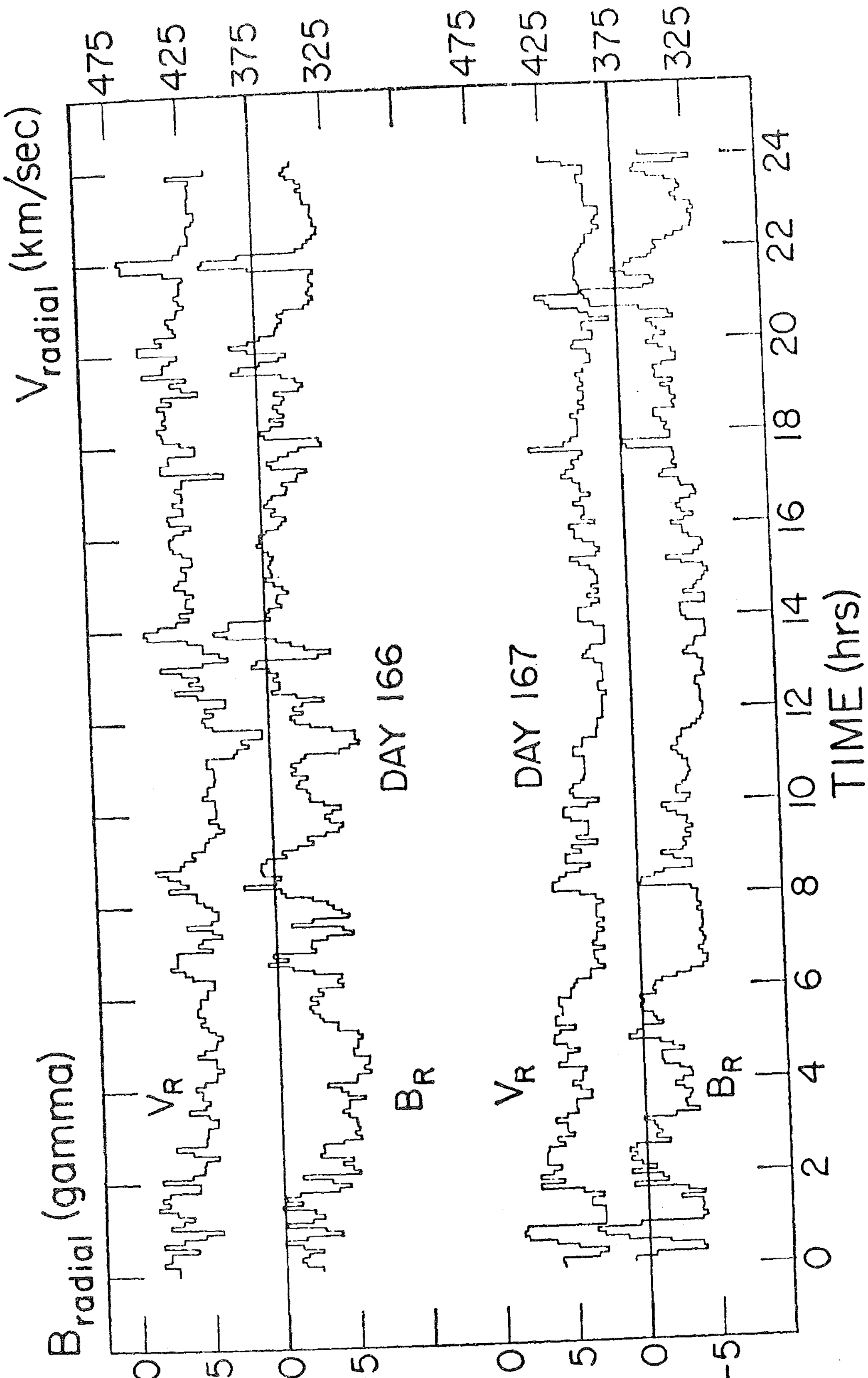


Figure 10



B_{radial} (gamma)
V_{radial} (km/sec)
V_R
B_R
DAY 166
DAY 167
TIME (hrs)
10
5
0
-5
475
425
375
325
0
2
4
6
8
10
12
14
16
18
20
22
24

Figure 11

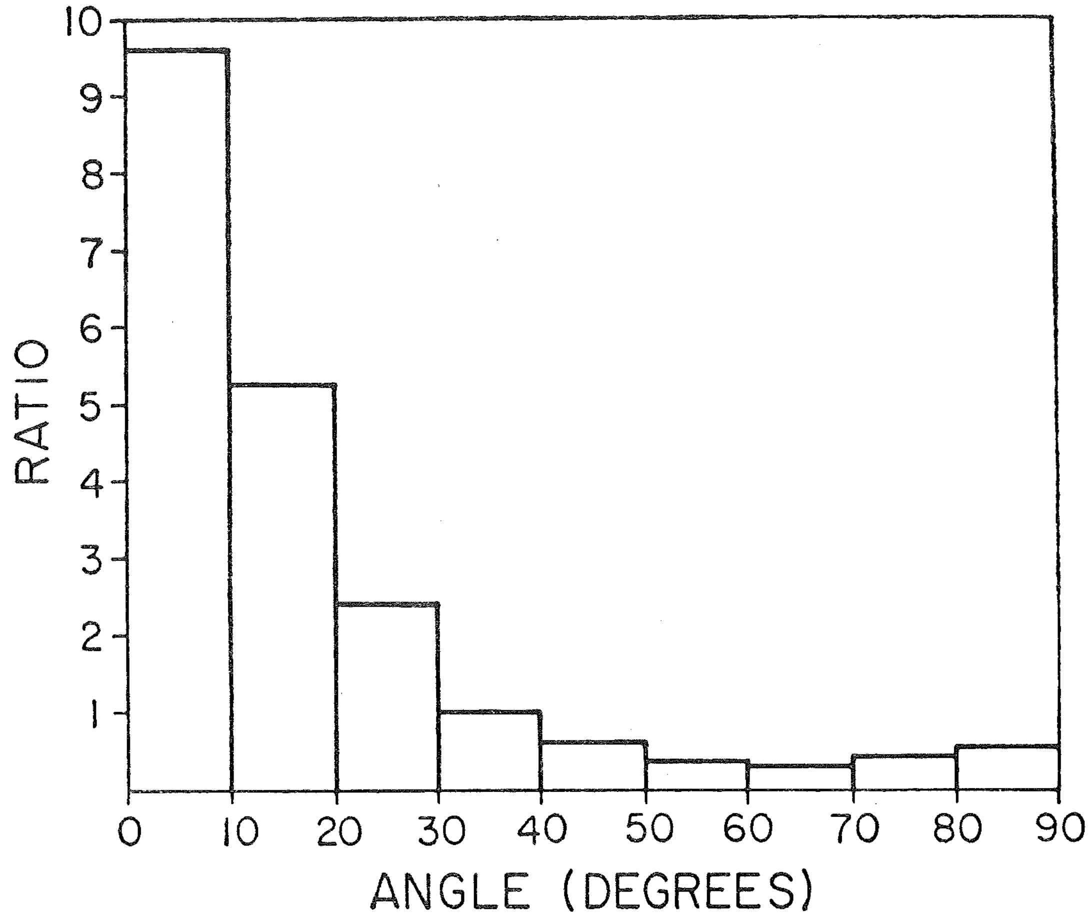
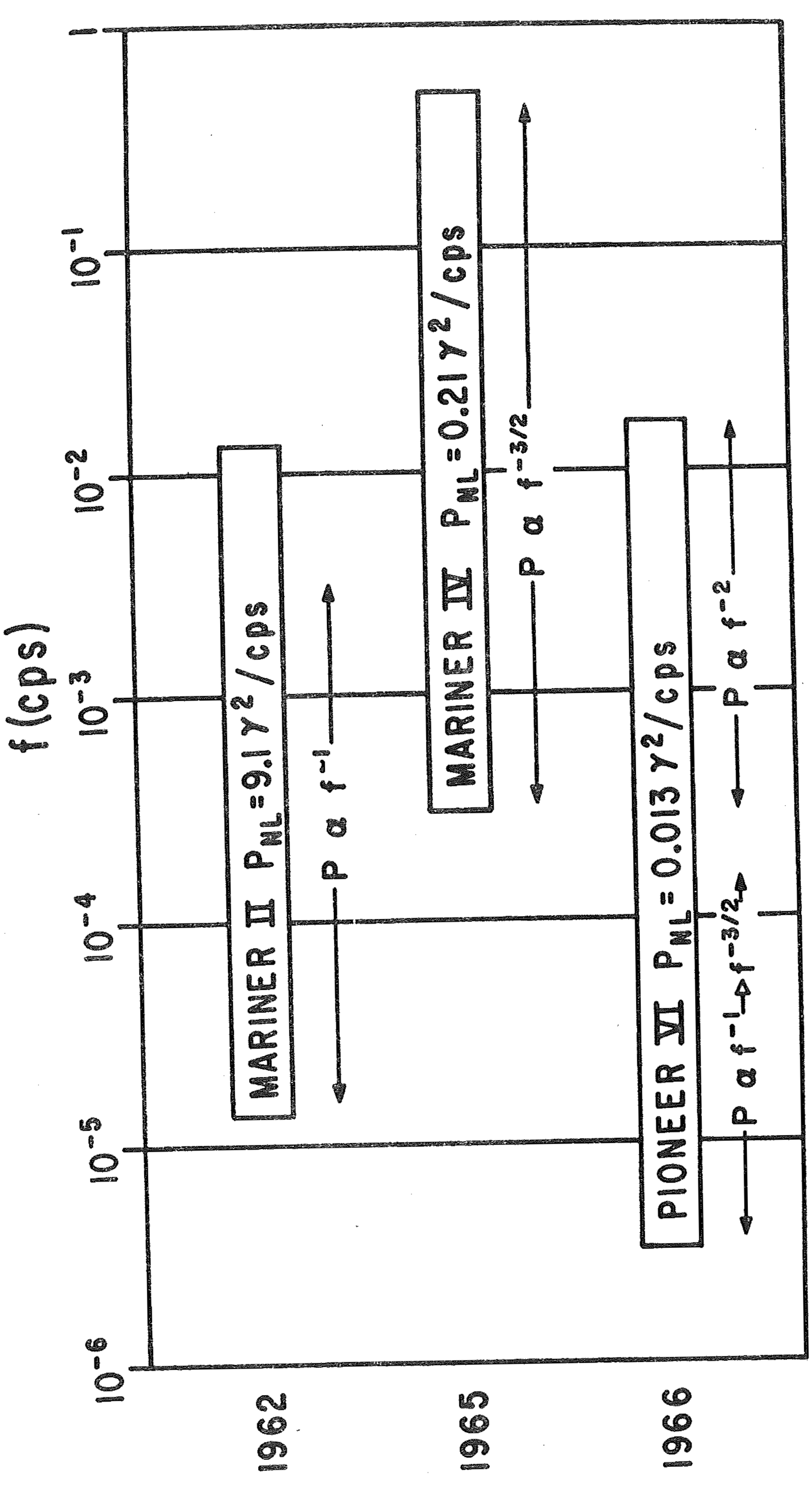


Figure 12



f (cps)
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
1962
1965
1966
MARINER II P_NL = 9.1 γ²/cps
P α f⁻¹
MARINER IV P_NL = 0.21 γ²/cps
P α f⁻³/²
PIONEER VI P_NL = 0.013 γ²/cps
P α f⁻¹ → f⁻³/²
P α f⁻²

Figure 13

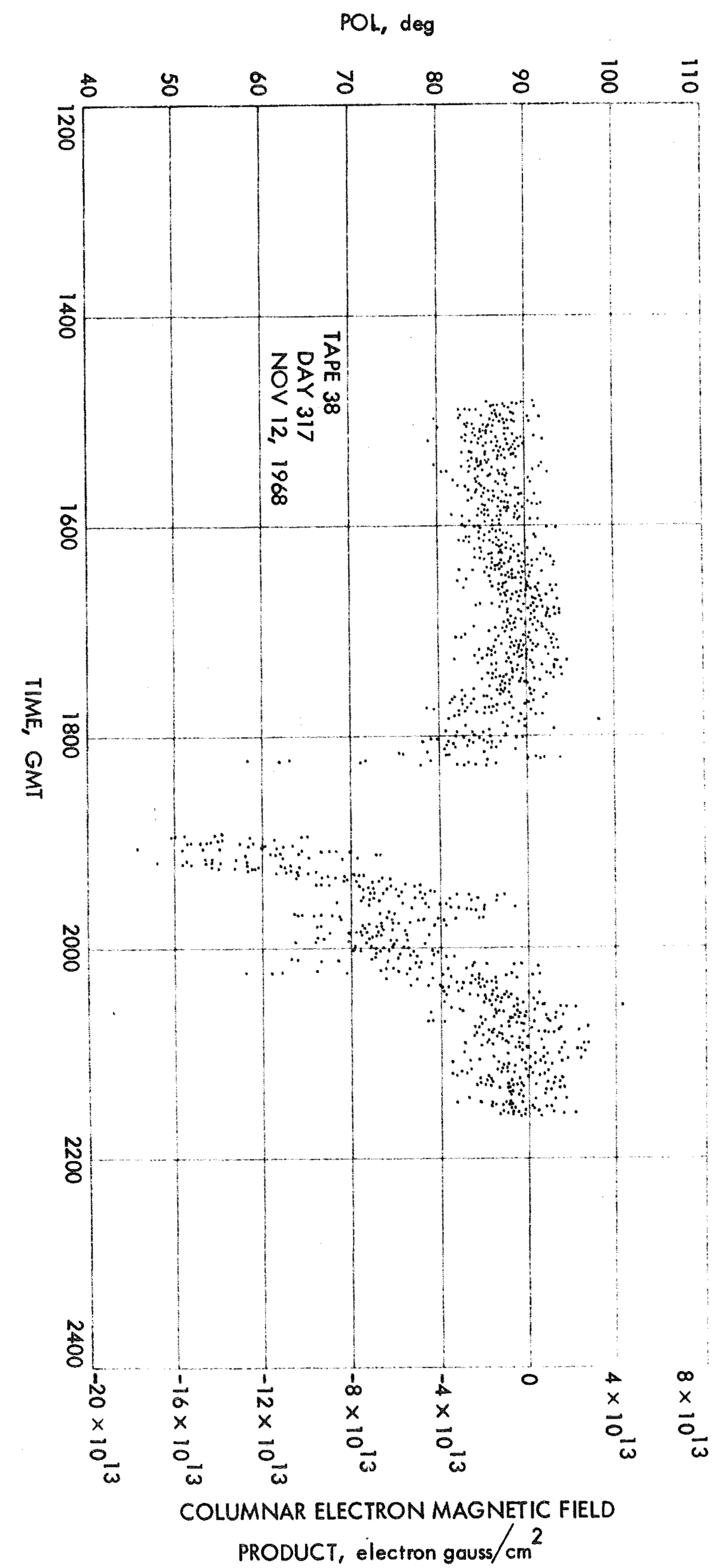

POL, deg
40
50
60
70
80
90
100
110
1200
1400
1600
1800
2000
2200
2400
TIME, GMT
TAPE 38
DAY 317
NOV 12, 1968
-20 × 10^13
-16 × 10^13
-12 × 10^13
-8 × 10^13
-4 × 10^13
0
4 × 10^13
8 × 10^13
COLUMNAR ELECTRON MAGNETIC FIELD
PRODUCT, electron gauss/cm^2

Figure 14

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Space Sciences Laboratory
University of California
Berkeley, California

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE

MAGNETIC FIELD VARIATIONS IN INTERPLANETARY SPACE

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Technical Report (Invited paper, 3rd ESLAB/ESRIN Symposium, Noordwijk, Holland September 1969.

5. AUTHOR(S) *(Last name, first name, initial)*

Wilcox, John M.

6. REPORT DATE
August 26, 1969

7a. TOTAL NO. OF PAGES
28

7b. NO. OF REFS
22

8a. CONTRACT OR GRANT NO.
ONR Contract Nonr 3656(26)

b. PROJECT NO. NR 021 101

c. NASA Grant NGR 02-003-230

d. NSF Grant GA-1319

9a. ORIGINATOR'S REPORT NUMBER(S)

Series 10, Issue 39

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES

Qualified requesters may obtain copies of this report from DDC.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Nuclear Physics Branch
Office of Naval Research
Washington, D. C. 20360

13. ABSTRACT

Magnetic field variations and structures in interplanetary space are described and related to the sun. Discrete flare-realted effects in the interplanetary medium occur within a large-scale interplanetary sector pattern related to a solar sector pattern that is ordered over a large extent in heliographic latitude and longitude. A random walk transport of photospheric field lines slightly modifies the over-all ordered pattern, but sector boundaries appear to resist the random walk process. There is a delay of approximately one solar rotation between appearance of an active region and its possible effect on the interplanetary sector pattern. A flare occurrence is most probable near a solar sector boundary. (U)

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Interplanetary magnetic field						
Solar magnetic field						
Solar flare						