



#284

MARINER 5

PLASMA PARAM AND B-FINE TIME

67-060A-03D

67-060A-05E



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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC
INFORMATION SYSTEM:

<http://nssdc.gsfc.nasa.gov/nmc/>

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

- a. Associated Documents To find associated documents you will need to know the document ID number and then click here.
<http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/>

- b. Core Catalog Materials

MARINER 5

PLASMA PARAM WITH B-FINE TIME TAPE

67-060A-03D, 05E PSFP-00086

THIS DATA SET HAS BEEN RESTORED. THERE WAS ORIGINALLY ONE 7-TRACK, 556 BPI TAPE, WRITTEN IN BIN. THERE IS ONE RESTORED TAPE. THE DR TAPE IS A 3480 CARTRIDGE AND THE DS TAPE IS 9-TRACK, 6250 BPI. THE ORIGINAL TAPE WAS CREATED ON AN IBM 360 COMPUTER AND WAS RESTORED ON AN IBM 360 COMPUTER. THE DR AND DS NUMBERS ALONG WITH THE CORRESPONDING D NUMBER AND TIME SPANS ARE AS FOLLOWS:

DR#	DS#	DD#	FILES	TIME SPAN
-----	-----	-----	-----	-----
DR005210	DS005210	D016999	1	06/14/67 - 11/21/67

MARINER 5

PLASMA PARAM AND B-FINE TIME

67-060A-03D

67-060A-05E

This catalog consists of 1 Mariner 5 Plasma Param and B-Fine Time data tape. The tape is 1 file, BIN, 556 BPI, 7 track created on an IBM/360.

<u>D#</u>	<u>C#</u>	<u>TIME SPAN</u>
D-16999	C-13143	6/14/67 - 11/21/67

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CENTER FOR SPACE RESEARCH

CAMBRIDGE, MASSACHUSETTS 02139

Mr. Don Hei
National Space Science Data Center
Code 601
Goddard Space Flight Center
Greenbelt, Maryland 20771

Sept. 20
Room 37-684

Dear Mr. Hei,

Enclosed is a description of the Mariner V Plasma-Field Data Package which MIT is submitting to the National Space Science Data Center for use by other experimenters. A combined field and plasma tape (MVMERG) is being sent to you separately.

Sincerely,

C.V. Solodyna
C.V. Solodyna

enclosures

MARINER V PLASMA-FIELD DATA PACKAGE

as submitted to the

NATIONAL SPACE SCIENCE DATA CENTER

September 1974

Principal Investigator:

H.S.Bridge

Co-Investigator:

A.J.Lazarus

ABSTRACT

We present a brief discussion of the basic analysis used to obtain plasma parameters from the MIT modulated grid Faraday cup flown on the Mariner V mission. A thorough description of a merged plasma and magnetic field tape submitted by MIT to the National Space Science Data Center is then presented, followed by a discussion of flow angle parameters.

The plasma experiment on Mariner V used a modulated grid Faraday cup sensor similar to those employed in the past by the MIT group and nearly identical to the sensor flown on Mariner IV (see Lazarus et al. 1967). The Mariner V spacecraft was attitude stabilized with the Faraday cup facing the Sun directly. The energy spectrum of the positive ion component of the solar wind was determined by measuring the incident current in 32 overlapping energy channels covering the energy/charge range from 50 to 8700 V. The alpha particle component was usually readily identifiable from the proton component because of the many energy channels. The time to complete the measurement of a positive ion energy spectrum was 5.04 min during the high data rate portion of the mission (launch to July 14, 1967) and 20.16 min thereafter.

The sensor accepts particles entering at angles as large as 60° from the Faraday cup symmetry axis (the Sun-spacecraft line). Flow angles were determined by measuring the fraction of the total incident current falling on each of the three sectors which formed the circular collector plate (see Appendix). The angular response of the plasma sensor is roughly proportional to the cosine of the entrance angle. Particles entering within approximately 20° of the symmetry axis are only slightly attenuated by the internal grid structure of the Faraday cup (See Figure A2). Since the observed solar wind flow direction is usually within a few degrees of the Sun-spacecraft line, it was assumed that the angular response was independent of the

entrance angle. This assumption is valid as long as there is only a relatively small angular spread in the particle velocities about the mean flow direction.

The analysis assumed that the proton component could be adequately described by an isotropic Maxwellian velocity distribution characterized by a number density, n , a most probable thermal speed, w_0 , ($\frac{1}{2} m w_0^2 = kT$), which is convected with a bulk velocity V . The angular response of the plasma sensor is thus nearly unity as long as w_0/V is less than about 1/3. This condition holds for most of the data, but more exact calculations were performed for very high thermal speeds. Each current measurement has an accuracy of $\pm 5\%$. The set of parameters describing a given energy spectrum (n , w_0 , and V) were obtained by taking the average value of the parameters fitting the spectrum within the measurement uncertainty. The approximate accuracy of the deduced plasma parameters are thus n , $\pm 5\%$, w_0 , ± 10 km/sec, and V , ± 5 km/sec.

In the following pages, a brief description of a data tape (MVMERG) is given which contains both plasma parameters and magnetic field averages for the Mariner V mission. An appendix is included for a more detailed description of flow angle parameters.

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MVMERG: Mariner V Merged Plasma and Field Tape

This seven track, binary tape contains proton and alpha particle plasma parameters, along with the Mariner 5 data from which these parameters were obtained. The tape is read as follows:

DIMENSION B(4),SSS(4),SEPOS(3),VABERR(3)

READ(1) YR,D,H,XM,S,FC,PV,PW,PD,AV,AW,AD,AP,
XLPC1,RPC2,ALPC,LV,MV,LW,MW,PDL,PDH,
ADL,ADH,LVA,MVA,LWA,MWA,NEG1,NEG2,
NEG3,NEG4,NEG5,IP,B,BTC,BNC,SSS,
CN,PVR,PVTQ,PVNQ,PVT,PVN,AVR,
PHIS,THETS,PHIS,THETA,PHIP,THETP,
PHIB,THETB,II,ALPHS,GAMS,
ALPHA,GAMA,ALPHP,GAMP,ALPHB,
GAMB,ICODE,SEPOS,VABERR.

EXPLANATION OF VARIABLES:

(a) time parameters

YR,D,H,XM,S give the time (U.T.) of taking of the first bit of the plasma spectrum. FC is the frame count.

(b) proton parameters

PV - radial component of the bulk speed (km/sec) (not corrected for aberration).

PW - most probable thermal speed (km/sec).

PD - number density (cm^{-3})

(c) alpha particle parameters.

AV - radial component of the bulk velocity (km/sec) (not corrected for aberration).

AW - most probable thermal speed (km/sec).

AD - number density (cm^{-3})

AP - percentage of alpha particles (by number).

(d) limits on parameters from fit

XLPC1 Percentage of excess flux in the channel which is located 2 below the peak. Percentage is relative to the total flux predicted by the fit.

RPC2 Percentage of excess flux in the 2nd and 3rd channel above the peak.

ALPC Percentage of excess flux in the 2nd channel above the alpha peak. Percentage relative to total flux of the alpha fit.

LV and MV are the lower and upper limits on PV

LW and MW are the lower and upper limits on PW

PDL and PDH are the lower and upper limits on PD

LVA and MVA are the lower and upper limits on AV

LWA and MWA are the lower and upper limits on AW

ADL and ADH are the lower and upper limits on AD

(e) parameters indicating the quality on the fits and protons

NEG1=0 all 5 channels (PK, $\pm 1, \pm 2$) had useable currents ($> 10^{-11}$),

NEG1=1 PK+2 had current $\leq 10^{-11}$

NEG1=2 PK-2 had current $\leq 10^{-11}$

NEG1=3 both PK+2 and PK-2 had currents $\leq 10^{-11}$

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NEG2=0 all 5 channels fit

NEG2=1 all but PK+2 fit

NEG2=2 all but PK+2 and PK-2 fit

NEG2=3 no 3 channel fit

Note: if no 3 channel fit, PD = - 1.0.

alpha particles:

NEG3=0 - APK,APK+1 channels had useable currents ($>10^{-11}$)

NEG3=1 - APK-1 had current $\leq 10^{-11}$

NEG3=2 - APK had current $\leq 10^{-11}$

NEG3=3 - APK+1 had current $\leq 10^{-11}$

NEG3=4 - both APK+1 and APK-1 had current $\leq 10^{-11}$

NEG3=6 - no alpha peak found.

NEG4=0 - APK,APK+1,APK+2 channels all fit

NEG4=1 - 3 channels (with measurable currents) fit

NEG4=2 - APK+1 or APK-1 had too low current; 2 channel fit made
with assumption AV=PV

NEG4=3 - no fit

Note: If no alpha fit, AD = - 1.0.

NEG5=0 - fit is consistent with the current measured in the APK+2
channel

NEG5=1 - fit is not consistent with the current measured in the
APK+2 channel

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IP=0 good data
OCIDE=0

IP=1 proton density (PD) less than 0, i.e., no fit
ICODE=1

IP=2 currents from the sum of the peak, (peak-1),
ICODE=ICODE+16 and (peak+1) channels correspond to $\gamma > 20^\circ$

IP=3 Mach number less than 2.5
ICODE=-1

ICODE=ICODE+2 Orientation of Mariner unknown

ICODE>16 or Angle determined from sum of currents in the
Mod (ICODE,4) $\neq$ 0 peak, (peak-1), and (peak+1) channels is bad

ICODE=28 The peak current was found in channels 1 to 7
or 27 to 32.

(f) magnetic field parameters

B 5.04 min average of the magnetic field taken over the plasma
sampling period. $B(1)=BR$, $B(2)=BT$, $B(3)=BN$, $B(4)=|B|$

BTC BT in solar ecliptic coordinates

BNC BN in solar ecliptic coordinates

SSS Standard deviations of the field components (RTN) and magnitude
taken over the 5.04 min plasma sample

CN Number of magnetic field measurements which were averaged to
obtain the 5.04 min field sample (maximum of 72)

(g) plasma flow velocities (km/sec)

PVR Radial flow velocity protons

PVTQ VT, solar equatorial coordinates

PVNQ VN, solar equatorial coordinates

PVT Transverse flow velocity, protons

PVN Normal flow velocity, protons

AVR Radial flow velocity, alpha particles

(h) flow angles (Sun-centered coordinate system)

PHIS ϕ determined from currents in the peak channel, (peak-1) channel, and (peak+1) channel

THETS θ determined from currents in the peak channel, (peak-1) channel, and (peak+1) channel

PHIA ϕ determined from (peak+1) channel

THETA θ determined from (peak+1) channel

PHIP ϕ determined from peak channel

THETP θ determined from peak channel

PHIB ϕ determined from (peak-1) channel

THETB θ determined from (peak-1) channel

II Number of the energy channel in which the peak current was found ($1 \leq II \leq 32$)

(i) flow angles (cup. centered coordinate system)

ALPHS α determined from currents in the peak channel, (peak-1) channel, and the (peak+1) channel

GAMS γ determined from currents in the peak channel, (peak-1) channel, and the (peak+1) channel

ALPHA α determined from (peak+1) channel

GAMA γ determined from (peak+1) channel

ALPHP α determined from peak channel

GAMP γ determined from peak channel

ALPHB α determined from (peak-1) channel

GAMB γ determined from (peak-1) channel

ICODE See Section (e)

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(j) position and aberration

SEPOS Spacecraft distance (in km) from the Sun

VABERR Velocity aberration (RTN) in km/sec $PVR = PV + VABERR(1)$.

Typical values $VABERR(1) = -2$, $VABERR(2) = 27$, $VABERR(3) = -1$.

The DD cards are the following:

//G.FTOLFOOL DD UNIT=TAPE7,LABEL=(1,NL),DISP=(OLD,DELETE),

// DCB=(RECFM=VBS,LRECL=304,BLKSIZE=3044,

// TRTCH=C,DEN=1),VOLUME=SER=MVMERG.

Appendix

The trajectory of Mariner V (figure A1) passed within 10,151 km from the center of Venus on Oct. 19, 1967. Because of the assumption that the solar wind may be represented as a cold plasma beam which does not interact with the 5 grids of the cup, the plasma entering the cup will make a circular spot on the split collector plate. The radius of the spot will be the same as the aperture, 1.5 inches. The basic geometry of the MIT Faraday cup is shown in figures A2 and A3.

In cup coordinates, the location of the plasma spot is completely specified by two angles γ and α as shown. The angle γ is the angle the solar wind velocity vector makes with the cup normal. The angle α is the angle between the center of the plasma spot and the line separating collectors 1 and 3. In these coordinates, $\alpha = 0^\circ$ is the line separating collectors 1 and 2. By comparing the currents incident upon these three collectors, the flow angles of the solar wind may be determined. The actual calculations are purely geometrical (Wentz, 1969), since the ratio of fractions of the area of the plasma spot appearing on any of the collectors is directly proportional to the fraction of the incident current delivered by the fully ionized solar wind.

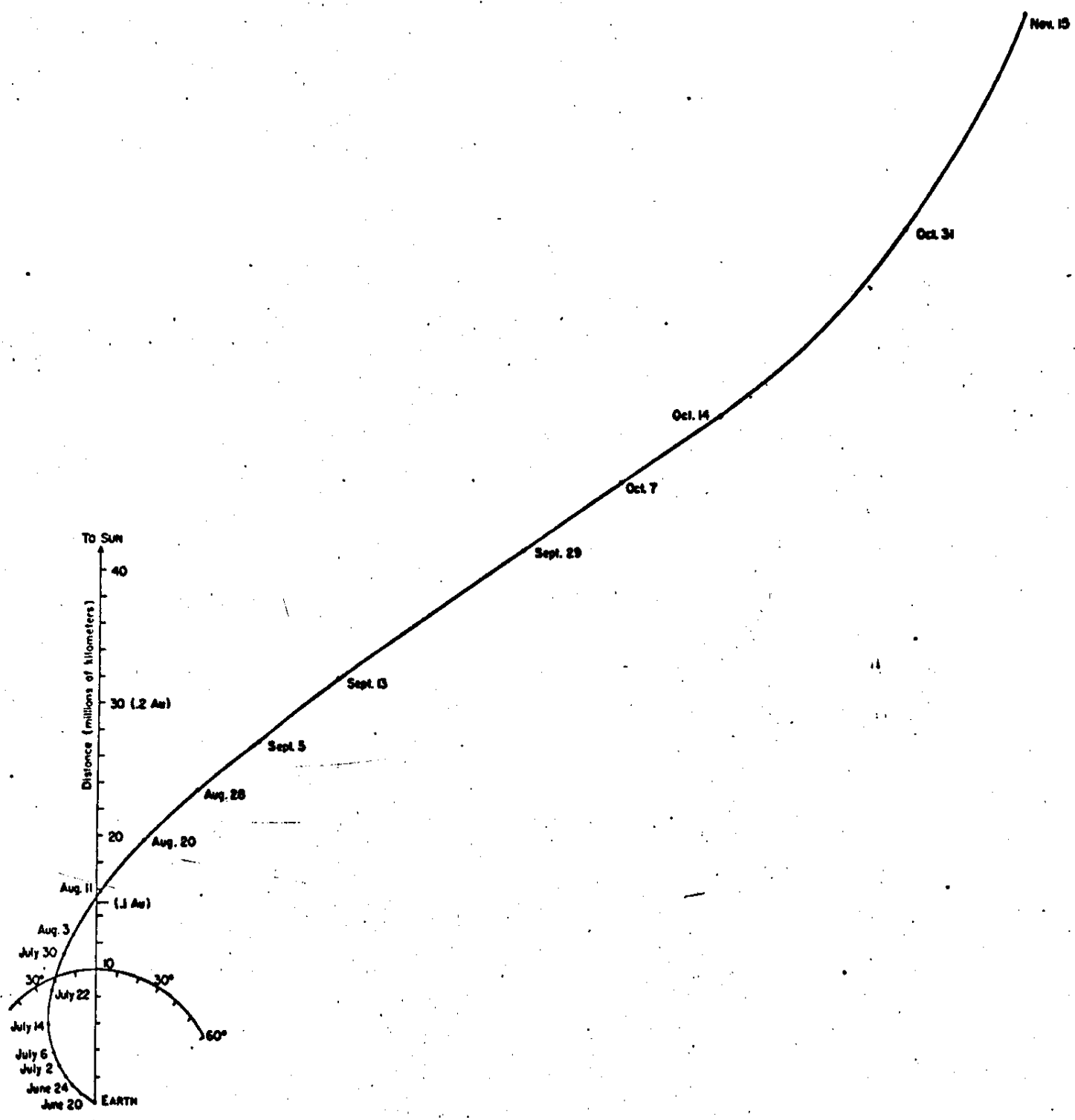
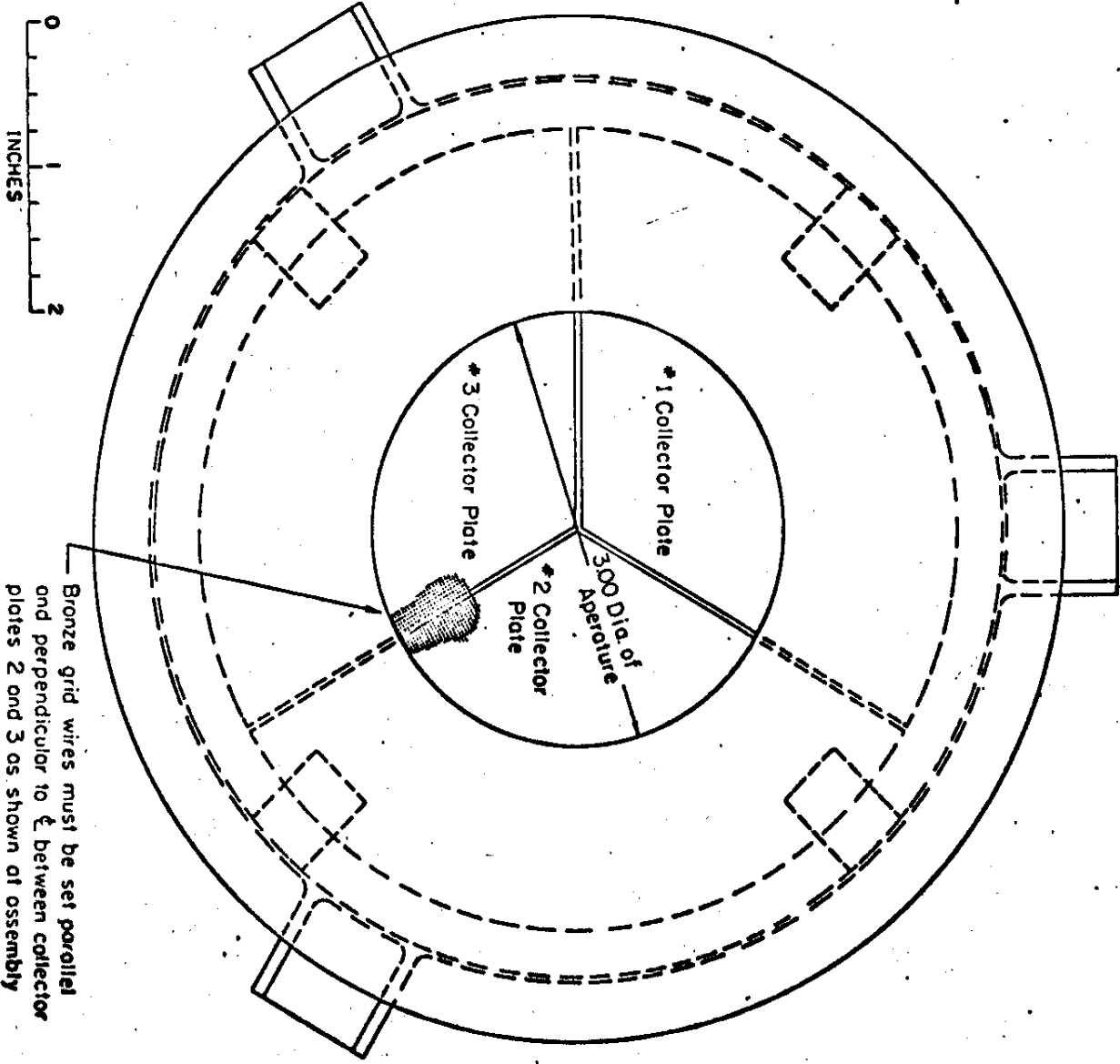
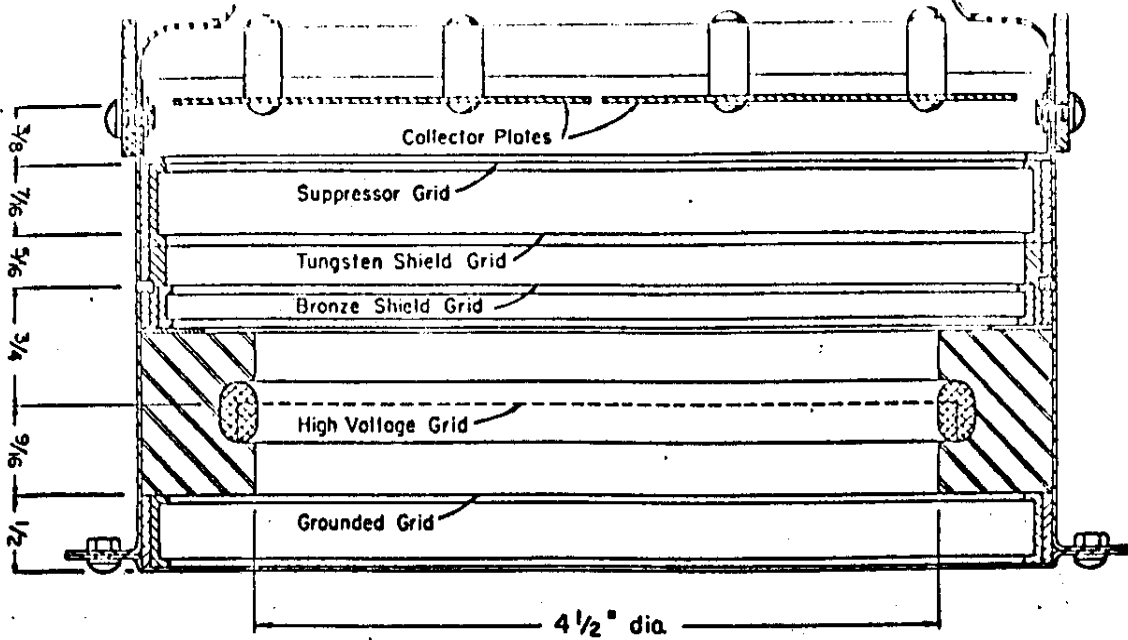


Figure A1



MARINER - VENUS '67 PLASMA PROBE SENSOR

Figure A2

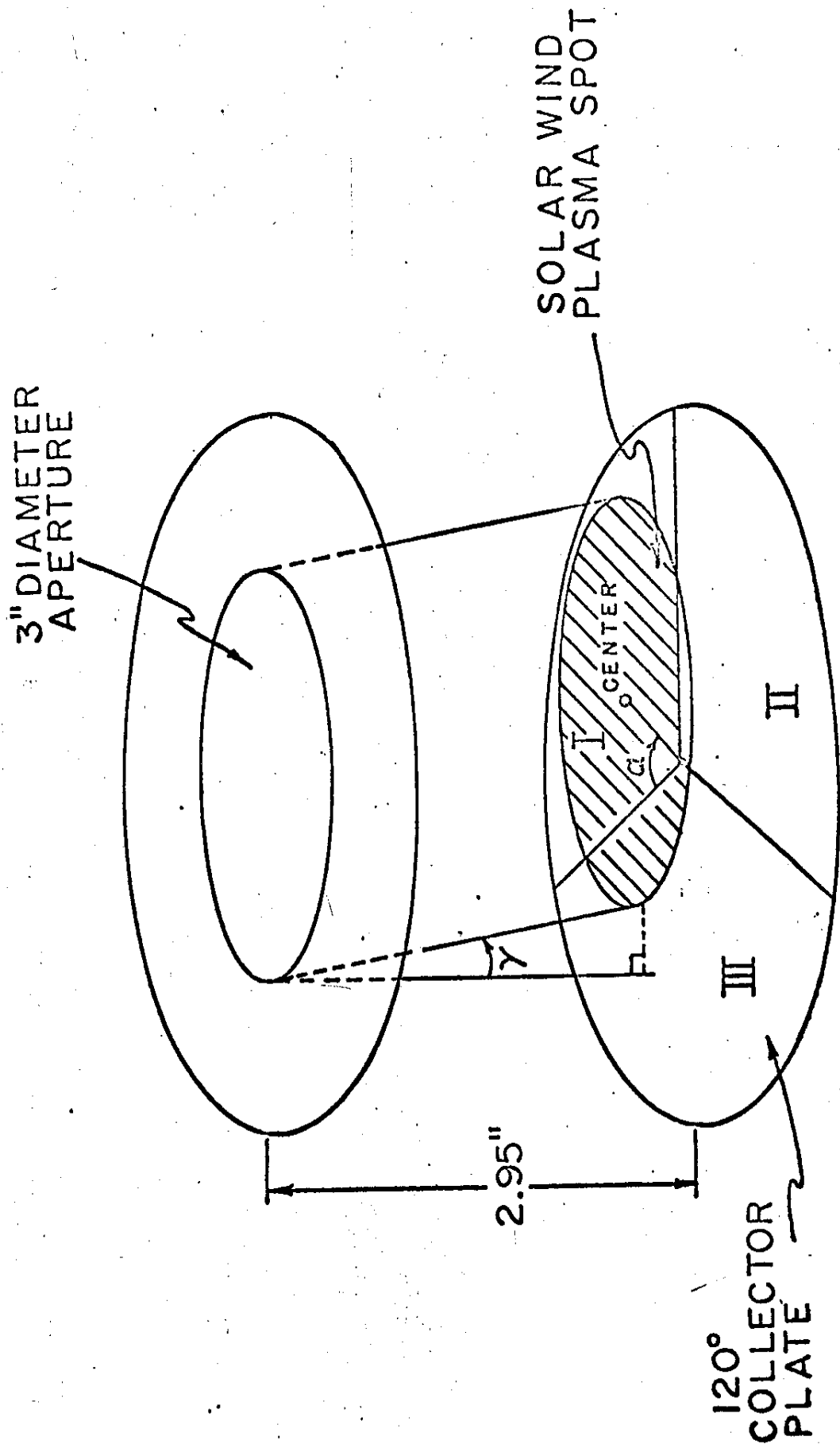


Figure A3

MARINER VENUS '67
FARADAY PLASMA CUP
COORDINATES

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Having determined γ and α , we desire to obtain the direction of the solar wind in terms of solar ecliptic coordinates θ and ϕ . To do this we introduce an auxiliary coordinate α' which is the angle the circular plasma spot makes with respect to the ecliptic plane. As seen from Figure A4, angles are related as follows:

$$a = \cos\theta\sin\phi = \sin\gamma\cos\alpha'$$

$$b = \sin\theta = \sin\gamma\sin\alpha'$$

$$c = \cos\theta\cos\phi = \cos\gamma$$

from which it follows that $\tan\gamma = \tan\gamma\cos\alpha'$. We choose the convention that $\phi > 0$ corresponds to EAST and $\theta > 0$ corresponds to SOUTH. Thus solar wind plasma coming from the SOUTH and EAST of the sun has $\theta > 0$ and $\phi > 0$.

Mariner V is equipped with a Canopus sensor to orient itself in space. Except for periods of rolling, the sensor locks onto Canopus. The Canopus sensor will, therefore, lie in the sun-Canopus-spacecraft plane. Taking the cross product of the vector from the sun to Canopus and the vector from the sun to the spacecraft, a vector perpendicular to the sun-Canopus-spacecraft plane is found. This vector is shown as the normal vector in Figure A5. A detailed calculation of this vector will be given later.

The angle the normal vector makes with the ecliptic plane is simply the arcsine of its North, or ZSE, component since all the vectors mentioned are unit vectors. Since the Faraday cup's orientation with respect to the Canopus sensor is known and fixed, the position of the plasma spot can be determined with respect to the ecliptic plane. Noting that X and Y, shown

SOLAR ECLIPTIC COORDINATES

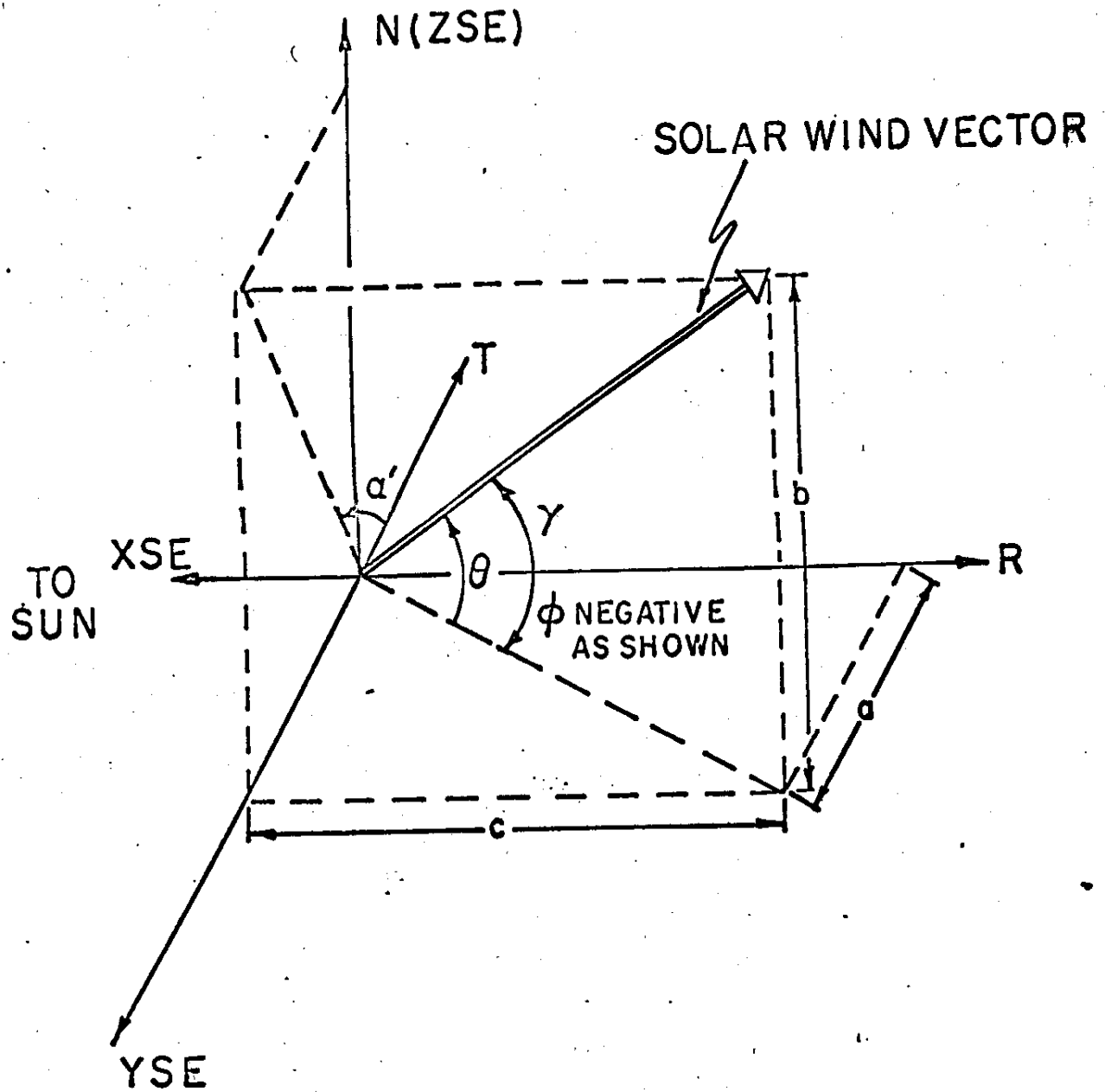


Figure A4

ORIENTATION OF MARINER V

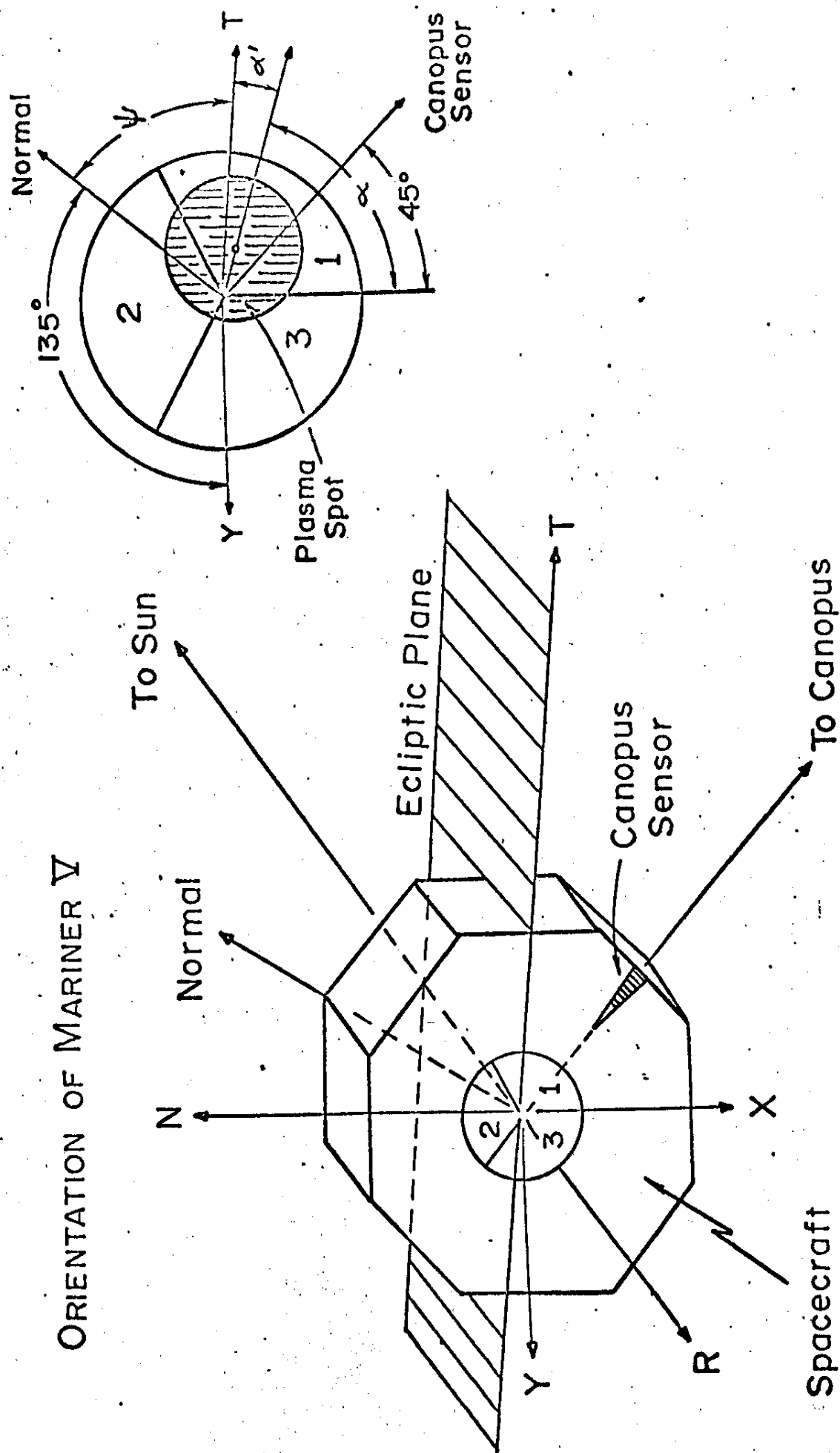


Figure A5

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in Figure A5, are fixed spacecraft coordinates, and that the Canopus sensor is 45° from the X-axis, the following equation is obtained by simply adding up the specified angles around the center of the cup:

$$\alpha - \alpha' + \psi + 135^\circ = 270^\circ,$$

or

$$\alpha' = \alpha + \psi + 225^\circ,$$

where α is, as before, the angle between the center of the plasma spot and the line separating collectors 1 and 3. The angle α' is the angle the spot makes with respect to the ecliptic plane. The angle ψ is the angle the normal vector makes with the ecliptic plane. The incident polar angle γ is independent of orientation and position because the spacecraft always has the normal to the cup pointed toward the sun. Thus given α , γ , and ψ , we may express the flow directions of the solar wind in solar ecliptic coordinates.

To calculate ψ , first the normal vector must be found. The sun-spacecraft vector depends upon the position of the spacecraft. In heliocentric coordinates, it equals

$$\mathbf{V}_p = (1/R) [XHE, YHE, ZHE],$$

where R is the distance between the spacecraft and the sun. The sun-Canopus vector is constant during the period of the Mariner V flight, and was found to be

$$\mathbf{V}_c = [-.024458, .240593, -.970318].$$

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The normal vector is the $V_p \times V_c$. The ZHE-component of the normal can be found. Taking the arcsine of this component to find ψ ,

$$\psi = \sin^{-1} [(.240593XHE + .024458YHE)/R].$$

During a roll maneuver, the phase of the Canopus sensor with respect to the ecliptic plane and the roll rate must be known to find the solar ecliptic angles. Once the phase and the roll rate are known, the procedure for finding the angles is identical to that described above except that now ψ is not a constant, but rather a function of time. This was done to correct for the roll of the spacecraft near the Earth. From the day 165, 06:43:31.15 UT to day 165, 22:38:01.06 UT, ψ as a function of time, in units of seconds after the reference time, day 165, 06:24:35.5 UT, is the following:

$$\begin{aligned} \psi(t) = & \sin^{-1} [(.240593XHE + .024458YHE)/R] \\ & - \text{Mod}\{297.54451 + t \cdot .0012194876(\text{Log}_e t) \\ & - .028646602\text{Log}_e t - .035652744\} \\ & (\text{Modulo } 0^\circ, 360^\circ) \end{aligned}$$

Although ψ is also a function of position during this period, the values for XHE and YHE of the spacecraft change so little in the 16-hour period as to make the arcsine term nearly a constant equaling -3.1° .

REFERENCES

Lazarus, A.J., H.S. Bridge, J.M. Davis, and C.W. Snyder,

Initial results from the Mariner 4 solar plasma
experiment, Space Res., 7, 1296, 1967.

Wentz, F.J., Determination of solar wind direction from Mariner V,

B.S. Thesis, MIT, June 1969.

[illegible]