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UPPER ATMOSPHERE COMPOSITION DATA FROM EXPLORER XVII [redacted]

NASA TMX 51836

by

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Introduction

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The Explorer XVII aeronomy satellite carried two double-focusing magnetic mass spectrometers designed (Meadows, 1960, Hall, 1960, Spencer, 1962) to measure the concentrations of the major neutral-particle constituents of the earth's upper atmosphere. The ambient densities of helium, oxygen, and nitrogen were obtained between north and south latitudes of 58 degrees and from the perigee altitude of 257 kilometers to an altitude in excess of 700 kilometers. Data for various local times, altitudes and geographic locations have been combined to provide a broader altitude coverage than experienced at any single location. Data are presented for helium, atomic oxygen and molecular nitrogen; molecular oxygen and atomic nitrogen data will be presented and discussed in a later report, with other data obtained under more varied conditions.

Experiment

The mass spectrometer measured the number densities of the various species which were in its ionizing, or sampling, region. Before reaching this sampling region however, some of the neutral particles underwent collisions with various parts of the spectrometer structure; thus the number measured by the spectrometer was generally different from the ambient number density. The relationship between the spectrometer measurements and the ambient number densities was calculated and found to be a

[redacted]

function of particle species, satellite velocity, and the angle between the spectrometer axis and the satellite velocity vector (angle of attack, α). Using the latter two quantities obtained from the tracking stations and the satellite's optical aspect system, calculations have been carried out for each species and have been used to convert the measured quantities to the ambient values presented here. The contribution of residual gas has also been taken into account.

The absolute accuracy of the number density data is $\pm$ 40 percent reflecting laboratory vacuum calibration error and the uncertainties in the ambient number density calculations. The relative accuracy of the data obtained for similar angles of attack is about 5 percent; for data obtained under conditions where the angles of attack differ by 70 degrees or more, the relative accuracy is about 30 percent. The mean mass data and the concentration ratios are good to $\pm$ 10 percent. Since the relative accuracy of the number density varies with the angle of attack, a data table is included which lists this quantity, the local sun time and other pertinent information.

Data

Figure 1 shows the ambient number densities of the major constituents plotted as a function of altitude for a number of different local times and locations. A single satellite interrogation (pass) is indicated by two data points joined by a straight line for molecular nitrogen and atomic oxygen and by one point for helium. The Nicolet model (private communication) is included for reference.

For the times concerned, the number densities of helium and atomic oxygen are comparable at about 600 kilometers, with helium predominant at higher altitudes. Between 300 km and about 600 kilometers, atomic oxygen is the major constituent, while in the 250 km to 300 km region, molecular nitrogen and atomic oxygen have nearly equal concentrations.

There is, at present, insufficient daytime data to determine scale heights for the sunlit atmosphere. However, during the night at higher altitudes, the concentration gradients are consistent with the scale heights for temperatures of 700° to 750°K.

There appears to be a deviation from nighttime diffusive equilibrium in the 300-350 km altitude range for N_2. This may be indicative of longer times required for N_2 to diffuse at these altitudes; however, as noted above the data shown are representative of many times and geographic locations and may not provide an accurate instantaneous vertical distribution. It is interesting to note that the data corresponding to passes 167, 182 and 183, for which the densities are higher than other nighttime passes, were obtained shortly after a minor magnetic disturbance which occurred on April 14. All data shown are measured values and are not averaged or smoothed in any way.

Figure 2 shows the variation of mean molecular mass with altitude. These data were calculated using the measurements of helium, atomic oxygen and molecular nitrogen only, other measured gases providing a negligible contribution to the mean mass. However, the presence of hydrogen, which the instrument was not designed to measure, would reduce the value of the mean mass somewhat at higher altitudes.

The total mass density, shown in Figure 3, was computed by summing the contributions from molecular nitrogen, atomic oxygen and helium. The results obtained in this way agree with the densities obtained independently by the pressure gauge experiments on Explorer XVII. This agreement lends support to the calculations relating the concentrations in the sampling region to the ambient number densities, as the pressure gage kinetics have been studied extensively (Horowitz). Also, the total density measurements from the mass spectrometers agree in general within a factor of two with atmospheric density calculated from satellite drag observations (Bryant, 1964).

Figure 4 shows the variation with altitude of the concentration ratios of helium to atomic oxygen and atomic oxygen to molecular nitrogen.

Pass & Station	Date	Local Time	α	Mag. Lat.	Mag. Long.
#15 BP	4/4/63	21.15 hrs.	6°	50°	-6.5°
#50 Col	4/6/63	0.65	16°	57°	-96°
#80 Col	4/8/63	0.99	9°	56.5°	-95°
#80 FTM	4/8/63	4.89	63°	28°	-24.5°
#118 BP	4/10/63	18.81	70°	46.5°	-2.5°
#120 GF	4/11/63	20.32	51°	60.5°	-37°
#138 BP	4/12/63	2.51	12°	49°	-17°
#152 BP	4/13/63	2.01	14°	50.5°	1.5°
#167 BP	4/14/63	1.65	20°	51°	-7°
#182 BP	4/15/63	1.54	25°	48.5°	-10.5°
#183 QUI	4/15/63	3.26	23°	16°	-10°
#197 BP	4/16/63	1.43	27°	45°	-14°
#211 BP	4/17/63	0.53	45°	53°	-2.5°
#226 BP	4/18/63	0.48	53°	50°	-5.5°
#241 BP	4/19/63	24.19	62°	49°	-12°
#243 Moj	4/19/63	0.64	54°	37.5°	-58°
#254 NFL	4/20/63	22.75	82°	59.5°	21.5°
#270 BP	4/21/63	23.30	80°	52.5°	-2.5°
#271 GF	4/21/63	22.88	85°	54.5°	-39.5°
#708 NFL	5/20/63	7.18	39°	60°	27°
#795 OOM	5/26/63	15.81	63°	-44°	-148°
#800 JOB	5/26/63	15.90	65°	-36.5°	80°
#888 JOB	6/1/63	13.24	33°	-27°	88.5°

The local sun time, angle of attack, magnetic latitude and longitude are averaged over the 4 minute pass. The stations involved are: BP-Blossom Point, Md.; COL-College, Alaska; FTM - Fort Myers, Fla.; GF - Grand Forks, Minn.; QUI - Quito, Equador; MOJ - Mojave, Calif.; NFL - Newfoundland; OOM - Woomera, Australia; JOB - Johannasburg, South Africa.

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3. Spencer, N. W. and C. A. Reber, A Mass Spectrometer for an Aeronomy Satellite, Proceedings of the Third International Space Science Symposium, Washington, D. C., May 1962.

4. Horowitz, R. and D. Kleitman, A Method for Determining Density in the Upper Atmosphere During Rocket Flight, Naval Research Laboratory. Report 4246, Washington, D. C.

5. Bryant, R., Densities Obtained from Drag on Explorer XVII,J. Geophys. Res. 69, 1423-1425, 1964.

Figure 1 - Ambient number densities of the major constituents vs. altitude. These data include many local times and geographic locations. The numbers for each pass refer to the orbit number and are referenced in Table 1. Nicolet's model for T = 700°K is included for reference.

Figure 2 - Mean molecular mass vs. altitude. The mean mass was calculated using the three major constituents measured, N_2, O and He. Nicolet's model is included for reference. Day and night passes are indicated by open and shaded data points.

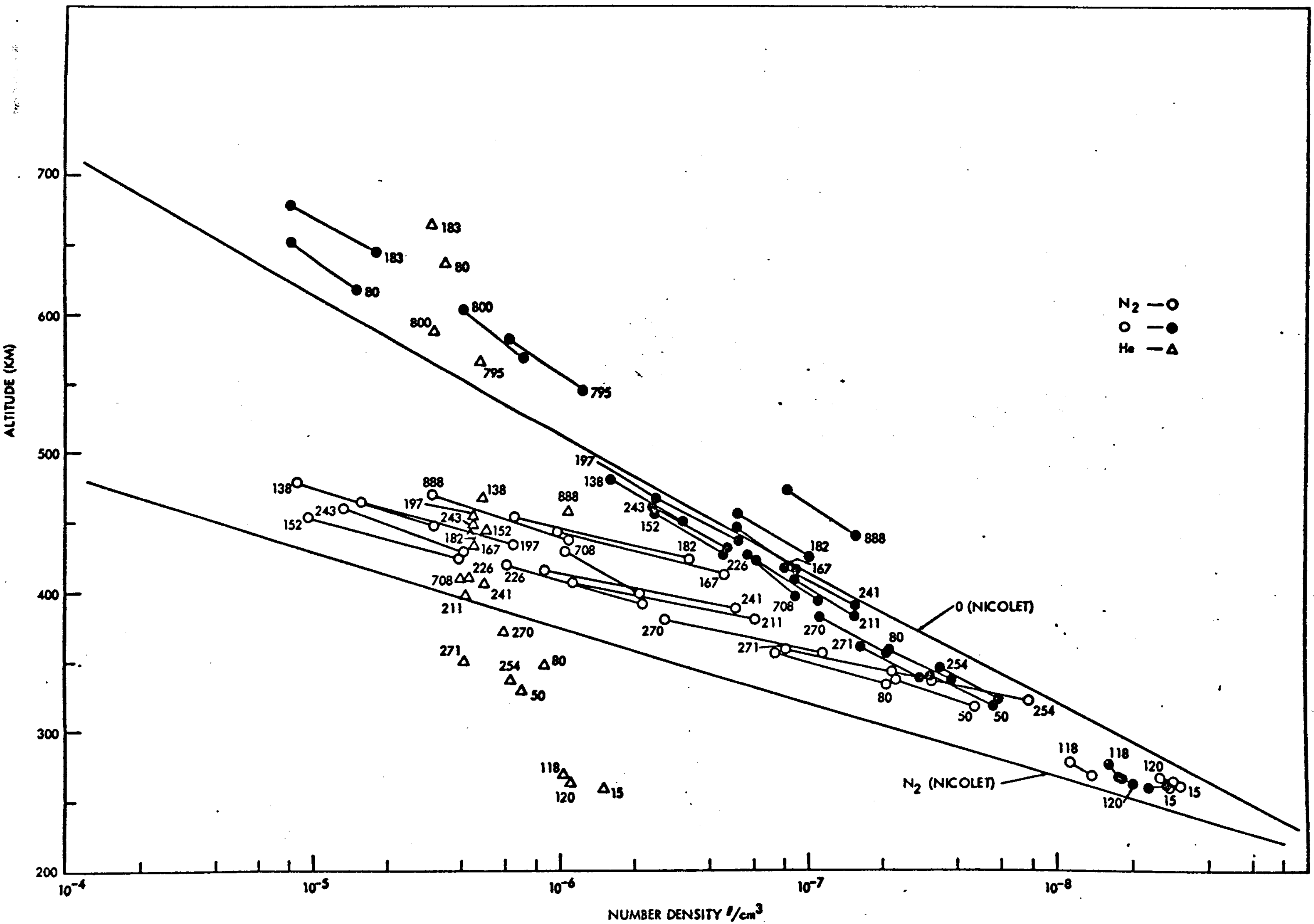
Figure 3 - Total mass density vs. altitude. The total mass density was calculated using the densities for N_2, O and He. The numbers for each pass refer to the orbit numbers referenced in Table 1. Nicolet's model is included for reference.

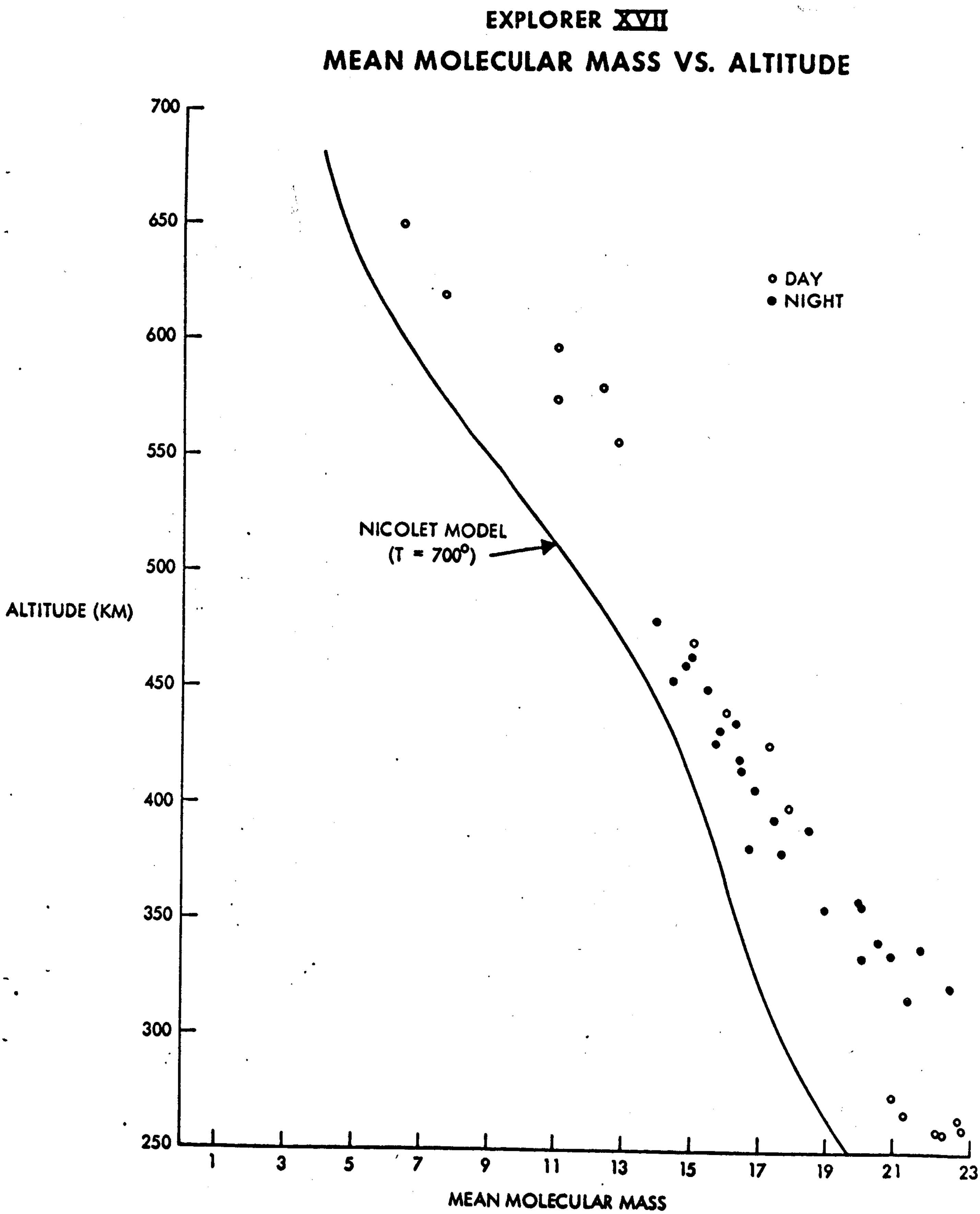
Figure 4 - Concentration ratios of the major constituents vs. altitude. Day and night passes are indicated by open and shaded data points.

Acknowledgement

I am indebted to Professor Marcel Nicolet for many hours of stimulating discussions regarding the data from Explorer XVII, particularly with respect to extracting the scientifically interesting from the technically involved.

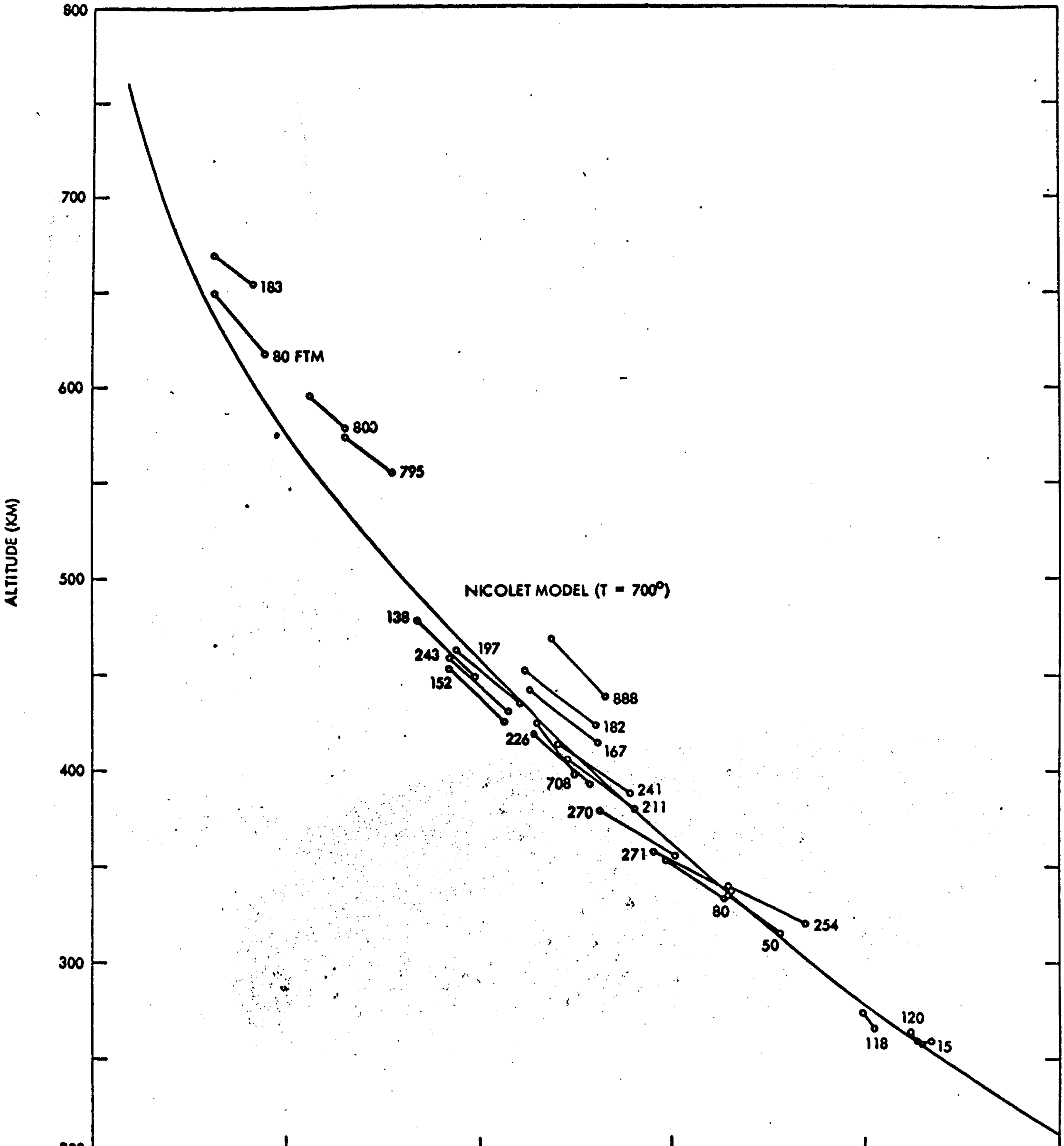
EXPLORER XVII
NUMBER DENSITY VS. ALTITUDE




EXPLORER XVII
MEAN MOLECULAR MASS VS. ALTITUDE
700
650
600
550
500
450
400
350
300
250
ALTITUDE (KM)
o DAY
• NIGHT
NICOLET MODEL
(T = 700°)
1
3
5
7
9
11
13
15
17
19
21
23
MEAN MOLECULAR MASS

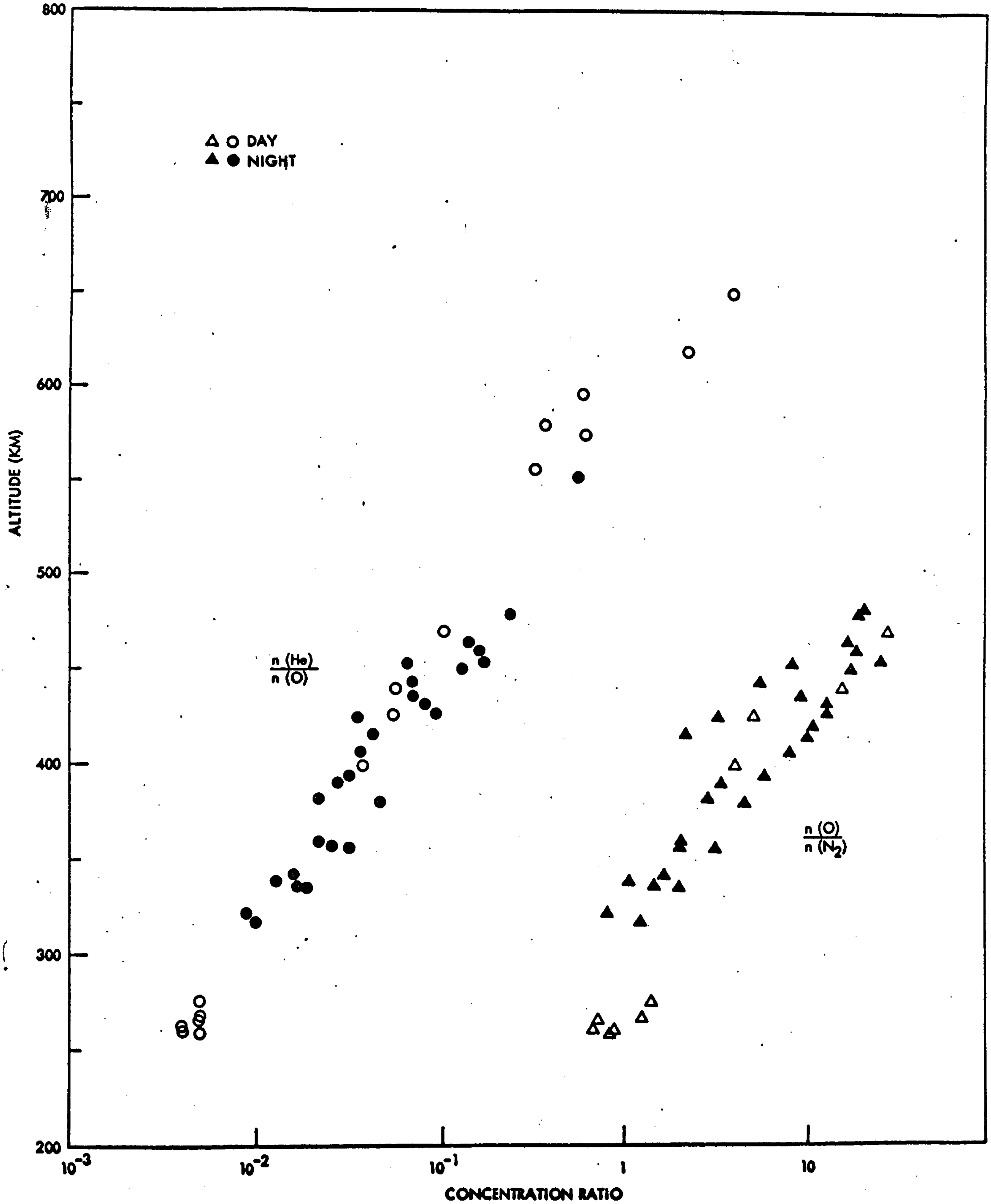
EXPLORER XVII

MASS SPECTROMETER TOTAL MASS DENSITY VS. ALTITUDE



EXPLORER XVII

CONCENTRATION RATIOS VS. ALTITUDE



The purpose of this letter is to present the initial atmospheric densities directly measured by the ionization gauges on the Explorer XVII satellite. The satellite has been described (Horowitz, 1963) and the gauges and their response to the atmosphere have also been reported (Newton, Pelz, Miller, Horowitz, 1963). The data presented in this letter were obtained with two types of ionization vacuum gauges, the hot-filament thermionic type (Bayard-Alpert) and the magnetron type (Redhead). The absolute accuracy of these data is believed to be $\pm$ 35 percent and the repeatability is $\pm$ 20 percent. A more complete discussion of the experiment will be included in a paper now in preparation (Newton, Horowitz, Priester, 1964).

The density data from 47 operations of the satellite in the altitude range of 255 km to 330 km for local times between 0700 and 2100 hours are plotted as a function of altitude in Figure 1. These data were recorded by the five northern mid-latitude minitrack stations:

(1) Blossom Point, Md.

(2) Grand Forks, Minn.

(3) Majove, California

(4) St. Johns, Newfoundland

(5) Winkfield, England

ATMOSPHERIC DENSITIES FROM EXPLORER XVII DENSITY GAUGES AND A COMPARISON WITH SATELLITE DRAG DATA

BY

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At the times the measurements were made, the daily planetary geomagnetic index (A_p) was between 0 and 50 and the 10.7-cm solar index ($F_{10.7}$) was between 70 and 100 x 10^{-22} w/m^2 cps. It is seen from Figure 1 that there is considerable variation in the atmospheric density at a given altitude (that is, greater than a factor of 3 at the altitude of 280 km) which is due in part to local time, geomagnetic activity, and solar activity effects.

To compare the directly measured densities with densities inferred from satellite drag, it is desirable to reduce the data to geomagnetically quiet conditions. In this regard, consider Figure 2 which shows $\Delta \log \rho$, the logarithm to the base ten of the ratio of the measured density to the Harris and Priester model density selected for the appropriate time and altitude, plotted versus the daily geomagnetic index (A_p). These points represent 120 density-altitude profiles for altitudes between 255 and 600 km and most local times; the data were recorded over the same five minitrack stations as the data presented in Figure 1. The darkened symbols represent an average of two or more passes within one day and the light symbols represent one pass. The passes have been individually corrected to an $F_{10.7}$ of 83 using Roemer's (1963) formula. The semiannual variation of the atmospheric density has been accounted for in an approximate way by decreasing the model densities by 18 percent for May and June 1963. An "eyeball" average of the data shows (a) that the relation between $\Delta \log \rho$ and A_p is nonlinear with the steepest slope applicable to the smaller A_p values, and (b) that the atmospheric density values are more sensitive to geomagnetic disturbances than has previously been reported. Very recently, Jacchia and Slowey (1964a) found independently that for near-quiet geomagnetic conditions the reaction of the atmosphere to variations in A_p is considerably larger than expected, based on their previous analyses.

Figure 3 shows the logarithm to the base ten of the gauge densities, at the average time and altitude of the pass, plotted versus local time and normalized to 280 km using the Harris and Priester model for S = 90 as a differential altitude transformer. Shown for comparison purposes are the densities obtained from drag observations of Injun 3 (Jacchia, Slowey, 1964b) and Explorer XVII (Bryant, 1964), and the Harris and Priester model with S = 90. The drag data have also been normalized to the 280 km altitude.

The Injun 3 drag data, indicated by squares, were selected for quiet geomagnetic conditions ($A_p \leq 2$) for the time interval of February 18 through June 30, 1963, when the latitude of the satellite varied between - 40 degrees and + 60 degrees. The Explorer XVII drag data, indicated by crosses, correspond to the time interval from April 3 to July 6, 1963, when the satellite perigee was between + 58 degrees and - 20 degrees.

The relation shown in Figure 2 has been used to adjust both the Explorer XVII drag-determined and gauge-measured densities to geomagnetically quiet conditions ($A_p = 2$). The Explorer XVII densities also have been normalized to a 10.7-cm solar index of 83, a small adjustment compared to those associated with the A_p. The A_p adjustment resulted in:

(a) A decrease of approximately a factor of 2 in the apparent scatter between the gauge-measured density values.

(b) A lowering of the average of the gauge-measured densities by a factor of 0.7.

(c) A lowering of Bryant's drag densities by approximately 60 percent.

It is seen in Figure 3 that the atmospheric densities determined by satellite drag techniques appear to be systematically higher by a factor of 2 than the adjusted gauge densities. This difference is greater than the combined uncertainties assigned to the separate sets of data and would seem to be due to a systematic error in one or both of the measurements. While the difference is not regarded as a serious discrepancy between the two techniques, it is large enough to require a re-examination of the measurements made by each.

A more detailed presentation of the atmospheric density data from these five minitrack stations and their geophysical interpretation is in preparation (Newton, Horowitz, Priester, 1964). The presentation will include (1) data of considerably greater altitude and local-time coverage, and (2) density scale-height computations. In addition, data from the other eight minitrack stations for the complete Explorer XVII orbit (perigee 255 km, initial apogee 920 km, 58 degrees inclination) are currently being analyzed and will be reported.

Acknowledgements

We wish to thank Mr. Nelson W. Spencer, Goddard Space Flight Center, for helpful discussions in the preparation of this letter.

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Figure 1 - Atmospheric density versus altitude measured by the Explorer XVII density gauges during 47 operations of the Satellite. The densities were measured for times between 0700 and 2100 hours, with A_p varying between 0 and 50, and with $F_{10.7}$ varying between 70 and 100×10^{-22} w/m^2 cps.

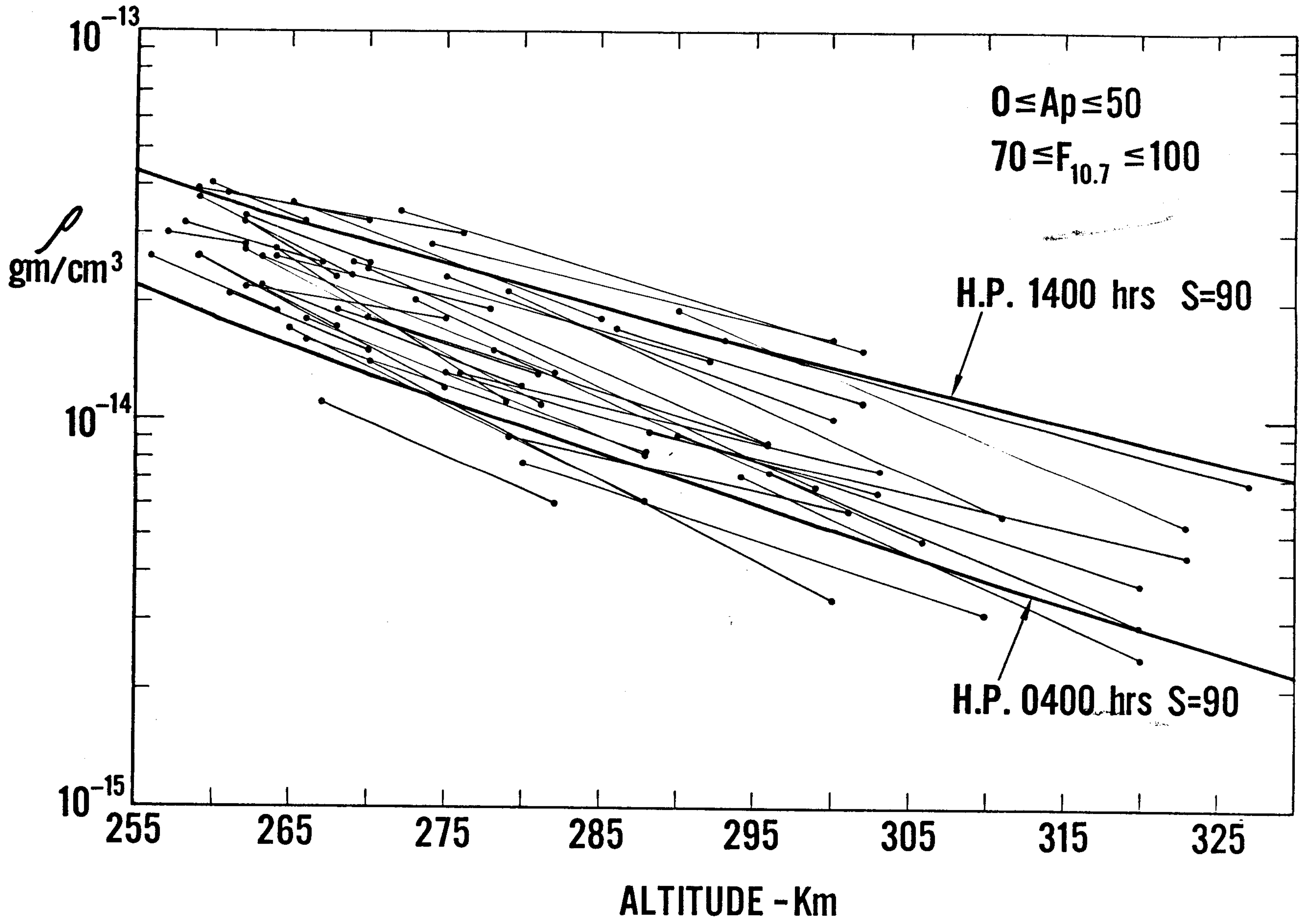
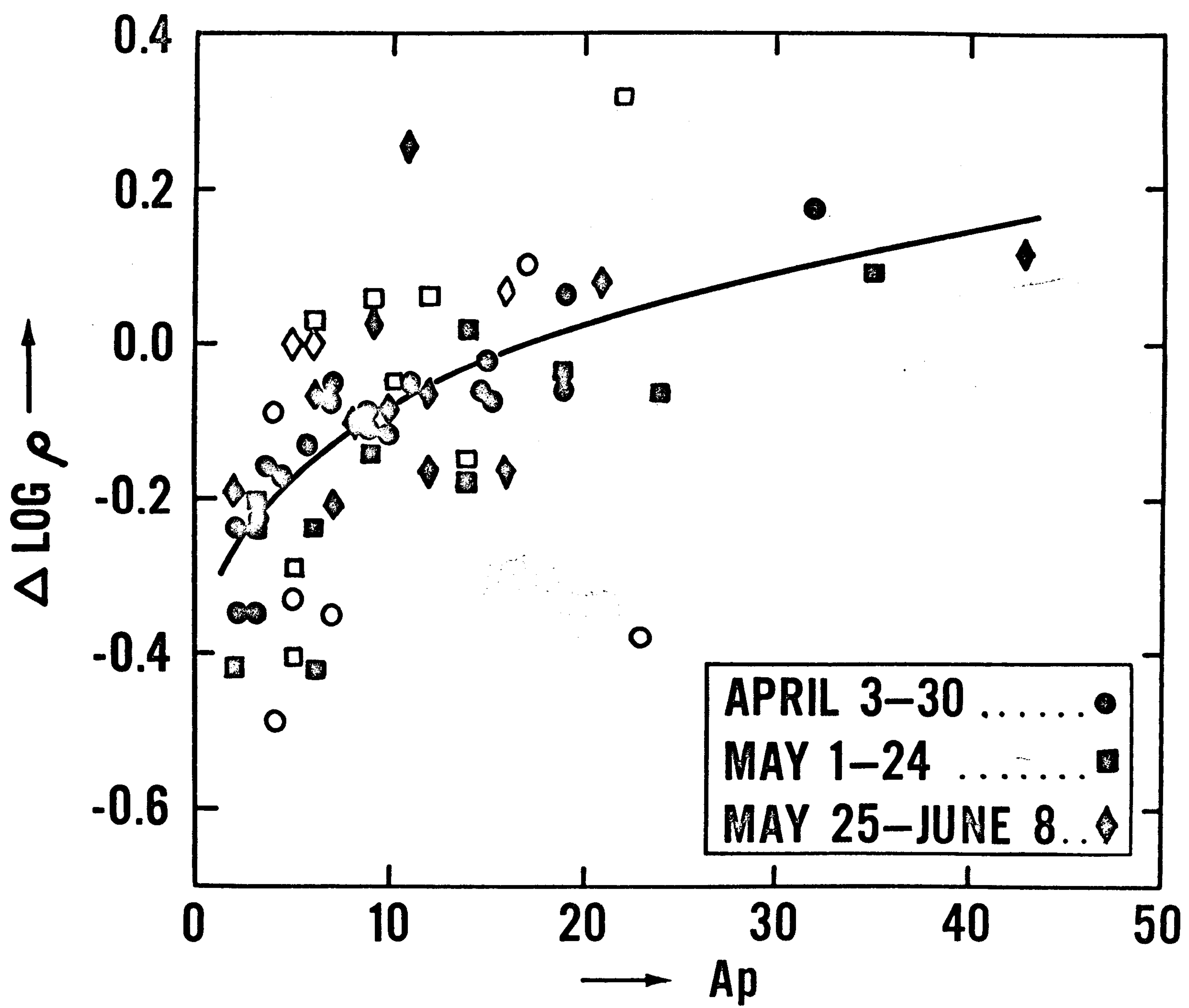
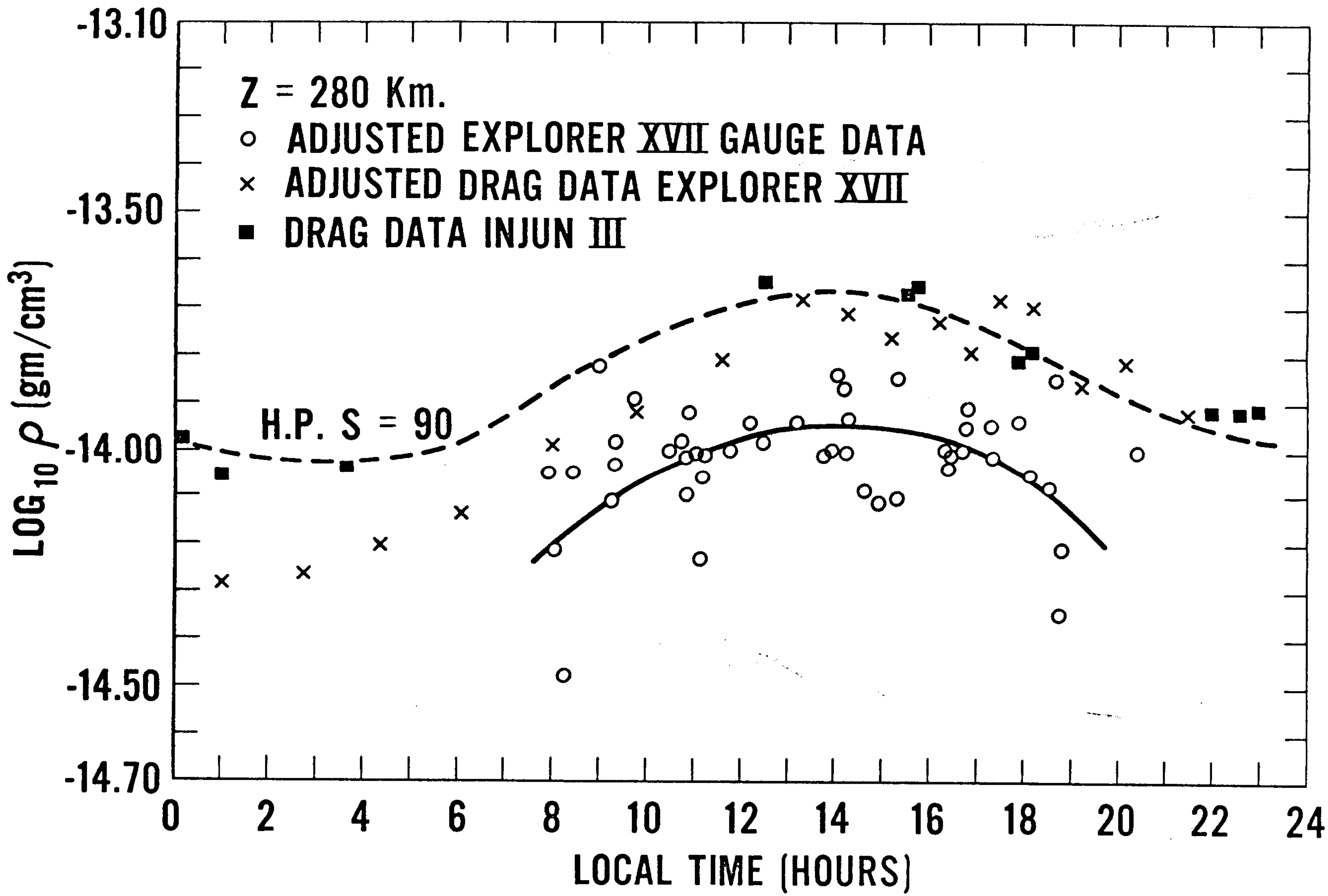

10^{-13}
ρ gm/cm^3
10^{-14}
10^{-15}
$0 \leq Ap \leq 50$
$70 \leq F_{10.7} \leq 100$
H.P. 1400 hrs S=90
H.P. 0400 hrs S=90
255
265
275
285
295
305
315
325
ALTITUDE - Km

Figure 2 - Daily average of the logarithms of the ratios of the gauge measured density to the Harris and Priester model density, plotted against daily geomagnetic A_p index. Solid symbols represent averages of measurements obtained from two or more passes of the satellite over the telemetry stations. Open symbols represent single passes. The data have been adjusted to correspond to $F_{10.7} = 83$. The semi-annual variation of the atmospheric density has been accounted for in an approximate way by decreasing the model densities by 18 percent for May and June 1963.



0.4
0.2
0.0
-0.2
-0.4
-0.6
Δ LOG ρ
0
10
20
30
40
50
Ap
APRIL 3—30
MAY 1—24
MAY 25—JUNE 8

Figure 3 - Logarithms of densities normalized to an altitude of 280 km versus local time. Injun 3 data are selected for geomagnetically quiet conditions. Explorer XVII data are adjusted to $A_p = 2$ using relation shown in Figure 2, and for an $F_{10.7}$ corresponding to 83.


Z = 280 Km.
ADJUSTED EXPLORER XVII GAUGE DATA
ADJUSTED DRAG DATA EXPLORER XVII
DRAG DATA INJUN III
H.P. S = 90
LOG$_{10}$ ρ (gm/cm^3)
-13.10
-13.50
-14.00
-14.50
-14.70
0
2
4
6
8
10
12
14
16
18
20
22
24
LOCAL TIME (HOURS)

FIRST ELECTROSTATIC PROBE RESULTS FROM EXPLORER XVII

by

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Introduction

On April 3, 1963, the Explorer XVII satellite was launched into a 58 degree inclination direct orbit having perigee and apogee altitudes of 258 and 927 kilometers, respectively. In addition to the neutral particle instruments (Spencer, Reber, 1963) (Newton, et.al., 1963), two cylindrical electrostatic probes were employed; one for the measurement of electron temperature (T_e) and the other for determining the positive ion density (N_i). The purpose of this letter is to report the variations in T_e and N_i observed above the Blossom Point, Maryland, telemetry station (latitude 38°N, longitude 77°W), and to present a brief discussion of the more immediate conclusions that can be drawn from the data.

The Experiments

Figure 1 is a block diagram illustrating either of the two independent probe instruments. Both instruments employ a two-element sensor consisting of a 10-cm long guard electrode, concentric with a collector electrode 0.056 cm in diameter and 23 cm long. The collector and guard electrodes were insulated from each other and from the satellite, which served as the reference electrode. An appropriate sawtooth voltage was applied to both collector and guard elements, but only the current to the collector was measured and telemetered. Voltage sweep rates, current sensitivities, and telemetry sampling rates were optimized to permit a measurement of T_e in approximately 50 milliseconds, corresponding to negligible translational and rotational motion of the satellite. The volt-ampere characteristics resulting from operation of the instruments thus permitted computation of electron-temperature and ion-density values, which can be considered measurements at a point.

Figure 2 shows a series of raw telemetry points from the T_e experiments which demonstrate the measurement resolution. The computational technique employed has been reported. (Langmuir, Mott-Smith, 1924) (Taylor, Brace, Brinton, Smith, 1963) (Nagy, Brace, Carignan, Kanal, 1963).

To permit greater confidence in the measurement accuracy of the Explorer XVII probe technique, a rocket (NASA 6.07) carrying an ejectable instrumentation employing a probe sensor identical to that of Explorer XVII was launched concurrent with a satellite pass at Wallops Island, Virginia. An ionosonde was also operating simultaneously nearby. The ionosonde and rocket probe data agree with the satellite data within a few percent, indicating that the satellite motion did not perturb the temperature and density measurements. A more detailed documentation of the rocket/satellite experiment will be provided in a later paper.

The Blossom Point Data

During its 100-day operational lifetime (April 3 to July 10, 1963), Explorer XVII was interrogated successfully about 650 times, most responses providing 4 minutes of measurements along the satellite path. The Blossom

Point (BP) passes, to be presented here, provided dense coverage over the eastern United States. During the active lifetime of the satellite, the latitude of perigee, initially 38°N, moved to its maximum northward excursion of 58 degrees, then moved southward, reaching 22°S at the time of battery exhaustion. Accordingly, most of the BP measurements were made near perigee and thus generally represent the F_2 region between 258 and 400 kilometers. Changes in T_e and N_i during these passes reflect latitude and/or local apparent time effects (approximately 10 degrees of latitude and 1 hour of local time) and not altitude change. These changes within passes are evident in Figure 3 which shows data measured over a 3-month period. The individual points connected by solid lines are the values of T_e and N_i measured at the beginning and end of some of the individual 4-minute passes. Most of these data are from southward passes during which a consistent decrease in T_e and an increase in N_i are observed. The reverse changes are observed within the northward passes, confirming that the change observed within the pass is a latitude effect. By drawing smooth curves through the end values of T_e and N_i from the individual passes in Figure 3, the gross diurnal variation at the extremes of latitude reached in the BP passes (40 to 55° North Magnetic) is made evident.

Several general characteristics of the ionosphere are also evident in Figure 3:

1. A steep morning rise in T_e and a more gradual rise in N_i.
2. A morning maximum in T_e (about 5 hours after local sunrise) and a continuing gradual rise in N_i during the day.

3. A decrease of T_e to an afternoon plateau (its value depending upon latitude) and a late afternoon maximum of N_i.

4. A possible minor maximum of T_e during late afternoon

5. A steep decline of both T_e and N_i at sunset

6. A nighttime plateau of T_e at about 1150°K, but moderately variable, and a relatively constant value of N_i.

Although the data at other sites have not been completely analyzed, they appear to exhibit the same gross characteristics as the data from Blossom point, the major differences being in the time of the morning T_e maximum and the value of T_e during the afternoon plateau.

Geophysical Implications of the Blossom Point Data

If one considers the neutral gas temperature (T_g) to be between about 700°K (at night) and 1000°K (daytime), the Figure 3 data show that thermal nonequilibrium is the normal condition near the F_2 maximum, both day and night. Thus, the Explorer XVII data confirm the author's earlier conclusions which were based on rocket probe data (Boggess, et.al., 1959) (Spencer, et.al., 1962) (Brace, et. al., 1963) that (a) the ionosphere is not in thermal equilibrium and (b) the degree of nonequilibrium is greater in the auroral zone than at midlatitudes.

The major implication of the nonequilibrium is that significant sources of local heating for the electrons are present and that some of these sources exist at night as well as during the day. This is borne out by calculations of the local electron heat flux density (Q) using the equation given by Hanson (1962),

$$Q = -\frac{3kN_e}{2}\left[\left.\frac{dT_e}{dt}\right|_{O} + \left.\frac{dT_e}{dt}\right|_{N_2} + \left.\frac{dT_e}{dt}\right|_{O_2} + \left.\frac{dT_e}{dt}\right|_{+}\right](\text{eV cm}^{-3}\text{ sec}^{-1}) \qquad (1)$$

where the derivatives represent the cooling rates of electrons to ions and to the indicated neutral species. In a calculation using the measured values of T_e and N_i, and the Harris and Priester model values (S = 90) for the neutral particle concentrations and temperatures, the locally deposited energy (Q) at 400 kilometers was determined to be approximately 250 eV cm^{-3} sec^{-1} at midday and 15 eV cm^{-3} sec^{-1} at night (Brace, Spencer, and Dalgarno, 1964). The daytime value is in reasonable agreement with the predictions of both Hanson (1962) and Dalgarno, et.al. (1963) but differs significantly from Ariel satellite data given by Wilmore (1964) who finds about 100 eV cm^{-3} sec^{-1} at 400 kilometers. The nighttime value of 15 eV/cm^{-3} sec^{-1} indicates a significant heating source, not yet identified.

The calculations further show that both the diurnal and latitudinal variations of electron temperature in the daytime ionosphere (Figure 3) are primarily reflections of corresponding variations in the local electron density (Willmore, 1964); thus there is no reason to believe that the observed latitude variation of T_e in the daytime is related to atmospheric heating by particles as a function of latitude (Willmore, et.al., 1962) (Spencer, et. al., 1962) (Brace, et. al., 1963).

It is particularly useful to compare BP data with the radar backscatter data of Evans (1964) because the measurements correspond to essentially the same latitude, longitude, and altitude. In March 1963, a month before the launch of Explorer XVII, Evans found that T_e/T_i, at 330 kilometers, reached a maximum value of 3 at midmorning, exhibited an afternoon plateau of about 2.3, and was variable between 1.3 and 2 at night. The satellite results at Blossom Point, expressed in terms of T_e/T_g, provide an esentially identical picture.

Inherent in this comparison of T_e/T_i and T_e/T_g is the assumption of equilibrium between ions and neutrals ($T_i = T_g$). In the altitude region below 400 kilometers where these data are compared, it is reasonable to make this assumption. However, as Hanson (1962) has pointed out, because the neutral particle scale height is less than the ion-electron scale height, the thermal contact between ions and electrons will predominate above some altitude and the ion temperature will approach that of the electrons. Hanson (1962), using an assumed model atmosphere, has calculated that T_i will exceed T_g above about 600 kilometers and approach T_e at 900 kilometers. Accordingly, T_i was predicted to lie about midway between T_e and T_g at 750 kilometers. Similar calculations using Explorer XVII BP data show that this transition occurs near 500 kilometers rather than 750 kilometers (Brace, Spencer, Dalgarno, 1964).

In summary, Explorer XVII measurements of T_e and N_i in the F_2 region above Blossom Point have shown that thermal nonequilibrium ($T_e > T_g$) is the normal condition both day and night and, further, that the degree of nonequilibrium is strongly latitude dependent in the daytime and moderately variable at night. The data also reveal a strong inverse relationship between the local values of T_e and N_i (or N_e), which is consistent with the equations employed by Hanson and Dalgarno in their studies of ionosphere heating. There is no evidence that the observed latitude dependence of T_e, seen in previous rocket flight data and apparent in Ariel satellite measurements, is related in an important way to particle fluxes at higher latitudes. Instead, the data suggest that the latitude dependence of T_e primarily reflects the global distribution of electron density and its controlling mechanism.

Reference

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FIGURE CAPTIONS

Figure 1 - Functional block diagram of either the T_e or N_i probe experiment. A sawtooth voltage applied to the guard and collector produces a volt-ampere characteristic from which either T_e or N_i can be derived depending upon the current sensitivity and sweep magnitude employed.

Figure 2 - Plot of raw telemetry data from T_e experiment during a night-time perigee pass at BP. The upper set of volt-ampere characteristics were measured by the 5-ua detector with a sweep of $0 \longrightarrow +1.5$ volts. The lower set, recorded a few seconds later, were measured by the 1-ua detector with a sweep of $0 \longrightarrow +0.75$ volts applied to the probe.

Figure 3 - Blossom Point results in the 260-400 kilometer altitude range. The points connected by lines represent values recorded at the beginning and end of particular passes. The inverse variation of T_e and N_i within individual passes has been identified with the latitude change in the pass.

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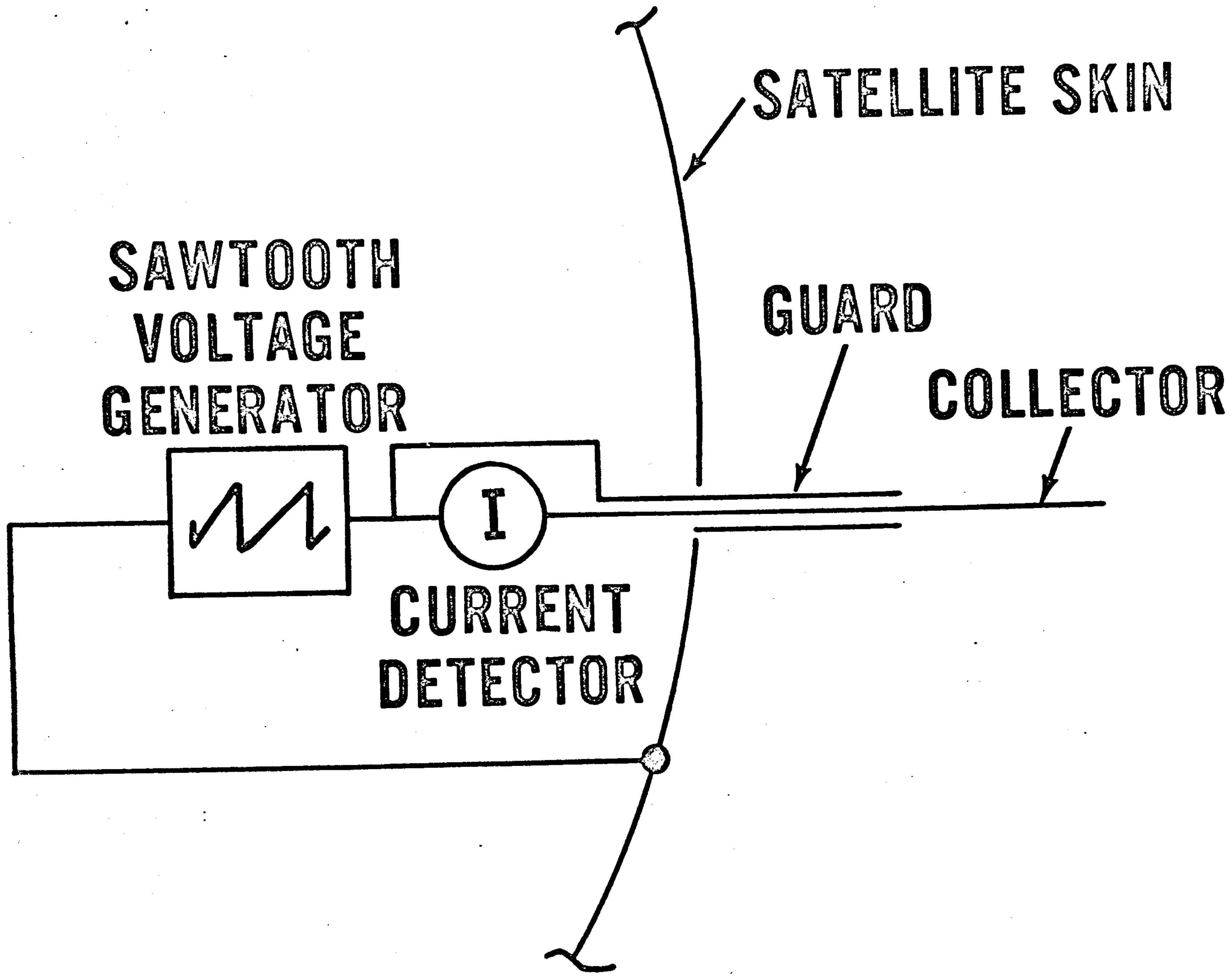
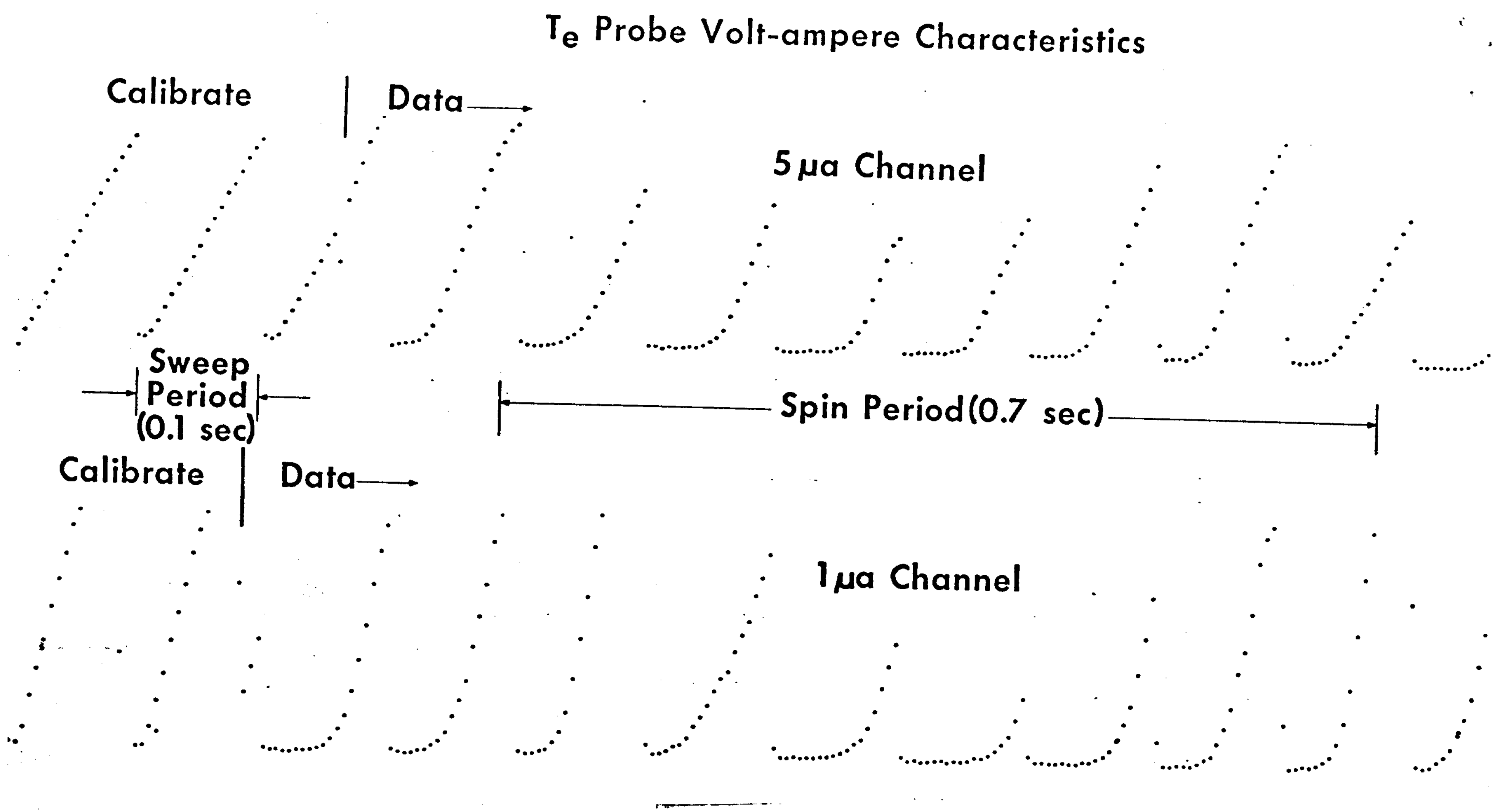
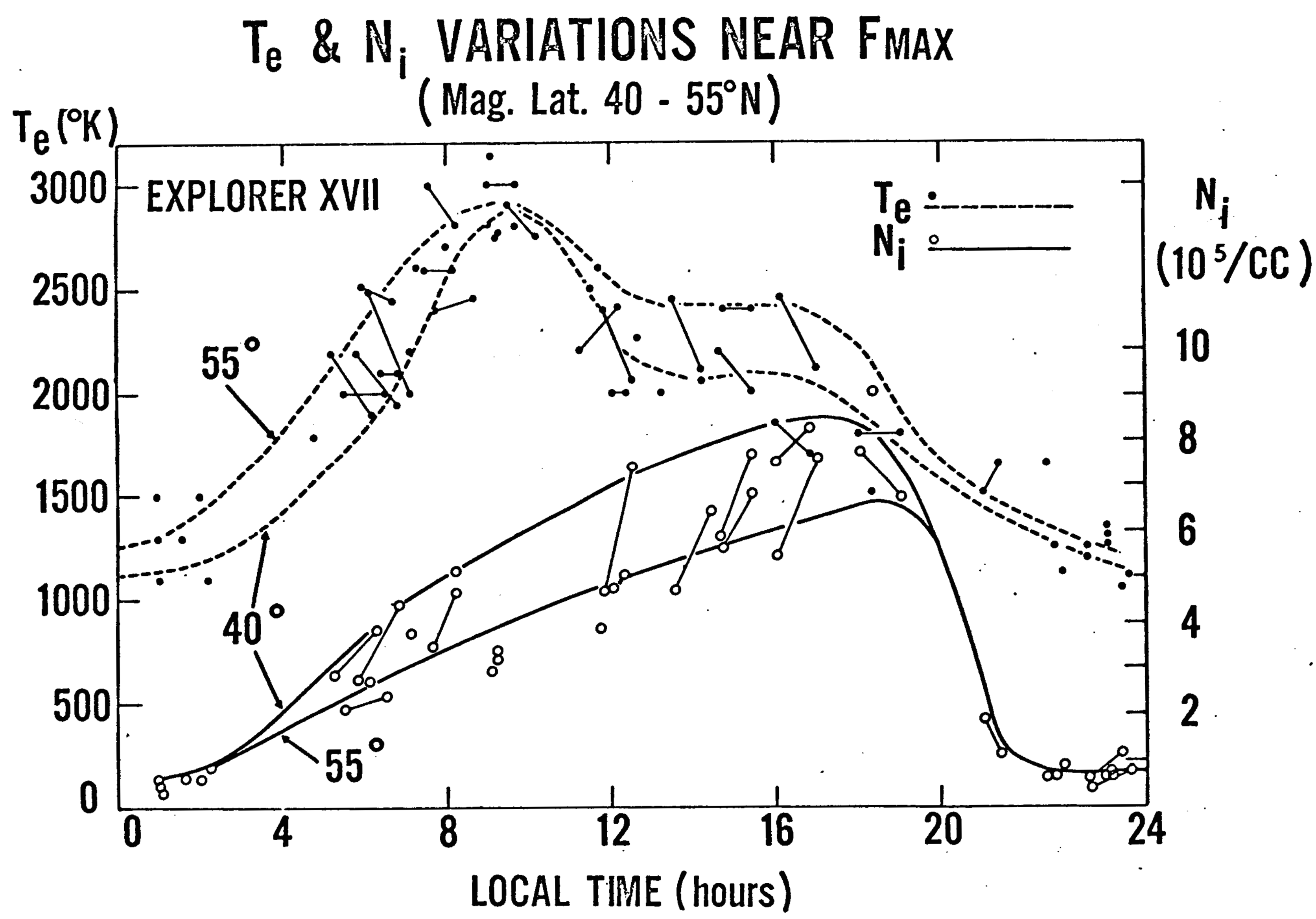

SATELLITE SKIN
SAWTOOTH
VOLTAGE
GENERATOR
GUARD
COLLECTOR
I
CURRENT
DETECTOR



T_e Probe Volt-ampere Characteristics
Calibrate
Data
5 μa Channel
Sweep Period (0.1 sec)
Spin Period (0.7 sec)
Calibrate
Data
1 μa Channel

2


T_e & N_i VARIATIONS NEAR FMAX
(Mag. Lat. 40 - 55°N)
T_e (°K)
3000
2500
2000
1500
1000
500
0
EXPLORER XVII
55°
40°
55°
T_e
N_i
N_i
(10^5/CC)
10
8
6
4
2
0
4
8
12
16
20
24
LOCAL TIME (hours)