PART I

SEMIANNUAL REPORT

NASA RESEARCH GRANT NGR 05-007-004

FOR THE PERIOD

JANUARY 1, 1969 - JUNE 30, 1969

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Part I: The Latest Semiannual Progress Report

Not attached

BACKGROUND INFORMATION

NASA research grant NGR 05-007-004 was awarded to the Institute of Geophysics and Planetary Physics of the University of California, Los Angeles, on March 1, 1962, for the support of a space-instrument development program. The participation of graduate students at the University is a basic part of this research effort.

The grant was renewed on July 1, 1963, with provision for a three-year step funding arrangement. Additional supplements have been provided in July 1964, July 1965, October 1966, October 1967, and October 1968.

The experimenters whose work is supported under this grant, in the course of this work, have participated or are participating in the Mariner-2, Mariner-4, Mariner-5, the satellites OV1-2 and OV1-12, both USAF, ATS-1, and the OGO-5 and OGO-6 projects. They are participating in preparations for flight experiments for the ATS-F and Pioneer/Jupiter spacecraft. Fabrication of the flight hardware for these experiments is usually funded under separate contracts.

During the reporting period magnetometer experiments were proposed for Apollo Lunar Missions, Phases I and II, and the Mariner Venus-Mercury Flyby. The proposal work was also supported under this grant.

SUMMARY OF WORK SUPPORTED WITH GRANT FUNDS

A. Particle Detectors Designed, Developed, or Fabricated at UCLA

1. Electron-Proton Spectrometer for Rangers 7, 8, and 9. This instrument was designed and developed at UCLA. Four units were fabricated under separate contract, calibrated, and delivered. They were not used because of a decision by NASA to concentrate on the television experiment.

2. Radiation Monitoring Instruments. Using some of the Ranger instrument concepts, we developed an electron spectrometer, a proton spectrometer, two similar proton threshold instruments, and an x-ray detector. All five of these were fabricated under separate contract and flown on the OV1-2 satellite. Another set of five were fabricated and used on the OV1-12 spacecraft. These instruments have been the chief source of scientific papers in the particle field which we have published to date.

3. OGO-5 Electron Spectrometer. The design and preliminary development of this instrument were performed under NGR 05-007-004 at UCLA. Fabrication was completed under separate contract, and the instrument is now operating satisfactorily in space. Preliminary organization and plotting of the first eight months of data are essentially accomplished, and analysis is proceeding.

4. OGO-5 Spectrometer for Air Force. The OGO-5 prototype instrument has been modified and delivered for Air Force use under a separate contract. A flight opportunity has not yet been assigned to this instrument.

5. OGO-6 Electron Spectrometer. Preliminary design of this instrument was accomplished at UCLA. The instrument is now operating in polar orbit on the OGO-6 spacecraft.

6. Low-Cost Electron Monitor. An inexpensive, lightweight, low-power electron detector has been designed and developed at UCLA with grant funds. One flight copy was built and delivered under separate contract to the Air Force during 1968. It is now in orbit and providing satisfactory data on the OV5-6 spacecraft.

7. High Speed Electron Detector. An electron detector to count at a maximum rate of 25 megapulses per second has been designed for use in the detection of fast variations associated with wave motion in the magnetosphere.

B. Magnetometers Designed, Developed, or Fabricated at UCLA

1. Mariner-4 Vector Helium Magnetometer. One of the investigators (Paul J. Coleman, Jr.) collaborated in the design, development, testing, and calibration of this magnetometer, which was on board Mariner 5 as well as Mariner 4. The magnetometer project was carried out at Jet Propulsion Laboratory. The efforts of the UCLA co-investigator were supported with funds from this grant.

2. ATS-1 Fluxgate Magnetometer. The design of this biaxial magnetometer was carried out under this grant. The

instrument is unique in that it provides measurements of the spin-axis vector component over a wide dynamic range with no sacrifice in resolution. Subsequent phases of the development and the fabrication, testing, and calibration were covered under a separate NASA contract.

3. OGO-5 Fluxgate Magnetometer. The design of this triaxial magnetometer was performed under this grant. The unique features of this instrument are a dynamic range of ±64,000 γ and a resolution of 0.12 γ over the entire range. As in the case of the ATS-1 magnetometer, the rest of the work through the delivery of the flight hardware was funded under a separate NASA contract.

C. Acoustic Detectors

The development of an extremely sensitive acoustic detector was funded in part under this grant. The detector has been used to study the effects of man-made disturbances in the ionosphere upon the atmospheric pressure at the surface as well as various natural phenomena.

D. Scientific Satellite

The preliminary design of a scientific satellite was supported under this grant. Subsequent phases of the design study have been carried out under a separate NASA contract.

E. Related Work

1. Studies of Magnetometer Noise. An investigation of the effects of probe hysteresis in fluxgate magnetometers was supported with grant funds. The results were published as a Master's thesis.

2. Magnetically Shielded Test Facility. A magnetically shielded room was designed with support from this grant. The construction and installation were paid for with funds from another NASA grant.

F. Data Reduction and Analysis

1. Mariner 2. Reduction and analysis, at UCLA, of data from the Mariner-2 magnetometer were funded under this grant.

2. Mariner 4. The preliminary reduction of the data from the Mariner-4 magnetometer was supported with funds from this grant.

3. ATS-1. Beginning October 1, 1968, the reduction and analysis of data from the ATS-1 magnetometer was funded under this grant.

PROGRESS DURING THE REPORTING PERIOD

A. Charged Particle Research

1. Electron Spectrometer for OGO 5. The UCLA OGO-5 experiment includes six directional electron detectors as well as a magnetometer. The OGO-5 spacecraft was launched on March 4, 1968. The experiment is operating properly at this time (August 14, 1969). A comprehensive data reduction program is proceeding smoothly, and a paper incorporating some first conclusions was presented at the American Geophysical Union meeting in April, 1968. All costs of the OGO-5 program are being borne by a separate project contract.

2. Electron Spectrometer for OGO-6. OGO 6 was launched during the reporting period. Early quick-look data indicate that one of seven detectors suffered a large gain loss of unknown origin shortly after turn-on. The other detectors are working properly, and computer programs are being prepared to organize and plot the data in a manner similar to OGO 5.

3. 40 kev Electron Monitor. This instrument was launched into a highly elliptical orbit on OV5-6 during the reporting period. Preliminary inspection of the data reveals proper operation, but the bulk of the data is not yet available.

4. High Speed Electron Detector for S^3 Satellite. The principal laboratory effort in the charged particles area has been the continuing design of the high speed electron detector

which we have proposed for use on the S^3 satellite. The development has been so successful that we have increased the maximum count rate capability to 25 megapulses per second. This work has been the responsibility of a graduate student of engineering under a NASA traineeship. The task has been completed and a complete operational breadboard has been constructed and tested. The student will receive a Ph.D. in the Engineering Department, with this work constituting his dissertation.

The breadboard consists of a three-stage amplifier, fixed threshold device, a fixed dead-time circuit, and appropriate high speed, low power flip-flops for buffer purposes. Only two amplifier stages are required for the electron detector, while all three are required for the solid-state proton detector version, which otherwise uses the same electronics.

5. OV1-2 and OV1-12 Radiation Instruments. During the period, two more scientific papers utilizing data from these instruments have appeared in the *Journal of Geophysical Research*. Copies of all of the four papers which have used data from these instruments have been sent to NASA Headquarters. These publications complete the basic effort from these experiments, although they have stimulated an interest in radial diffusion of both electrons and protons which

is being pursued with other data.

Magnetic tapes containing all of these data, as well as the ephemeris, have been forwarded to the Space Science Data Center in accordance with the agreement made with NASA when analysis of these data was funded by NASA.

B. Magnetic Fields Research

1. Introduction. The research activities to be discussed in this section are directed primarily toward the study of magnetohydrodynamic phenomena in the tenuous plasmas above the ionosphere and in interplanetary space. A secondary goal of the research is the direct measurement of the magnetic fields of planetary bodies. The work includes the development of the instruments with which to obtain such measurements and in some cases the reduction and analysis of data obtained with these instruments.

2. Instrument Development. In the magnetometer development project the effort to develop a new synchronous demodulator for fluxgate magnetometers was continued. In the new design, active (transistorized) circuits would replace the transformers in the old demodulator. This change should result in reductions in weight and power and an increase in reliability. During the reporting period a breadboard of the demodulator was completed.

3. Experimental Studies.

a. Alouette 1. Some interesting lines have been found in the ionograms from the topside sounding satellite, Alouette 1. The origin of these lines is presently unknown although there has been considerable speculation. During the reporting period the analysis of the ionograms was continued as part of a doctoral research project.

b. ATS 1. The ATS 1 project at UCLA was transferred to this grant on October 1, 1968. The synchronous, equatorial satellite ATS 1 carries a UCLA magnetometer. During the reporting period the analysis of substorm related phenomena was extended. However, most of the effort of project personnel was directed toward developing faster data reduction programs on the recently installed IBM 360-91 computer.

4. Theoretical Studies - The Solar Wind. From the Weber-Davis model of the solar wind expansion and observations of plasma fluctuations, a model for the density fluctuations in the solar wind is being developed. Further studies of the angular momentum associated with low frequency fluctuations in the solar wind rely upon measurement of the specific ways in which the density, velocity, Alfven speed, and density fluctuations depend upon radial distance. During the reporting period work on this problem continued.

Also, studies of solar wind expansion, including rotational and electromagnetic effects, were continued. One of these studies is a doctoral research project.

C. Proposals

During the reporting period six proposals were produced by the group supported under this grant. These proposals were submitted to NASA in response to NASA "Announcements of Flight Opportunities". One was a proposal for a magnetometer for the Mariner Venus-Mercury Flyby Mission. The other five proposals, for the Apollo Lunar Missions, were: Magnetometer experiment for Phase I, magnetometer experiment for Phase II, UCLA subsatellite for Phase II, experiment payload for Phase II, and a magnetometer experiment intended for the subsatellite proposed by Professor Kinsey A. Anderson, University of California, Berkeley.

D. Student Participation

A basic purpose of our research is to make it possible for students to participate in scientific experiments within the rapidly developing field of space science. The following graduate students have participated in our programs during the period covered by this report:

1. Joseph Barfield, Department of Planetary and Space Science. Mr. Barfield is studying the physics of the magnetosphere and the interplanetary medium.

2. J. Dale Barry, Department of Planetary and Space Science. Mr. Barry has been studying spectral lines recently discovered in the ionograms from Alouette II.

3. Mac C. Chapman, Department of Planetary and Space Science. Mr. Chapman has participate from the beginning in the program of radiation monitoring instruments for the Air Force satellite. The results of these successful experiments will be incorporated into Mr. Chapman's Ph.D. dissertation.

4. Donald Childers, Department of Physics. Mr. Childers is studying the physics of the magnetosphere. He is presently working with data from ATS 1.

5. Neal M. Cline, Department of Mathematics. Mr. Cline has been responsible for the development of a number of programs employed in the analysis of data from the Mariners.

6. Alan Eskovitz, Department of Engineering. Mr. Eskovitz is developing the instrumentation for the charged

particle instrument for the UCLA satellite project. This work is a doctoral research project.

7. Kenneth Lee, Department of Physics. Mr. Lee is studying the physics of the magnetosphere and interplanetary space, using data from OGO 5.

8. John Schieldge, Department of Meteorology. Mr. Schieldge is concerned with the interaction of the solar wind with the magnetosphere.

9. Lawrence Sharp, Department of Planetary and Space Science. Mr. Sharp's efforts are focused on the development of spacecraft magnetometers.

10. Mr. Paul J. Sroka, Department of Planetary and Space Science. Mr. Sroka is working with ground-based and satellite observations of magnetospheric substorms.

11. Albert Tomassian, Department of Planetary and Space Science. Mr. Tomassian has undertaken a definitive study of the phoswich circuit developed in our laboratory and used on the Air Force radiation monitoring instruments. Mr. Tomassian continues to work in the broad area of charged particle detection.

12. Ray Walker, Department of Planetary and Space Science. Mr. Walker's work here includes studies of data received from the OV1-2 satellite and preparation for similar data from the OV1-12 satellite.

13. C.R. Winge, Jr., Department of Planetary and Space Science. Mr. Winge is developing models of the solar

expansion which include the effects of electromagnetic forces and solar rotation.

14. Edwin Winter, Department of Planetary and Space Science. Mr. Winter is studying the interaction of the solar wind with planetary and cometary bodies.

15. Richard E. Young, Department of Planetary and Space Science. Mr. Young is concerned with models of the solar wind.

All of the registered graduate students whose support is provided by this grant are employed as research assistants in classifications normally open to graduate students under long-established UCLA regulations. Their rates of pay are established by the Regents of the University at levels appropriate to their classifications. A considerable effort is made to assign research tasks which are of special interest to the student, but the tasks themselves are not necessarily related directly or indirectly to thesis research which the student may eventually perform.

E. Publications and Reports

Papers resulting, wholly or in part, from the research supported under this grant are listed chronologically below. An asterisk denotes a paper completed since the last report.

Coleman, P.J., Jr., L. Davis, Jr., E.J. Smith, and C.P. Sonett, Interplanetary magnetic fields: Preliminary observations from Mariner II, Science, 138, 1099, 1962.

Farley, T.A., The growth of our knowledge of the earth's outer radiation belt, Rev. Geophys., 1, 3, 1963.

Smith, E.J., L. Davis, Jr., P.J. Coleman, Jr., and C.P. Sonett, Magnetic fields measured in the vicinity of Venus: Preliminary observations from Mariner II, Science, 139, 909, 1963.

Coleman, P.J., Jr., Characteristics of the region of interaction between the interplanetary plasma and the geomagnetic field: Pioneer 5, J. Geophys. Res., 69, 3051, 1964

Smith, E.J., L. Davis, Jr., P.J. Coleman, Jr., and C.P. Sonett, Interplanetary magnetic field measurements: The Mariner II magnetometer experiment, in The Solar Wind, (Proceedings of the Conference on the Solar Wind, Pasadena, 1964), edited by R.C. Mackin and M.M. Neugebauer, Pergamon Press, New York, 1966.

Sonett, C.P., D.S. Colburn, L. Davis, Jr., E.J. Smith, and P.J. Coleman, Jr., Evidence for a collision-free magnetohydrodynamic shock in interplanetary space, Phys. Rev. Letters, 13, 153, 1964.

Smith, E.J., L. Davis, Jr., P.J. Coleman, Jr., and C.P. Sonett, Magnetic measurements near Venus, J. Geophys. Res., 70, 7, 1964.

Smith, E.J., L. Davis, Jr., P.J. Coleman, Jr., and C.P. Sonett, Chapter XII, Planet Venus, edited by R.V. Meghreblian, in proof.

Coleman, P.J., Jr., The Mariner-2 magnetometer experiment and associated data reduction procedures, Publication No. 447, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, May, 1965.

Farley, T.A., Space Sciences, VI, NASA Document No. SP-114, Washington, D.C., 1966.

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Smith, E.J., L. Davis, Jr., P.J. Coleman, Jr., and D.E. Jones, Magnetic field measurements near Mars: Mariner 4 preliminary report, Science, 149, 1241, 1965.

Coleman, P.J., Jr., Irregularities in the interplanetary magnetic field, Publication No. 467, Institute of Geophysics and Planetary Physics, University of California, Los Angeles,1965.

Coleman, P.J., Jr., Interaction of the solar wind with the planets, AIAA Journal, 4, (1), 4-9, 1965.

Coleman, P.J., Jr., L. Davis, Jr., E.J. Smith, and D.E. Jones, Variations in the polarity distribution of the interplanetary magnetic field, J. Geophys. Res., 71, 2831-2839, 1966.

Coleman, P.J., Jr., Hydromagnetic waves in the interplanetary plasma, Phys. Rev. Letters, 17, 207-211, 1966.

Coleman, P.J., Jr., Variations in the interplanetary magnetic field: Mariner 2, 1, Observed properties, J. Geophys. Res., 71, 5509-5531, 1966.

Coleman, P.J., Jr., and E.J. Smith, An interpretation of the subsidiary peaks at periods near 27 days in the power spectra of C_i and K_p, J. Geophys. Res., 71, 4685-4686, 1966.

Snare, R.C., and C.R. Benjamin, A magnetic field instrument for the OGO-E spacecraft, IEEE Trans. Nuc. Sci., NS-13, 333-339, 1966.

Barry, J.D., and R.C. Snare, A fluxgate magnetometer for the Applications Technology Satellite, IEEE Trans. Nuc. Sci., NS-13, 326-331, 1966.

Siscoe, G.L., L. Davis, Jr., E.J. Smith, P.J. Coleman, Jr., and D.E. Jones, Magnetic fluctuations in the magnetosheath: Mariner 4, J. Geophys. Res., 72, 1-17, 1967.

Coleman, P.J., Jr., L. Davis, Jr., E.J. Smith, and D.E. Jones, The polarity pattern of the interplanetary magnetic field during solar rotations 1798-1808, J. Geophys. Res., 72, 1637-1643, 1967.

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Coleman, P.J., Jr., Variations in the interplanetary magnetic field and some effects upon solar cosmic rays, Planet. Space Sci., 15, 975-995, 1967.

Ballif, J.R., D.E. Jones, P.J. Coleman, Jr., L. Davis, Jr., and E.J. Smith, Transverse fluctuations in the interplanetary magnetic field: A requisite for geomagnetic variability, J. Geophys. Res., 72, 4357-4364, 1967.

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Barry, J.D., P.J. Coleman, Jr., W.F. Libby, and L.M. Libby, Radio reflection by free radicals in the earth's atmosphere, Science, 156, 1730-1732, 1967.

Snare, R.C., and G.N. Spellman, Digital offset field generator for spacecraft magnetometers, Publication No. 618, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, 1967.

Barry, J.D., and L.L. Simmons, A heater for a fluxgate magnetometer sensor on the fifth Orbiting Geophysical Observatory satellite, IEEE Conf. IGA, 34C62, 1967.

Farley, T.A., Van Allen radiation belts, in The Encyclopedia of Atmospheric Sciences and Astrogeology, ed. by R.W. Fairbridge, 1075-1083, Reinhold Publishing Co., New York, 1967.

Schubert, G., and P.J. Coleman, Jr., The angular momentum of the solar wind, Astrophys. J., 153, 943-950, 1968.

Coleman, P.J., Jr., Turbulence, viscosity, and dissipation in the solar-wind plasma, Astrophys. J., 153, 371-388, 1968.

Winge, C.R., Jr., and P.J. Coleman, Jr., The motion of charged particles in a spiral field, J. Geophys. Res., 73, 165-173, 1968.

Chapman, M.C., and T.A. Farley, Absolute electron fluxes and energies in the inner radiation zone in 1965, J. Geophys. Res., 73, 6825-6833, 1968.

Farley, T.A., Radial diffusion of electrons at low L values, J. Geophys. Res., 74, 377-380, 1969.

Intriligator, D.S., Albedo neutron source for high-energy protons trapped in the geomagnetic field, Phys. Rev. Letters, 20, 1048-1049, 1968.

Farley, T.A., A.D. Tomassian, and M.C. Chapman, Evaluation of CRAND source for 10 to 50 Mev trapped protons, J. Geophys. Res., 74, in press, 1969.

Farley, T.A., Radial diffusion of starfish electrons, J. Geophys. Res., 74, in press, 1969.

*Cummings, W.D., P.J. Coleman, Jr., and G.L. Siscoe, The quiet day magnetic field at ATS 1, submitted to J. Geophys. Res., 1969

F. Abstracts

Abstracts of papers and talks concerning results of the research performed, wholly or in part, under this grant are included in this section. These abstracts pertain to papers completed during the reporting period and to talks prepared during this period.

The Quiet Day Magnetic Field at ATS 1

W.D. Cummings
P.J. Coleman, Jr.
G.L. Siscoe
University of California, Los Angeles

A study of the quiet day magnetic field at ATS 1 for the interval January through June, 1967, is presented. For each of 28 quiet days the H component (perpendicular to the equatorial plane) is Fourier decomposed to yield approximate values for the gradient in the field of the external currents evaluated at the earth. These gradients are used to calculate the equatorial component of the interaction force between the solar wind and the earth. The average force for the six month interval was 34×10^{11} dynes. The force was directed away from the sun-earth line by about 12° on the average, although there was considerable variation from day to day. This deviation is a factor of two or three times that expected from the orbital motion of the earth in the radial solar wind, and is consistent with Walters' effect.

Submitted to the Journal of Geophysical Research.

Outer Zone Electron Intensities

T.A. Farley
University of California, Los Angeles

The directional spectral intensities of electrons in the energy range from 55-1200 kev have been measured on the OGO-5 spacecraft, launched on March 4, 1968. The variations of these spectrums with direction and location throughout the outer radiation zone will be presented.

Presented at the American Geophysical Union Annual Meeting, Washington, D.C., April, 1969.

Evidence for Field-Aligned Currents at the Synchronous Orbit during Magnetospheric Substorms

W.D. Cummings
R.R. Lewis
P.J. Coleman, Jr.
University of California, Los Angeles

Magnetometer data from ATS 1 are examined for several magnetospheric substorms. As previously reported, the onsets of the expansive phase of a polar substorm is coincident with a sudden increase of 30-50 γ in the magnetic field strength at the synchronous orbit near midnight. In addition to the field strength change, which represents a return from a depressed value to the normal value, there is sometimes a temporary change in field direction. The direction change is in the east-west direction and occurs at the beginning of the recovery in field strength. We suggest that the direction change is caused by field-aligned currents located at the near edge of the plasma sheet in the tail. If the field-aligned current flows on two L shells, parallel to $\vec{B}$ on one shell and anti-parallel on the other, then the east-west magnetic field would only be observed when the satellite is between the two shells. According to this interpretation, the near edge of the plasma sheet must have been inside the synchronous orbit prior to the onset of the expansive phase, and it must have moved outward across the synchronous orbit during onset.

Presented at the American Geophysical Union Annual Meeting, Washington, D.C., April, 1969.

Magnetic-Field Variations at ATS 1 and on the Earth's Surface

Paul J. Coleman, Jr.
University of California, Los Angeles

The geostationary satellite ATS 1 (geocentric range 6.6 earth radii) is stationed in the geographic equatorial plane at longitude 150° W. Magnetic-field measurements at ATS 1 have established the existence of several types of quasi-periodic fluctuations and broadband noise in the distant geomagnetic cavity: (1) Sinusoidal fluctuations transverse to the local mean field have been observed rather frequently during quiet times. These fluctuations are elliptically polarized and amplitude modulated. During a given event, they are nearly monochromatic. However, their period changes from event to event over the range from 50-300 sec. These fluctuations most often occur just after dawn and in the early afternoon LT (local time). They have never been detected between 17 and 22 hrs LT. They are similar in many respects to Pc 4 and 5. (2) Other types of fluctuations are coincidental with magnetospheric substorms. Abrupt changes in the D (eastward) component of the field sometimes occur at ATS 1 between midnight and dawn LT early in the expansion phase of a substorm. On occasion, these transients in D have been accompanied by quasi-sinusoidal fluctuations of roughly 3-sec period and about 0.5-γ amplitude. Fluctuations of roughly equal amplitudes occur in all three components, D, H (northward), and V (vertical).

These fluctuations at ATS 1 are probably associated with the 3-sec enhancement in noise bursts recorded at the surface. (3) Irregular fluctuations of relatively large amplitude, primarily in the H component, have also been detected during the expansion phases of substorms. They occur throughout the local night. The spectrum of the fluctuations falls rather steeply with decreasing period. These fluctuations are probably associated with the irregular pulsations observed at the surface during substorm expansions. (4) During the recovery phase of substorms, quasi-sinusoidal waves with periods of roughly 20 sec and amplitudes of about 0.5 γ have been recorded at ATS 1 near 0600 LT. Fluctuations of roughly equal amplitude appear in all three components. The periods observed to date lie in the range associated with the irregular band-limited pulsations that usually occur at the surface between midnight and 1000 LT during substorm recoveries. (5) Relatively large-amplitude compressional oscillations occur regularly during the main and recovery phases of geomagnetic storms in the late morning and afternoon LT. Their periods range from 2-15 min. Their amplitudes are typically 15 γ and range up to 40 γ. (6) Transverse fluctuations with periods of about 5 sec and occurring simultaneously with the storm-time compressional oscillations have been detected on one occasion. These fluctuations had amplitudes of 1.5-2 γ. They were left, circularly polarized. During the event, which occurred in the afternoon LT, fluctuations of similar period were recorded at College, Alaska. These fluctuations were classified as irregular PC 1 and may be IPDP. The observations of the phenomena listed above will be reviewed. The relation of these effects at ATS 1 to radiation-belt and surface phenomena will be discussed.

To be presented at the General Assembly of the International Association of Geomagnetism and Aeronomy, Madrid, Spain, September, 1969.