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PROJECT: ATMOSPHERE EXPLORER-B

(To be launched no earlier than May 11)

Cat 31

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NEWS NASA

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NASA TO LAUNCH ATMOSPHERE EXPLORER

The National Aeronautics and Space Administration will launch a 495-pound spacecraft into a 750 by 170 mile orbit aboard a Delta launch vehicle from Cape Kennedy, Fla. no earlier than May 11.

Called Atmosphere Explorer-B, the aeronomy spacecraft will carry eight experiments to measure temperatures, composition, densities and pressures in the upper atmosphere, on a global basis.

If successfully placed in orbit, AE-B will be named Explorer XXXII; at the same time, it will give the three-stage Delta launch vehicle a record of 35 spacecraft orbited in 38 launches.

This will be the first use by the Delta of a new third-stage motor (the FW-4 solid propellant unit) although FW-4 stages have been used on three Scout launch vehicle flights.

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Primary scientific goal of the AE-B experimenters is to collect accurate data which will provide a better understanding of how and why changes occur in the upper atmosphere.

A secondary objective is to study the effects of short-term disturbances in the atmosphere caused by radiation from solar storms. These storms now occur more frequently because of an increasing level of solar activity. One vitally important effect of such storms is disruption of short-wave radio communications which use the ionosphere as a reflector in bouncing signals around the globe.

Solar activity varies over an 11-year period. During this cycle, the activity of the Sun slowly tapers off from a high point for about the first nine years and then rapidly rises back to the high phase during the remaining two years.

Since the last high point was in 1957, the Sun is just entering its period of maximum change. By launching the AE-B at this time, the experimenters have the opportunity to cover much of this period of maximum change during the spacecraft's expected lifetime of about a year.

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The AE-B will be the second aeronomy spacecraft launched by NASA. The first, Explorer XVII (AE-A), was launched April 3, 1963. Designed for a lifetime of three months, this battery-powered spacecraft lasted 100 days. It provided the first worldwide measurements of upper atmospheric constituents and parameters which have already revised man's thinking about the physics of the atmosphere.

The AE-B is similar to Explorer XVII, but weighs 55 pounds more than its predecessor. It is a 35-inch-diameter stainless steel, hermetically-sealed sphere. This houses the necessary electrical and mechanical instrumentation.

The only appendages on the spacecraft are a canted turnstile antenna and two electrostatic probes which protrude 18 inches on each side of the spacecraft's equator. The remainder of the scientific instruments are mounted in vacuum-sealed holes on the spacecraft surface. A total of 2064 solar cells are bonded directly to the spacecraft shell to provide electric power to recharge the batteries, thus extending its lifetime to about a year.

Other changes are expected to improve data collection and recording capabilities. These include a tape recorder to store scientific data picked up over areas where there are no ground stations and a spin-axis orientation system to help keep the spacecraft oriented properly for maximum use of scientific instrumentation.

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Some pressure will be built up inside the sealed spacecraft during its lifetime due to the hydrogen and possibly some oxygen generated by the batteries. Pressure will be relieved by three fuel cells. These cells produce an electrochemical reaction upon contact with hydrogen or oxygen, to change the gases into water, and store the water.

Pressure relief beyond the lifetime of these cells will be attained by a motor-driven vacuum valve. This unit will permit the battery gases to leak out of the spacecraft on command at a rate of about three pounds a day.

The Atmosphere Explorer program is directed by the Physics and Astronomy Programs Division of the Office of Space Science and Applications at NASA Headquarters. Project management is under the direction of Goddard Space Flight Center, Greenbelt, Md., which also is responsible for tracking and data acquisition and the Delta launch vehicle. In addition, all experiments on board are the responsibility of GSFC scientists.

The AE-B was designed and built by Goddard's Spacecraft Technology Division and the Aeronomy Branch. Prime contractor for the three-stage Delta launch vehicle is the Douglas Aircraft Company, Inc., Santa Monica, Calif. The FW-4 motor is developed by United Technology Corp., Sunnyvale, Calif.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS)

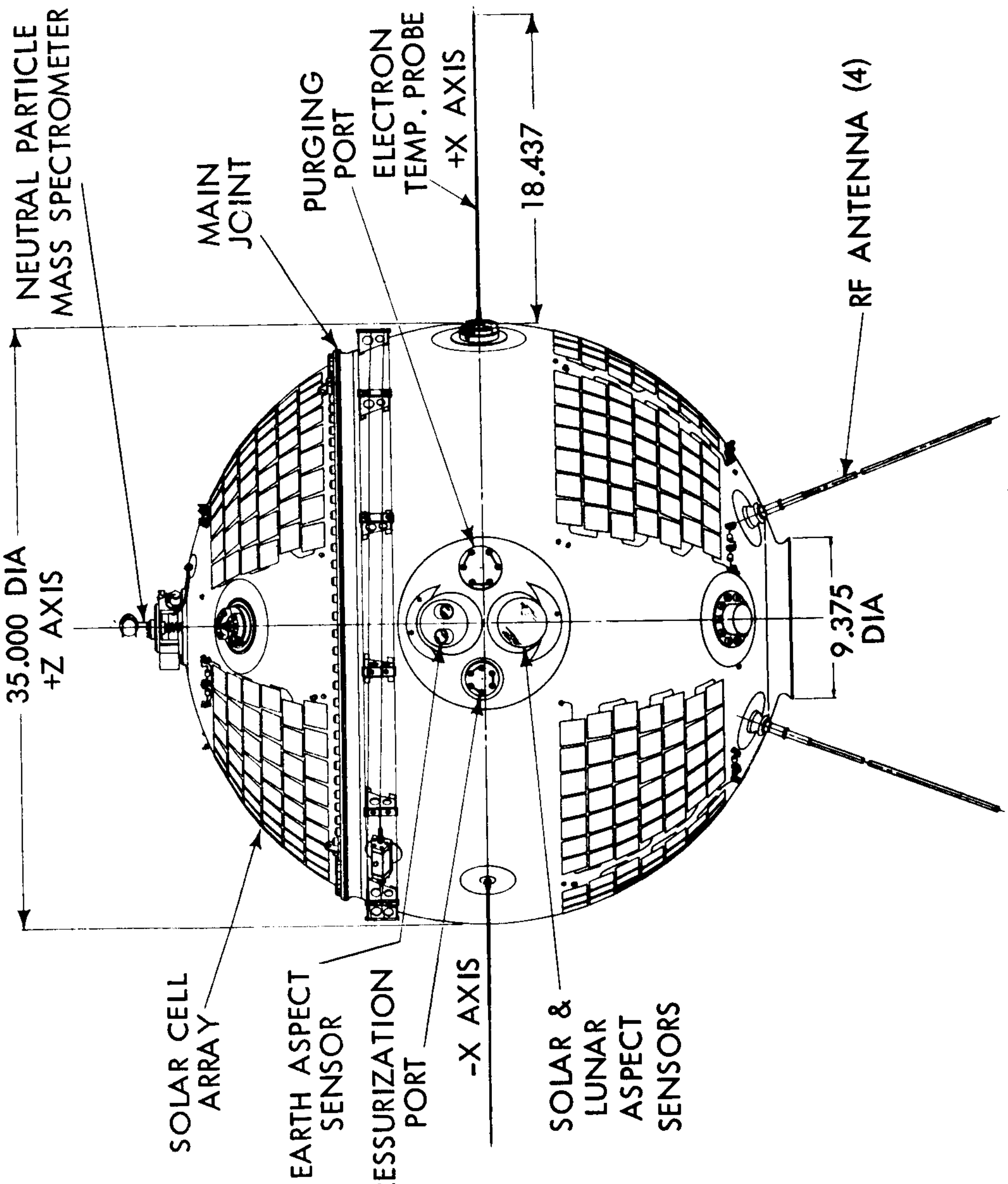
AE-B SCIENTIFIC OBJECTIVES

The Atmosphere Explorer-B (AE-B) is the second aeronomy spacecraft of a series which began with the launch of Explorer XVII in April, 1963.

The primary scientific goal of the AE-B investigators is to obtain sufficiently accurate measurements of the upper atmosphere around the globe and its variations with time of day, season and year. Such data will permit identification of the underlying processes of this region of the atmosphere and an evaluation of their relative importance.

The experiments and orbital parameters of the AE-B have been selected to provide, with simultaneous operation, the basis for the study of physical processes as opposed to, for example, studies which are primarily mapping, descriptive, or of a survey nature.

A second objective of the AE-B project is to study the effects of short term perturbations of the atmosphere which are induced by the direct and delayed effects of solar storms. These effects will be primarily evident in the auroral regions and in the area of the South Atlantic magnetic anomaly.



AE-B SPACECRAFT FRONT VIEW

Scheduling of the spacecraft's operations therefore will include extensive coverage of these regions as well as extensive global and temporal coverage.

THE SPACECRAFT

The basic spacecraft structure of the Atmosphere Explorer-B consists of a spherically-shaped, 35-inch diameter shell. The hermetically sealed shell is made of stainless steel, 25/1000ths of an inch thick. Access to the internal components of the spacecraft is through a bolted lid section.

A total of 2064 solar cells are affixed directly to the spacecraft shell. Five trapezoidal-shaped patches of these cells are located on the top of the spacecraft and seven on the bottom. Each patch consists of 43 modules of cells connected in series with each module containing four solar cells connected in parallel.

The only appendages on the spacecraft include a canted turnstile antenna which projects from the bottom. Additionally, there are two electrostatic probe experiments, one projecting from each side of the spacecraft. These probes are 18.4 inches long.

The AE-B is designed to be vacuum tight, thus preventing the spacecraft from measuring its own gaseous discharges as it orbits the Earth. The integrity of the spacecraft's internal pressure is maintained by copper shear gaskets located at the various joints.

Stainless steel was used for the spacecraft shell because of the excellent vacuum properties of this metal. Stainless steel does not outgas extensively in the vacuum of outer space. That is, it does not release electrons extensively which could be picked up by spacecraft sensors.

The AE-B is spin-stabilized, employing a yo-yo de-spin mechanism to attain the proper spin rate of 30 revolutions per minute. This mechanism consists of two long wires with weights at their ends which automatically unlatch in orbit. The wires unwind from around the spacecraft's equator due to the centrifugal force of the weights.

As the weights swing out, the spinning spacecraft provides the kinetic energy (energy of motion) to speed the weights in their ever-widening circles. The spacecraft provides this energy only at the expense of its own spinning motion, and thus begins to slow its spin. When they reach the full length of the wires, the weights are released. At this point, the spacecraft is spinning at the desired rate.

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Since the AE-B is spin stabilized, the experiments are located on the spacecraft in such a manner as to take advantage of the favorable aspect of the spinning motion. The experiment sensors are located on the spacecraft as follows:

-- Nearly equally spaced around the spacecraft equator:

One neutral-particle mass spectrometer

One ion-mass spectrometer

Two magnetron density gages

Two electrostatic probes

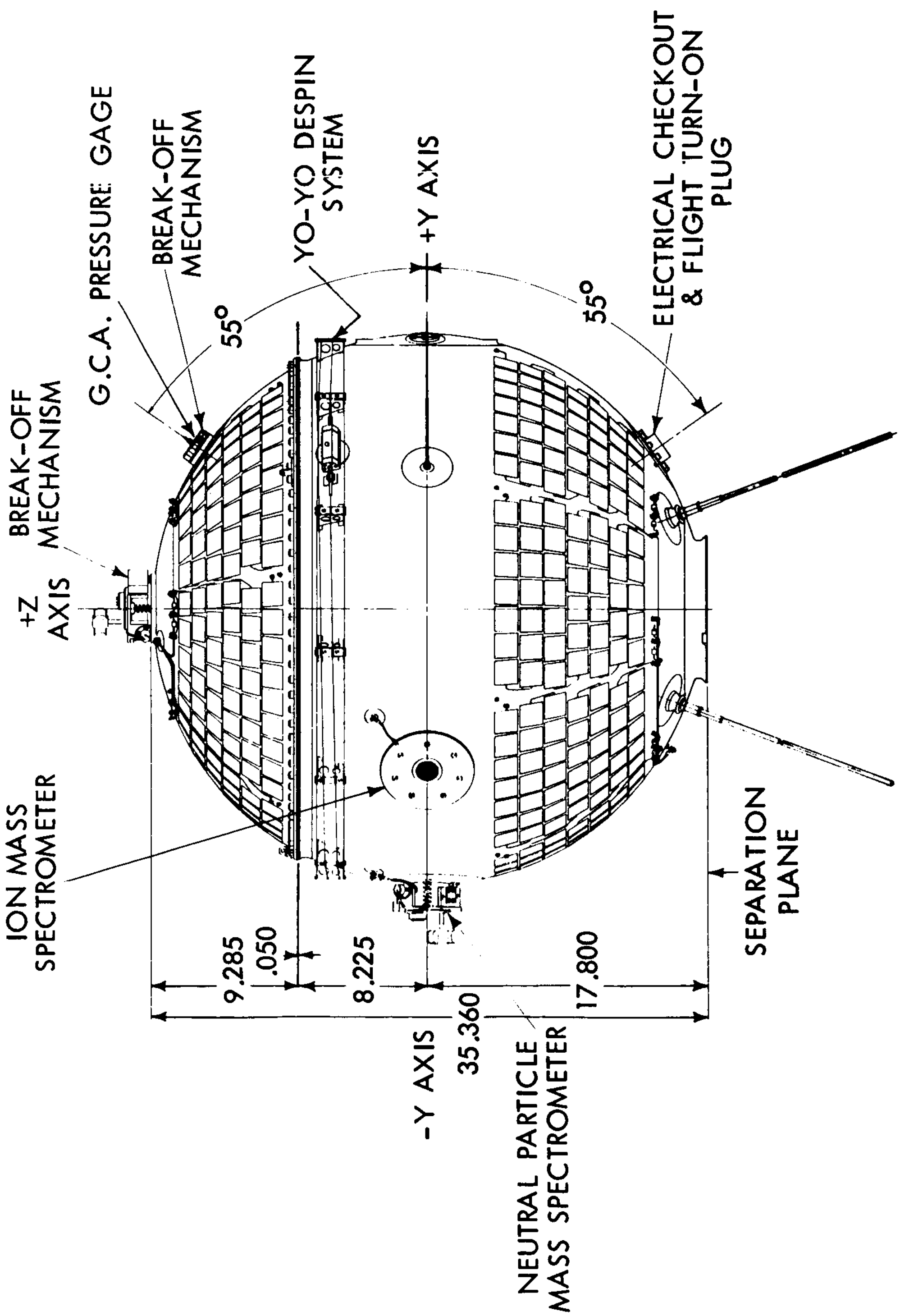
-- 55-degrees off the spacecraft equator toward the top:

One magnetron density gage

-- On the top at the spin axis:

One neutral-particle mass spectrometer

In the primary mode of operation, the AE-B will generally spin through space to make certain that its sensors detect information in the direction of the spacecraft's orbital path. Thus, the gas-sampling sensors located around the spacecraft's equator are arranged so as to be cyclicly oriented first in the direction of the spacecraft motion, and then in the direction opposite to the forward motion after the spacecraft rotates 180 degrees.



AE-B SPACECRAFT SIDE VIEW

SCIENTIFIC EXPERIMENTS

The selection of the eight experiments for the AE-B was based on the results of the Explorer XVII spacecraft and upon the needs of the resulting data studies. In particular, these experiments will make high-resolution direct measurements of neutral and charged particle constituents and other parameters of the Earth's upper atmosphere. In particular, these experiments are designed to collect data for analyzing the distributions and concentrations of the particles and their energies.

All of the experiments onboard the AE-B were provided by the Goddard Space Flight Center.

A description of the AE-B experiments follows:

Ion Mass Spectrometer

The AE-B carries one ion mass spectrometer to measure the concentration and scale height of the ionic constituents of the atmosphere. This instrument is located on the spacecraft's equator. It is designed to collect data on the following atmospheric ions: hydrogen, helium, atomic nitrogen and atomic oxygen.

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Ions enter the spectrometer through an orifice in the spacecraft's skin and are accelerated along the axis of the instrument. This is accomplished by means of an electric field created within a series of parallel grids in the spectrometer. The acceleration potential of this field is varied such that only the selected ions (hydrogen, helium, etc.) reach the resonant velocity of the instrument. These are collected and measured as an ion current which is then converted to ambient ion density. The particles of interest can be identified by the potential required to accelerate them to resonant velocity.

Neutral-Particle Mass Spectrometer

Two such spectrometers are carried on the AE-B to help determine the concentration and temperature of the neutral constituents of the atmosphere. One of these units is located on the spacecraft's equator while the other unit is located on the top at the spacecraft's spin-axis. These spectrometers are nearly identical to those employed on the Explorer XVII, except for several relatively minor but significant changes which allow for more precise measurements. The neutral particle mass spectrometers are designed to measure the concentration of the following neutral atmospheric constituents: atomic hydrogen, helium, and both molecular and atomic nitrogen and oxygen.

A neutral-particle mass spectrometer counts electrically neutral particles in space by breaking such particles into positive ions and negative electrons. The resulting ions are made to move through electric and magnetic fields of known strength which deflect the particles. The extent of this deflection depends largely on the mass of the particles; particles of the same mass will be deflected along the same path.

A sensing device in the spectrometer is located such that it intercepts the stream of particles so they can be counted. Since the field strength and location of the sensor is specific for certain masses of particles, and since the mass of the ion is specific for each component that is ionized, selected components of the atmosphere can be identified.

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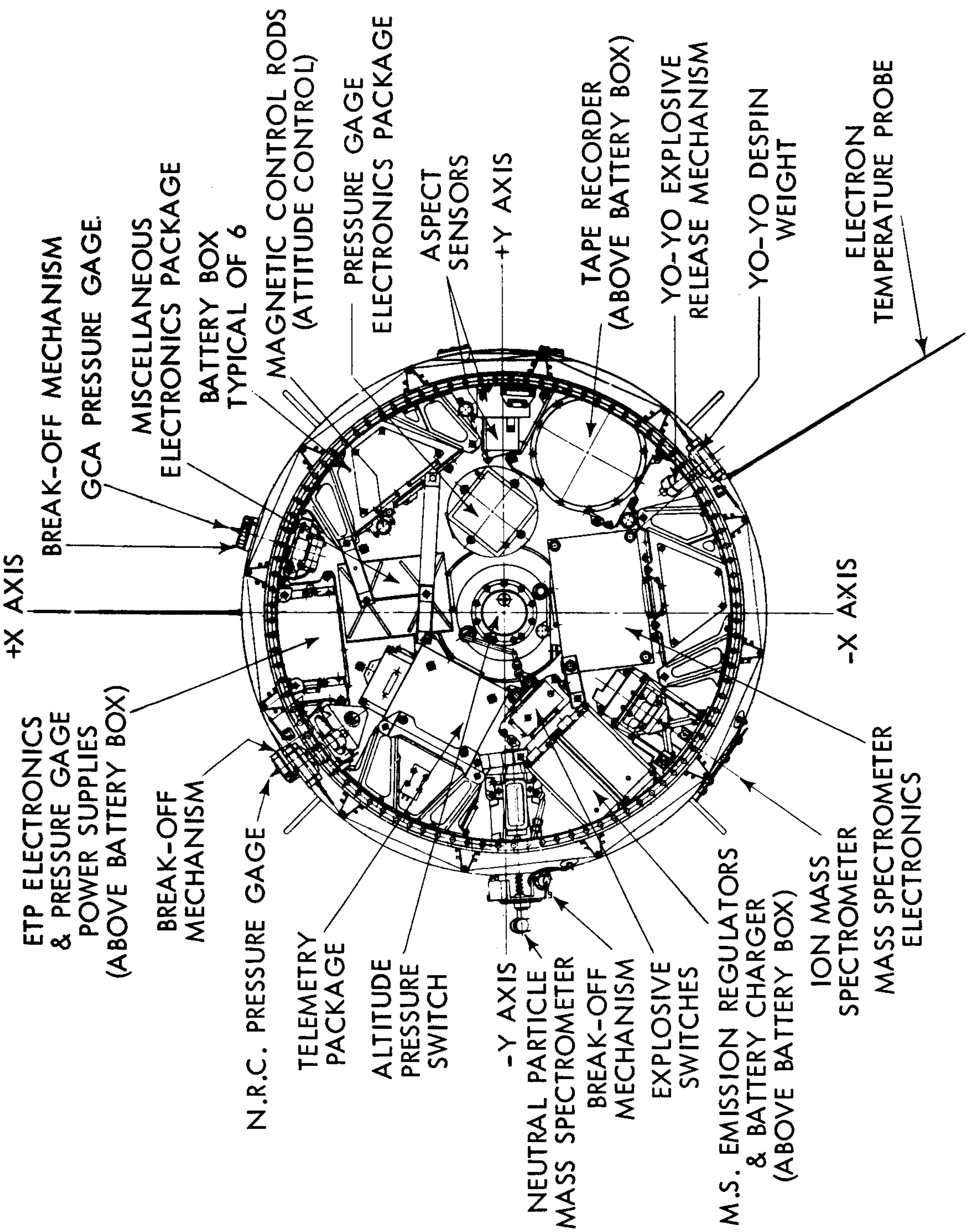
Density Gages

Three magnetron density gages are included in the AE-B's scientific payload to help determine the total netural particle density and scale height in the atmosphere.

Two of the gages are located on the spacecraft's surface at the equator. The third gage is located 55 degrees off the equator towards the top of the AE-B. All of the gages are vacuum-sealed into openings on the spacecraft surface. These orifices give the gages an unimpeded view from horizon to horizon.

A magnetron gage employs a cold-cathode to produce electrons. These are trapped in the gage's magnetic and electric fields which have lines of force perpendicular to each other.

Because the electrons are trapped in the fields, they have long paths of movement, thus making it more likely that they will collide with any neutral gases entering the gage. Such collisions produce ions. The number of ions generated is measured as a current which is proportional to the particle density in the gage. This gage density is, in turn, proportional to the atmospheric density.



INTERIOR VIEW
CENTER SECTION
AE-B SPACECRAFT

Electrostatic Probes

The AE-B carries two electrostatic probes to determine the concentration and temperature of thermal electrons in the upper atmosphere. These probes are cylindrical electrodes which protrude about 18 inches out from either side of the spacecraft at the equator. Two probes are used to insure that one of them always will be ahead of the spacecraft and thereby free from the plasma wake behind the orbiting AE-B.

In the launch configuration, these spring-mounted probes are held down close to the spacecraft by the nose fairing of the launch vehicle. Once the nose fairing has been ejected during flight, however, the two probes spring straight out in their orbit configuration.

When a voltage is applied to an electrostatic probe immersed in a plasma, such as the AE-B will be in orbit, an electron current is collected as a function of the applied voltage. Proper interpretation of this current gives the density and temperature of the ambient electrons in the immediate vicinity of the spacecraft.

The AE-B electrostatic probes are similar to those flown previously on Explorers XVII, XXII, XXVII, XXXI, Tiros VII and Alouette II and numerous sounding rockets.

Thus, all of the data collected with these spacecraft can be correlated with the data from the AE-B probe.

OPTICAL ASPECT SYSTEM

The function of the Optical Aspect System on the AE-B is to permit the spacecraft's orientation to be determined at any time with respect to the Earth, Sun or Moon. This information is necessary for the correct interpretation of the scientific data collected by the spacecraft's experiments.

The Optical Aspect System consists of four sets of sensors for collecting aspect data regardless of whether the spacecraft is experiencing day or night. It also has a switching system for turning off those aspect sensors not in use at any given time.

Daylight Aspect Sensors

1. Digital Sun Sensor and Sun Slit: This sensor gives a seven-bit indication of the angle between the spin axis of the spacecraft and the Sun.

The digital Sun sensor employs seven photocells placed a short distance behind a light mask with seven different patterns of rectangular openings. Light entering the openings at a particular aspect angle illuminates none, any, or any combination of the seven photocells.

As many as 128 separate possible sun angles can be measured in this manner.

The Sun slit part of this sensor, which has a 140-degree field of view, provides an additional pulse at the instant when the aspect sensor sweeps across the Sun.

2. Visible Earth Horizon Sensors: There are two such sensors on the AE-B. They are narrow pencil-beam detectors which are sensitive to Earth shine in the visible part of the energy spectrum. These sensors are mounted at 68 degrees and 112 degrees, respectively, with respect to the spacecraft's spin axis.

Night Sensors

1. Infrared Earth-Horizon Sensors: These sensors are identical to the visible Earth-horizon sensors with the exception that they are sensitive only to the seven-to-15-micron region of the ultraviolet portion of the energy spectrum.

2. Moon Slit Detector: This detector provides an output pulse whenever its aspect sensor sweeps across the Moon. It is turned on only at night.

Day-Night Switching Detectors

There are two types of day-night switch detectors which are actually identified as Sun switch detectors. The first senses whether the Sun is shining on the spacecraft. If it is, the infrared horizon sensors and the Moon slit detectors are turned off. Otherwise, these aspect sensors are left on. The second type of Sun switch detector blanks the output of the Earth-horizon detectors whenever they sweep across the Sun.

SPACECRAFT POWER SUPPLY

The basic power supply of the AE-B consists of about 178 pounds of silver-zinc batteries with a total capacity of 10,500 watt hours. This is the same type of power supply employed on the Explorer XVII which had sufficient power for 100 days of operation. If the batteries on the AE-B are utilized on the same five turn-on per day basis as the Explorer XVII, the AE-B could be expected to have battery power enough for six months operation. The additional battery lifetime is made possible by improvements in shelf life, better battery pack balancing and reduced power demands.

Unlike the Explorer XVII, the AE-B has been equipped with a modest solar cell system which is expected to provide 10 watts of power on the average when commanded.

This system gives the AE-B project personnel the capability of extending the useful lifetime of the spacecraft beyond the six months period as well as increasing the turn-on rate if desired.

The solar cells are bonded directly to the spacecraft's stainless steel shell, thus avoiding the use of paddles. This will minimize outgassing to such an extent that the particle flow will not be detectable by the experiment sensors.

INTERNAL PRESSURE RELIEF

Since the AE-B is a hermetically sealed spacecraft with an extended lifetime, some pressure will be built up internally due to the hydrogen normally generated by its batteries. A small amount of oxygen also might be produced.

As a means of preventing a large pressure built up, the AE-B is equipped with three Gas Combination Cells which have the job of minimizing execessive pressure for about nine months after launch. These devices each contain an exposed gas electrode on which hydrogen or oxygen is absorbed. When hydrogen is absorbed, it reacts electrochemically with an oxidizer (copper oxide) stored inside the device to produce water.

If oxygen also is present, the two gases react catalytically on the exposed electrode surface, also forming water. All of the water produced in this fashion remains within the combination cells.

Release of excessive pressure beyond the lifetime of the Gas Combination Cells is attained by a motor-driven vacuum valve. This valving permits the evolved gases to leak out of the spacecraft on command at the rate of about three and a half pounds per square inch a day until the pressure is adequately reduced. The valve is then commanded to close until needed again.

TELEMETRY AND DATA RECORDING SYSTEM

Telemetry: Two identical telemetry systems are used on the AE-B. Each of these redundant systems are solid state assemblies which supply an output power of 500 milliwatts each. These pulse code modulated (PCM) systems are capable of handling 8640 bits/second.

The turnstile antennas on the AE-B provide an approximate omni-directional pattern with lows expected to be less than about four decibels. These antennas are used with the command receiver, tracking transmitter, and the telemetry system.

<u>Data Recording</u>: As a means of permitting greater geographical coverage than was possible with the Explorer XVII, the AE-B has been equipped with a single-speed, continuous-loop tape recorder. This unit, controllable with an onboard timer, timer-clock system, can be commanded to record scientific sensor data over any geographical area where there is no ground station. To minimize its complexity, this recorder has a capacity adequate for accommodating only a single turn-on (four minutes of operation at 8640 bits/second) of the spacecraft.

The onboard timer can be preset and initiated upon command to turn the recorder on through the spacecraft electrical control system. The time base for the timer is driven by a tuning fork (plus or minus 0.1 percent accurate) and provides one-minute turn-on resolution referenced to command time.

The accuracy of the system can be verified by a command readout of the clock up to 128 minutes after initiation of the delay timer.

SPIN-AXIS AND SPIN-RATE CONTROL SYSTEM

<u>Spin Axis Control</u>: The spin axis of the spin-stabilized AE-B generally will be maintained normal to the orbit plane with a magnetic spin-axis orientation device.

In this manner, the spacecraft's experiment will gain optimum orientation for collecting data. Generally, the magnetic device provides control of the spacecraft's residual magnetic field upon command and thereby affords control of the spin axis.

The spin-axis orientation device on the AE-B achieves spin-axis orientation by generating a magnetic dipole moment within the spacecraft along the spin (X) axis. This moment will react with the Earth's magnetic field to produce spin-axis precession. At 30 rpm, the precession rate will be nominally 1/4 degree per minute, enough to cancel out any deviation of the spin axis from the orbital plane.

Explorer XVII, in which no control was employed, experienced a precession of about 10 degrees a day and only infrequently achieved an optimum orientation.

Spin Rate Control: Spin rate control of the AE-B is achieved by means of a magnetic dipole moment generated in the spacecraft's Y-Z plane and properly phased with respect to the Earth's magnetic field. This moment will produce a torque to increase or decrease spin rate. The sense of the torque may be selected by command. This system will be able to change the spin rate 15 rpm per 24 hours of system operation. Less than one watt of power is required when the spin rate system is on.

DELTA LAUNCH VEHICLE

Delta program management is under the direction of the Office of Space Science and Applications' Launch Vehicle and Propulsion Programs. Project management is the responsibility of Goddard Space Flight Center. Prime contractor for the Delta launch vehicle is the Douglas Aircraft Company, Santa Monica, Calif.

Successful orbiting of the AE-B onboard the Delta will give this vehicle a record of 35 spacecraft orbited out of 38 launches.

The Delta vehicle has the following characteristics:

Overall length:	90 feet
Maximum diameter:	8 feet
Nominal liftoff weight:	114,000 pounds

First stage: Douglas Aircraft Co. Thor Missile.

Burning time:	About two minutes and 25 seconds
Thrust:	172,000 pounds
Fuel:	Kerosene/liquid oxygen
Weight:	Over 50 tons

Second stage: Aerojet-General Corp., AJ-10-118A propulsion system.

Burning time:	About two minutes and 40 seconds

Thrust:	7550 pounds
Fuel:	Liquid UDMH/Red Fuming Nitric Acid
Weight:	Two and one-half tons

<u>Third stage</u>: United Technology Corp., FW-4.

Burning time:	31 seconds
Thrust:	5450 pounds
Fuel:	Solid propellant
Weight:	About 660 pounds
Length:	About 62 inches
Diameter:	19.6 inches

The flight sequence for the Delta is as follows: After burnout, the first stage falls away and the second stage ignites immediately. Thirty seconds after second stage ignition, the nose fairing is jettisoned. It is this fairing which protects the AE-B, the third-stage rocket and the third-stage instrumentation from aerodynamic heating during flight through the atmosphere. After second-stage burnout, the vehicle begins a coast period of approximately seven minutes. Near the end of this period, small rockets mounted on a table between the second and third stage ignite and spin the table up to 90 revolutions per minute. The second stage separates and the third stage ignites and burns to achieve orbital velocity of about 17,000 miles an hour.

Third stage separation then takes place and the payload is pushed into orbit, after which it is de-spun to the desired spin rate of 30 revolutions per minute.

ATMOSPHERE EXPLORER-B FACT SHEET

SPACECRAFT

Weight: About 495 pounds total:

Experiments	50	lbs.
Structure	92	"
Batteries	178	"
Other	175	"
	495	"

Structure: A 35 inch diameter stainless steel spherical shell with appropriate internal structure. Structure surface fitted with 2064 solar cells.

Appendages: A canted turnstile antenna consisting of four 3/8th of an inch diameter rods measuring 20-1/8 inches long protruding from the bottom of the spacecraft. There also are two 18.4 inch long electrostatic probes protruding from either side of the spacecraft at the equator.

Lifetime: Designed for six months useful lifetime without recharge. This can be extended to nine months or a year with recharge.

LAUNCH PHASE

Site:	Complex 17B, Cape Kennedy, Eastern Test Range.
Vehicle:	Three-stage Delta.
Launch Azimuth:	45 degrees.
Orbital plan:	Apogee: 750 miles (1200 kilometers) Perigee: 170 miles (250 kilometers) Period: About 100 minutes Inclination: 64 degrees

POWER SYSTEM

Power supply:	Multiple silver-zinc battery packs with a total capacity of 10,500 watt-hours. The solar cells feed an average of ten watts of power on command during the spacecraft's lifetime.
Voltage:	Voltage requirements vary from 3.1 to 21 volts.
Pressure relief:	The battery evolved gases inside the hermetically sealed spacecraft are combined as water by three gas combination cells to minimize the pressure. Pressure relief beyond the life of these cells is attained by a motor-driven vacuum valve.

This valve permits the gases to leak out of the sealed spacecraft at the rate of about three pounds a day on command.

COMMUNICATIONS AND DATA-HANDLING SYSTEM

Telemetry:	Pulse code modulation (PCM) 8640 bits/second.
Transmitter:	Requires about one-half watt output.
Encoder:	45 channels at 20 nine-bit samples/second.
Tape recorder:	An endless loop unit with more than two million bit capacity (2.1×10^6) per readout.

TRACKING, TELEMETRY AND COMMAND STATIONS

All tracking and telemetry stations are part of the Goddard Space Flight Center's Space Tracking and Data Acquisition Network (STADAN). Primary stations: Rosman, North Carolina, and Fairbanks, Alaska. These stations will be used to acquire telemetry data from the spacecraft and relay it in real time to the AE-B control center at Goddard by way of microwave communications facilities. Commands for the spacecraft, originating in the control center, will be sent by the same microwave system to the primary stations for subsequent transmission to the spacecraft. Secondary stations: These stations, listed below, will be used as scheduled by project requirements for command and telemetry functions whenever the spacecraft is not in view of the primary stations.

Blossom Point, Maryland; College, Alaska; Fort Myers, Florida; East Grand Forks, Minnesota; Johannesburg, Republic of South Africa; Kano, Nigeria; Lima, Peru; Goldstone Lake, California; St. Johns, Newfoundland; Canberra, Australia; Quito, Ecuador; Santiago, Chile; Winkfield, England.

PARTICIPANTS IN AE-B

NASA HEADQUARTERS

Dr. Homer E. Newell	Associate Administrator for Space Science & Applications
Jesse L. Mitchell	Acting Director, Physics & Astronomy Programs Div., OSSA
Frank Gaetano	AE-B Program Manager
R. Horowitz	AE-B Program Scientist
Vincent L. Johnson	Director, Launch Vehicle & Propulsion Programs
T. B. Norris	Delta Program Manager

GODDARD SPACE FLIGHT CENTER

Dr. John F. Clark	Acting Director
Dr. John W. Townsend, Jr.	Deputy Director
Dr. George F. Pieper	Assistant Director for Space Sciences
Nelson W. Spencer	Chief, Laboratory for Atmospheric and Biological Sciences & AE-B Project Manager
Larry Brace	AE-B Project Scientist
Peter L. Luppino	Tracking & Data Systems Manager

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William R. Schlinder	Delta Project Manager
Robert H. Gray	Assistant Director, Unmanned Launch Operations

DOUGLAS AIRCRAFT COMPANY

Marcus F. Cooper	Director, Florida Test Center, Cape Kennedy
J. Kline	Delta Systems Engineer

EXPERIMENTERS

H. Taylor	Ion Mass Spectrometer (1)
C. Reber	Neutral Particle Mass Spectrometer (2)
L. Brace	Electrostatic Probes (2)
G. Newton	Pressure Gages (3)

All experimenters are members of the Aeronomy Branch of the Laboratory for Atmospheric and Biological Sciences at the Goddard Space Flight Center.

PRINCIPLE CONTRACTORS

Aero Geo Astro Corp. College Park, Md.	Ion Spectrometer
Applied Physics Lab. Howard County, Md.	Spin-axis Orientation
The Budd Company Philadelphia,	Spacecraft shell
Consolidated Systems Corp. Monrovia, Calif.	Two Mass Spectrometers
GCA Corp. Bedford, Mass.	Two Density Gages
National Research Corp. Equipment, Corp. Newton Highlands, Mass.	One Density Gage

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Yardley Electric Co. New York City	Silver-zinc batteries

UNIVERSITY PARTICIPANT

University of Michigan Space Physics Research Lab.	Two electrostatic probes

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