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PROJECT: AIR DENSITY/INJUN EXPLORER B
(AD/I-B)

SCHEDULED LAUNCH: Nov. 19, 1964

CONTENTS

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SCOUT TO LAUNCH
AIR DENSITY AND
INJUN SATELLITES

Two National Aeronautics and Space Administration satellites designed to investigate simultaneously the density and radiation characteristics of the upper atmosphere will be launched by a four-stage Scout rocket no earlier than Nov. 19.

Successful separation of the two spacecraft will mark the first time NASA will have orbited more than one satellite with a single launch vehicle. The Scout will be launched down the Pacific Missile Range from Vandenberg Air Force Base, Lompoc, Calif.

Purpose of the dual satellite experiment, labelled Air Density/Injun Explorer B (AD/I-B), is to provide more detailed information on complex radiation-air density relationships in the upper atmosphere.

Once in orbit, the 135-pound payload will separate into a 12-foot polka-dotted sphere for air density and atmospheric heating measurements and a two-foot diameter satellite bearing particle detectors to measure the bombardment of the atmosphere by energetic particles from space.

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The amount of energy brought into the Earth's upper atmosphere by these colliding energetic particles is not known, although there is evidence that this energy is one of the factors governing the atmosphere's density, temperature and composition at high altitudes.

The Air Density Explorer will continue high altitude density measurements in the polar regions, determine the sources of atmospheric heat by comparing data with that of Injun and other satellites, and determine density and temperature variations of the atmosphere as a function of latitude.

The satellite also will be used with Explorer XIX (similar in orbit and structure) to provide global comparative measurements of the three types listed above. Explorer XIX was launched last year.

The Injun Explorer will measure the flux of corpuscular radiation into the atmosphere (the atmospheric bombardment by charged particles from space) and will sample the concentration and energy distribution of the charged particles.

The research experiments are part of the program of NASA's Office of Space Science and Applications. Project management is assigned to the Langley Research Center, Hampton, Va., where the project was conceived.

Scientists have selected a near-polar orbit, inclined about 82 degrees to the Equator, for both spacecraft. Apogee (high point) is planned for about 1,500 statute miles (2,400 kilometers) with the perigee (low point) at about 330 miles (525 kilometers). The two satellites will orbit the Earth once every 115 minutes.

After orbit is achieved, each satellite will receive an Explorer designation with the appropriate Roman numeral. The NASA Explorer series consist of small satellites carrying specific groups of experiments into orbits selected for the experiments involved.

Data obtained by the Air Density and Injun Explorers will be correlated with other worldwide scientific investigations being made during the 1964-65 International Quiet Sun Year (IQSY), a period of minimum solar activity.

BACKGROUND INFORMATION FOLLOWS

BACKGROUND

As the Earth moves through space in its orbit around the Sun, its environment is constantly bombarded by a shower of energetic particles, originating both at the Sun and from other sources in the universe.

Solar radiation is the major energy source for the Earth's atmosphere and the ionosphere. However, various observed phenomena probably should be attributed to the bombardment by energetic particles.

The Earth's magnetic field, consisting of invisible lines of force extending from pole to pole, affects the motion of charged particles and, in special cases, traps those which come within its influence, forming the Van Allen radiation region.

The charged particles entering the magnetic field are diverted from their original courses and follow spiralling paths along the magnetic lines of force. Where the magnetic lines descend steeply (toward) the Earth at the polar regions, the downward spiralling energetic particles frequently collide with particles of air at the upper fringes of the atmosphere.

Such collisions release energy and heat the atmosphere. The Aurora Borealis in the North Polar regions and the Aurora Australis in the South Polar area represent the release of such energy in the form of light.

Collisions of energetic particles with the Earth's upper atmosphere occurs to a much lesser extent over the rest of the Earth. Scientists suspect in some cases, that charged particles penetrate to low altitudes at mid-latitudes and may be a cause of some of the faint glow of the night sky.

These collisions may also contribute to the formation of the upper ionosphere, the region of ionized air in the upper atmosphere which serves so usefully as an electronic reflector to carry radio waves around the curvature of the globe.

SCIENTIFIC OBJECTIVES

The extent to which energy is brought into the Earth's upper atmosphere by these colliding energetic particles is of prime interest to scientists. The amount of energy is not known.

To obtain a more detailed understanding of complex radiation-air density interrelationships, the dual satellite experiment has been designed specifically to measure both particle flux and energy, and atmopsheric density at the same time and in the same general location. In this way, data from each set of measurements can be used to interpret data from the other.

Air density is measured by using lightweight satellites in eccentric Earth orbits. These satellites experience drag (atmospheric resistance) at their perigees (the points in the elliptical orbits where they swing down closest to the Earth). This resistance can be measured and translated into measurements of how dense the atmosphere is in that particular region.

Careful calculations have led to the selection of an orbit whose perigee point will move around the Earth about once every six months. The planned launch has been timed so that the perigee point will arrive in the North Polar region about the time of the winter solstice, Dec. 21, when the North Pole is in maximum darkness.

As the perigee point continues to shift, it will arrive over the South Polar region about the time of the vernal or spring equinox (March 21), when the length of the day and night are equal. Three months later it will return to the North Pole at the time of summer solstice (June 21), when the region is in maximum sunlight, and back again to the South Polar region at the time of autumnal equinox (Sept. 21).

Thus the satellites will make their density and radiation measurements first at the seasonal extremes, and later as they slowly drift out of synchronization with the seasons at other times of the year as well. In this way, a wide range of measurements will be recorded which will indicate seasonal and other systematic as well as non-systematic variations.

Measurements of density from the drag of Explorer XIX, a 12-foot balloon satellite launched Dec. 19, 1963, are continuing. Explorer XIX is also in a near-polar orbit. Comparison of latitude and day-to-day density variations may be obtained by using data from both Explorer XIX and the new air density satellite. The relative effects of solar-induced disturbances on the atmosphere also can be compared.

The systematic variations to be studied include air density changes related to latitude, variations between day and night, altitude changes, and variations connected with the 11-year solar activity cycle.

AIR DENSITY EXPLORER

Existing knowledge of the Earth's upper atmosphere and its density has in the main been gathered from observations of satellite orbit variations.

Although the atmospheric density diminishes rapidly as one moves away from the Earth's surface, enough gas molecules and atoms are sparsely distributed at altitudes of 300 to 500 miles (400 to 800 kilometers) to provide very small amounts of resistance to spacecraft moving through them.

The proper term for such resistance is drag, and, like any other physical property, it can be measured accurately only by instruments especially suited to the job.

Air Density Explorer is a 12-foot, 19-pound inflatable sphere considered ideal for drag measurements at the fringes of the atmosphere. Its size and light weight make it exceptionally sensitive to the small quantities of drag it is intended to measure. Furthermore, its spherical shape means that the same frontal area is always exposed to the atmosphere.

Several previous lightweight spherical satellites launched by NASA have collected much useful information about upper atmosphere densities. These include Explorer IX, launched from Wallops Island Feb. 16, 1961; Explorer XVII, launched from Cape Kennedy April 2, 1963; and Explorer XIX launched from Point Arguello, Calif., Dec. 19, 1963.

Among the important scientific findings of Explorers IX and XIX are the detailed measurements of the density of the Earth's upper atmosphere which undergoes large short-term variations from solar radiation changes. Over a long time scale, a ten fold decrease or more in atmospheric density has been measured during the period of solar minimum and is indicative of direct relationship with the 11-year solar cycle. Evidence has been found of a very high sensitivity of atmospheric density and temperature to small solar events.

The Air Density Explorer is built of four alternating layers of ½ mil thick aluminum foil (a mil is one-thousandth of an inch) and ½ mil plastic film known as Mylar (polyethylene terephthalate). The inner layer is plastic, the outermost is aluminum foil which reflects both sunlight and radio waves so the satellite can be tracked by both optical and radar techniques. It was built by technicians of the Langley Research Center, who bonded together 40 flat triangular sections of the aluminum-Mylar sandwich to form a sphere.

Temperature control while the satellite is in sunlight is provided by 4,000 white spots evenly distributed over the sphere and covering about one-fifth of its total area. Each four-inch diameter spot is formed by zinc oxide pigmented methyl silicone elastomer paint.

The area covered by the spots was selected to properly balance the heat absorption and emission charateristics of the differing surfaces so that the spacecraft's temperature inside will be maintained within an acceptable range.

To supplement optical tracking, a radio tracking beacon has been placed inside the skin of the satellite, diametrically opposite a group of nickel-cadmium batteries which form a part of the power supply. Four groups of solar cells, protected from radiation damage by quartz windows, are located on the outer surface of the satellite. They provide energy to recharge the batteries and electrical power to operate the tracking beacon. All elements of the beacon electrical system are interconnected by ribbon wire.

A strip of plastic at the equator of the sphere divides it in half so that both metallic hemispheres can serve as antennas for the tracking beacon.

Injun Explorer

The 90-pound Injun Explorer is made of pressed metal. Roughly spherical in shape and 24 inches in diameter, it has 40 flat surfaces, 30 of them studded with solar cells to provide the satellite with electrical power.

Within the Injun Explorer and extending slightly beyond its surface is the cylindrical tube in which the folded Air Density Explorer will ride into orbit plus the ejection and inflation equipment needed to transform the folded satellite into a sphere.

Inside the Injun Explorer and protruding from its surface are 16 separate sensors for measuring radiation of different kinds and intensities. Two sensors are mounted on folding booms which will extend outward after injection into orbit.

The Injun Explorer carries a permanent magnet which will align the satellite with the magnetic lines of force around the Earth, in much the same way that a compass needle aligns itself parallel to magnetic force lines. A magnetic damping rod is provided to stop any spinning or tumbling motions Injun Explorer may have when it is separated from the launch vehicle.

Extending from the Injun's surface is a boom-mounted magnetometer which will measure how accurately the satellite is aligned with the Earth's magnetic field. The magnetometer controls an internally mounted electromagnet which can be used to adjust any misalignment.

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The 16 radiation sensors which are the primary scientific instruments of the satellite fall into two general classes -- those which view radiation approaching the Injun from specific directions and those which detect particles coming from any direction. There are five omnidirectional sensors and 11 directional instruments.

Three of the five omnidirectional sensors are Geiger-Mueller tubes, measuring protons and electrons in different ranges of energy. Two others are spherical retarding potential analyzers, mounted on booms extending outward from the Injun Explorer.

The 11 directional detectors are intended to look in great detail at the radiation environment through which the satellite passes. All are adjusted to respond only to particles arriving from specific directions; hence, when the Injun is correctly oriented by its magnetic equipment, the directions of motion of the energetic particles will be measured.

Four of the 11 directional sensors are Geiger-Mueller tubes; two are scintillation counters; and three are cadmium sulphide type detectors. There also is one cadmium sulphide detector equipped with a shielding magnet to divert low energy protons, and one P-N type junction detector with a discriminator circuit.

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The satellite has two Sun sensors to indicate the direction of the Sun when the spacecraft is not in the Earth's shadow.

The Injun Explorer carries a command receiver, a tape recorder, a low power telemeter (72 milliwatts) and a high power telemeter (three watts).

All measurements, except those of the spherical retarding potential analyzers, are continuously telemetered as they are made by means of the low power transmitter which also serves as a radio tracking beacon.

By means of the command receiver, the tape recorder and spherical retarding potential analyzer can be turned on when required. The recorder can store the measurements of all the Injun Explorer instruments for a five hour period. When the satellite is over a receiving station, the high power telemeter can be commanded to relay the full five hours of stored data in only eight minutes.

Total weight of both spacecraft and the separation adapter is 135 pounds.

The Injun spacecraft was designed and built by the State University of Iowa under NASA contract.

In addition to the instruments provided by the University, it carries two particle detectors prepared by the U.S. Air Force Cambridge Research Laboratories. These detectors are capable of measuring the energy and flux of electrons and protons for particles of very low energy. It is already known that more of the energy for heating the upper atmosphere by particles bombardment is derived from the low energy of particles.

Mission Sequence

The Air Density/Injun Explorer will be launched in a southerly direction with injection into orbit occurring 1,750 miles west of Guatemala, some 1,300 statute miles down range, 9½ minutes after launch. Initial apogee will occur over Madagascar.

A little more than nine minutes after launch, the Scout adapter separation timer will be started to begin the sequence of events necessary to establish both the Injun and the Air Density spacecraft in their selected orbits.

After burnout of the fourth stage motor and while the dual payload and fourth stage are spinning at approximately 180 rpm, the timer will activate squibs to open a valve on a steel inflation bottle containing nitrogen gas compressed to 1,800 pounds per square inch. The squibs are fired about 25 after launch.

Nitrogen gas immediately flows into a bellows which expands to push the folded Air Density Explorer out of its cylindrical container. A wire cable limits the distance the folded satellite may move beyond the container, and when the cable becomes taut, the nitrogen gas passes through a disconnect mechanism, thereby inflating the 12 foot sphere. Inflation has the effect of slowing the spin rate of the entire assembly.

When pressure in the bellows decreases to a preset level, the disconnect mechanism releases the satellite from its container and a separation spring shoves it away from the Injun Explorer and the fourth stage assembly.

After separation, the nitrogen inflation gas is immediately allowed to escape from the sphere through the open valve stem, reducing the internal pressure to that of the space environment.

The aluminum-Mylar sandwich structure is sufficiently rigid to maintain the spherical shape even after the inflation gas leaves the 12-foot sphere.

The Air Density Explorer should be completely inflated and separated from the Injun Explorer about 29 minutes after launch.

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At $58\frac{1}{2}$ minutes after launch, the timer sets off an explosive bolt device which separates the Injun Explorer from the fourth stage motor case, and the separation sequence is then complete.

Launch Vehicle

Scout is a four-stage launch vehicle using four solid propellant rocket motors capable of carrying payloads of varying sizes on orbital, space probe or reentry missions. Scout is 72 feet long and weighs 20 tons at lift-off.

Scout, developed by NASA's Langley Research Center, Hampton, Va., is manufactured by Ling-Temco-Vought, Inc., Dallas.

The four motors are connected with sections which contain guidance, control, ignition, instrumentation systems, separation mechanisms, and the spin motors required to stabilize the fourth stage. Guidance is provided by a strapped-down gyro system and control is achieved by a combination of aerodynamic surfaces, jet vanes, and hydrogen peroxide jets.

Scout is capable of placing approximately a 240-pound payload into a 300-mile orbit or of carrying a 100-pound scientific package some 7,000 miles away from Earth.

Scout stages include the following motors:

First Stage:	Algol IIB - 105,000 pounds average thrust burning 68 seconds.
Second Stage:	Castor I - 62,000 pounds average thrust burning 42 seconds.
Third Stage:	Antares (ABL X-259) - 22,000 pounds average thrust burning 36 seconds.
Fourth Stage:	Altair (ABL X-258) - 5,800 pounds average thrust burning 24 seconds.

Altair II (X-258) Performance Package

Special instrumentation to measure the flight performance of the fourth stage Altair II rocket motor will be carried in a rack on top of the stage. It will monitor such things as shock, vibration, chamber pressure, temperature and acceleration.

The performance package was prepared by NASA's Goddard Space Flight Center which is responsible for the engineering measurements and which will analyze the results of the experiment. Additional information on the Altair II's performance will allow more accurate prediction of its performance in future launches.

Tracking

Tracking for the forthcoming launch is divided into two phases, the first during the ascent trajectory flight and the second after the two satellites are operating in orbit.

Launch vehicle tracking will be accomplished by the normal radar facilities of the Pacific Missile Range, supplemented by a Goddard Space Flight Center mobile telemetry trailer stationed in San Diego, Calif., and a range ship stationed near the insertion point.

After orbit is achieved, the two satellites will be tracked by NASA's STADAN network (operated by Goddard) and the Smithsonian Astrophysical Observatory Baker-Nunn Camera network. During the first orbit, data from the Injun Explorer will be read out by STADAN stations at Johannesburg, South Africa, and College, Alaska.

Air Density Injun Team

NASA Headquarters

Raymond Miller, Program Manager; Maurice Dubin, Program Scientist; and Warren A. Guild, Scout Program Manager.

Scientific Investigators

Air Density Spacecraft:

Langley Research Center -- William J. O'Sullivan, Principal Investigator; Gerald M. Keating; and Claude W. Coffee, Jr.

Smithsonian Astrophysical Observatory -- Dr. Luigi Jacchia, Principal Investigator.

Injun Spacecraft:

State University of Iowa -- Dr. J. A. Van Allen, Principal Investigator; Dr. Louis Frank; William A. Whelpley; and George E. Frohwein.

Air Force Cambridge Research Laboratory -- Dr. R. C. Sagalyn, Principal Investigator.

Project Participants

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State University of Iowa -- William A. Whelpley, Injun Explorer Spacecraft Manager, and George E. Frohwein, Injun Explorer Systems Engineer.

Air Force Cambridge Research Laboratory -- William P. Sullivan, AFCRL Instrumentation Engineer.

Launch Vehicle

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Integration Engineer; and Robert M. Dvorak, Scout Range Coordinator.

Goddard Space Flight Center -- Robert A. Dorlan, Altair Performance Vibration Engineer and Robert W. Conrad, Altair Performance System Engineer.

Launch Operations

Pacific Launch Operations Office -- William H. Evans, Director, PLOO; V. Dean Crowder, Langley Vehicle Test Director, PLOO; and Lt. Col. H. M. Sloan, Launch Control Officer, USAF 6595th Aerospace Test Wing, Vandenberg, AFB.

(Editor's Note: Artist sketch on final page shows separation in orbit of (left to right): last stage of Scout launch vehicle, Injun satellite with instruments deployed, and the 12-foot diameter air density spacecraft. These events will occur soon after orbit is achieved.)

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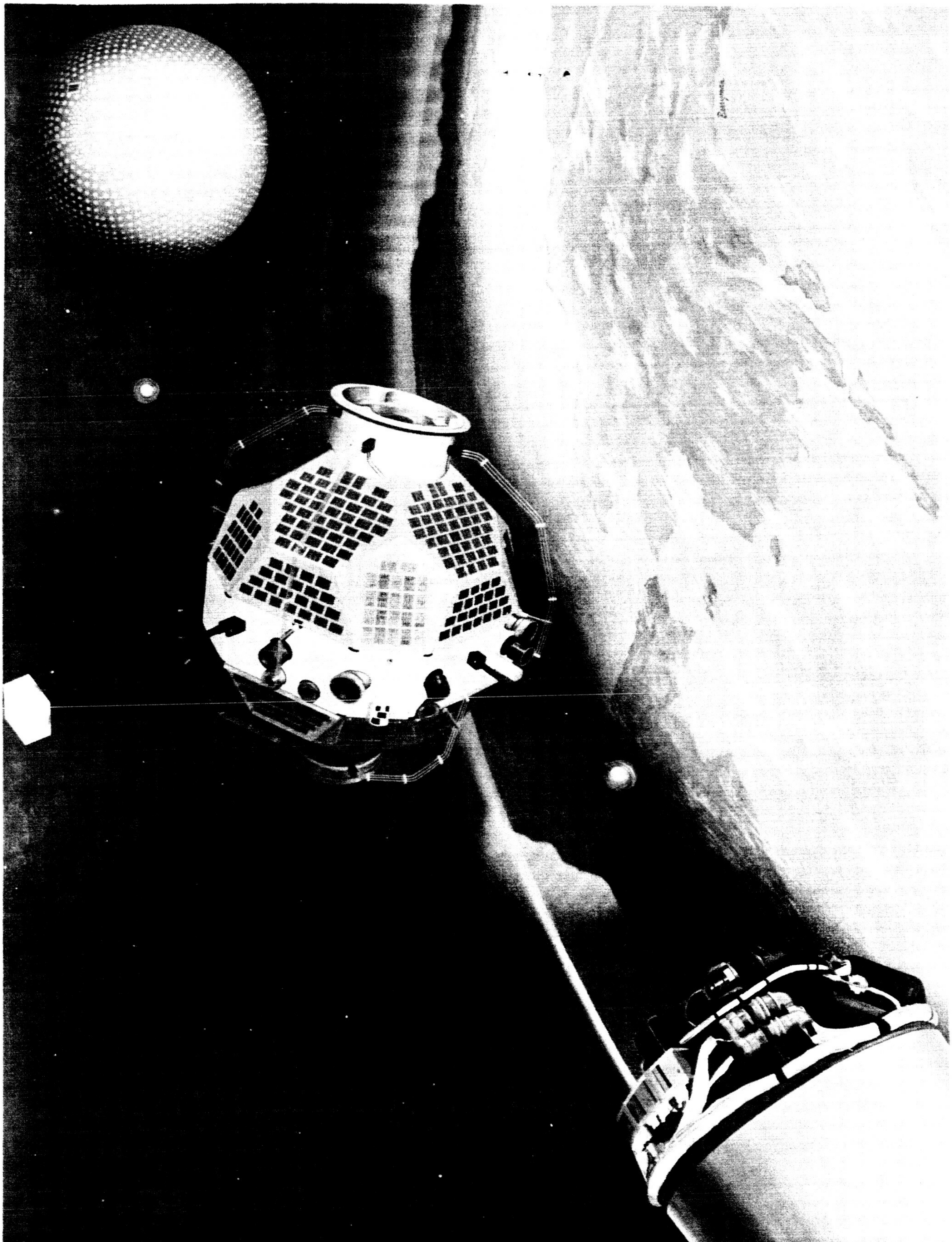

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