Apollo 17 Lunar Ejecta And Meteorites (LEAM) Experiment

Instrument Overview

The Apollo 17 Lunar Ejecta And Meteorites (LEAM) Experiment was designed to directly measure the speed, direction, and total kinetic energy of particles impacting the lunar surface. Part of the Apollo Lunar Surface Experiments Package (ALSEP) set up by the astronauts at the Apollo 17 site, the LEAM system comprised a deployable detector unit connected to supporting electronics in the ALSEP central station by a cable. The scientific objectives of the LEAM instrument were to: (1) determine the background and long-term variations of cosmic dust influx rates in cislunar space, (2) determine the extent and nature of lunar ejecta produced by meteorite impacts on the lunar surface, (3) determine the relative contribution of comets and asteroids to the Earth's meteoroid ensemble, (4) study possible correlations between the associated ejecta events and the times of the Earth's crossing of cometary orbital planes and meteor streams, (5) determine the extent of the contribution of interstellar particles toward the maintenance of the zodiacal cloud as the solar system passes through galactic space, and (6) investigate the existence of an effect called 'Earth focusing of dust particles.'

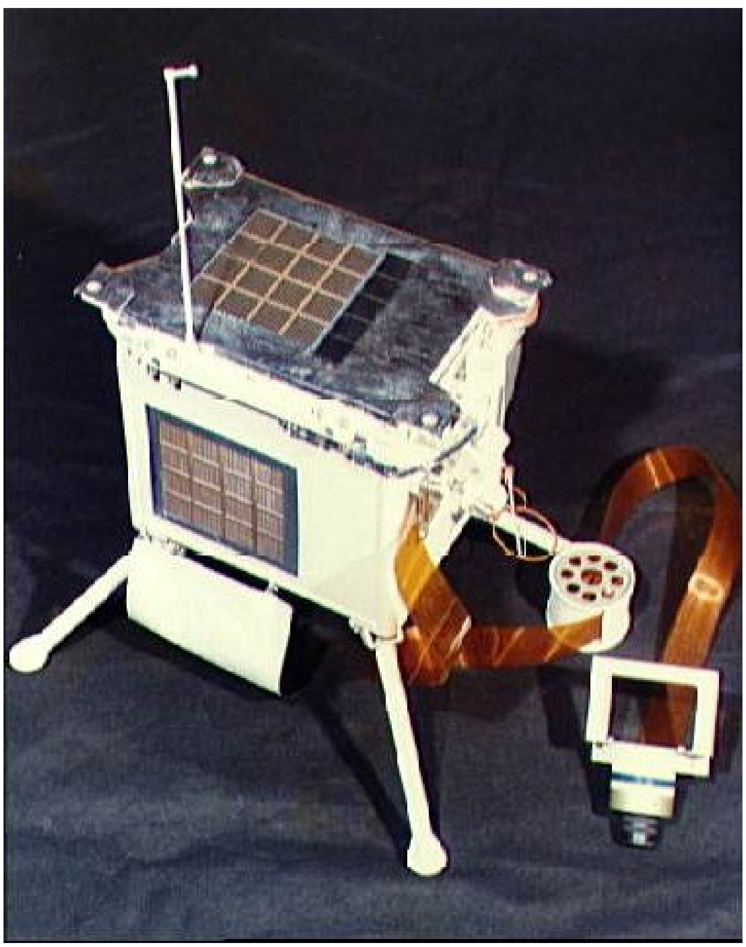

Figure 1 - The LEAM deployable detector unit

Instrument Description

The deployable detector unit (Figure 1) had a mass of 7.4 kg and was powered by 6.6 W. It consisted of a set of three external sensor systems, designated the East sensor, West sensor, and Up sensor, mounted on a box held above the ground by four legs. A cable and astromate connector linked the detector unit to the central station electronics. The external sensor systems consisted of suppressor and collector plates, impact plates, film frames, and microphones. The experiment had a mass of 7.4 kg and used 6.6 W of power. The field of view of each sensor was a square cone with a half-angle of approximately 60 degrees and an angular resolution of plus or minus 26 degrees. The terrain blocked about 60% of the East and West sensors' field of view. LEAM measured particle impacts in an energy range of 1 to 1000 ergs with a primary frequency of measurement of 0.0001 impacts/sq m/s. The time-of-flight sensor could measure velocities ranging from 2 to 72 km/sec. The external unit was erected and deployed on the lunar surface 7.5 meters southeast of the ALSEP central station at 20.19 N latitude, 30.76 E longitude. The unit was leveled to plus or minus 5 degrees. The East sensor pointed 25 degrees north of east, the West sensor 25 degrees south of west. Two covers, which could be jettisoned by ground command, shielded the detector plates from particles produced during lunar module ascent liftoff and seismic profiling explosions.

The East and Up sensors consisted of a front planar sensor array (A), a rear planar sensor array (B) mounted 5 cm behind the front array, and an acoustical impact plate (microphone) backing the rear film-grid. The basic setup involved a 4 x 4 array of sensors in the front and a 4 x 4 array in back. A particle's flight direction could be determined by the location of the sensor detecting it in front and the location in back, with the velocity determined by the time between the detections, and the particle energy by the amplitude of the detections.

The front planar sensor array (Figure 2a) had five basic components, all were approximately 10 cm square plates stacked in a parallel fashion. The outermost component was a thin beryllium copper wire mesh, called the suppressor grid, which was kept at a potential of -7 volts. The mesh was supported by a thin lexan structure which formed an array with 4 x 4 square (2.5-cm on a side) openings. Mounted on the other side of the support structure was the collector grid, made of four parallel 2.5 x 10 cm thin beryllium copper wire grid strips oriented "horizontally" (see figure) covering the 10 x 10 cm detector area (the A-grid). The collector grid was isolated from the suppressor grid and kept at a bias of +24 V. Each strip was connected to a separate amplifier.

Behind the collector grid was the film sensor array which comprised four parallel conducting film strips (the A-film) oriented "vertically" in a plane normal to the sensor direction. The film was composed of three layers of parylene with metals deposited on the surfaces of each layer to give a composite sheet of, from front (outward-facing) to back, 300-A (angstrom) thick aluminum, 700-A parylene, 500-A copper, 300-A aluminum, 3000-A parylene, 300-A aluminum, 500-A copper, 500-A parylene, adhesive, and a beryllium copper mesh. Each film strip was held at a potential of -3.5 V and was connected to an amplifier. Behind the film sensor array was another collector grid, identical to the first and connected to it electrically. The four horizontal grid strips and four vertical film strips defined the 16 distinct 2.5 x 2.5 cm square areas on the grid. Directly behind the collector grid was a suppressor grid identical to the front suppressor grid and connected to it electrically.

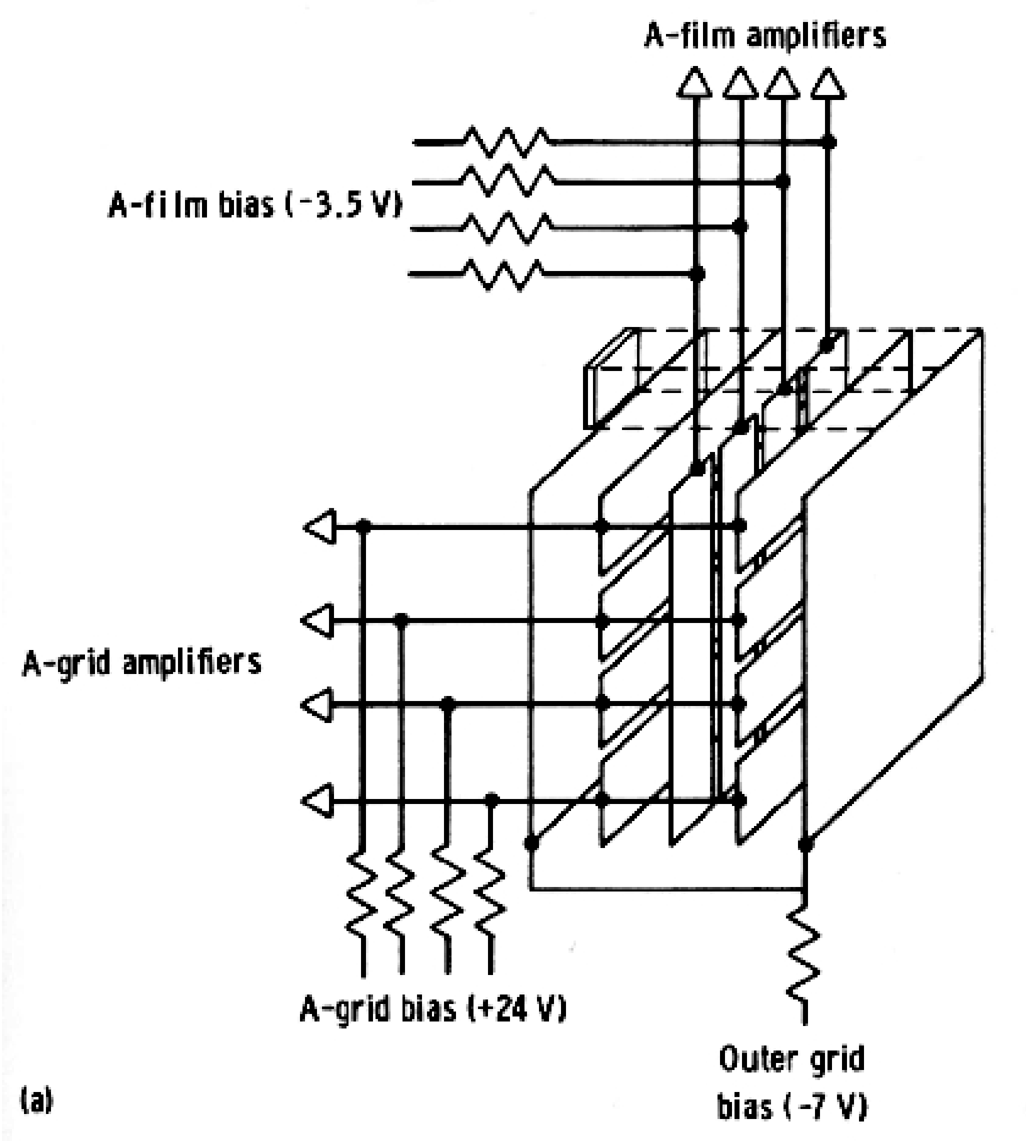

Figure 2a - Front (A) film-grid electronics configuration for the East and Up sensors.

The rear planar array (B) was mounted 5 cm behind the front array and consisted of a suppressor grid, collector grid (B-grid), and film sensor array (B-film) identical to the A array but without the second collector and suppressor grids (Figure 2b). Instead of these grids, the B-film strips were backed by a 60-micrometer-thick molybdenum sheet cemented to a quartz acoustical sensor plate with an attached microphone crystal to detect the acoustic signal of an impact.

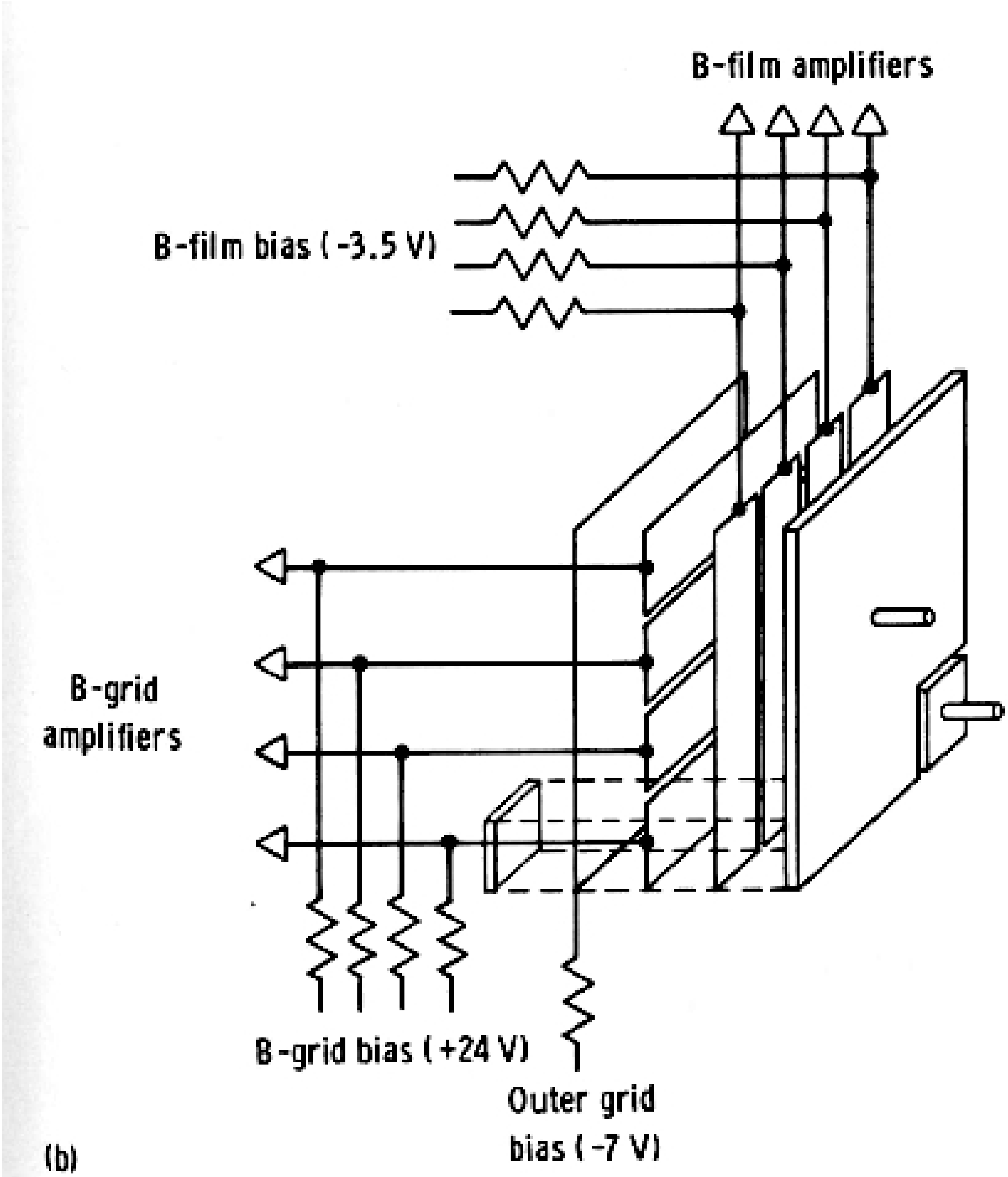

Figure 2b - Rear (B) film-grid electronics configuration.

An upper portion of the rear film array and a lower portion of the front film array on the East sensor were used as controls. An epoxy resin coated them, isolating them from products of ionization but not from electrical or magnetic radiation. A live microphone attached to a separate impact plate having 1/3 the area of the main microphone plate was also used as a control.

The West sensor, mounted on the opposite side of the LEAM unit from the East sensor, was designed differently. It had no front array, specifically so it could record low-speed ejecta impacts on the microphone plate without retardation by a front film. There was no capability to measure particle speed or direction. A microphone control was attached in the lower right corner of the rear plate of the West sensor, having one-fifteenth the effective area of the main microphone plate.

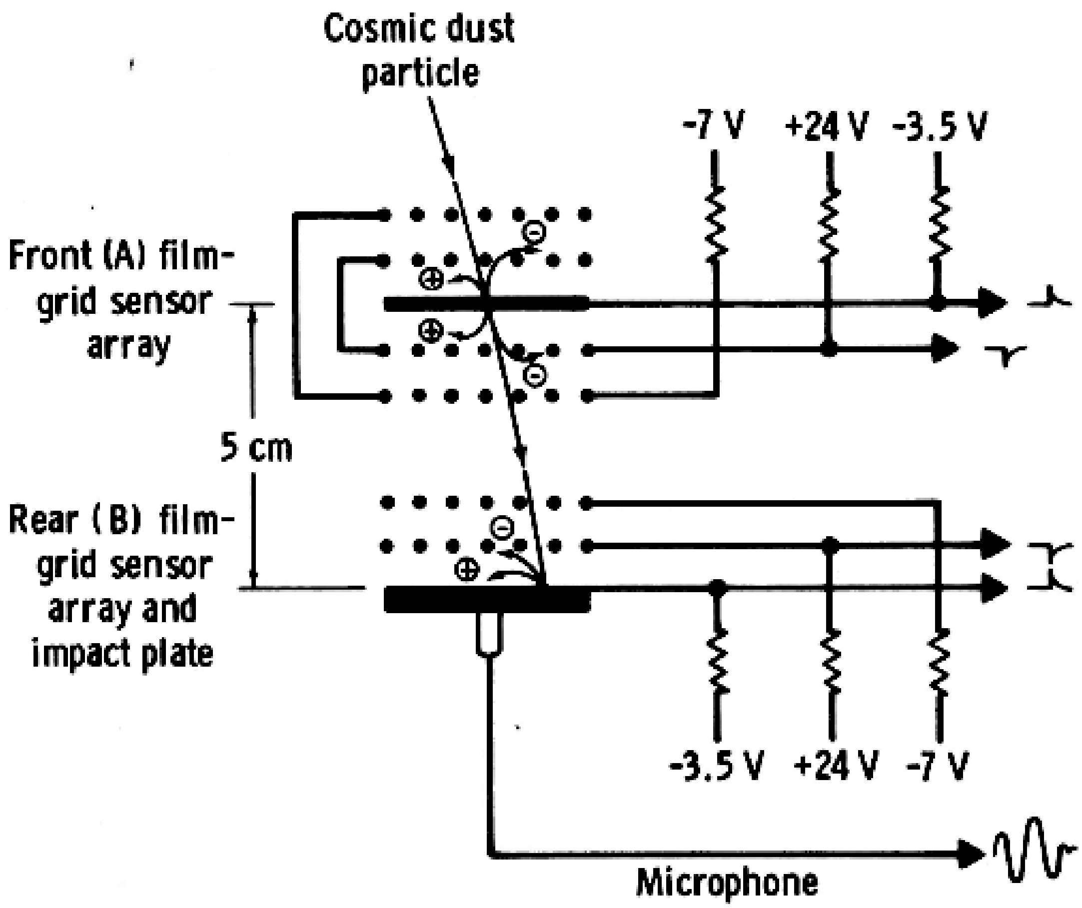

Figure 3 - East and Up sensor operation during particle impact.

Instrument Operation

For the East and Up sensors, when a high energy hypervelocity particle strikes the front film, it produces an ionized plasma (Figure 3). Electrons from the plasma are kept within the array by the negatively charged suppressor grid and collected on the positively charged collector grid, producing a negative pulse which is amplified and recorded. The positive ions from the plasma are collected on the negatively biased film, producing a positive pulse. Pulse-height analysis yields an estimate of the kinetic energy of the particle. The particle, continuing on its path, strikes the rear array and generates a second set of pulses there. When the front film is penetrated by a particle, a time-of-flight 4-MHz electronic clock is activated. The clock shuts off when the particle impacted on the rear film thus measuring particle speed and direction. The location of a front array impact is determined by the combination of grid (horizontal strip) and film (vertical strip) pulses, yielding 1 of 16 possible locations (each 2.5 cm sq) for the front array. Combining this with the location of the (slightly later) impact on 1 of the 16 locations on the back array yields 1 of a total of 256 possible combinations / directions. If the particle momentum is sufficient it will strike the acoustic plate and generate a signal. A peak-pulse-height analysis of the acoustic signal gives the remaining momentum of the particle. Each strip is connected to a separate amplifier, which in turn feeds into an accumulator counter. For the West sensor, with no front film, only the rear array pulse and microphone output is measured.

A complete readout of the LEAM data, 100 bits embedded in the ALSEP data stream, took approximately 3.019 seconds. One full data readout from LEAM comprised 31 measurements. These were transmitted in Words 31 and 39 of the general telemetry stream. Data were read continuously during LEAM operation. High and low amplitude test pulses could be alternately fed to the input of all amplifiers in order to check their condition, initiated either automatically or by ground command.

Operational History

After deployment, the LEAM instrument was turned on by ground command at 03:19 UT on 12 December 1972 for a period of two hours to verify proper performance. Two calibration commands were transmitted and LEAM responded normally. It was commanded off until after LM ascent and detonation of the seismic profiling surface charges. The LM lifted off from the Moon on 14 December at 22:54:37 UT. The first shield cover, protecting the thermal mirrors from dust contamination, was jettisoned by ground command at a sun angle of 130 degrees (40 degrees past lunar noon, roughly 08:00 UT on 21 December). The LEAM was turned on at approximately 23:00 UT on 23 December, about 60 hours before the first lunar sunset. The second cover, protecting the sensor systems, was left in place until 60 hours after sunset to allow measurement of background noise and extraneous pulse rates. It was then removed by ground command at approximately 23:00 UT on 27 December.

As the first full lunar day (January 1973) approached local noon, the experiment began to overheat and was turned off to prevent damage. A new procedure was put in place in which the experiment was turned off each lunation for 8.3 Earth days centered around local noon. The experiment proceeded under this new protocol until July 1976, when, at the P.I.'s request, the instrument was left on through the lunar day. It started overheating on July 8 and failed and started returning only static data on July 16. It was turned to standby and later turned back on, but no further data were returned after this time.

Figures 2a, 2b, and 3 are from the Apollo 17 Preliminary Science Report (1973).

References

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Berg, O.E., and F.F. Richardson, The Pioneer 8 Cosmic Dust Experiment, NASA Technical Note D-5267, 1969.

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