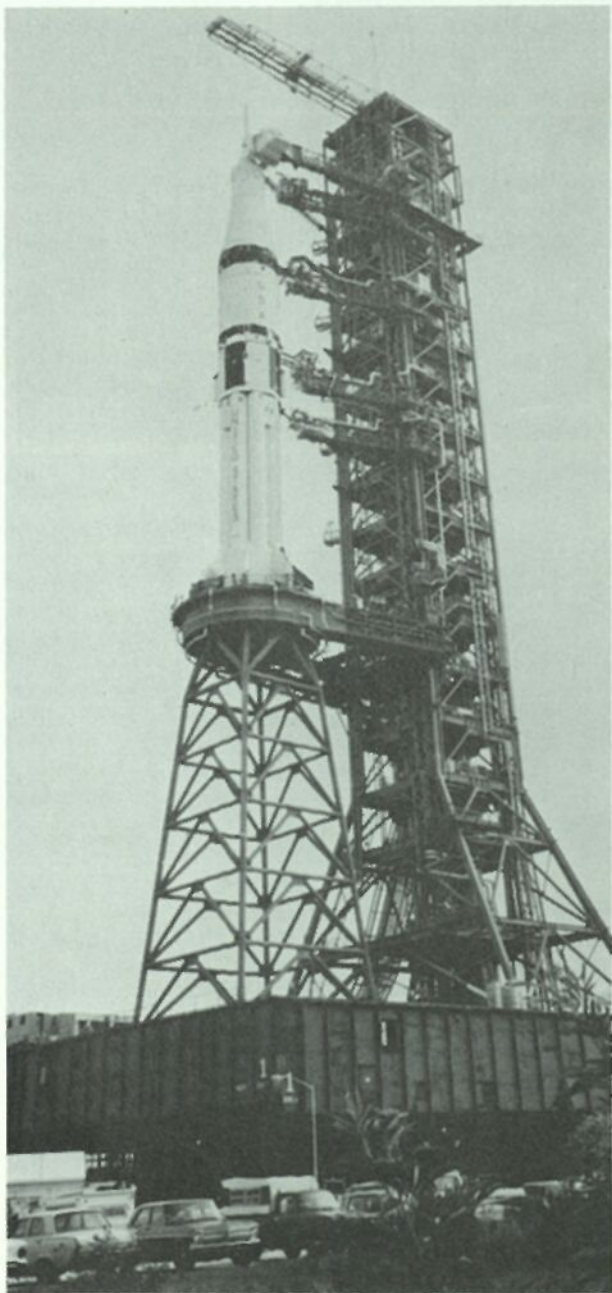


NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



# mission report



## The Second Skylab Mission: A Scientific Cornucopia

The unprecedented wealth of information gained from man's longest and most productive space voyage — the second Skylab mission — has paved the way for major advances in knowledge about the Sun, Earth, and life itself. The second Skylab mission also demonstrated that man can live and work efficiently for long periods in space.

In addition, new world records were achieved for the longest time (59 days, 11 hours, and 9 minutes) and distance (about 34½ million kilometers, or 21½-million miles) man has traveled in space. The men circled Earth 852 times, also a new record.

Launch from the John F. Kennedy Space Center, Florida, took place at 7:11 a.m. EDT, July 28, 1973. Splashdown in the Pacific about 370 kilometers (230 miles) southwest of San Diego, California, occurred at 6:20 p.m. EDT, September 25, 1973. The crew included Alan L. Bean, Commander; Owen K. Garriott, Science Pilot; and Jack R. Lousma, Pilot.

The second Skylab mission again served as a reminder that space missions are never routine and that unexpected hazards can develop. It also re-emphasized the importance of man in a space vehicle to make judgments and interpretations, respond to unforeseen events, refine and improvise experiments, and repair or replace faulty equipment.

This publication presents highlights of the second Skylab mission. It includes both achievements and preliminary scientific results and mission events.

### Increased Understanding of Earth

The astronauts returned with nearly 16,000 pictures of Earth and about 29 kilometers (18 miles) of magnetic tape recording additional Earth data. The pictures and data will contribute to man's efforts to make good use of his planet and its resources.

Astronauts Bean, Garriott, and Lousma made 39 successful Earth passes rather than the 26 planned before the mission. Each required changing the spacecraft's usual Sun-oriented position so that its

*Skylab 3 roll-out. Saturn IB is the launch vehicle.*





*View of Mission Control Center, Houston, Tex.*

Earth-viewing instruments were pointed straight down at the surface from which they were acquiring information. The crew also snapped a large number of Earth photographs with their handheld cameras.

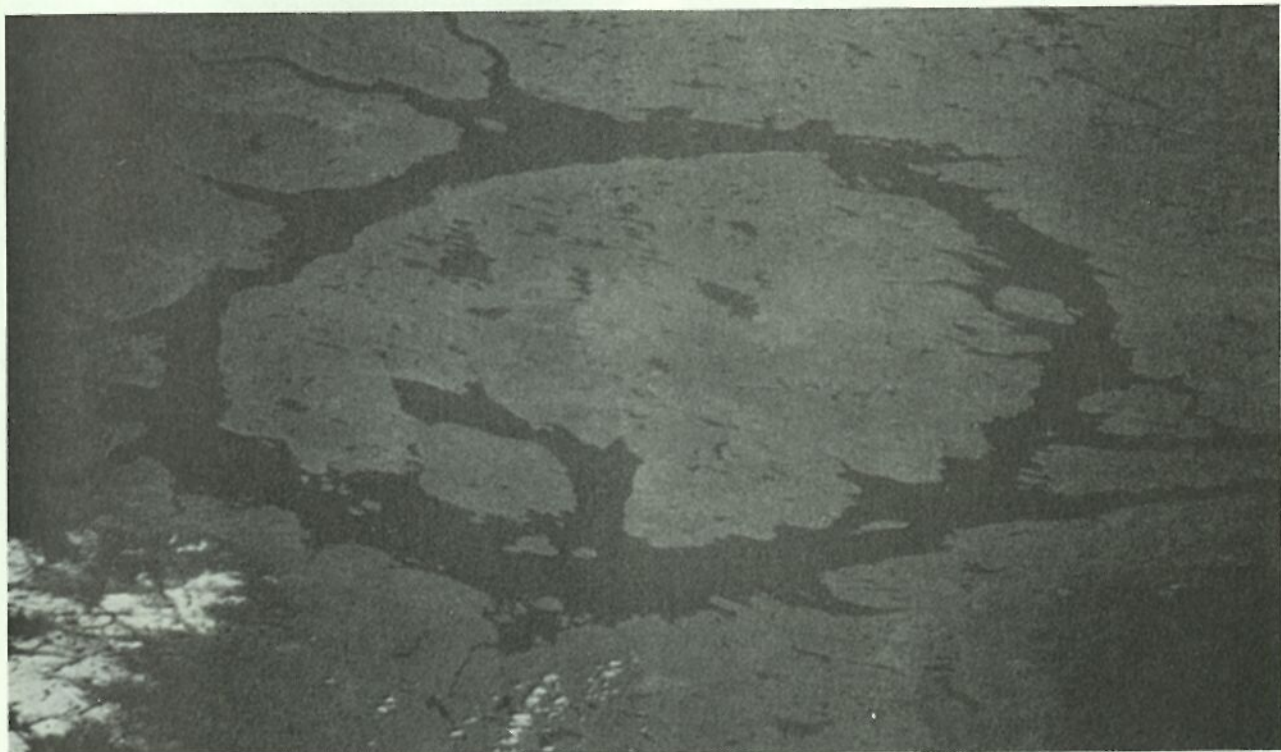
The Earth survey pictures cover most of the United States and sections of 33 other countries. They include broad areas of all continents.

The pictures and data support studies, both in the United States and abroad, in ecology and environmental quality, agriculture, forestry, mapping, geology, water resources, fishing, oceanography, mineral prospecting, and meteorology.

Their scope is suggested by the following examples from the 116 investigations which are using data from the second Skylab mission.

- Mapped the saline soils in Weslaco, Texas.
- Conducted inventories of rice and related crops in California and Louisiana.
- Studied the rangeland ecosystem of Sierra-Lahorton and Colorado Plateau.
- Studied infestation of Hemlock Looper in hemlock trees in Essex County, Massachusetts.
- Defined surface morphologic and geologic features related to mineral deposits in parts of Colorado, Nevada, Utah, California, Arizona and Pennsylvania.
- Analyzed the Anadarko Basin oil fields in Oklahoma.
- Studied drainage basins in northern California, Arizona, Texas, New England and Lalle Ontario area of New York.
- Mapped surface features related to ground water explorations and water resources inventory in the Midwest.
- Evaluated the usefulness of microwave data for determining sea state during calm and disturbed conditions.
- Examined the growth and termination of hurricanes using information gathered for Ava, Christine, and Delia.
- Mapped the four million tons of seaweed in the Sargasso Sea east of Florida as a possible Earth resource.
- Correlated the chlorophyll content, thermal patterns, and water mass variations in the eastern Gulf of Mexico with sportfish catches to assess the effects of water environment on the distribution of game fish.
- Analyzed conditions preceding severe storms in Oklahoma.
- Demonstrated applications to land use studies in the states of California, Colorado, Texas, Nebraska, Iowa, Indiana, Maryland and New York, and the countries of Mexico and Australia.
- Identified soil moisture distribution para-





*Revealed from the Skylab vantage point in space is this apparent impact structure, in the vicinity of Manicouagan Reservoir, Quebec, Canada.*



*Lake Mead area, Colorado River, parts of Nevada and Arizona from Skylab.*



meters, soil and plant relationships, and possible underground water in the parched regions of Africa.

- Tested the utility of remote sensing for updating the 1970 census in thirteen U. S. cities.
- Developed photomaps and updated existing maps of the U. S.
- Demonstrated the use of space photography for mapping of a remote area such as the "Green Heli" of Paraguay.

#### **Revolutionary Advance in Solar Knowledge**

The astronauts obtained 77,600 telescopic images of the Sun's corona, or outer atmosphere, in the X-ray and ultraviolet and visible-light portions of the spectrum. They spent more than 300 hours on solar astronomy as compared to the 200 planned. The information they obtained may contain the answers to many puzzling questions about the Sun and perhaps contribute to development of non-polluting, unlimited energy sources.

Most solar data were obtained when the Sun was

high over the Earth's horizon to avoid their being blocked or obscured by the Earth's atmosphere. Some observations were made, however, through the Earth's atmosphere to measure its constituents.

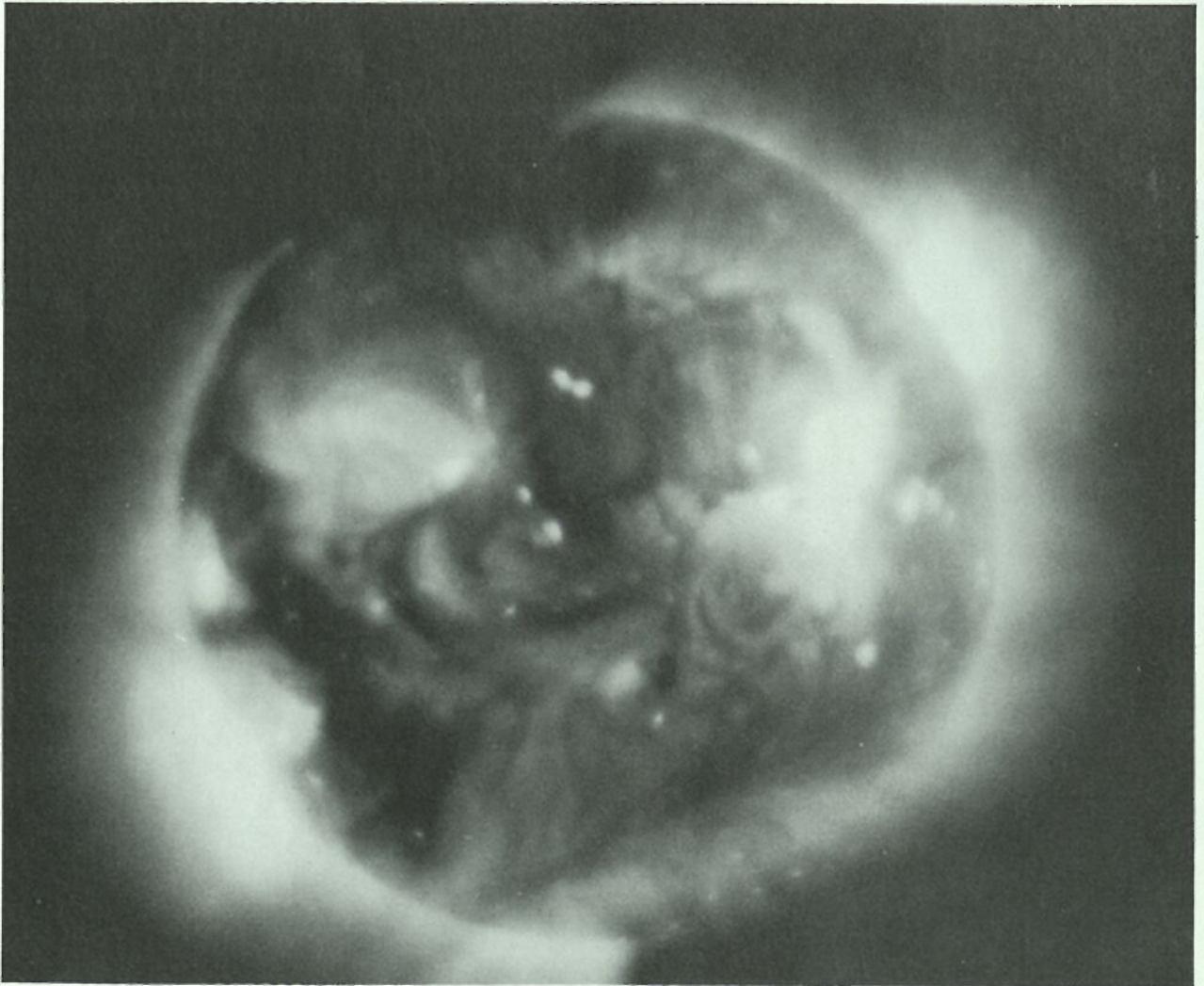
Among preliminary observations and discoveries of the second Skylab mission are:

- Coronal holes—places in the Sun's corona cooler and more rarified than the rest of the solar atmosphere—extend downward to the chromosphere (the region where solar temperature reaches a minimum). In the coronal holes, solar magnetic fields stretch outward rather than curve back to the Sun's surface. Scientists speculate that the holes may be the source of the solar wind, the hot electrified gas particles rushing outward from the Sun. The particles travel along solar magnetic lines of force.

- Solar bright points, discovered by Skylab, occur all over the Sun rather than just in the equatorial zone between 40°N and 40°S where most violent activities take place.

- Solar flares—massive outbursts of matter

*Solar image in X-ray wavelengths, taken from Skylab, reveals extremely hot corona.*







*Arabella at work.*

from the Sun's surface—sometimes arch back to a different area of the Sun and trigger new flares at these areas. Scientists had suspected but never observed this.

- Giant bubbles—often bigger than the Sun—were observed rising into the outer corona. They are believed to be responsible for magnetic storms on Earth.

- Coronal transients—eruptions that frequently occur in connection with solar flares—reshape a big volume of the corona, including its magnetic fields.

- Prominences—condensed streams of hot gas—erupt more frequently than astronomers expected.

- The life histories of many sunspots—relatively cool dark areas on the Sun—were recorded on film.

Although the Sun was supposed to be in the relatively quiet part of its 11-year cycle, it burst into extraordinary activity during a good part of the second Skylab mission. As a result, the astronauts not only obtained quiet Sun information but also photographs of an active Sun, including some 100 solar flares. The Earth's magnetic field shielded the astronauts from cosmic and other deadly particle radiation generated by this intense solar activity. Although in orbit, Skylab was not outside of the geomagnetic field which extends to an altitude of at least 64,000 kilometers (40,000 miles). The crew also observed and photographed auroras resulting from this intense solar activity.

#### **New Knowledge About Life Processes**

During all manned space missions, astronauts have experienced many changes in their bodily systems and elements that on Earth must cope with the pull of gravity. Among these are losses in muscular

tissue, bone calcium, red blood cells, total blood volume, and other fluids and weakening of the heart and circulatory system.

The samples of blood, urine, feces, and perspiration which the astronauts brought back with them plus the thorough tests and medical examinations of the astronauts after their return add to knowledge about biochemical changes resulting from weightlessness and from return to Earth's gravity. The contribution that this knowledge makes to understanding of life processes may lead to new medical advances. The knowledge is also important in planning for future long duration manned space flight missions.

Doctors concerned about the effects of prolonged weightlessness are encouraged by the fact that the astronauts' physical reactions to weightlessness appeared to have stabilized after about the 39th day in space. And, after return to Earth, the astronauts readapted much more quickly than those on the first mission. Doctors attribute the leveling off and improved reconditioning mostly to the astronauts' daily hour of rigorous exercise, chiefly on a stationary bicycle, during their long space mission.

Certainly one of the stars of the second Skylab mission was Arabella, a common cross spider. Arabella was part of a spider sister act in space (her co-worker was named Anita) intended to compare webs spun in weightless and Earth environments. After a couple of days of disorientation, Arabella spun webs resembling those made on Earth.

Garriott commented: "It seems she learned very rapidly in zero g without the benefit of any previous experience."

Anita, given her chance sometime later, began spinning normal webs almost immediately. Scientists note she had time to adapt to zero g.

The spider experiment was one of 25 selected for Skylab among those submitted by high school science students. It was suggested by Judith S. Miles, Lexington, Mass.

Another intriguing life science experiment involved Mummichug minnows. Those brought aboard at first swam tail up in tight loops. Those hatched from eggs that had been carried into space were observed to swim normally (as on Earth) in zero g. Scientists are mystified by this development.

Thus, the second Skylab mission showed that living things appear to be able to function effectively in space after a period of adaptation.

As in the first Skylab mission, weightlessness proved stimulating to the astronauts. For example, 12-hour workdays were no problem, and the crew became so proficient that they asked for and were given additional assignments. As a result, the crew completed about 1½ times the work originally planned for them despite a severe bout with motion sickness that hampered them during their first few days in space. To get well, the astronauts took scopolomine/d/amphetamine, a drug that blocks nerve pathways between the inner ear and stomach.

#### **Space Manufacturing**

The astronauts formed crystals and alloys to



determine the practicability of manufacturing new or improved products in space. The metallic spheres and the crystals formed appeared to be more perfect and the alloys stronger than those made on Earth.

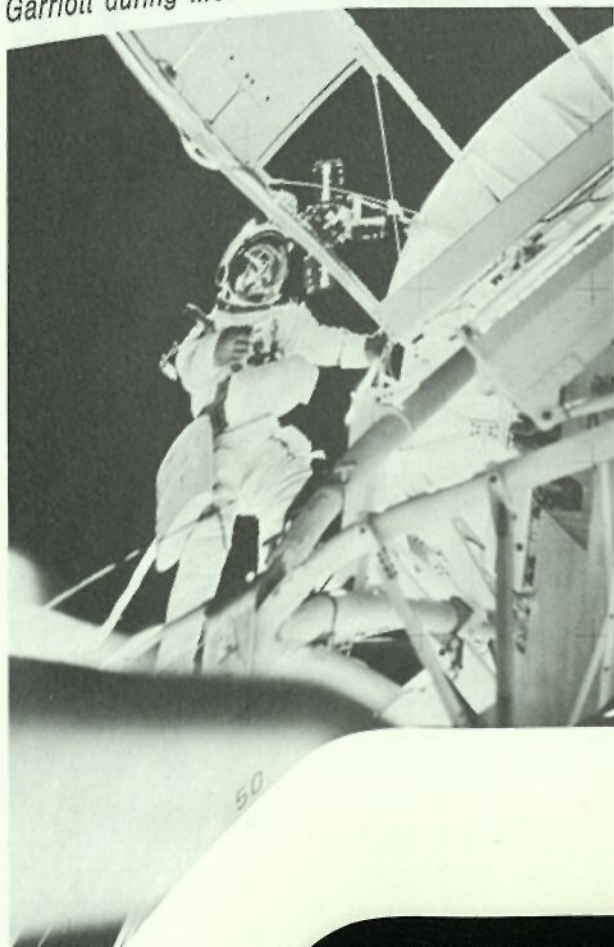
The astronauts also found that they could weld pieces of metal with electron beams. This demonstrates that large structures can be built in space.

#### Red Alert

The workmanlike performance which characterized the Skylab astronauts was carried out despite a problem early in the mission which could have developed into a serious emergency. While the crew were maneuvering their modified Apollo ferry craft (Skylab 3) to rendezvous with the orbiting space station (Skylab 1), Astronaut Bean reported seeing "some kind of sparklers." Mission Control, Houston, Tex., noted a pressure drop in one of four thruster assemblies, which are small rockets used for steering the craft, and concluded that propellant was leaking. To contain the situation, Mission Control ordered the astronauts to shut the leaking assembly down. Six days later, another thruster sprang a leak and had to be shut down. Among other things, the thrusters are needed to orient the Apollo ferry craft so that its main rocket can fire in the right direction for safe reentry and return to Earth.

Round-the-clock preparations were immediately begun to activate the Skylab rescue vehicle: an Apollo craft modified to accommodate five rather than three astronauts and a Saturn IB rocket vehicle to launch the rescue ship into orbit. At the same time, ground personnel initiated studies of the failures on Skylab 3.

*Garriott during first EVA.*



*Lousma flies experimental Buck Rogers' type backpack inside of Skylab.*

The two leaks were found to be unrelated and not, as feared, indicative of a general system breakdown. One was caused by a stuck valve; the other, by loose fittings. The two remaining thruster assemblies checked out perfectly.

The next steps were to determine whether and how Skylab 3 could be steered with half of its operating thrusters. Computer studies and ground simulations showed how it could be done. The information was flashed to the astronauts aboard Skylab 1.

The astronauts were told that they would stay aloft for 59 days, as planned. Preparation of a rescue vehicle was continued, but on a less urgent basis. Before separating Skylab 3 from Skylab 1, the astronauts were to check pressures in all their rocket systems and then fire the two good thrusters for a second to assure that they worked.

All went as intended. Astronauts Bean, Garriott, and Lousma were able to complete their mission and return safely to Earth in their own ship.

#### Three (Including One Record) EVA's

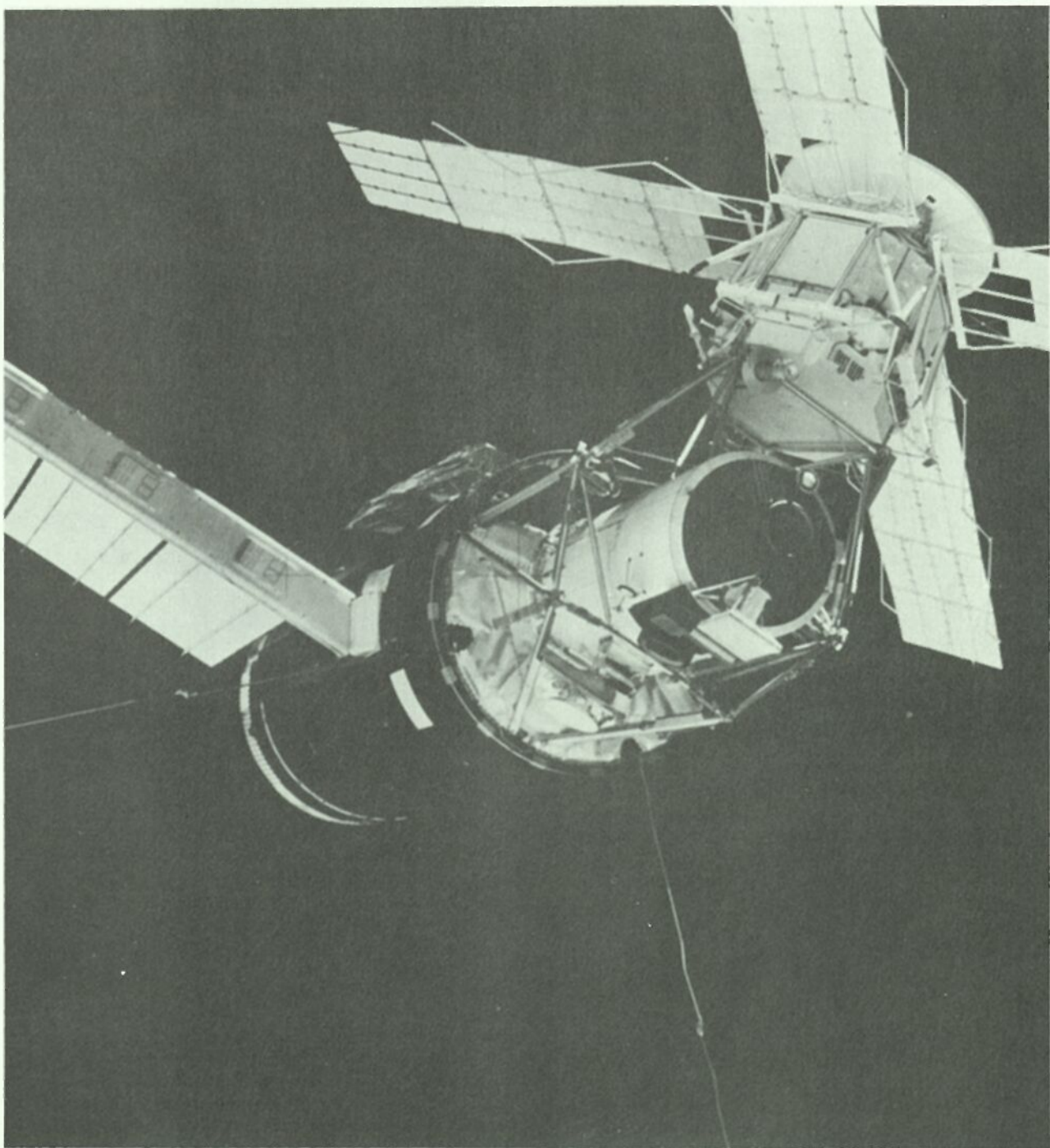
Three EVA's (extravehicular activities) were carried out to perform operational and repair work. The



first, on August 6, 1973, totaled 6 hours 31 minutes and set a new world record for spacewalks. Between 1:32 p.m. and 8:01 p.m. EDT, astronauts Garriott and Lousma loaded film canisters in their telescopic cameras, installed panels to measure micrometeoroid (cosmic dust) impacts, inspected the thrusters of the Skylab 3 ferry craft (they could find no apparent cause for the leakage), and erected a new awning over the parasol that had been set up

by the first Skylab astronauts to cool down their overheated space station, whose heat shield had been lost. (See "Man Still Matters—the Story of the First Skylab Mission," MR-13). Solar radiation and micrometeoroids had caused some deterioration of the parasol.

In the second EVA, from 12:24 p.m. EDT to 4:55 p.m. EDT, August 24, Garriott and Lousma plugged in an assembly of six gyroscopes on Skylab 1, the



*View of Skylab space station (Skylab 1) as the second Skylab crew approached it in their Apollo ferry craft (Skylab 3).*



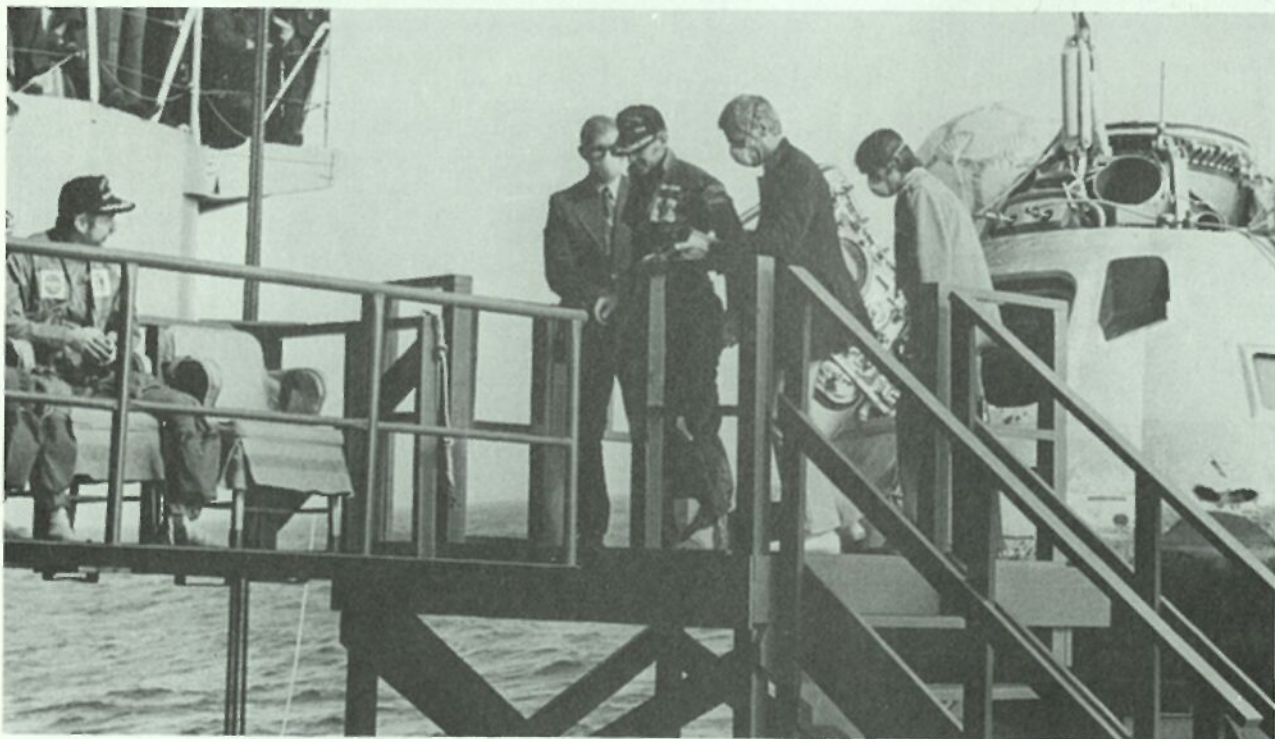
space station. The gyroscopes are needed to keep Skylab 1 from pitching up and down, yawing from side to side, or rolling. With this replacement, Skylab was held steady by three good gyroscopes in each of its three axes. One in each axis could do the job, but redundancy is a form of insurance for this vital function. The astronauts also reloaded film in their solar telescopes and retrieved the micrometeoroid panel they had set up during their first EVA.

The third and final EVA was conducted as part of the preparations for completing the mission. Bean and Garriott were outside their craft from 7:18 a.m. EDT to 9:59 a.m. EDT, September 21, to unload film cassettes from their six solar telescopes. In this as in other EVA's, the astronauts viewed with awe the Earth below and the sky above and were reluctant to return to their spacecraft.

The film, tape recordings, and samples acquired through the second Skylab mission will keep scientists and planners busy for years to come. Out of these will be derived new knowledge that can contribute to making this a better world for all mankind.

"By your scientific endeavor and your physical endurance you have converted a space vehicle into a repository of more scientific knowledge than mankind can immediately consume. In doing so, you have provided the basis for a quantum jump in human knowledge."

—From the message of President Richard M. Nixon to the Skylab 3 astronauts, September 25, 1973.



Bean is assisted from spacecraft to chair mounted on forklift truck which carried the astronaut to the ship's laboratory. These were part of precautions taken at splashdown because of concern over degradation of bodily systems due to length of mission. The men are aboard the U.S.S. New Orleans, a helicopter carrier, which is the main recovery ship.