



APOLLO 13 ACCIDENT REPORT

The explosion which cut the Apollo 13 Moon mission short was probably caused by failure of two automatic switches governing a heater inside the oxygen tank which subsequently ruptured and damaged the spacecraft's service module (see *Flight* for May 14, page 829). The switches were apparently damaged during a countdown demonstration on the launch pad three or four days before the April 11 launch. This new information on the mishap was reported on May 27 by Mr Edgar M. Cortwright, chairman of the Apollo 13 review board. The investigation and subsequent modification of the tank will delay the take-off of Apollo 14 until December 13 at the earliest.

Mr Cortwright said that failure of the small thermal switches to cut off automatically allowed the wires in the tank to heat to a temperature of 538°C. This burned insulation off the wires, permitting them to spark and start a fire in the oxygen tank. Earlier, the cause of the explosion had been traced in a general way to a short-circuit in one of several wires leading to fans, heaters and a gauge inside the tank. Further pinpointing of the short-circuit, said Mr Cortwright, came as a result of tests conducted by the Beech Aircraft Corporation, manufacturers of the steel alloy tank, at Boulder, Colorado.

The switches were apparently weakened during the partial draining of the supercooled oxygen from the tank, a normal procedure of pre-flight checkout. The process, called "detanking", is more severe than operation of the tank during an Apollo flight. The heaters are run for longer periods of time and higher current loads are put on the equipment than during flight.

The oxygen tank exploded on April 13, two days after the launch, and some 205,000 miles, 328,000km from Earth, causing an abandonment of the Moon-landing phase of the mission.

GERM RETURNS FROM MOON

A Nasa scientist has reported that a micro-organism, thought to have been accidentally deposited in the Surveyor 3 camera prior to its launch to the Moon three years ago, was recovered from inside the camera when it was returned to Earth by the Apollo 12 crew in November last year.

Capt Frederick J. Mitchell, a micro-biologist at the Nasa Lunar Receiving Laboratory at the Manned Spaceflight Centre, Houston, said the micro-organism—*Streptococcus mitis*—apparently survived the launch, the three-day, Moon-bound journey in the vacuum of space, and 950 days in the hostile lunar environment. *Streptococcus mitis* is a common respiratory organism which does not normally produce disease in man, and the retrieved organism produced no disease on inoculation into animals.

A five-month microbial analysis of the retrieved Surveyor parts and the back-up camera (as a control) began early this year following the release from quarantine of the Apollo 12 crew. The micro-organism was found in a small (1 cubic millimetre) piece of polyurethane foam which was used as insulation in circuit boards inside the camera housing. The foam was placed in a bacterial media solution, at 37°C and the first signs of life were observed after four days of incubation. On the next day the tube was "turbid" with growth, said Capt Mitchell.

Similar tests were conducted on a Surveyor 3 back-up TV camera which had been retained in "bonded" storage by Hughes since the April 17, 1967, launching. Test samplings

were made; the micro-organism was not found in the back-up camera. The samples were taken by the same individuals and the procedures were identical to those used with the retrieved camera.

Both cameras went through a series of "thermal vacuum tests" before the launch of Surveyor 3. In instances where repairs were needed the shroud on the camera was removed, the repair made, the shroud replaced and the camera then subjected to another thermal vacuum test. Capt Mitchell said the micro-organism was probably accidentally deposited on the camera during one of the times the camera shroud was removed for repairs.

These procedures, and the high vacuum of space, are thought to have been responsible for the preservation of the organism in a lyophilised (freeze-dried) state. Investigators had previously predicted that it might be possible for organisms to survive in such circumstances.

EARTH AND OCEAN PROGRAMME

A group of scientists from American Government, universities and industry has submitted a report to Nasa on potential goals and benefits of initiating an Earth and ocean programme during the next decade as an extension of the geodetic satellite programme. Such studies, the report says, could be expected to make a major contribution to the understanding and ultimate prediction of earthquakes, tidal or seismic sea waves, volcanic eruptions and hurricanes.

The report, "Solid-Earth and Ocean Physics," which is the result of a study sponsored by Nasa and the Massachusetts Institute of Technology, would also aid in the change from "exploitation to recycling in the use of materials extracted from the Earth's crust."

The expanded programme costs are estimated at about \$10 million (£4.2 million) in the early 1970s to about \$50 million (£21 million) by the middle of the decade—and possibly double that, depending on the national economy and need for data. The geodetic satellite programme, started in 1964, has cost \$14.5 million (£6 million) to date.

The study would identify the mechanisms that cause earthquakes as well as variations of the gravitational field. Examination of the general circulation of the oceans at all depths would account for current flows, temperature, salinity, and spatial and time variations. This information would be helpful in climatological forecasting and in determining the capacity of the oceans to assimilate pollutants.

Improved understanding of the global heat balance through study of ocean currents and heat transfer of air-sea interaction could be gained and identification could be made of the internal driving forces and complex mechanisms of interaction of the Earth's core, mantle and crust. These could give a greater understanding of continental drift and ocean floor spreading.

Definition of the locations and mechanisms of energy dissipation in the oceans would help explain such phenomena as the ocean tide pattern and the evolution of the Earth-Moon system, while explanation of the mechanisms associated with the variations in the rotation rate and wobble of the Earth's rotation axis and their possible association with major earthquake events could be found.

The report suggests that a network of geodetic stations that could be interrogated by satellite or aircraft be placed along a known earthquake fault zone; for example, the San Andreas fault system in California. The 1969 study stemmed from Nasa efforts in satellite geodesy, initiated in 1962, that resulted in the National Geodetic Satellite Programme (NGSP) in 1964, a joint endeavour of the Department of Defence, Department of Commerce and Nasa.

OLDEST MOON ROCK

A "lemon-sized" lunar rock returned by the Apollo 12 crew has been found to be chemically unique and to possess the highest concentration of naturally radioactive elements yet observed in Moon samples. Preliminary examination indicates that this rock has an apparent age of 4,600 million years—the oldest rock yet found on the Moon and the oldest seen by man.

During examination of Apollo 12 samples at the Lunar Receiving Laboratory this 83-gramme (approximately three-