APOLLO

# 13's glitch, 14's delay

## Human error, not design failure, at fault in the last mission's abort. Nevertheless the next shot faces further postponement

NASA

*Apollo 13 review board: Human error caused the blast.*

There has rarely been an accident that has received as much scientific and engineering scrutiny as the explosion in the oxygen tank triggering the abort of Apollo 13 in April (SN: 4/18, p. 387). In the two months since the accident, tests of the oxygen tank and the service module bay area, under direction of a special review board, have been first priority at most of the National Aeronautics and Space Administration's research and flight centers.

**The board,** composed of top NASA and contractor personnel, was commissioned by Administrator Thomas Paine to find the answer to the explosion. The job was complicated by the loss of Apollo 13's service module; as a consequence, the test procedures had to rely entirely on telemetered data and simulation. Although the final report and recommendations will not be turned in until June 15, a profile of the accident has emerged.

According to board chairman Edgar M. Cortright, director of NASA's Langley Research Center, the cause of the explosion has been traced to a human failure before launch, and not, as was originally suspected, an intrinsic failure of the Apollo spacecraft. The Apollo system had previously made two almost flawless lunar landings. The finding of human error restores a faith in the engineered system, a faith that had been shaken by the mishap. Nevertheless, there will be considerable tightening of procedures, even if it means a further postponement of Apollo 14 into next year.

The evidence points to a mistaken, improvised procedure in the final hours before launch. During the prelaunch preparations at Cape Kennedy for Apollo 13, where all systems go through their final checkout before a lunar trip, the engineers had difficulty getting the liquid oxygen out of its tank after a countdown run (SN: 5/9, p. 455). At that time engineers, using ground support equipment, turned the heaters on in the oxygen tank to vaporize the oxygen and force it out, a method never before used. The voltage applied to the heater's thermostat switches from ground support equipment was 65 volts; the switches were rated at 30 volts.

The result was that the switches were welded shut. No longer protected by thermostats, the heaters operated for the 58 hours between activation, three hours before launch, and the explosion three-quarters of the way to the moon. The temperature in the heater tube assembly, according to Cortright, could have exceeded 1,000 degrees F.

Tests to reproduce this situation showed that temperatures this high cause the Teflon coating on the wires to bake and the insulation to be destroyed. The exposed wires would then arc when they touched metal or ground. When the fan motors were turned on in flight to cycle the oxygen on the night of April 13, the wires shorted, igniting the brittle Teflon insulation inside of the tank. The insulation burned to the top of the tank, where it reached additional insulation around other wires, creating, in Cortright's words, "a local furnace" that burned a small hole through the top of the tank.

**The oxygen** then sprayed out into the service module bay area, enveloping the mylar insulation in bay 4, which exploded in a sharp pulse, blowing the service module's panels off.

Narrowing the search to the welded switches at the Cape involved going through log books that are kept during all countdown procedures. There was no real-time display of the subsystem on monitoring consoles at ground control to show that the switches had been destroyed. A change there is one possible consequence of the investigation.

**The effect** of these findings on the launch of Apollo 14, which was originally scheduled for October, then delayed until December after the abort (SN: 5/16, p. 478), is still not known. Officials are publicly holding to the December date, but the chances are good that Apollo 14 may not be launched until January or February. Both budgetary restraints on the overall program and a detailed, time-consuming examination of the Apollo spacecraft and countdown procedures to avoid a repetition of the 13 accident are involved.

After the review board report comes in next week, NASA officials will be able to direct their energies to what modifications, if any, will be necessary to ensure the safety of the Apollo 14 flight. One modification will not be necessary; the switches which caused the trouble in Apollo 13 have already been taken out of the 14 and 15 spacecraft because they were found not to be needed.

Proposed modification of the ascent stage of the lunar module so that it could act as a lifeboat in case of emergency—as the whole LM did in Apollo 13—does not look practical. There is no way the ascent stage can supply power directly to the command module at present, and giving it that capability would require a major redesign. The Apollo 16 LM will have that capability.

Meanwhile, the Apollo 15 spacecraft itself, says NASA, may not fly. Its Saturn 5 booster may be used instead to launch the second of a pair of planned Skylabs in the next few years. Production of Saturn boosters has been suspended (SN: 3/14, p. 264). □