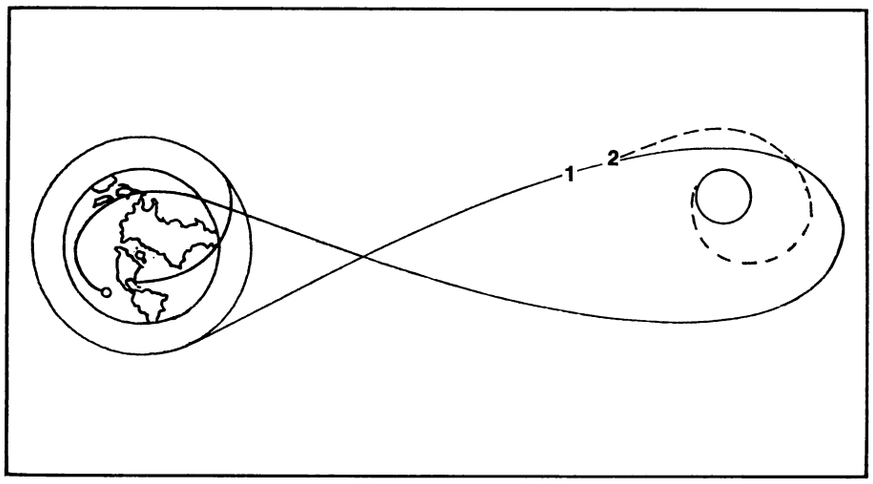
Untimely end of Apollo 13

Fra Mauro mission aborts 190,000 miles out on the way to the moon



Robert Trotter

Fifty-five hours into Apollo 13 (1), power, oxygen loss triggered abort (2).

The United States has launched 23 manned spacecraft, two of which brought men to the moon, and has logged more than 5,890 man-hours in space. This week the stream of almost unbroken successes ran out. After Apollo 13 had logged 55 of those hours, the United States faced its worst space crisis to date and its most hazardous problem in manned flight: a circumlunar abort of Apollo 13 some 190,000 miles from the earth.

The decision to abandon the mission to the moon's Fra Mauro highlands and bring the astronauts back came late Monday after attempts to locate and correct an electrical system failure in the service module, powering the command module, proved fruitless. The three-man Apollo 13 was three-quarters of the way to the moon when a system failure, accompanied by either an impact or an explosion, brought the mission to a close.

Early in the crisis it became clear that the astronauts were in no immediate danger. But in the moments after the event, two of the astronauts had to crawl into the dormant lunar module to activate life-support systems. And throughout the hours and days that followed, the possibility of returning the astronauts safely to earth depended on that spidery lifeboat's oxygen and power.

The original flight team had been exposed to rubella days before Saturday's launch. Because one astronaut had no rubella immunity, Apollo planners had faced the choices of either a flight postponement or an unprecedented crew substitution four days before launch. The substitution of John L. Swigert for measles-prone command module pilot, Thomas K. Mattingly, turned out to be prophetic for the ill-fated flight. Swigert and lunar module pilot Fred Haise Jr., during the training periods, wrote the training book on malfunction procedures for both modules.

Lovell

Haise

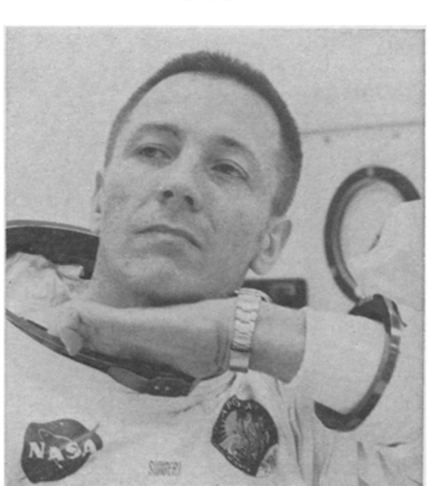
James Lovell, the commander, has logged more hours in space than any other astronaut.

The crisis developed 55 hours into the flight, after a loud bang aboard the spacecraft, followed by gas visible from the spacecraft, and a rapid drop in oxygen pressure. Whatever happened triggered the shutdown of two of the spacecraft's three fuel cells, one major electrical circuit and required the shutdown of the entire electrical system.

The service module bay area, where the disaster struck, contains the three fuel cells, along with two cryogenic oxygen and two hydrogen tanks. The fuel cells are power plants generating electricity, heat and water through an exothermic chemical reaction of oxygen and hydrogen.

Two possibilities for the cause of the breakdown were proposed. One is that a meteorite hit the spacecraft; another is that the pressure release valve of the oxygen tank stopped working and a tank exploded.

The abort was achieved with one firing of the descent engine of the LM. It came less than five hours after the trouble began, and it was necessary to place the spacecraft back into a free-return trajectory that could swing the craft around the moon and back to earth without further firings. Apollo 13 had been on a trajectory that would have whipped the craft around the



Photos: NASA

Swigert

moon and missed the earth by 50,000 to 150,000 miles.

The engine firing was designed to move the crippled spacecraft back into a free-return trajectory, aimed at a landing in the Indian Ocean.

Another firing, after the spacecraft was on its way around the moon and two hours past its orbital low point, was necessary to get the crew back to the Pacific.

But following this one, Apollo 13 was no longer headed for the reentry corridor. Tracking data after the burn showed the spacecraft was on a course which would have skipped it off the atmosphere, into the orbit around the sun, missing earth by 86 nautical miles.

The miscalculation was the result of an inaccurate alignment of the lunar module guidance system at the time the booster was fired.

The platform had been aligned 20 hours earlier, using the command module guidance system before it was shut down. There was no way to update the alignment accurately.

Except for the uncertainty following the initial incident, and some trouble with excess carbon dioxide in the cabin atmosphere fixed by a jury-rigged filter, that was the flight's most anxious time, up to reentry and splashdown.

A third midcourse correction was made late Wednesday night to head back toward the reentry corridor, and a fourth, refining burn was used Friday morning to hit the corridor's middle.

The most intricate and hazardous activities of the aborted flight came after 6:23 a.m. Friday, Houston time, as preparations for reentry and splashdown were to be made. For reentry, the crew was completely dependent on the command module, which had been virtually out of action since the emergency began.

Its thrusters had to be heated prior to transfer of power from the lunar module; its computer had to be given enough fresh information to give it a reasonable chance of bringing the crew down accurately, and its reentry batteries, which had already been used in the emergency, had to be pumped back up.

The crew was asked to photograph the damaged service module as they jetissoned it four and a half hours before reentry. Without those photographs, any possibility of learning the cause of the disaster would be forever lost in the Atlantic Ocean. The lifeboat lunar module was to be dropped off an hour before splashdown. This left the command module's three, overused reentry batteries as the only source of power for the helium pressured control thrusters needed to maneuver the crew to splashdown in the Pacific early Friday afternoon. □

POLLUTION

Mercury in Lake St. Clair

Mercury poisoning has been a problem for man since the beginning of the industrial revolution. The bizarre mental symptoms of mercury poisoning gave rise to the phrase, "mad as a hatter," in the 19th century, when mercury compounds were used to treat felt in hat-making. New industrial and agricultural uses for mercury have created new hazards, and 111 people in Minamata, Japan, were killed or disabled from eating fish contaminated with mercury from a plastics plant in the 1950's.

Recently, the Department of Agriculture acted against mercury compounds used as fungicides after three members of a New Mexico family were grotesquely disabled after eating meat from pigs that had been fed fungicide-treated grain.

Despite mercury's bad record, most Federal agencies in the United States—with the exception of the Food and Drug Administration, and it has been hampered by limited jurisdiction and funds—have been oblivious to the possible effects of the use of the metal in dozens of industrial processes. But a mercury scare that began in Canada last month promises to rouse the United States' regulatory agencies from their lethargy.

Late in March, the Canadian Government announced that it had found mercury levels as high as five parts per million in pickerel from Lake St. Clair near Detroit on the Canadian-United States border. Basing its action on a legal limit of 0.5 parts per million of mercury in fish, the Canadians placed an embargo on all fish from the lake and the St. Clair River, and stopped commercial and sport fishing.

This week, Michigan and Ohio authorities followed suit with a ban on fishing, not only in Lake St. Clair, but also in the Detroit River and the western end of Lake Erie—where scientists from the Food and Drug Administration had found mercury levels of up to 1.4 parts per million in walleyed pike. The FDA, the Federal Water Pollution Control Administration and the Bureau of Commercial Fisheries now plan extensive monitoring programs throughout the United States.

Edward Hearnden of the Canadian Department of Fisheries and Laurence O'Leary, director of the Lake Huron FWPCA office, say the sources of mercury are clear: chlorine alkali plants owned by the Dow Chemical Co., on the St. Clair River in Canada and by Wyandotte Chemical Co. on the Detroit River in the United States. The plants produce sodium hydroxide and chlorine gas electrolytically from brine, using metallic mercury as one of the electrodes. The mercury was apparently released at the Dow plant from leaking tanks and at the Wyandotte plant from venting an otherwise closed system that circulates brine between the plant and salt caverns. Both companies are acting to eliminate mercury discharges from their effluents.

Plant officials had thought that the relatively inert and insoluble metallic mercury released from the plants collected harmlessly on river bottoms. But Richard Ronk, acting chief of guidelines and compliance research at FDA, says there is good evidence that anaerobic bacteria, common in streams with high levels of industrial effluents and low levels of oxygen, convert the mercury to more soluble methylated forms, the most toxic class of mercury compounds and are the ones which are responsible for the many Japanese deaths and disabilities.

It is possible that even with elimination of mercury from industrial effluents, the mercury on the stream bottoms will be a long-term source of the dangerous methylated compounds, Ronk says.

Whether metallic mercury and inorganic mercury compounds are methylated biologically has not been clearly established. Doubt still exists, for example, as to whether this happened at Minamata, or whether the plastics plant effluent was already methylated, says Dr. Leonard J. Goldwater, Duke University toxicologist. Mercury compounds vary greatly in toxicity, and he believes that current concern over mercury contamination is little more than hysteria until actual compounds have been isolated. He points out that metallic mercury, as well as some inorganic compounds, are not toxic except at very high doses, although he agrees the methylated compounds are highly toxic.

There is no doubt that determining what compounds are involved will be important, especially in establishing what the chronic low-level toxic doses of various mercury-containing substances really are. The 0.5 parts per million tolerance in both Canada and the United States is based on a single mammalian test with a particular compound, for example.

Also being questioned is whether low-level mercury poisoning is linear, with at least some poisoning occurring with the smallest possible dose, or of the threshold variety, with no poisoning occurring except beyond a certain level.