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 jettisoned 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.