mineral waters. Sodium sulfate (380 million tons) more commonly called Glauber's salt, is used as filler in detergents, a laxative, a diuretic and in dyeing and printing textiles. Magnesium chloride (210 million tons) is used in making magnesium metal, sugar refining, disinfectants, construction and fireproofing wood.

Key to the operation is the fact that different minerals precipitate or crystallize at different concentrations. Sodium chloride comes out first, the lithium chloride is last.

Taking advantage of the desert climate, chemical engineers use solar energy to supply the precipitation energy. Without the sun the operation would not be practicable, since gas or coal would cost too much.

In the process, the minerals are extracted in sequence by two main routes: concentration via evaporation, and precipitation. Ordinary salt, of which 6 million tons are produced annually, is the first to be precipitated in salt ponds. The remaining brine moves by pumping and gravity to the harvest ponds, where the crude salts of sodium sulfate precipitate and are harvested and trucked to a processing plant for recovery. The remaining brine flows on to other harvest ponds, where the crude potassium sulfate salts precipitate. They are also harvested, trucked and then recovered at a plant. The bittern or brine left over after the salts have precipitated out, are pumped to a plant where a high-purity magnesium chloride is recovered.

The final stage will be the construction of a plant to remove the lithium chloride.

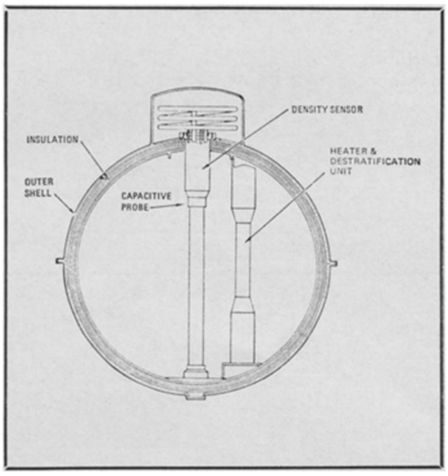
"We can't start up a (lithium) plant until GSL has supplied us with sufficient bitterns feedstock," says E. E. Smith, president of Lithium Corp. "The earliest would be 1973." There will be further delays to mesh the Salt Lake operation with other Lithium Corp. operations.

Although the system may sound simple enough, its construction was an engineering feat. The pond system, with its 130 miles of dikes and 14,000 acres of pond area, required the handling of 6 million cubic yards of material—all of which was done in six months in 1967.

In addition, to get the potassium sulfate, conventional processing proved inadequate and chemical engineers were forced to develop a new method. "We developed a process by ourselves," says Dr. Gerhard Flint, vice president of corporate development for GSL. He describes it as a unique two-stage leach-crystallization process with an intermediate material, shoenite, which was converted to potassium sulfate, the desired end product. □

APOLLO REVIEW BOARD

Shorts in the system



NAR

Oxygen tank: Internal items must go.

In the weeks since the Apollo 13 mission was aborted because of a major power breakdown, space officials have been fairly confident that they could locate the malfunctioning subsystem and change the design to eliminate the probability of a repeat.

That feeling continued last week, when the appointed Apollo 13 Review Board verified earlier suspicions that the instigator of the eruption in the oxygen tank had been a short circuit (SN: 5/2, p. 431).

A single component failure should be easy to fix. But that failure caused the shutdown of a major system, an event that Apollo planners had not predicted. They are thus having to review the whole system, not just the oxygen tank, to see if any other such conditions exist.

Dr. George Low, Deputy Administrator of the National Aeronautics and Space Administration, described the most probable sequence of events. A short could cause a type of combustion that would raise temperature and pressure beyond the valve capability and rupture the tank. The tank would then blow off one of the side panels of the service module.

Dr. Low further narrowed the short circuit to the wires leading to the tank's fans or fan motors. These are encased within the tank itself, along with temperature gauges, quantity sensors and heaters. The heater wires themselves are eliminated as possible culprits since the heaters were not on at the time. The current leading to the gauges and sensors has been written off as well; it is so low that these wires are unlikely candidates.

If the wires leading to the fan components are the culprits, this will necessitate investigating other spacecraft areas where similar situations may exist. The prime targets will be sections of the crafts where wires could make contact with combustible materials. One probable point of investigation is the tanks containing nitrogen tetroxide, the oxidizer used for the service and command module fuel systems, although the components inside these tanks, such as gauges, require very little current compared to the fan motors.

Since the fans and motors in the oxygen tank are of the same design that flew successfully on other Apollo flights, the design itself is not the prime suspect. The board (in scrutinizing the complete history of the oxygen tanks from their birth at Beech Aircraft in Boulder, Colo., to their death in deep space) has come up with some events that may have affected the performance of the components where the breakdown occurred.

One notable event was the need to replace the motors and fans at Beech Aircraft because the initial ones did not meet specifications. Another occurred at North American Rockwell at Downey, Calif., where the service module is built, when the tank slipped in a hoist, jarring it. And at Cape Kennedy, prior to launch, there was an anomaly that made it difficult to empty the tank of its oxygen, and an untried method was used. These events, while not particularly significant in themselves, are being examined, says Dr. Low.

"We had some anomalies in every Apollo flight. But none of them was as critical, none of them was potentially as catastrophic as these might have been on Apollo 13," he says.

After the cause has been identified, tests must be devised to reconstruct the entire sequence of events. Changes to the tanks themselves are inevitable: the fans, fan motors, wiring, all nonmetallic and aluminum parts that could react with oxygen will be removed from within the tank.

The fans, which are used to stir the liquid oxygen to keep it from forming layers of different temperatures, might be eliminated entirely, according to some space engineers. It has been necessary to use the fans only infrequently on previous Apollo flights.

What the board's ultimate findings will mean in terms of the launch date for Apollo 14, no one at NASA is predicting. However, Dr. Low remains confident. "There was a time when we launched Apollo flights on two month (intervals) and made some very major dramatic changes in those fairly short periods of time," he says. □

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to *Science News*.
www.jstor.org