Bee-Hive

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3 ON

As a major Project Apollo contractor, United Aircraft took a pivotal part in the lunar landing mission last summer. It helped put man on the moon, keep him alive there, and return him to earth. Thousands of United Aircrafters contributed to the efforts, some of which stretch back to the 1950s, in research, design, development, manufacture, and test that went into the equipment the corporation created for Project Apollo. Three men at United Aircraft had special responsibilities in Apollo 11. They are the program managers for three sets of equipment that were instrumental to the success of the mission.

By Frank Giusti

1 JACK LEE: Chief of the Powerline

John Maxim Lee took his first airplane ride at the age of four or five, back in the early '30s, as a passenger on a test flight of a Fairchild Pilgrim. The pilot wore a parachute. No one else aboard did; not young Lee, his sister, his mother, or his father.

"My father was project engineer at the time for Fairchild on the Pilgrim, and the plane had a rattle or a noise or something, and they wanted to take it up to see what was wrong," Lee recalls. "It was a Saturday, so he took the family along. The test pilot was Dan Beard, who later became a vice president of American Airlines."

Young Lee doesn't recall that he was beset by nervousness at all when he went up without a parachute in the Fairchild Pilgrim, a single-engine, fabric-skinned monoplane. But understandably he admits to a feeling of anxiety during Apollo missions.

Lee is program manager for Pratt & Whitney Aircraft's Powercel® units, or fuel cells, which generate all electricity aboard the command and service modules throughout the Apollo flights. The Apollo 11 mission, in which Neil Armstrong and Edwin Aldrin landed on the moon, lasted 195 hours from liftoff to splashdown. Pratt & Whitney Aircraft's Powercels aboard were actually in operation for a total of 255 hours, beginning five days before launch. They continued on line until 25 minutes before splashdown when the service module, containing the fuel cells, was jettisoned from the command module carrying the astronauts to a landing.

Three fuel cells are aboard for each Apollo mission. They produce electricity through a controlled electrochemical reaction between hydrogen and oxygen, both stored aboard in liquid form but supplied to the cells in a gaseous state. A by-product of the chemical reaction is pure water, which Armstrong and Aldrin drank and used to reconstitute their food and do certain cooling jobs. The powerplants are each capable of supplying up to 2,200 watts of electricity.

"They fill all the electrical needs of the spacecraft; not only the everyday requirements we on earth might have at home, like cooking, heating, and cooling," Lee said, "but also for such equipment as TV cameras, communications, telemetry, and the guidance computer. These functions and others all depend on the fuel cells for their electrical power."

During the Apollo 11 mission, data on the Powercels' performance was gathered by Pratt & Whitney Aircraft engineers at NASA's Manned Spacecraft Center in Houston and transmitted by facsimile apparatus for analysis 'round the clock by engineers at the company's South Windsor Engineering Facility in Connecticut. Lee himself was on duty there about 12 hours a day. He slept when the astronauts did, while their spacecraft was powered down and the load on the fuel cells was light.

"We kept an especially close check on performance while Armstrong and Aldrin were on the moon," he said. "Because Collins was alone in lunar orbit in the command module, he was too busy to monitor all his systems in full detail. So we watched the fuel cell performance extra carefully."

Lee feels the pressure during a mission. "The equipment is out there, a quarter of a million miles away: three powerplants operating on the same gas supply and feeding into the same power system," he said. "They must work, and they must work perfectly. You can't reach out to touch them. You can't fix them if anything goes wrong. They just have to work."

And work they have. Since the first Powercel flew in space in 1966, 24 of the units have accumulated more than 3,000 hours of operating time in eight Apollo flights, three unmanned and five manned. Although

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there are three fuel cells aboard, two can fill the power requirements for a complete mission, and one is sufficient to provide all the power needed to return the astronauts safely to earth.

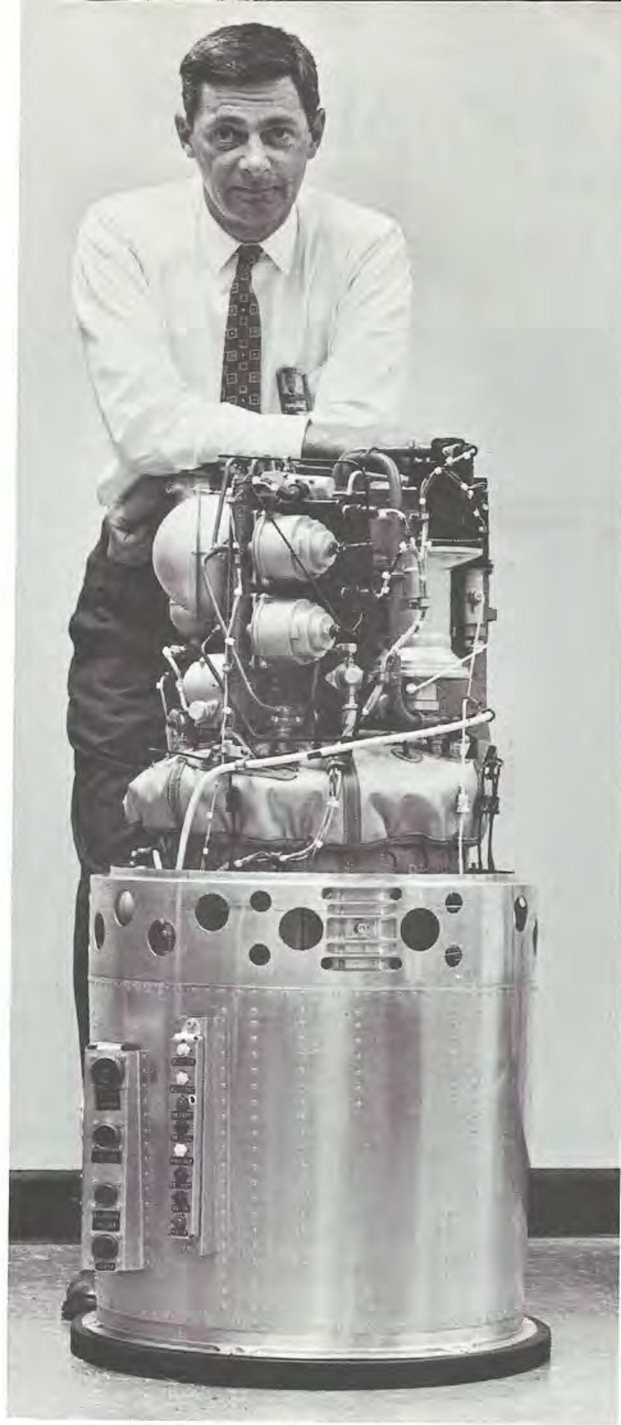
"You're always aware during a mission," Lee said, "that if anything is going to go wrong, it will be the unexpected. The anticipated you've already taken care of, on the basis of past experience."

The Apollo cells are flight-qualified for 400 hours of operation, or more than twice the duration of the maiden lunar landing mission. There were no fuel cell problems during Apollo 11, and when the mission was over, Lee felt relief and pride at the achievement of "the huge team of which we're a small part."

But the pressure is never really off him, even at splashdown. While one mission is in progress, he and his fuel cell team are getting ready for the next one. When Apollo 11 splashed down, the three fuel cells for Apollo 12 were in their spacecraft at Cape Kennedy being prepared for vacuum testing, in which the entire spacecraft and its systems, with the astronauts aboard, go through procedures in a space simulation chamber.

Lee, a slim, dark-haired man of 42 who sails in his 35-foot sloop and does woodworking for relaxation, has been managing the company's Apollo fuel cell program since 1967. He is quick to stress that, while he happened to be manager at the time of the moon landing, the real credit for the cells' successful development and performance goes to hundreds of people, many of them now working elsewhere in the company, who have contributed to the project over the years. At its peak, early in 1964, he pointed out, more than 1,000 persons at Pratt & Whitney Aircraft were directly involved in the program. Lee has taken part since 1962 when Pratt & Whitney Aircraft was selected as fuel cell subcontractor to North American Rockwell Corporation, the Apollo prime contractor. What he marvels at most about the lunar landing program is how the efforts of thousands of persons of diverse skills and disciplines, spread all across the country, are marshalled, organized, and coördinated to achieve an objective of such magnitude.

For Jack Lee, pursuit of an engineering career was, as he puts it, "all but inescapable" because of his family background. His father, John G. Lee, a prominent figure in aeronautical circles, was with United Aircraft for more than 30 years and, at his retirement in 1964, was director of research for the corporation. On his mother's side, too, Jack Lee comes by a strong technical heritage. His maternal great-grandfather was Sir Hiram Stevens Maxim, who developed the first successful automatic machine gun and experimented with a steam-powered flying machine in England in the 1890s. Sir Hiram's son, Hiram Percy Maxim, invented the Maxim silencer for handguns.



Lee is shown with a Powercel® of the type that generates on-board electricity during Project Apollo missions.

Like his father and maternal grandfather before him, Jack Lee went to Massachusetts Institute of Technology, earning his degree in chemical engineering and economics in 1951. On graduation, already married and the father of two, he took a job with Du Pont. He went with another company after six years at Du Pont, and finally joined Pratt & Whitney Aircraft in 1959, going directly into fuel cell projects, then in their infancy at the company.

From then on, Lee's efforts were directed at the day when the company would lay a powerline to the moon and back.

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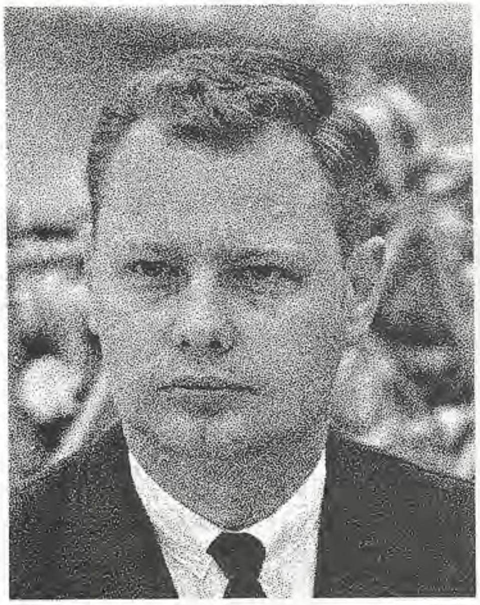


2 KEN HOWER: Environmental Controller

A red telephone sits on a shelf behind Kenneth L. Hower's desk at Hamilton Standard. The less the phone rings during Apollo missions, the happier Hower is.

The phone is a hot line linking Hower's office in Windsor Locks, Connecticut, directly to NASA's Manned Spacecraft Center in Houston. Whenever in-flight problems arise in the Apollo gear for which Hower is responsible, he or whoever else is manning the phone can expect it to ring. During Apollo 11, it scarcely rang at all.

"There were only a couple of minor problems with our equipment," Hower said. "It worked beautifully."

What worked so well, bringing gladness to Hower as program manager, was the lunar module's environmental control system. This is the apparatus that kept Neil Armstrong and Edwin Aldrin alive and well all the time they were in the lunar module, the spidery spacecraft that separated from the command module in lunar orbit, landed on the moon with the two astronauts, and then brought them back to the orbiting mother ship for the return journey to earth.

The system was in use for a total of about 33 hours during the eight-day mission, providing life support for Armstrong and Aldrin in an environment totally lacking in the things needed to sustain human life. It supplied oxygen for breathing and ventilation. It pressurized the spacecraft. It removed carbon dioxide and other noxious gases the spacemen exhaled. It maintained temperature and humidity at safe and comfortable levels. It provided water for drinking and preparing food and for equipment needs.

And it did these jobs faultlessly.

"Our philosophy in developing the equipment has been to think of all the worst things that could possibly happen, add a factor for safety, and then test at those demands for a far longer period than it would be used during an actual mission," Hower said. "That's where we got our confidence."

Before the environmental control system flew on its first manned Apollo flight in March, 1969, it had been tested for a total of more than 2,500 hours at Hamilton Standard, at Grumman Aerospace Corporation, prime contractor for the lunar module, and at NASA installations in Houston and Cape Kennedy.

The wringing-out process was rigorous. The gear was punished to a degree it would never experience in service.

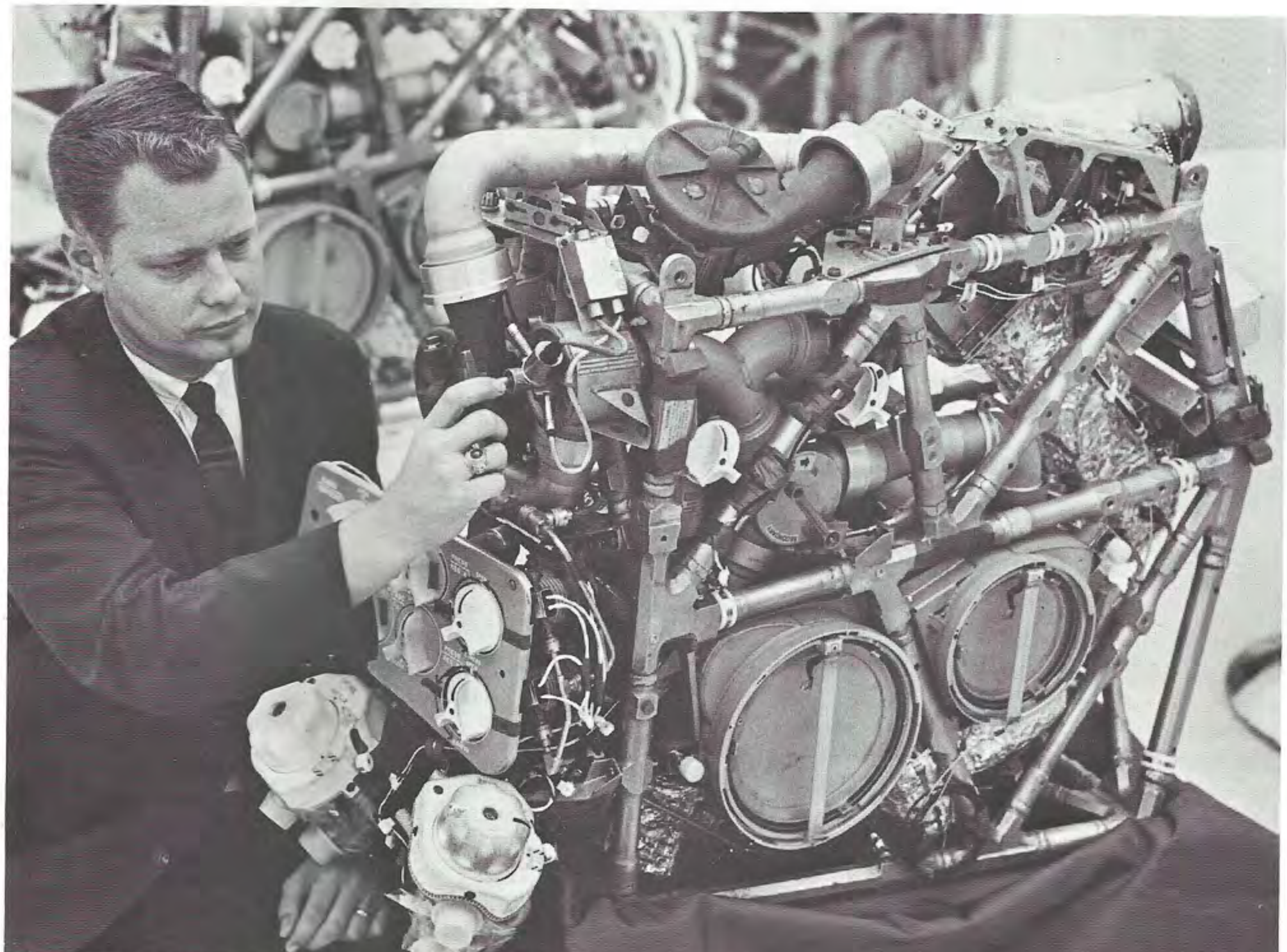
"It was built and tested to withstand vibrations, acceleration, shock, and pressure extremes up to one-third greater than were expected in the mission," Hower said. "Although it was designed to operate in a clean spacecraft, in one test it was blasted at high speed with solid abrasive material. In humidity testing, it was given so much moisture that water dripped from it."

All rotating parts were run and run and run again to prove out their bearings and other critical parts. For added security, extra sets of critical components — water separators, fans, pumps — are built right into the control system. The most critical are switched into service automatically in the event of a malfunction. Others can be placed in use manually, if needed.

The system itself is an assortment of units, assemblies, and subsystems installed here and there about the lunar module. The heart of the system, its atmosphere revitalization package, is a skillfully engineered labyrinth of pipes, valves, controls, tanks, and fans arranged compactly within a frame about the size of a large suitcase and mounted directly behind the lunar module pilot.

The man in charge of this life-sustaining collection of space hardware is a blonde, boyish-looking mechanical engineer of 34, given to skiing and youth and church work in his off hours, who moved into space life support systems, just as Hamilton Standard itself did, from earlier experience in aircraft environmental controls.

As a student at Penn State, where he took his degree in 1956, Hower had thought of Hamilton Standard only as a famous propeller manufacturer, little knowing that it was embarked at the time on a drive to diversify into other flight products. Dr. Alexander H. Zerban, then a senior project engineer at Hamilton Standard, came to the campus one day to address the undergraduate chapter, of which Hower was president, of the American Society of Mechanical Engineers. Zerban, who is now engineering dean at the University of Hartford, told about Hamilton Standard's diversi-



The heart of the Hower-managed environmental control system is this unit, which purifies and circulates oxygen for rebreathing.

fication and showed the students a tiny turbine, two and a half inches in diameter, and a small electrical motor, both devised by the company for use in controlling the atmosphere within aircraft cabins. "He really opened my eyes to some of the interesting things the company was doing, particularly in pneumatics and thermodynamics," Hower recalls. "I said to myself: 'Here's a company on the move.' "

After graduation, Hower went to work at Hamilton Standard in aircraft environmental controls. He moved on to space life support projects as the division extended its environmental interests from atmospheric to space flight. He was a project engineer on the Apollo life support backpack, headed a NASA-sponsored study of life support needs for a trip to Mars, and worked on an Air Force experiment to recover oxygen for re-use from exhaled carbon dioxide for long-term missions.

Before taking up his current responsibility last February, he was program manager for the environment-controlling gas management assembly for NASA's Biosatellites, earth orbiters that went into space carrying plants, insects and, last June, a pigtailed monkey. He went to Cape Kennedy for the Apollo 11 launch last July 16, returning to Hamilton Standard immediately afterwards to be close to the red phone when the lunar module's environmental controls were activated on the third day of the mission. When it was over, he experienced a two-fold sense of gratification: "I was proud that it was our country that landed men on the moon first, and I was proud and happy that our equipment helped get them there."

Hower knows the pressures and long work-weeks common to those in positions of responsibility in the space program. Yet he also finds time for the outside activities, centered in his case in church work, that lend balance to one's life. He and his wife draw special satisfaction from serving as advisers to their church's youth organization, made up of 150 teen-agers.

"They're good kids, but they're troubled," he said. "More than anything, they need adult understanding. That's what my wife and I try to provide."

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3 CAL BEGGS: Leader of the Pack

Treading the moon's surface that historic night last summer, Neil Armstrong and Buzz Aldrin were kept alive by box-shaped units strapped to their backs like hikers' knapsacks. A quarter of a million miles away, in a control room at Houston, a part-time tenor who has had a guiding hand on the Apollo backpack from its conception watched two television screens with bridled excitement.

On one screen were the pictures of the moonwalk as transmitted live from Tranquillity Base. On the other was data telemetered from the moon showing that the backpacks were performing splendidly.

John C. (Cal) Beggs, watching the TV screens, felt warm and good about it all. For the Apollo backpack, or portable life support system, has engrossed him since it was little more than a glint in the eyes of Hamilton Standard space engineers more than seven years ago.

Beggs had supervised shaping of the design offered in the original technical proposal, on the strength of which Hamilton Standard won NASA's design competition for the backpack assignment. With awarding of the contract in the fall of 1962, he became senior project engineer, responsible for organizing the engineering team to design and develop the system. He moved up to assistant program manager in 1965 and to program manager in 1967.

In the Houston control room with Beggs on the night of the moonwalk were a half-dozen other engineers from NASA and Hamilton Standard, including Craig Castle and Edgar H. Brisson, chiefs of the company's support teams at Houston and Cape Kennedy, respectively, and Fred Goodwin, engineering project manager. They had before them graphs plotting the performance of the backpacks as recorded three months earlier when Armstrong and Aldrin had worn them during ground tests. Working from the telemetered data shown on a closed-circuit TV screen, the men in Houston now plotted the backpacks' performance during the actual moonwalk and compared the two graphs.

"The two plots were virtually duplicated," Beggs said. "I've never seen data of this type so classic in nature."

Because he has been intimately associated with the project from the first, a curious thing happened to Beggs on the night men walked on the moon. "I had been absorbed in the program for years in such detail, as an intensive engineering program, that I had lost my sense of awe at what we were trying to do," he said. "Then, watching the astronauts on the moon, I was drawn up short. Suddenly, I was reawakened to the awesomeness and magnitude of the accomplishment. It was quite a feeling."

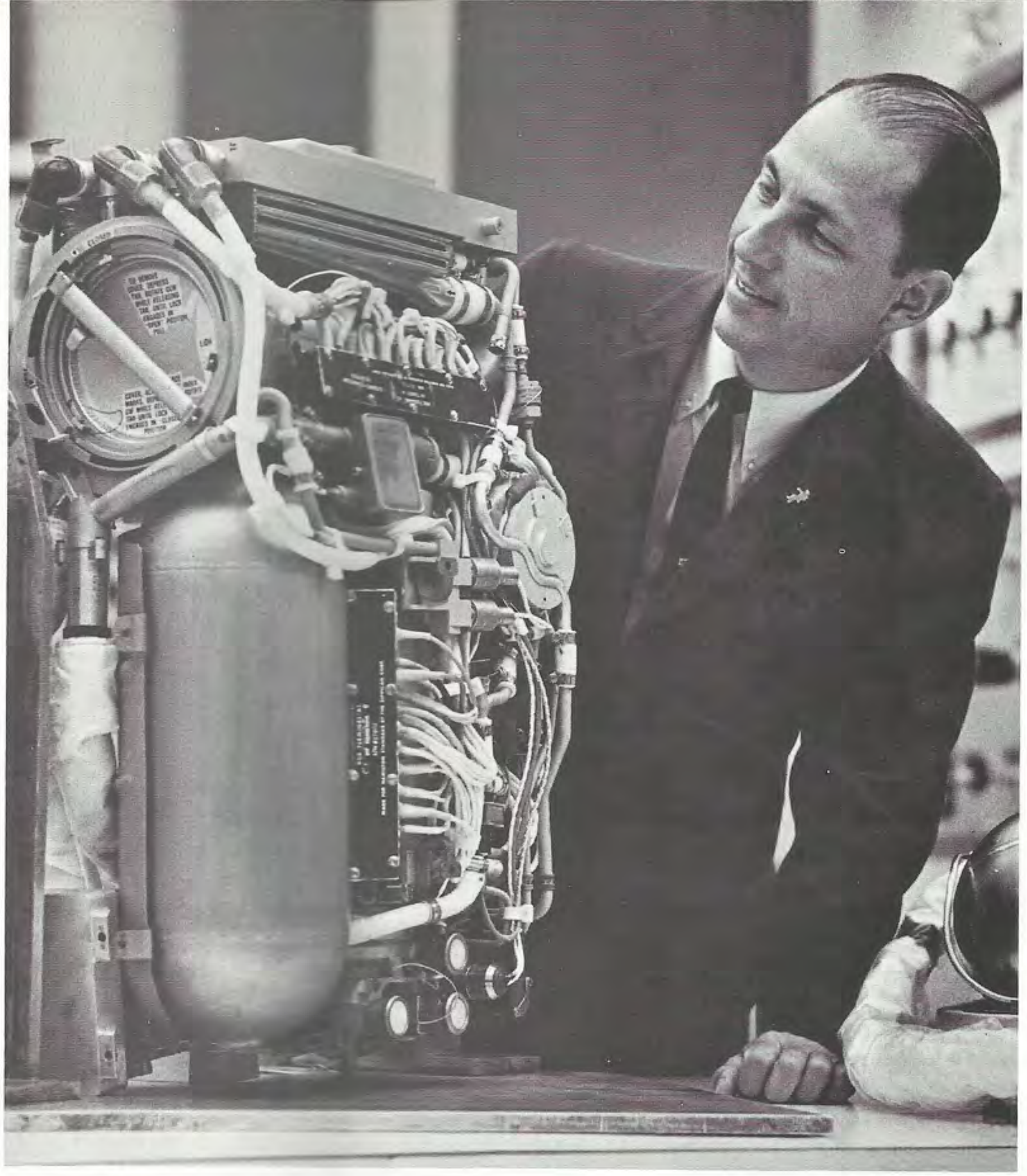
What he felt best about, of course, was the flawless functioning of the packs the astronauts wore to create and maintain a livable environment within their space suits in the airlessness of the moon. "We went into the mission with a high degree of confidence that the equipment would work properly," he said. "The units Armstrong and Aldrin wore had been thoroughly shaken down. In preparatory tests, they had gone through the equivalent of five or six missions."

In tests at Houston a few months before the Apollo 11 flight, Ken Mattingly, an astronaut assigned to the crew for the coming Apollo 13 flight, strapped on a backpack and worked as hard as he could at lunar chores in a deliberate effort to cause it to break down. "He couldn't do it – and he darn near exhausted himself in the process," Beggs said.

For such a small unit – 36 by 18 by 10 inches, including a backup oxygen supply mounted atop the basic pack – the system performs a big job. For up to four hours of activity by a spaceman on the moon, it supplies an artificial atmosphere in space roughly equivalent to what he would have on earth.

Specifically, it gives him the oxygen he needs to breathe; maintains pressure in his space suit; controls the humidity level in the suit; carries away heat he generates while working on the moon and also any that might leak through the walls of his suit; removes the toxic gases, such as carbon dioxide, given off as he breathes; and provides a means of communication with his fellow moon explorer and with controllers on the ground. Although the unit weighs 125 pounds, the Apollo 11 astronauts felt weights of only 21 pounds on their backs because the gravity on the moon is one-sixth of that on earth.

Armstrong was outside the spacecraft on the lunar surface for almost two and a half hours and Aldrin for slightly less than two hours, both wholly dependent all



Beggs was gratified at the flawless performance on the moon of the life support backpack, shown here without its casing.

the while on their backpacks for life support. At the end of the moon prowl, the units still had plenty of unexpended supplies left for continued lunar operation.

"There was enough oxygen left, for example, for more than three hours of additional extravehicular activity," Beggs explained. "Our calculations showed that at the end of the moonwalk, the expendable with the least time left was the battery powering the system, and there was more than two and a half hours of battery power still left in each pack."

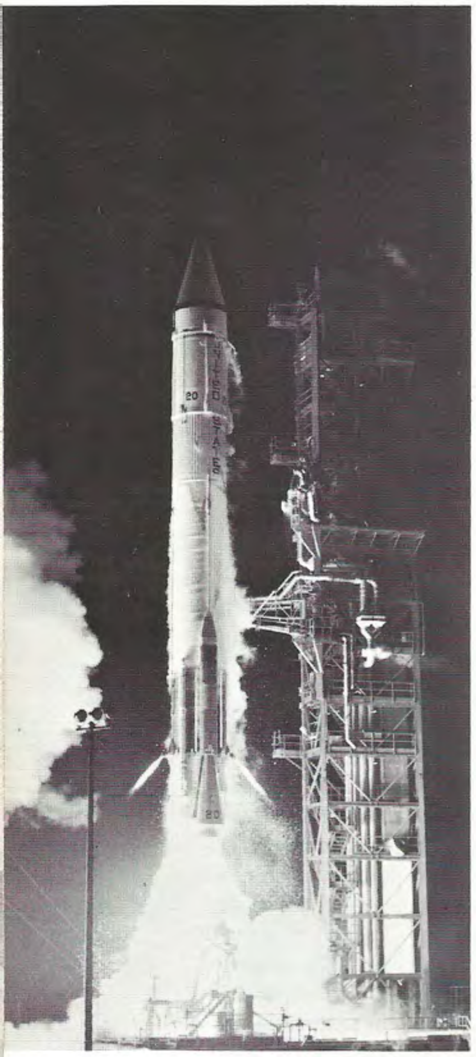
For lengthened stays on the lunar surface, the backpack can be recharged easily enough when its expendables run down. The astronaut merely returns to the lunar module and replenishes the pack's consumable supplies, stored in the vehicle: oxygen, battery, feedwater for the cooling mechanism, and a canister of chemicals for removing gaseous contaminants.

The leader of the pack has spent 21 of his 45 years with Hamilton Standard, having joined the division as a test engineer right after graduation from the University of Illinois in 1948. "I was graduated as an aeronautical engineer," Beggs said. "But I've never done a day of aeronautical engineering." Before going into space life support work, he was assigned to the engineering of aircraft environmental controls. He took part in development of the air conditioning for such aircraft as the F-8U and F-104 fighters, B-52 and B-58 bombers, and Convair 880 jetliner.

"The greatest challenge in developing life support equipment for space use is the extreme emphasis on absolute reliability," Beggs said. "There is no margin for error in equipment to be used to keep men alive on the moon. That's something we instilled in all our people and our vendors."

Cal Beggs enjoys two things more than his work – singing and sailing. Though he has never had formal voice training, he is an accomplished tenor who is a church soloist, who has sung with a ten-voice choral group that has given professional concerts throughout Connecticut, and who has played lead roles in several operettas produced by the Gilbert & Sullivan Workshop of Manchester, Connecticut.

Best of all, though, he likes sailing. A few days after the Apollo 11 mission, he went on vacation. He spent much of it sailing his 23-foot sloop on Long Island Sound. As he tacked and heeled in the waters around Fishers Island, he felt exhilarated by the sun and breeze and the spray – and the memory of two men jouncing stiff-legged on the moon with those lovely, life-giving packs on their backs.



A nighttime launch of the Atlas-Centaur rocket on February 24 sent the Mariner 6 spacecraft on its way to Mars.

MISSION

The Mariner probes gave earthlings views of Mars never seen before. The photo below, from Mariner 7, shows the planet from a distance of 716,000 miles. The Mariner 6 picture at right was from 333,000 miles. The prominent white area at the bottom rim is the south polar cap. The two probes, launched a month apart, sent back 200 pictures to NASA's Jet Propulsion Laboratory.

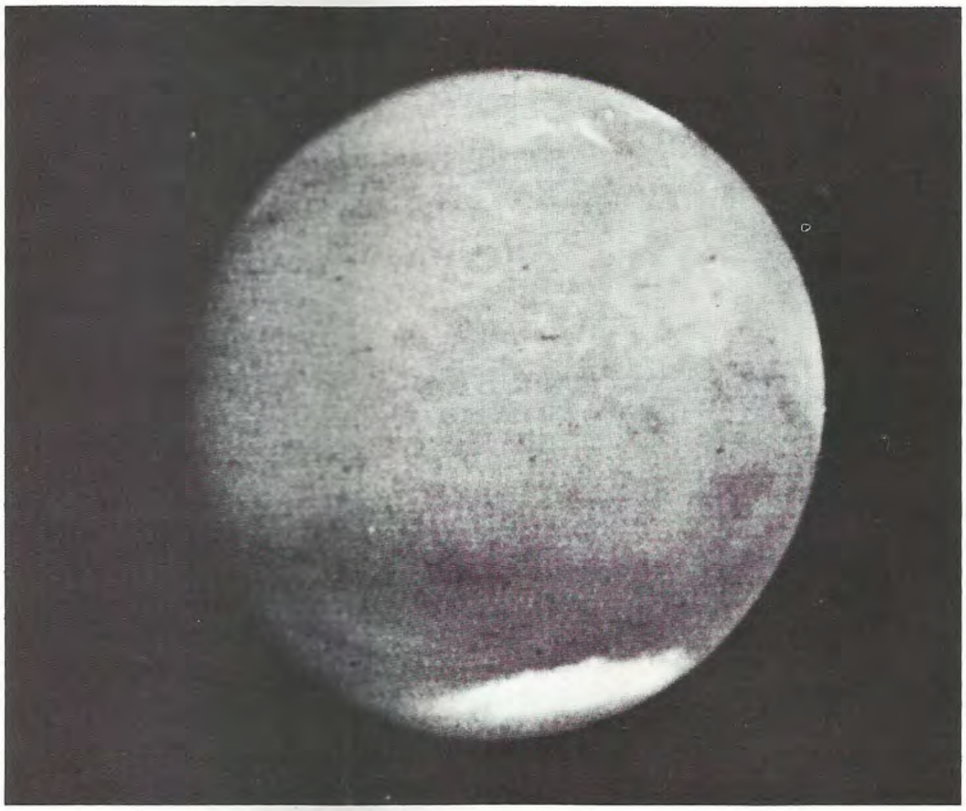
High, rounded ridges, deep valleys, craters ranging in diameter from a quarter of a mile to 500 miles, and snow in the south polar region characterize the surface of Mars as shown in pictures returned to earth from the Mariner 6 and 7 space probes.

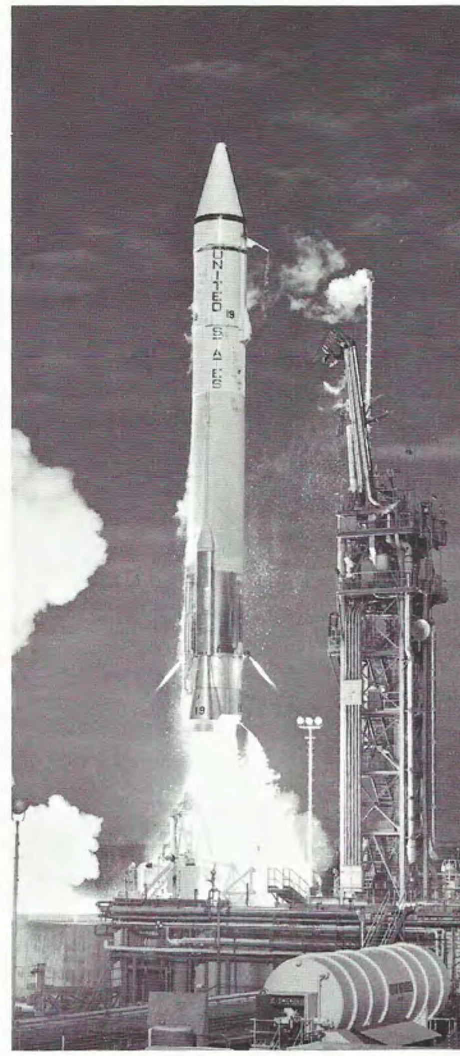
The pictures also disclosed a wild, chaotic region, hundreds of thousands of miles square, unlike any terrain found on either the earth or the moon. After detailed study of the pictures, scientists concluded that Mars was inhospitable to life.

Launched a month apart, the two Mariner craft came to within 2,000 miles of the Red Planet on July 30 and August 4, respectively, before speeding off into orbit around the sun.

The 200 Mariner pictures, some of which are reproduced on these pages, were sent more than 60-million miles through space and were among the most dramatic yet received by the National Aeronautics and Space Administration's Jet Propulsion Laboratory

TO MARS



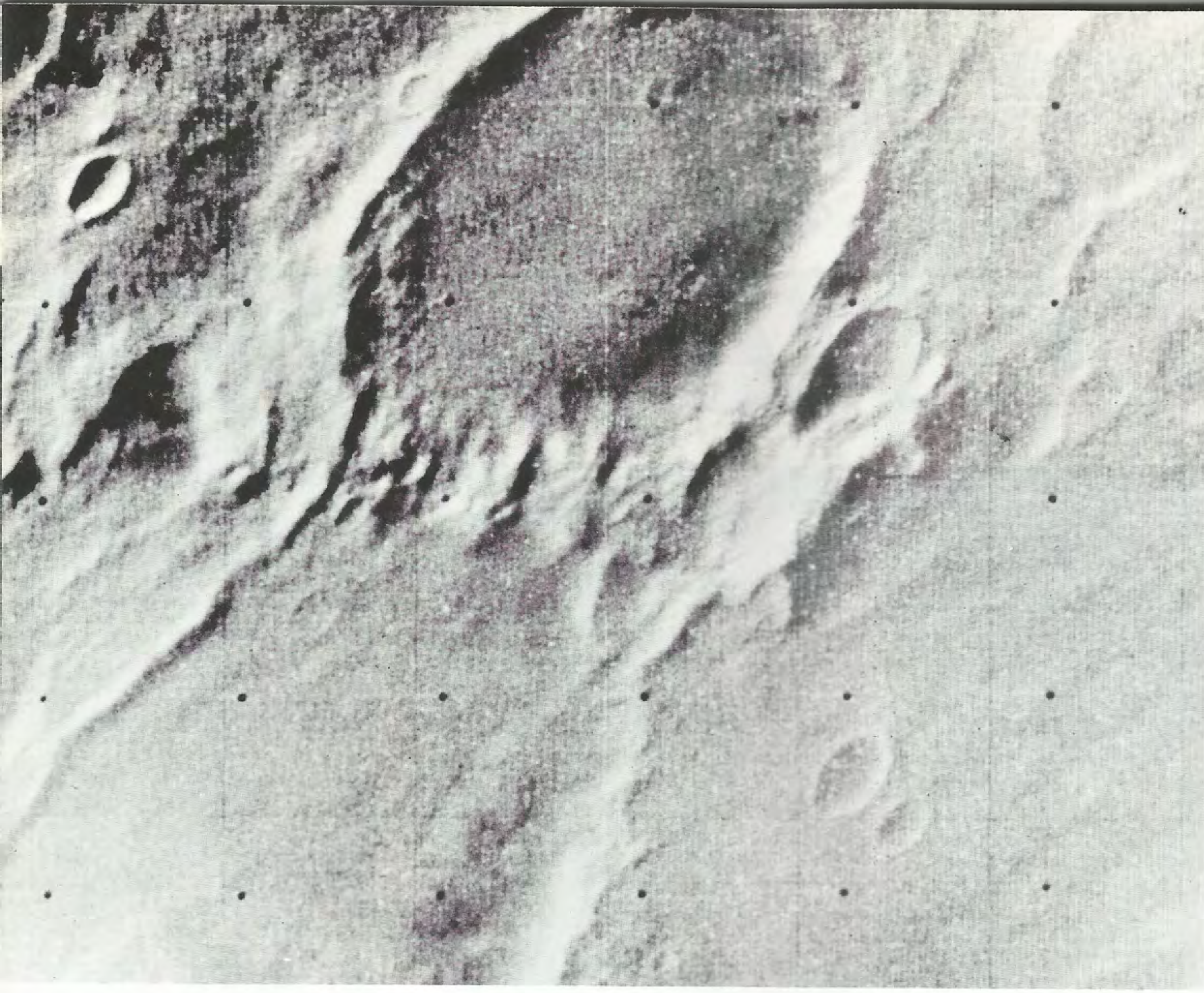


The Mariner 7 mission was launched March 27. The rocket's Centaur stage has two Pratt & Whitney Aircraft RL10 engines.

in Pasadena, California. The picture-taking was concentrated on the equatorial and south polar regions, while the spacecraft's instrumentation recorded information about the planet's atmosphere, temperatures, and gravity.

Mariners 6 and 7 soared into space February 24 and March 27 atop General Dynamics-built Atlas/Centaur launch vehicles. Two RL10 liquid hydrogen rocket engines, designed and built by Pratt & Whitney Aircraft, provided combined thrust of 30,000 pounds to power each of the two Centaur stages. The RL10s burned for seven minutes and 15 seconds to take the Mariner's speeds up to the approximately 24,500 miles an hour needed to escape the grip of the earth's gravity.

The Mariner 6 and 7 missions marked the first time the RL10 engine had been used in an interplanetary mission. A total of 72 RL10s have now operated successfully in space.



What looks like a giant footprint is made up of two adjacent craters, foreshortened by the camera's viewing the south polar cap of Mars from an oblique angle. This high-resolution picture from Mariner 7 shows an area of approximately 200 by 85 miles.

This picture of the Red Planet's south polar cap region, which includes the south pole, shows a wide variety of crater sizes and forms, as well as linear and blotchy features not obviously related to the cratering. The craters on Mars are shallower than those on the moon.