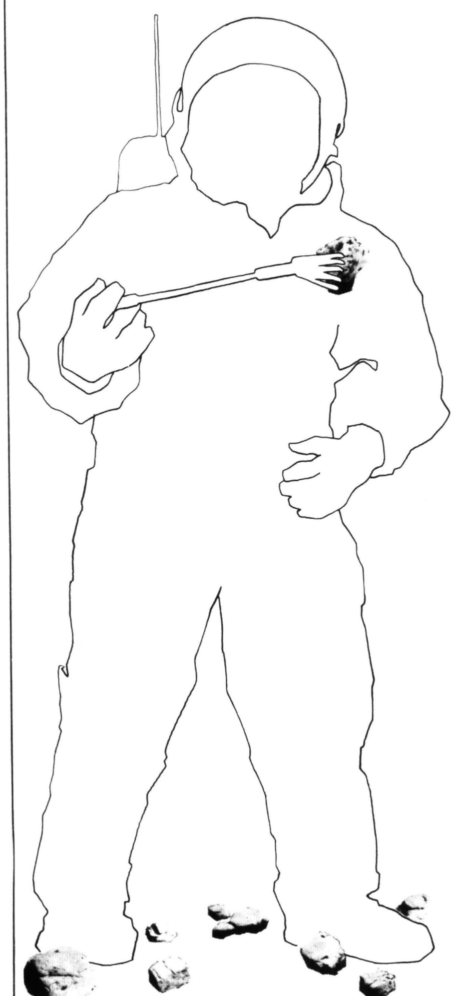
bits of another world

50 Pounds of Rocks Brought Back from the Moon Will Help Unravel Age-Old Scientific Mysteries



by L. B. TAYLOR, JR.

When Dr. William Kemmerer, a biomedical specialist at NASA's Lunar Receiving Laboratory in Houston, was in high school, he once encountered the following "multiple choice question" on an IQ test: The moon is made of green cheese. This is (a) absurd, (b) unlikely, or (c) probable. He selected "b" and flunked the question. The instruction sheet listed "a" as the correct reply.

Though to this day Dr. Kemmerer still feels strongly that his answer, at that time, was the most suitable one offered, he is now ready to change his choice. For very soon, perhaps within weeks or months, man will *know* what the lunar surface, or at least a small portion of it, consists of.

The American astronauts who make the historic, first manned landing on the moon will bring back, in their Apollo command module, about 50 pounds of the most precious material man has ever known; more valuable than its weight in silver, gold, platinum, diamonds, emeralds or any other matter in which man places the ultimate in Earthly values.

In specially sealed containers will be geological samples of the lunar surface.

And Stones Shall Speak

"Scientifically, this will be worth more than any other material in history," says Dr. Elbert King, curator of the Lunar Receiving Laboratory, where the samples will be brought for initial studies.

"How important will these rocks be?" asks Dr. Gordon Goles, associate professor of chemistry and geology at the University of Oregon. "To question that is to question the importance of knowledge. When we examine these samples we really will be searching for answers about our origin. There is a good chance that we may find, in these rocks, some of the earliest records of events in the solar system's history."

Dr. King believes man should be able to tell the age of the moon through detailed analyses of the samples; and from this and other information, it may be possible to determine the origin of the moon, and thus explain many puzzling mysteries about lunar-planetary relationships. Was the moon once a part of Earth . . . is it a wanderer from space, trapped in Earth's gravitational field . . . or were the moon and Earth formed during the same period of time?

"We have already made some quite important discoveries about the lunar composition," says Dr. P. R. Bell, lab director. "Surveyor's scoop showed us the surface has a lumpiness to it, and that clods of matter break up easily. The bulk of the material may be finer than frog hair, very fine grained. What we have learned so far has only been the appetizer."

Scrupulous Selection

Because of the enormous scientific importance attached to the return of these samples, perhaps the most elaborate preparations ever are being taken for their exportation. To begin with, the first Americans on the lunar surface will not randomly grab handfuls of rocks. Astronauts have had extensive geological field training—in the Grand Canyon, in California's Medicine Lake Highlands, in the volcanic terrain of Meteor Crater, in the arctic wastelands of Iceland, and in Alaska's Valley of 10,000 Smokes. They have learned what types of rocks and soil samples will be of most value to examining scientists. They will probably be able to distinguish, for instance, a lunar rock from an extra-terrestrial meteorite that has pounded into the face of the moon.

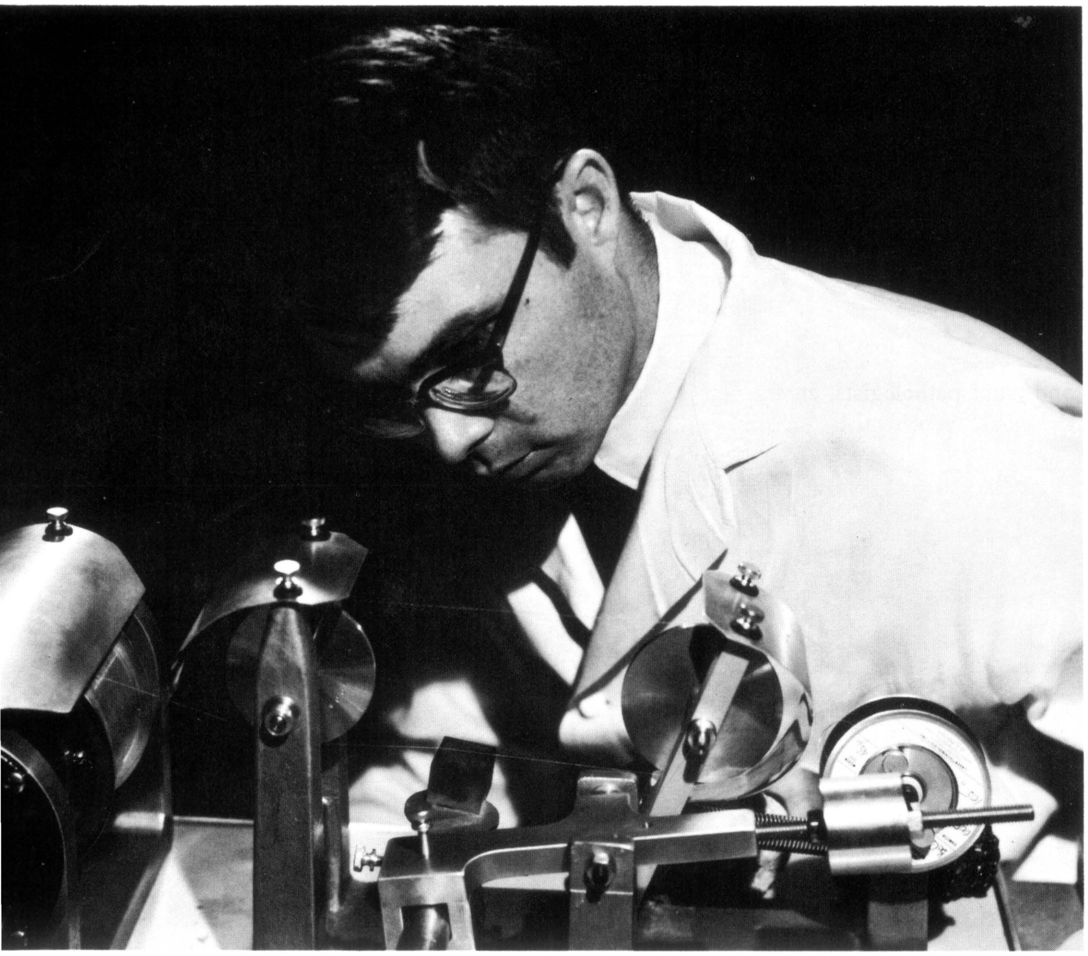
Once the samples have been chipped and collected, the astronauts will carefully store them in two 8 by 10 by 19-inch aluminum boxes a quarter of an inch thick, each with an inner suspended web of woven aluminum mesh to cushion the ride back. The boxes will be triple sealed. Inside, the contents will be in an ultra-high vacuum.

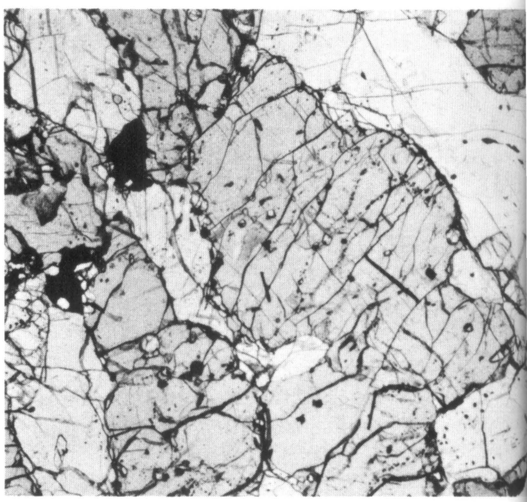
Such precautions actually serve a dual purpose. Not only will they preserve the samples from deteriorating—from any exposure to the astronauts or to anything terrestrial—but they will also isolate the rocks should they be "contaminating."

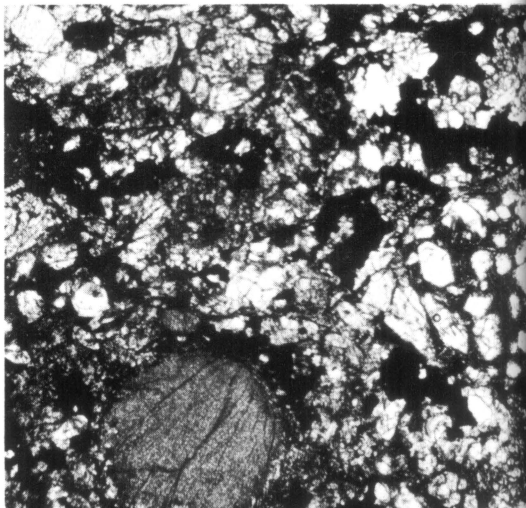
"We're not likely to find anything in the way of harmful bacteria or other life forms," says Dr. Bell. "The odds are enor-

"The bulk of moon material may be finer than frog hair," says Dr. P. R. Bell, left, Director of NASA's Lunar Receiving Laboratory. Wire saw, imbedded with diamond chips, left below, is used to slice thin section of meteorite for microscopic study. A similar process will be used on lunar samples.

Under the powerful eye of a microscope, lunar samples may appear much like meteorites. In fact, many scientists believe the rare achondrite, a stony meteorite without small rounded grains, below, may have fallen from the moon. More common chondrite, bottom, descended from outer space.







"Our purpose," says NASA's Dr. Wilmot Hess, left, chairman of the Preliminary Examination Team, "is to carry out a series of physical, chemical and mineralogical analyses to understand the contents of the samples."

mously against it, but we can take no chances. Our lab will have a quarantine one step more severe than those imposed at the strictest communicable disease hospitals in the world."

In fact, the astronauts and the lunar samples will share quarters in an ultra-modern, multi-storied $8 million building, which includes gas analysis and vacuum laboratories, a biological preparation laboratory, a physical-chemical test area, and an underground radiation counting laboratory. Dr. Bell points out the building will be thoroughly sealed with absolute filters and reduced air pressure inside, so in the remote event of a leak the air will flow inside, not outside.

Lunar Rock Research

The astronauts will be closely examined by bio-medical experts, and if no adverse effects are shown, they will be released about 21 days after they leave the moon. The sample containers, or "rock boxes," will be subjected to a series of sensitive tests during this critical period. They will be placed in glassed vacuum chambers, sprayed for exterior germs, and dried with currents of dry nitrogen.

Working through openings in the glass with thick rubber gloves, a technician will then insert a thin, flexible tube into a special receptacle on each box. This puncture will send any trapped gases, lunar or otherwise, through a tube, where it will be examined by a super-sensitive rare-gas mass spectrometer.

With movements that have been practiced to perfection, the operator will next open the boxes, and man on Earth will have his first look at fragments of another world. He will view them through high-powered microscopes, measure them, and weigh them on a sensitive scale. Special cameras will photograph the samples from all angles, and a video-monitor system will record everything.

Two tiny chips or pinches of dust will be taken of each sample; one will go to the physical-chemical laboratory for a fairly detailed evaluation of the mineralogy, petrology and geochemical compositions.

The other chips will be studied thoroughly in the biomedical portion of the lab. Here, over the next few weeks, varieties of Earth plants, tissue cultures, insects, flathead minnows, shrimp and oysters, and Japanese quail, among other life forms, will be exposed to the lunar samples to see if any change occurs in their physical characteristics. Cockroaches were selected, interestingly enough, because they are one of the hardiest insects known to man, and have survived as a genus for millions of years. Also to be exposed will be a group of white mice born by Caesarean section in sterile surgery and raised in a completely sterile environment. Since there have been no Earthian "bugs" to infect the mice, if they become sick during the quarantine, it will almost certainly be through their exposure to the lunar rocks.

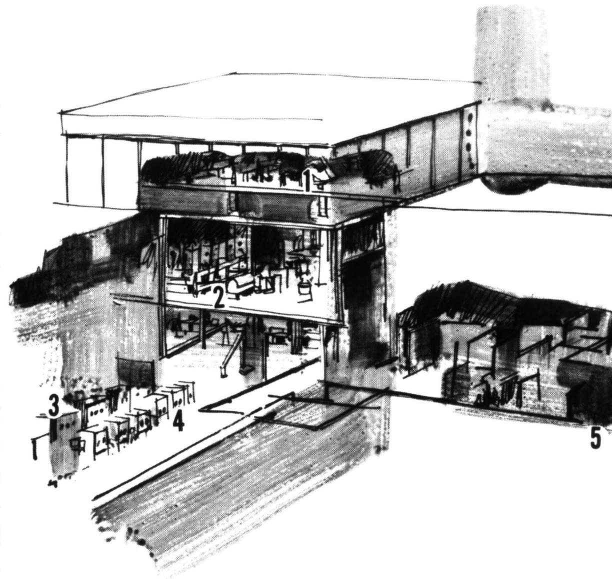
"Ideally," says Dr. Kemmerer, "we'd like to subject the samples to all areas of the Earth environment—from the arctic tundra to the deserts to the rain forests. But because of space and time limitations, we had to select a representative cross section of plant and animal life."

For the biomedical and physical-chemical work, Dr. Bell has assembled a versatile staff of specialists. Included are microbiologists, virologists, veterinary and plant pathologists, entomologists, physiologists, geochemists, petrologists, physicists, geologists, nuclear chemists, seismologists, lunar and planetary scientists and electrical and mechanical engineers.

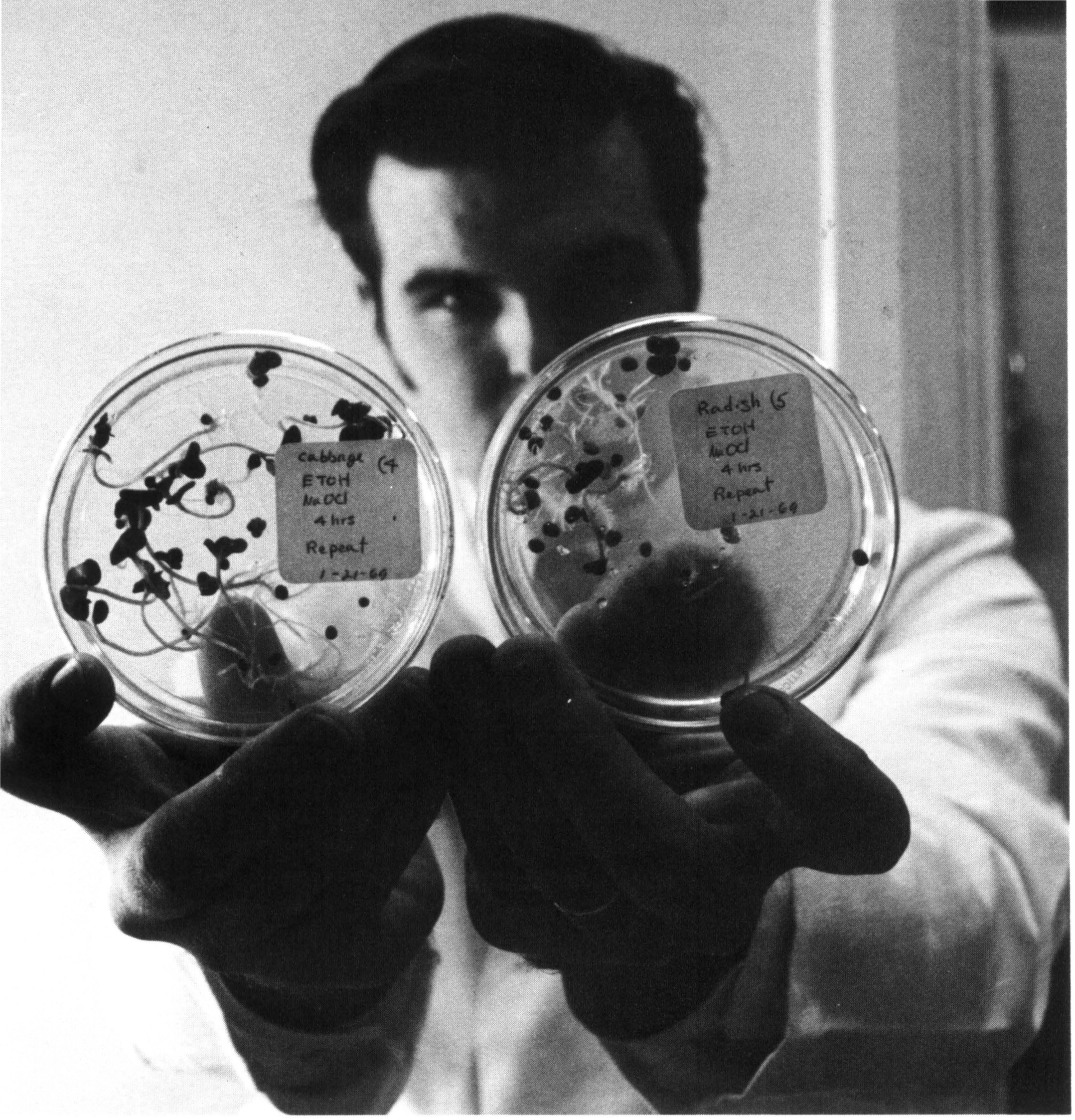
Time Factor Critical

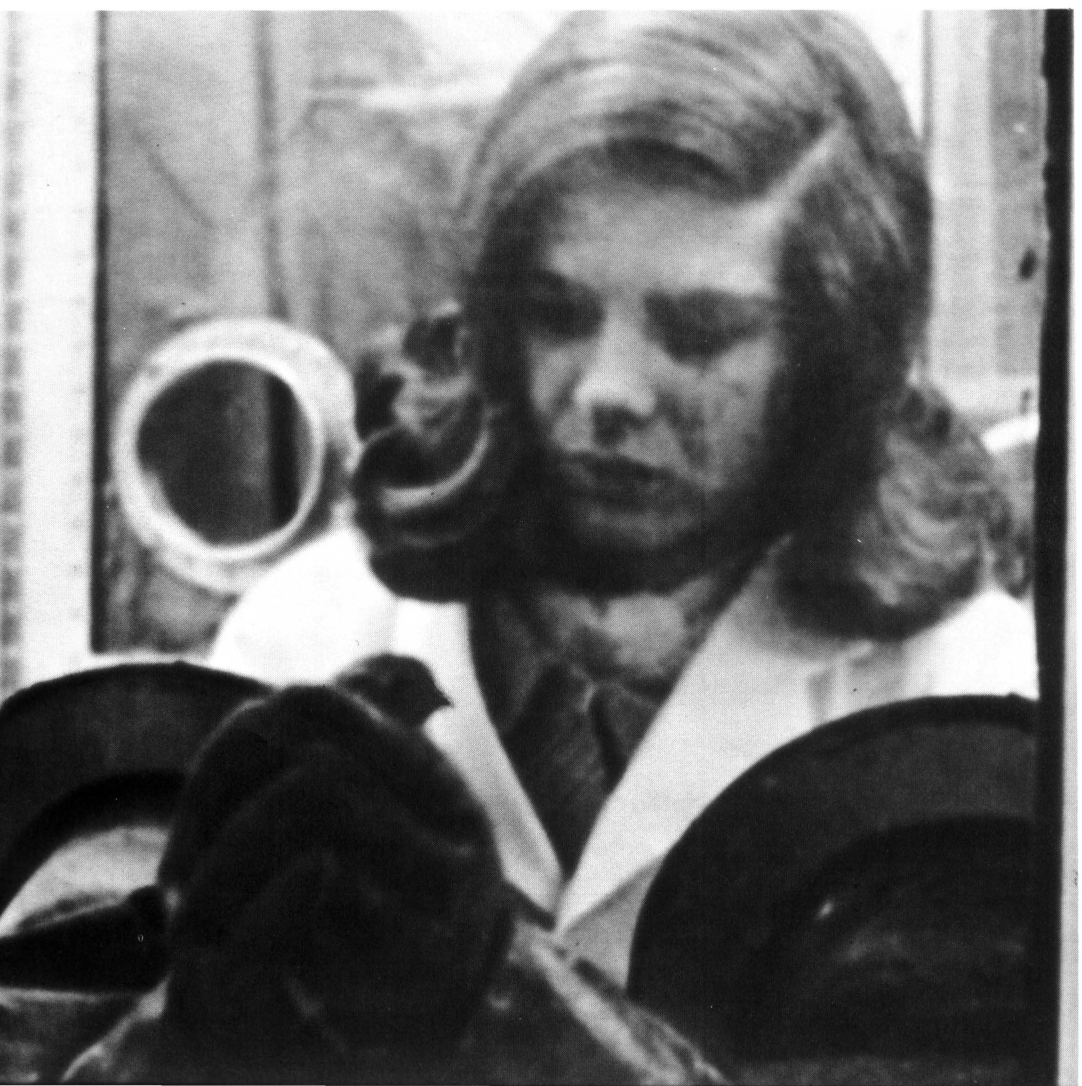
Much important investigative work will be done in the lunar lab, some of it during the quarantine period while the samples are still "fresh." This will include "time critical" experiments, such as the determination of cosmic ray and natural radioactivities in the material; information that would disappear if not collected soon after the samples have been brought to the lab.

NASA's Dr. Wilmot Hess is chairman of the Preliminary Examination Team (PET). "Our purpose is to understand the material, to carry out a series of physical, chemical and mineralogical analyses that



Ultra-modern $8 million Lunar Receiving Laboratory consists of (1) Gas Analysis Lab; (2) Vacuum Lab; (3) Biological Preparation Lab; (4) Physical-Chemical Test Area; and (5) an underground Radiation Counting Lab.





will enable us to understand the contents of the samples," explains Dr. Hess. The team will help the lab's scientists catalog, sort, describe and test the material by physical, chemical and biological techniques. "Based on this work, we can prepare the samples for release to the principal investigators (PIs) who will make thorough, specialized studies."

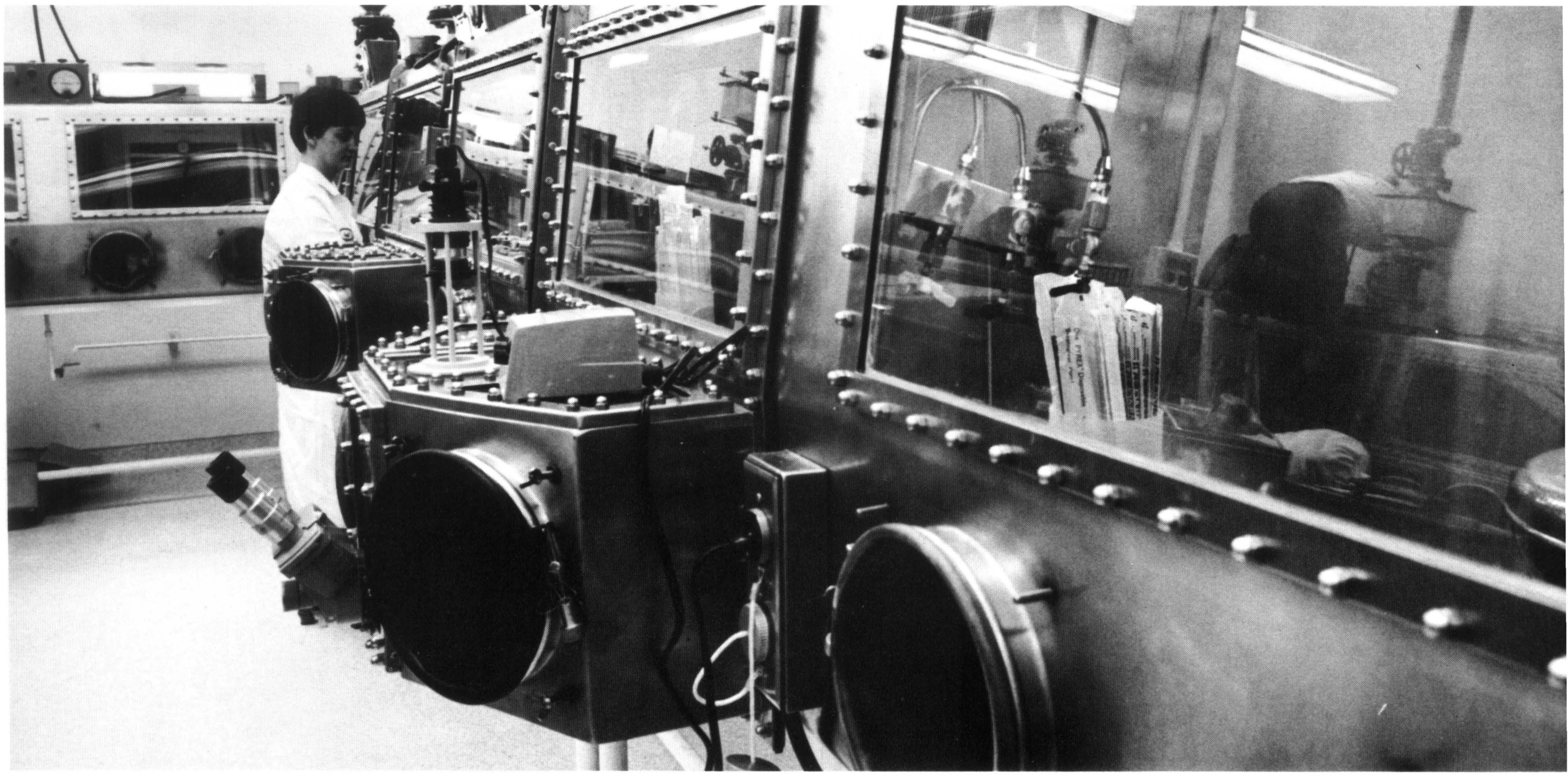
There are approximately 135 principal investigators located at major universities, laboratories and research centers around the globe. Never before in history has such a world-renowned scientific team been assembled to participate in one project. Among them is the widely acclaimed lunar expert Dr. Harold C. Urey of the University of California at San Diego, as well as the 1968 Nobel prize winner in physics, Dr. Luis C. Alvarez. Nearly every scientist selected is acknowledged as an international leader in his specific field of study.

Spectrum of Tests

Depending upon individual requirements, the PIs will receive samples ranging from about 20 milligrams, (barely a visible speck), to 250 or more grams (about half a pound). These scientists will use a variety of powerful analytical tools—computers, mass spectrometers, X-ray defraction and florescence units, etc.—to extract as much data as possible.

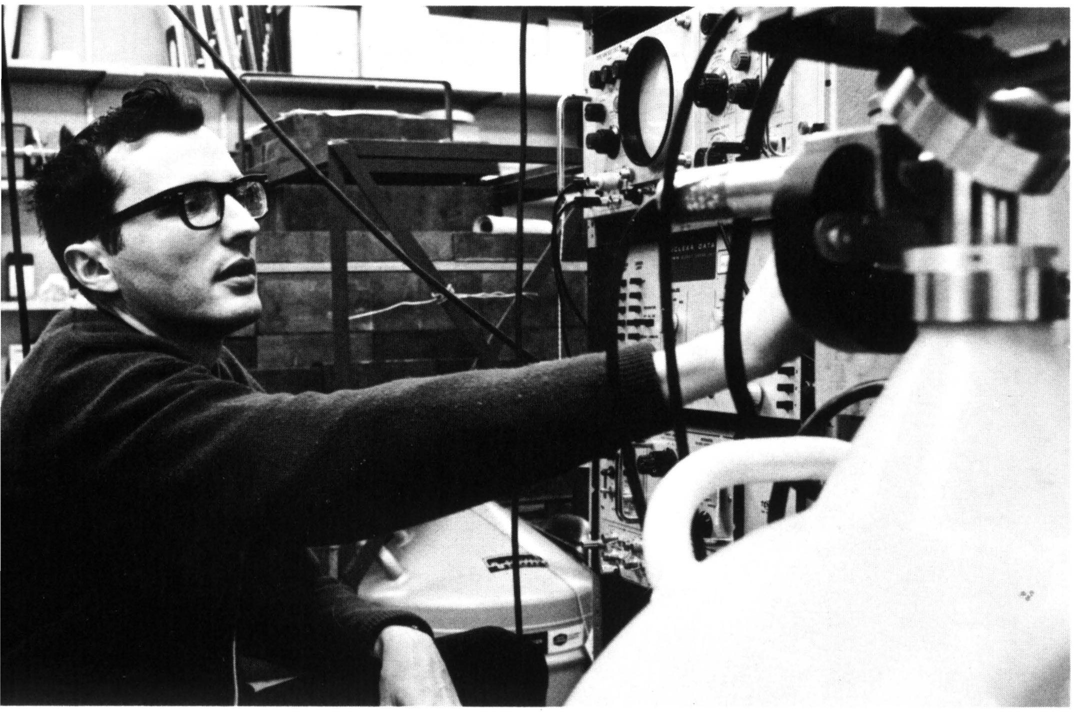
Basically, the investigations will cover mineralogy and petrology, crystallography, microprobe analysis, radiation and shock effects, alpha particle-autoradiography, chemical, isotope and rare gas analysis, cosmic ray induced and natural radioactivity measurements, light stable isotope, magnetic, thermal and elastic-mechanical measurements, determination of electrical properties and electromagnetic measurements, and biochemical and organic analysis.

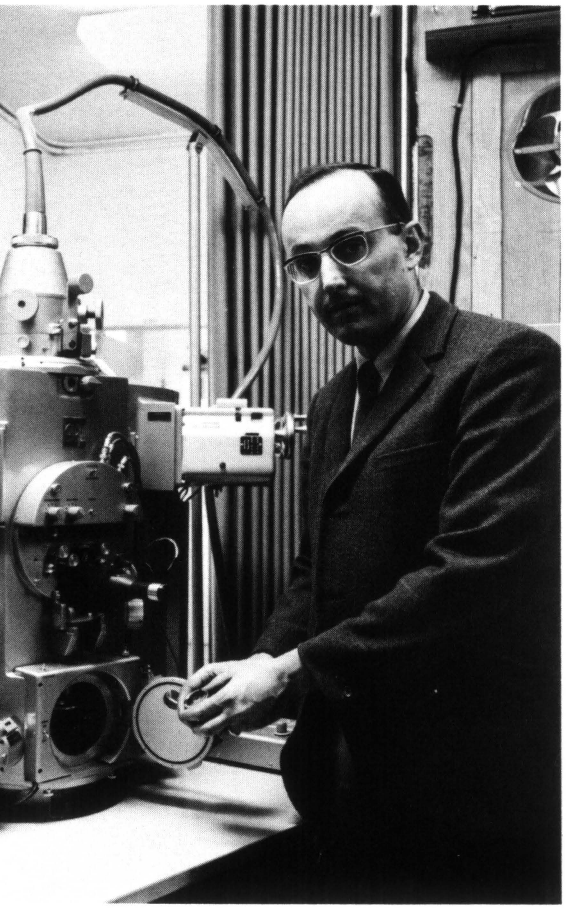
For example, a small portion, perhaps only 10 grams of lunar powder, will be sent to Lee C. Peck at the U.S. Geological Survey laboratories just outside Denver, Colo. Peck, one of the nation's leading rock analysts, will run a series of tests that will determine, precisely, the nature and



In sterilized, glass-enclosed cabinets of NASA's virology lab, delicate tissue cultures will be exposed to lunar rocks in a test to see if any germs have been brought back from the moon. NASA's Dr. Elbert King, right, examining a meteorite, believes age of moon may be learned via analyses of samples.

Cabbage and radish plant specimens, grown in a germ-free atmosphere, above left, will be placed in containers with lunar rock samples to see whether contamination develops. Similar tests will be conducted with animals, birds, such as Japanese quail held in rubber-gloved hands of laboratory analyst, left.





Dr. Gordon Goles, above, and Dr. Daniel Weill, left, both of the University of Oregon, are among the more than 135 international scientists and researchers who will examine the lunar samples. Dr. Goles believes there is a good chance some of the earliest records of events in the history of the solar system may be uncovered through analyses.

content of the major constituents in the sample he receives.

"All rocks are the same in regard to these major constituents," Peck says. "You will always find silica, alumina, ferrous and ferric oxide, magnesia, calcium, sodium, potassium, titanium and manganese oxide, carbon dioxide, phosphorus oxide, and if not water, at least compounds of oxygen and hydrogen. I expect the lunar rocks to be similar to those on Earth."

Under Peck's supervision, the samples will be crushed to 100 mesh powder and then run through a sequence of chemical tests which separates the basic elements, one by one. Similar analyses will be done at other laboratories in the U.S. and abroad.

At other sites, more specialized examinations will be conducted. At the University of Oregon in Eugene, for instance, Dr. Daniel F. Weill, professor of geology, hopes to determine the temperature and mode of rock formation by study of phase chemistry.

"We will be looking at a group of minerals and maybe some glass with an electron probe microanalyzer," he says. "The size of the crystals and the distribution of the elements among them may indicate whether the rock, once liquid, took a long time to solidify and the approximate temperatures at which the various minerals started to solidify."

Key to Moon Mystery

From such information, Dr. Weill might be able to conclude whether the lunar rocks formed on the surface or inside the moon; whether they are of impact melting or volcanic origin. Such data may provide valuable clues about the moon's history, perhaps even far beneath the surface.

Dr. Weill's associate at the University of Oregon, Dr. Gordon Goles will expose a portion of the lunar samples to a nuclear reactor. Through a neutron activation process, he plans to determine the precise number and amount of certain elements in the samples that would be difficult to measure by other means. These would include such alkali metals as sodium, potassium, rubidium and cesium, and rare Earth elements like lanthnum, cerium, samarium and europium.

"It will be interesting to learn what kind of rare Earth pattern is found in the lunar samples," Dr. Goles says. "It will give us a first order test of the origin of the moon. Radioactive elements will provide a crude index of the moon's past as a volcanic heat engine."

Scientists are careful to point out that no one principal investigation in itself will fully answer questions about the moon, the moon-Earth relationship, or the origin of the solar system. But each probe, each test, each examination, will add a piece to the overall puzzle. When the investigations are completed, meetings will be held and reports filed. Then, samples that were not destroyed in the testing will be distributed to other scientists for a "second generation" of tests. Also, some original rocks will be kept in the NASA lab for later studies, perhaps when new state of the art advances are made in investigative techniques.

More Samples Needed

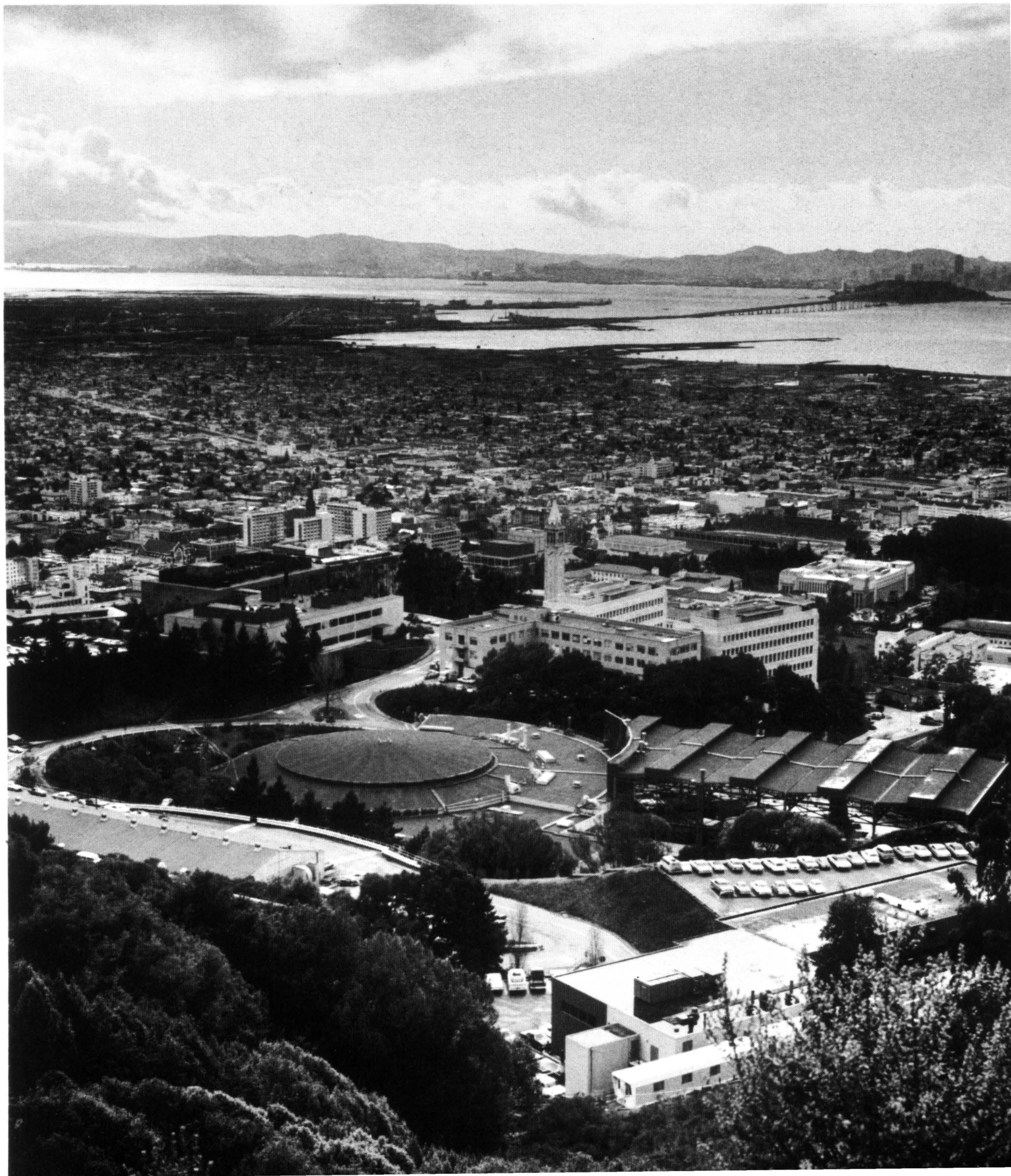
Even after all this data is compiled and analyzed, only partial and perhaps cautious conclusions can be reached, for the lunar samples will come from only a tiny segment of the moon's surface. Data will have to be correlated with what is received from samples obtained on subsequent Apollo flights to other areas.

But even a handful of first hand lunar information is enough to excite everyone involved.

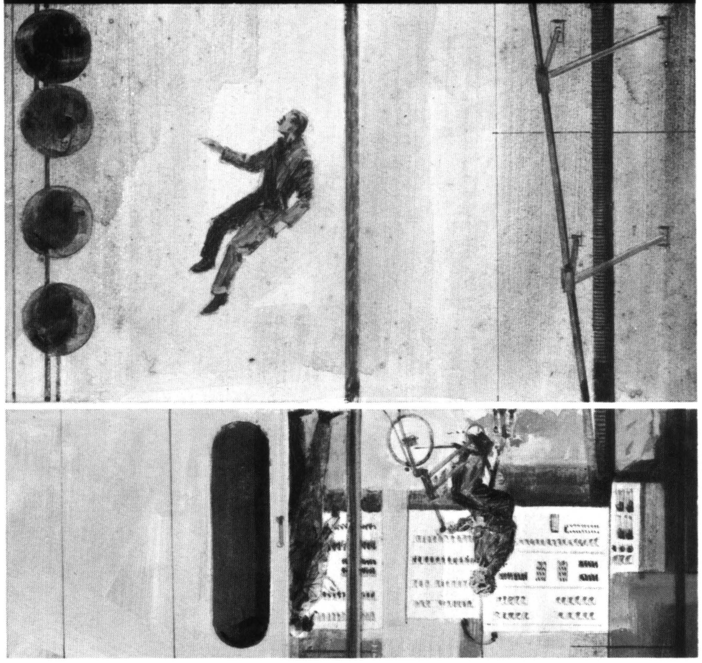
"From zero to plus X, that's a big step in itself," Dr. Goles says. "Personally, I find the excitement mounting as the date for the lunar landing draws near. I can see myself with my nose pressed against the glass during the quarantine period."

Says Dr. Philippe Eberhard, University of California physicist who will work with Dr. Luis Alvarez in a search for magnetic monopoles in the samples: "To me it's like being on Christopher Columbus' boat. This is an unparalleled opportunity for the scientist."

Ten grams of lunar dust will equal in size the amount of powder held by Lee C. Peck, above, of the U.S. Geological Survey in Denver. Peck and rock analyst Mrs. Vertie Smith, right, will run a series of tests on 10 grams of lunar samples to determine the nature and content of their major constituents. Principal investigators who will perform detailed analytical work on the "moon dust" have been selected from leading research centers and institutions of higher learning, such as the Univ. of California at Berkeley, below.



home is 200 miles up



Apollo Applications Program Precedes Day When Man Will Live on Orbiting Space Stations

Tucked neatly in orbit 200 miles up, circling Earth every 90 minutes, U.S. astronauts live in a weightless wonderland.

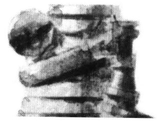
Their home-above-home is roughly the size of two "wide-load" house trailers. It has a surprising number of conventional conveniences and several that man has never before experienced.

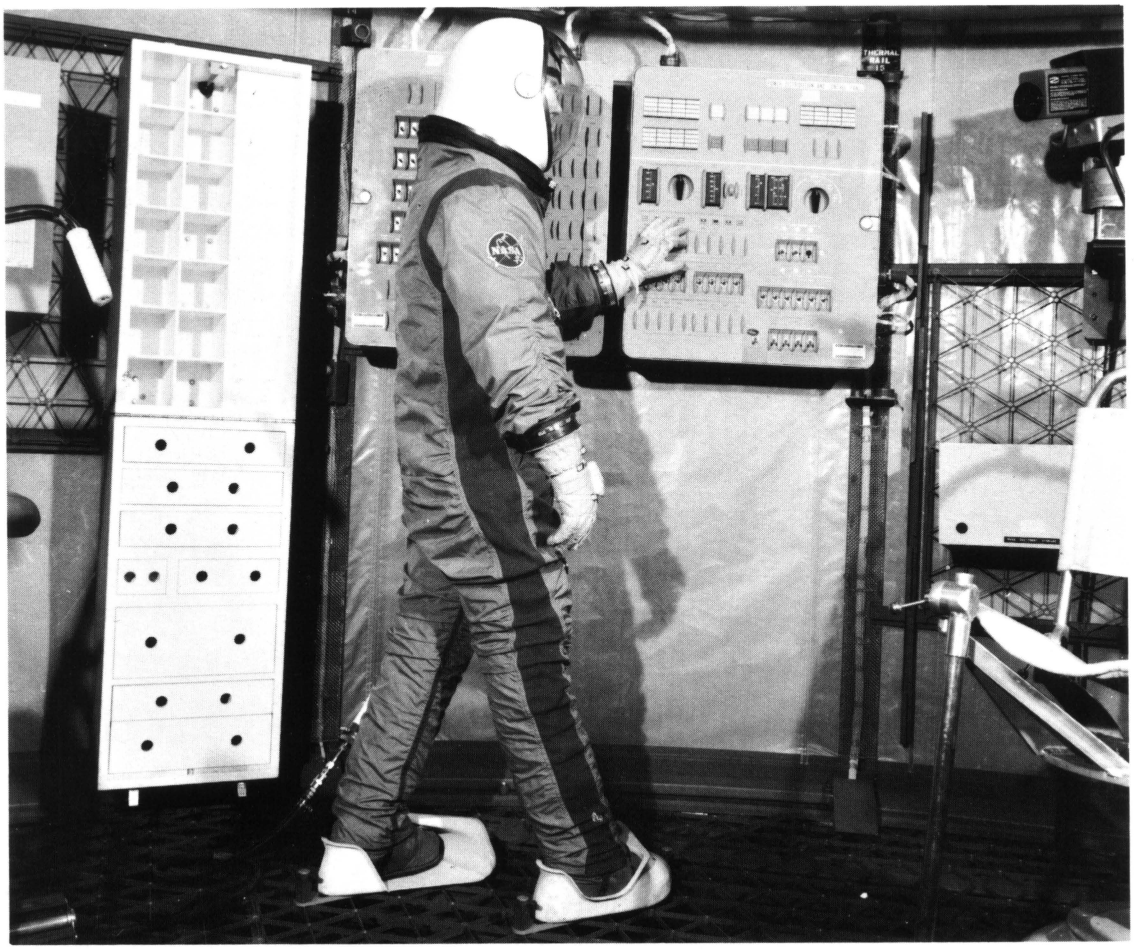
For one, without benefit of yoga, the astronauts can sleep with equal comfort in either a horizontal or vertical position. They can stand rightside up or upside down on either side of a see-through, metal grid floor. They dine in sealed compartments without the need of napkins. Overhead exhaust fans suck up any floating food particles. Shaving and bathing, troublesome chores on earlier manned flights, present no problems.

In the zero G environment, man needs not walk. By merely pushing a finger against a wall he can propel himself from sleeping quarters to the bathroom, or to an exercise or work area. He can dive, float, spin, sail, or, like a fly, walk on walls and ceilings with virtually no effort at all. How does it feel to live under such conditions? One space expert said it is like jumping off a swimming pool diving board and never hitting the water. The atmosphere is pleasant and comfortable, and the work is interesting and varied — to the point where astronauts will not mind spending nearly two months at a time on such missions.

When will all this occur — 1985, 1990, the 21st century? In fact, such fantasy-like flights will become realities in the near future, perhaps by late 1971 or early 1972. They will be part of what has come to be known as the Apollo Applications Program (AAP).

"We have become convinced, by virtue of studies and ex-





Inside mock workshop a NASA employee checks power control panel. Special footwear, hooked into flooring, may not be used.

perience, that beyond the lunar landing, an Earth-orbiting station — an inhabitable island in space — is the next logical, practical, and necessary step in manned space flight," says Dr. Wernher von Braun, Director of NASA's Marshall Space Flight Center in Huntsville, Ala. "Our first AAP missions will be interim steps toward the ultimate attainment of this goal."

"John F. Kennedy said we were to be a space-faring nation," adds Bob Thompson, AAP program manager at NASA's Manned Spacecraft Center in Houston. "What we are buying with Apollo is not just the ability of landing two men on the moon. We are buying a broad base of technology and competence. AAP is one attempt at how to best utilize this base in further developing an overall space flight capability."

Strange Environments

To go farther from Earth, in both duration and length of missions, a vast storehouse of knowledge must be accumulated on how man functions in strange environments. What are the physiological effects on astronauts who stay up months instead of days? How effectively can they work? What can they do that unmanned instrumented satellites cannot? These are among the essential questions AAP hopes to help answer.

It is not an end-all program, nor was it intended to be. It was, rather, designed to extract the most useful information possible at the most reasonable price. This will be done largely through the extended use of modified hardware originally designed and planned for Apollo.

"Home," for instance, will be the spent S-IVB second stage of the Saturn IB rocket — a 58-foot-long cylinder 22 feet in diameter. Such bulky items, once their propellants were expended, were long thought of as castoff by-products of space flight. Their additional use is considered a first rank dollar savings bonus of the launch vehicle program.

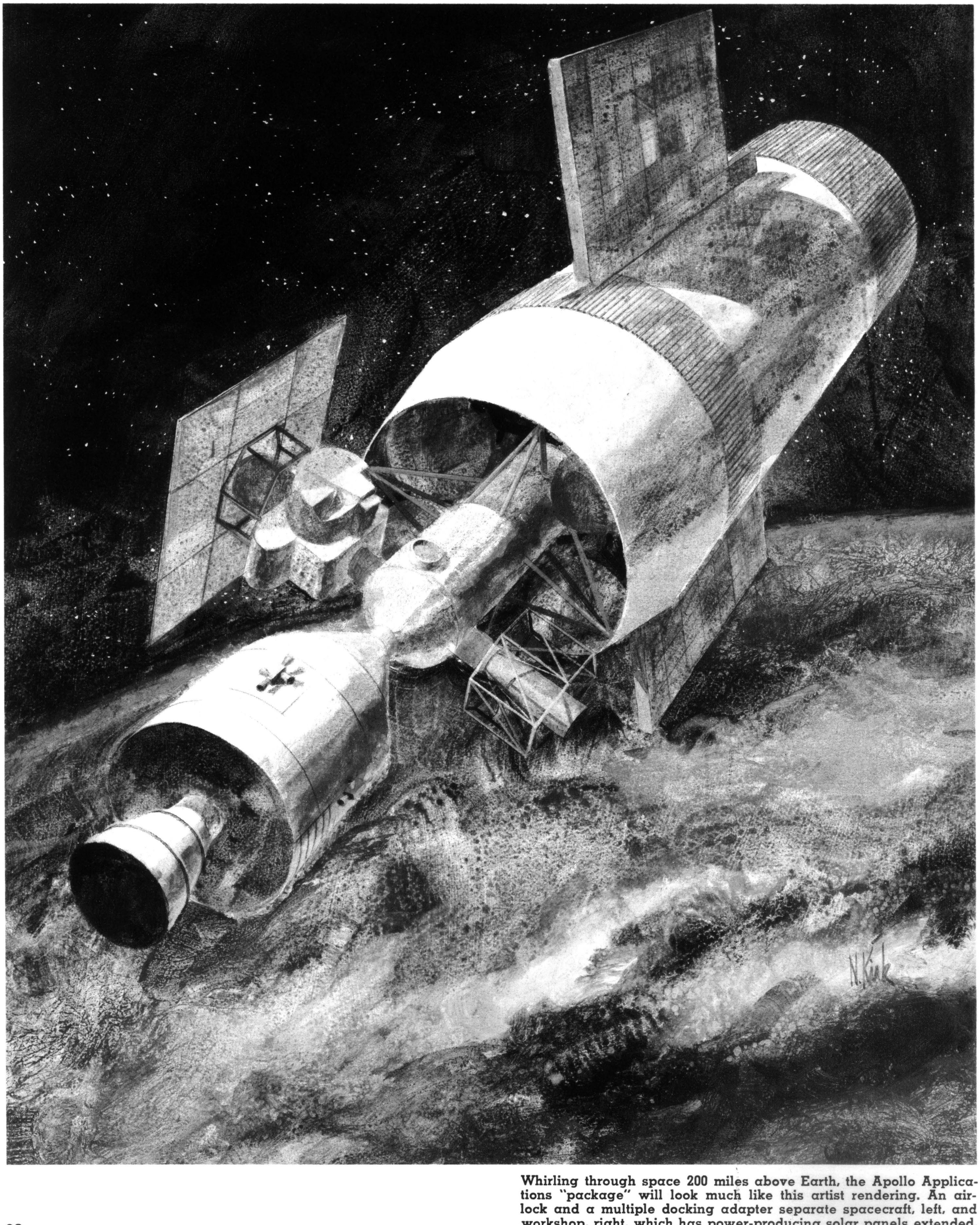
For AAP, the stage's liquid hydrogen tank will be drained and thoroughly purged in orbit after fulfilling its role as a propulsive stage. It is then transformed into a flying workshop enclosing 10,000 cubic feet of habitable quarters. This will give astronauts, as Thompson describes it, "a living environment comparable to a submarine, as opposed to the small aircraft-cockpit-size room they had in past spacecraft."

Several key pieces of equipment, which will not interfere with the propellant flow during the powered launch phase of flight, will be pre-installed in the tank. This will include an aluminum, grid-pattern flooring, making the workshop a "two-story" dwelling; partitions, some with telephone-booth-like doors; and a cloth ceiling. Wrapped around the stage will be a thin aluminum sheet, which serves dual purposes as a micro-meteoroid shield and as insulation, giving the S-IVB the character of the world's largest thermos bottle. Design of the workshop is being done jointly by personnel at the Marshall Space Flight Center (MSFC), and at McDonnell-Douglas in St. Louis, where modifications to the stage are also being made.

Sky-High Living

Attached to the throat of the rocket stage will be a 16-foot-long airlock, designed and built especially for the program by McDonnell-Douglas. It has four viewing ports and a hatch through which astronauts have access to space outside without having to depressurize the entire cluster.

The airlock connects to a multiple docking adapter (MDA), 17 feet long, which looks and functions something like a giant orbiting socket. It is being designed and produced at MSFC. Three other spacecraft or large experiment modules can be hooked up with its docking ports. It also has 1,500 cubic feet



Whirling through space 200 miles above Earth, the Apollo Applications "package" will look much like this artist rendering. An airlock and a multiple docking adapter separate spacecraft, left, and workshop, right, which has power-producing solar panels extended.

"With Apollo, we are buying a broad base of technology and competence. AAP is one attempt at how to best use this base in developing an overall space flight capability," says NASA Program Manager Bob Thompson, above left. "A number of Apollo's systems are being left intact or will only be slightly modified for AAP," says Program Manager Len Tinnan, examining model configuration with Engineering Manager Jim Bates, right. Most design changes for the applications program involve the service module. Below, engineers examine Apollo Applications instrument panel.

of storage for experiments, equipment and supplies. The AAP command and services modules (CSM) link into the "mouth" (end docking point) of the MDA.

When the entire cluster has been assembled, the wing-like solar panels of the workshop are extended, and experiment modules have been docked to the MDA — the overall configuration has an unworldly, super-bug-like appearance beyond the imagination of even the most avid science fiction aficionado. (See artist's concept, page 28.) It was designed for service, however, not looks.

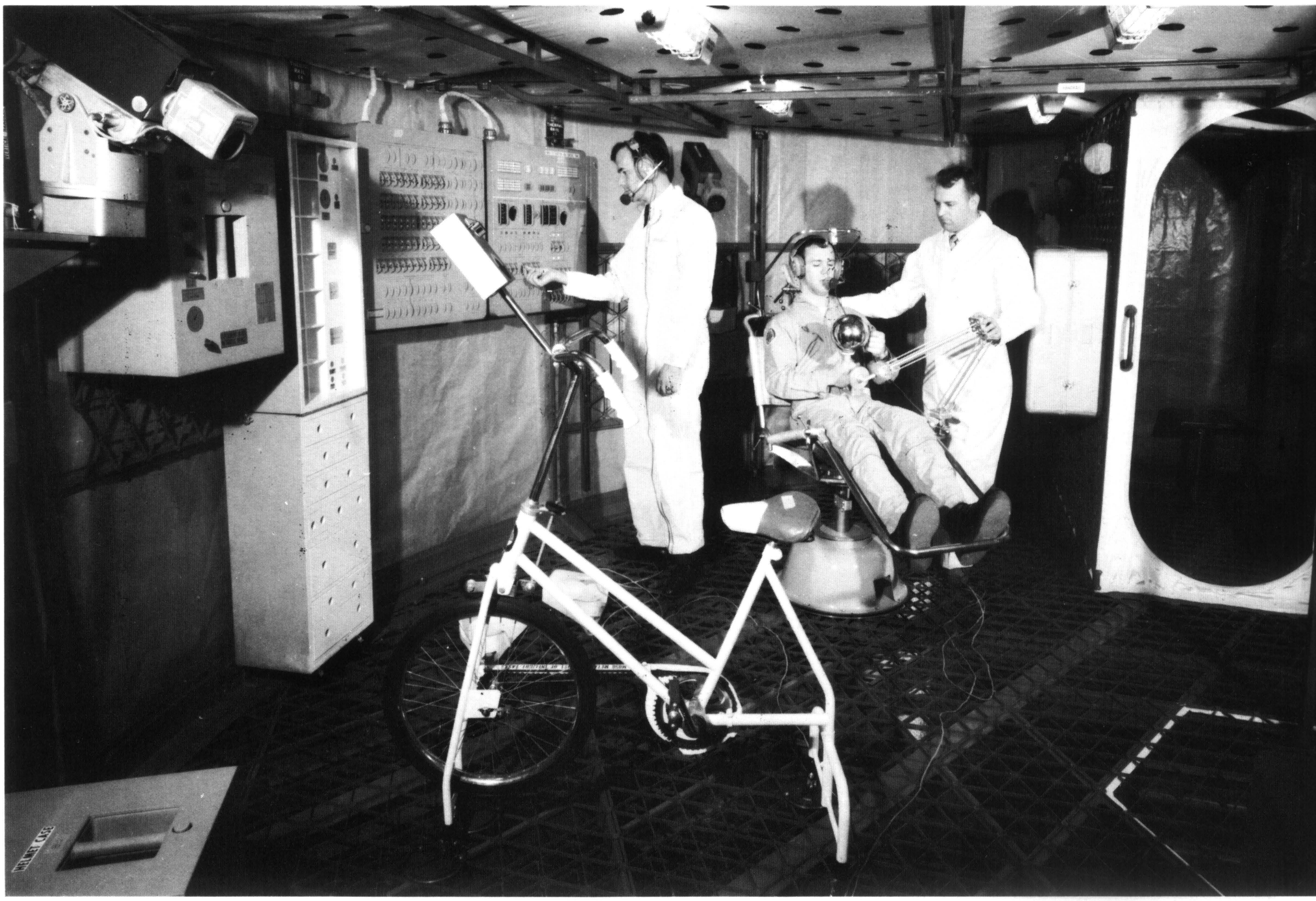
Here's how it will work:

An unmanned vehicle will lift off from Saturn launch complex 37 at Cape Kennedy and soar into an elliptical orbit, roughly 185 by 210 nautical miles above Earth. This package will include the S-IVB workshop, with folded solar cells, the airlock and the MDA.

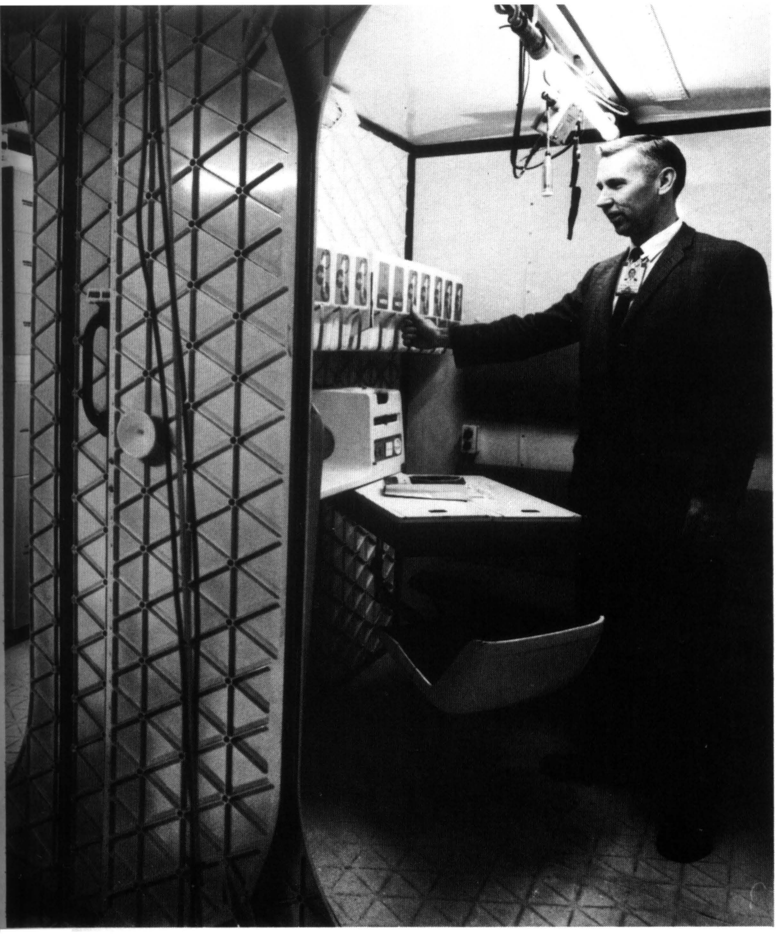
The next day, from adjacent launch complex 34, a manned Apollo-derived spacecraft, specifically modified for this mission and loaded with experiments and supplies, will lift off. Within hours, the crew, calling upon experience of previous flights, will track, rendezvous and dock with the MDA-airlock-S-IVB, circularize the orbit, properly orient the cluster, and pressurize all units. Once this has been done, they can take off their suits and helmets, crawl through hatches, and live in "shirt sleeves." Throughout the mission one or more men will stay in the command module, which serves as the command center for communications to Earth. The airlock and MDA are somewhat like a hallway leading into the cavernous workshop. The main living qaurters will be in a sectioned-off, six and a half-foot high segment of the liquid hydrogen tank.

It may take a few days, possibly four or five, to set up the

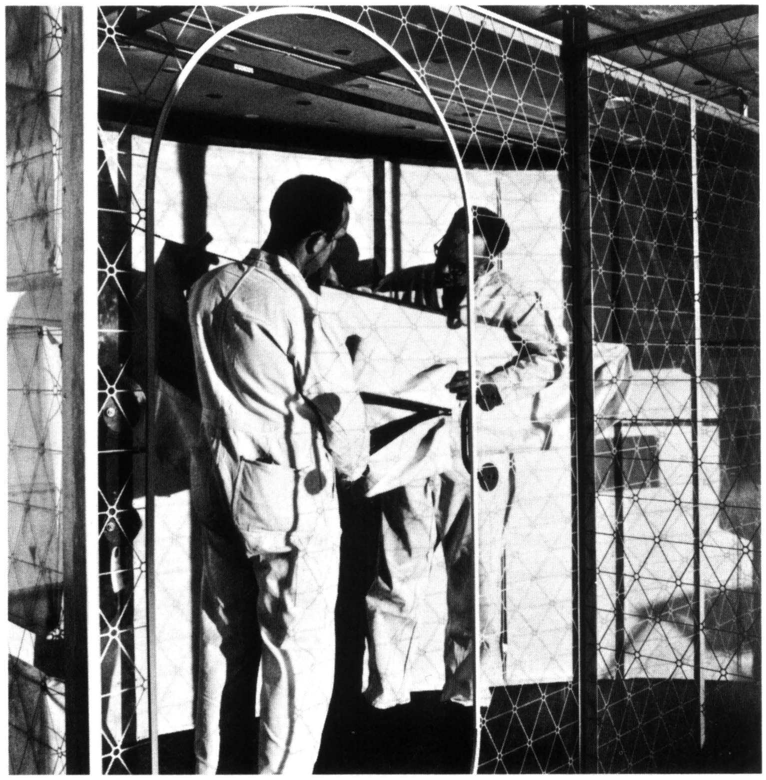
Cone-shaped primary structures for the AAP birds are virtually identical to Apollo. There are to be numerous changes inside the command and service modules.



In spacious crew quarters of mock orbital workshop, technicians test types of equipment which may be included on AAP flights.



Astronauts will have all the comforts of home and then some 200 miles above Earth. Dining area, left, will be sealed off during meal-times, and exhaust fans will suck up any floating crumbs. Though crewmen could sleep in vertical position, they will probably use hammocks, below.



various experiments and "put the house in order." Astronauts eat, sleep, work and play in an orbit that has been circularized at about 210 nautical miles. They perform a variety of physical and scientific tests, ranging from cardiovascular function assessments to electron beam welding to time and motion studies. They are in constant touch with ground controllers and medical specialists.

Assuming all goes well, the three crewmen will button down the workshop cluster for future use, crawl into their CSM, undock, and head back to Earth after 28 days in space — twice as long as any previous manned flight.

56 Days In Space

Two months or so later, after the still-orbiting workshop cluster has been reactivated by ground control, three more crewmen liftoff from complex 34. Again, they rendezvous, dock and set up shop — this time for up to 56 days. The orbit has by now decayed to about 200 nautical miles. Following more work, long duration medical experimentation and data gathering, which will include extra vehicular activity, they come home, leaving behind the stored cluster.

In about 30 days a third team goes up and remakes connections, 190 miles up. One to five days later an unmanned lunar module ascent stage and a 20,000-pound Apollo telescope mount (ATM) package will be launched from complex 37. Its rendezvous with the cluster will be directed from the ground and astronauts already aboard the orbital assembly will help nurse it into its MDA berth.

This manned solar observatory will provide a fresh capability to perform a variety of astronomical experiments where the sun and stars can be clearly observed without being blurred by Earth's atmosphere.

With the landing of the third team, the currently planned AAP flight program will be completed. Then will come months of data analysis and evaluation. Nearly 50 major experiments conducted by the three astronaut teams will be assessed.

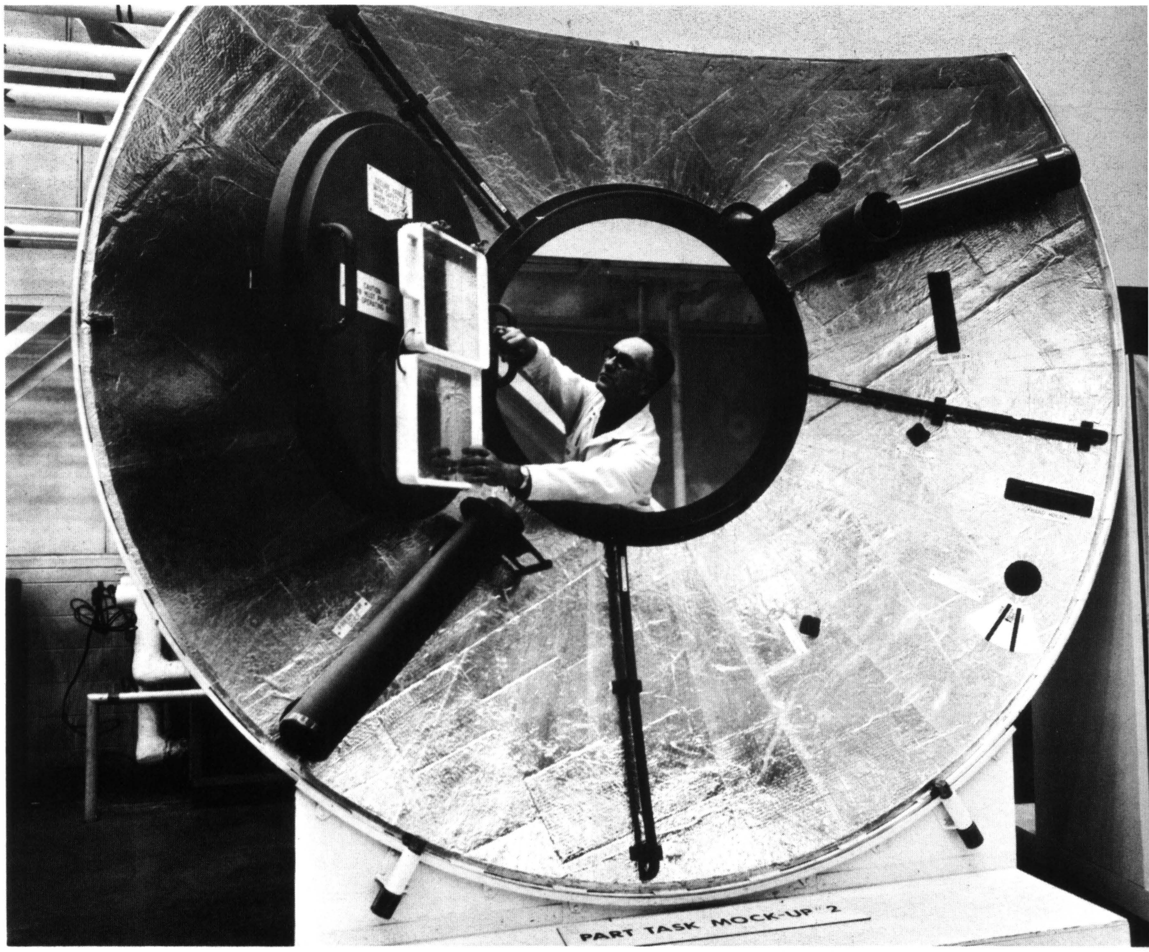
Though the first Apollo Applications launch will not occur until 1971 at the earliest, Space Division personnel have been busy on AAP plans for more than four years. Since last February, work has intensified on final spacecraft design changes.

"Actually, a number of Apollo's major systems are being left intact or will only be slightly modified," says Program Manager Len Tinnan.

The primary structure will be untouched. The guidance and navigation, stabilization control, Earth landing, reaction control and launch escape system will remain unchanged. Minor alternations are all that have to be made to the RF (radio frequency) communications system and to the spacecraft's electrical power systems. Large portions of other key components and systems throughout the command and service modules can be adapted to AAP's modifications.

Most of the major design changes involve the service module," says Engineering Manager Jim Bates. "For example, more cryogenics will be needed for the environmental control system (ECS), and the electrical power system."

Apollo carries about 640 pounds of oxygen and 56 pounds of hydrogen, for life support and power, and no nitrogen. To support 56-day missions, the AAP CSMs must each haul 3,600 pounds of oxygen and 213 pounds of hydrogen. In addition, 400 pounds of nitrogen will be on board — since astronauts will live in a two-gas (oxygen nitrogen) atmosphere in orbit rather than on pure oxygen as in the past.



Roomy hatches, such as the one being checked at right, will allow astronauts free movement through orbiting "home's" various units.

To accommodate the extra load, seven new, larger storage tanks will replace Apollo's four smaller ones. They will take up some of the room once allotted to service propulsion system (SPS) tanks. Lunar-bound spacecraft are equipped with two fuel and two oxidizer tanks which hold 40,000 pounds of propellants used in crucial maneuvers near the moon. Because AAP vehicles will not travel beyond Earth orbit, less than half the SPS propellant supply will be needed, so two tanks can be deleted, and the room vacated can be used for new AAP expendables.

Additional room must be found for reaction control system (RCS) propellant storage. The AAP craft will "jockey" more in orbit — attitude control maneuvers for rendezvous, docking, etc. — and it will have a backup de-orbit capability, thereby requiring nearly three times more fuel and oxidizer (3,600 pounds to 1,280 pounds for Apollo). Space Division engineers propose to add 16 storage tanks for this.

Another primary change involves the electrical power systems (EPS) fuel cells. Apollo cells have a designed lifetime of about 700 hours. A 56-day flight, however, equals 1,344 hours. Consequently, new fuel cells, smaller, lighter and with a longer lifetime, will be substituted for AAP.

Wiring changes are necessary too — to support audio, remote antenna switchings and a caution detection system, among other things. Also, a new umbilical cable will be installed to transfer power from the orbital workshop to the command module for the longer missions.

On Apollo, there are 81 signals on the main display panel linked to caution detection system monitors. For AAP, 12 more will be added. These are triggered if something aboard malfunctions — say a faulty thermostat fails to shut off a heater, causing pressure to increase in an RCS tank. Monitors will be in every section — command module, S-IVB workshop, MDA, ATM — so astronauts can hear any signal regardless of where they are.

"One significant change is being dictated by the different profile of the AAP mission," Bates explains. Apollo spacecraft enroute to and from the moon have the capability of being oriented, in a slow roll fashion, so one side is exposed, or hidden, from the sun for a great length of time. AAP spacecraft will be in a fixed attitude orientation, however. To compensate, a number of heaters will be added to warm areas of the craft permanently in shadow. These will heat SPS storage tanks, RCS tanks in the command module, and water tanks, among others.

Following acceptance of the design changes, four AAP spacecraft will be built in Downey — for the three manned flights and one currently planned spare flight vehicle. Structural shells, in fact, are already on the fabrication line in Bldg. 1.

The program, which until recently has been mostly on paper, is now gaining momentum. Production, delivery and checkout schedules are taking shape, and designs will soon become hardware.

NASA Administrator Thomas O. Paine envisions someday the operation of a large space station, housing dozens of astronauts, in orbit about the Earth. The station would serve as an observatory to study the sun and other stars, to make measurements of the Earth's natural resources, to serve as a launching platform for flights to the moon, and as a repair station for other, unmanned spacecraft, such as communications and weather satellites.

What will be learned from the Apollo Applications flights will go a long way toward transforming vision into reality.

Slipping into mock AAP command module at Space Division, astronaut Paul Weitz, above, checks ease of ingress. Apollo 7 veteran Walt Cunningham, left, oversees AAP progress for astronauts.

Bubble-helmeted Weitz, left, tries the command module hatch on for size during recent series of "fit" checks at Downey. At right is astronaut Joseph Kerwin who also participated in the spacecraft tests.