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MAY, 1969
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The magazine of space news

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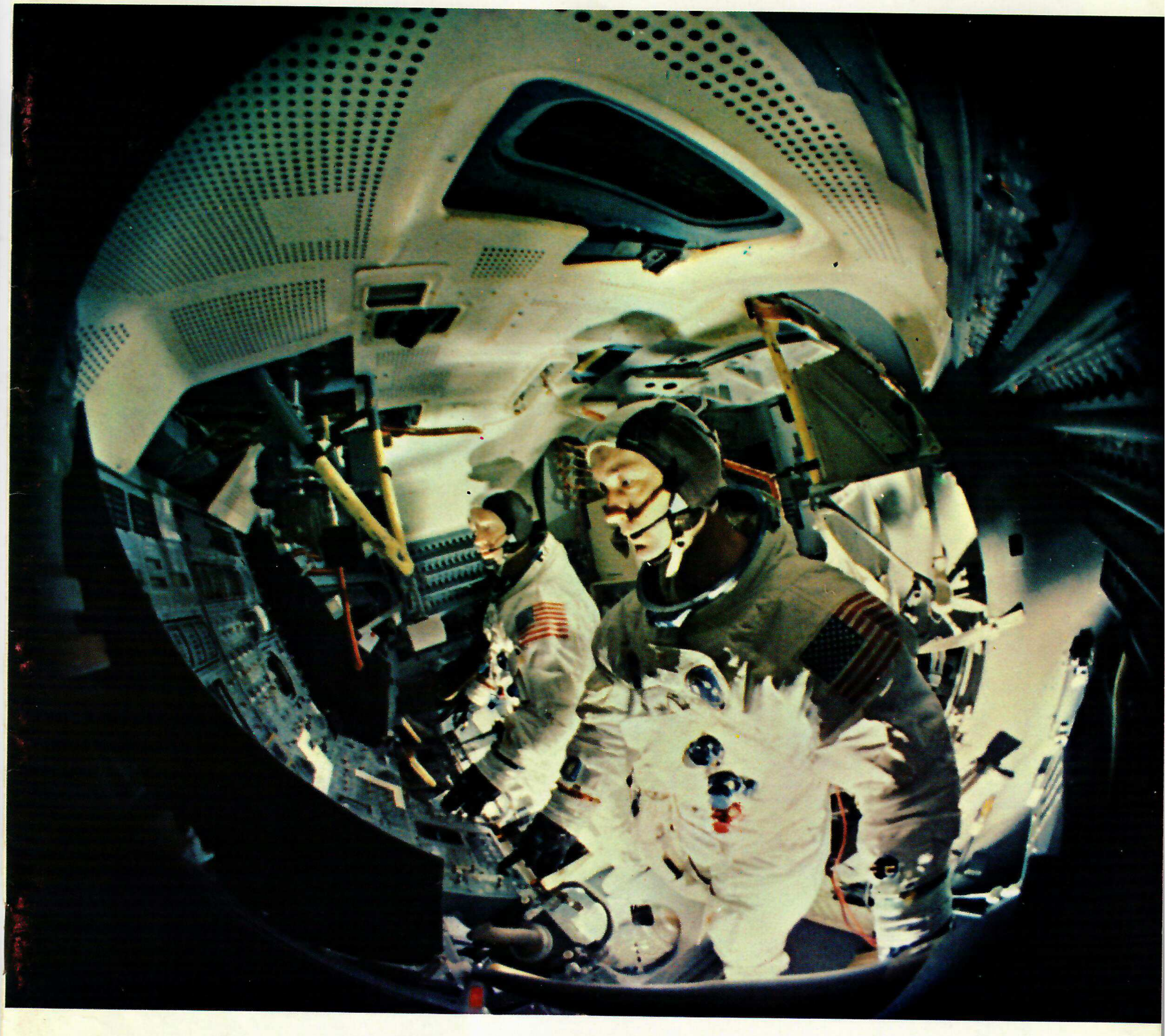

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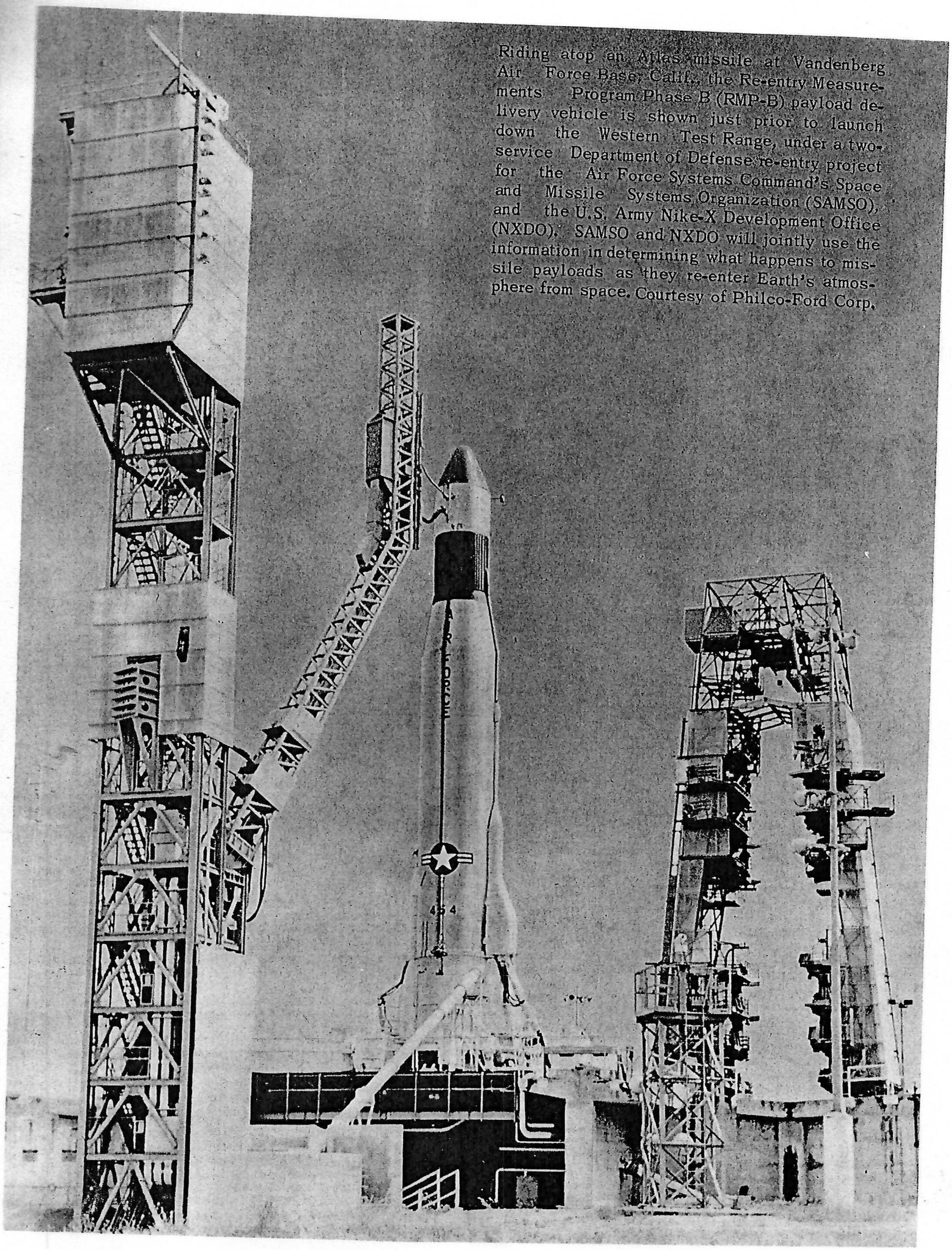
ANTARCTIC RESEARCH, A PRELUDE TO SPACE RESEARCH



Riding atop an Atlas missile at Vandenberg Air Force Base, Calif., the Re-entry Measurements Program Phase B (RMP-B) payload delivery vehicle is shown just prior to launch down the Western Test Range, under a two-service Department of Defense re-entry project for the Air Force Systems Command's Space and Missile Systems Organization (SAMSO), and the U.S. Army Nike-X Development Office (NXDO). SAMSO and NXDO will jointly use the information in determining what happens to missile payloads as they re-enter Earth's atmosphere from space. Courtesy of Philco-Ford Corp.

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COVERS:

FRONT COVER:

Fish-eye lens provided this all-inclusive view of interior of lunar module spacecraft simulator during prelaunch practice mission performed by Apollo 9 Commander James A. McDivitt, foreground, and Lunar Module Pilot Russell L. Schweickart. (NASA photo.)

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GUEST EDITORIAL

The interplanetary era has begun. The flawless flight of Apollo 8 around the moon has given man his first truly objective look at his world. He has seen his beautiful blue-tinged planet as a united whole where all men are one. And the world will never be the same. As man continues his onward advance into space, he will, perhaps, find greater unity than he has ever known.

The flight of Apollo 8, at first called "risky" and "foolhardy" by critics of our manned space program, was carried out with such precision that all dissent was drowned out by a worldwide flood of praise. Everyone seemed to realize the epoch-making significance of Apollo 8's achievement. Man at last had broken free of Earth's gravity and soared into interplanetary space.

The world press generally commended the Apollo 8 feat and the Japanese press made the interesting observation that the United States had won the first "heat" in the lunar race. This is probably an accurate observation. The United States still has to check out the all-important lunar module in Earth orbit on the February Apollo 9 flight and then in lunar orbit on the Apollo 10 mission. If everything works as planned and no snags develop, Apollo 11 will land Neil Armstrong and Edwin Aldrin on the moon in July or August of this year. During this period the Soviet Union will have ample opportunity to forge ahead of the United States in the lunar gambit.

The Soviet Union has already shown that it can send spacecraft around the moon and back to Earth with the flights of Zond 5 and 6 in late 1968. The Soviets have also demonstrated that they can rendezvous and dock orbiting spacecraft either automatically as shown by Cosmos 186 and 188 or manually as shown by the flights of Soyuz 2 and 3 and most recently by Soyuz 4 and 5. Just as the flights of Zond 5 and 6 indicate a Soviet manned lunar capability, the flights of Soyuz 4 and 5 clearly indicate the Soviets' intention to establish long-term orbital space stations.

The Soyuz spacecraft are composed of three modules: a rather spacious work/rest module about 175 cu. ft. in volume, a command module similar to our Apollo command module about 143 cu. ft. in volume, and a service module containing engines and two large wing-like solar panels which supply power (this, incidentally is something we do not have on our manned spacecraft and may indicate a Soviet intention to conduct long-duration space missions longer than any we have yet flown).

By studying the Soviet Zond Lunar spacecraft (note the January issue of this magazine), and the Soyuz spacecraft one can readily see that each could be combined to form a potential manned lunar spacecraft. It would be composed of a Zond module plus the Soyuz command and service modules; the work/rest module would not be needed. This craft would be capable of performing a manned circumlunar or lunar orbital flight but not a lunar landing. With a modified Zond module or a fourth lunar landing module this craft could land Soviet cosmonauts on the moon.

It is difficult to determine just what the Soviet Union ultimately hopes to accomplish in space. They now have hardware capable of performing a great variety of manned and unmanned missions. It is obvious, however, that their current priorities in space are first to construct large manned space stations and second to land men on the moon. Their ability to construct elementary space stations has already been demonstrated by Soyuz 4 and 5. To reach the moon, land and return they still must have (1) a large booster rocket comparable to our Saturn 5, and (2) a manned vehicle capable of descending and ascending from the lunar surface. The Proton booster may be a possible Soviet manned lunar vehicle but its thrust is rated at only 3 million pounds. For a booster of this size to be used in a manned lunar landing mission at least two or three launchings (and rendezvous and docking maneuvers) would be required.

Spurred on by American competition and the desire to regain lost prestige, the Soviet Union may yet be first in landing men on the moon. It must be remembered that prior to Apollo 8 the Soviet Union was ahead of this country in every major phase of lunar research. The Soviet Union was first to photograph the moon's far side (Lunik 3), first to soft land a probe on the moon (Luna 9), first in orbiting satellites around the moon (starting with Luna 10), and first to send probes around the moon and back to Earth (Zond 5 and 6). A country which has been first in so many facets of lunar exploration and space exploration in general, will not be satisfied to remain in second place for long. - E. A. Aggen, Jr.

Reprinted from ANTARCTIC JOURNAL of the U.S., Vol. IV, No. 1, January-February 1969.

Antarctic Research, A Prelude to Space Research[1]

ERNST STUHLINGER

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In the northern winter of 1966–1967, four members of the National Aeronautics and Space Administration had the good fortune of being invited by the National Science Foundation to spend a week of observing and learning on the Antarctic Continent. This voyage proved for each of us the most exciting, fascinating, and impressive trip we ever took. By far the deepest impression I received was from a hut built in 1911 by Captain Robert Falcon Scott on Ross Island in McMurdo Sound. This hut is still in excellent shape. On one of the walls there are a number of shelves filled with instruments for scientific research: glasses and bowls, scales, anemometers, thermometers, transits, even Bunsen burners with bottled gas. It is known that Scott carried and used research instruments on his ill-fated march to the Pole in 1911–1912, and that he recorded scientific observations up to the last days of his life.

A Continent for Science

Many of the early antarctic travelers, beginning with James Cook in 1772, combined the keen eye of the scientific observer with the adventurous spirit of the true explorer. However, the hardships of antarctic travel with its continuous struggle against a thoroughly hostile environment, together with the lack of suitable instruments for antarctic research, did not leave much room for early scientific observations. The first one and a half centuries of antarctic exploration, therefore, are distinguished mainly by the discovery of coastlines and mountain ranges, glaciers and snow fields, and, in 1911, the South Pole itself. Somewhat surprisingly, the United States had no noncommercial activities in Antarctica between the Wilkes Expedition in 1840 and the first expedition of Admiral Byrd, who flew over the Pole in a Ford trimotor airplane in 1929. This flight marked the end of the adventurous period and the beginning of the technological period of antarctic exploration, although it must be said that even the 1968 traveler who flies in a few hours from McMurdo to the Pole in the protected comfort of an LC–130 cannot avoid a feeling of high adventure.

The period of technological development of transportation and housing in Antarctica lasted from 1928 till about 1961, when the Antarctic Treaty among 12 member nations was ratified. This Treaty declared the land area south of 60° south latitude an international reserve for scientific research. By that time the technologies needed to live and to move around in Antarctica with reasonable comfort and safety would permit almost any kind of scientific research. Actually, a steep rise of scientific activities in Antarctica occurred as early as the period of the International Geophysical Year, when seven U.S.-IGY stations were built on the Continent. Rear Admiral George Dufek, Commander of *Operation Deep Freeze,* landed at the South Pole in 1956, and Dr. Paul Siple with 17 companions wintered at the Pole in 1957. Ever since that time the Pole Station has been occupied by Americans who were frequently joined by citizens of other nations.

With the Antarctic Treaty, the Continent developed into a research laboratory of the first order. Antarctica is an ideal continent for science. It is a place where nature goes to its extremes and where unusual environs can be studied as nowhere else on Earth. The lowest temperatures, the strongest winds, the deepest ice occur in Antarctica. Ninety percent of all the ice on Earth lies on the Antarctic Continent, but the land nurtures no trees, shelters no native mammals other than an occasional seal, and supports only a few species of birds. Although it is larger than the United States, Antarctica, to our present knowledge, has never had a native human population. It did have, though, a rich plant life, and probably also an animal life many millions of years ago. The fossilized trunk and stump of a huge tree were found only a few hundred miles from the Pole. Small insects, mites, nematodes, and Protozoa live in the dry-valley area near McMurdo, but they persist under conditions which are unique in many respects. For almost six months each year, the sun does not set, but the ensuing night lasts just as long. Winter temperatures are extremely low, and even during the austral summer, when the temperature is above freezing, food is very scarce. The field lines of the Earth's magnetic field are quite unusual in Antarctica. They have a very steep angle, and even become vertical at one point. Above this region, no Van Allen belts are encountered; slow protons and very soft cosmic rays from extraterrestrial space enter the atmosphere through this magnetic funnel.

It is not surprising that Antarctica has attracted scientists of many interests: physicists and geologists, glaciologists and petrologists, meteorologists and biol-

[1] Adapted from an address delivered at the Orientation Program for participants in the U.S. Antarctic Research Program, 1969, at Skyland Lodge, Shenandoah National Park, Virginia, September 18, 1968.

ogists, and even psychologists, who want to investigate the most enigmatic of all research subjects under the unusual antarctic conditions—man.

The Problem of Logistic Support

The development of Antarctica into a continent for science was a great and challenging experiment in itself. The basic problem was how to provide a group of scientists in a remote antarctic outpost with the necessary support which would permit them to live and to work under extremely hostile conditions. This problem, which is simple to formulate, but very difficult to solve, is encountered in a very similar form by those who are preparing the astronauts' flight to the moon, and later to the planets. The great similarity between the logistic support problems for the U.S. Antarctic Research Program and the forthcoming program of lunar exploration was indeed the reason why the four of us, Drs. Robert R. Gilruth and Maxime A. Faget, from the Manned Spacecraft Center in Houston, and Dr. Wernher von Braun and I, from the Marshall Center in Huntsville, spent a week with USARP in Antarctica in January 1967.

We wanted to learn how the Office of Antarctic Programs and the U.S. Navy have solved the many problems of maintaining productive research under environmental conditions which are certainly the most extreme and the most unforgiving to be found on Earth. Very simply, the four of us wanted to go to Antarctica because this was as close to lunar conditions as we could get here on Earth. Admittedly, there are some differences. There is an atmosphere in Antarctica, there is gravity six times that on the moon, and the nearest hospital, in New Zealand, is only 8 to 10 flight hours away, weather permitting. However, at a remote outpost in the mountains or on a glacier, where the few men of a scientific team may spend weeks or months in field studies, human life depends entirely on the technological reliabilities of a stove and of a radio transmitter. If both failed, death would be imminent unless safety measures had been carefully prepared.

Scientists and the Support Force

When the four of us from NASA looked at the many fascinating activities through the eyes of space-project developers, we registered in our minds a number of impressions which certainly will find their ways into our space program planning. We were greatly impressed by the large and complex machinery that is needed for the logistic support of the U.S. Antarctic Research Program. During the austral summer about 200 scientists live in Antarctica; the logistic system employs about 2,000 uniformed men to support these scientists. Logistic support includes transportation of men and materials between the U.S.A. and Antarctica, and all across Antarctica; building and maintenance of permanent stations; supply of field stations; communications; mail; food and kitchen services; medical care; electrical power; heating; water supply; vehicle maintenance; clothing; shipment of scientific instruments and collected samples; and emergency evacuation. Scientists are responsible only for their own housekeeping, and, of course, for their scientific projects. At all the smaller field stations, however, scientists voluntarily and gladly help with such mundane chores as snow shoveling, snow melting, and station upkeep.

This very comfortable situation for the scientists has evolved from practical field experience during the first years of continuous antarctic research. I am sure that many scientists in the U.S.A. envy their fortunate colleagues in Antarctica for this excellent support.

Each field station, as well as each permanent base, has a station scientific leader who is directly responsible to the Office of Antarctic Programs in Washington. Each station also has an officer-in-charge who, through channels, is the representative of the Commander, U.S. Naval Support Force, Antarctica. He is responsible for the safety and welfare of all persons at the station, and for the support of their activities. In case of an emergency, declared jointly by the station scientific leader and the officer-in-charge, the latter directs station activities. We felt that this system, which has proved highly satisfactory in Antarctica, may well set the prototype for the organization of future stations in Earth orbit and on the moon.

Scientific Field Work

The first flight to the lunar surface by astronauts is hoped for before the end of 1969, and two more flights of a similar nature will follow within a short time. A package of scientific instruments prepared for these early lunar landings, the Apollo Lunar Scientific Exploration Package, or ALSEP, will be deployed manually on the surface of the moon. After deployment, the instruments (see accompanying table) will work automatically, and they will radio

ALSEP Experiments

Passive seismic sensor
Lunar surface magnetometer
Solar wind spectrometer
Suprathermal ion detector
Cold cathode ionization gauge
Heat flow measurements
Active seismic sensor
Charged-particle lunar environment detector
Laser ranging retro-reflector
Field geological investigations

their observational data back to Earth for a period of several months, perhaps for a full year. Besides the ALSEP, the astronauts will have some simple tools, such as a hammer, a scoop, a corer, and a rock-sample retriever. All tools have been designed with long handles, because an astronaut in his space suit can not bend down to the lunar surface. If he were to fall, he would have great difficulties in getting up again. Easy movements and close-up observations familiar to antarctic explorers will not be possible on the moon, at least not during the first landings; however, the collection of rock samples, a very rewarding and fascinating activity for geologists in the ice-free parts of Antarctica, will of course be possible on the moon with simple tools.

Surface Mobility

Another severe limitation presently imposed upon lunar exploration is the lack of mobility. An astronaut will probably be able to walk a distance of a few hundred feet to examine very exciting details of the lunar surface in the close vicinity of the landing point, but he will not have an opportunity to inspect other places, perhaps only a few miles away, which may have totally different surface features. Mobility in Antarctica at the present time is achieved most conveniently with helicopters and with a variety of surface vehicles, from the big Tucker Sno-Cat down to small motor-driven one-man vehicles, or even by a team of dogs. A lunar roving vehicle has been under development by NASA for some time; one version, developed by Bendix, is presently undergoing extensive field testing. This vehicle will be of great usefulness once it is deployed on the moon, although it does not yet fully reflect the lesson which antarctic explorers have been taught during many years of polar exploration: There should be a variety of vehicles available for different purposes. The largest should offer sufficient well-protected space within its cabin to permit the travelers to live and work in comfort. The smallest vehicle should offer access to a driver in a heavy and clumsy suit; it should be so small and light that the driver can manually pull it out of a ditch; engine, tracks, and other components should be replaceable under field conditions. Of course, it is desirable that none of the various types of vehicles should ever have any malfunction or breakdown.

Safety Measures in Antarctica

We were greatly interested in hearing about the safety measures in effect at the small field stations. Besides the plans for normal operations, complete plans and provisions for emergency situations must exist. In Antarctica one of the main dangers is that of fire. When the four of us visited Antarctica in January of 1967, we did not fully realize the magnitude of that danger also for the space program. Two weeks after our return, the very tragic accident at Cape Kennedy, in which three astronauts lost their lives, made it clear that fire is a most imminent danger for space explorers. All buildings in Antarctica, even temporary shelters, are amply equipped with fire-warning systems, fire extinguishers, and quick exits. All camps and stations have "fall-back" camps a few hundred meters away which are equipped to provide shelter, food, and communications. Should the main camp be damaged or destroyed by fire, the crew can survive in this emergency camp for days or even weeks until a rescue party arrives. It is obvious that a similar arrangement on the moon, and even in Earth orbit, will significantly increase the safety of the astronauts.

The Role of Man

The exploration of space began with observations made from the surface of the Earth; balloon flights extended our observational capabilities, and high-altitude rockets added even more to this capability. The advent of satellites meant a big leap forward for space research, as illustrated by the discovery of the Van Allen belts with the first Explorer satellites. Probes to the planets and flights to the moon have already resulted in a wealth of new knowledge about our neighbors in space. Very slowly, man is now taking his place in this program of space exploration, at first as a pilot, and gradually as an explorer and scientist.

Polar exploration evolved the other way. It began with human travel and discovery. The new territories were seen and recorded first by human eyes, and the storing, sorting, and analyzing of observational data were done by human minds long before, and even long after, such instruments as magnetic tape and the high-speed computer were developed.

Obviously, these two great exploration programs can mutually benefit from each other's methods. How little we would know about the polar regions of the Earth if we had only photographed them from high-flying airplanes, and if instrumented capsules, dropped by parachute, had provided the only data on surface features, rock formations, fossils, plants, and animals!

On the other hand, would it not be reasonable to leave to automated stations many of the routine observations in Antarctica of temperature, snowfall, weather, aurora, cosmic rays, ionospheric activity, whistler signals, micropulsations, and seismic waves? The space program has produced remarkable technological knowledge of, and practical experience with, automatic sensing and data-handling systems; why

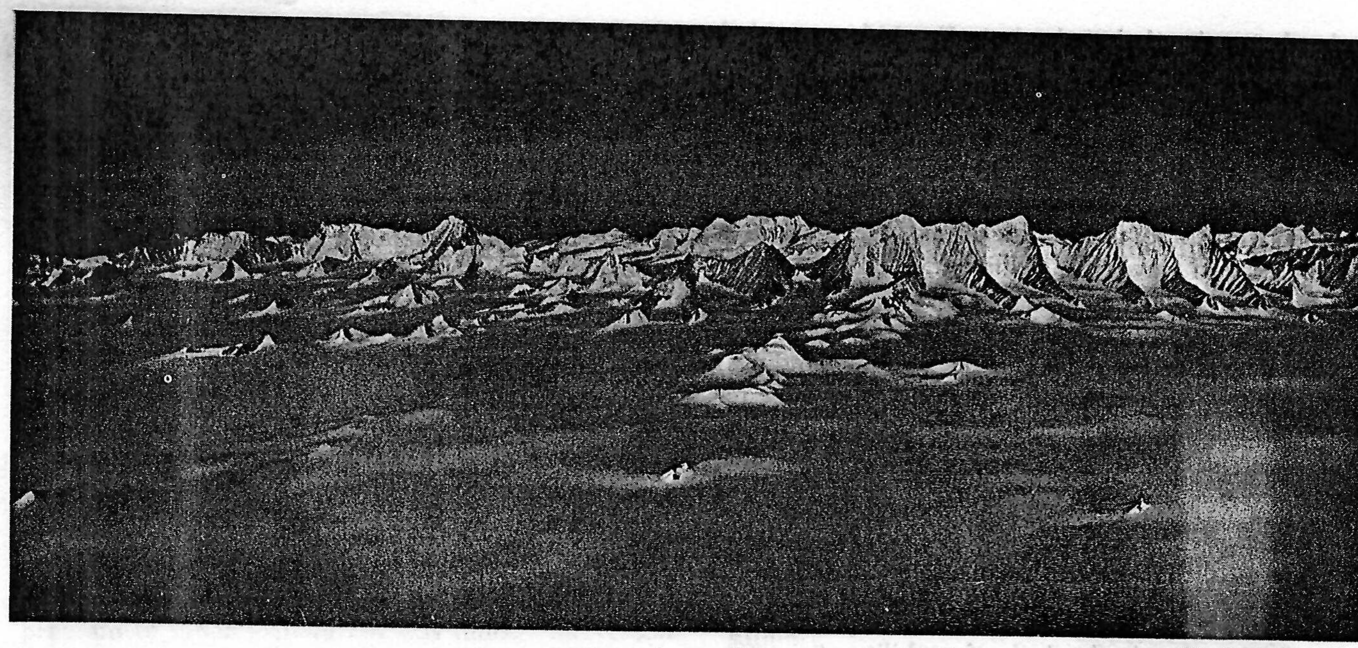


Photo: U.S. Navy

Antarctic Landscape: A section of the Sentinel Range, Ellsworth Mountains.

not use them now at remote places on the Earth's surface? Unmanned stations on the polar ice cap are far cheaper to establish and maintain than permanently manned stations. Manned stations and human sensors should be reserved for those research objectives that need the presence of a human mind to be really successful, such as biological studies, fossil search, and a number of geological investigations.

Automated Stations for Antarctica

Possibilities of automated stations for polar research have been studied repeatedly. Stanford University recently made a detailed and very interesting study [2] concerning an automated data-taking and -transmitting station for environmental parameters. The cost to build an automatic station and maintain it on a year-round basis in Antarctica is about one-tenth of the cost of an equivalent manned station. Surprisingly, the most expensive single component of the station turns out to be the electrical power supply. Isotope-heated, thermoelectric supplies would appear very appropriate. Such power sources are under development for space projects; the SNAP 27, for example, will power the ALSEP package of scientific instruments for lunar exploration. However, all space power sources are very expensive. As a consequence of the very high transportation cost to the moon or even into Earth orbit, all space instruments must be small, light, and reliable. In fact, a reliability factor of 99.9 percent is desirable for space instruments. This very high reliability requirement is the main reason for the high cost of space experiments. Ground-based automatic instruments are quite satisfactory with a reliability factor of about 95 percent. As an indication of the cost of attaining this degree of reliability, it would be cheaper in most cases to develop a new instrument of a 95 percent reliability than to improve the reliability of an instrument from 95 percent to 99.9 percent.

Another factor contributing to the high cost of space experiments is the need to minimize weight. Transportation to Antarctica is far cheaper than space transportation, and a few extra pounds on antarctic instruments would not hurt. In the specific case of an isotope-heated power source, an isotope with a shorter lifetime could be used for earthbound power supplies. Semiannual replacement would be satisfactory for antarctic use as servicing visits could be made in October and in March. Another alleviating factor on the Earth's surface is the atmosphere, which helps by carrying the heat away from surfaces through convection and by providing an efficient heat transfer between adjacent metallic surfaces. The development of a cheap isotope-heated electrical power supply for terrestrial use could possibly be undertaken jointly by the Atomic Energy Commission, the Office of Antarctic Programs, the Environmental Science Services Administration, the Coast Guard, telephone companies, oceanographic research organizations, and even the Federal Aviation Agency.

Survey-Type and Exploration-Type Research

Research projects in Antarctica fall into two dis-

[2] *Feasibility Study of an Automated, Unmanned Geophysical Observatory for Operation in Antarctica,* by John A. Jenny and William F. Lapson. Technical Report No. 3433–1, Radioscience Laboratory, Stanford Electronics Laboratories, Stanford University, February 1968.

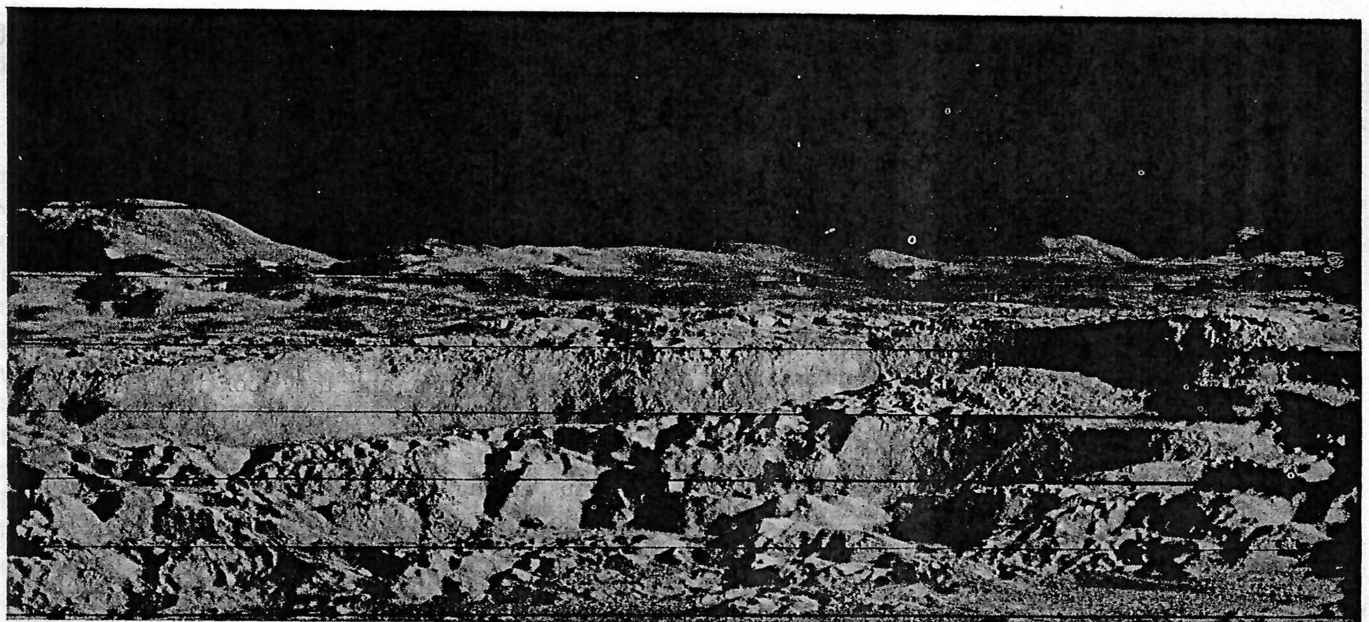


Photo: NASA

Lunar Landscape: Portion of the crater Copernicus, photographed by Lunar Orbiter II.

tinct categories according to their objectives: First, the survey-type measurements, such as recordings of cosmic rays, aurora, ionospheric activity, magnetic fields, winds, temperatures, glacier movements, whistler signals; and second, the exploration-type studies, which include geological observations, paleontological searches, and biological studies. Survey-type observations are generally carried out by young scientists who fabricated and tested their equipment at home in close cooperation with their senior colleagues. In Antarctica, their main objective is to operate the instruments, to record data, and to send the observational material home to their laboratories for analysis and evaluation. It is conceivable that this type of research work will be taken over more and more by automated stations in the future.

Exploration-type observations in Antarctica are carried out by experienced senior scientists, ably assisted by younger associates. Geologists, paleontologists, and biologists spend as much of their time as possible in the field in direct personal association with the objects of their research. The success of this work depends on the ability of the scientist to reach his area of interest, to look for the right objects, to recognize important specimens, facts, and relations, to draw conclusions while exploring, and continuously to adjust, modify, and develop his research program as his exploration proceeds and his knowledge increases. The biologists among these explorative scientists may maintain a small laboratory at the McMurdo Station to supplement and expand their research activities. It should be quite obvious that this exploration-type research cannot be automated; it definitely needs the live scientist as the most important factor in the project.

This fact was driven home to us NASA visitors very vividly when we visited the dry-valley area together with Dr. Roy E. Cameron, from the Jet Propulsion Laboratory, and Dr. Russell W. Strandtmann, from Texas Technological College, in January of 1967. As we walked over the ice-free terrain of Marble Point, Dr. Strandtmann pointed out to us the various forms of algae and arthropods that live in that region, and he described their ingenious ways of adaptation to this unusual environment. Each rock sample which he selected with the trained eyes of the research biologist contained on its protected underside some specimens of algae, mites, or small insects; the samples which we untrained space engineers picked up did not show any traces of life. "No wonder," said Dr. Strandtmann. "This is the difference between a live, alert, intelligent, highly trained and motivated scientist, and a lifeless robot. Do you see now," he added, "why we scientists believe that man should go in person to the moon and to Mars?" Although this remark made it painfully clear to us that scientists sometimes hold us space-flight developers in low esteem, we were very happy to recognize in Dr. Cameron and Dr. Strandtmann brothers-in-arms who share our long-held conviction, namely, that man himself, and not just his instruments, should travel to the moon and to Mars.

It appears possible that in the long run the structure of USARP will change to some extent. As a consequence of severe budget limitations, some of the present permanent stations may have to be closed; but at least three stations would, I hope, remain open—McMurdo, Palmer, and Pole. Several automatic stations, requiring semiannual or annual visits, will probably be established, and a number of small, portable field stations would be maintained. They can be airlifted easily in modular units from one place to another after a research objective has been accomplished.

Automated stations would keep direct radio contact with their home bases in the United States or other countries with the help of satellites such as the Applied Technology Satellites or the Intelsat. In fact, antarctic stations have for several years been using signals from, or relayed by, satellites in polar orbits.

The most significant contributions that antarctic research will make to our basic scientific knowledge in the next several years will very likely concern the genesis of the Earth and the evolution and adaptation of life. The Antarctic Continent has probably gone through more drastic changes than the rest of the Earth; furthermore, some of the evidences of early stages of development, both geological and biological, may be better preserved and less contaminated in Antarctica than at other places on our globe. The recent find of a jawbone of an ancient amphibian, a Labyrinthodont, which also lived in Africa and India, appears to give powerful support to the hypothesis of the old Gondwanaland and the subsequent drift of its fragments to the places where we find Asia, Africa, Australia, and Antarctica today.

The division of antarctic research into survey-type and exploration-type activities has a very interesting parallel in space research. Numerous survey-type observations of the Earth, the sun, other celestial bodies, and the space between will certainly be made on a continuing basis from Earth-orbiting satellites. These observations will not require the continuous presence of man in orbit. However, there are other observations of an exploratory type which simply should not be left to the operation of a programmed machine, as pictures obtained from the recent Lunar Orbiter project prove. These pictures show many unexpected features, such as lava flow channels, outcrops of deep layers of materials, strong color differences, and other peculiarities which geologists feel must be seen *in situ* by a scientist who could mentally record, sort, analyze, and integrate thousands of visual pictures from a millimeter to a kilometer in scale within minutes and arrive at a satisfactory understanding of a geological situation unobtainable from TV pictures alone.

The need for the presence of a scientist who can interact immediately with his subject of research is even more obvious when we think of the search for life on the planet Mars. How complex would an instrument have to be in order to substitute for a human mind trained in experimental biology and highly motivated to detect any possible indications of living organisms? I believe that it would be hopeless to try to make such a substitution.

Psychological Effects During Life in Isolation

We found the scientists in Antarctica invariably in high spirits, filled with strong motivations for their work. They greatly appreciate the opportunity of doing research in Antarctica. They read much (scientific books, travel, fiction), listen to music, and tend to their scientific activities.

Support personnel, lacking the strong personal motivation of the scientists, also display a pleasant spirit, but they often find life somewhat boring under antarctic conditions, and they look forward to their trip home.

A few simple rules on how to avoid psychological problems arising from the unusual circumstances of antarctic life have resulted from the long experience gained in Antarctica. A single small room for each man is far preferable to larger rooms with multiple occupancy. Privacy of a few hours per day appears to be of great importance. A man should know beforehand that the next few hours will belong to him alone and that nobody else will sit at his table, whistling the "Bridge on the River Kwai," or inhaling vigorously through his nose every 15 seconds, or oscillating his leg toward the table. I feel that the lessons learned in Antarctica should be, and will be, heeded in the planning and designing of the quarters for astronauts on prolonged journeys through space.

On a piece of equipment near the Pole, we found a statement printed in huge letters: "I hate people." If the writer did this at the beginning of his polar adventure, it was a mistake to have selected him. If he did it at the end, it was high time to ship him home. Admittedly, Antarctica has the lowest population density of all continents; only outer space has a lower density. However, it is easier to escape the omnipresence of people in New York than in Antarctica, or in outer space. A man who is "allergic" to close contact with others simply should not be picked for either isolated assignment.

Experience dictates that living quarters in isolation should be as comfortable, and as much like home, as possible. At the long-wire station near Byrd, for example, we met a few young chaps who had their snow-covered quarters beautifully equipped with walnut paneling, easy chairs, sofa, coffee corner, house bar, and an excellent hi-fi set with a large collection of classical records.

It may be interesting to note in this context that there is a strong tendency among space planners at the present time to provide simulated gravity for astronauts on prolonged space flights by rotating the spacecraft. Medical or biological effects would probably not demand this, but the "gravitational" force, even if it amounted to only a fraction of one g, would contribute toward a homelike environment.

Efficiency of the U.S. Antarctic Research Program

After we had lived for a week among the antarctic researchers and their support personnel, we had developed the greatest admiration for the remarkably effective cooperation between the support organization, which is a part of the U.S. Navy, and the scientific projects, which are coordinated by the National Science Foundation. The great flexibility, the immediate response to the need of scientific teams, the absolute minimum of red tape in Antarctica and in the New Zealand staging area, and the high degree of motivation for accomplishment often appeared to us like a dream come true. It is realized that this excellent cooperation and high degree of efficiency certainly did not come into existence by themselves; they are the result of a very determined and sincere effort by both parties, and the fact that this effort has led to such a remarkable success reflects greatest credit upon both the U.S. Naval Support Force, Antarctica, and the Office of Antarctic Programs.

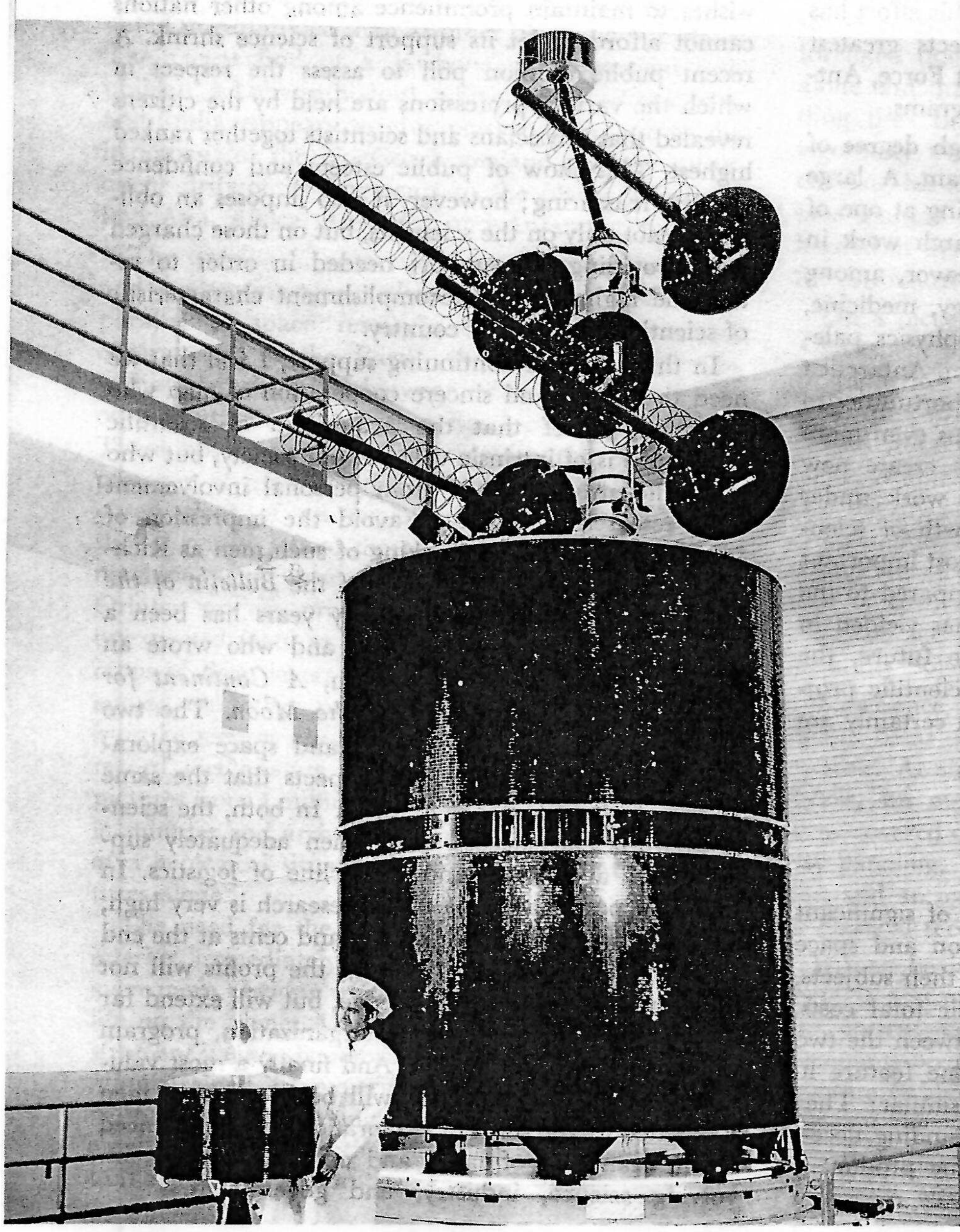
We were equally impressed by the high degree of cost-effectiveness of the antarctic program. A large number of parties, some of them wintering at one of the permanent stations, are doing research work in about 15 major fields of scientific endeavor, among them geology, aeronomy, physics, biology, medicine, glaciology, oceanography, astronomy, geophysics, paleontology, and psychology. For all of them, Antarctica represents an open frontier with vast opportunities to acquire new scientific knowledge. Perhaps even more important, it offers the opportunity to create new scientists trained in scientific research work under unusual circumstances. The steady growth of scientific capabilities is certainly one of the most important objectives a nation can have. When compared to the rich scientific harvest which USARP has yielded in the past and promises to yield in the future, the yearly expenditures of $8 million for scientific projects and $20 million for logistic support certainly are modest and exceedingly well spent.

A Plea for Science

There are, very obviously, a number of significant differences between antarctic exploration and space exploration. The two programs differ in their subjects, their histories, their environments, their total costs. But, there are also many similarities between the two programs, and there is in particular one feature in which the two programs are painfully similar: They both have to fight hard to obtain the funding necessary for their continuation. Their prime product is scientific knowledge, something not easily measured in dollars-and-cents benefits that accrue to each taxpayer every year. Scientific knowledge frequently can be valued in hard money, or as improved living, or for contributions to health, but this process takes a time which often is longer than the memory of the average citizen. In view of this fact, our argument for the continuation of strong research programs in Antarctica as well as in outer space should be based very simply and directly on the assertion that the acquisition of scientific knowledge is one of the very basic fibers in the makeup of a healthy, strong, and progressive society. It ranks on an equal status with such other basic fibers as a modern technology, a high living standard, advanced medical capabilities, an efficient governmental system, and a satisfactory national defense system. Even during times of rising living costs and dwindling resources, a nation which wishes to maintain prominence among other nations cannot afford to let its support of science shrink. A recent public opinion poll to assess the respect in which the various professions are held by the citizens revealed that physicians and scientists together ranked highest. This show of public esteem and confidence is quite reassuring; however, it also imposes an obligation, not only on the scientists, but on those charged with providing the support needed in order to retain the high level of accomplishment characteristic of scientific work in our country.

In this quest for continuing support, I feel that we need the strong and sincere cooperation of men who share our belief that the acquisition of scientific knowledge is of intrinsic value to our society, but who are sufficiently detached from personal involvement in a research program to avoid the impression of being parochial. I am thinking of such men as Richard S. Lewis, managing editor of the *Bulletin of the Atomic Scientists,* who for many years has been a warm friend of both programs, and who wrote an excellent book on each of them, *A Continent for Science,* and *Appointment on the Moon.* The two programs, antarctic exploration and space exploration, are so similar in many respects that the same arguments hold for both of them. In both, the scientific efforts can succeed only when adequately supported by a complex and costly line of logistics. In both, the potential value of the research is very high, but cannot be counted in dollars and cents at the end of each fiscal year. Also in both, the profits will not be limited to scientific knowledge, but will extend far into the areas of technology, organization, program planning, and management. And finally a most valuable product in both cases will be a group of men motivated by the spirit of exploration and experienced in the handling of large and complex projects involving science, industry, and government.

TELCOMSAT–
World's Largest Satellite



The world's largest communications satellite dwarfs an engineer and a full-scale model of tiny 80-pound Syncom (left), the world's first synchronous communications satellite, launched in 1963. The 1,600-pound jumbo satellite, shown here at Hughes Aircraft Company, El Segundo, Calif., where both satellites were built, will be used by the U.S. Air Force, Army and Navy to conduct experiments in communications among military units in the field, aircraft and ships at sea. An ultra high frequency helical antenna array atop the giant satellite will provide signals so powerful they can be picked up by ground antennas as small as one foot in diameter. When in synchronous orbit, 22,300 statute miles above Earth, the spin-stabilized satellite's solar cells and outer structure will spin at 54 revolutions per minute while the antennas remain stationary and pointed at Earth.

The world's largest and most powerful communications satellite was launched by the U.S. Air Force on February 8, 1969 aboard a Titan 3-C booster toward a synchronous orbit 22,300 statute miles above Earth.

The 1,600-pound experimental satellite, two stories high and more than eight feet in diameter, carried a cluster of antenna systems capable of radiating signals that can be received by all types of ground terminals, including those with antennas as small as one foot in diameter.

The giant satellite, designed and built for the Department of Defense by Hughes Aircraft Company, Culver City, California, will be used by the U.S. Army, Navy and Air Force to test the feasibility of using synchronous satellites for tactical communications with small mobile ground stations, aircraft and ships at sea.

The tests will determine whether hundreds of small mobile terminals with varying power levels can effectively be used with a single satellite. Another objective of the mission will be to determine the best frequency bands to be used for tactical service. The tests will be in the ultra high frequency (UHF) and the super high frequency (SHF) ranges.

The satellite's communication antennas are mechanically "de-spun" to keep them pointed toward Earth.

The new satellite will test for the first time in space a new Hughes concept of stabilization called Gyrostat, which defies the theory that all spin-stabilized satellites must be "short and squat", looking like over-sized hatboxes.

Heretofore, satellites have been designed for the inertia characteristics of a disk rather than a rod. The Gyrostat principle, however, is designed to permit stabilization of long slender bodies.

The new principle holds that satellites can spin around their minor axes and permit some parts to spin while other parts remain stationary, with never a wobble in the spacecraft.

The concept not only permits variations in the length configuration of communications satellites, thus allowing full utilization of the booster shroud, but it also enables important payloads, such as antennas or telescopes, to remain stationary so that they may be precisely pointed in any direction.

The tactical satellite joined other Hughes-built synchronous satellites currently in operation, including Syncom II, the world's first synchronous communications satellite, successfully launched in July 1963 and now above the Indian Ocean.

Others are Syncom III, above the Pacific; Early Bird, the world's first commercial communications satellite, over the Atlantic; three Intelsat II satellites, in commercial operation above the Atlantic and Pacific; and two Applications Technology Satellites, ATS-1 and ATS-3, above the Pacific and over Brazil, which Hughes built for the National Aeronautics and Space Administration.

SATELLITE DESCRIPTION

The free world's largest experimental communications satellite is designed to provide testing for tactical communications between military units in the field, ships at sea and aircraft.

It is as tall as a two-story house and is over eight feet in diameter.

The spacecraft, which weighs approximately 1,600 pounds, will radiate signals capable of being picked up by all types of ground terminals, including antennas as small as one foot in diameter.

The satellite uses a dual-spin configuration, employing a spinning rotor to stabilize the spacecraft in pitch and yaw axes and using despin control to point a directional antenna system toward the earth.

The satellite is equipped with three antenna systems consisting of a five-element helical ultra high frequency (UHF) array.

Two frequency bands will be used during tests of the satellite in orbit. One is the standard military UHF band used for air-ground communications; the other is the super high frequency (SHF) band.

The antennas are mounted on the despun section and enable the use of narrow beam, high gain antenna patterns, which are necessary to meet the very high power communications power-and-receive-capability requirements associated with the satellite's mission.

All of the electronic equipment directly associated with the communications mission for the ultra and super high frequency repeaters is also despun and is located on an electronic shelf beneath the antennas inside the forward solar panels.

The bulk of the telemetry and command subsystem equipment, including the test, telemetry and command antenna is mounted on the same shelf. Locating all the communications hardware on the spacecraft's despun section avoids the transferring radio frequency energy of very high power and multiple frequencies across a rotating joint. Also mounted on the same shelf are those portions of the power subsystems needed to power all despun electronics as well as regulate direct current voltages.

The nutation damper necessary to remove small spin axis oscillations produced by the separation and maneuver transients is located inside the despun antenna mast.

A despin bearing and power transfer assembly provides the required control torque to keep the despun section pointed toward the earth's center.

Besides providing spacecraft attitude stability, the spinning rotor and the forward internal equipment shelf contains the solar cell power source, batteries for operation during eclipses, attitude sensors, spacecraft propulsion, and electronics required to control the despin motor torque.

The satellite, once in geo-stationary orbit, will be reoriented with the rotor spin axis normal to its orbit plane so that the sun-line remains within plus or minus 24 degrees of normal to the spinning solar cell panels. Solar cell panels on both forward and aft portions of the spacecraft contain a total of 60,000 solar cells.

Attitude sensors for sun and Earth utilize the rotor spin to provide the scanning function. This permits the use of simple fixed sensors with no moving parts.

Similarly, the execution of all the required propulsive maneuvers can be accomplished using two fixed jets employing hydrogen peroxide (H_2O_2) liquid propellant for radial and axial control. These can be pulsed by command over a selected segment of the rotor spin cycle.

In addition, the rotor spin provides an artificial centrifugal gravity field which keeps the liquid propellant in the tanks at the valve opening location. Spin up tanks, pressurized with gaseous nitrogen oxide (N_2) prior to launch, provide the impulse necessary to spin up the rotor following separation from the Titan 3-C booster. These tanks are located underneath on the spinning portion of the spacecraft.

The despin control electronics that process the Earth sensor data to compute the despin torque signals is also mounted on the spinning portion of the spacecraft.

Temperature control of the spacecraft is entirely passive, utilizing the uniform thermal exposure of the rotor's spin-plane to the sun's rays to provide a benign environment for all spinning equipment. The despun section of the satellite, where the bulk of the electrical power is dissipated, incorporates a special thermal finish to control temperature through radiative heat transfer.

The satellite configuration incorporates extensive redundancy in all critical areas of the spacecraft. All the electronics, with the exception of the communication repeater, have at least one backup unit normally switchable by ground command.

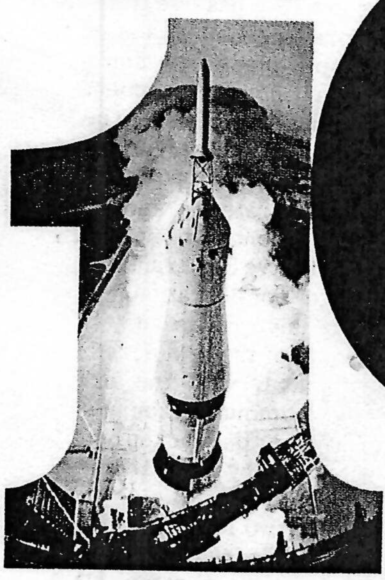
Four sensors (two for Earth, two for sun) are provided where one of each is sufficient to support all critical mission functions.

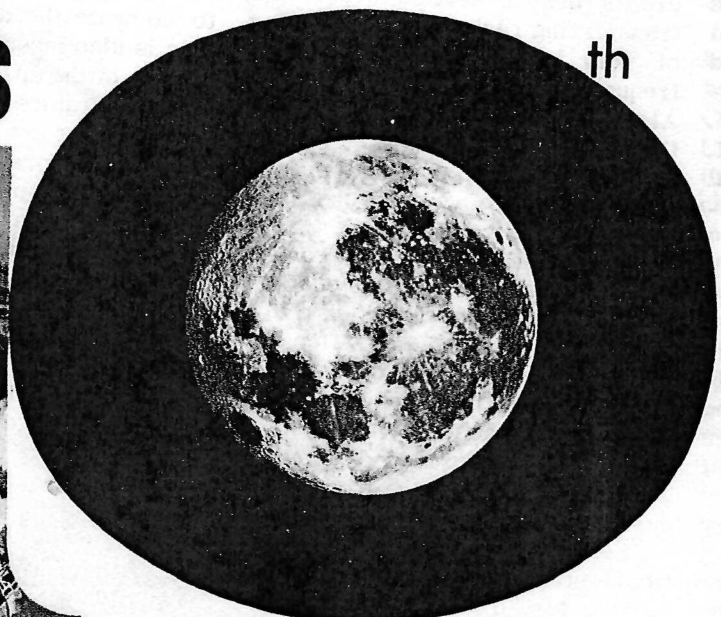
Two completely independent propulsion systems are provided to complete the mission once station acquisition has been achieved. Redundancy for eclipse operation is provided by six battery packs, each of which comprises three batteries. Any one of the three can provide sufficient power to sustain required housekeeping functions during the longest eclipse period.

Reprinted from January 1969 issue of Rendezvous.
Courtesy of Bell Aerosystems Co.

Born in a year dominated by Soviet space achievements, NASA since 1958 has produced a long list of world records for the U.S.

NASA's 10th





by Don Norton

ELEVEN years ago this month the world was learning a new language generated by the successes of the Soviet Union's space program. "Sputnik"—the name for the first man-made object to achieve orbit—had become part of every language, and "Laika," the orbiting dog, was temporarily as famous as Lassie.

For Americans accustomed to thinking of themselves in terms of Yankee ingenuity, the early Russian space feats had a tremendous impact. The nation was taking a second look at itself and its educational institutions from the universities down to the grade schools.

The United States had been working since September 9, 1955 toward launching an Earth satellite during the International Geophysical Year (1957-58). The rocket was to be based on an earlier scientific sounding rocket, the Viking, which had made its first flight in May, 1949.

At the time, the Viking was the largest and most ambitious of the nation's sounding rockets, and had the most advanced liquid propellant engine available. The choice of this system was recommended by two features: It was the only one then in existence which had been designed from the start for scientific payloads, and its development would least interfere with the nation's separate military missile program.

On July 29, 1955, the United States had formally announced its intention to launch a satellite in support of the Geophysical Year. The satellite was to be entirely for scientific purposes. The Department of Defense was to supply the rocketry. Scientific responsibility was assigned to the American Academy of Sciences, and fiscal responsibility to the National Science Foundation. This program was later to be called Vanguard.

By spring of 1956 the Vanguard rocket basic design had been completed, and was launched for the first time on October 23, 1957 with a live first stage and dummy upper stage. It achieved a 109-mile-high, 335-mile-long trajectory downrange from the former Cape Canaveral.

The following December 6, the first Vanguard with three live stages failed to launch a test satellite—settling back on the pad and exploding. And on February 5, 1958, the next attempt failed after 57 seconds' flight, with the rocket veering offcourse and breaking apart at 20,000 feet. Vanguard successfully placed its first payload, a 3¼-pound object, in orbit on March 17, 1958.

Vanguard had four more failures, then placed Vanguard II in orbit on February 17, 1959. The program came to an end with the orbiting of Vanguard III in September, 1959. The rocket's upper stages were used in later combinations.

In the meantime, the Soviet Union had already succeeded in placing the first man-made object in Earth orbit—Sputnik I, on October 4, 1957. The active payload weighed about 184 pounds, but had attached to it a spent rocket casing estimated at four tons. On November 3, Sputnik II had been placed in orbit with a payload weight of 1,120 pounds, carrying "Laika" and the same size spent rocket casing.

One of the effects of the early Soviet success with the Sputniks was to bring off the shelf a previous plan of the Army Ballistic Missile Agency at Huntsville, Ala. to launch satellites on the Jupiter C, a four-stage rocket which was a direct outgrowth of the military missile program. The Jupiter C plan was given the go-ahead on November 8, 1957.

Jupiter C placed Explorer I, the first U.S. satellite, into orbit on Janu-

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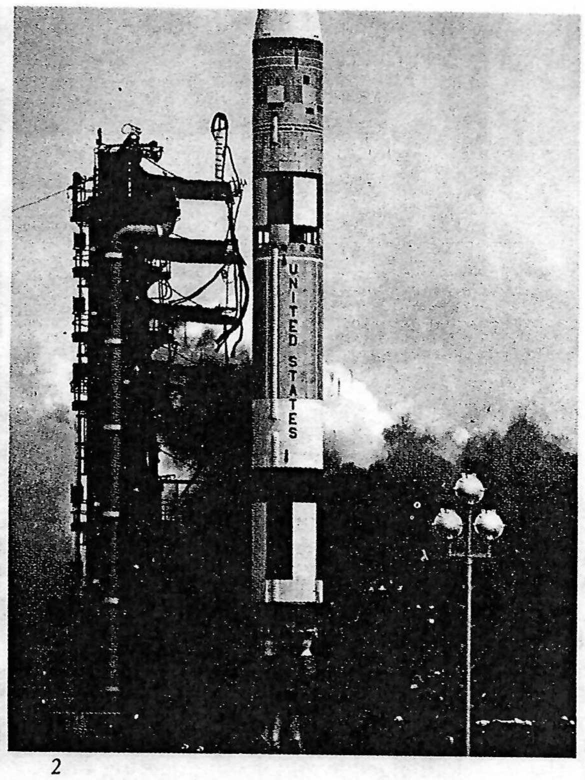

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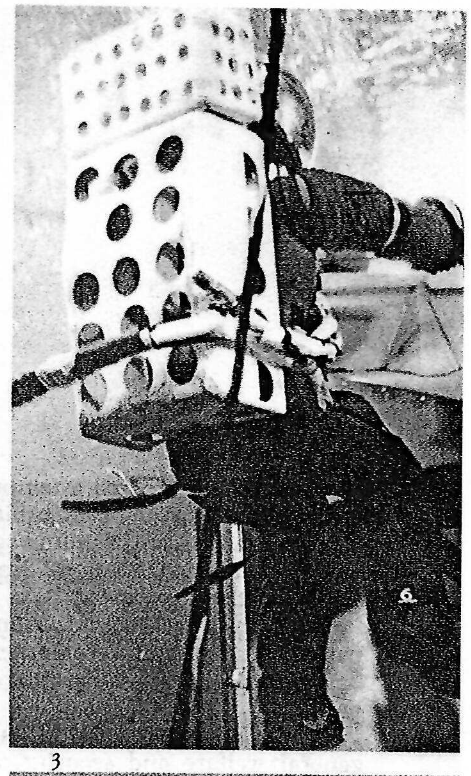

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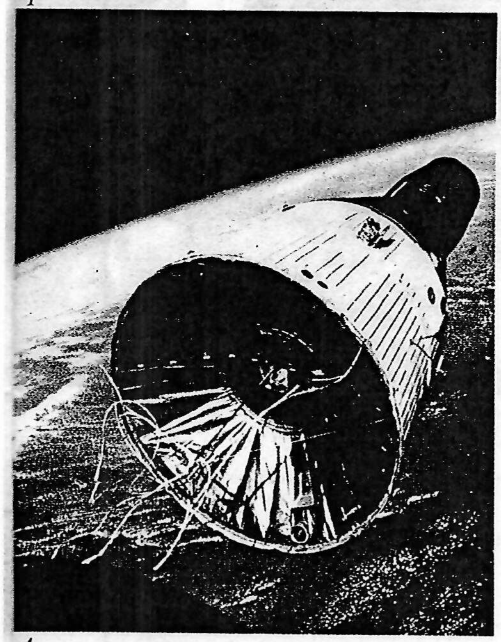

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1. *Edward H. White II walks in space during orbit of Gemini-Titan 4.*

2. *Gemini-Titan at liftoff.*

3. *Apollo astronaut trains underwater in simulated lunar gravity at NASA's Manned Spacecraft Center.*

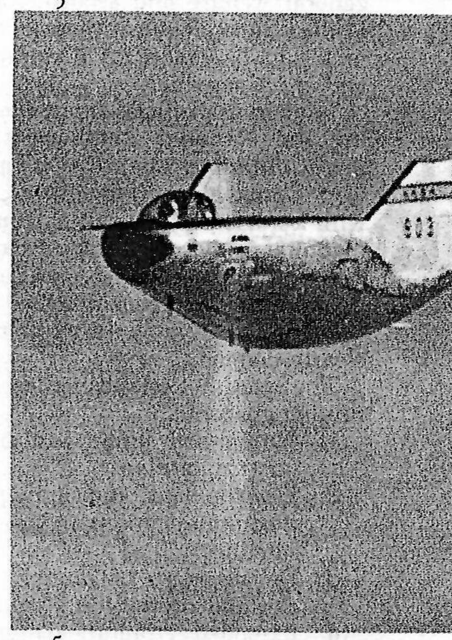
4. *Gemini 7 spacecraft photographed through the hatch window of Gemini 6.*

5. *Flight test of M2-F2, a lifting body reentry vehicle studied by NASA.*

6. *Echo I, a gleaming 100-foot globe, spent eight years in orbit and was seen by millions of people.*

7. *"Fisheye" camera look into a Gemini capsule.*

8. *Giant air passage in the 16-foot transonic wind tunnel at Langley Research Center. The curved vanes force air to make a smooth right-angle turn.*



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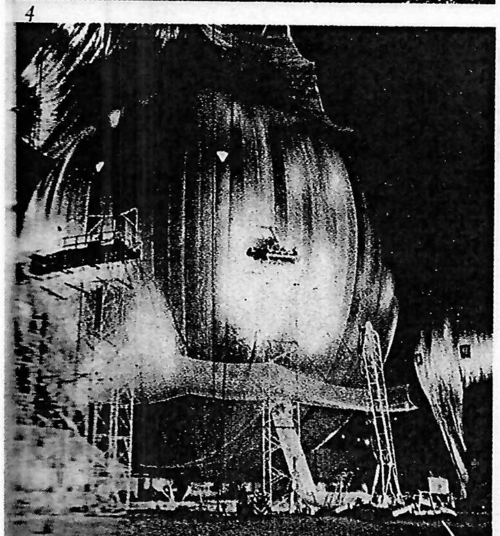

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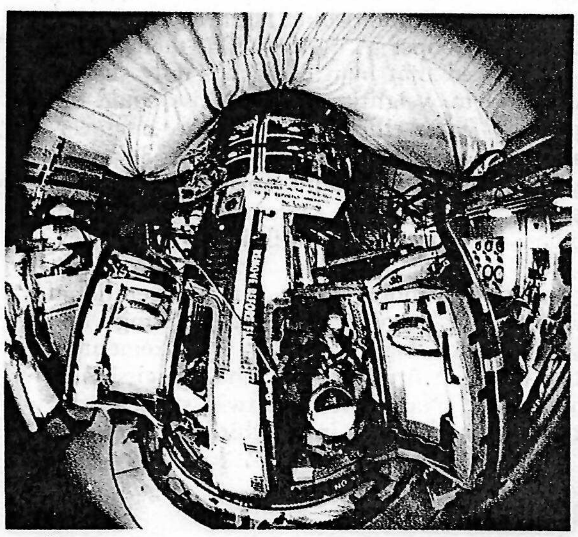

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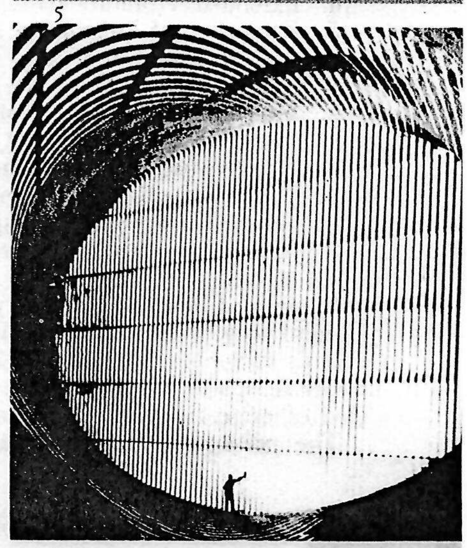

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ary 31, 1958, on its first attempt. Explorer I's total weight in orbit was 30.8 pounds — an 18-pound active payload attached to a 12.8-pound spent fourth-stage casing.

With this background, Congress passed the National Aeronautics and Space Act of 1958, which states, in part:

"The Congress declares that the general welfare and security of the United States requires that adequate provision be made for aeronautical and space activities."

That is the official language giving the National Aeronautics and Space Administration its mandate. NASA came alive on October 1, 1958 with a nucleus of personnel from the National Advisory Committee for Aeronautics, its facilities, and personnel and space projects inherited from the Army and Navy. Its mission was clearly defined.

The Space Act established the continuing goals of:

1. Unmanned lunar and planetary exploration.
2. Development and application of communications and weather satellites.
3. Development of launch vehicles and propulsion systems.
4. Extended aeronautical research.
5. Expansion of knowledge relating to space and how man adapts to it.
6. International cooperation in space research.
7. Effective use and dissemination of new scientific and technical knowledge derived from space-related research and development.

In manned flight, the Mercury and Gemini programs produced 20 world records which include nearly 2,000 hours in space and a distance traveled of more than 17 million miles.

The present manned program is Apollo, designed to land men on the moon and return them safely in this decade. This goal was set by President John F. Kennedy in May, 1961.

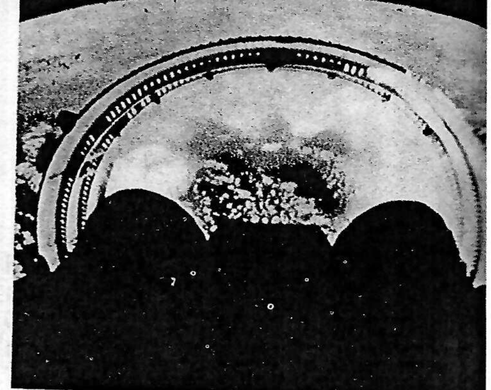
The first phase of the manned flight program, Project Mercury, was initiated seven days after NASA was established. Its objective was to launch a man into orbit and return him safely to Earth. This objective challenged available engineering and technology to design and develop a spacecraft which would give astronauts a habitable environment, shield him from the environment of space, withstand the aerodynamic forces imposed by rocket-powered flight and survive temperatures of up to 3,000 degrees F. during reentry into the Earth's atmosphere.

The engineering design concepts employed to accomplish the task were successfully demonstrated through suborbital flight tests, including the manned flights by astronauts Alan B. Shepard Jr. on May 5, and the late Virgil "Gus" Grissom on July 21, 1961.

The Project Mercury objective was achieved on February 20, 1962, when John H. Glenn Jr. completed a three-orbit mission. The succeeding missions by M. Scott Carpenter and Walter M. Schirra Jr. later that year and final orbital flight by L. Gordon Cooper Jr. in May, 1963 demonstrated that man could not only survive in weightlessness but also could operate efficiently as a pilot-engineer-experimenter for as long as 34 hours.

The Gemini program was announced in December, 1961 to advance the capabilities of man to explore space for up to two weeks duration and to perfect operational techniques of rendezvousing and docking in space, a requirement of the Apollo lunar landing mission.

Named for the twin stars, Castor and Pollux in the third zodiacal con-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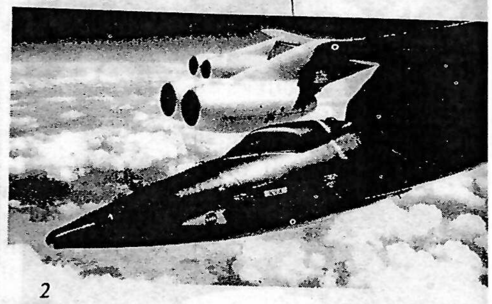
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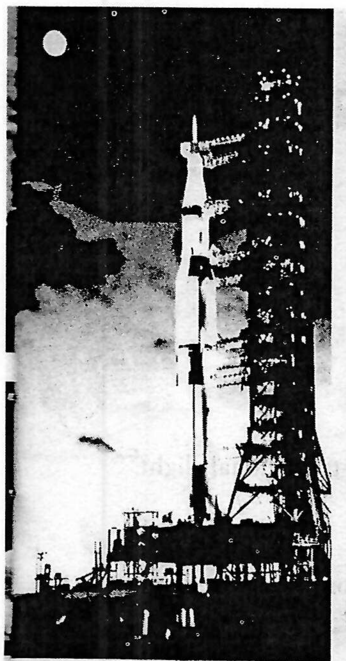

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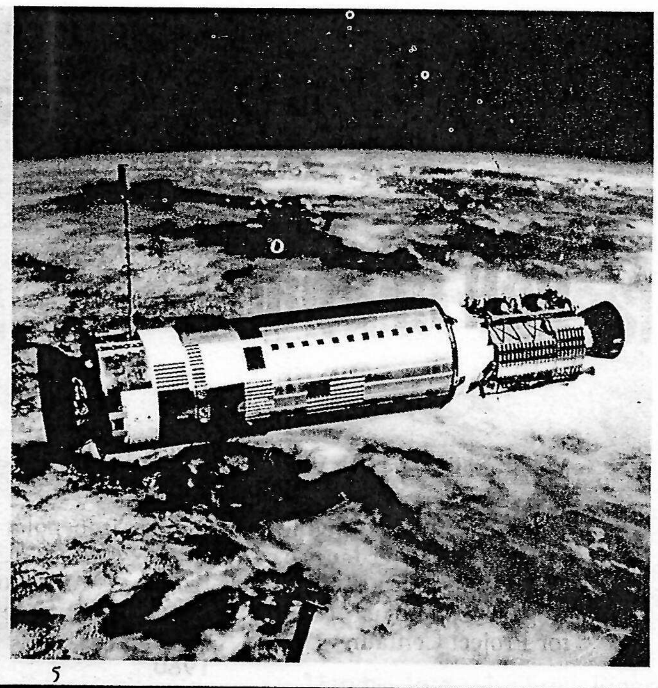

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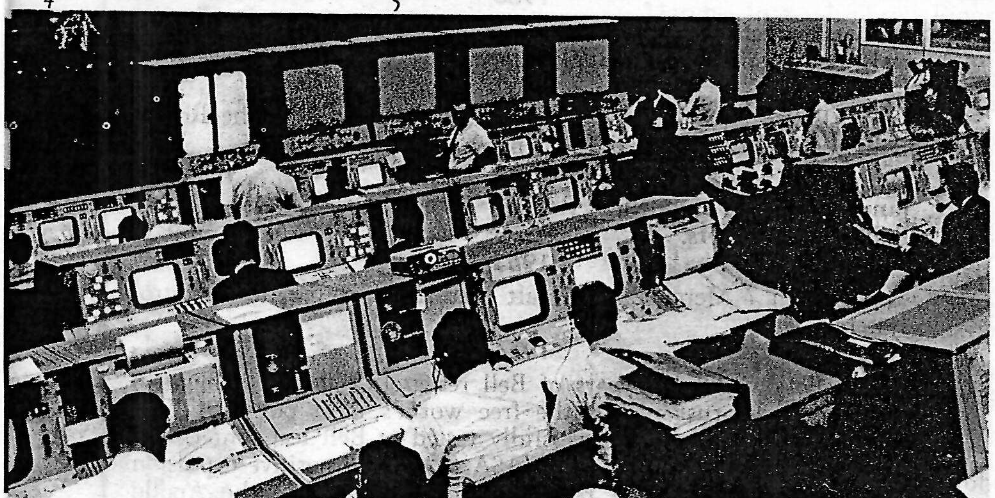

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1. Separation of the first two stages of the Saturn V during the flight of Apollo 6.

2. X-15 tucked under the wing of a B-52 before research launch.

3. Surveyor III's soil sampler device had scooped up lunar material and put it on a footpad before this photo was taken. Cameras took a close look at the soil's composition.

4. With the moon shining in the background, Apollo 7 is prepared for launch.

5. Agena target vehicle as seen from the Gemini 7 spacecraft. As part of Gemini 7's mission, the Bell Aerosystems-built Agena engine was fired nine times in space.

6. Overall view of the Mission Operations Control Room during the space flight of Gemini 5.

stellation, the Gemini spacecraft accommodated a two-man crew. Two unmanned test flights preceded 10 manned missions during 1965 and 1966. Sixteen astronauts participated.

The long duration flights of four, eight and 14 days confirmed, from a medical viewpoint, that man could carry out the Apollo lunar landing mission. Although physiological changes occurred, they were of a temporary nature and did not impair the ability of the crews to carry out prescribed tasks. No abnormal physiological reactions were observed during the flights.

Gemini pilots carried out 10 rendezvous maneuvers with other orbiting spacecraft using seven different rendezvous modes. Nine dockings were achieved with Agena vehicles, and powered by Bell Aerosystems' Agena rocket engine, astronauts achieved altitudes up to 853 statute miles.

Astronauts demonstrated that work can be performed outside of a spacecraft in more than 12 hours of extravehicular activity. And a station-keeping exercise was performed by the undocked spacecraft and Agena connected by a tether.

Gemini proved that man could operate effectively in space, respond to the unexpected and execute alternate and contingency plans when necessary. Also, the NASA flight operations team, supported by the Department of Defense recovery forces and the U.S. Weather Bureau, achieved the capability of meeting unexpected situations quickly.

Unmanned satellites are another of NASA's important efforts. In the 10 years since the space agency's birth, they have added greatly to knowledge about the Earth and space.

One family of these satellites, the Explorer series, has greatly advanced the frontiers of space research. The first Explorer (the nation's first man-made satellite) made one of the significant discoveries of the space age.

Explorer I confirmed existence of a previously theorized zone of intense radiation in space surrounding Earth. This was later named the Van Allen belt for the scientist responsible for the experiment.

Other discoveries by unmanned satellites:

Explorer XXIV measured thin wisps of air in the upper atmosphere and determined air density by latitude and altitude.

Explorer XXI provided data on the composition of Earth's ionosphere to bounce back certain radio waves, thus making possible long range radio communications on Earth.

Explorer XVII studied the composition, density, pressure and other properties of the upper atmosphere.

Explorers XVI and XXIII provided information on micrometeoroids (tiny particles of matter in space).

Explorer XXXVII (Radio Astronomy Explorer I) opened a new window to the universe by monitoring the low frequency natural radio signals from space that atmosphere cuts off from ground observatories.

Other unmanned satellites monitor solar radiation, the influence of the sun on the Earth and space, the effect of space on plants and animals, and many other experiments.

A statement by the late Dr. Hugh L. Dryden, former NASA deputy administrator, explains a guiding principle of the space agency. He said:

"None of us knows what the final destiny of man may be—or if there is any end to his capacity for growth and adaptation. Wherever this venture leads us, we in the United States are convinced that the power to leave the Earth—to travel where we will in space—and to return at will—marks the opening of a brilliant new stage in man's evolution." ■

Bell in Space

1958

May—Bell X-14 jet VTOL made first complete transitional flight.

1959

February—Agena engine put satellite into polar orbit in first successful Discoverer launch.

May—Bell selected to provide reaction controls for Project Mercury.

August—Company receives contract to provide reaction controls for Project Centaur.

1960

January—Plasma-jet generator developed by Bell for testing materials used in space vehicle applications.

1961

June—Bell announced it had built and demonstrated the Rocket Belt, possible forerunner of lunar flyers.

1962

January—Agena propelled Ranger 3 to moon. Vehicle carried Bell velocity meters.

1963

May—Faith 7 Mercury spacecraft used Bell reaction and control system.

1964

April—Following nine years of Bell research and development, a 40,000-pound-thrust rocket, the free world's most powerful fluorine-hydrogen rocket, is successfully tested at Bell test center.

April—Contract received from NASA to provide positive expulsion propellant tanks for the reaction control system of the Apollo Lunar Module.

1965

November—Agena engine functions perfectly on Mariner III and IV flights to Mars.

December—Contract received to build rocket propellant positive expulsion tanks for camera-carrying Lunar Orbiter spacecraft.

September—Bell's earth orbital scene generator (GEOS) simulator delivered to NASA for use by Gemini astronauts. It was later converted for lunar flight training of Apollo astronauts.

1966

March—First firing of the Agena rocket engine while docked with a manned spacecraft, Gemini 7.

April—Bell received a patent for the Jet Flying Belt, a personal propulsion unit that is powered by a small turbojet engine.

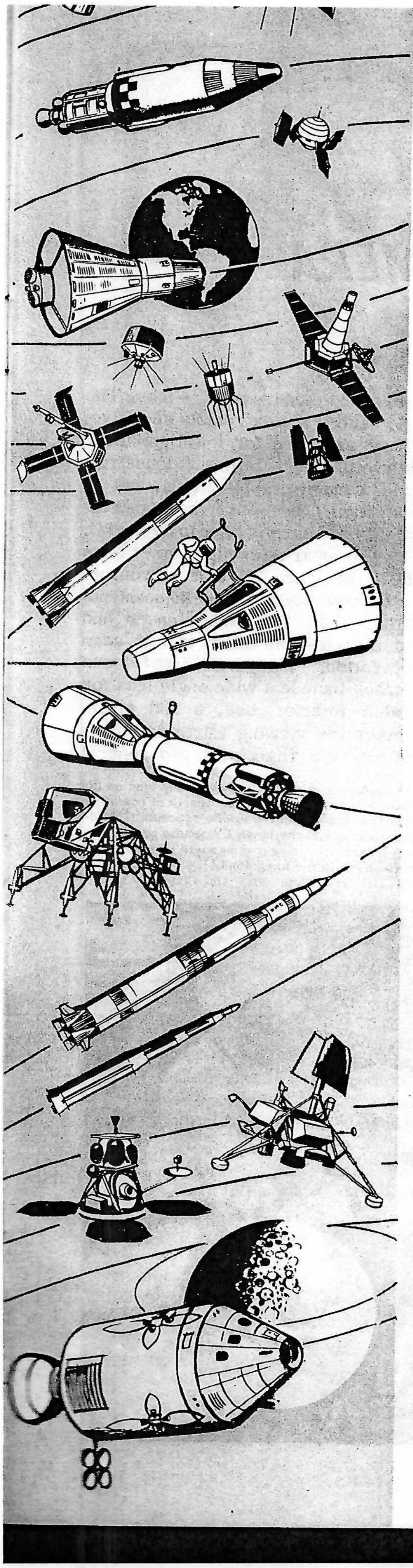
1967

March—Bell receives a NASA contract for three Lunar Landing Training Vehicles, to be used by Apollo astronauts.

May—First public test flight of the Bell X-22A V/STOL.

1968

August—Bell propulsion system helped guide the first launch of Minuteman III approximately 4,400 miles from Cape Kennedy to a bull's-eye near Acension Island.



NASA Milestones

1958

October—First NASA launch, Pioneer I, which reached an altitude of 70,717 miles to become the first deep space probe.

1959

August—Placed in an elliptical Earth orbit, Explorer 6 transmitted information from seven experiments including the first crude TV photo of Earth.

1960

March—In a solar orbit, Pioneer 5 returned telemetry to a distance of 22.5-million miles from Earth.

1961

May—Initial U. S. manned sub-orbital flight, Alan Shepard in "Freedom 7," Mercury-Redstone 3.

1962

February—John Glenn in "Friendship 7" began the U. S. manned orbital space flight program.

1963

July—The first successful synchronous satellite, Syncom 2, was placed in an inclined orbit over Brazil.

1964

July—In the first of three successful Ranger missions, Ranger 7 photographed the moon during the last 1,120 miles of its approach and subsequent hard landing.

1965

March—Gus Grissom and John Young in Gemini 3 began second, two-man phase of U. S. manned space program.
April—First commercial communication satellite. Early Bird (Intelsat I), placed in synchronous equatorial orbit above the Atlantic Ocean.
June—"Space walk" by Ed White during Gemini 4.
December—First rendezvous in space performed by Walter Schirra and Tom Stafford in Gemini 6A.

1966

March—First docking experiment, by Neil Armstrong and David Scott in Gemini 8.
May—First U. S. try at a lunar soft landing. Surveyor I touched down in Oceanus Procellarum.

1967

August—Launch of Lunar Orbiter 5, last and most ambitious project mission, completed mapping of entire lunar surface.
September—Surveyor 5 soft landed on Mare Tranquillitatis, returning 19,006 photos and performed the first on-site chemical analysis of an extraterrestrial body.
November—First launch of Apollo 4 / Saturn 5 demonstrated launch vehicle capability and spacecraft development.

1968

October—Launch of Apollo 7, first manned flight in nation's effort to send astronauts to the moon and bring them back.
December—In man's greatest achievement of the decade, Apollo astronauts Frank Borman, James A. Lovell and William A. Anders orbited the moon.

APOLLO MOON TV CAMERA

The television camera that American astronauts will use on a "space walk" during the Apollo 9 mission and which they will later take to the surface of the moon was built by the Westinghouse Electric Corporation for the National Aeronautics & Space Administration's Manned Spacecraft Center, Houston, Texas. The camera can withstand temperature extremes ranging from 250 degrees Fahrenheit during the lunar day to 300 degrees below zero Fahrenheit at night. Because of a special electronic tube it uses, it can produce pictures even in lunar darkness. It is designed to operate in the vacuum of space and on the lunar surface as well as in the pure oxygen atmosphere of the spacecraft.

On the next space mission, now scheduled to be launched no earlier than February 28, 1969, the camera is scheduled to be removed from the Earth-orbiting lunar module by one of the Apollo astronauts who will use it on a "space walk" to show television viewers both the spacecraft and Earth as seen from his point of view.

Later, on the lunar landing mission, the camera will be placed on an access hatch of the descent stage of the lunar module (LM). After the LM has landed on the lunar surface, the access hatch will open, aiming the camera at the ladder the astronauts will descend and also at the point where the first American will set foot on the moon.

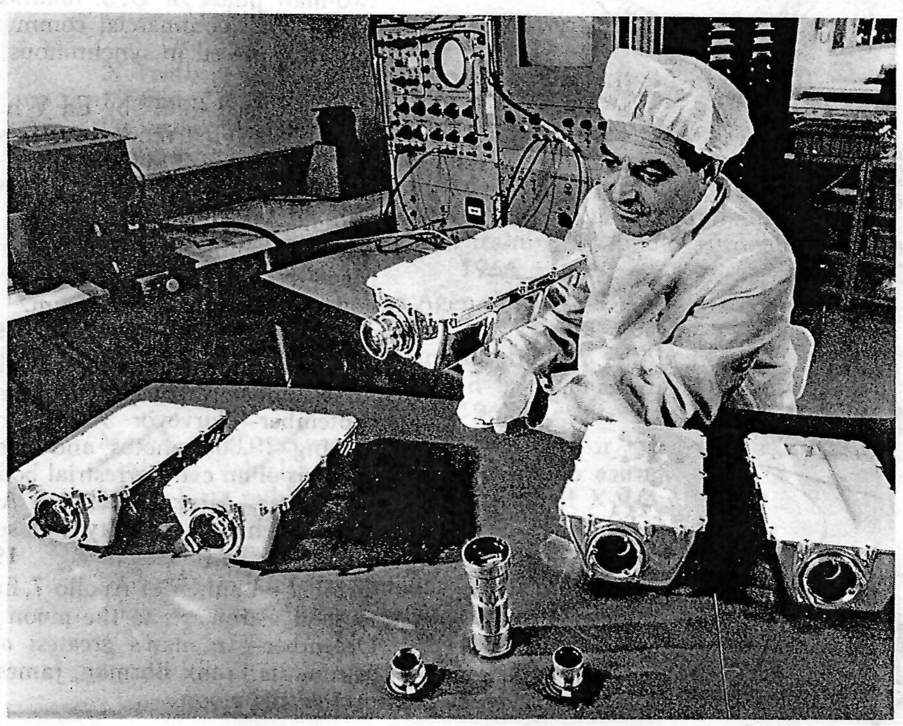
One of the unique capabilities of the camera is its sensitivity to low light levels. During the lunar night the camera will produce clear images using only the light reflected to the moon by Earth's surface. A conventional vidicon camera does not have this low-light capability.

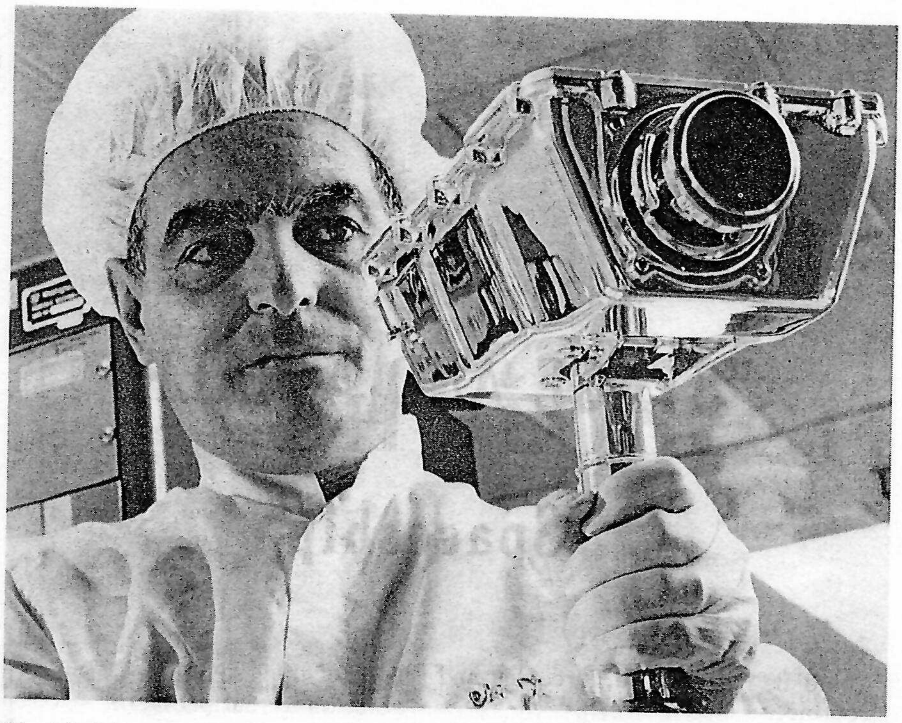
In scientific terms the camera is capable of operating over a light range from 0.007 to 12,600 foot-lamberts. This wide range is accomplished through the use of the secondary electron conduction (SEC) imaging tube, which was invented and developed by scientists at the Westinghouse Research Laboratories, Pittsburgh, Pa.

The SEC tube converts light into electrical signals much as in a standard imaging tube in a conventional television camera. Before the electrical signals are converted into a visible image, however, they are amplified hundreds of times. The SEC tubes are extremely sensitive. They are used for low-light-level surveillance in military, industrial and security applications and in astronomy, because of their inherent ability to literally "see in the dark".

The lunar television camera has been designed so that astronauts will have to make no adjustments other than to change lenses and to switch from slow to fast scan operation. The four fixed focus lenses include a wide angle lens for cabin interior use, a 100 millimeter for viewing Earth and moon during the flight and two general

One of these five television cameras will be used by American astronauts when they land on the moon. The cameras are all "flight" models. As such, all of the cameras are capable of operating in the vacuum of space or in the 100 percent oxygen atmosphere of the Apollo spacecraft. Holding one of the 7-1/4-pound units is Stanley Lebar, manager of the lunar TV camera program for Westinghouse. Each camera will have a set of four lenses, including a wide angle lens, mounted on the camera Mr. Lebar is holding, and three others shown in the foreground.





This television camera is the one Apollo astronauts will take with them when they land on the moon. The camera is capable of operating both in the vacuum of space and in the 100 percent oxygen atmosphere of the Apollo spacecraft. In addition, the special imaging tube in the camera will make it possible to produce pictures in the darkness of the lunar night. The camera can withstand temperature extremes ranging from the 250 degrees Fahrenheit it will encounter during the lunar day to 300 degrees below zero at night.

purpose lenses - one for the lunar day and the second for the lunar night.

The camera's handle serves as an electrical connector that can be engaged and disengaged without the contacts welding in the vacuum in space or on the moon's surface. The camera will be equipped with one of two handles - one with a nine-foot cable for use inside the spacecraft or the other with a 100-foot cable for use outside the spacecraft. The cable carries d-c voltage to the camera and a video signal back to the transmitter in the spacecraft. In operation, the camera needs only 6-1/2 watts of power. A conventional TV camera needs several hundred watts.

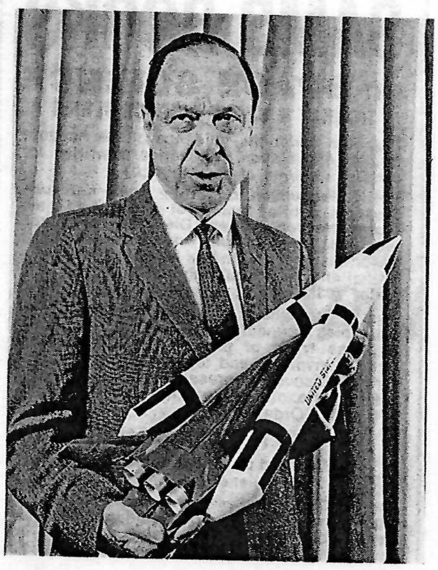
Live picture signals from the camera will be sent to Earth and will be received at NASA's Manned Space Flight Network where they will be converted to commercial broadcast signals for home television viewing.

In building the camera, Westinghouse engineers concentrated on three "essential characteristics" - reliability, performance and portability. Eighty percent of the camera's circuitry is, therefore, made up of molecular electronic functional blocks and thin film circuits. About 250 components make up the electronic portion of the camera. If standard components had been used throughout, 1300 would have been required.

The camera was severely tested at the Defense & Space Center and subjected to a variety of environmental conditions. These included shocks of more than 8 G's, 130 decibels of acoustical noise, severe vibrations of from 10 to 2000 cycles per second, pressure variations ranging from sea level to approximately the vacuum found in space as well as the high and low temperature found on the moon.

The camera's internal operating temperature will range between zero and plus 130 degrees Fahrenheit. This level will be maintained due to the reflective quality of the camera's highly polished surface and internal design for minimum power dissipation.

Since convection is not possible in a vacuum, heat generated within the camera will be conducted to a radiating surface. The camera can operate, however, well beyond this zero-130-degree range.



The "STAGE AND A HALF" Spaceship

A new form of spacecraft would return to Earth as easily as a jet airplane and could be used again and again.

The new concept could lead the United States into an age in which missions beyond Earth's atmosphere would be inexpensive, frequent and routine.

Future space centers might be more like jet airports, blending the newer space technologies with those of aircraft to achieve truly low-cost space transportation.

Lockheed's concept is a "stage-and-a-half" vehicle concept for space shuttle between the ground and Earth orbit.

Such a vehicle would be a sleek, delta-shaped craft that would jettison its huge auxiliary fuel tanks after rising into space.

The auxiliary tanks, forming a "V" into which the space vehicle would be neatly wedged, would supply thrust for the spacecraft's ascent. Once in space, the tanks would be dropped and the mission carried out normally in support of the payload concerned.

At mission's end, the spacecraft - with its astronauts and complex equipment - would re-enter the atmosphere at blinding speed and glide like an airliner to a horizontal landing at a spaceport.

Use of a stage-and-a-half vehicle for space shuttle service - transporting men, provisions and equipment between earth and orbit - could lead to a giant step toward thorough manned exploration of space.

Space stations are a natural progression in space development and have been basic to all long-range space planning. However, they become useful only when the logistics problem is solved. Re-usable space supply ships are the most practical solution to that problem.

The versatile state-and-a-half concept would be useful in other ways. Such a vehicle would lift an upper stage and payload into low Earth orbit, then separate and return to Earth as the upper stage powered the payload into a higher orbit or a trajectory for the moon or planets.

Another kind of mission would permit retrieval from space of complex, expensive payloads. The stage-and-a-half vehicle could carry a payload into orbit, support it while it carried out its work, then return it to Earth for refurbishment and re-use.

Because the vehicle would not require all of today's typical components or would carry them as intrinsic equipment, more room would be available for payload instruments. This kind of mission would be most applicable to programs in which repeated flights were necessary or more "cost-effective" than a few flights of long duration.

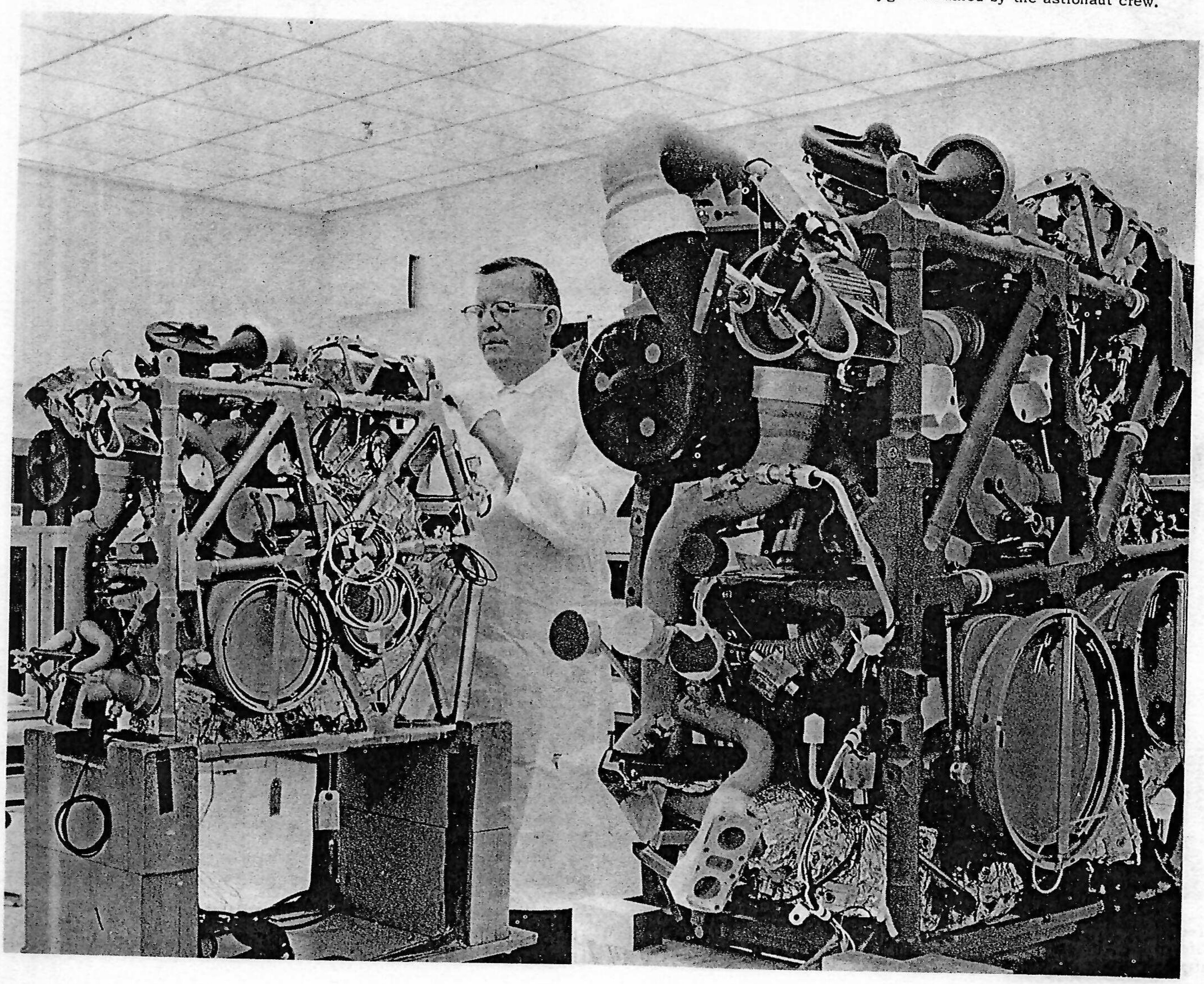
The ability to return to Earth as easily as an airplane would be a major factor in cutting space costs.

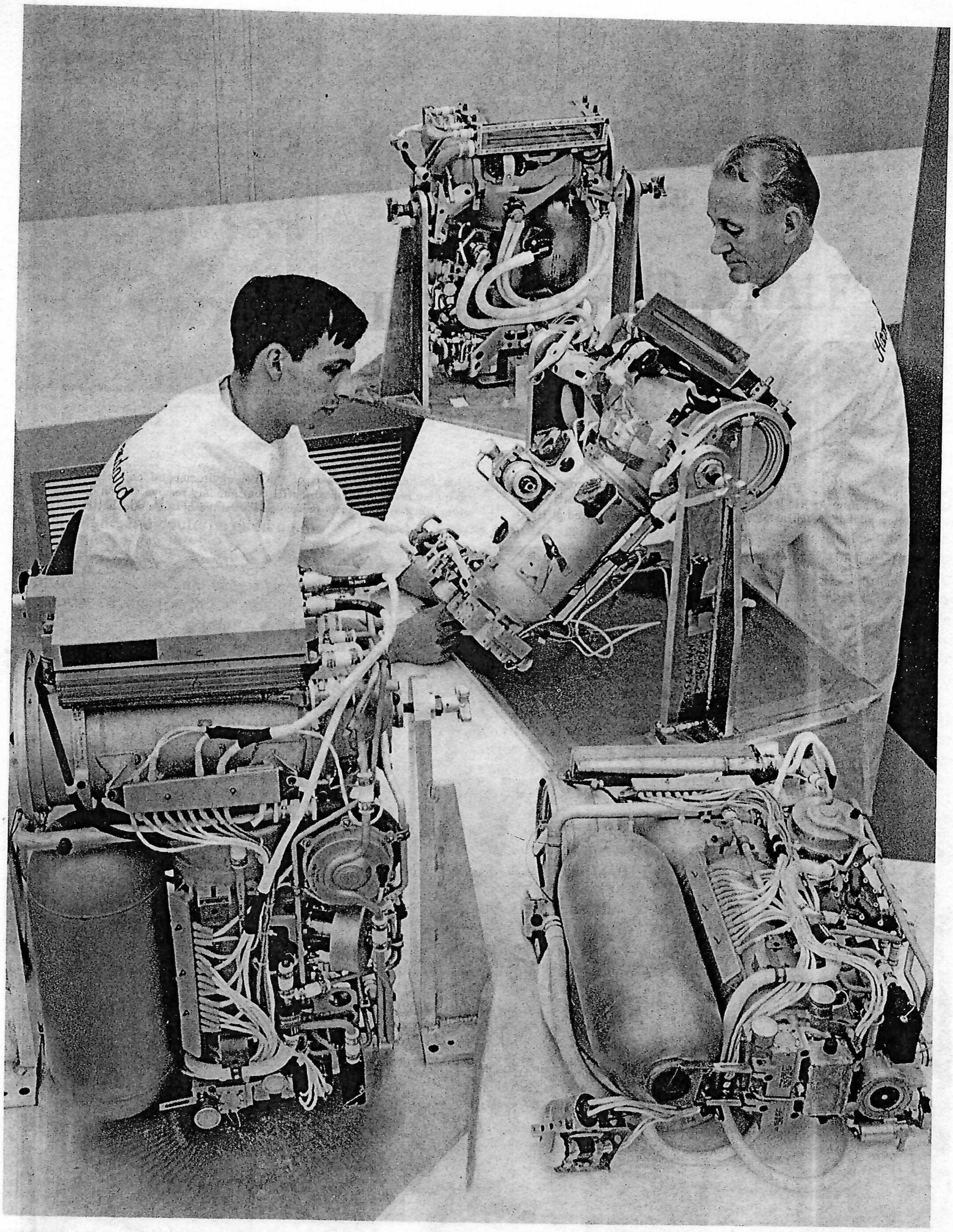
Most of the technologies necessary for maneuvering re-entry and horizontal recovery of spacecraft at existing jet airfields are available.

The concept has been studied in a variety of hypothetical missions, in sizes ranging up to 125 feet overall and payload capabilities from 500 to 50,000 pounds.

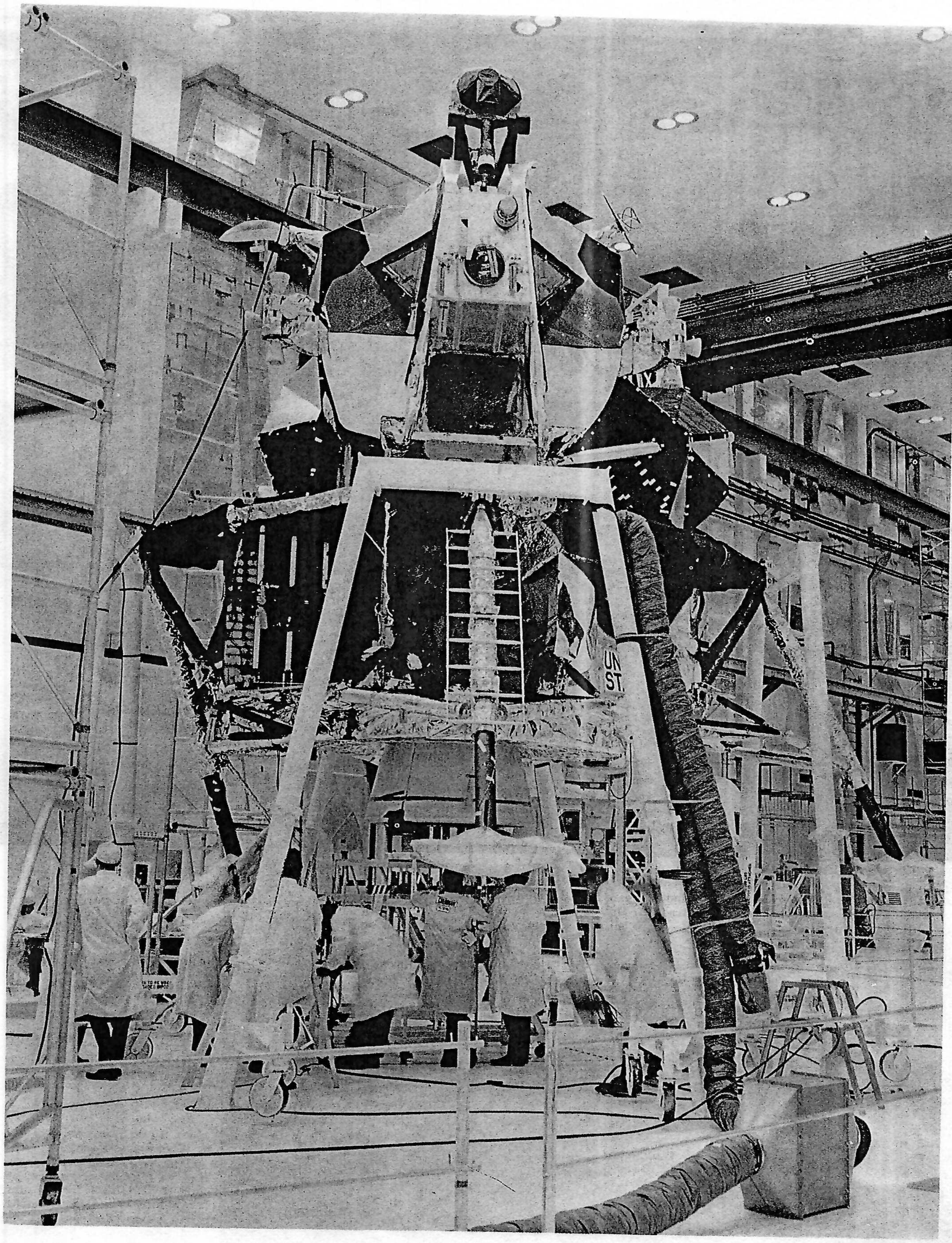
PHOTO SECTION

Atmosphere aboard Lunar Module spacecraft which will undergo its first manned test during Apollo 9 mission will be circulated and purified by revitalization package similar to those shown being assembled at Hamilton Standard. The heart of the LM environmental control system, atmosphere revitalization unit will continuously remove carbon dioxide and other contaminants from the oxygen breathed by the astronaut crew.





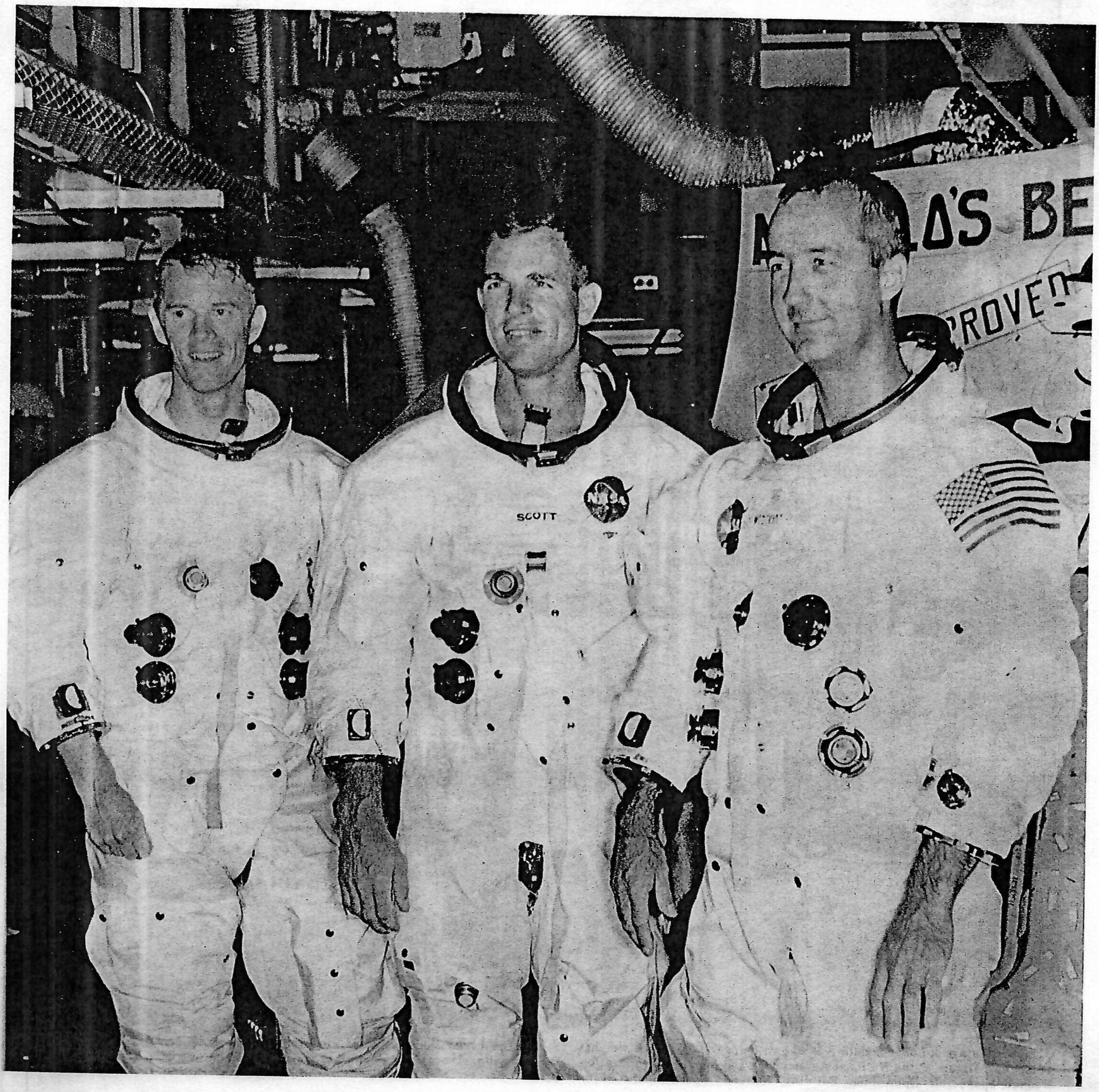
Technicians in Hamilton Standard laboratory work on Apollo portable life support systems which will allow astronauts to make extravehicular trips on the moon's surface. Backpack supplies and purifies oxygen for breathing purposes, pressurizes and ventilates space suit, and cools the astronaut. It also has a radio-telemetry set.

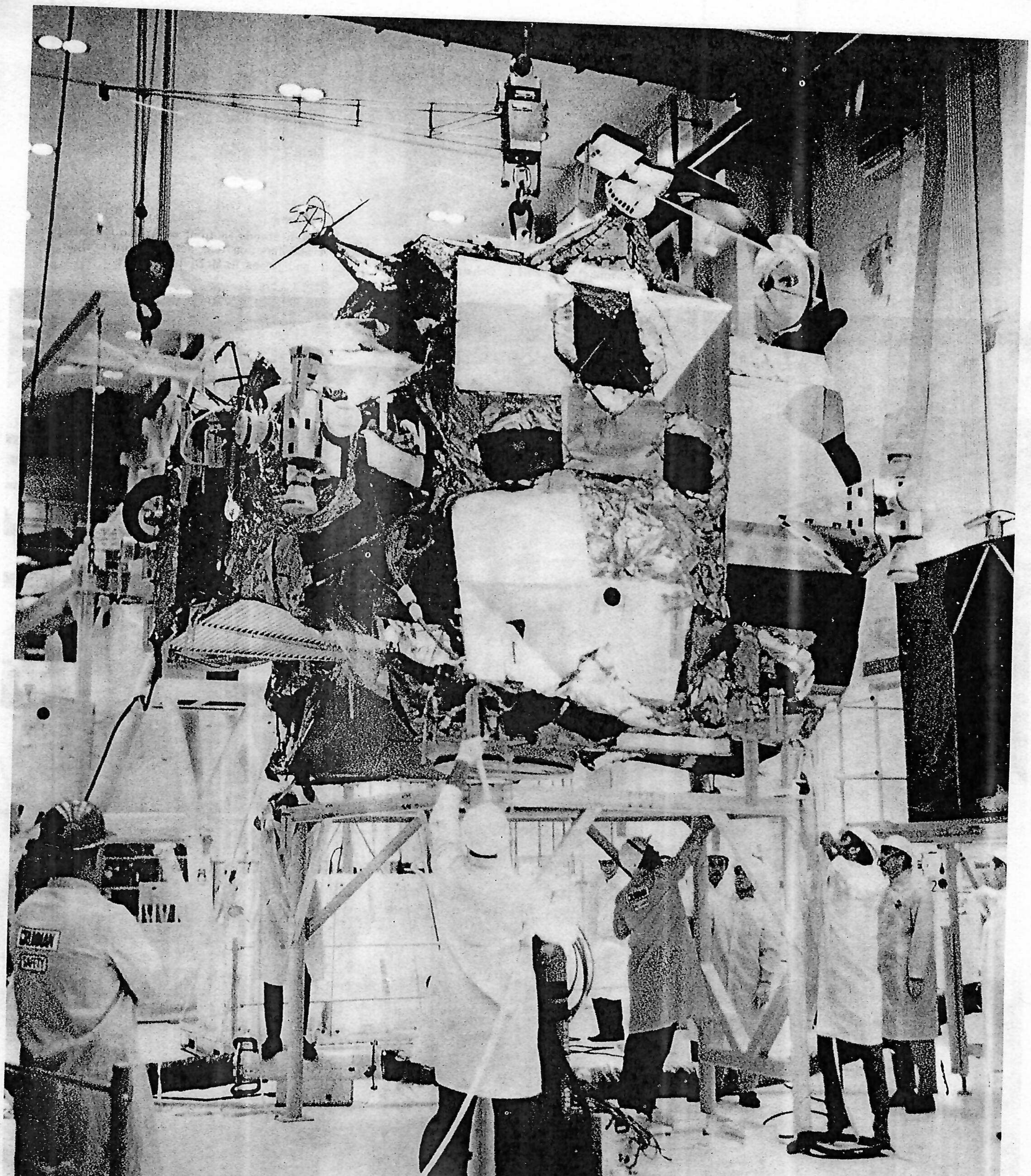


Lunar Module 3 undergoes a landing gear deployment test. The first lunar landing craft to fly a manned mission. It was part of the Apollo 9 mission flown by Astronauts James A. McDivitt, Commander; David R. Scott, command module pilot, and Russell L. Schweikart, lunar module pilot.

Life support backpack like the one to be worn by Astronaut Russell L. Schweickart on his two-hour space stroll during Apollo 9 Earth-orbital mission. Designed for astronauts exploring the lunar surface, backpack supplies life essentials, and radio-telemetry communications for up to four hours. Fiberglass shell protects backpack against micrometeoroids. Extra 30-minute supply in oxygen purge system on backpack works independently for emergency use. Backpack is covered by thermal insulation material like purge unit.

The prime crew of the third manned Apollo space mission stands in front of Apollo Command Module 103 after egress during crew compartment fit and function test activity. Left to right, are Astronauts Russell L. Schweickart, David R. Scott, and James A. McDivitt.



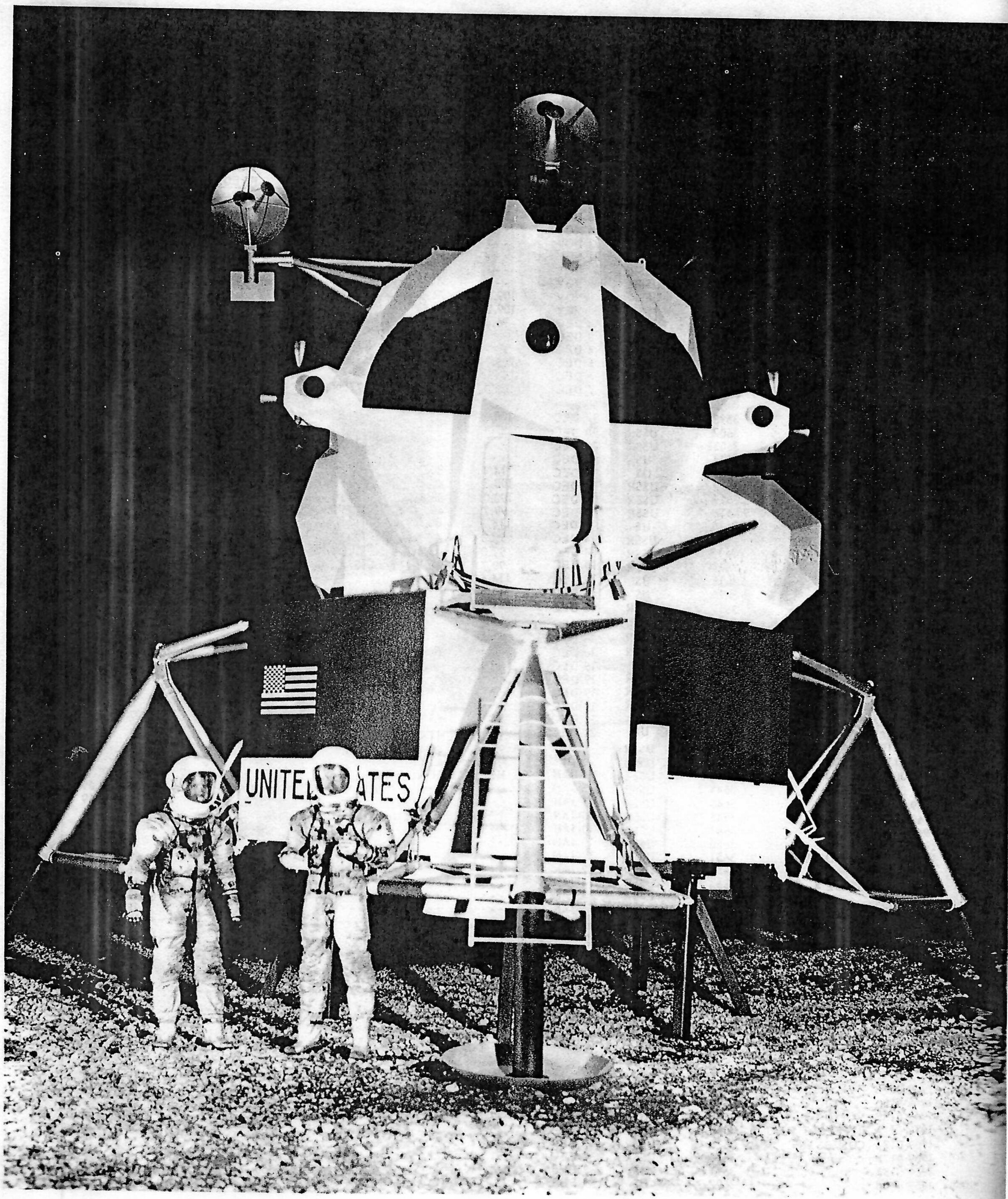


The ascent stage of Lunar Module 3 is shown being moved to the weight/balance fixture at the National Aeronautics and Space Administration Manned Spacecraft Operations Building, Kennedy Space Center, Fla.

The Lunar Module ascent stage houses the crew compartment, the ascent engine and its propellant tanks, and all the crew controls.

SATELLITE REPORT

OBJECT	CODE NAME	CATALOGUE NUMBER	SOURCE	LAUNCH	NODAL PERIOD	INCLI-NATION	APOGEE Km.	PERIGEE Km.	TRANSMITTING FREQ. (MC/S)	DECAY
1968 0103A	PROTON 4	3544	USSR	16 NOV	91.6	51.5	465	248		
1968 0103B		3545	USSR	16 NOV	---	---	---	---		25 JAN 69
1968 0104A	COSMOS 254	3562	USSR	21 NOV	---	---	---	---		29 NOV 68
1968 0104B		3563	USSR	21 NOV	---	---	---	---		27 NOV 68
1968 0105A	COSMOS 255	3574	USSR	29 NOV	---	---	---	---		7 DEC 68
1968 0105B		3575	USSR	29 NOV	---	---	---	---		5 DEC 68
1968 0106A	COSMOS 256	3576	USSR	30 NOV	109.4	74.0	1227	1172		
1968 0106B		3577	USSR	30 NOV	109.2	74.0	1222	1167		
1968 0107A	COSMOS 257	3578	USSR	3 DEC	91.6	70.9	438	269		
1968 0107B		3579	USSR	3 DEC	---	---	---	---		16 JAN 69
1968 0108A		3594	US	4 DEC	---	---	---	---		12 DEC 68
1968 0109A	HEOS-4	3595	ESRO	5 DEC	6792.7	28.2	224428	4339	$136.650	
1968 0109B		3596	US	5 DEC	---	---	---	---		27 DEC 68
1968 0110A	OAO-A2	3597	US	7 DEC	100.3	35.0	777	765	$136.441$136.259 $400.549	
1968 0110B		3598	US	7 DEC	100.2	35.0	812	721		
1968 0111A	COSMOS 258	3602	USSR	10 DEC	---	---	---	---		18 DEC 68
1968 0111B		3603	USSR	10 DEC	---	---	---	---		17 DEC 68
1968 0112A		3604	US	12 DEC	---	---	---	---		28 DEC 68
1968 0112B		3605	US	12 DEC	114.4	80.3	1474	1387		
1968 0113A	COSMOS 259	3612	USSR	14 DEC	100.3	48.4	1331	213		
1968 0113B		3613	USSR	14 DEC	100.0	48.3	1308	216		
1968 0113C		3614	USSR	14 DEC	99.7	48.3	1274	213		
1968 0112D		3618	US	12 DEC	114.7	80.5	1513	1379		
1968 0113A	COSMOS 259	3612	USSR	14 DEC	99.3	48.4	1237	213		
1968 0113B		3613	USSR	14 DEC	99.0	48.4	1213	214		
1968 0113C		3614	USSR	14 DEC	99.7	48.3	1274	213		
1968 0114A	ESSA 8	3615	US	15 DEC	114.6	101.8	1465	1416	$136.770$137.500	
1968 0114B		3616	US	15 DEC	114.5	101.8	1461	1413		
1968 0115A	COSMOS 260	3619	USSR	16 DEC	712.1	64.9	39589	489		
1968 0115B		3620	USSR	16 DEC	---	---	---	---		6 FEB 69
1968 0115C		3621	USSR	16 DEC	---	---	---	---		18 JAN 69
1968 0115D		3622	USSR	16 DEC	708.4	64.8	39408	488		
1968 0116A	INSTELSAT 3 F-2	3623	US	19 DEC	1435.9	0.7	35810	35791		
1968 0117A	COSMOS 261	3624	USSR	19 DEC	---	---	---	---		12 JAN 69
1968 0117B		3625	USSR	19 DEC	---	---	---	---		7 JAN 69
1968 0117C		3628	USSR	19 DEC	---	---	---	---		6 JAN 69
1968 0118A	APOLLO 8	3626	US	21 DEC	---	---	---	---		27 DEC 68
1968 0118B		3627	US	21 DEC	HELIOCENTRIC ORBIT					
1968 0119A	COSMOS 262	3629	USSR	26 DEC	95.0	48.4	780	257		
1968 0119B		3630	USSR	26 DEC	94.8	48.4	767	257		
1969 001A	VENUS 5	3642	USSR	5 JAN	HELIOCENTRIC ORBIT					
1969 001B		3643	USSR	5 JAN	---	---	---	---		6 JAN 69
1969 001C		3646	USSR	5 JAN	---	---	---	---		7 JAN 69
1969 002A	VENUS 6	3648	USSR	10 JAN	HELIOCENTRIC ORBIT					
1969 002B		3649	USSR	10 JAN	---	---	---	---		11 JAN 69
1969 002C		3650	USSR	10 JAN	---	---	---	---		13 JAN 69
1969 003A	COSMOS 263	3651	USSR	12 JAN	---	---	---	---		20 JAN 69
1969 003B		3652	USSR	12 JAN	---	---	---	---		18 JAN 69
1969 004A	SOYUZ 4	3654	USSR	14 JAN	---	---	---	---		17 JAN 69
1969 004B		3655	USSR	14 JAN	---	---	---	---		15 JAN 69
1969 005A	SOYUZ 5	3656	USSR	15 JAN	---	---	---	---		18 JAN 69
1969 005B		3657	USSR	15 JAN	---	---	---	---		17 JAN 69
1969 005C		3658	USSR	15 JAN	---	---	--	---		18 JAN 69
1969 006A	OSO 5	3663	US	22 JAN	95.6	32.9	559	537	$136.290	
1969 006B		3664	US	22 JAN	95.6	32.9	561	538		
1969 007A		3665	US	22 JAN	---	---	---	---		3 FEB 69
1969 007B		3666	US	22 JAN	---	---	---	---		26 JAN 69
1969 008A	COSMOS 264	3667	USSR	23 JAN	---	---	---	---		5 FEB 69
1969 008B		3668	USSR	23 JAN	---	---	---	---		30 JAN 69
1969 008C		3671	USSR	23 JAN	---	---	---	---		13 FEB 69
1969 009A	ISIS-A	3669	CANADA	30 JAN	128.3	88.4	3526	578	$136.080$136.410 $136.590$137.950 $401.750	
1969 009B		3670	US	30 JAN	128.2	88.4	3515	578		
1969 010A		3672	US	5 FEB	88.7	81.5	282	146		
1969 010B		3673	US	5 FEB	114.1	80.4	1440	1394		
1969 011A	INTELSAT 3 F-3	3674	US	6 FEB	1435.4	1.3	35809	35786		
1969 012A	COSMOS 265	3675	USSR	7 FEB	91.8	71.0	457	272		
1969 012B		3676	USSR	7 FEB	91.6	71.0	434	274		
1969 013A		3691	US	9 FEB	144.6	0.6	22906	22850		
1969 013B		3692	US	9 FEB	144.6	0.6	22906	22850		



Science and the Moon

Courtesy of Axe Science Corporation.

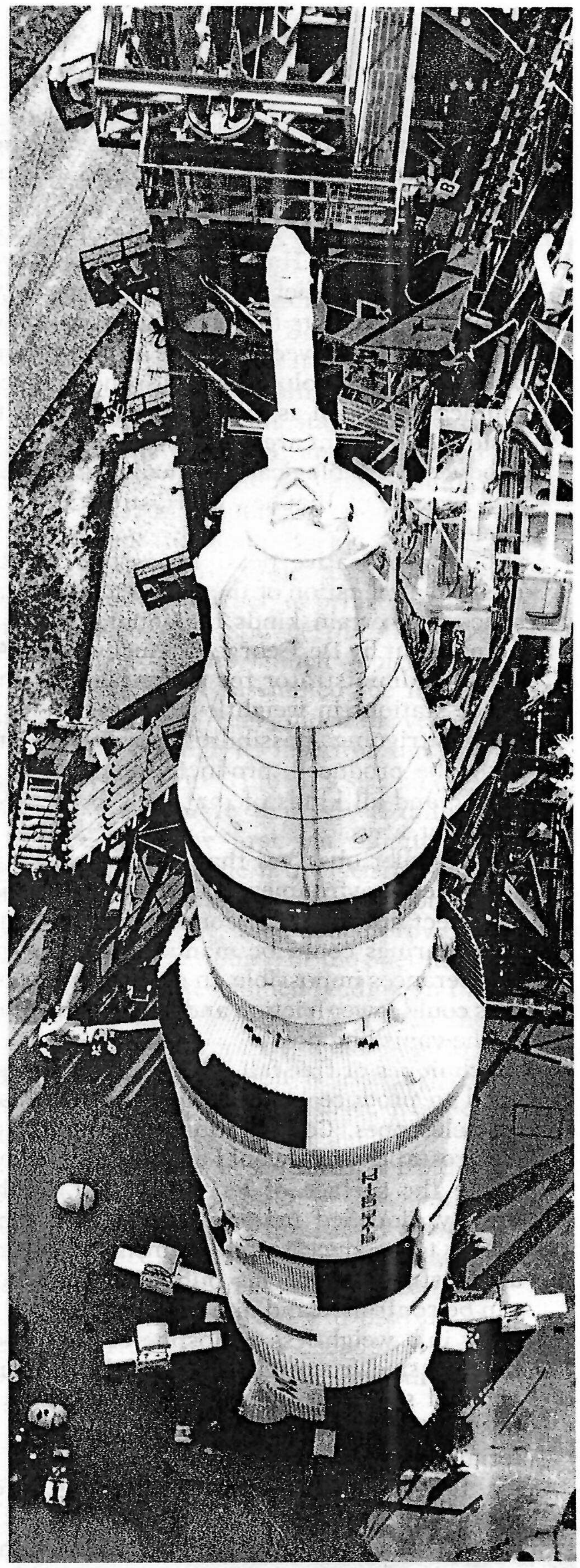
That science and technology have no boundaries was demonstrated by the awesome flight to the moon of Apollo 8. The 147-hour half-a-million-mile voyage provided a glimpse of the heights to which applied science can soar.

Apollo-Saturn was a machine of three and one-half million parts working flawlessly. Apollo-Saturn is a national program with more than 20,000 different companies in support. The creation alone of the Saturn V launch vehicle required the direct efforts of 350,000 people, inventing, fabricating, testing. The success of the first manned flight around the moon can be expected to have effects on the funds available for continuation of the space program of the National Aeronautics and Space Administration.

Even before Apollo 8 returned to earth, the details of Apollo 9's earth-orbit test flight of a lunar landing vehicle were being readied for takeoff early this year. Apollo 10 is to follow quickly. Then, Apollo 11 is expected to make an actual moon landing by September. After the Apollo program, the new administration must chart the course of future federal spending for space exploration. The $24 billion space program, on which costs run close to $4 billion a year, will head towards a post-Apollo program for orbiting manned space stations which could cost another $10 billion.

The Apollo 8 flight and the total space program have different meanings for science, government, industry and the investor. Dr. Wernher von Braun, director of the Marshall Space Flight Center, at Huntsville, Alabama, has said: "The real payoff does not lie in mining the moon or in bringing back gold, but in enriching our

Full-scale mockup of the NASA/Grumman Apollo Lunar Module. A vehicle of this type will be employed in the first manned mission for a lunar landing in 1969.



The Apollo 8 atop the Saturn V in preparation for the historic launching to the moon at Cape Kennedy, Fla.

economy and our science in the new methods, new procedures, new knowledge and advanced technology in general."

A survey of more than 3,500 American businessmen by the Harvard Business Review shows certain belief that space research will bring great benefits to man. Of those surveyed, 96 per cent believed that the space program will produce revolutionary advances in communications such as telephone, radio and television; 88 per cent are of the opinion that it will produce new biological and medical knowledge, and 79 per cent, that new fabricating metals will emerge.

Some provocative possibilities for direct industrial application of the unique conditions of space for certain kinds of manufacturing are pointed out by Dr. George E. Mueller, NASA associate administrator for space flight. Manned space stations in weightless orbital flight provide intriguing possibilities. New materials could be produced, products made more precisely, and all kinds of materials processed in different ways.

Dr. Mueller observes that liquid floating in a weightless environment takes on the shape of a perfect sphere. It is conceivable that metal ball bearings could be manufactured in space to tolerances impossible on earth. Perfect bearings could lower friction and noise levels almost to the vanishing point.

Techniques of free-fall casting could be developed to produce large flawless optical blanks for telescopes. Combinations of spinning and electrostatic forces would enable technicians to shape the surface of lenses as well. Without gravity, liquefied materials and gases can be mixed to produce stable foams. The blending and distribution of gas bubbles in any liquid can be controlled and directed into desired patterns in a weightless atmosphere. The production of a steel foam, with many of the properties of solid steel but light as balsa wood, is one possibility. Mixtures of radically different materials, with different weights such as steel and glass to produce composite materials, offer a promising avenue.

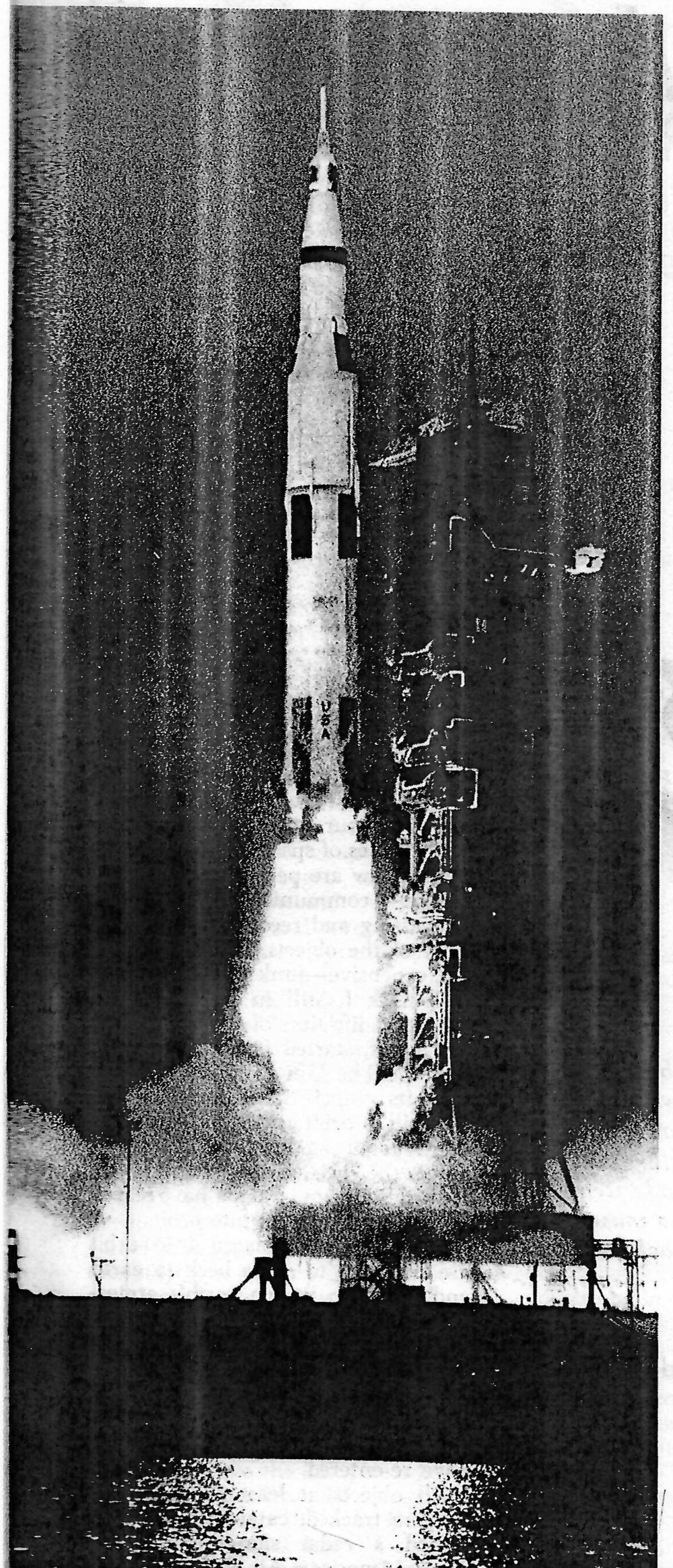
Space factories, Dr. Mueller concedes, must await the development of less expensive means of putting a payload in orbit and making them accessible as reusable space vehicles. "Only a decade ago, technology was pushed to its very limits in order to barely achieve orbital flight," he recalls. "Our first Vanguards and Explorers cost on the order of a million dollars per pound of payload to fly into space. A 'space shuttle,' which we can now foresee, should evolve into a system which can deliver usable payload at a cost that might approach $5 per pound."

He points out that the basic design for an economical space shuttle vehicle could also be the progenitor of an aircraft for high altitude point-to-point earth transport. Such a transport would put any point on the earth within an hour's travel time.

All of the major Apollo-Saturn contractors share the credit for the performance of the space vehicles. These well established organizations in the aerospace industry also share in the expenditures for the space program. The extent to which these giants of the industry will continue to grow and to prosper through participation in the space program can be determined only by close examination of the effectiveness with which they transform their glamorous assignments into profitable enterprises.

The greatest ultimate advantages in the developments of the space program in technology may rest with companies as yet small and obscure which are able to seize on new products or processes and extend them into applications unperceived by larger competitors. Because the procurement program for space exploration extends downward from the prime contractors to such a vast network of suppliers of parts, materials and services, scientific fruits of the project may emerge in many unexpected places. It is the function of the Axe Science Corporation management to seek out and evaluate these emerging investment opportunities in the field of science.

A partial rollcall of the major companies engaged in the Apollo-Saturn program indicates the vast industrial platform which has been constructed by this country's aerospace entrepreneurs in the relatively brief period since the



first flight of the Wright brothers. North American Rockwell is the prime contractor on the Apollo spacecraft. Aerojet-General Corporation provided the service module engine which was fired out of radio contact with the earth on the other side of the moon to place the spacecraft in lunar orbit and was then again fired to put it back on an earth trajectory. Boeing built the first stage of the Apollo 8's Saturn V booster rocket, which provided 7½ million pounds of thrust. North American built stage two, with one million pounds of thrust, and McDonnell Douglas Corporation developed and built the third stage which put Apollo 8 on a precise course to intercept the moon. Boeing Company also has the responsibility, under a technical integration-evaluation contract, to bring together the major components and certify that the Apollo spacecraft and its launch vehicle will function together. IBM assembled the instrument unit—or "brain"—that guided the vehicle from the takeoff through its insertion into the moon trajectory. The instrument's special digital computer made more than seven million calculations during the first ten minutes of flight alone and issued the proper engine-ignition commands. The mission trajectory control work was done by TRW, Inc., which provided the "soft-ware" for that phase of the operation. The vehicle for the first manned landing on the moon, the lunar module—the LM—is in the hands of Grumman Aircraft Engineering Corporation. Bendix Corporation is assigned the experimental package for the U. S. manned moon landing.

These names of leaders in the aerospace industry offer only a surface projection of the scientific achievements which are being accomplished through the space program. The stimulation given all science and technology by the example of the Apollo-Saturn program will provide investment opportunities for a decade to come for those who can discern the changing currents in the stream of progress.

Blast-off for manned lunar orbital flight, the most remarkable exploration voyage in history. The flawless performance of the space craft testifies to the potential of the combination of science, technology and industry.

space debris

Explorer I has been in orbit for 11 years, and will remain in orbit for several thousand more. It's the same story for hundreds of other man-made items, as space becomes a museum of man's past achievements in space.

by Harold R. Williams

Reprinted from January 1969 issue of RENDEZVOUS.

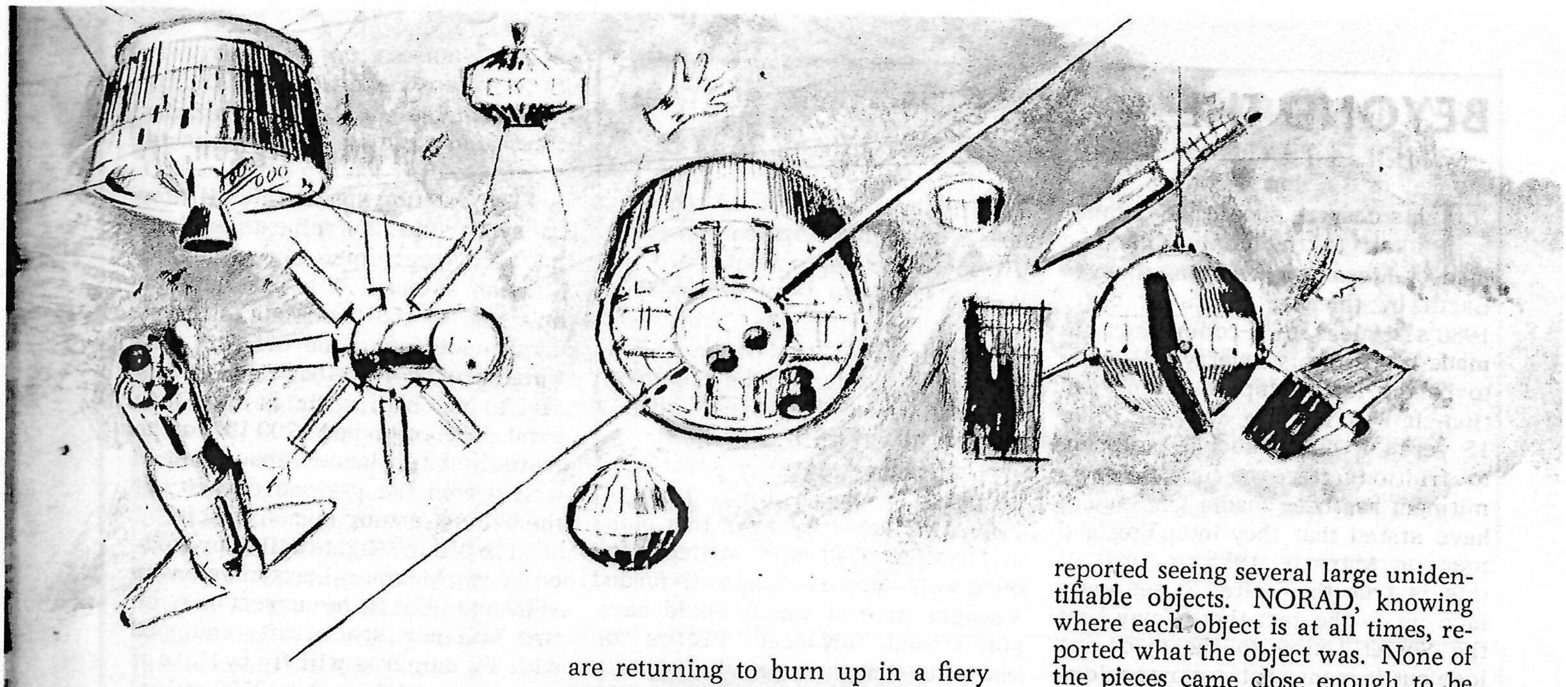
Courtesy of Bell Aerosystems Co.

YOU can't see them, but floating over your head are more than 1,300 pieces of space flotsam and jetsam. A few are performing valuable service — communications, weather forecasting and reconnaissance—but most of the objects are just plain—but expensive—junk.

Sputnik I, still in orbit with an estimated life time of more than 10,000 years, started it all on October 4, 1957. The United States followed with its grapefruit sized Explorer I, also still in orbit and expected to stay there about as long as Sputnik I. Since the two early satellites, the United States and Russia have placed thousands of objects into orbit.

Most satellites placed into orbit are designed to come back to earth and burn up in the earth's atmosphere. But sometimes things go wrong. For example, a Russian rocket attempting an interplanetary mission blew up when re-ignition was tried and sent more than 500 separate pieces into orbit, most of which have re-entered.

All objects at least 30 inches in size are tracked, catalogued and assigned a radar signature by the North American Air Defense Com-



mand (NORAD). NASA's Goddard Space Flight Center keeps track of all objects in space, including Russian missions, and publishes a monthly satellite situation report. The latest report counted 1,358 objects in orbit, most of which are garbage.

Not all the garbage is rocket hulks or jagged chunks of metal. Astronaut Ed White lost a glove. Later Gemini fliers dumped food wrappers, used umbilicals and oxygen tanks, and other items not needed. A camera, flight plan book and several photographic plates were lost in space during Gemini X.

A project called West Ford was the worst case of space litterbugging. A capsule containing more than 400 million small copper needles was opened 2,000 miles above the earth on May 10, 1963. Each needle was 0.7 inch long and 0.001 inch in diameter. The experiment was to try and bounce radio signals from the needles instead of using jammable communications satellites. The needles stayed in a dense cloud for several weeks, then they spread out, eventually forming a ring completely around the earth, stretching from pole to pole. Experiments halted when the needles spread so far apart that tracking became impossible.

The most debris from one launch still in orbit are the 217 pieces from a United States Titan III launch on Oct. 15, 1965. In 1961, the Russian satellite Omicron I left 211 objects still in orbit. Pieces from each launch are returning to burn up in a fiery reentry.

But not all the objects in space burn up. Some survive the intense reentry heat. Debris has crashed in Africa, South America and Arizona, and hundreds of jagged pieces have gone down in oceans around the globe. John Glenn displays on his desk a piece of the Atlas rocket that sent him into orbit, and several pieces of metal from a Russian spacecraft were recovered in the North Central part of the United States.

It is this debris reentering the atmosphere that has been called a danger to peace by renowned British astronomer Sir Bernard Lovell.

Sir Bernard, director of the Jodrell Bank Observatory, said misidentified space debris could cause a world war. He said that space is being polluted by man-made objects that could be mistaken for ballistic missiles and start another war by mistake. Lovell said at the present rate of launchings, more than 2,500 objects could be floating in space in the next 10 years.

He recalled one serious incident during the Cuban missile crisis in October, 1962. It was the same Russian rocket mentioned earlier that exploded upon restarting. Lovell said, "This cloud came toward Alaska, where it was picked up by the Ballistic Early Warning System. It might for the moment have looked like a mass intercontinental missile attack." He said computers revealed the cloud was harmless "but the potentialities for misidentification were there."

Although there are hundreds of pieces in orbit, none have collided as far as is known. Gemini astronauts reported seeing several large unidentifiable objects. NORAD, knowing where each object is at all times, reported what the object was. None of the pieces came close enough to be recognized or considered dangerous.

However, NASA is studying the possibility of space debris coming back to earth and striking inhabited areas. Almost $1 million has been spent in the study but no results have been announced as yet. The closest a piece has struck near a populated area was in 1967 when a metal sphere smashed to the ground in Mexico near a small village. After an examination by NASA scientists it was identified as coming from a Gemini adapter section.

Space is a tempting place to dump things, and some plans have been suggested by scientists that sound fantastic, but may still be logical. Some engineers have suggested that the world's growing population will someday demand a heavenly garbage dump. They argue that by the time such a plan is needed, the cost of launching will be much smaller than it is now. Why not load up a rocket with garbage, they ask, and send it into orbit? The garbage would disintegrate upon reentry and the world would have a solution to a serious problem.

Present plans in Apollo call for even more space litterbugging. Two parts of the Saturn V booster will be left in orbit by moon-bound astronauts. Once on the moon, the astronauts leave that alien soil in the ascent stage of the Lunar Module. After it has rendezvoused with the Command Module, the LM ascent stage will be left to circle the moon. When the Command and Service Modules come closer to earth, the Service Module will be discarded and left to circle the earth. ■

BEYOND THE MOON

Erich A. Aggen, Jr.

This country should now commit itself to the goal of landing men on Mars and returning them to Earth by the late 1970's or early 1980's. Unless this commitment is made by 1970 this country will cease to be the leading space-faring nation. It will require at least 10 to 15 years to bring such a program to fruition after the initial commitment has been made. The Soviets have stated that they intend to land men on Mars by 1985 or 1990. If this is true the United States must face up to the fact that it may beat the Soviet Union to the moon but lose out in manned planetary exploration.

In 1964, NASA estimated that the basic decision to go to Mars would precede an exact definition of the program by at least two to three years. In addition, NASA believed that such a decision would almost certainly have to be made by the president because of the resources needed for a successful manned mission and its national and international importance. NASA also said in 1964, that the development of a post-Saturn 5 launch vehicle depended on the establishment of a manned Mars project. Otherwise, NASA stated, Saturn 5 would continue to be "a way of life". Although the Saturn 5 could conceivably send men to Mars with the use of nuclear upper stages, it is not an optimum vehicle for such a mission.

By 1966, NASA's Manned Spacecraft Center was pushing hard for approval of a manned Mars fly-by mission in 1975. The MSC proposal envisioned the injection of a 4-man spacecraft into a transplanetary trajectory in September, 1975, on a 683-day mission. The spacecraft would pass within 200 miles of the red planet 130 days later and return to Earth in July, 1977. The mission would deliver 30,000 lbs. of scientific equipment to the vicinity of the planet and also return two pounds of Martian soil with the help of a specially-designed probe. Besides investigating Mars, the mission would study Phobos and Deimos, the asteroids, and Jupiter and Saturn. The fly-by mission would require a seven year development program. To meet the September, 1975, injection date, the development would have to begin this year. Obviously, this mission is not now being considered. President Nixon has shown no inclination to propose such a project.

Unmanned Mars exploration - initiated by the historic July 14, 1965, Mariner 4 fly-by of that planet, has been greatly stifled. The once well-supported and well-funded Voyager project which would have soft-landed advanced probes on Mars has been cancelled due to budget cuts. It has been replaced by Project Viking - a project significantly smaller in scope and scientific objectives than Voyager. The project will launch two orbiter-lander spacecraft toward Mars in 1973.

NASA plans two launchings in June-August, 1973, each with Titan-Centaur launch vehicles. Each vehicle will carry one orbiter-lander.

The spacecraft will be injected into Mars orbit and maintained in a mated mode for approximately 10 days while surveying the surface for suitable landing sites.

The Mars soft-landers will weigh 1800 lbs. and will be lowered to the Martian surface by three systems: an aeroshell, parachute and three vernier engines. With the deceleration systems expended, the landers will weigh about 1000-1100 lbs. each on the surface, including 40-50 lbs. of scientific instruments.

Primary purpose of Project Viking is to determine whether or not any type of life exists on Mars. Cameras and meteorological devices will also be carried by the landers to determine the precise nature of the Martian surface and atmosphere.

Data from the landers will be transmitted to Earth through the orbiting spacecraft. A backup transmission system will be furnished in the landers in case the orbiting spacecraft fail for some reason. Only about 30 minutes of each orbit will be reserved for transmission from the surface to the orbiters.

The orbiting spacecraft will also carry various instruments such as infrared spectrometers to study the Martian surface. It is possible that only one of the two would simplify data acquisition. The orbiters will weigh around 4400 lbs. each, mostly fuel to put both vehicles into Mars orbit. The combined 6200 lbs. of the mated orbiter-lander spacecraft is well within the payload capacity of the Titan-Centaur launch vehicle.

The Viking flights will be preceded by two Mariner-Mars missions in 1969 and 1971. In the current mission two Mariner spacecraft equipped with TV cameras will fly by Mars at a distance of less than 2500 miles. Mariner 4 only came within 6118 miles of the planet. The 1971 mission will place two spacecraft in orbit around Mars. After the Viking missions another unmanned Mars flight is tentatively scheduled for 1975. No further flights to Mars are planned beyond the 1975 effort.

For this nation to maintain a viable manned space program beyond Apollo a manned Mars project is a virtual necessity. Mars is the next logical step in the exploration of the solar system. It is not necessary to establish permanent manned space stations and lunar bases before going to Mars. These projects can be carried out at the same time in conjunction with one another.

The reasons for going to Mars are even more urgent and worthwhile than the reasons for going to the moon, although it is the necessary first step. Mars possesses a tenuous atmosphere and this factor alone makes it an attractive objective. Data gleaned from Mariner 4 showed that Martian surface conditions are similar to those existing on the moon. The bulk of Mars' atmosphere would tend to collect in its craters. Thus, the craters may be focal points of life on Mars.

Seasonal changes on Mars may indicate plant life on its surface. Dr. William Sinton of the Smithsonian Institute has researched this subject and found that the dark areas on Mars are probably covered with plant life. By monitoring infrared wave lengths beyond visible light, Dr. Sinton discovered that the greenish regions reflected resonance peculiar to the carbon-hydrogen and aldehyde combinations found in plant molecules. Other areas did not reflect this resonance. Thus far, this is the best evidence we have that Mars harbors life.

Mars is 4100 miles in diameter and has a mass 1/10th that of Earth. The surface temperatures can reach up to 80 degrees F. at high noon on the equator and drop below -50 degrees F. at midnight. Martian craters and other surface features such as mountain ranges are much more eroded than those on the moon due to the corrosive effects of dust storms, movement of rubble down slopes caused by wide temperature variations, and impact debris from meteorites. Light colored substances around the rims of some Martian craters as photographed by Mariner 4 and what appears to be frost around the Martian polar regions may indicate the presence of water vapor in the Martian atmosphere. Scientists have suggested that if the substance on the crater rims and at the polar regions is frost that it may turn directly into vapor and then back again to frost without becoming water.

Pressure suits and pressurized surface stations will be required in exploring Mars because the surface pressure of the Martian atmosphere is estimated at less than 10 millibars as compared to Earth's 1000 millibars. The fact that Mars has an ionosphere capable of reflecting radio frequencies as high as 3000 kilocycles means that radio communications may be maintained between widely separated expeditions on Mars.

Mars has no magnetic field or radiation belt similar to Earth's. Since magnetic fields are believed to be associated with the motion of fluid in a planet's core, Mars is thought to have a solid core.

Only after Man himself has set foot on Mars will he be able to unlock its secrets. Who knows what will be discovered on that red world, a world that has beckoned to man for ages? Perhaps we will find the remnants of an ancient civilization or "merely" plant life - which will be enough in itself, for it will destroy for all time Man's conceited notion that this planet is unique.

BOOK REVIEWS

THE MOON, P.J. Adams, B.Sc., Ph.D (Sales Section British Information Services, 845 Third Avenue, New York, N.Y. 10022, $.50).

Considerable public interest has been focussed on the Moon and its environment as a result of the spectacular advances in space technology during recent years. The avowed intention of American and Russian scientists to make manned landings on the Moon within the next few years has also stimulated the scientific need to know more about the Earth's nearest neighbour in space.

An exhibit has been mounted at the Geological Museum, South Kensington, which provides an outline to some of the present-day knowledge concerning the Moon's surface features, their geological relationships, history and likely origin. The exhibit, which reflects current progress in lunar exploration, has been prepared by the Museum, incorporating information, maps and photographs supplied by lunar research groups in the Soviet Union, the United States of America and the United Kingdom.

This booklet is intended, not so much as an exhibit guide, but as a brief review of facts, observations and hypotheses and geophysicists. Our growing knowledge of the varied geological processes which have shaped the Earth will undoubtedly contribute to a better understanding of the nature and history of the Moon.

THE PERFORMANCE OF HIGH TEMPERATURE SYSTEMS, Volume 1, Edited by Gilbert S. Bahn (Gordon and Breach, Science Publishers, 150 Fifth Avenue, New York 11, N.Y., 280 pages, clothbound, $19.50).

The Performance of High Temperature Systems - Proceedings of the Third Conference on Performance of High Temperature Systems, Pasadena, California December 7-9, 1964, edited by Gilbert S. Bahn, The Marquardt Corporation, Van Nuys, California.

THE MILKY WAY: Galaxy Number One, Franklyn M. Branley (Thomas Y. Crowell Company, 201 Park Avenue South, New York, N.Y. 10003, $4.50).

During a year when man will conquer the moon, young readers are more interested than ever in the heavens. Now THE MILKY WAY: Galaxy Number One traces the growth of man's knowledge of his galaxy from astrology to radio astronomy.

Partly a history of man's discoveries, THE MILKY WAY also explains simply and clearly to young readers the vastness of the galaxy's mass, volume, density, rate of motion, length, and breadth. Breathtaking and precise illustrations are by Helmut K. Wimmer. THE MILKY WAY is a part of Dr. Branley's well-thought-of series, Exploring Our Universe. He has written over forty science books for young readers.

HANDBOOK OF TECHNIQUES IN HIGH-PRESSURE RESEARCH AND ENGINEERING, D.S. Tsiklis (Plenum Publishing Corporation, 227 West 17th St., New York, N.Y. 10011, $35.00).

This important volume stands alone in its field describing materials, designs, equipment, procedures and experience of high-pressure experimentation as applied to laboratory, prototype, and industrial usage. In remarkable detail, it covers the details of equipment suitable to synthesis of new materials, measurement of physical properties, chemical reactions, chemical processing, strength of materials, metalworking, optical, thermal, and x-ray phenomena, and geological studies on a broad, comparative scale. It presents a comprehensive collection of sources, reporting on the most recent advances in the field.

ASTRODYNAMICS GUIDANCE AND CONTROL MISCELLANEA, (Pergamon Press Inc., 44-01 21st Street, Long Island City, New York 11101, U.S.A. $94.00 per set).

Four Volumes - Astrodynamics: Guidance: Miscellanea; Spacecraft Systems: Education; Propulsion and Re-entry; Life In Spacecraft.

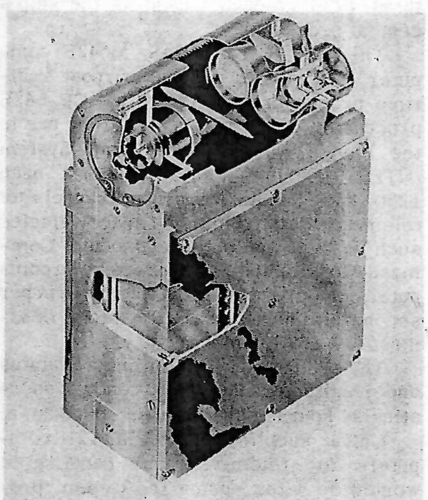
IN THE NEWS

SBRC RADIOMETER TO HELP UNLOCK SECRETS OF MARS - Some of the knotty mysteries of the planet Mars, a subject of speculation since the earliest days of astronomy, may soon be unraveled by earthbound scientists.

A precision instrument, designed and built by the Santa Barbara Research Center, a subsidiary of Hughes Aircraft Company, will perform the key role of "taking the temperature" of Mars during a fly-by of two Mariner spacecraft. By studying the temperature characteristics, scientists hope to learn something about the surface of the planet and possibly about its atmosphere. The two vehicles will pass by Mars during July and August.

The SBRC instrument, a two-channel radiometer that will measure temperature in two basic ranges, has four major purposes:

1. To measure the temperature of the surface of the planet;
2. To complement the information from the TV camera and relate physical features to temperature changes;
3. To measure the cooling curve as the instrument scans across the line from light to dark, and, by determining how fast the surface cools, tell something about the composition of the surface;
4. To scan across Mars' polar cap and possibly establish if the cap is composed of dry ice (frozen CO_2) or water ice or a mixture of both.



MARINER MARS 1969
INFRARED RADIOMETER

This instrument, a two-channel infrared radiometer, will "take the temperature" of the planet Mars during a fly-by of the Mariner spacecraft.

The radiometer uses highly sensitive thermopile detectors. These thermopiles consist of antimony-bismuth junctions deposited on a sapphire substrate by thin-film evaporative techniques. The two channels are 8 to 12 microns (for detecting in the "hot" ranges around 300 degrees K) and 18 to 25 microns (for detecting in the "cold" ranges around 140 degrees K). (Equivalent Fahrenheit temperatures are 81 degrees and -207 degrees, respectively.)

The radiometer uses two telescopes, each with a one-inch aperture, to focus light on the detectors. A simple, three-position stepping mirror allows the telescope fields of view to view space, the planet and an internal reference surface. In this way the instrument uses space as a zero radiation point so that absolute radiometric measurements of the planet surface can be made. Calibration is checked by viewing the reference surface periodically. Total weight of the instrument is 7.5 pounds including electronics.

LOCKHEED PROPULSION COMPANY SUCCESSFULLY TESTS PROMISING MONOPROPELLANT LIQUID ROCKET ENGINE - An advanced liquid monopropellant fuel has been statically test fired in a rocket propulsion engine by Lockheed Propulsion Company.

The fuel has undergone static test firings in the first of a series of company sponsored tests scheduled to extend firing durations to several minutes.

These engines in selected applications such as reaction control thrusters hold great promise when compared to other monopropellant systems based on the use of hydrazine and hydrogen peroxide. The new propellant is non-toxic, non-corrosive, stable when used with conventional materials including metals and rubber, and is highly reliable and inexpensive.

Hydrazine is toxic, expensive and requires special handling while high purity hydrogen peroxide is sensitive to shock, difficult to store for extended periods of time and is low in specific impulse.

The propulsion system consists of a flight configured combustion chamber of stainless steel. The monopropellant is injected at the forward end through a single orifice. Key to the design is the ignition system which consists of a solid propellant igniter which, when ignited, instantly builds up the necessary temperature in the combustion chamber in the neighborhood of 2200 degrees F to ignite and sustain the combustion process of the monopropellant.

Although only single starts and stops have been demonstrated thus far in the tests, multiple igniters could be utilized with each igniter capable of a large number of starts based on the pulse rocket motor concept. As many as 40-starts and stops have been accomplished in a single system of a type that is directly applicable as an igniter for the monopropellant.

The monopropellant engine is easily throttleable over a wide range by merely controlling the flow of the monopropellant through its simple injector.

Tests thus far have produced a predictable constant thrust and the operation is characterized by an extremely quick start-up and shut-down capability.

Hydrazine has a slightly higher specific impulse but in space limited situations, the greater density of the new propellant more than compensates.

The small rocket propulsion engine used in static tests of an advanced liquid monopropellant fuel is held by Robert W. Roberts, project engineer for the development of the propulsion concept at Lockheed Propulsion Company, Redlands, California.

IF THE THREE AMERICAN ASTRONAUTS in Apollo 9 were asked to vote on their favorite oxidizer, chances are good that nitrogen tetroxide would win hands down.

Nitrogen tetroxide, or N_2O_4, helps provide the thrust for the Apollo service module's main propulsion engine, for the Apollo command module's attitude control system, and for the propulsion system of the Lunar Module (LM). It is safe, and as the Apollo 8 mission demonstrated, it is reliable. If you're an Apollo astronaut, those two features count for more than anything else.

When combined under pressure with hydrazine in the spacecraft engine, N_2O_4 creates an instantaneous hypergolic (ignition upon contact) reaction. The engine is stopped by simply shutting off the flow of fuel and oxidizer, and can be restarted at will. This property of nitrogen tetroxide makes it ideal for the many engine starts and stops required to put a spacecraft into a lunar flight path, into lunar orbit, and to take it out of lunar orbit and direct it back to Earth, as was done in the fantastic Apollo 8 mission.

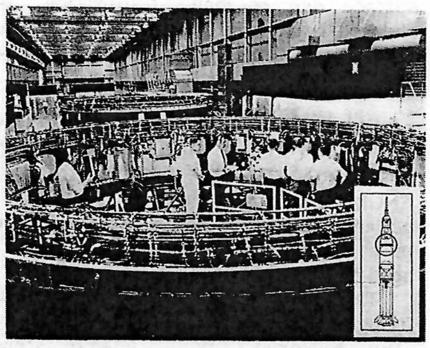
The Apollo 9 mission is the first full test of the LM, which is designed to taxi two astronauts from an orbiting spacecraft to the lunar surface before year's end Just as the Apollo 8 depended on its non-redundant single engine to take it around the moon and back to Earth, so will two moon-bound astronauts depend on LM's single engine to haul them safely to and from the moon's pocked landscape in a future mission.

N_2O_4 was the oxidizer used in the highly successful unmanned Surveyor series of spacecraft which soft-landed on the moon.

Nitrogen tetroxide, in addition to its hypergolic properties, has another feature which makes it ideal for use in space missions. Unlike liquid oxygen, which must be stored at extremely low temperatures, N_2O_4 remains in liquid form at ambient temperature. Thus, under fuel tank pressure, no special insulation is required around the fuel tanks which hold it, resulting in an overall spacecraft weight reduction.

About 850 pounds of nitrogen tetroxide are used in the Apollo spacecraft's main propulsion system. Lesser amounts are used in both the Apollo attitude control system and LM propulsion system.

INSTRUMENT UNIT (IU) of the Saturn Rocket used to launch the Apollo 8 mission. This 3 foot high 21.7 foot diameter ring is the smallest of the Saturn's stages and carries the intricate electronic and electrical equipment needed to guide, navigate and issue commands to control the Saturn launch vehicle from lift-off to separation. Designed by NASA's Marshall Space Flight Center and associated contractors, IBM is the prime contractor for the fabrication, assembly and test. Foamflex coaxial cable assemblies manufactured by Phelps Dodge Electronic Products Corporation are used in the ultra-high frequency radio equipment in the IU instrumentation sub-system. 1/2 inch 50 ohm cable sections were cut to precise length and bent to specified radii, then shipped in specially designed containers 17 feet long to protect the configurations. The IU equipment, among other things, relayed data regarding performance and other flight information to Earth at the rate of 6,480 numbers per second. During the six hours the IU was operational on the lunar flight this equipment relayed more than 25 million numbers.



A TEAM FROM SPERRY RAND CORPORATION'S UNIVAC DIVISION has one prime function during Project Apollo missions: making sure that computers at critical tracking sites throughout the world continue handling hundreds of thousands of bits of data per second without interruption.

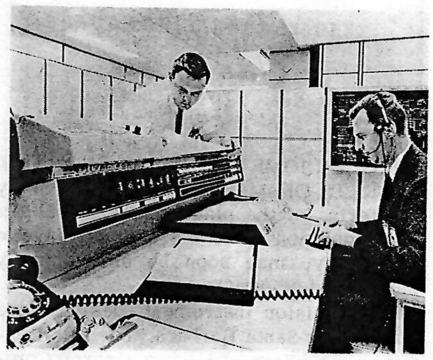
The team consists of five men, experts in every facet of the UNIVAC 1230 computers which process trillions of bits of telemetry and command information during Apollo missions.

Members of the team, called the Apollo Network Support Group, are stationed on each mission at the sites which are most critical to mission success. If a 1230 should fail for any reason, a Univac man is trained to have it operating again within a few minutes. All members of the group have worked with the 1230's since they were first installed in the network in 1965, and therefore familiar with both the "hardware" and the operational programs.

"Our job is to provide for any possible emergencies which can occur in the tracking station computers," comments Pierre Iskos, supervisor of the team. "On the ground, as in space, you must provide for all possible contingencies even if they are not expected."

A team member usually goes to a critical site four or five days before an Apollo launching, and remains until splashdown.

On lunar missions, these sites are usually the 85-foot-antenna deep space stations at Madrid, Spain; Goldstone, California; and Honeysuckle, Australia, which handle data after Apollo leaves Earth



orbit and during its subsequent journeys to the moon and back.

Should a computer emergency occur, the Univac expert can usually tell what has occurred almost immediately.

"We have been trained since Day One to diagnose what's happened and remedy the situation," Iskos comments. "This can be a valuable addition to the capability of the computer operators at the site."

The Apollo Network Support Group is attached to the Manned Flight Engineering Division at NASA's Goddard Space Flight Center in Greenbelt. Univac's Federal Systems Division provides the team under a network support contract from Goddard. Members of the group also provide NASA with engineering advice on special problems.

The Apollo tracking network includes over 40 UNIVAC 1230's. Each land-based tracking site has two 1230's, one for telemetry and the other for command data. If one computer fails while handling critical data, the other computer can immediately take its place. Each tracking ship has a third 1230 computer used as the ship's central processor.

The UNIVAC 1230 (NASA M642B) computer is a rugged general purpose real-time processor (similar to the CP-642B processor) originally designed for use in the Navy's Naval Tactical Data System (NTDS). During Apollo missions, each 1230 can handle separate channels of telemetry data from three space vehicles such as the Apollo Lunar Module, Command Module, and S-IVB stage. The computers can process 75,000 bits of data per second on each channel, or a total of almost two trillion bits per day.

The 1230's usually go on mission status one month before launch and continue operating 24 hours a day until after splashdown.

Univac supplied 14 UNIVAC 1218 computers for telemetry data handling at worldwide sites during the Gemini program. NASA subsequently awarded Univac the contract for the 1230's. Most of the Apollo Network Support Group also worked with the 1218's during Gemini.

What's it like at a site during an Apollo mission?

"Very tense," replies Iskos. "Until splashdown, that is."

How does he feel about his work, which has taken him over 200,000 miles in the last four years?

"I don't think I could describe my feelings," Iskos says. "Nothing can compare with working on a national project like Apollo. All five of us are totally dedicated to it."

Members of the team are:

Pierre Iskos, with the support group since before the initial checkout of the 1230's in May, 1965.

Gerald Spitzer, who worked with the 1218's during Gemini and subsequently was named to the Apollo group.

Roger Christensen, stationed in Bermuda for Gemini, subsequently named to the Apollo team.

Marvin L. Williams, at Grand Turk during Gemini, subsequently named to the Apollo team.

Fred Vey, who has worked with the 1230's since before they were installed for Apollo.

Besides supervising the support team, Iskos also functions as an advisor to the station director of the Network Test and Training Facility.at Goddard.

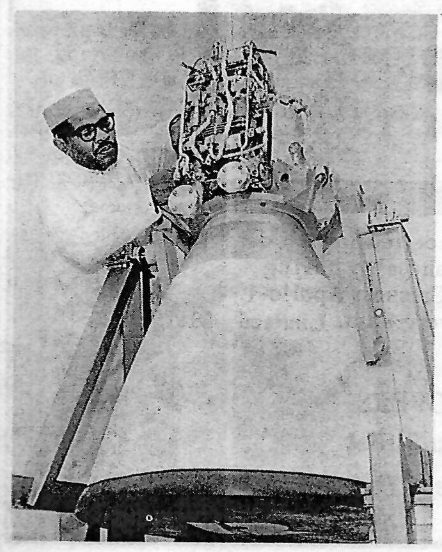
LM ASCENT ENGINE GETS FIRST MANNED FLIGHT IN SPACE - The last of 87 rocket engines on the Apollo/Saturn V space vehicle to be tested by man in space - the lunar module ascent engine considered by many to be the most critical engine of all - was flown by astronauts for the first time during the Apollo 9 mission.

On the actual moon flight, the 3500-pound-thrust ascent engine must start on command, then burn for nearly eight minutes to get the two astronauts in the LM off the moon's surface and back to the Apollo command module.

During the engine's first manned test, astronauts James McDivitt and Russell Schweickart fired the engine for approximately three seconds. This allowed separation from the descent stage and rendezvous with the command module.

A little more than four hours later, after the astronauts had returned to the command module, the engine was refired by remote control for approximately 360 seconds to deplete propellants, check performance and accelerate the ascent stage by about 3500 miles per hour.

Lunar module ascent engine is worked on by James Smith in final assembly area



at Canoga Park, California, plant of Rocketdyne, a division of North American Rockwell Corporation. The 3500-pound-thrust ascent engine will boost two astronauts off the moon for rendezvous with orbiting command module on the actual moon flight.

'MOON SPEEDOMETERS' HELPED ASTRONAUTS - A pair of "moon speedometers" helped guide astronauts James McDivitt and Russell Schweickart in rendezvous and docking maneuvers when they flight-tested the lunar module during the Apollo 9 mission.

The devices made by Honeywell's Aerospace Division monitor the "space taxi's" forward and lateral velocity so the astronauts know how much they are drifting and how fast they are approaching their target, in this case the Apollo 9 command module.

The "moon speedometers" and hand controls will be getting their first lunar module flight test by astronauts, who will manually maneuver the moon vehicle during the final phase of their descent to the moon on the actual landing mission.

IT'S OFFICIAL now that the fifth Orbiting Solar Observatory (OSO), launched January 22, 1969, is a success.

On Tuesday (February 25), the National Aeronautics and Space Administration declared OSO V an official success following the completion of certain requirements. The success criteria was acquisition of "high spectral resolution data in the 1 to 1250 angstrom range during one complete solar revolution of 27 days, including raster scans of the solar disc and selected wavelengths." The 27-day period started following turn-on of the last experiment on January 30.

NASA headquarters stated that the secondary objective was "to obtain useful data from nonpointed experiments (in the wheel) and from the pointed experiments (in the sail) beyond one solar rotation with extended observations of single lines and solar flares." These requirements also have been met.

"The OSO V is the most complex OSO launched to date," said John Thole, OSO project manager at the NASA Goddard Space Flight Center. He said that the quality of data received from the experiments and the spacecraft is excellent. The OSO's eight major experiments are a combination of 39 instruments. Because of improvements incorporated in OSO V, the the rate of data being returned is more than double from previous OSOs.

ITT SUBSIDIARY ANNOUNCES OPENING OF SATELLITE-CABLE SERVICE TO AFRICA - Opening of a direct, combined satellite and cable communication link between the United States and the Republic of South Africa was announced February 24, 1969 by ITT World Communications, a subsidiary of International Telephone and Telegraph Corporation. The announcement coincides with the inauguration of the new South African-European coaxial cable system.

Under a proposed tariff filed with the Federal Communications Commission, the ITT subsidiary will introduce minute-by-minute charges on fully automatic telex calls from the United States to the Republic of South Africa. Initially, it will operate six channels for message, telex and leased channel service via the Intelsat III Atlantic satellite and 6,000-mile coaxial underseas cable between Capetown and Lisbon, Portugal.

The undersea-to-outer space link will give South Africa access to one of the most modern and advanced communication systems in the world. Previously, traffic between the two countries was carried by transatlantic cable to London and thence, by high-frequency radio, to South Africa.

Communications over the new link will be routed via satellite from the Earth station in Etam, West Virginia, to the ITT-built Earth station operated by Compania Telefonica Nacional de Espana (CTNE) and located near Madrid, Spain. The radio signals will then travel by cable to the Canary Islands, completing the final hop to Capetown via the new South African-European coaxial cable system. By the time they reach their destination, they will have travelled from ocean depths of 8,000 feet to 22,300 miles in space.

Though only the size of a British penny in diameter, the lightweight cable can carry as many as 360 separate two-way telephone conversations simultaneously.

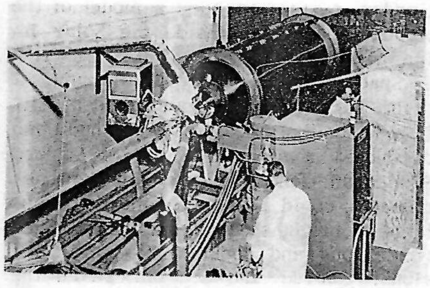
GLASS BEAD BOMBARDMENT HELPED APOLLO VIII RETURN - A special machine which hurls a high velocity stream of glass beads at the thin inner skin of space vehicle's re-entry propellant tanks enabled NASA to send Apollo VIII to the moon without fear of tank failure upon re-entry into Earth's atmosphere.

Designed and manufactured by Vacu-Blast Corporation of Belmont, California, the process - called shot peening - is a space age version of the ancient sword maker art of ball peen hammering to increase the fatigue strength of the slender weapons.

During the early stages of testing for extended orbiting times, NASA ran into trouble with early failure of these propellant tanks. Under simulated flight conditions the tanks were failing after one to three days, and it was discovered that the titanium alloy used for the fuel and oxidizer tanks was adversely reacting to the nitrogen tetroxide propellant causing corrosion, which, under internal pressurization, caused tank failure. As a result of such failures, the scheduled launch dates of several of the space programs were threatened.

Since it was not feasible to use an alternate tank material because of increased weight, added time and expense, it was imperative that a method for preventing such stress corrosion failure of the titanium tanks be found.

Shot peening, a process which bombards the surface of a component with a hail of hard, spherical particles such as steel shot was seen as a possible solution



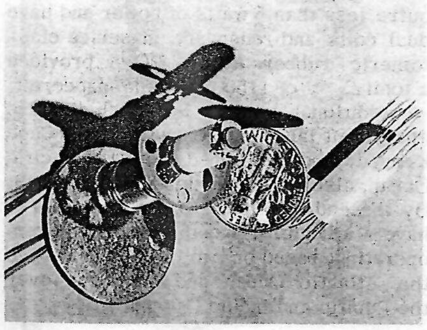
to this critical problem. The shower of shot minutely deforms the surface, setting up permanent compressive stresses - each surface grain of metal is "pushing" against adjoining grains in an overall expansive effect. It can best be visualized as a force which effectively squeezes shut any cracks or potential cracks.

However, conventional steel shot could not be used on the tanks because the media would have a tendency to inbed itself in the tank wall and contaminate it.

NASA sought the advice of Vacu-Blast because of the company's heavy experience in the design and manufacture of shot peening systems. Vacu-Blast engineers suggest using spheres of glass (commonly known as glass beads or glass shot) instead of the heavy steel shot.

Employing equipment which uses a high velocity of compressed air to hammer the inner surface of the thin missile propellant tanks, Vacu-Blast processed the first tanks destined for the Gemini Flights in its Belmont laboratories. It was found that the shot peening process increased the life of the tanks from an average of two days to something in excess of twenty days.

THIS TINY UNIT is a pressure transducer assembly which provides electrical indication and control for a space-orientated nuclear reactor being developed at NASA's Lewis Research Center, Cleveland. The new unit is capable of operating at temperatures up to 1000 C, the highest yet achieved. In its space application, the transducer houses a series of electrical wires inside a bellows to measure the pressure of liquid potassium circulating through a loop in the reactor. To protect these vital electrical leads from the searing corrosion of the potassium in the event of bellows failure, researchers selected a material called Lucalox® ceramic, an exotic ceramic material produced by General Electric's Lamp Glass Department, Cleveland.



A THERMOELECTRIC POWER GENERATION SYSTEM, which is the highest power radioisotope fueled device built to date for the space program, has been delivered. It was developed for the California Institute of Technology's Jet Propulsion Laboratory by the Westinghouse Astronuclear Laboratory.

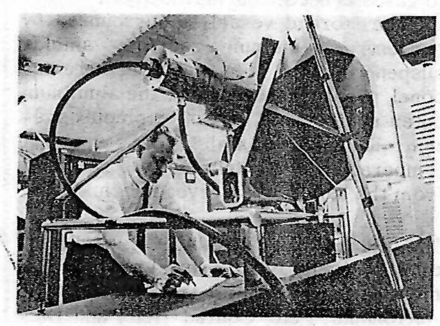
This radioisotope thermoelectric generator has the highest efficiency of any such device built in the past and the lowest development cost of terms of watts per dollar.

Output of the unit is about 120 watts, 3.5 volts at 34 amperes. Its efficiency is nearly six percent. The generator consists of a heat source, heat pipe, thermoelectric module and planar radiator. For testing purposes, the unit is operated with electrical heaters instead of a radioisotope as the heat source.

Thermal energy produced by the heat source is transferred to the interior of a tubular thermoelectric generator by the heat pipe. The interior of the generator is the hot side of the thermoelectric couples; the radiator is the cold side.

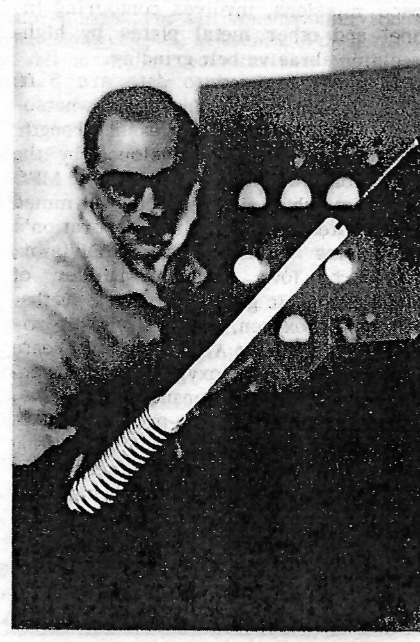
The generation system is the first practical application of the heat pipe which up to now has been largely a laboratory curiosity. The heat pipe is highly efficient; it transfers almost 100 percent of the heat from its evaporator section at one end to the condenser section at the other end.

Design of the tubular thermoelectric module is a result of eight years of development and testing at the Westinghouse laboratory. Total testing time on developmental modules exceeds 180,000 hours. The modules can operate in air, inert gas, even submerged in liquids. Tests in Westinghouse and government laboratories have shown that the monolithic modules can resist impacts as great as 10,000 g's and are not sensitive to thermal cycling or nominal overheating.

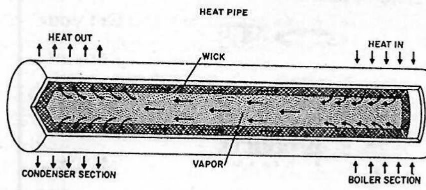


Shown on test just before the unit was shipped, this prototype radioisotope thermoelectric generator is the highest power generator built to date for the space program. The unit consists of a power source, a heat pipe to conduct thermal energy from the power sources to the generator, a thermoelectric generator, and a radiator that dissipates heat and acts as the cold side of the thermoelectric generator. In the tests, electrical heaters were used in place of a radioisotope power source. The power line for the electrical heaters enters the unit from its hot end, shown at the upper left in the photo. The radiator is on the right.

This photo shows a demonstration of a heat pipe at the Westinghouse Astronuclear Laboratory. The highly efficient heat pipe transfer over 500 times as much heat per unit weight than any solid rod of the same diameter. Unlike the large reduction in temperature with length along a



solid rod, the temperature along the length of the heat pipe is uniform. The photo shows this by the uniformity of the glow on the surface of the entire heat pipe. The operating temperature of this heat pipe is about 1350 degrees F. The heat is provided by the induction heating coil seen at the lower left.



As shown in this diagram, the heat pipe makes use of the large quantities of heat involved in fluid vaporization. The device is composed of a closed, evacuated tube with a wire mesh "wick" around its internal surface. The wick is saturated by a liquid with a low vapor pressure. (The fluid used in the heat pipe is liquid sodium.) Heat applied to one end of the heat pipe causes the fluid in the wick to vaporize. The vapor travels rapidly to the other end of the heat pipe where it condenses and its heat of vaporization is released. The fluid is drawn back to the evaporator end of the heat pipe by the capillary forces in the wick.

A CALIFORNIA-DEVELOPED PROCESS for reducing weight of metal plate will allow a significant weight reduction in the CGSS (cryogenic gas storage system) hardware for America's first 56-day manned space flight in the Apollo applications Program, according to project engineers.

The long three-man flight has been scheduled by the National Aeronautics and Space Administration for 1971 as a follow-up to the Apollo mission to land men on the moon and return them safely to Earth.

The relatively little-known weight saving process, already employed in other space missions, involves contouring Inconel and other metal plates by high-precision abrasive belt grinding.

Blank sizes used to date are 5 ft. sq. The grinding has no effect whatsoever on the final spherical vessel strength.

The process was developed by the Huntington Park, California-based MPC Industries which is producing slimmed down plates for Bendix Corporation's Instruments & Life Support Division, Davenport, Iowa, designer-builder of unique cryogenic gas storage systems that will supply oxygen, nitrogen and hydrogen on NASA's first AAP flight and create a "shirt-sleeve" oxygen-nitrogen environment for the astronauts.

MPC's plate reducing process is used to generate a blank configuration that results in a constant wall thickness in the formed hemisphere. Minimum weight and maximum strength are imperative.

Seeking both, Bendix engineers specified plate of heavier wall thickness than otherwise indicated and turned to MPC to perform one of its specialties - contour grinding - by which variable amounts of metal are removed from different areas.

Plates received from MPC are shaped into perfect hemispheres at Bendix. The hemispheres are butt welded together. The result: a complete spherical storage tank of uniform thickness. Inconel 718 and aluminum 6061 are used.

In MPC's experience, contour grinding can remove approximately 25 lbs. from a typical 5 ft. x 5 ft. x .184 in. thick Inconel plate and approximately 5 lbs. from an aluminum plate of similar dimensions.

Taper grinding - a related form of precision grinding also performed by MPC - has been used with Inconel, stainless steel, titanium, aluminum and other plate for the Delta missile series, the B-70, X-15 and Concorde, among others. Significance of grinding for weight control is shown in available aerospace information. According to space engineers at the Jet Propulsion Laboratory, Pasadena, it takes something between 65 and 90 lbs. of propellant to orbit 1 lb of payload - the variations depending on such factors as altitude of orbit and size of launch vehicles.

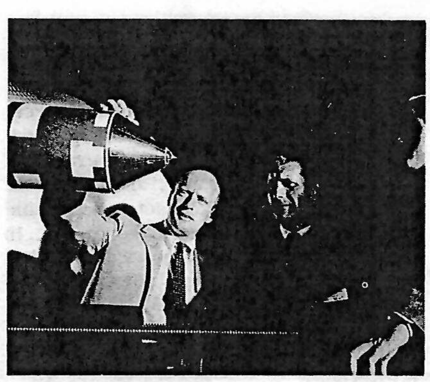
A general rule-of-thumb is that 90 lbs. of propellant are required to orbit each pound of payload for smaller launch vehicles, this decreasing to 65 lbs. of propellant per pound of payload to orbit larger, more "energetic" launch vehicles.

Bendix is building 10 CGSS systems. Only five of the systems will be used on the initial flight - enough to store 3,400 lbs. of usable cyrogenic fluids, including 2,400 lbs. of oxygen, considered ample to sustain the breathing needs of an average man for five years.

A primary part of each system is a spherical Inconel 718 pressure vessel in which the cryogenic oxygen, nitrogen or hydrogen fluids are stored for conversion to gases as needed during the flight.

The storage vessel is surrounded by concentric aluminum radiation shields suspended in a vacuum between the Inconel pressure vessel and the aluminum outer shell and is part of a complex system designed to stabilize the internal temperature and minimize loss resulting from the boil-off of the cryogenic fluids.

UNDER HARSH, DRAMATIC LIGHT conditions simulating the visual environment men face in space, America's Apollo Astronauts Pete Conrad (left) and Dick



Gordon (center) examine a model of the Apollo spacecraft inside the Solar Illumination System at Lockheed Missiles & Space Co., Sunnyvale, California. At right, his face hidden in shadow, is William Kincaid, Jr., Lockheed engineer who conducted a study for NASA's Manned Spacecraft Center to determine how astronauts could best overcome the problems of bright sunlight and glare during rendezvous and docking on Apollo missions. Conrad and Gordon crewed the Gemini 11 mission in which they linked their Gemini spacecraft with a Lockheed-built Agena Target Vehicle.

HYDRAZINE PROPULSION SYSTEM Maintains Intelsat III's Attitude Control - The first operational spacecraft equipped with a hydrazine-fueled attitude control system - Intelsat III, launched December 8, 1968 - is being maintained in its synchronous, equatorial orbit as planned. The 330-pound spacecraft reached its station above the Atlantic ocean nine days after launch.

Intelsat III also is the first experimental or operational satellite to depend entirely on a hydrazine-fueled propulsion system for attitude control.

Four small rocket engines - the heart of Intelsat III's positioning and orientation propulsion subsystem (POPS) - orient the satellite's spin axis, move the spacecraft to the proper position above the equator and maintain Intelsat III at the proper location and attitude.

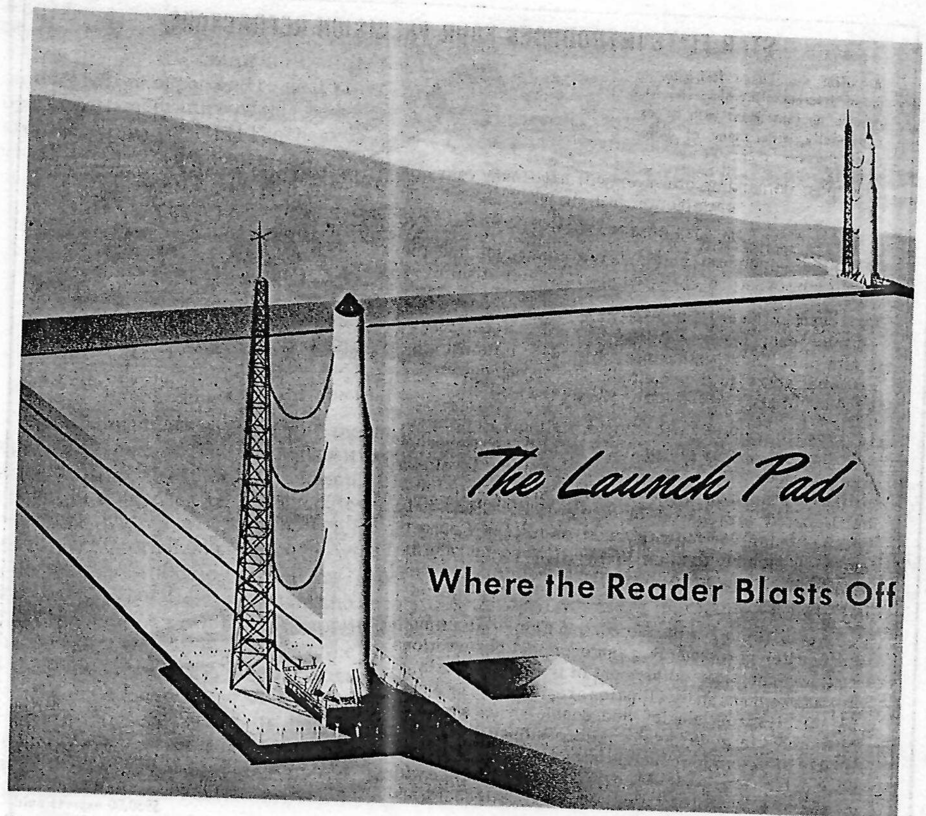
To date, the first Intelsat III's POPS has been pulsed 4,800 times.

The four thrusters provide impulses normal (radial firing) and parallel (axial firing) to the spacecraft spin axis to effect positioning and orientation corrections. POPS utilizes monopropellant hydrazine supplied from a blowdown propellant feed system.

POPS consists of two independent subassemblies, each with one radial and one axial thruster, a fill and drain valve, and assorted plumbing. The subassemblies are connected by a squib-actuated valve. Either of the subassemblies can perform any required maneuver.

The thrusters each deliver 4.0 pounds of thrust initially and 0.7 pounds after five years of operation, with a tank pressure blowdown range of 600 to 75 psia. Shell 405 catalyst contained in the engine thrust chamber provides spontaneous decomposition of the hydrazine and allows both pulse and steady-state operation. The solenoid-actuated propellant valves require less than 5 watts of power and have dual coils and redundant, in-series elastomeric rubber seats. POPS provides a total Δ V of 1150 fps to the spacecraft.

Additional Intelsat IIIs, including the spacecraft launched February 5 from Cape Kennedy and positioned above the Pacific Ocean, also will be equipped with a POPS. By the end of 1969, COMSAT expects to have a global commercial system operating, based on two Intelsat IIIs above the Atlantic Ocean and one each over the Pacific and Indian Oceans.



Dear Mr. Palmer:

I would be most appreciative if you would include the following announcement in your calendar of events through the month of April:

April 19, 1969 - Embry-Riddle Aeronautical Institute Alumni Association National Convention will be held in Daytona Beach, Florida.

Thank you very much.

Gregory P. Allen
Alumni Director
P.O. Box 2411
Daytona Beach, Florida
32015

Dear Sirs:

As a reader of your magazine I find your articles to be very appropriate and very informative. But, I feel that the space program is not being well supported by the Congress or other official agencies, outside of NASA. I believe that a magazine such as SPACE WORLD with a large circulation should urge its readers to write to their congressman and their representatives and try to promote the space program. The manned flight program after the initial Apollo Application missions will be almost non-existent. There is no need to tell the readers the benefits of a program, for I am sure that they are well aware of them.

The moon offers us the secrets of the universe, along with much wealth, and possibilities. Just imagine a world untouched, with all its secrets on the surface, and not buried under hundreds of feet of earth, the mineral deposits, and all that scientific knowledge. By the end of the 1970's exploration of the moon will be well under way, and the development of nuclear rockets will open up a new frontier, Mars. We should except its challenge and not discard what we have learned. Support must be given to long range programs for planet exploration, such as Voyager, and Mariner. If, and I hope soon, the United States decides to become interested in a manned flight to Mars, we must not be caught short on techniques. Unmanned exploration must be carried out to prepare us. These programs must be established and funded now! Once again I appeal to all readers to write to your congressman.

Marvin Rubenstein
8830 Dorchester Avenue
Chicago, Illinois 60619

Dear Mr. Palmer:

When a third polarizer is inserted between 2 "crossed" polarizers, and rotated to the proper position, it causes the latter to "open up". This cannot be explained by the electromagnetic theory of light.

It is possible and evident, that each polarizer changes the axis direction of photons traversing it. This checks with the phenomenon of plane polarization, where the axes are changed to a single orientation after reflection from a surface.

Dr. William T. Thomas, Jr.
Optical Consultant
President,
Daytona Beach Stargazers
408 Vermont Avenue
Daytona Beach, Florida 32018

Dear Mr. Palmer:

Just a few words to let you know I still consider SPACE WORLD tops. It is the best ever and I am very well pleased with the articles, the very easy to read print and the excellent photos.

A very fine job indeed.

What's happened to Radio? It is sort of a review of my past life.

I started in Radio (Wireless) with a crystal Det receiver and a spark coil transmitter just before World War One.

I made my living at it from the end of World War One in 1918 until I retired from it in the middle of 1967. 49 years of radio. I stayed with it all through the crash of the early 30s.

I am a bit confused by the above mentioned article in March 1969 issue of SPACE WORLD. In earlier articles you mention the use of V.H.F. F.M. for voice communication between the Lunar Landing Module and the Lunar Orbiting Module. In the March issue you mention the use of V.H.F. A.M. modulation which I think is incorrect.

V.H.F. Narrow band F.M. would be better than A.M. modulation.

You mention the use of phaselock for precise frequency control of the receiver. Right. It is also used to obtain a high degree of selectivity necessary for deep space communi-

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cations such as slow scan picture transmission. The selectivity is determined by the "Q" of the phase shift network, and by the I.F. frequency selected, such as 455 K.C. for Moon Bounce Communication to perhaps 10 M.C. for the Apollo voice link to Earth; and the doppler effect for navigation and ranging as you mention in the earlier issue. Check on that V.H.F. A.M. I think it is an error.

I greatly appreciate the articles on space communication. Now that I am retired it helps to keep me informed on the new developments.

I have enclosed a check for a two year renewal. If I take that long, long trip before it expires, send them by phase lock narrow band laser beam.

Edgar O'Brien.
4147 N. Meade Avenue
Chicago, Illinois 60634
W.A.9JKJ.

Dear Editor:

It must be evident to space enthusiasts that the subject that we are all involved in is in trouble. Congress is ever increasing its cuts in space spending and for some of us that means less jobs for future employment. Why are they doing this? Because space has become a word which is too foreign to so many Americans; result, less interest, and less money.

I started a club in January and at the present we are going all out to see that this constant decrease in money going into space is halted. We have printed flyers and are distributing them.

We could use new members. Write me. Together maybe we could end this unnoticed crisis.

Sal A. Lagonia, President
John Glenn Aerospace
118 Florence Street
Mamaroneck, New York
10543

Dear Mr. Palmer:

Over the past few months I have been in touch with Mr. R.W. Jones of Clark, New Jersey. He indicated you might print the enclosed description of a "Momentor."

This paper should follow this thought experiment which points out the subtlety of a Momentor. Use a uniform disc and bar. Rotate them on a frictionless surface so their center of mass has no translational motion. A piece near rim breaks off of disc. The remaining disc is unbalanced so they get equal and opposite momentum. When a small end breaks off the bar the remaining portion is still in balance. The remaining bar has no mechanism to give it translation motion. Many space drives, similar to the Dean drive, with contra rotating eccentric masses have been proposed and patented. They all reduce to the disc while a Momentor is like the bar.

Please advise if and when you will print this. I am a government employee and have submitted it as a suggestion and feel if it isn't printed soon it will be history rather than news.

John W. Ecklin
40 Alexis Road
Woodbridge, Virginia
22191

"Momentor" by John W. Ecklin

If a mass is made to rotate around its center of mass (cg) or the point of dynamic balance by a motor shaft (X) at the cg, only a torque will be felt on X. This torque can be cancelled by rotating an identical mass in an opposite direction and speed. This description always assumes at least two such operating systems so torques will always cancel.

Figure 1 is a top view of a mass which has an essentially uniform distribution of weight. T will be released to fly in a tangent. S is constructed so it can be shifted toward (and away from) the center and X is square so it can shift in the slot as shown and still rotate the mass.

During the instant T is released and begins its tangential flight, S and X are shifted so the remaining mass maintains a balanced force on X. (The shift of S towards the center could precede the release of T so if a force is developed it will be in the same direction as stopping T.) Stopping T produces the "ONLY" permanent unbalanced force or thrust. Shifting X and S produces a force at right angles to the force developed in stopping T. This force, at right angles, is also cancelled by the opposite operating system where X & S will be shifting in an opposite direction at the same time. The two identical systems can be mounted side by side or stacked over and under each other.

It is obvious this system can be returned to normal with only temporary unbalanced forces which eventually cancel. (The force to return T from its stopped position is cancelled when T is stopped near S. Stopping each motor and again returning them to speed causes only cancelling torques. Thus T can be repetitively released in the same direction. The energy to the motors and for control could be supplied by an atomic pile or any other source of stored potential energy.

Not so obvious is the fact that T can remain connected and be unbalanced for the same 180 degrees of each revolution to produce thrust. There are thousands of methods of mechanizing a Momentor which is a combination of the words motor and momentum.

Since energy and mass are now thought to be equivalent, is a system which is consuming energy a closed system? In other words, is the law for the conservation of momentum correct?

This long and rather complex description simply concerns releasing a portion of a rotating mass while always maintaining a balanced force on the motor shaft. When you see the preceding sentence is possible, it is easy to see stopping the released portion develops an unbalanced force.

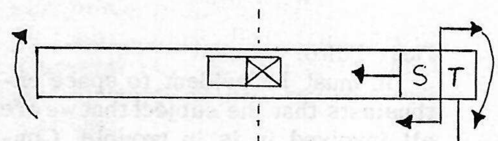
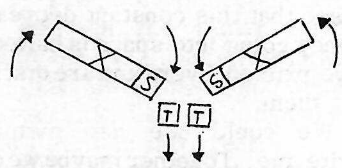


FIG. 1

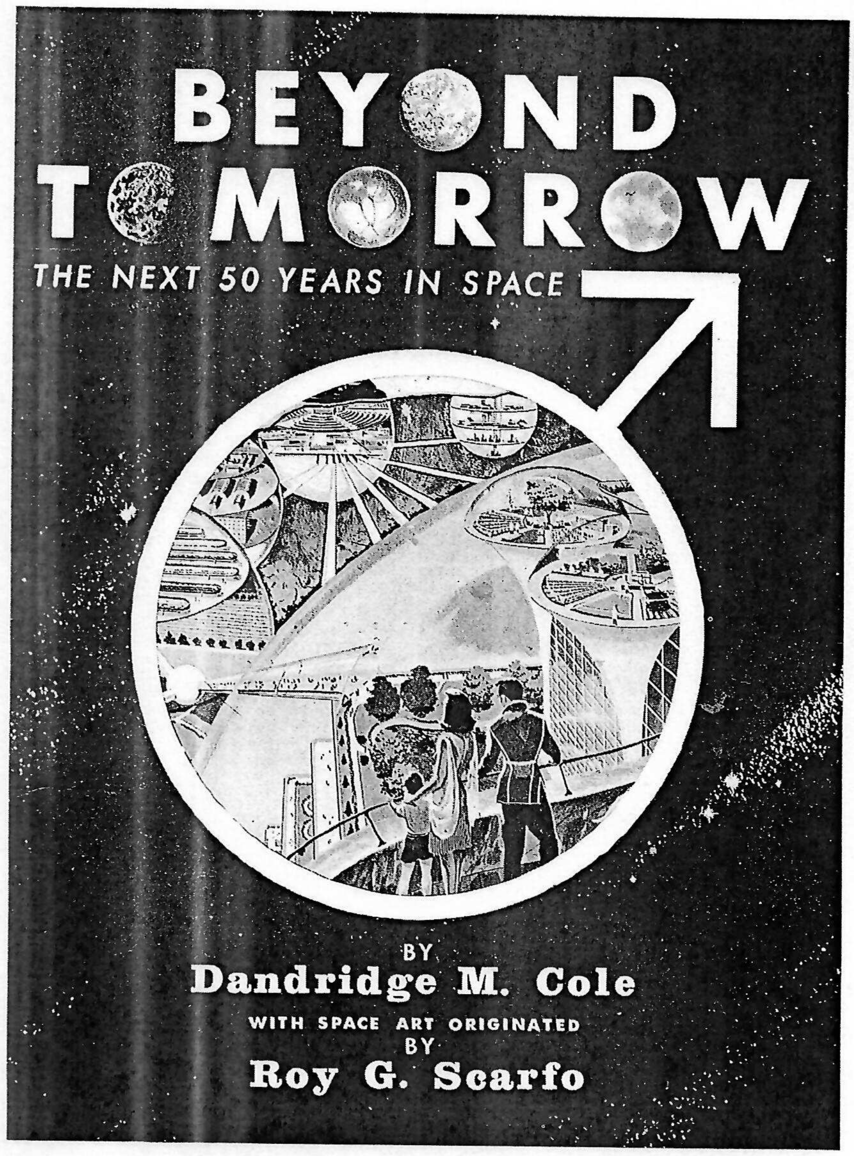
$$F/\sqrt{1-(v/c)^2} = \frac{C m' m}{r^2}$$

--- Track for motor



★★★★★★★★★

Will You Live To Go To Mars?



If you think so, here is a book you should read. This is a picture of Space as it is today, and will be tomorrow, in the opinion of a leading Space scientist and one of America's top Space artists. We are going out into the realm of the stars, to take our place in that strange community of unknown planets. We should have some facts at our disposal so that we will know what it will be like "out there". This book is one you will find tremendously exciting, scientifically plausible, emotionally staggering, inspiring yet frightening. You owe it to yourself to put "space travel" into a scientific framework. This book will do it! Highly recommended by the editors.

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