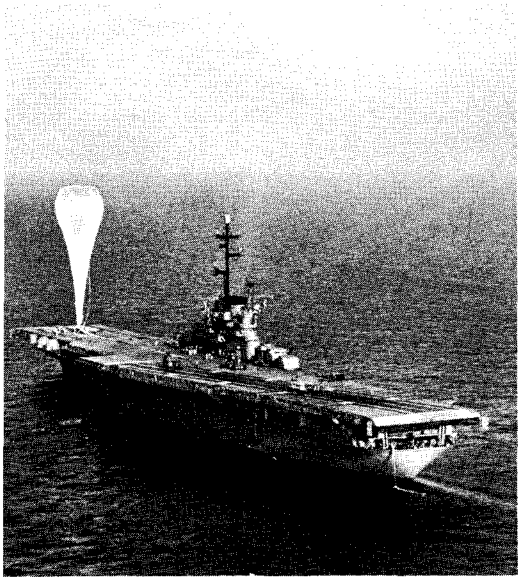
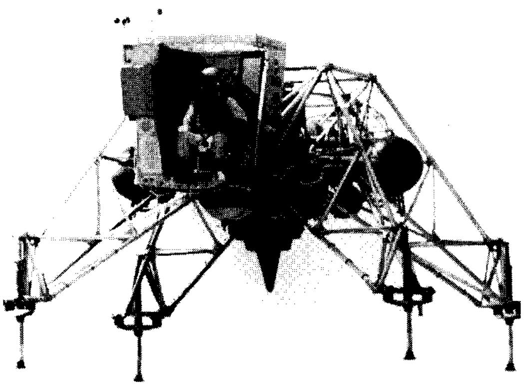
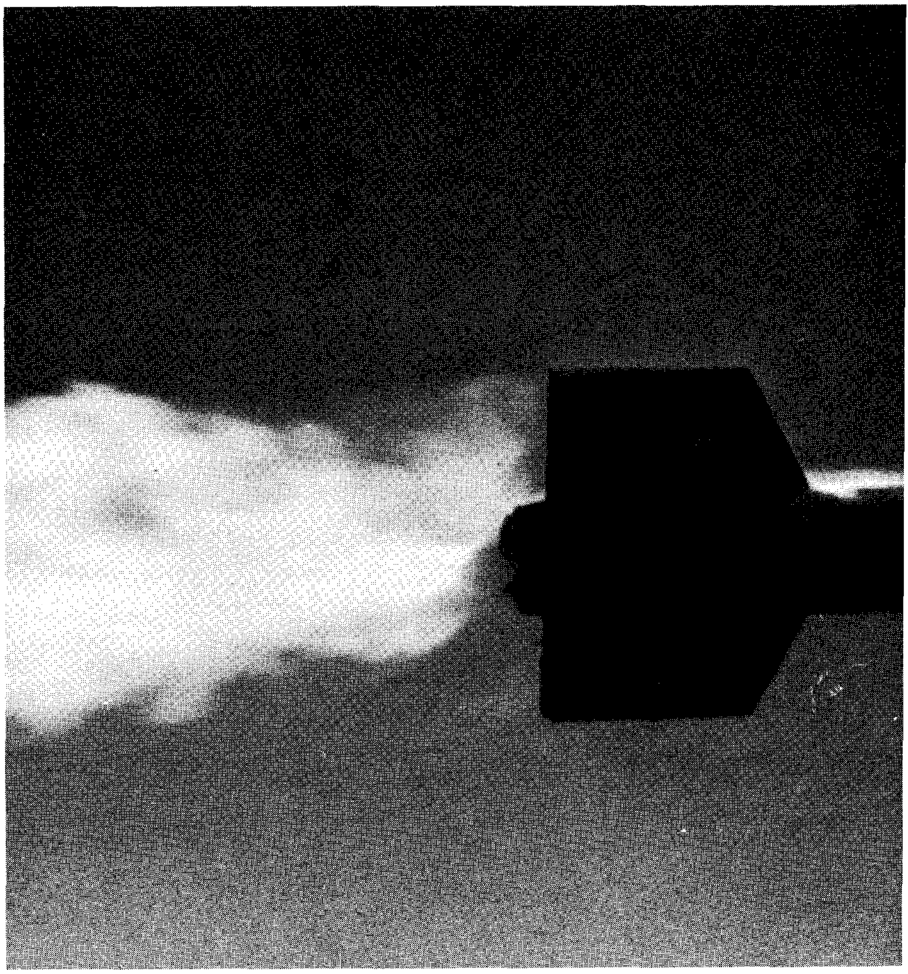
MANNED







Cdr. Malcolm Ross and LCdr. Victor Prather lift off Antietam enroute to a world record altitude of 21½ miles, set in May 1961. Below, Navy astronaut Charles Conrad, Jr., commander of Apollo 12, operates a lunar landing training vehicle. The X-15 rocket-powered aircraft, right, used to explore the edge of space, benefited from acceleration force studies conducted at the Navy's Medical Acceleration Laboratory.

In 1935 after the record flight of Tex Settle and Mike Fordney, another balloon, sponsored jointly by the Army Air Corps and the National Geographic Society, rose to the then incredible altitude of 72,395 feet. Its sealed gondola manned by Captains A. W. Stevens and O. D. Anderson, *Explorer II* established a mark unchallenged for two decades. Undoubtedly, WW II had a tendency to divert interest in high altitude research experiments. And, too, there were those who felt that the mark set by Stevens and Anderson could not be surpassed by a manned balloon, a conclusion based on the fact that a rubber balloon expands during ascension into the stratosphere — to the point where it finally explodes.

But, at the end of the war, Navy interest began to center on the use of plastics, which do not have the expansion characteristics of rubber. The first plans for a manned balloon flight into the upper atmosphere were made by the Office of Naval Research (ONR) in 1946. At that time, it was realized that a stable platform, from which scientific observations could be made, was

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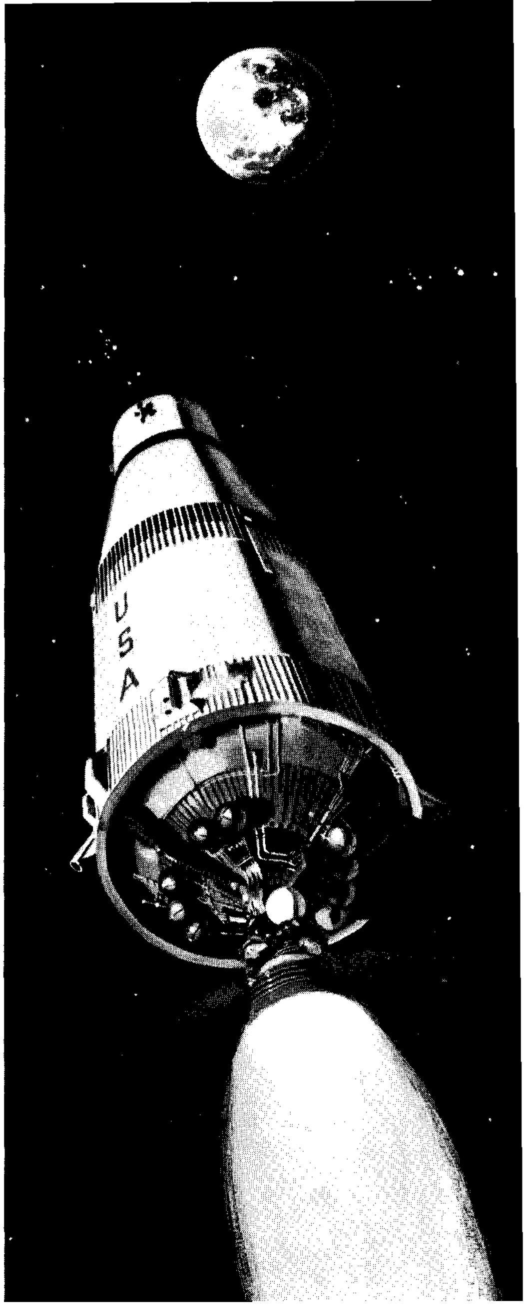

needed to gather information on near-space physics, nuclear energy, cosmic radiation and in connection with future high altitude flight. The inherent limitations of conventional aircraft and the rockets and rubber balloons used in high altitude studies precluded their use for carrying observers to the stratosphere.

The original project, *Helios,* was named for the Greek sun god. A contract with the University of Minnesota and General Mills, Inc., called for the construction of plastic balloons and a gondola equipped with a battery of scientific instruments. A sealed cabin was to be supported by 100 of the balloons at an anticipated altitude of 100,000 feet for 10 hours.

Dr. Jean Piccard and Mr. O. C. Winzen were among the principals in the project, working along with ONR's Commander George Hoover. Their concept was to use a thin plastic material which permitted a reduction in the weight of the balloon itself to only a fraction of that of a rubber balloon, thereby allowing the plastic cluster to reach a considerably higher altitude.

Because of a lag in technology, the ambitious plan for manned flight was replaced in 1947 by Project *Skyhook,* which involved the use of polyethylene balloons carrying instrument packages to extreme altitudes. Thousands of these balloons were sent into the stratosphere for basic research.

In 1952, a new technique was developed in which meteorological *Deacon* rockets were lifted above 70,000 feet by *Skyhook* balloons. At a fixed altitude, a pressure switch would fire the *Deacon* from an almost vertical position. With the aerodynamic drag of

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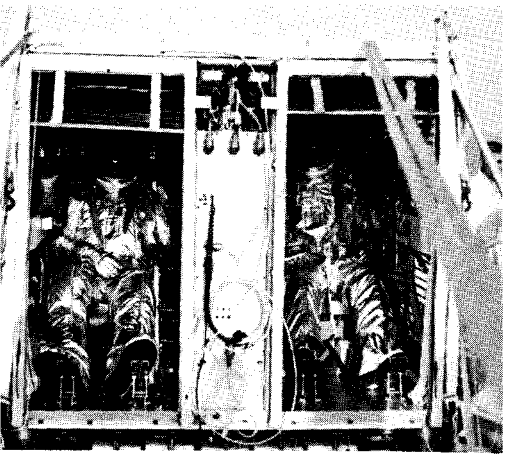


Ross and Prather, wearirng full-pressure flight suits sit in Stratolab V gondola awaiting hook-up for flight.

lower altitudes thus eliminated, the rocket could achieve a near vacuum ballistic trajectory and attain heights greatly in excess of those reached by surface-level firings. This efficient operation had been proposed by LCdr. Morton Lee Lewis of BuAer in 1949 while conducting *Skyhook* experiments aboard the USS *Norton Sound.*

So successful were the *Skyhook's* that in 1954 plans were laid to entrust the lives of men to a thin film of polyethylene plastic. Project *Stratolab* came into being the following year as a practical, economical method of obtaining fundamental data in the fields of astronomy, astrophysics and physics of the upper atmosphere. During the next six years, five *Stratolab* flights were made, four of which used gondolas originally constructed for the abortive *Helios* project.

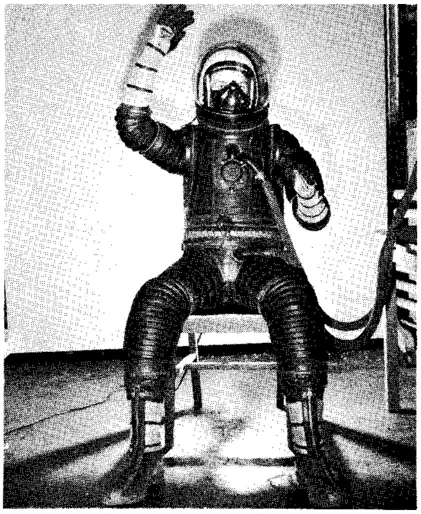
Test equipment included cameras to photograph the formation, growth and decay of contrails created by jet aircraft; special gamma telescopes for cosmic radiation study; and, most important, a wide variety of aeromedical experiments. Captain N. L. Barr of the Medical Corps developed a telemetered (radio-transmitted) version of an electrocardiograph to record the pilots' physiological reactions, heart reactions and respiratory conditions.

In 1956, *Stratolab I,* manned by Lieutenant Commanders Malcolm D. Ross and the above mentioned M. L. Lewis, attained a record altitude of 76,000 feet. As the flights progressed, the altitudes increased until on May 4, 1961, Cdr. Ross and LCdr. Victor A. Prather* (MC), a scientific observer, reached 113,739 feet in *Stratolab V.*

The *Stratolab* experiments made a number of contributions to the manned space flight program. Protons, associated with solar flare activity on the sun, were measured and found to be of such high intensity as to have an ominous import regarding their effects on man in space. This discovery necessitated development of a system whereby solar flare activity could be predicted and monitored.

Telescope astronomy provided a means of obtaining photographs of a quality and resolution heretofore impossible with earth-bound telescopes. Subsequently, an infrared system enabled unprecedented astronomical study.

*It is regrettable that both Lewis and Prather lost their lives in Stratolab-associated accidents: Lewis in a ground accident while testing a balloon gondola suspension system; and Prather at the conclusion of the record Stratolab V. Prather fell from the sling of the recovery helicopter into the sea. Water filled his suit before rescuers could get to him.



MODEL I HIGH ALTITUDE SUIT AT ACEL

The early *Stratolab* gondolas were sealed aluminum balls. *Stratolab V's* balloon hoisted an open, cage-like gondola equipped with adjustable "Venetian blinds" on its side to provide variations of the sun's radiation effects. What made this feature possible were the special full-pressure space suits worn by Ross and Prather.

The Navy *Mark IV* life-support garment had its origins in the early Thirties, not long after the exploits of Soucek and Champion. Pioneer globe-circling aviator Wiley Post requested the B. F. Goodrich Company to fabricate a type of rubber suit that he could wear in an attempt to break the Italian aircraft altitude record of 47,000 feet. Engineer Russ Colley came up with a fairly rigid suit of heavy rubberized cloth, capped with a diver's helmet. (It was stitched together on Mrs. Colley's home sewer; it eventually ruined her machine.)

Such an outfit had a bizarre appearance. One day in 1934, Post made an emergency landing in the desert and, spotting a car that had pulled up on a nearby road, he plodded over to it in his strange suit and helmet, waving at the driver. Post had to chase the frightened man around the car before catching him and convincing him that he was truly of this planet.

Within 20 years, most of the problems of suit maneuverability had been solved. Colley devised swivel joints, rotating bearings and fluted joints. (He had observed a tomato worm in his garden and was inspired by its chenille-like bands expanding and contracting. Thus, the 1952 suit resembled a conglomeration of tomato worms and small rubber tires.)

Its joints allowed neck and shoulders to move in one plane only — but this was progress. Since rubberized fabric tends to take on the flexibility of sheet metal when pressurized, a suit pressure of 3.4 psi (equivalent to atmospheric pressure at 35,000 feet) was selected so as not to destroy mobility in zero-pressure conditions. This pressure also allowed the user to breathe 100 percent oxygen at all times without resorting to fatiguing pressure breathing and at the same

NAVY MARK I FULL-PRESSURE SUIT

time did away with the uncomfortable face mask. The Navy's Air Crew Equipment Laboratory at Naval Base, Philadelphia, meanwhile developed an aneroid pressure suit controller which automatically sensed the cabin altitude and pressurized the suit accordingly — a welcome improvement over the previous manual control system which was annoying if not hazardous.

The lab began working on space equipment well before any object had been placed in orbit. Work began to provide an emergency suit for pilots at 50,000 feet. Step by step the researchers added improvements until they had a garment which would enable man to work outside the earth's atmosphere. Six years and 25 experimental models after Colley's semi-rigid accordion pleats, the Navy and Goodrich developed the *Mark IV* full pressure suit with features that gave it a head start on the space age. Weighing only 20 pounds, it was made from nylon fiber coated with neoprene.

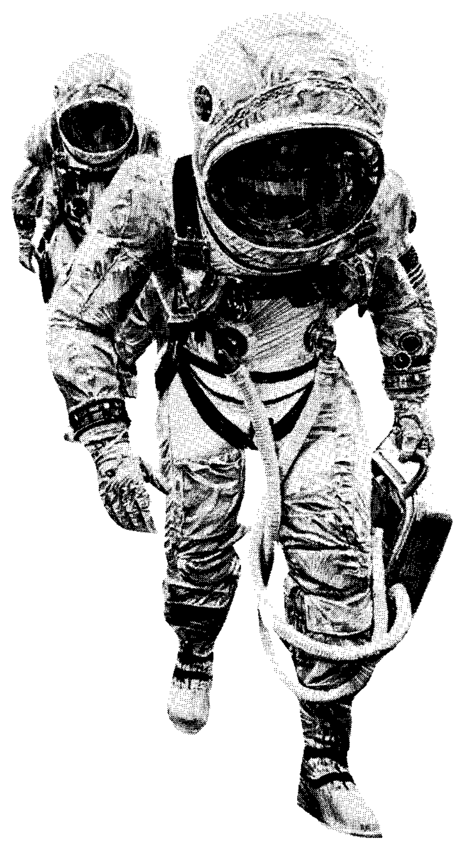
In its development, problems had to be solved in the areas of weight and bulk reduction, ventilation, air and water tightness, mobility, temperature insulation and land/sea survival capability. The *Mark IV* overcame these problems so well that NASA selected a modified version in 1959 and ordered 21 suits for use by the Project *Mercury* astronauts. The NASA "life support garment" added a coating of silver spray as a heat buffer and radiation shield. Picked for its mobility, compactness, reliability and pressure integrity, the suit looked more like a conventional flight suit than its man-from-Mars-appearing predecessors.

NASA had used the *Mark IV* suit earlier, during its X-15 research project — a forerunner of *Mercury, Gemini* and *Apollo* designed to probe the outer fringes of the earth's atmosphere. The X-15 was an exploratory vehicle used to examine aerodynamic heating, stability and control at high speeds on the edge of space — problems likely to be encountered in manned space flight. LCdr. Forrest S. Petersen, one of the pilots assigned to the X-15 project, wore the suit while reaching the then record altitude of 102,000 feet in the rocket-powered craft. "We found out a great deal about space and equipment," he says. "We learned about reaction controls and how much a man could handle at high speeds. We also learned a lot of lessons and techniques in manufacturing equipment which would withstand the extreme high temperatures caused by friction."

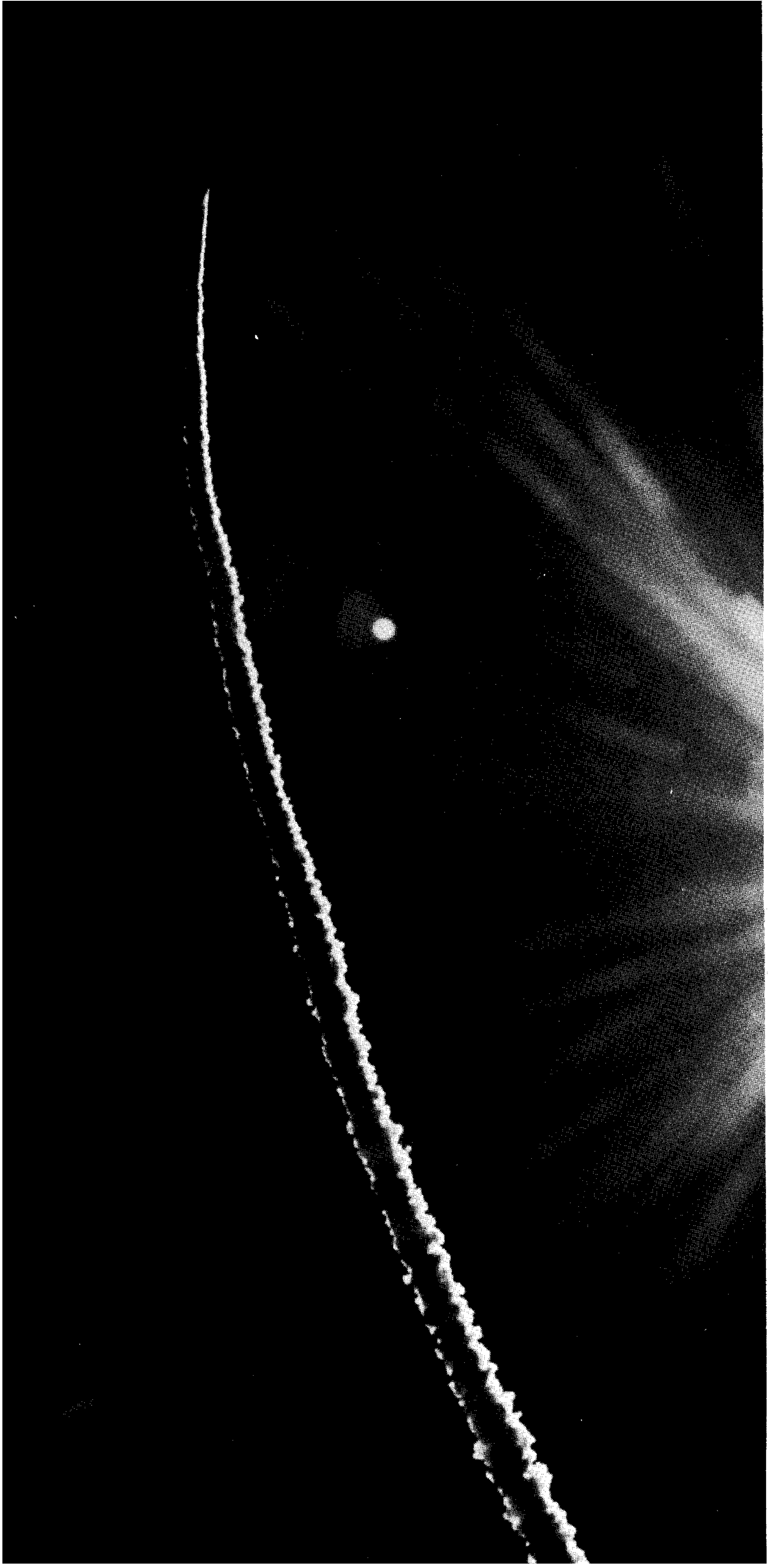
Among other things studied during this initial preparation for space flight were the biological and physical effects of acceleration forces occurring in the X-15. The National Advisory Committee for Aeronautics (NACA), after two years of intensive study of the problems likely to be encountered in manned space flight, submitted a proposal to the Department of Defense for the construction of an airplane capable of the extremely high speeds and altitudes necessary for the desired exploration. The X-15 was designated the test vehicle, and NACA began preparations for its flights by defining the flight profiles needed to gather the needed information. The Navy's Aviation Medical Acceleration Laboratory (AMAL), Johnsville, Pennsylvania, was asked to provide an environment in which man and machine could be subjected to practically all of the actual flight stresses and phenomena caused by acceleration forces.

In order to determine how these factors would affect the pilot's control abilities, AMAL (now the Aerospace

LCdr. Petersen, Navy X-15 pilot, wears Mark IV full-pressure suit later adopted for NASA's space flight program.

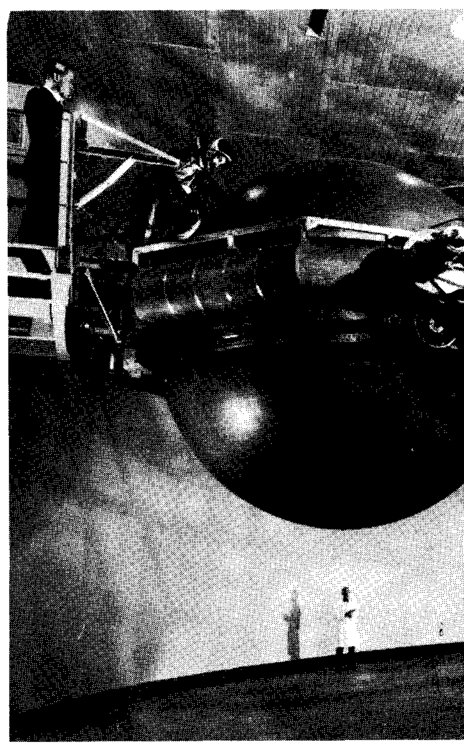


Drawing by Paul Calle
Courtesy NASA



Medical Research Department) combined its centrifuge with the Naval Aeronautical Computer Laboratory's (NACL) analog computer to reduce all variables concerning pilot toleration to acceleration forces to known factors. The tests included studies of the pilot's ability — under high G loads — to exercise the precise manual control necessary to keep the X-15 on its exacting flight profile, execution of emergency procedures during uncontrolled gyrations and application of minute corrections necessary to boresight the only safe re-entry corridor.

In March 1957, the first centrifuge program was conducted at AMAL to evaluate pilot tolerance, performance and ability to control the aircraft at forces up to 8 G's. By November, a second series was begun to evaluate the pilot's ability under specific flight conditions during exit and re-entry of the atmosphere. In this group of tests, the pilot was able to control the centrifuge through NACL's "closed loop" system linked to its computer which, by processing control signals together with aerodynamic equations, placed the appropriate G forces on the gondola. More tests in the summer of 1958 led to changes in the instrument

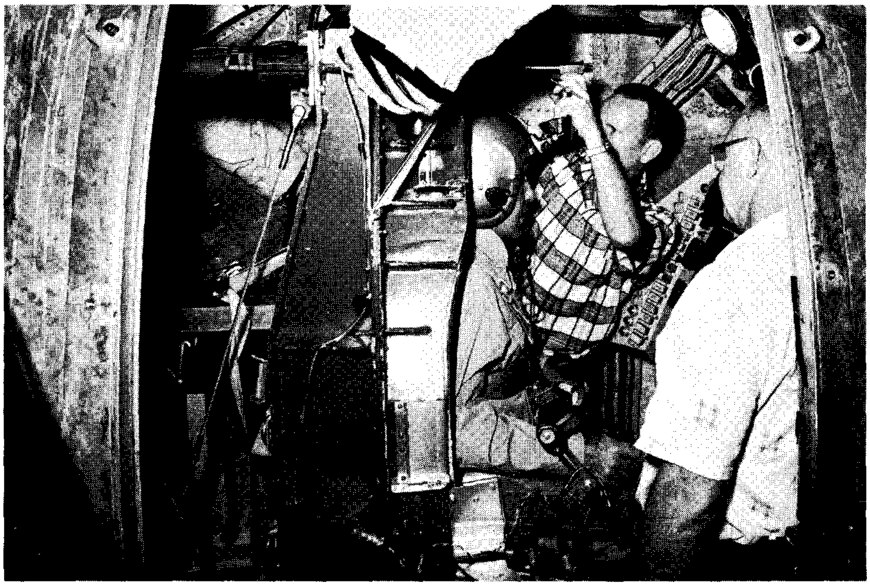


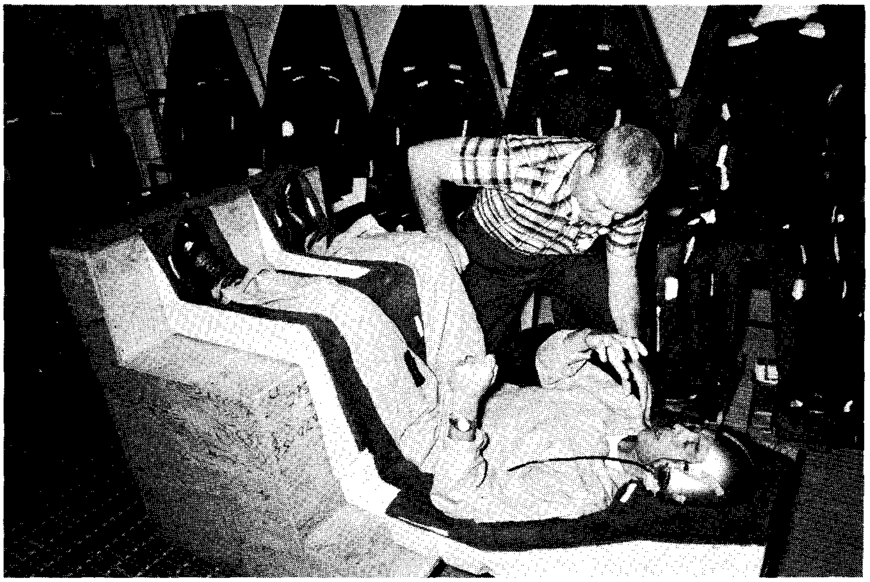
panel and to improvements in the pressure suit.

As the tests for the X-15 project came to an end, NASA (which had by this time absorbed NACA) came forward with new requirements. Data was needed to evaluate three types of proposed spacecraft — the high drag capsule, the high drag variable lift capsule and the glide capsule. Navy, Marine and Air Force pilots were selected to participate in the simulation program — which evolved into the astronaut acceleration simulation training program. The high drag capsule *(Mercury* spacecraft) was the type selected, based in part on the results of some 231 dynamic runs in the centrifuge. These dynamic runs explored problems associated with each type of craft. Further acceleration testing commenced in June 1959 when the centrifuge was used to simulate boost/orbital problems anticipated during the launch phase of manned space vehicles. Pilot physiology and performance of launch and orbital tasks were the subject of the tests, which simulated the effects of two-stage and four-stage accelerations ranging from 3 to 15 G's. These tests aided in the solutions of some basic questions concerning the degree of manual vs. automatic control which would be appropriate in achieving orbital research. The simulation also enabled evaluation of an astronaut contour couch developed at Johnsville in conjunction with NASA's Langley Research Center.

Later that summer, the original seven *Mercury* astronauts began their acceleration training at Johnsville and, for the first time, were able to experience some of the physiological effects of the acceleration they might expect to encounter during launch and re-entry. Using a preliminary test model of the proposed *Mercury* three-axis side-arm control stick and a *Mercury-type* control panel built by the Naval Air Development Center, the seven astronauts made 147 runs in the centrifuge. Participating engineers and scientists made another 98 runs in order to become familiar with the problems of launch and re-entry G forces. In all, the *Mercury* astronauts,

X-15, left, soars upward in quest for space data. Below, Navy centrifuge is prepared for test to study effect of acceleration forces. Wally Schirra is assisted before simulated space flight in centrifuge gondola. His right hand rests on Mercury three-axis control. Alan Shepard, below right, tries acceleration couch at the Aviation Medical Laboratory.





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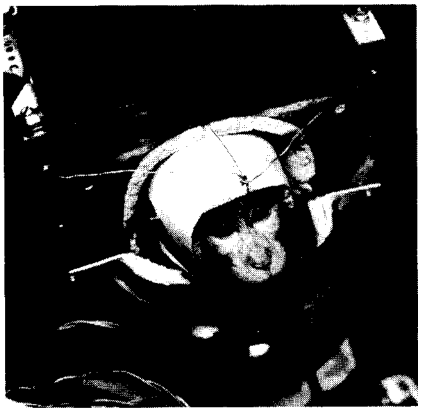

Naval Aerospace Medical Institute bio-pack is fitted on monkey, Able, during early space flight. Richard Gordon, undergoes water survival training at Pensacola, center. Below, UDT members rig Navy-developed flotation gear on Gemini capsule.

between 1959 and 1963, took part in eight acceleration training programs ranging from familiarization and equipment refinement to complete mission runs and continuing refresher training.

While the *Mercury* project was still being readied, other space programs were being serviced by AMAL's centrifuge. They included human engineering studies for use in *Gemini* design, military astronauts' classes from the USAF Aerospace Research Pilots School and feasibility evaluations for NASA's Manned Spacecraft Center. In June 1963, astronaut training for the *Gemini* program began. A wide range of normal and emergency conditions were simulated and a continuing evaluation of the *Gemini* cockpit was conducted. Studies of *Apollo* mission problems started a few months later in September and the following month, initial full-scale *Apollo* simulation runs were commenced to provide early information for preliminary equipment design based on the effects of acceleration on crew performance. Training for astronauts and design evaluation of spacecraft equipment continued throughout the *Gemini* program while preparations were made for the *Apollo* series. In June 1965, AMAL completed its services to the *Apollo* program with a series of tests which evaluated two types of *Apollo* pressure suits and collected data for suit refinement and selection.

NASA also called on the Naval Aerospace Medical Institute (NAMI), Pensacola, Fla., to contribute to the Manned Space Flight program. There a number of NASA-requested studies were conducted over the years, including the effects on man of spatial disorientation, sound and vibration, and prolonged low-grade rotational forces (the latter in connection with problems of providing an artificial gravity in an orbiting space station). Physiological research with small mammals at NAMI produced bio-packs for the primates who preceded man into space. Other research studied the effects of prolonged weightlessness and lack of exercise on an astronaut's cardiovascular system. Additional experiments ranged from the study of cosmic radiations' effect on the ionization of a spacecraft's atmosphere to research into the effects of high and low magnetic fields on man. (The moon's magnetic field is only one-thousandth that of earth.) NAMI studies concerning capsule egress and sea survival led to a decision to develop a flotation device for the re-entry craft. The Naval Air Rework Facility (NARF) at NAS Pensacola got the job of developing and constructing the device. Under the direction of John Staples, a flotation collar was designed and fabricated for use with the *Mercury* capsule. Later, other versions were built in NARF's shops for the *Gemini* and *Apollo* spacecraft. Special recovery equipment for lifting the capsules from the sea was also designed and built by the facility. Not to be left out, one other Pensacola activity joined in advancing the space program. NAS Pensacola's Schools Command assisted by providing water survival training for the astronauts.

The Navy's Air Crew Equipment Laboratory (ACEL), in addition to its earlier work in developing the *Mark IV* space suit, fitted and trained the astronauts in its use. During the training phase, ACEL's low pressure chamber, also used for the *Mercury* project, was put to use. The capsule was placed inside and the atmosphere was evacuated to near space-like conditions; then various emergencies were simulated, from fire in the capsule to loss of interior air pressure.