NASA Apollo Program
Historical Information

NASA Apollo Command Module News Reference

North American Aviation (NAA)
1968

APOLLO SPACECRAFT NEWS REFERENCE

COMMAND MODULE

It took 400 years of trial and failure, from da Vinci to the Wrights, to bring about the first flying machine, and each increment of progress thereafter became progressively more difficult.

But nature allowed one advantage: air. The air provides lift for the airplane, oxygen for engine combustion, heating, and cooling, and the pressurized atmosphere needed to sustain life at high altitude. Take away the air and the problems of building the man-carrying flying machine mount several orders of magnitude. The craft that ventures beyond the atmosphere demands new methods of controlling flight, new types of propulsion and guidance, a new way of descending to a landing, and large supplies of air substitutes.

Now add another requirement: distance. All of the design and construction problems are re-compounded. The myriad tasks of long-distance flight call for a larger crew, hence a greater supply of expendables. The functions of navigation, guidance, and control become far more complex. Advanced systems of communications are needed. A superior structure is required. The environment of deep space imposes new considerations of protection for the crew and the all-important array of electronic systems. The much higher speed of entry dictates an entirely new approach to descent and landing. Everything adds up to weight and mass, increasing the need for propulsive energy. There is one constantly recurring, insistent theme: everything must be more reliable than any previous aerospace equipment, because the vehicle becomes in effect a world in miniature, operating with minimal assistance from earth.

Such is the scope of Apollo.

Appropriately, the spacecraft was named for one of the busiest and the most versatile of the Greek gods. Apollo was the god of light and the twin brother of Artemis, the goddess of the Moon. He was the god of music and the father of Orpheus. At his temple in Delphi, he was the god of prophecy. Finally, he was also known as the god of poetry, of healing, and of pastoral pursuits.

The Apollo Spacecraft News Reference was prepared by the Space Division of North American Rockwell Corp., Downey, Calif., in cooperation with NASA's Manned Spacecraft Center.

The book is arranged in five distinct parts. The first (identified by white tabs) includes general information about the program, the elements of the spacecraft and launch vehicles, and the missions. The second part (blue tabs) is a detailed description of the Apollo modules. The third (tan tabs) contains descriptions of the equipment and operation of major subsystems. The fourth (green tabs) concerns vital operations and support, and the fifth (gray tabs) contains a series of references.

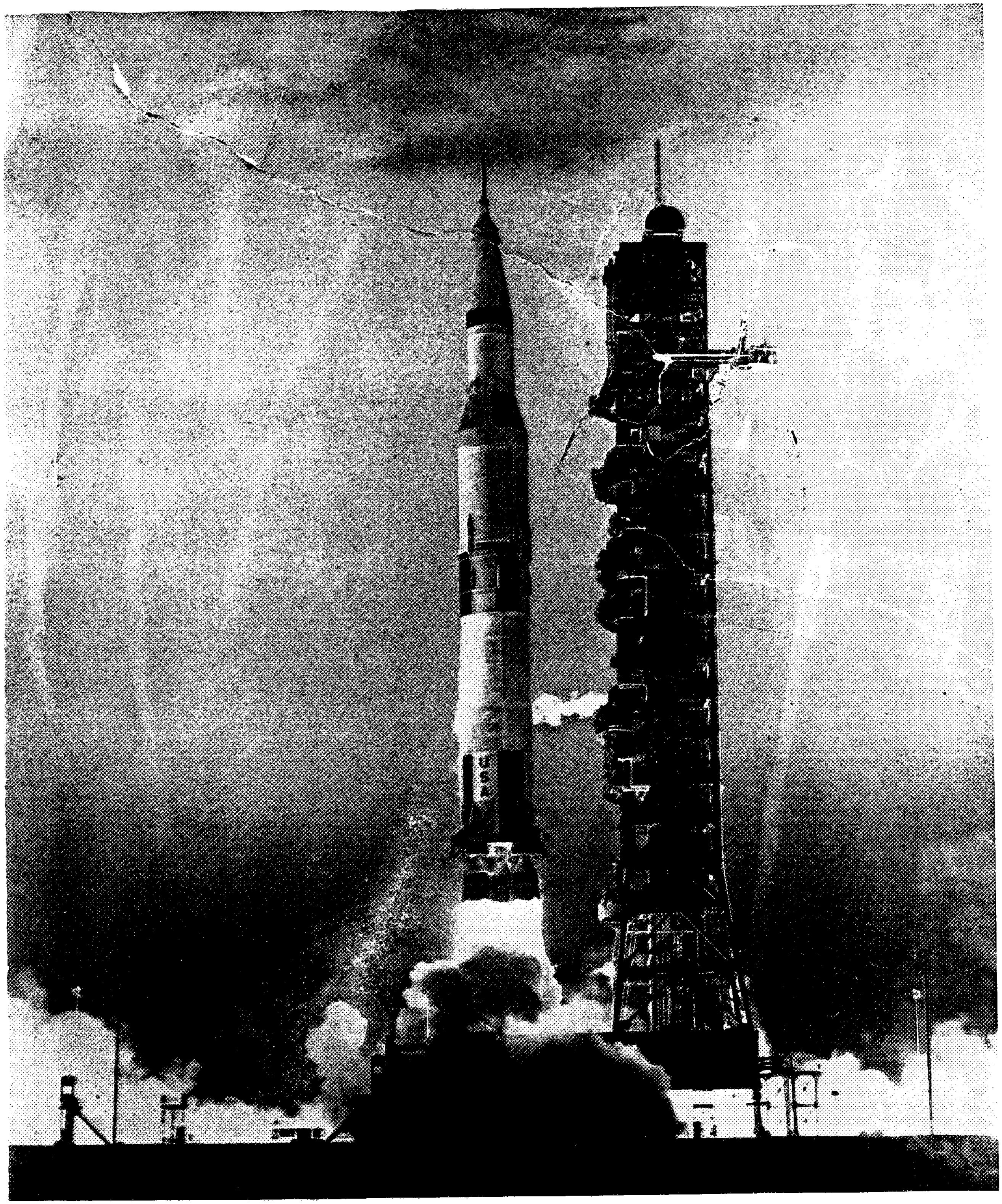
Information on most of the subsystems follows this format: first, a general description of the system, its equipment, and its function; second, an equipment list containing all major data about key equipment; and third, a detailed description of subsystem operation. The general description should provide all the information normally needed about each subsystem; the detailed description is necessarily quite technical and is included in response to requests for this level of detail.

Descriptions and data are taken from the latest available information. As modifications are made to equipment in response to continuing tests, the book will be amended to reflect these changes.

Photographs or illustrations in this volume are available for publication. Prints may be ordered according to the code designation (P-1, P-2, etc.) appearing at the lower left corner of each illustration. Send requests to:

Public Relations Department
Space Division
North American Rockwell Corp.
12214 Lakewood Blvd.
Downey, Calif. 90241

CONTENTS



P-1

Saturn V lifts Apollo spacecraft off pad in unmanned flight test

APOLLO PROGRAM

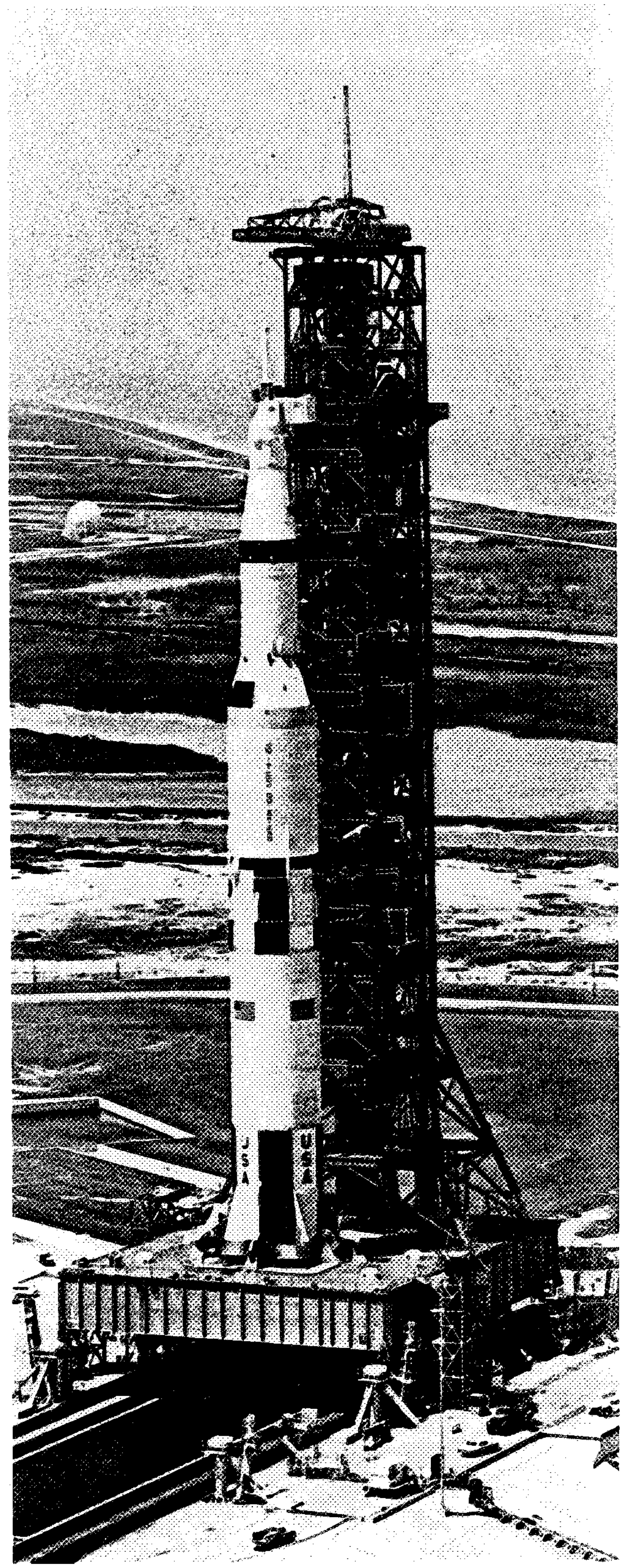
Apollo is the United States program to land men on the moon for scientific exploration and return them safely to earth. It has been described as the greatest scientific, engineering, and exploratory challenge in the history of mankind.

The challenge essentially was to create an artificial world: a world large and complex enough to supply all the needs of three men for two weeks. The world had to contain all of the life-sustaining elements of earth—food, air, shelter—as well as many special complex extras (navigation, propulsion, communications). Perhaps the greatest challenge was that of reliability; everything had to work and keep working no matter what the circumstances. Unlike the previous manned space programs in which crewmen could return to earth almost within minutes if an emergency arose, it could be as much as three days before the Apollo crew can get back to earth from the moon.

A parallel problem was to develop a launch vehicle large enough to put this world into space and to send it on its way to the moon 239,000 miles away. Many different plans were examined before the technique of lunar orbit rendezvous was selected.

NASA announced the Apollo program and its objectives in July of 1960. As President Kennedy pointed out to Congress on May 25, 1961, the overall objective is for this nation "to take a clearly leading role in space achievement which in many ways may hold the key to our future on earth." Of the lunar landing mission in particular, he said: "No single space project in this period will be more exciting, or more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or so expensive to accomplish."

On Nov. 28, 1961, after a series of studies on the feasibility of the project, NASA awarded the basic Apollo spacecraft contract to the Space Division of North American Rockwell Corporation (at that time North American Aviation, Inc.). Development of a large carrier rocket—the Saturn program—had begun in late 1958 and in early 1962 was changed and expanded to meet the new goal of a landing on the moon.



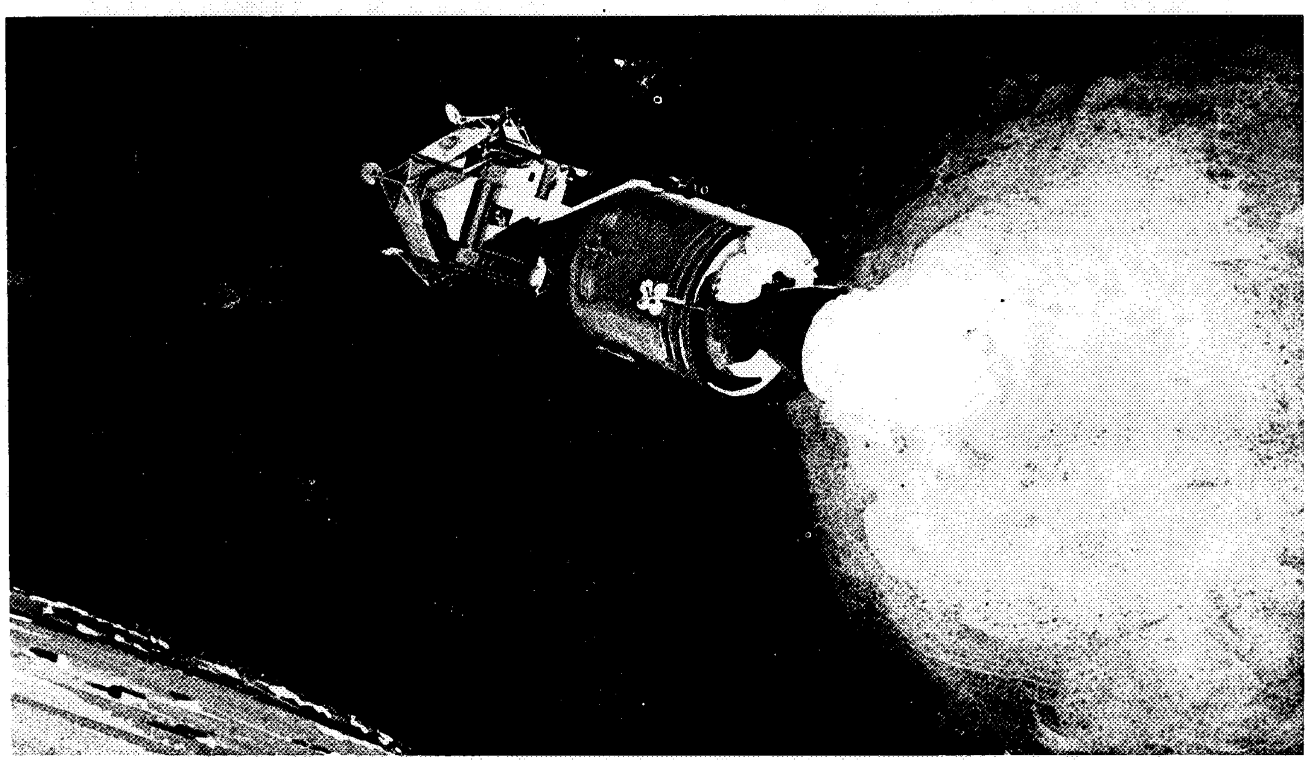
P-2 *Saturn V/Apollo shortly before launch*

Briefly, the objective of the program is to send a three-man spacecraft to the moon and into orbit around it, land two of the three men on the moon while the third remains in orbit, provide up to 35 hours on the moon, return the two moon explorers to the orbiting spacecraft, and return all three safely to earth. The entire trip, from launch to earth landing, is expected to last between 8 and 10 days; the Apollo spacecraft has been designed for 14-day operation to give a wide margin of safety.

The program is the most extensive ever undertaken by any nation. During the peak in 1966, more than 20,000 companies and 350,000 persons throughout the country participated directly in it. North American Rockwell Corp.'s Space Division is principal contractor for the spacecraft's command and service modules, the launch escape system, and spacecraft-lunar module adapter, and the Saturn V second stage (the S-II). The rocket engines for all stages are produced by North American Rockwell's Rocketdyne Division. The lunar module (LM) contractor is Grumman Aircraft Engineering Corp. Spacecraft associate contractors include the Massachusetts Institute of Technology and AC Electronics Division of General Motors Corp. for the guidance and navigation subsystem, International Latex Co. for space suits, and United Aircraft Corp. for lunar surface life support equipment. Major North American Rockwell Space Division subcontractors for Apollo (contracts of more than $500,000) are listed in Part 5..

The Saturn program involves three separate launch vehicles. Two of them are used with Apollo spacecraft: the Saturn IB, a two-stage vehicle with a first stage thrust of 1,600,000 pounds, which is used for earth-orbital missions of the Apollo program; and the Saturn V, a three-stage vehicle with a maximum off-the-pad thrust of 7,500,000 pounds, which will be used for some earth-orbital missions and for the lunar mission. The Saturn I launch vehicle was used to develop large rocket engine technology.

The Apollo program is under the management of the Office of Manned Space Flight, Headquarters NASA. The Apollo spacecraft program is directed by NASA's Manned Spacecraft Center in Houston, Tex. The Saturn program is under the management of NASA's Marshall Space Flight Center in Huntsville, Ala. Pre-flight checkout and testing and launch activities are directed by NASA's Kennedy Space Center at Cape Kennedy, Fla.



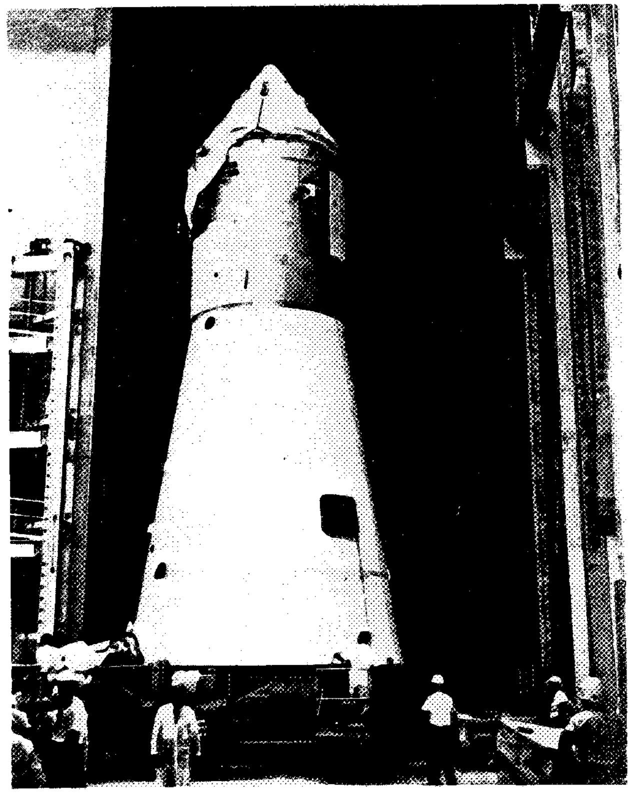
P-2a *Artist's conception of Apollo spacecraft in orbit around the moon before lunar landing*

APOLLO SPACECRAFT

The Apollo spacecraft is the entire structure atop the launch vehicle. It is 82-feet tall and has five distinct parts: the command module, the service module, the lunar module, the launch escape system, and the spacecraft-lunar module adapter.

The three modules make up the basic spacecraft; the launch escape system and adapter are special-purpose units which are jettisoned early in the mission after they have fulfilled their function. The launch escape system is essentially a small rocket which will thrust the command module—with the astronauts inside—to safety in case of a malfunction in the launch vehicle on the pad or during the early part of boost. The spacecraft-lunar module adapter serves as a smooth aerodynamic enclosure for the lunar module during boost and as the connecting link between the spacecraft and the launch vehicle.

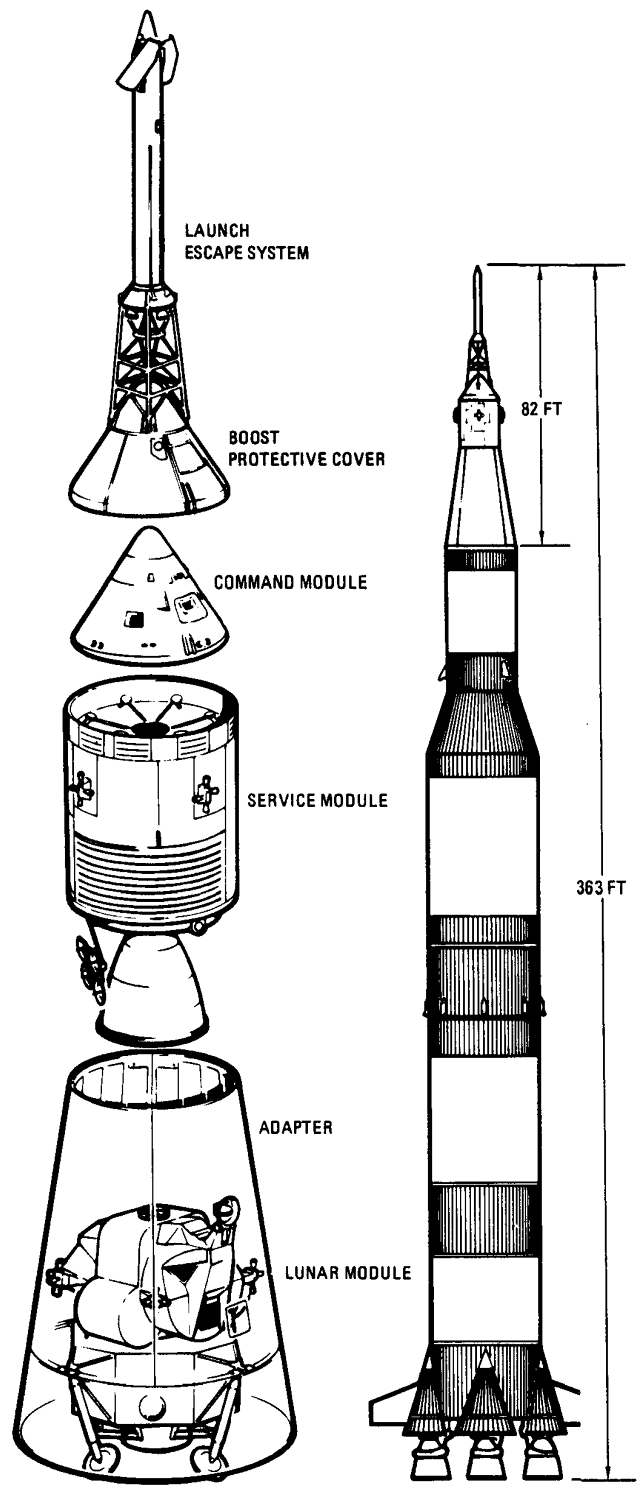
The spacecraft program has been divided into two parts, referred to as Block I (early earth-orbital test) and Block II (lunar mission version). The Block I program has been completed, and all future Apollo spacecraft flights will be with the Block II lunar mission type.



P-3

Spacecraft just before mating with Saturn V

	CM	SM	LM
Shape	Cone	Cylinder	Bug-like cab on legs
Height	10 ft, 7 in.	22 ft, 7 in. excluding fairing	22 ft, 11 in. (legs extended)
Diameter	12 ft, 10 in.	12 ft, 10 in.	29 ft, 9 in. (legs extended)
Habitable volume	210 cu ft		160 cu ft (approx.)
Launch weight	13,000 lb (approx.)	53,000 lb (approx.)	32,500 lb (approx.)
Primary material	Aluminum alloy Stainless steel Titanium	Aluminum alloy Stainless steel Titanium	Aluminum alloy



Apollo spacecraft

The basic difference in the two versions was in the addition, in Block II, of some equipment and systems designed specifically for the lunar mission. NASA's purpose in dividing the program was to get basic structure and systems tested in space as quickly as possible, while providing the time and the flexibility to incorporate changes. Thus, in addition to lunar equipment, Block II contains a great number of refinements and improvements of equipment and systems, many the result of continuing research and many evolving from the Block I unmanned flight and ground tests.

The spacecraft and systems described in this book are Block II.

For brevity, abbreviations for a few basic items of the Apollo program will be used throughout the book. For the spacecraft, these are CM for command module, SM for the service module, LM for the lunar module, CSM for the command and service modules together, and SLA for the spacecraft-lunar module adapter.

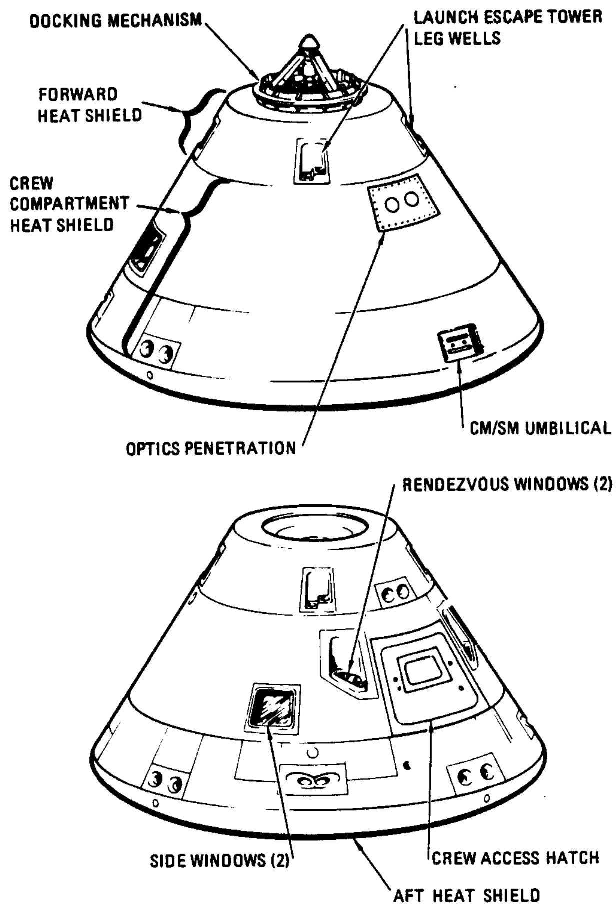
Abbreviations and acronyms are a key part of the engineering jargon; thousands are used commonly in the Apollo program. Many of the major ones are listed at the end of the glossary. Otherwise, they appear in this book only on a few diagrams or schematics where it was impossible because of limited space to spell them out. If the text does not make it clear what item of equipment is being referred to, a check with the glossary should provide the answer.

COMMAND MODULE

This is the control center for the spacecraft; it provides living and working quarters for the three-man crew for the entire flight, except for the period when two men will be in the LM for the descent to the moon and return. The command module is the only part of the spacecraft that returns to earth from space.

The CM consists of two shells: an inner crew compartment (pressure vessel) and an outer heat shield. The outer shell is stainless steel honeycomb between stainless steel sheets, covered on the outside with ablative material (heat-dissipating material which chars and falls away during earth entry).

The inner shell is aluminum honeycomb between aluminum alloy sheets. A layer of insulation separates the two shells. This construction makes the



P-5 *Command module*

CM light as possible yet rugged enough to stand the strain of acceleration during launch, the shock and heat of earth entry, the force of splashdown, and the possible impact of meteorites.

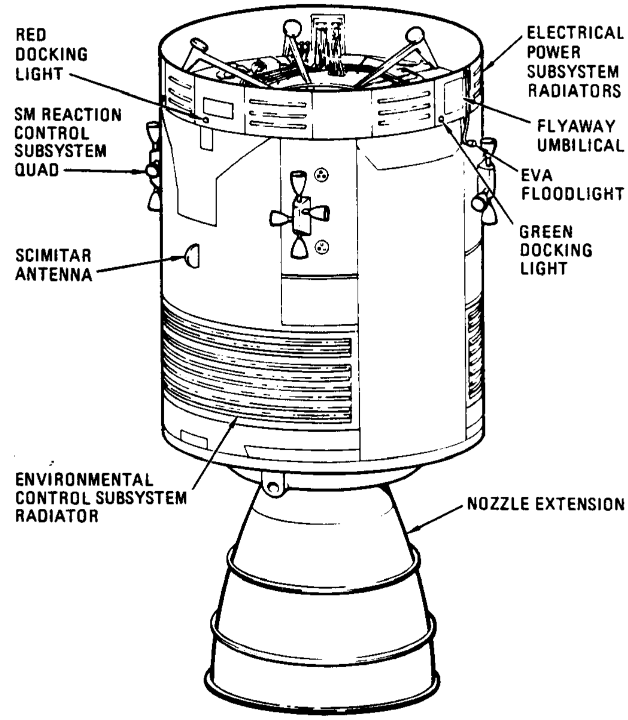
Inside, it is a compact but efficiently arranged combination cockpit, office, laboratory, radio station, kitchen, bedroom, bathroom, and den. Its walls are lined with instrument panels and consoles, and its cupboards (bays) contain a wide variety of equipment. In flight, the cabin is air conditioned to a comfortable 70 to 75 degrees. The atmosphere is 100-percent oxygen, and the pressure is about 5 pounds per square inch (a little better than one-third of sea-level pressure of 14.7 pounds per square inch).

The command module's controls enable the crew to guide it during flight. Test equipment permits checkout of malfunctions in spacecraft subsystems. Television, telemetry and tracking equipment, and two-way radio provide communication with earth and among the astronauts during moon exploration and the moon orbit rendezvous. These and other subsystems, such as the reaction control, guidance and navigation, earth landing, and parts of the environmental control and electrical power, occupy almost every inch of available space in the module.

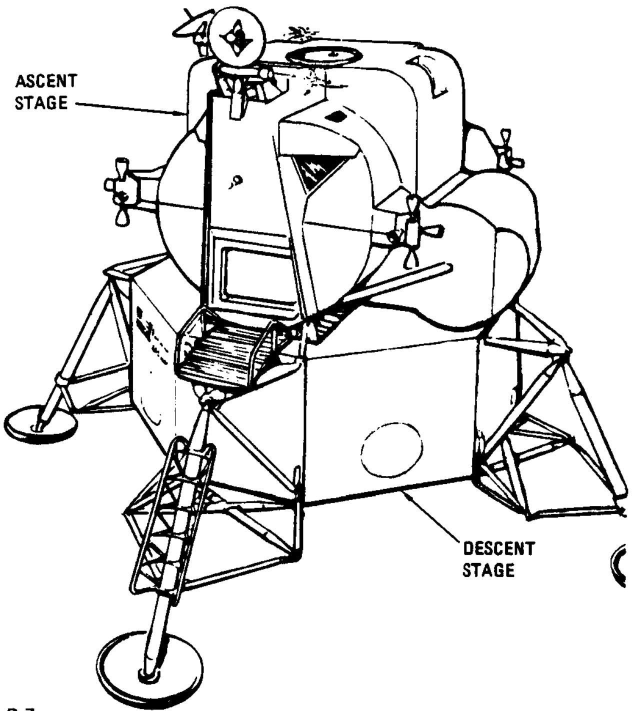
Although crewmen can move about from one station to another, much of their time will be spent on their couches. The couches can be adjusted so the crew can stand or move around. Space by the center couch permits two men to stand at one time. The couches are made of steel framing and tubing and covered with a heavy, fireproof fiberglass cloth. They rest on eight crushable honeycomb shock struts which absorb the impact of landing. Control devices are attached to the armrests.

SERVICE MODULE

The service module's function, as its name implies, is to support the command module and its crew. It houses the electrical power subsystem, reaction control engines, part of the environmental control subsystem, and the service propulsion subsystem including the main propulsion engine for insertion into orbit around the moon, for return from the moon, and for course corrections.



P-6 *Service module*



P-7

Lunar module

The SM is constructed of aluminum alloy. Its outer skin is aluminum honeycomb between aluminum sheets. Propellants (a combination of hydrazine and unsymmetrical dimethylhydrazine as fuel and nitrogen tetroxide as oxidizer) and various subsystems are housed in six wedge-shaped segments surrounding the main engine.

The service module is attached to the command module until just before earth entry, when the SM is jettisoned.

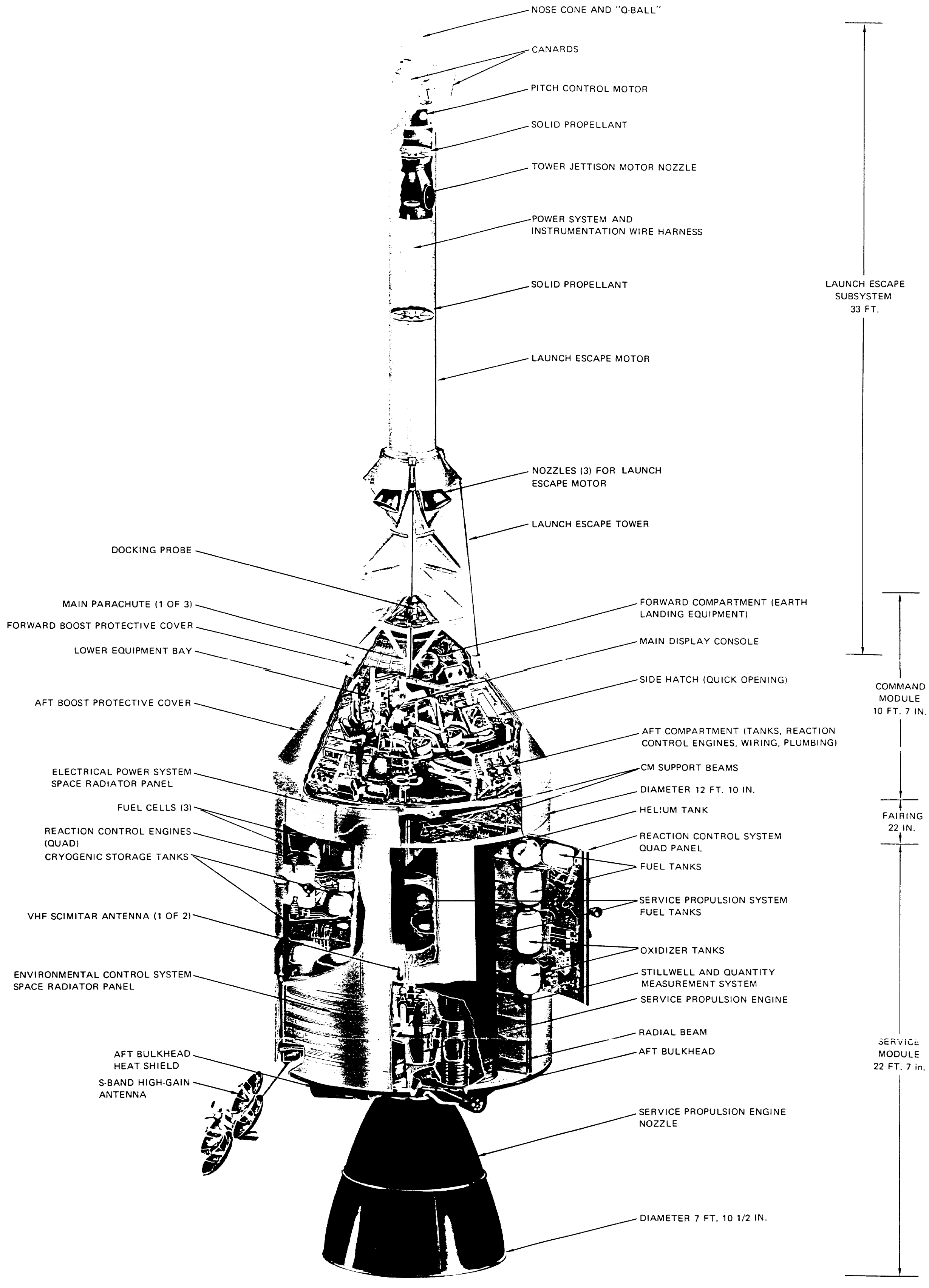
LUNAR MODULE

The LM will carry two men from the orbiting CSM down to the surface of the moon, provide a base of operations on the moon, and return the two men to a rendezvous with the CSM in orbit. Its odd appearance results in part from the fact that there is no necessity for aerodynamic symmetry; the LM is enclosed during launch by the SLA and operates only in the space vacuum or the hard vacuum of the moon.

The LM structure is divided into two components: the ascent stage (on top) and the descent stage (at the bottom). The descent stage has a descent engine and propellant tanks, landing gear assembly, a section to house scientific equipment for use on the moon, and extra oxygen, water, and helium tanks.

The ascent stage houses the crew compartment (which is pressurized for a shirtsleeve environment like the command module), the ascent engine and its propellant tanks, and all LM controls. It has essentially the same kind of subsystems found in the command and service modules, including propulsion, environmental control, communications, and guidance and control.

Portable scientific equipment carried in the LM includes an atmosphere analyzer, instruments to measure the moon's gravity, magnetic field, and radiation, rock and soil analysis equipment, a seismograph, a soil temperature sensor, and cameras (including television).



Apollo command and service modules

PAGE NOT COPIED

PAGE IS BLANK

PAGE # 8

LAUNCH VEHICLES

Development of launch vehicles for the lunar landing mission represents a tremendous stride forward in rocket propulsion: they are bigger, more powerful, and vastly more complex than previous U.S. launch vehicles.

Development of the Saturn family began in late 1958 under the Department of Defense's Advanced Research Projects Agency. The work was conducted by the Army Ballistic Missile Agency at Redstone Arsenal in Huntsville, Ala., which in 1960 was transferred in part to NASA to become the nucleus of the Marshall Space Flight Center.

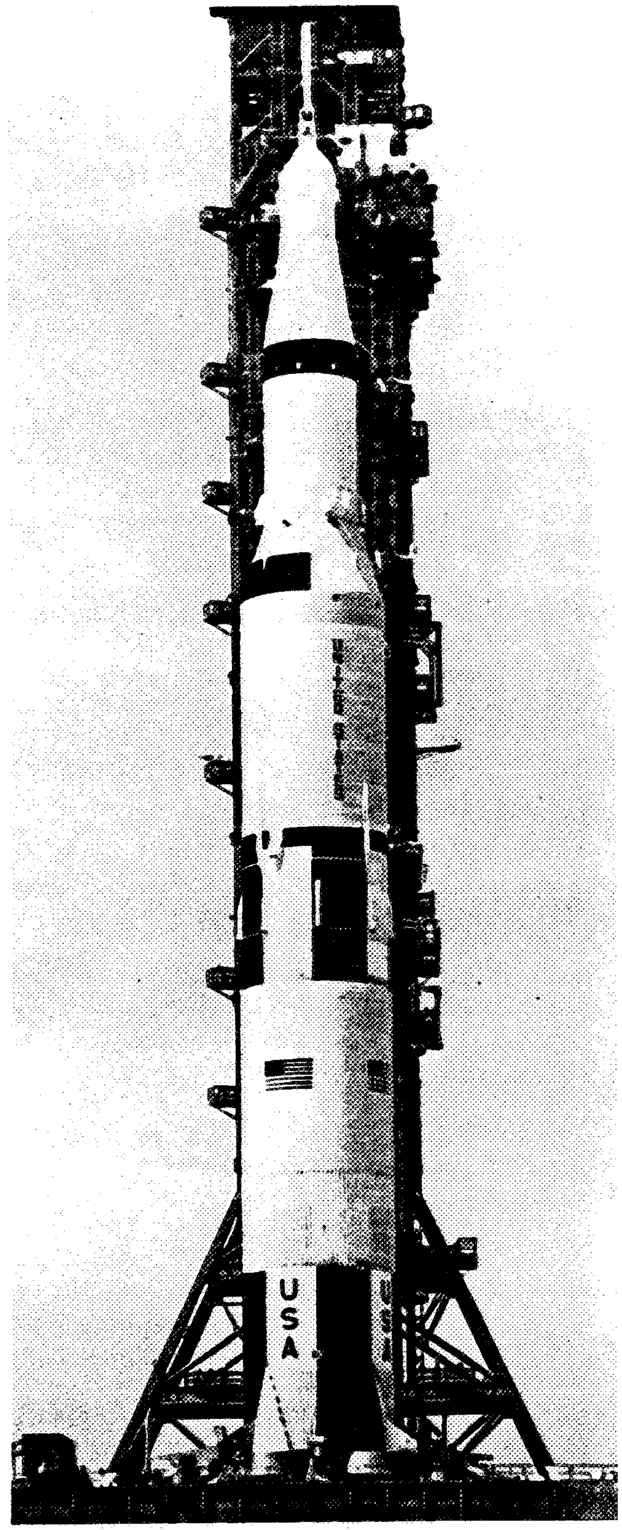
Studies under Dr. Wernher von Braun aimed at developing a booster with a total thrust of 1.5 million pounds had been conducted in 1957.

There are three launch vehicles in the Saturn family: the Saturn I, which had a perfect record of ten successful flights; the Saturn IB, and the Saturn V. The name Saturn was adopted in 1959 and at that time applied only to the 1.5 million-pound thrust vehicle which became the Saturn I.

This stepping stone approach led to the development of Saturn V in three phases: Saturn I, which used primarily modified existing equipment; Saturn IB, which uses a modified first stage of the Saturn I and a new second stage and instrument unit; and the Saturn V, which uses new first and second stages and the third stage and instrument unit of the Saturn IB.

Development of the engines needed for the Saturn vehicles was begun separately, but much of it was in parallel with the vehicle program. Work started on the F-1 engine, the nation's largest, in 1958 and on the hydrogen-powered J-2 engine in 1960. The J-2, which burns a cryogenic (ultra low temperature) propellant composed of liquid hydrogen and liquid oxygen, was the key to development of the powerful upper stages of the Saturn IB and Saturn V.

The Saturn I program is complete. From 1961 through 1965 it was launched 10 times successfully, putting Apollo boilerplate (test) vehicles and Pegasus meteoroid technology satellites into orbit.



P-8

Saturn V launch vehicle (with Apollo)

The first launch of a Saturn IB came in early 1966 and also was the first space test of an Apollo spacecraft. Succeeding tests also have been successful.

The first flight test of the Saturn V was November 9, 1967, when it boosted an Apollo spacecraft into space. A NASA report described the performance of the North American Rockwell-produced Apollo spacecraft as satisfactory in all respects.

The Saturn IB and the Saturn V are the basic heavy launch vehicles of the United States civilian space program. Saturn V will be used for Apollo test flights and for lunar missions. The Saturn IB will be used with smaller payloads.

In the early studies on the Saturn, many configurations were considered. The Saturn I originally was designated C-1; the Saturn V was C-5. Although the other configurations were dropped, the designations "I" and "V" remained.

Specific figures are given on weight, height, and amount of propellant for each Saturn vehicle. However, all are approximate. Like Apollo, changes and improvements affect the figures, particularly those on weight. In addition, each launch vehicle produced and each mission is somewhat different.

SATURN IB

The Saturn IB has two stages and an instrument unit (IU).

The first stage (S-IB) built by the Chrysler Corp., is the same size and shape as the first stage of the Saturn I (S-1), but was redesigned to cut its weight and increase its power.

The second stage (an S-IVB), produced by McDonnell Douglas Co.'s Missile and Space Systems Division, is a large, all-cryogenic booster. The cryogenic propellant—liquid hydrogen at 423° below zero F and liquid oxygen at 297° below zero—provides more energy per pound of weight than the chemical fuels used previously, but posed many problems in insulation, handling, and engine systems.

The instrument unit (IU), a cylindrical-shaped segment mounted atop the second stage, contains equipment for sequencing, guidance and control, tracking, communications, and monitoring. It was designed by NASA and is being produced by IBM's Federal Systems Division.

The engines for the Saturn IB are designated the H-1, used in the first stage, and the J-2, used in the second stage. Both are produced by North American Rockwell's Rocketdyne Division. The H-1 engine was used for the first stage of the Saturn I, but was uprated, first 200,000 pounds, then to 205,000 for the Saturn IB. The stage has eight H-1 engines for a total thrust of 1,600,000 pounds. The J-2 engine used on the second stage is more than 11 feet long and weighs about 3400 pounds. It has a thrust of up to 225,000 pounds at high altitude.

Basic facts about the two-stage Saturn IB:

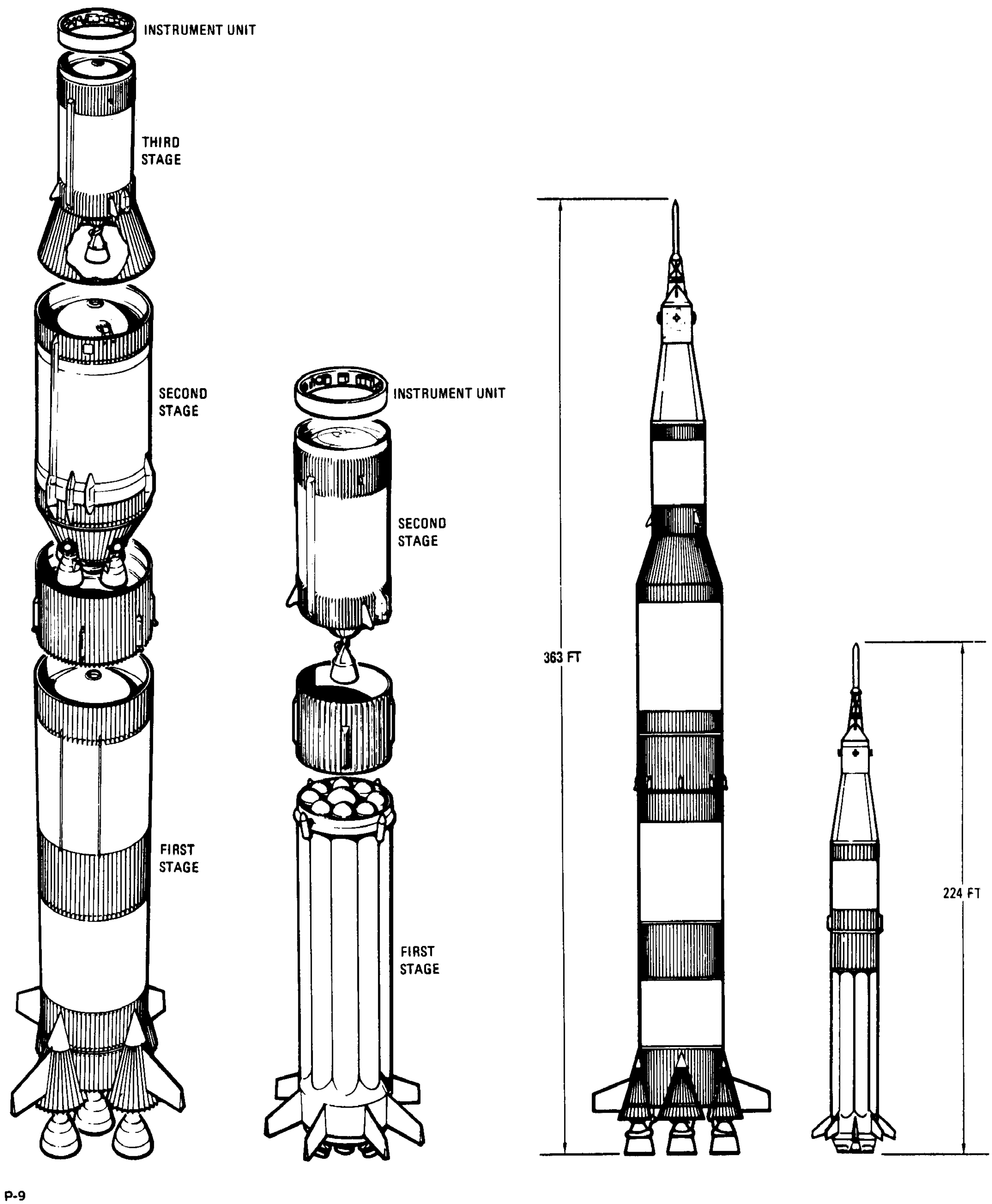
Height	138 ft (vehicle only) 224 ft (with spacecraft)
Weight	1,300,000 lb (with propellant) 153,000 lb. (dry)
Payload	40,000 lb in low earth orbit

FIRST STAGE

Height	80.3 ft
Diameter	21.4 ft
Gross weight	1,000,000 lb
Propellant weight	910,000 lb
Propellant	RP-1 and liquid oxygen
Engines	8 H-1's
Thrust	1,600,000 lb (sea level)

SECOND STAGE

Height	58.4 ft
Diameter	21.7 ft
Gross weight	253,000 lb
Propellant weight	230,000 lb
Propellant	Liquid hydrogen and liquid oxygen



Saturn V (left) and Saturn IB

Engine	1 J-2
Thrust	225,000 lb (vacuum)

INSTRUMENT UNIT

Height	3 ft
Diameter	21.7 ft
Weight	4500 lb (approximate)

SATURN V

The Saturn V is the nation's largest and most powerful launch vehicle. It has three stages and an instrument unit.

The first stage produced by the Boeing Co.'s Launch Systems Branch, is 138 feet high (higher than any entire pre-Saturn launch vehicle) and weighs close to five million pounds when fueled. The function of this stage is to lift the enormous weight (more than 6.2 million pounds) of the Apollo/Saturn V space vehicle off the pad and carry it to an altitude of about 38 miles and a speed of about 6000 miles per hour.

The second stage, built by North American Rockwell's Space Division, is the largest and most powerful hydrogen-fueled stage ever produced. It is 81.5 ft. tall and weighs more than 1 million pounds fueled. It takes over from the first stage and boosts its payload of the third stage and Apollo spacecraft into space (an altitude of about 118 miles) and to a speed of more than 14,000 miles per hour.

The third stage is essentially the same as the second stage of the Saturn IB. On the Saturn V it serves in a double capacity. After the second stage burns out and is jettisoned, the third stage's engine burns briefly, just long enough to increase its velocity to about 17,400 miles per hour and put it and the Apollo into earth orbit. It stays connected to the spacecraft from one to three orbits, then its engine is reignited at the proper moment to power itself and the spacecraft toward the moon.

The instrument unit for Saturn V is essentially the same as on the Saturn IB. Like the third stage, however, it is modified and improved to help it carry out the different missions of the Saturn V.

There are two types of main engines used on the Saturn V, both built by North American Rockwell's Rocketdyne Division. The first stage uses the F-1, the most powerful engine ever produced. It is 19 feet long, weighs about 18,500 pounds and produces 1,500,000 pounds of thrust. The first stage has five F-1 engines for a total thrust of 7,500,000 pounds. Both the second and third stages use the J-2 engine, the largest hydrogen-fueled engine ever built. The J-2 engine produces up to 225,000 pounds of thrust; the second stage uses five J-2 engines producing a maximum of 1,125,000 pounds of thrust. The third stage uses one J-2 engine.

Basic facts about the Saturn V:

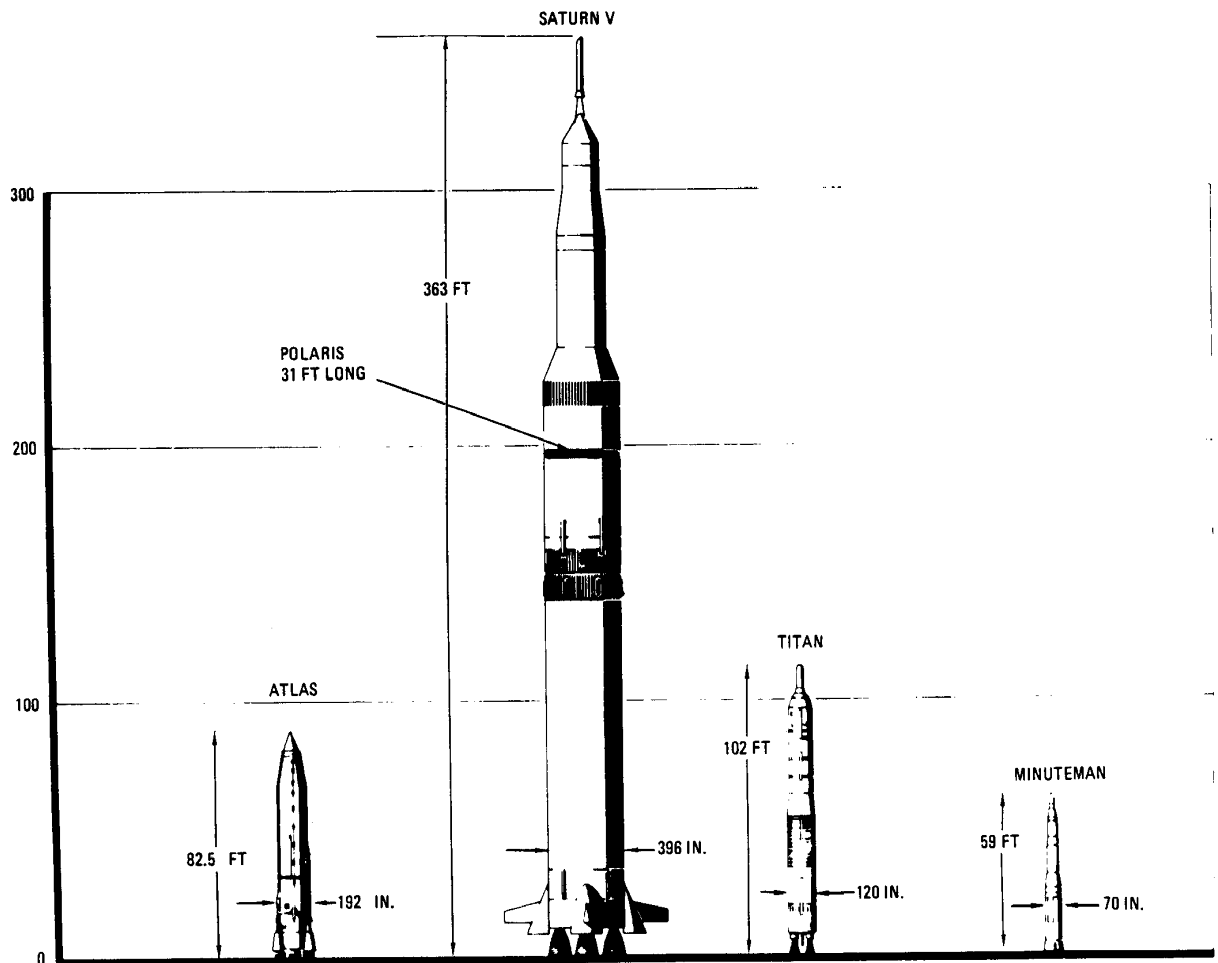
Height	282 ft (vehicle only) 363 ft (with spacecraft)
Weight	6,200,000 lb (with propellant) 430,000 lb (dry)
Payload	270,000 lb in low earth orbit 100,000 lb translunar injection

FIRST STAGE

Height	138 ft
Diameter	33 ft
Gross weight	4,792,000 lb
Propellant useable weight	4,492,000 lb
Propellant	RP-1 and liquid oxygen
Engines	5 F-1's
Thrust	7,500,000 lb (1,500,000 lb each engine)
Burning time	150 sec

SECOND STAGE

Height	81.5 ft
Diameter	33 ft



Comparison of U.S. missiles and launch vehicles

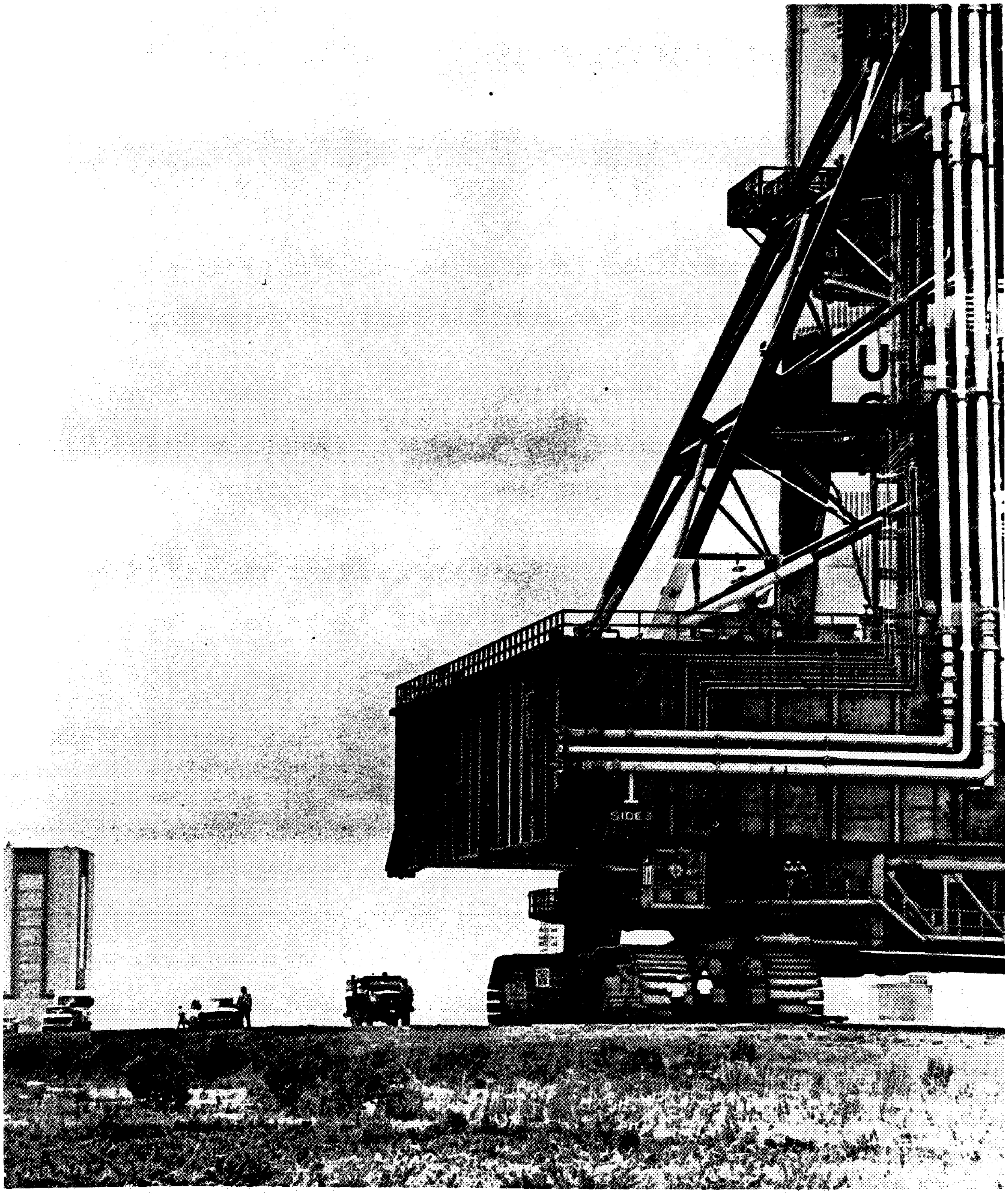
Gross weight	1,037,000 lb at liftoff
Propellant useable weight	942,000 lb
Propellant	Liquid hydrogen and liquid oxygen
Engines	5 J-2's
Thrust	1,125,000 lb (225,000 lb each engine)
Burning time	359 sec

THIRD STAGE

Height	58.5 ft
Diameter	21.7 ft (lower interstage expands to 33 ft)
Gross weight	262,000 lb
Propellant useable weight	228,000 lb (excluding reserves)
Propellant	Liquid hydrogen and liquid oxygen
Engine	1 J-2
Thrust	225,000 lb maximum (at altitude)
Burning time	480 sec (2 burns)

IU

Height	3 ft
Diameter	21.7 ft
Weight	4500 lb (approximate)



P-11 *Gigantic mobile launcher inches along on way to launch pad carrying Saturn V/Apollo*

MISSIONS

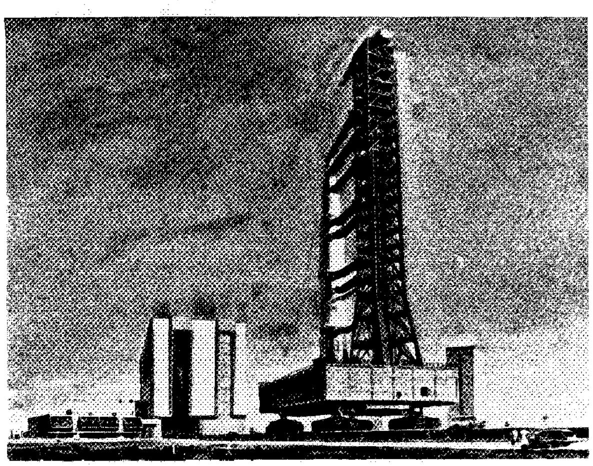
Apollo missions fall into two categories: earth-orbital and lunar. Earth-orbital and lunar-orbital missions are part of the flight-testing program to test the spacecraft, the launch vehicles, launch and communications equipment and procedures, and crew operations. The lunar mission calls for the landing of two American astronauts on the moon, exploration of the moon, and return to earth.

EARTH-ORBITAL MISSIONS

NASA's schedule of Apollo development missions is a flexible one that progresses logically toward accomplishing a lunar landing mission. The flight test program consists of unmanned flights, manned flights in earth orbit, a lunar orbital flight, and, finally, the lunar landing flight. Alternative flight plans are prepared for use in the event contingencies arise.

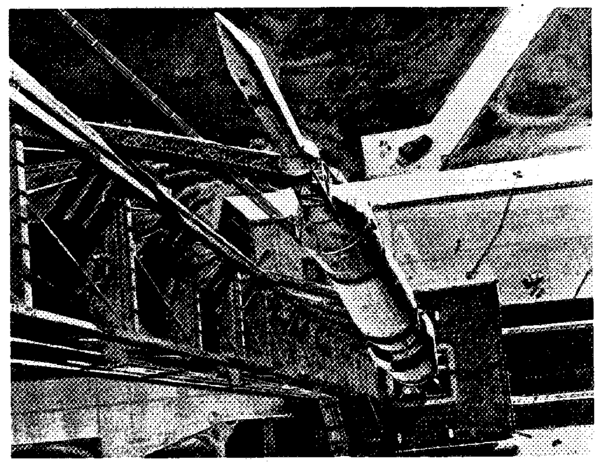
Previous flight tests of the Apollo command, service, and lunar modules--all unmanned--have been successful. CSM tests were aimed primarily at the operation of its subsystems and of man-rating the subsystems (certifying for manned space flight). Particularly important were tests of the heat shield and command module structure, which survived such rigorous conditions as the 5,000-degree heat during atmospheric entry from a lunar mission. The spacecraft's compatibility with the Saturn launch vehicles has been demonstrated.

Primary objective of the manned missions is to determine the proficiency of the crew in the complex tasks required during the lunar missions and to test the operation of the manned space flight network, the communications link that will be used during the lunar mission. Crew tasks to be evaluated are those required for navigation, transposition and docking, rendezvous and docking, major propulsion maneuvers, entry, and recovery.



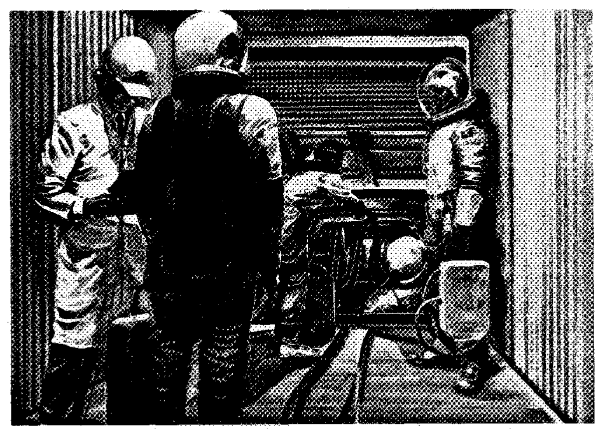
P-12

Mobile launcher carries space vehicle to launching pad



P-13

Apollo and Saturn are checked out before launch



P-14

Three astronauts enter the command module

The first manned mission is designed to test the adequacy and overall performance of all CSM subsystems, including its life support and environmental control subsystems, over a substantial period. In the first mission, only the command and service modules will be launched with a Saturn IB.

The second manned flight, designated Apollo 8, calls for low earth-orbital checkout of the spacecraft and upper portion of the Saturn V launch vehicle. The flight will be in some senses an expansion of the Apollo 7 mission. No lunar module will be flown.

The third manned earth-orbital mission will involve the CSM and LM and is designed to demonstrate the combined operation for the first time of the complete spacecraft.

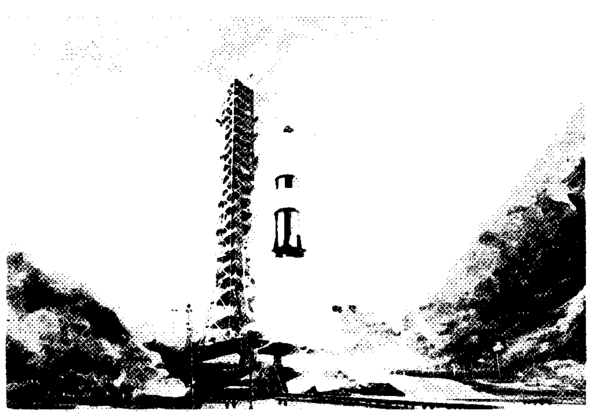
LUNAR MISSION

A lunar mission will mark the first time that astronauts will not be within minutes of earth. The landing mission will be a milestone in man's history--the first time man will set foot on another celestial body.

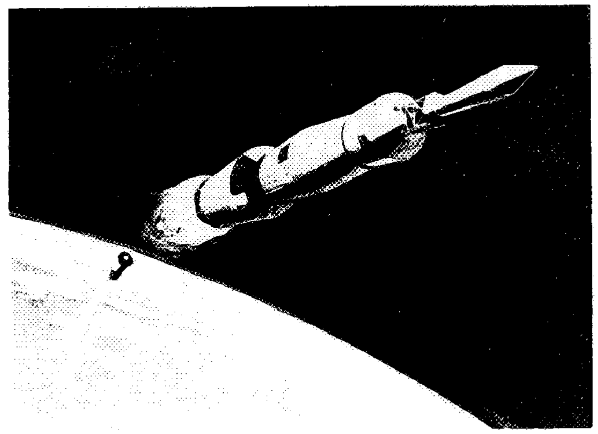
For planning purposes, the lunar mission is divided into phases. To gain an understanding of how the mission will be accomplished, each of these phases, with the exception of pre-launch and post-landing, is described.

EARTH ASCENT

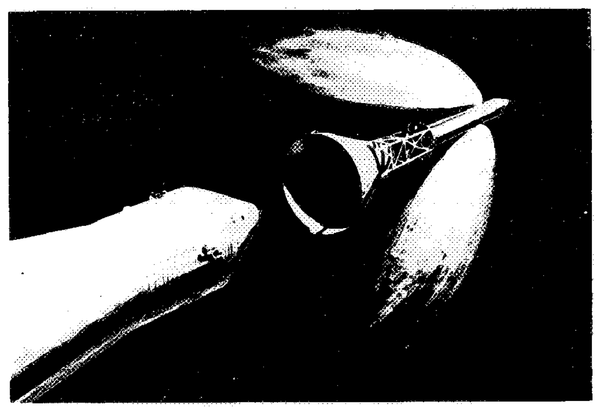
At liftoff, the Saturn V's first stage, developing over 7-1/2 million pounds of thrust from its five F-1 engines, lifts the 6.4 million-pound space vehicle off the pad and boosts it on its way. The first stage burns for about 2-1/2 minutes and reaches a velocity of about 5400 miles per hour and an altitude of about 40 miles. After the F-1 engines cut off, retrorockets on the first stage fire to achieve separation from the second stage. Four seconds later, the second stage's five J-2 engines ignite to boost the third stage and spacecraft to an altitude of approximately 114 statute miles. During its approximately 6 minutes of firing, the second



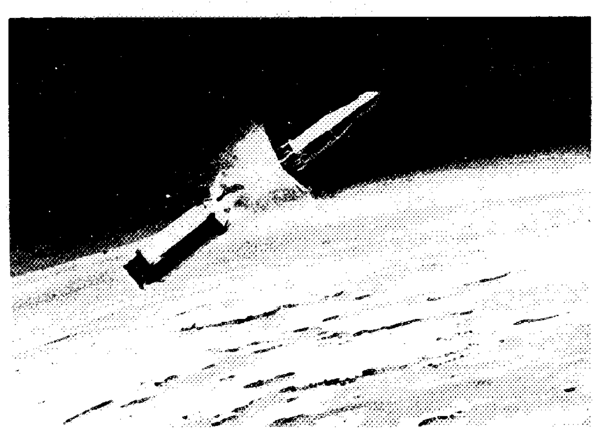
P-15 *First stage lifts huge space vehicle off pad*



P-16 *Second stage ignites after first stage falls away*



P-17 *Launch escape assembly is jettisoned*



P-18 *Third stage ignites as second stage falls away*

stage increases velocity to about 15,000 miles per hour. When its engines cut off, the second stage is jettisoned.