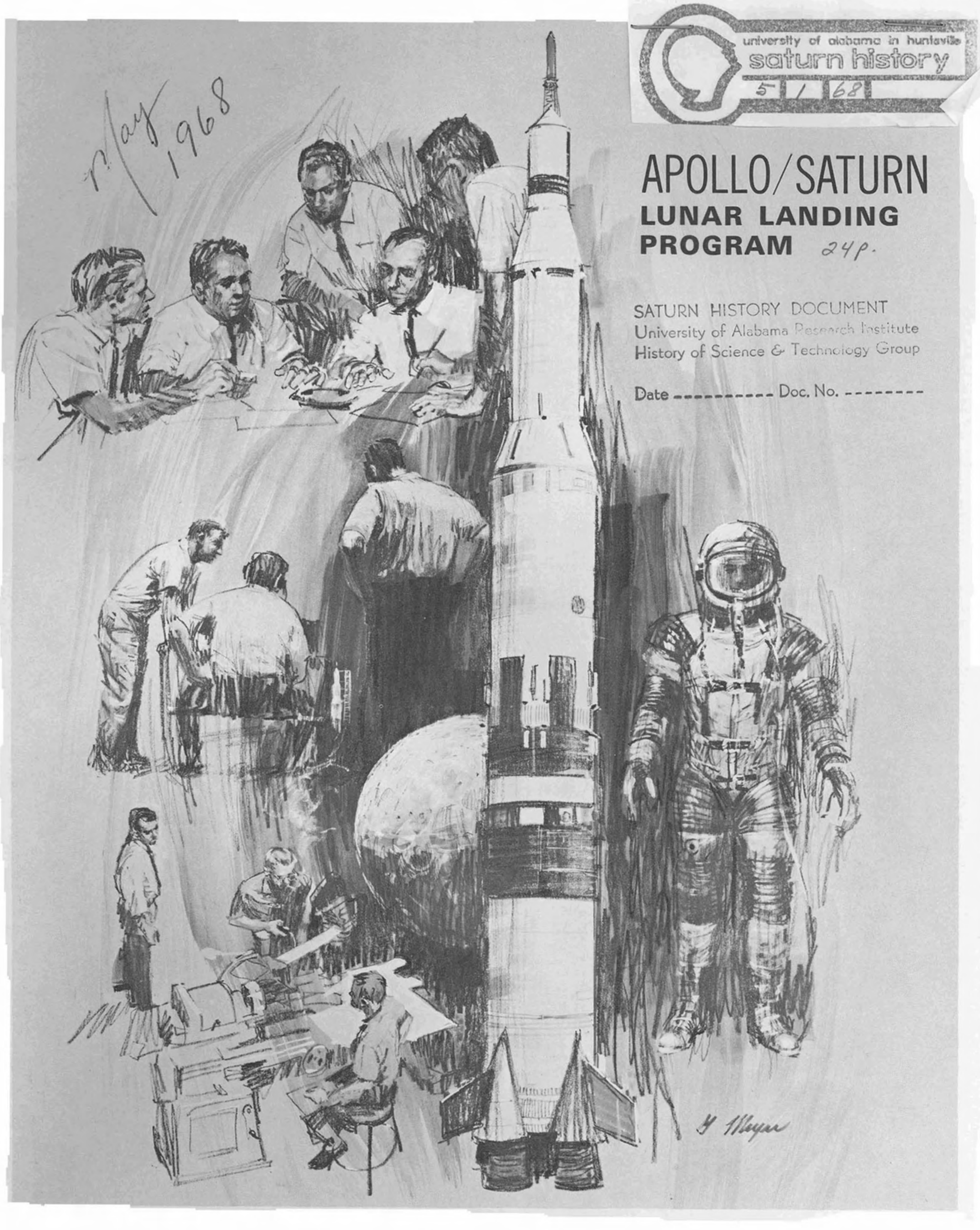
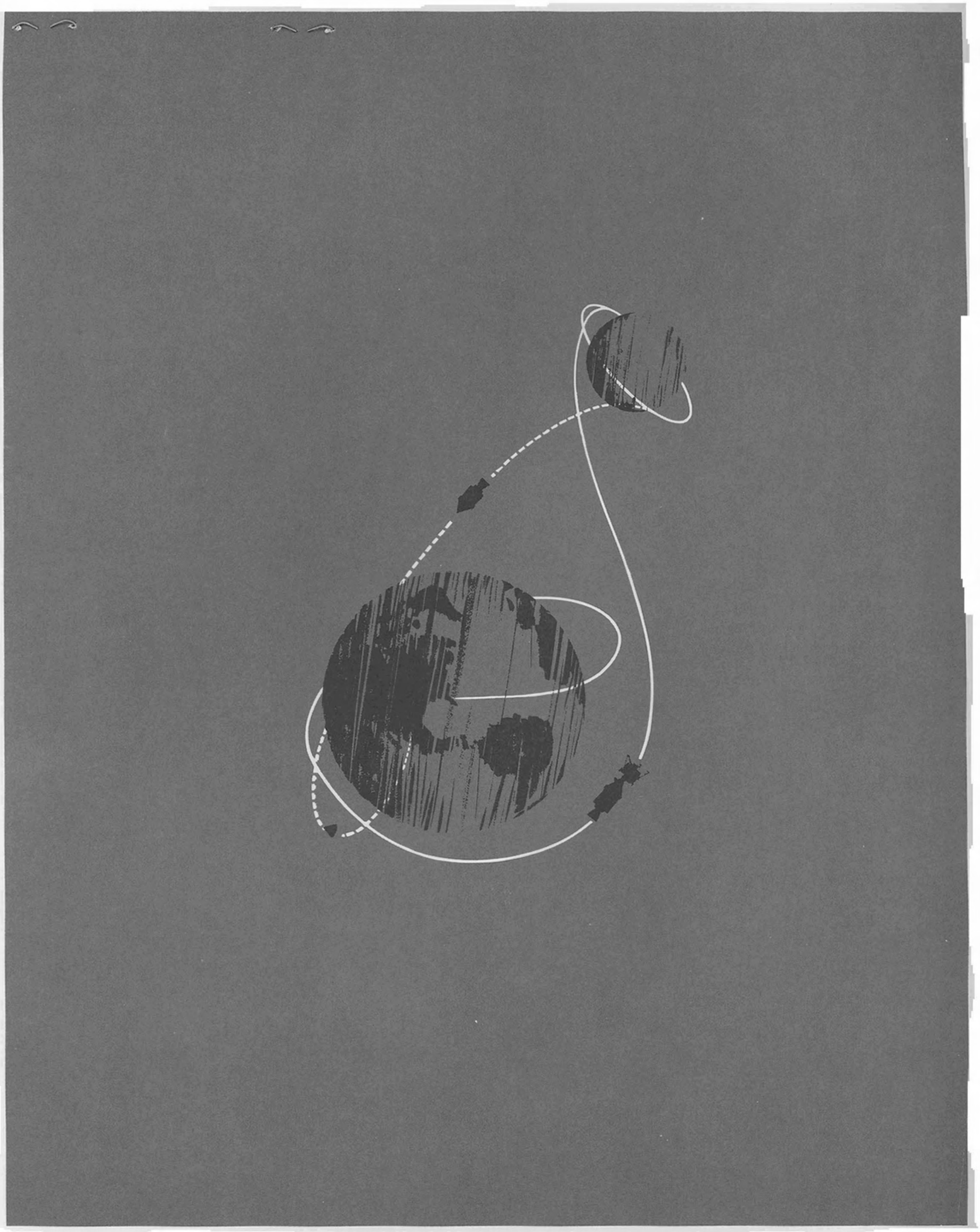
May 1968

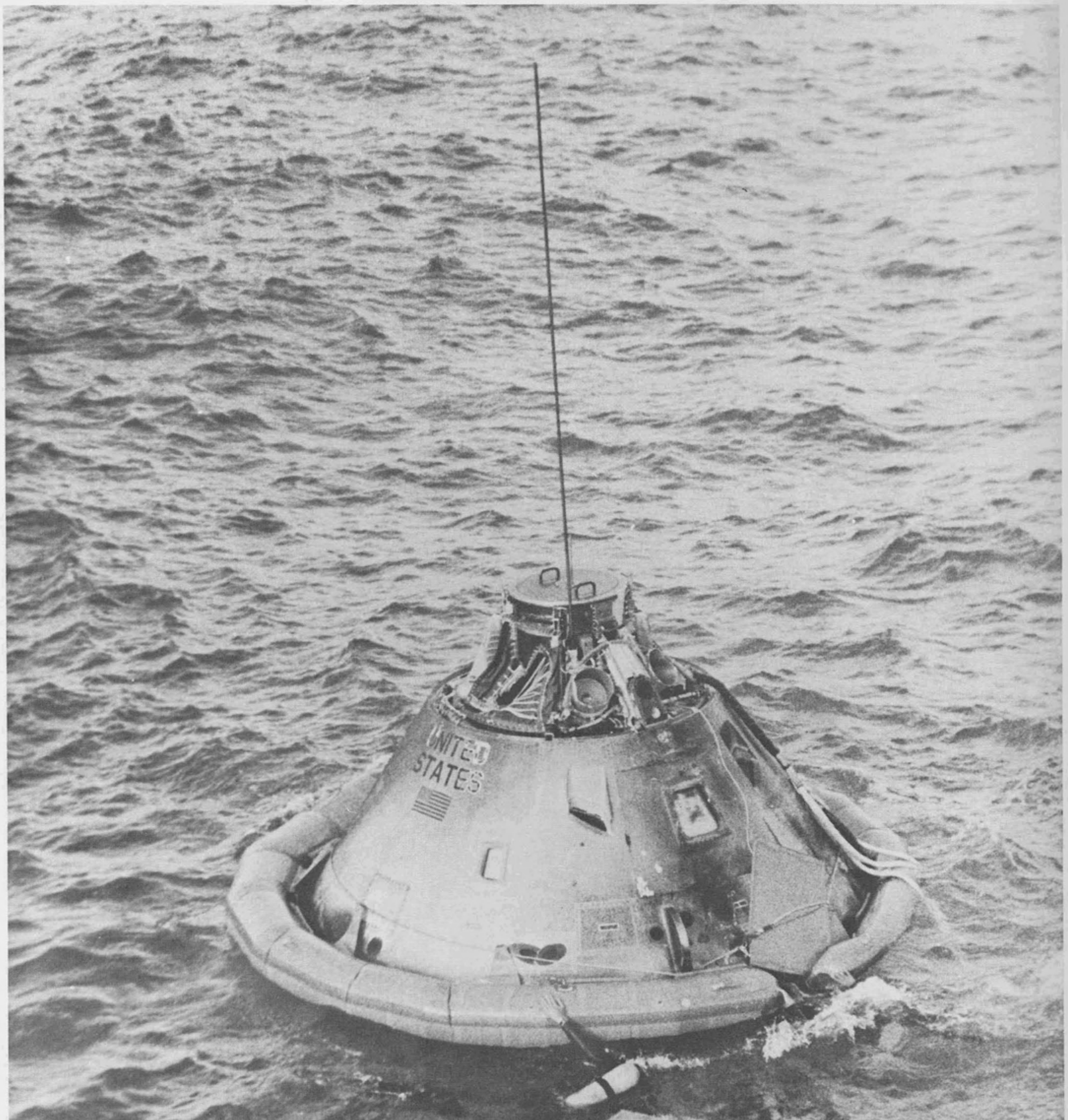
APOLLO/SATURN
LUNAR LANDING PROGRAM

24p.





APOLLO/SATURN LUNAR LANDING PROGRAM



Frogmen secure flotation collar around Spacecraft 009 in recovery after high-heat re-entry test.

APOLLO PROGRAM

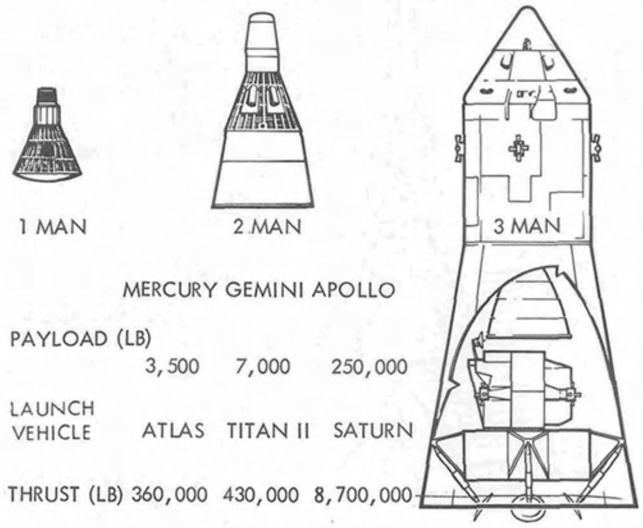
Apollo is the United States program to land men on the moon for scientific exploration and return them safely to earth. It has been described as the greatest scientific, engineering, and exploratory challenge in the history of mankind.

The challenge essentially was to create an artificial world: a world large enough and complex enough to supply all the needs of three men for two weeks. A parallel problem was to develop a booster large enough to put this world into space and to send it on its way to the moon 250,000 miles away.

NASA announced the program and its objectives in July of 1960. More than a year later (Nov. 28, 1961), after a series of studies on the feasibility of the project, NASA awarded the basic Apollo contract to North American Aviation's Space Division. Development of the booster—the Saturn program—was begun in late 1958 under the Advanced Research Projects Agency.

Briefly, 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 of exploration 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 about 8 days; the Apollo spacecraft has been designed for 14-day operation to give a wide margin of safety.

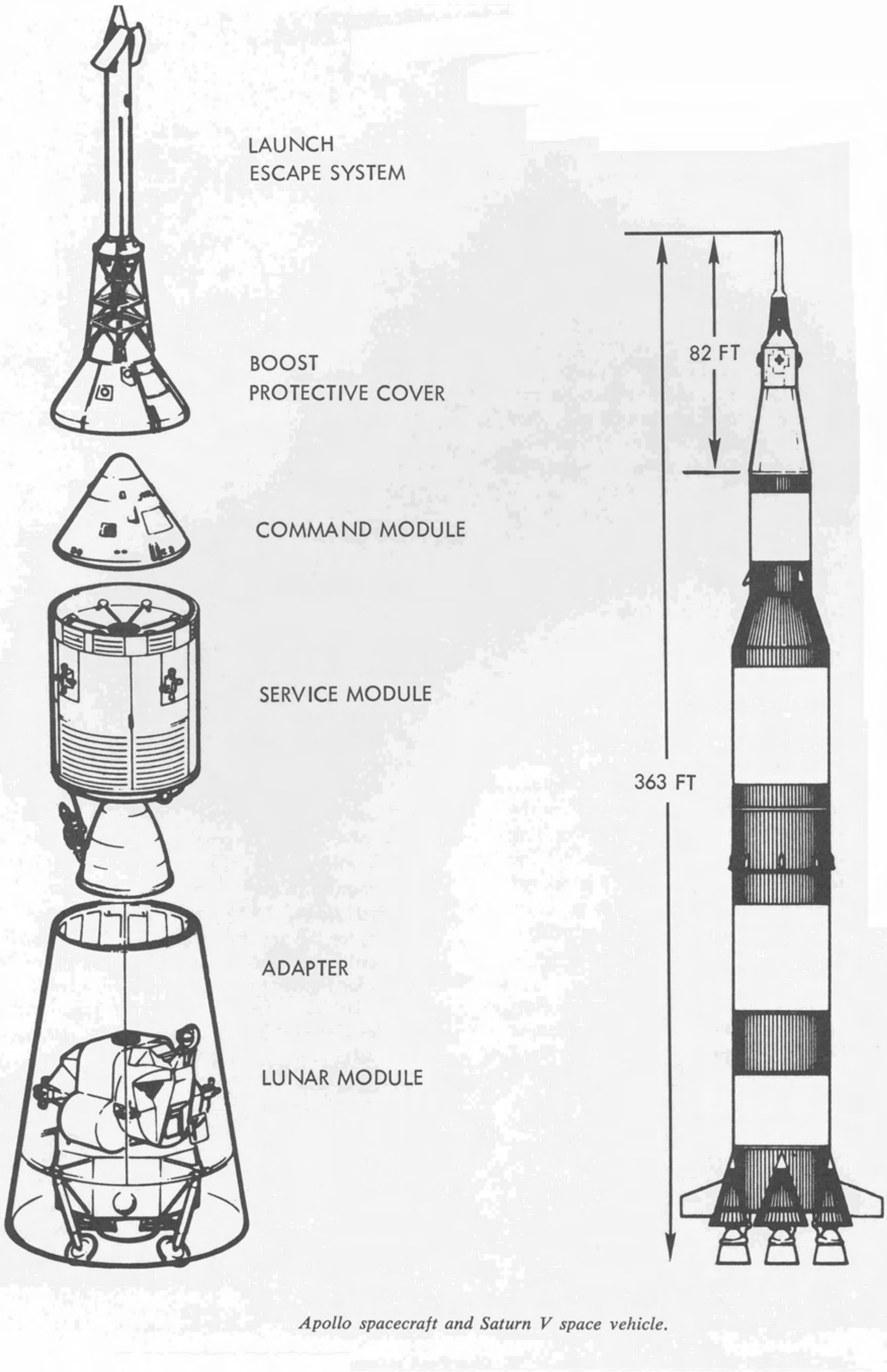
The program is the most extensive ever undertaken by any government. More than 20,000 companies and 300,000 persons throughout the country have participated in it. North American is principal contractor for the spacecraft's command module, service module, launch escape system, and spacecraft-LM adapter. The LM (lunar module) contractor is Grumman Aircraft Engineering Corp. Associate contractors are Massachusetts Institute of Technology, for the guidance and navigation system, and David Clark Co. and International Latex Co., for space suits.



Manned spacecraft

The Saturn program involves two separate launch vehicles: the Saturn IB, a two-stage vehicle with a total thrust of 1,800,000 pounds, which is used for earth-orbital missions of the Apollo program; and the Saturn V, a three-stage vehicle with a total thrust of 8,700,000 pounds, which will be used for some earth-orbital missions and for the lunar mission. Saturn IB contractors are: Chrysler Corp., for the first stage; McDonnell Douglas Space Systems Center, for the second stage; and IBM, for the instrument unit. Saturn V contractors are: Boeing Aircraft, for the first stage North American Rockwell's Space Division for the second stage; McDonnell Douglas, for the third stage; and IBM, for the instrument unit.

The Apollo program is under the technical direction 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 technical direction of NASA's Marshall Space Flight Center in Huntsville, Ala.



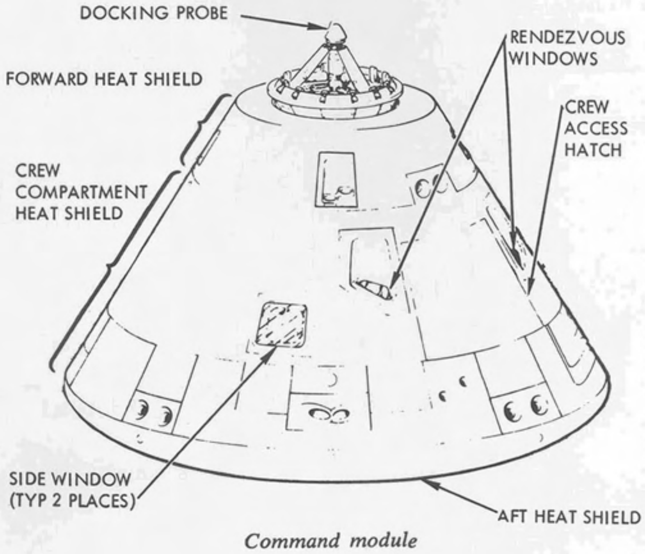
Apollo spacecraft and Saturn V space vehicle.

COMMAND MODULE

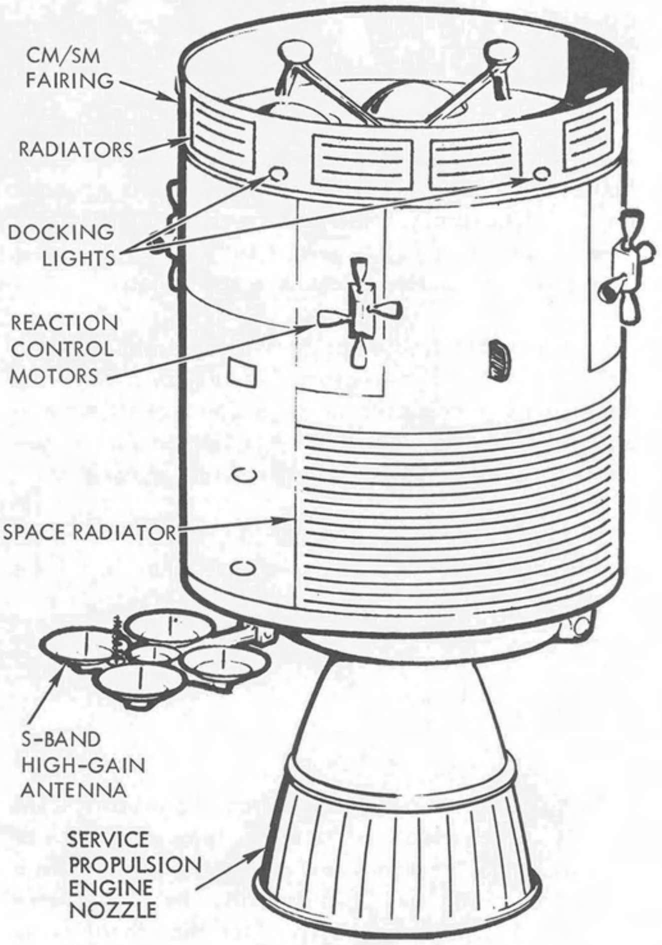
This is the control center for the moon flight; it provides living and working quarters for the three-man crew for the entire flight, except for the period when two men will be in the LM for the descent to the moon and return.

The CM consists of two shells: an inner crew compartment and an outer heat shield. The outer shell is composed primarily of stainless steel honeycomb between stainless steel sheets, covered on the outside with ablative material (heat-dissipating material which can be burned away during re-entry). The inner shell is constructed primarily of aluminum honeycomb between aluminum alloy sheets. The two shells are fastened rigidly together, with a two-layer insulation (micro-quartz fiber) in between. This construction is designed to make the CM as light as possible yet still rugged enough to stand the strain of acceleration during launch and return to earth, the shock and heat of re-entry, the force of landing, and the possible impact of meteorites during flight.

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. The cabin will be air conditioned to a comfortable 75 degrees. The atmosphere will be 100-percent oxygen, and the pressure will be 5 pounds per square inch (a little better than one-third of sea-level pressure of 14.7 pounds per square inch).



Command module



Service module

The CM is equipped with controls to enable the crew to guide it during flight. Test equipment will give the crew means of checking out malfunctions in spacecraft systems. Television, telemetry and tracking equipment, and two-way radio will provide communication with earth and among the astronauts during moon exploration and the moon orbit rendezvous. These and other systems, such as the reaction control, earth landing, and parts of the environmental control, and electrical power systems, 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. One of the couches can be folded down so the crewman 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 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 system, reaction control engines, and part of the environmental control system, as well as the main propulsion engine for return from the moon and for midcourse correction.

The SM is constructed primarily of aluminum alloy. Its outer skin is constructed of aluminum honeycomb between aluminum sheets. Propellants (hydrogen and oxygen) and various systems 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 it will be jettisoned.

LUNAR MODULE

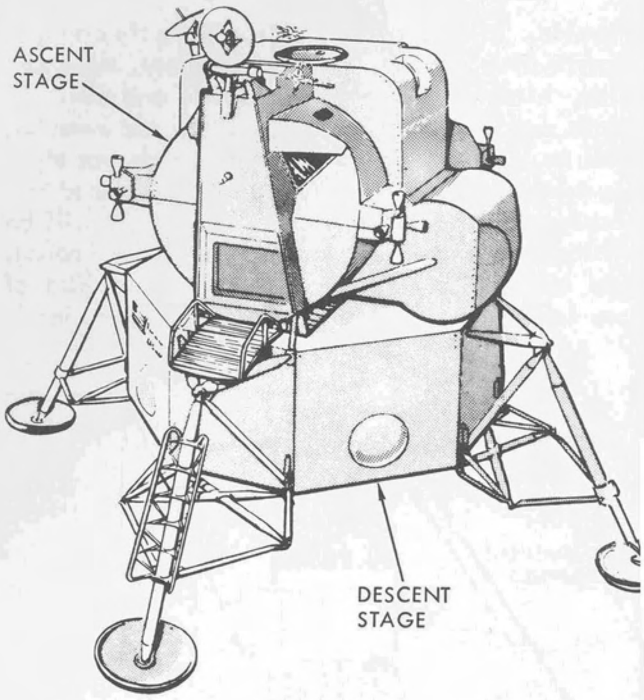
The LM will carry two men from the orbiting CSM down to the surface of the moon, provide a base ot operations on the moon, and return the two men to a rendezvous with the CSM in orbit. Its odd appearance results in part from the fact that there is no necessity for aerodynamic symmetry; the LM is enclosed during launch by the spacecraft-LM adapter (a smooth aerodynamic shape), 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 consists primarily of the descent engine and its propellant tanks, the landing gear assembly, a section to house scientific equipment for use on the moon, and extra oxygen, water, and helium tanks.

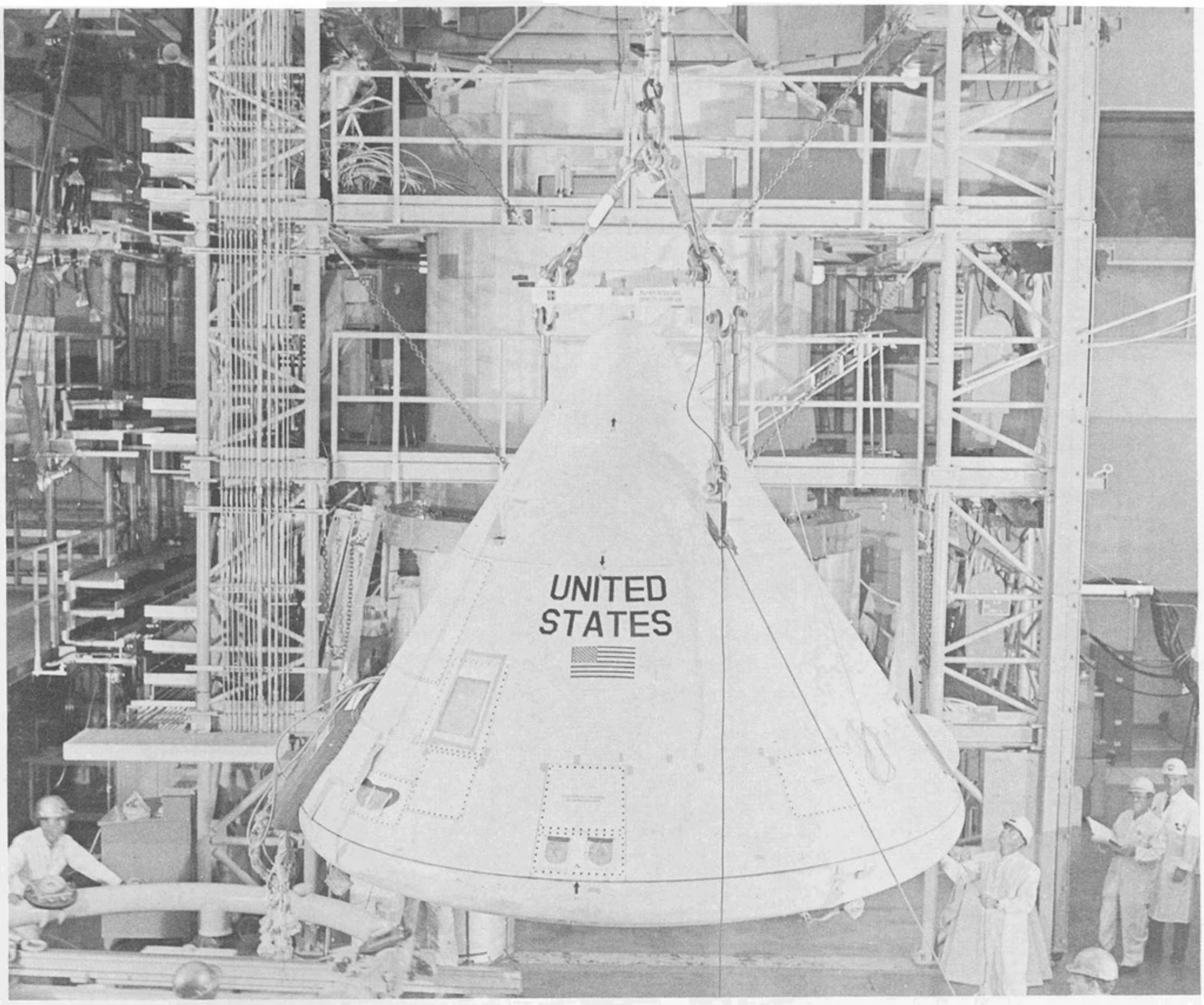
The ascent stage houses the crew compartment (which is pressurized for a shirtsleeve environment like the command module), the ascent engine and its propellant tanks, and all the crew controls. It has essentially the same kind of systems found in the command and service modules, including propulsion,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

Portable scientific equipment carried in the LM will include such things as 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).

After separating from the command module in lunar orbit, the LM lands on the moon using its descent engine. It provides shelter and a base of operations for its two crewmen for the lunar stay of up to 35 hours. After the lunar exploration, only the LM's ascent stage returns to orbit and rendezvous with the CSM; the descent stage serves as a launch platform and is left on the moon's surface. After the two LM crewmen have returned to the CM, the LM ascent stage is jettisoned. It remains in orbit around the moon when the CSM begins the journey back to earth.

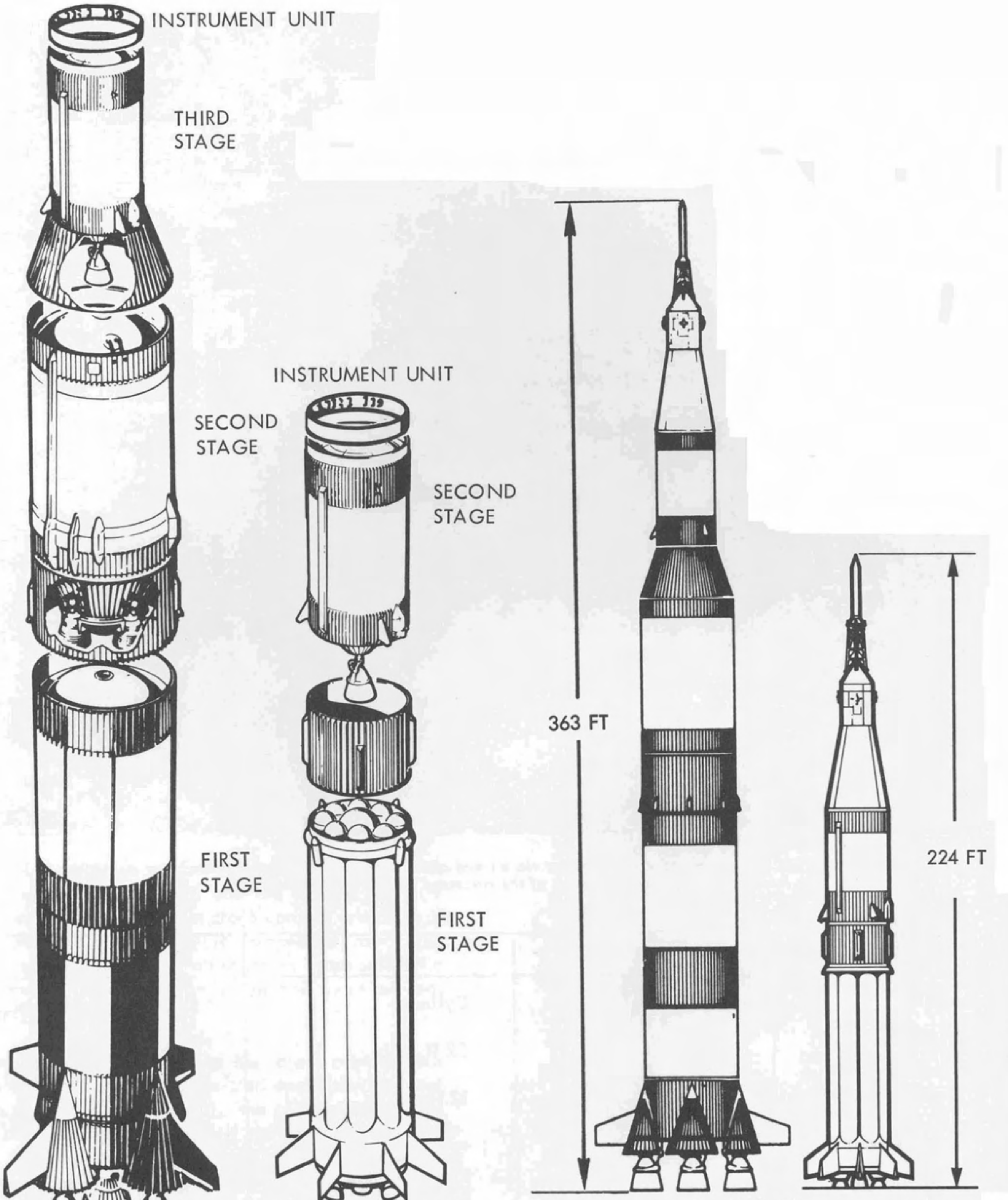


Lunar module



Spacecraft 009 is lowered onto dolly in Downey clean room after final tests before it was turned over to NASA; craft was later launched atop Saturn IB in test of the command module's heat shield.

	CM	SM	LM
Shape	Cone	Cylinder	Bug-like cab on legs
Height	10 ft. 7 in.	22 ft. 7 in.	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.
Launch weight	13,000 lb. (approx.)	55,000 lb. (approx.)	32,000 lb.
Primary material	Aluminum alloy Stainless steel Titanium	Aluminum alloy Stainless steel Titanium	Aluminum alloy



Saturn V (left) and Saturn IB launch vehicles.

LAUNCH VEHICLES

The launch vehicles used in the Apollo program are the Saturn IB for earth-orbit missions, and the Saturn V for lunar missions.

SATURN IB

The Saturn IB was conceived by NASA's Marshall Space Flight Center, which has technical direction of launch vehicles, as the quickest, most reliable, and most economical way to develop a vehicle with the ability to check out the Apollo spacecraft and train astronauts in earth orbit.

The Saturn IB has two stages and an instrument unit (IU). The IU, a cylindrical-shaped segment mounted atop the second stage, contains equipment for sequencing, guidance and control, tracking, communication, and monitoring. It was designed and developed by MSFC and is produced by IBM's Federal Systems Division.

Basic Saturn IB facts:

OVER-ALL VEHICLE

Height	138 ft. (launch vehicle only)
	224 ft. (with spacecraft)
Weight	1,3000,000 lb. (with propellant)
	153,000 lb. (with spacecraft dry)
Payload	40,000 lb. in low earth orbit

FIRST STAGE (CHRYSLER)

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 Rocketdyne H-1's
Thrust	1,600,000 lb. (sea level)

SECOND STAGE (McDONNELL DOUGLAS)

Height	58.4 ft.
Diameter	21.7 ft.
Gross weight	253,000 lb.
Propellant weight	230,000 lb.
Propellant	Liquid hydrogen and liquid oxygen
Engine	Rocketdyne J-2 (one)
Thrust	225,000 lb. (vacuum)

IU (IBM)

Height	3 ft.
Diameter	21.7 ft.
Weight	4,500 lb. (approximate)

SATURN V

The Saturn V is the nation's largest and most powerful launch vehicle. It will be used to launch the Apollo spacecraft on the lunar landing mission.

It is composed of three stages and an instrument unit.

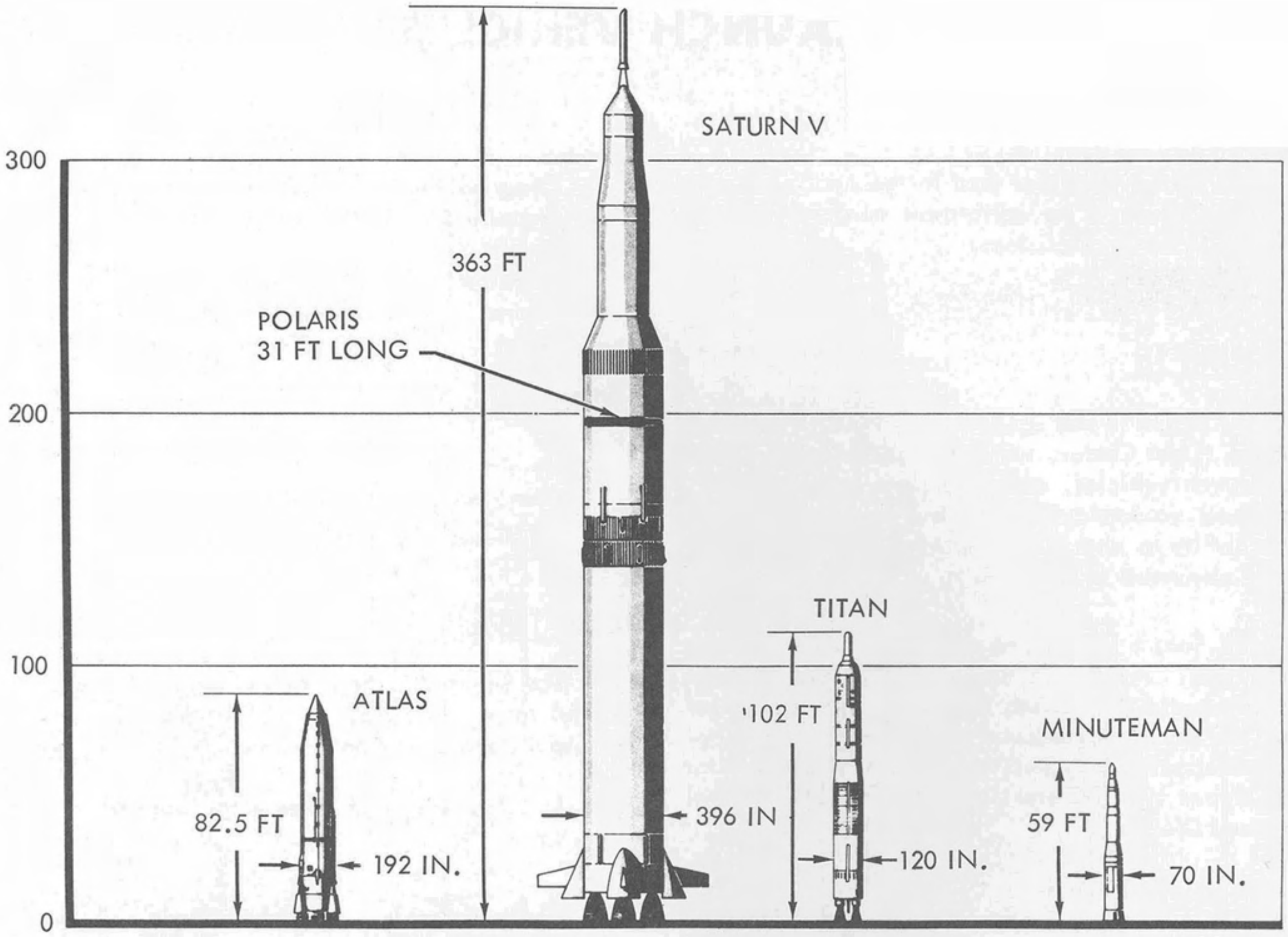
Basic Saturn V facts:

OVER-ALL VEHICLE

Height	282 ft. (launch vehicle only)
	363 ft. (with spacecraft)
Weight	6,200,000 lb. (with propellant)
	430,000 (without payload)
Payload	270,000 in low earth orbit
	100,000 lb. trans lunar injection

FIRST STAGE (BOEING)

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



Comparison of Saturn V with other vehicles

P-9

SECOND STAGE (SPACE DIVISION)

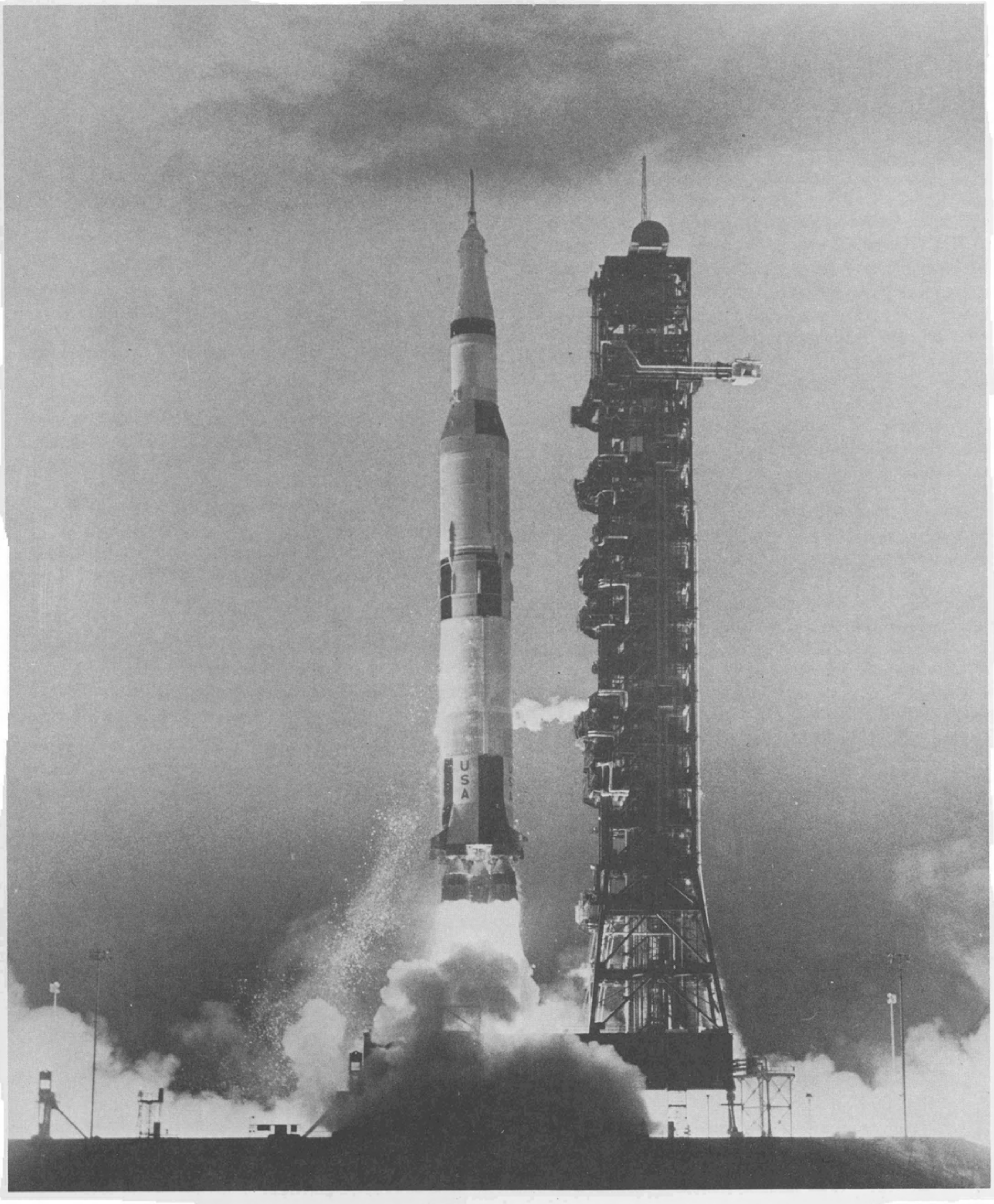
Height	81.5 ft.
Diameter	33 ft.
Gross weight	1,037,000 lb. at liftoff
Propellant useable weight	942,000 lb.
Propellant	Liquid hydrogen and liquid oxygen
Engines	5 Rocketdyne J-2's
Thrust	1,125,000 lb. (225,000 lb. each engine)
Burning time	359 sec.

THIRD STAGE (McDONNELL DOUGLAS)

Height	58.5 ft.
Diameter	21.7 ft. (lower interstage expands to 33 ft.)
Gross weight	262,000 lb. at liftoff
Propellant useable weigh	228,000 lb. (excluding reserves)
Propellant	Liquid hydrogen and liquid oxygen
Engine	1 Rocketdyne J-2
Thrust	225,000 lb. maximum
Burning time	491 sec.

IU (IBM)

Height	3 ft.
Diameter	21.7 ft.
Weight	4,500 lb. (approximate)



Saturn V lifts Apollo command and service modules off pad at Kennedy Space Center.

APOLLO CHRONOLOGY

1960

July 29 – Project Apollo, an advanced spacecraft program to land men on the moon, was announced by NASA.

Oct. 25—NASA selected General Dynamics, General Electric, and Martin to conduct individual feasibility studies of an advanced manned spacecraft as part of the Apollo project.

1961

Jan. – NASA studies of a manned lunar-landing program were completed. Both a direct-ascent trajectory using large Nova-type launch vehicles and an earth-orbit rendezvous technique using Saturn-type launch vehicles were considered.

May 15 – Final reports on Project Apollo study contracts were submitted by General Dynamics, GE, and Martin.

May 25 – President Kennedy presented a plan to Congress for accelerating the space program based on a national goal of landing a man on the moon before the end of the decade.

July 28 — NASA issued a request for proposal to 12 companies for development of the Apollo spacecraft.

Aug. 9 – NASA selected MIT's Instrumentation Laboratory to develop the guidance and navigation system for the Apollo spacecraft.

Sept. 19 – NASA announced that the recently established Manned Spacecraft Center would be located at Houston, Tex.

Nov. 28 – NASA announced that a contract had been awarded to North American's Space Division for the Apollo spacecraft program.

Dec. 21 – The first four major Apollo subcontractors were announced: Collins Radio, telecommunications systems; Garrett Corporation's AiResearch Division, environmental control equipment; Honeywell Inc., the stabilization and control system; and Northrop Corporation's Ventura Division, parachute earth landing system.

1962

Jan. 22 – The first Apollo engineering order was issued, for fabrication of the first mockups of the Apollo command and service modules.

Feb. 13 – Lockheed Propulsion Company was selected to design and build the solid-propellant launch-escape motor for Apollo.

Mar. 2 – Marquardt Corp. was selected to design and build the reaction-control rocket engines for the Apollo spacecraft.

Mar. 3 – Aerojet-General Corp. was named as subcontractor for the Apollo service propulsion system.

Mar. 9 – Pratt and Whitney was selected to build the Apollo fuel cell.

Mar. 23 – Avco Corp. was selected to design and install the ablative material on the spacecraft outer surface.

April 6 – Thiokol Chemical Corp. was selected to build the solid-propellant rocket motor to be used to jettison the Apollo launch escape tower.

July 11 – NASA announced that the lunar rendezvous mode would be used for the moon mission. This new plan called for development of a two-man lunar module to be used to reach the surface of the moon and return the astronauts to the lunar-orbiting command module.

July 16 – Beech Aircraft Corp. was selected to build the storage tanks for supercritical gases.

Aug. 22 – The length of the Apollo service module was increased from 11 feet 8 inches to 12 feet 11 inches to provide space for additional fuel.

Sept. 7 – Apollo command module Boilerplate I was accepted by NASA and delivered to SD's Engineering Development Laboratory for land and water impact tests.

Nov. 7 – Grumman Aircraft was named by NASA to design and build the LM.

1963

Mar. 12 – Apollo Boilerplate 13, the first flight-rated boilerplate to be completed, was accepted by NASA and shipped to MSFC.

July 23 – Dr. George E. Mueller was named director, NASA's Office of Manned Space Flight.

Nov. 7 – The first launch test – a pad-abort test of Boilerplate 6 – was conducted at White Sands.

1964

February – A boost protective cover was added to the launch escape system in order to protect the windows of the CM and the heat shield surfaces from soot from the LES motor.

May 13 – The second test flight of the Apollo program occurred at White Sands when Boilerplate 12 was launched by a Little Joe II vehicle during a high-stress, high-speed abort test. The launch escape system worked as planned, except that one of the three parachutes cut loose. The CM was landed without damage.

May 28 – Apollo command module Boilerplate 13 was placed in orbit from Cape Kennedy following launch by a Saturn I booster. This was the first Apollo vehicle to be placed in orbit, and the third Apollo test flight.

Sept. 18 – Apollo Boilerplate 15 was successfully orbited at Cape Kennedy by a Saturn I two-stage launch vehicle. This was the fourth Apollo test flight.

Dec. 8 – The fifth Apollo test flight occurred at White Sands when Boilerplate 23 was lifted off the pad by a Little Joe II in a high Q abort test.

1965

Feb. 16 – Apollo Boilerplate 16 was launched from Cape Kennedy in a micrometeoroid test. A Pegasus satellite was carried aloft in a modified Apollo SM. All equipment functioned as planned. This was the sixth Apollo test flight.

May 19 - Apollo Boilerplate 22 was launched at White Sands in a planned high-altitude test of the launch escape system. The Little Joe II disintegrated at low altitude, resulting in an unscheduled but successful low-altitude abort test. This was the seventh test flight.

May 25 – The second Pegasus satellite was put into orbit at Cape Kennedy during the Saturn I launch of Apollo Boilerplate 26. This was the eighth Apollo test flight.

June 29 – Apollo Boilerplate 23A was successfully launched at White Sands during a pad abort test. All systems functioned as planned. This was the ninth Apollo test flight, and the fifth abort test. This boilerplate module, previously designated Boilerplate 23, had been launched at White Sands during a high Q test.

July 30 – Apollo Boilerplate 9A was launched at Cape Kennedy and was used to place the third Pegasus satellite into orbit.

Oct. 20 – The first actual Apollo spacecraft, SC-009, was accepted by NASA and subsequently shipped to Cape Kennedy.

Dec. 26 - Apollo SC 009 was mated with Uprated Saturn at the Kennedy Space Center.

Dec. 31 - Command modules accepted by NASA by the end of 1965 included 18 mockups, 18 boilerplates, and 2 spacecraft.

1966

Jan. 20 - A power-on tumbling abort test of the launch escape system was conducted at White Sands with the launch of SC 002. This was the sixth and final launch escape test; the LES was then declared qualified.

Feb. 26 - SC 009 was launched aboard Uprated Saturn in successful test of command module's ability to withstand re-entry temperatures. Test was first flight of unmanned spacecraft and first flight of Uprated Saturn.

Aug. 25 - SC 011 was launched successfully in the Second flight of an unmanned Apollo spacecraft to test command module's ability to withstand reentry temperatures under high heat load. The flight was three quarter earth orbit with recovery of the command module successfully completed in the Pacific Ocean near Guam.

1967

Jan. 27 - Three astronauts died in a spacecraft accident at Kennedy Space Center on the launch pad during a prelaunch test.

Nov. 9, 1967 - Apollo 4 (SC 017) the first launch of a Saturn V space vehicle was successfully carried out. The spacecraft for the mission entered the atmosphere at almost 25,000 miles an hour. Heat shield temperatures exceeded 5,000 degrees. It was the first test of a spacecraft returning at lunar velocities and the first launch of a hydrogen-powered Saturn V second stage (S-II).

1968

April 4 - Apollo 6 (SC 020) second flight of a Saturn V space vehicle, was partially successful. The spacecraft functioned satisfactorily. However, launch vehicle engine problems caused the spacecraft to go into alternate mission mode. The service propulsion engine burned for a record length. All subsystems performed well.

APOLLO BRIEFS

The possibility of a sporadic micrometeoroid as big as a cigarette ash striking the command module during an 8-day lunar mission has been computed as 1 in 1230. If a meteoroid did strike the module, it would be at a velocity of 98,500 feet per second. The probability of the command module getting hit is 0.000815. The probability of the command module not getting hit is 0.999185.

* * *

The heat leak from the Apollo cryogenic tanks, which contain hydrogen and oxygen, is so small that, if one hydrogen tank containing ice were placed in a room heated to 70 degrees F, a total of 8-1/2 years would be required to melt the ice to water at just above freezing temperature. It would take approximately 4 years more for the water to reach room temperature. The gases in the cryogenic tanks are utilized in the production of electrical power by the Apollo fuel cell system and provide oxygen for the use of the crew.

* * *

When the Apollo spacecraft passes through the Van Allen Belts on its way to the moon, the astronauts will be exposed to radiation roughly equivalent to that of a dental X-ray.

With gravity on the moon only one-sixth as strong as on earth, it is necessary that this difference be related to the Apollo vehicle. A structure 250 feet high and 400 feet long in which cables lift five-sixth of the spacecraft vehicle is being used in tests to simulate lunar conditions and their effect on the vehicle.

* * *

The command module panel display includes 24 instruments, 566 switches, 40 event indicators (mechanical), and 71 lights.

* * *

The command module offers 73 cubic feet per man as against the 68 cubic feet per man in a compact car. By comparison, the Mercury spacecraft offered 55 cubic feet for its one traveler and Gemini provided 40 cubic feet per man.

* * *

The angular accuracy requirement of midcourse correction of the spacecraft for all thrusting maneuvers is one degree.

If your car gets 15 miles to a gallon, you could drive 18 million miles or around the world about 700 times on the fuel required for the Apollo/Saturn lunar landing mission.

* * *

When the Apollo re-enters the atmosphere it will generate energy equivalent to approximately 2300 kilowatt hours of electricity - enough to light the city of Washington for about 6-1/2 seconds; or the energy generated would lift all the people in the USA three inches off the ground.

* * *

There are 27 different means of communication in the telecommunications system: ground to spacecraft links, 5; spacecraft to ground links, 7. Nine different frequencies are used (1 HF, 3 VHF, 1 UFH, 2 S band, 2 C band), and 5 antenna systems.

* * *

The fully loaded Saturn V launch vehicle with the Apollo spacecraft stands 60 feet higher than the Statue of Liberty on its pedestal and weighs 13 times as much as the statue.

* * *

During its 3.5 second firing, the Apollo spacecraft's solid-fuel launch escape rocket generates the horsepower equivalent of 4,300 automobiles.

* * *

The engines of the Saturn V launch vehicle that will propel the Apollo spacecraft to the moon have combined horsepower equivalent to 543 jet fighters.

* * *

The Apollo environmental control system has 180 parts in contrast to the 8 for the average home window air conditioner. The Apollo environmental control system performs 23 functions compared to 5 for the average home conditioner. There are 23 functions of the environmental control system, which include: air cooling, air heating, humidity control, ventilation to suits, ventilation to cabin, air filtration, CO_2 removal, odor removal, waste management functions, etc.

* * *

The Saturn V that will boost the Apollo spacecraft to the moon generates the horsepower equivalent to drive an automobile 18 million miles—a 34-year trip at 60 miles an hour.

* * *

The maximum differential pressure that the inner structure of the command module can withstand is 8.60 psi. The environmental control system restricts the differential pressure to be less than 6.0 psi.

* * *

The 12-foot-high Apollo spacecraft command module contains almost 20 miles of wire, enough to wire 50 two-bedroom homes.

* * *

The astronaut controls and monitors the stabilization and control system by means of two handgrip controllers, 34 switches, and 6 knobs.

* * *

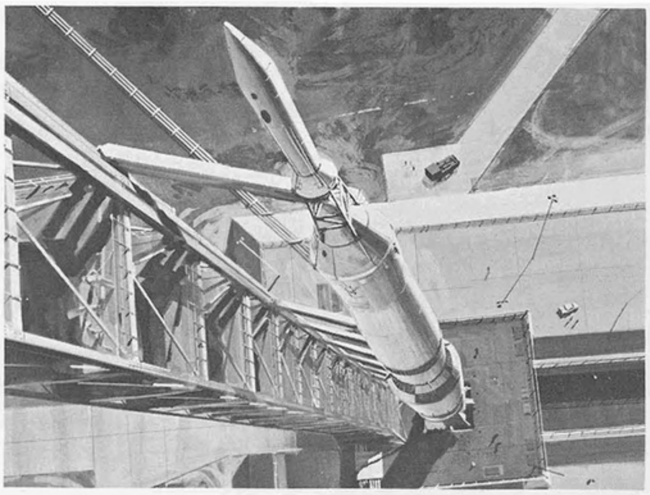
The command system of the acceptance checkout equipment can generate up to 2048 separate stimuli or 128 analog signals, or combinations of both, and route them to spacecraft and other checkout systems at a million bits per second. In contrast, hand-operated commercial teletype generates 45 bits per second and automatically, over voice channel, it generates 2400 bits per second.

* * *

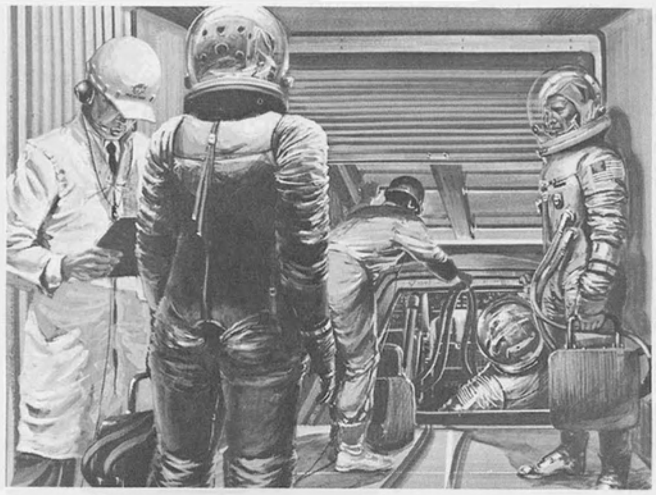
The Apollo command module can sustain a hole as large as one-half inch in diameter and still maintain the pressure inside for five minutes, which is considered long enough for an astronaut to put on a spacesuit.

* * *

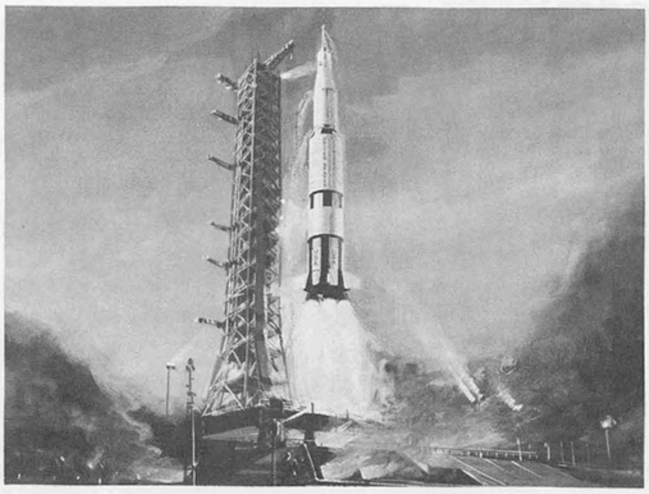
Total amount of fuel in the booster plus service module and lunar excursion module is 5,625,000 pounds.



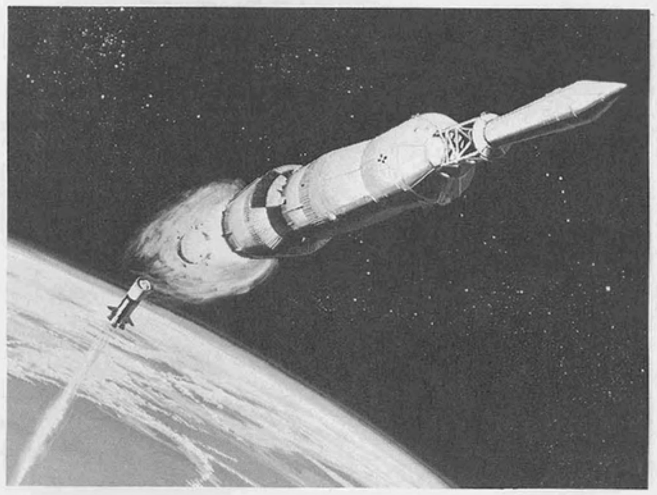
Giant booster undergoes last-minute checks before launch



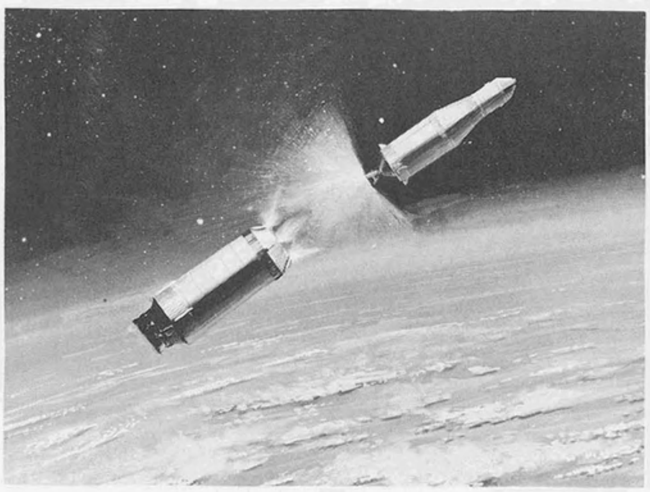
Astronauts enter CM from service tower after final checks



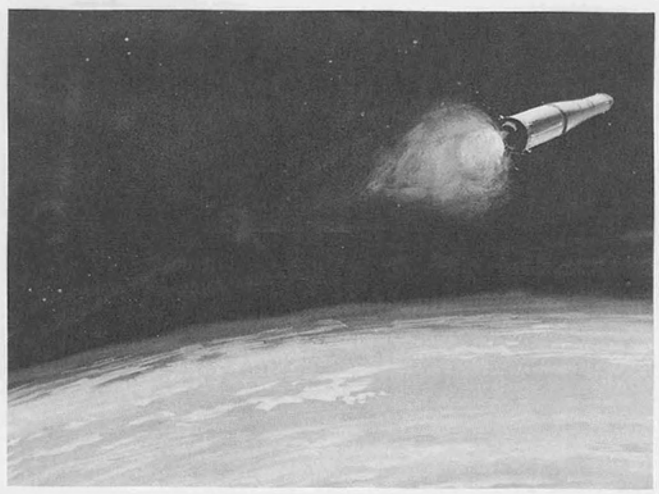
Saturn V lifts Apollo spacecraft off pad at Cape Kennedy



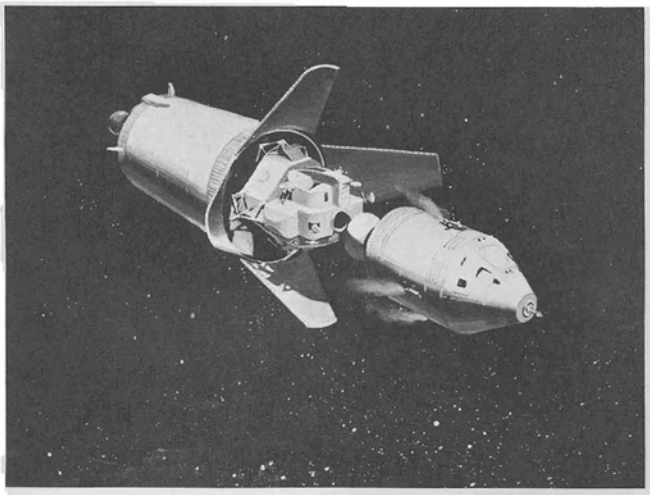
Saturn V second stage ignites as the first stage falls away



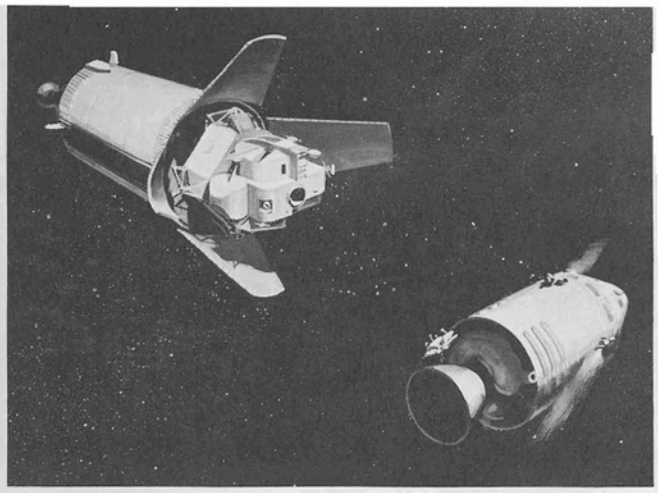
Second stage is jettisoned and third stage is ignited



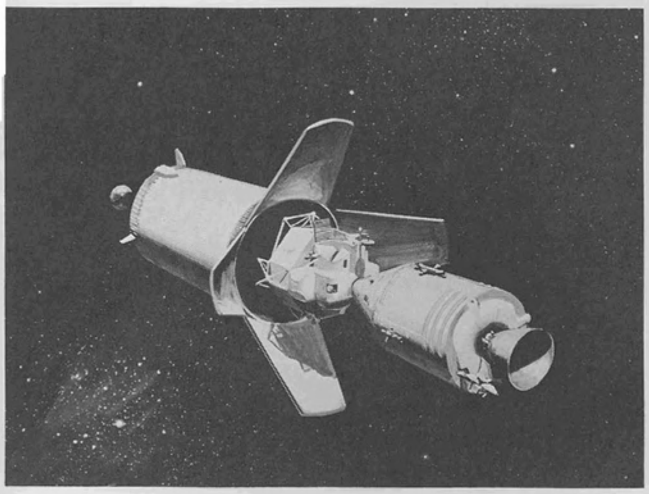
Third stage pushes spacecraft out of earth's orbit



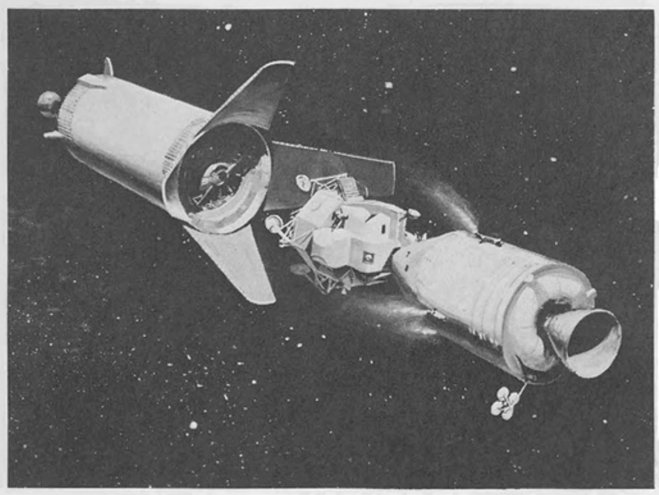
Adapter panels are opened and CSM separates



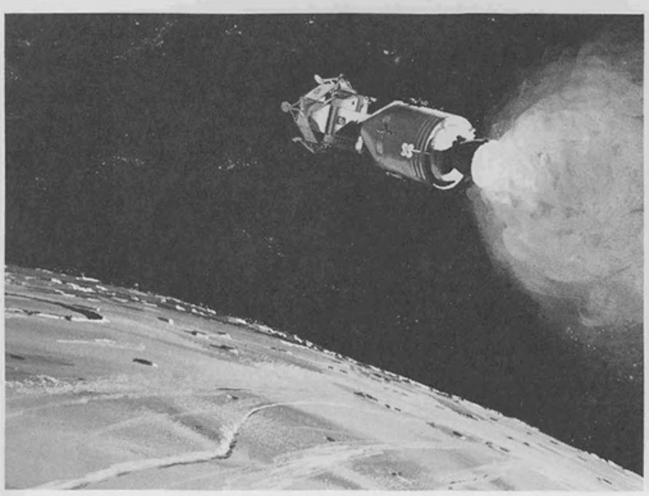
CSM turns around to get into position for docking



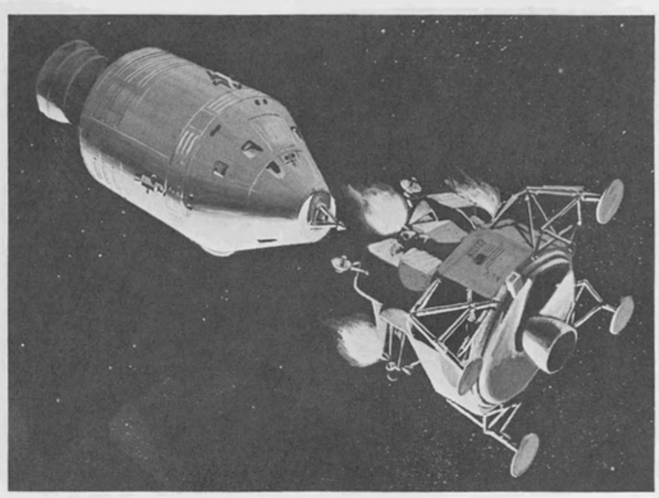
Command module docks with LM



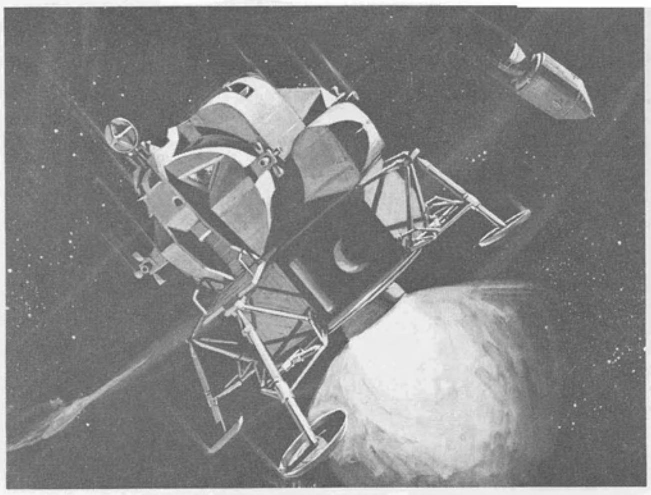
After docking, spacecraft leaves third stage behind



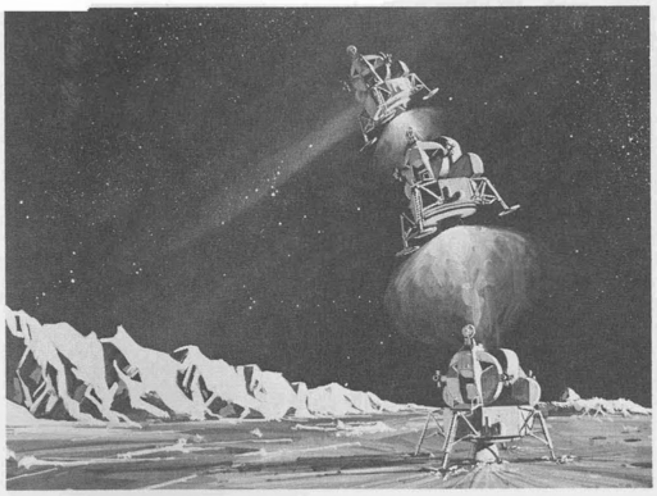
SM engine fires to put spacecraft in orbit around moon



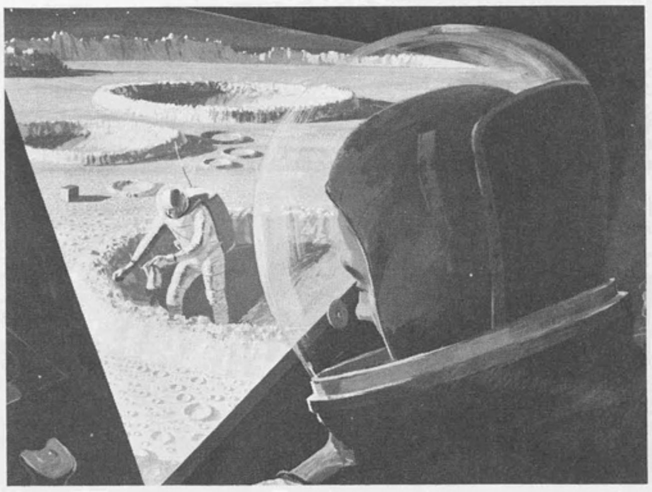
LM separates from CSM to begin descent to moon



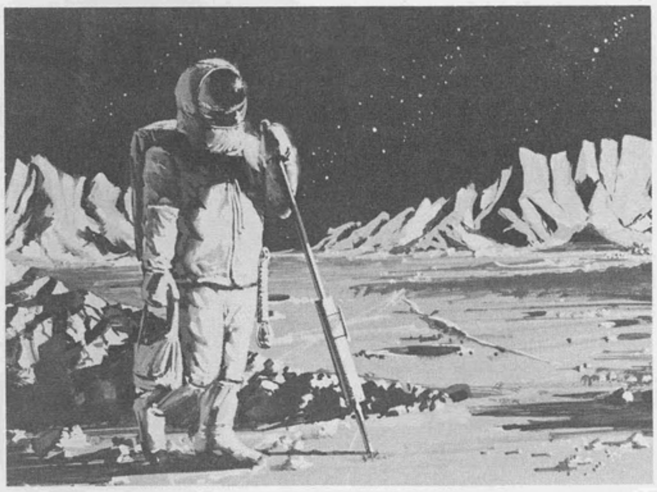
LM engine fires while CSM remains in orbit



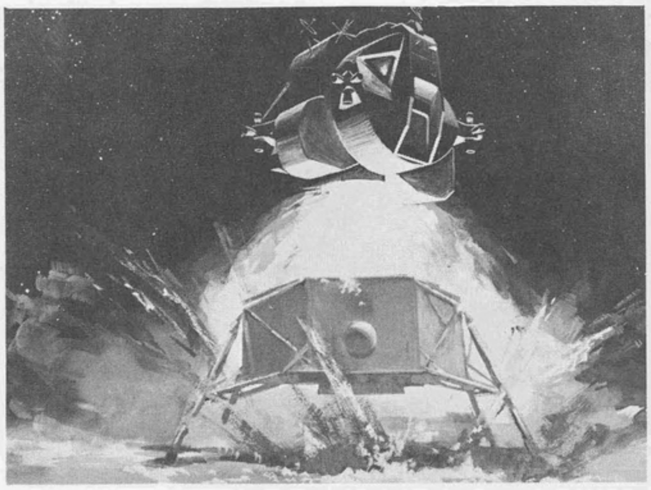
Two astronauts guide LM to landing on lunar surface



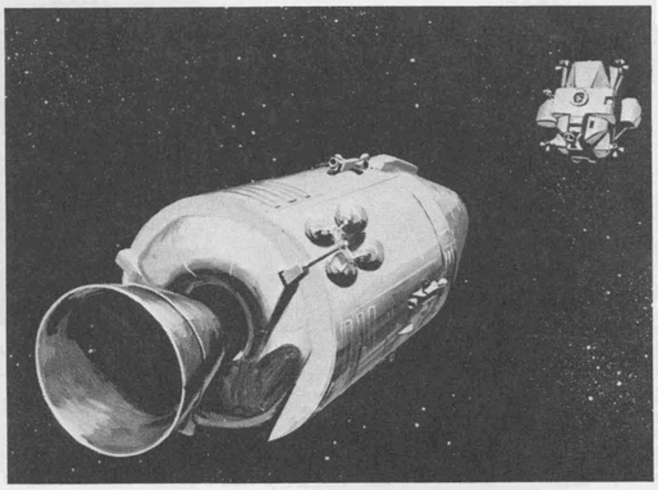
Astronaut gathers soil samples from the lunar surface



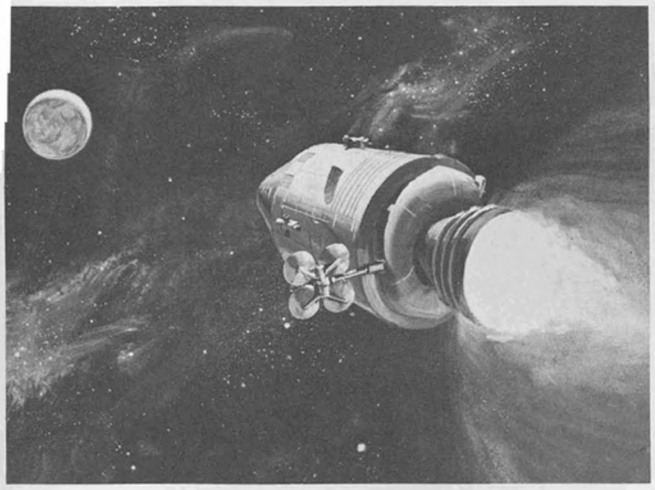
Astronaut explores surface of moon



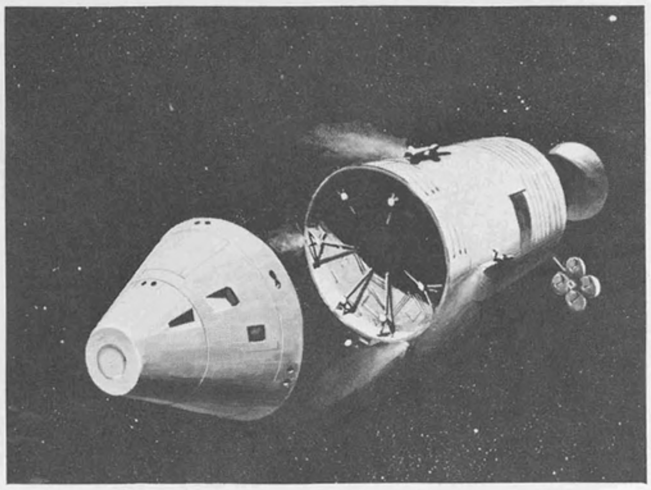
Engine fires to lift LM ascent stage off moon and into orbit



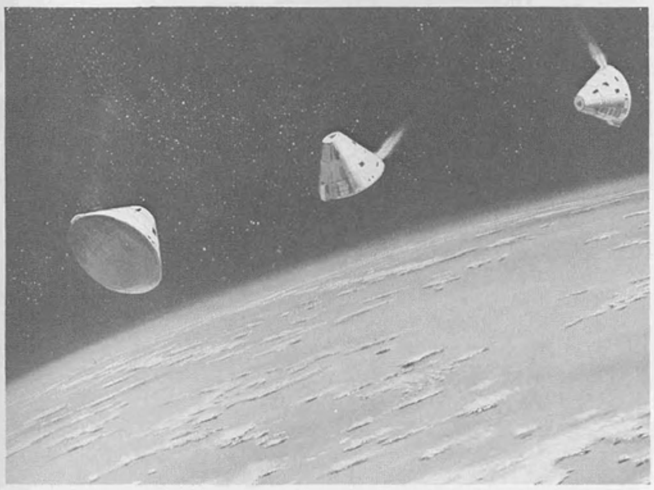
Astronauts in LM line up their craft for docking with SC CSM



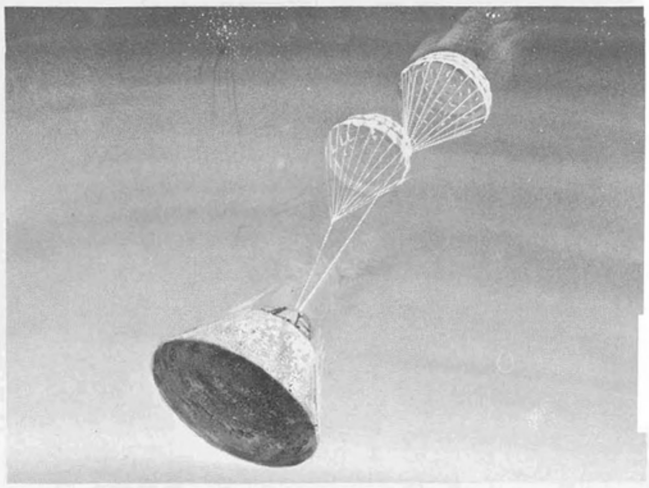
SM engine fires to start homeward journey; LM stays behind



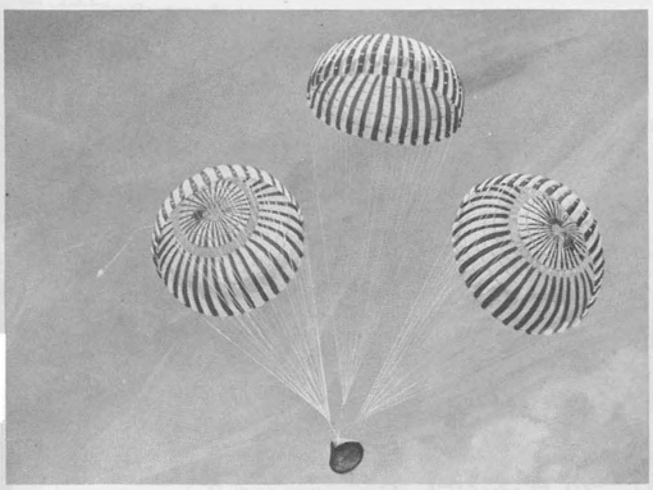
SM is jettisoned as CM prepares for entry into atmosphere



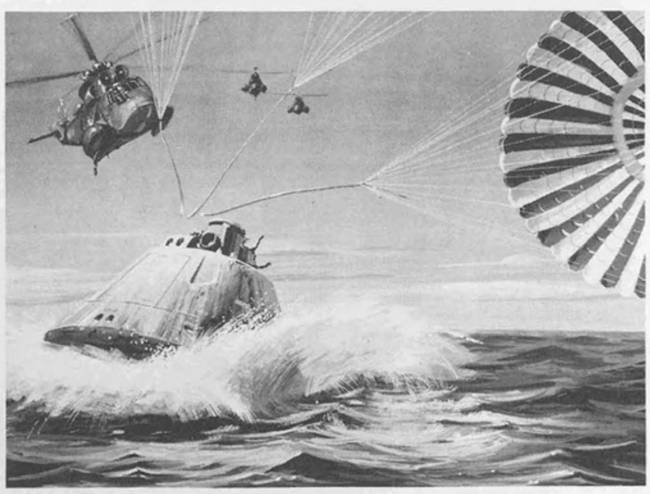
Pilot orients CM so base heat shield takes friction heat



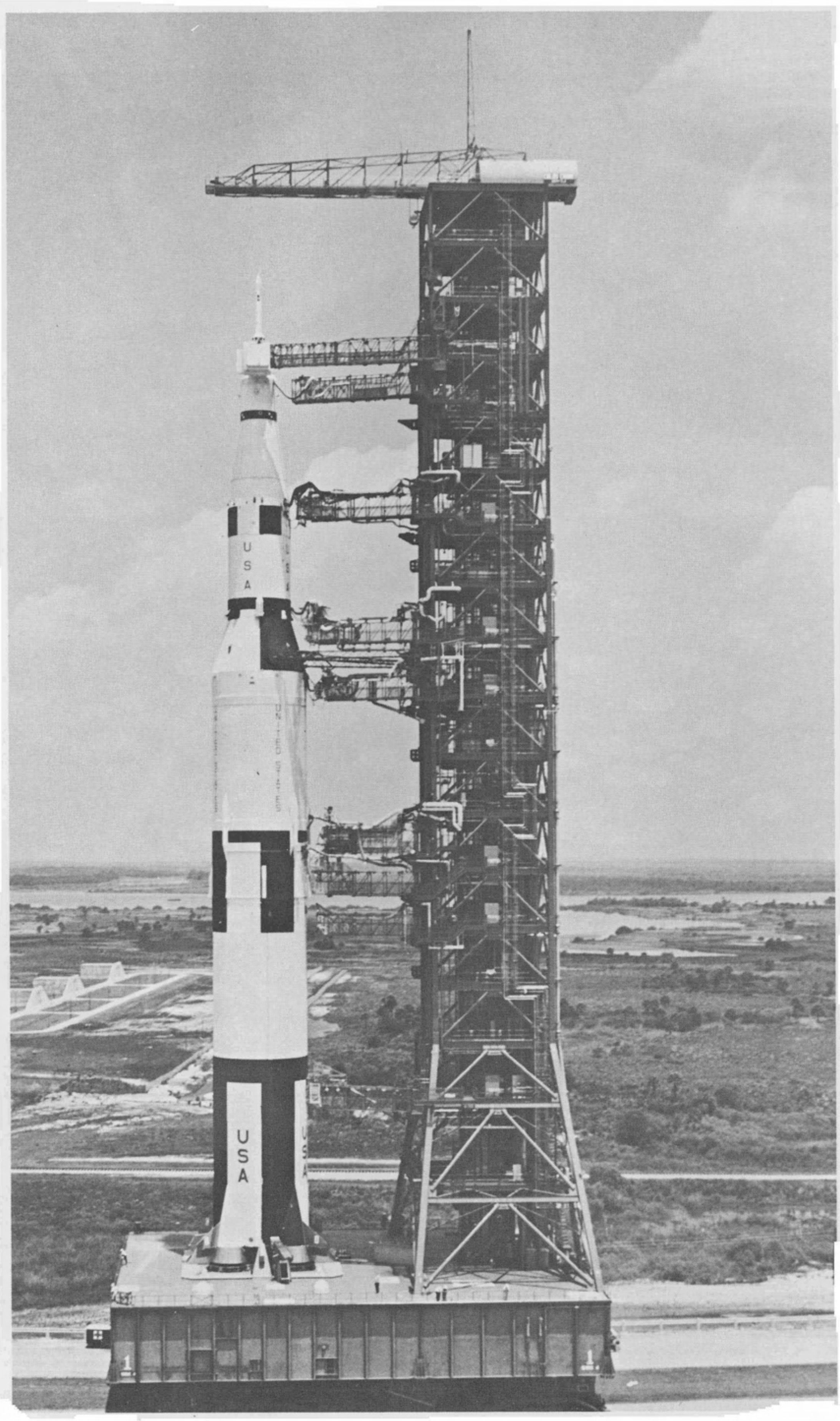
Drogue parachutes are deployed for initial slowing of CM



Main parachutes are deployed to lower CM safely to surface



Recovery forces move in as the CM floats in water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