DAVE C.

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

VII . 3

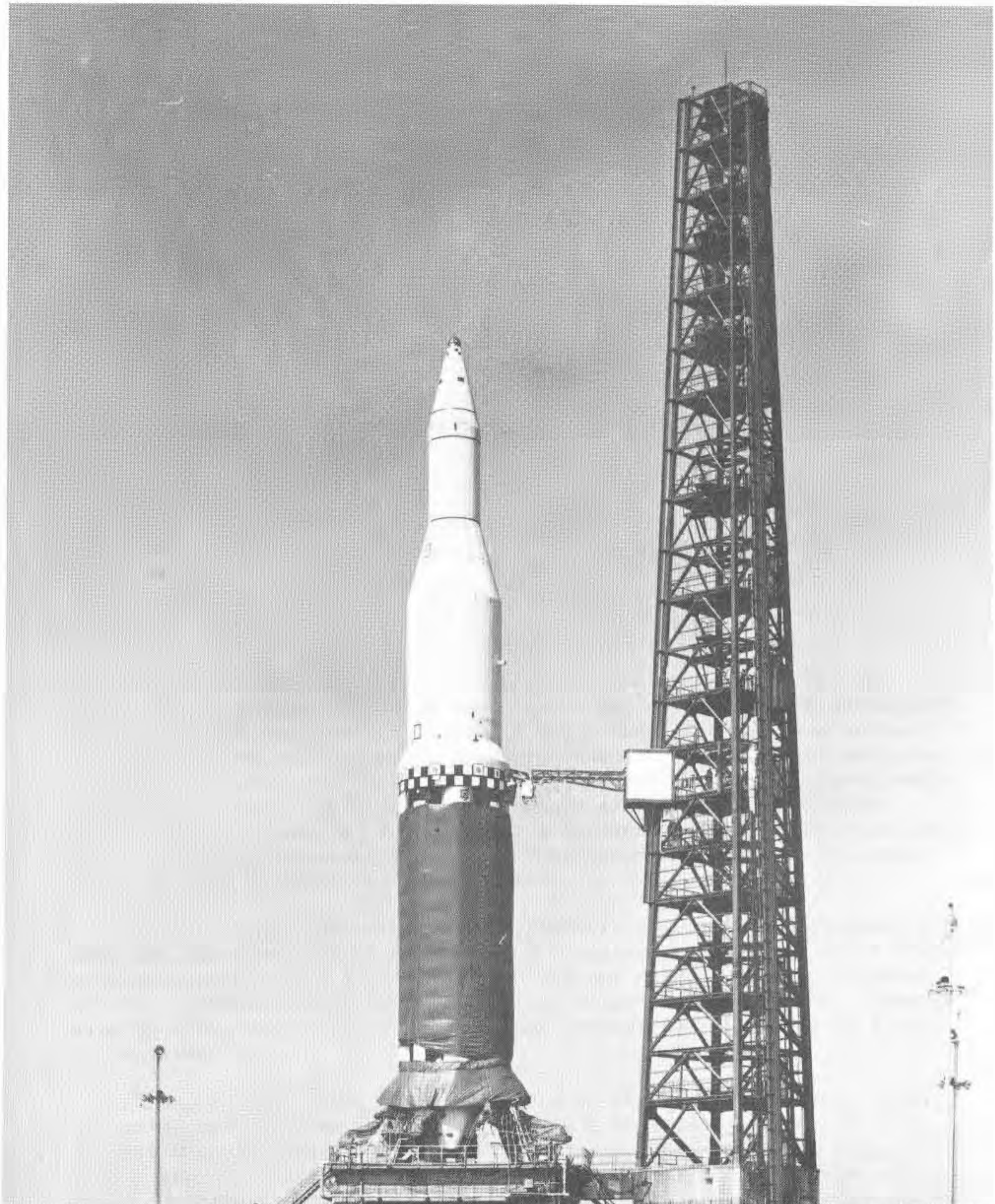
SATURN ILLUSTRATED CHRONOLOGY

APRIL 1957—NOVEMBER 1962

Prepared By:
Saturn Systems Office

National Aeronautics and Space Administration

NASA



Saturn

Illustrated Chronology

In April 1957, the scientific organization directed by Dr. von Braun, began studies of launch vehicles having payloads of 20,000-40,000 pounds (orbital missions) or 6,000-12,000 pounds (for escape missions). To lift payloads of this magnitude, high-thrust booster stages were essential. Accordingly, in December 1957, the von Braun group, then working with the Army Ballistic Missile Agency (ABMA), submitted to the Department of Defense a "Proposal for a National Integrated Missile and Space Vehicle Development Program". This document indicated the need for a booster of 1,500,000 pounds thrust.

To secure this amount of thrust, ABMA first considered clustering four 380,000 pound thrust Rocketdyne E-1 engines, then in an early stage of development. This initial concept was not carried fruther, because of the estimated length of time required to develop the engine. However, studies continued to determine if other engines could be used in a similar application.

Then, in July 1958, representatives of the Advanced Research Projects Agency (ARPA) expressed interest in a clustered booster of 1,500,000 pounds thrust that would use rocket engines already tested and of proven reliability. On August 15, 1958, ARPA Order 14-59 formally initiated what was to become the SATURN project. The order authorized a research and development program for a large, space vehicle booster. To secure the desired thrust of one-and-a-half million pounds,

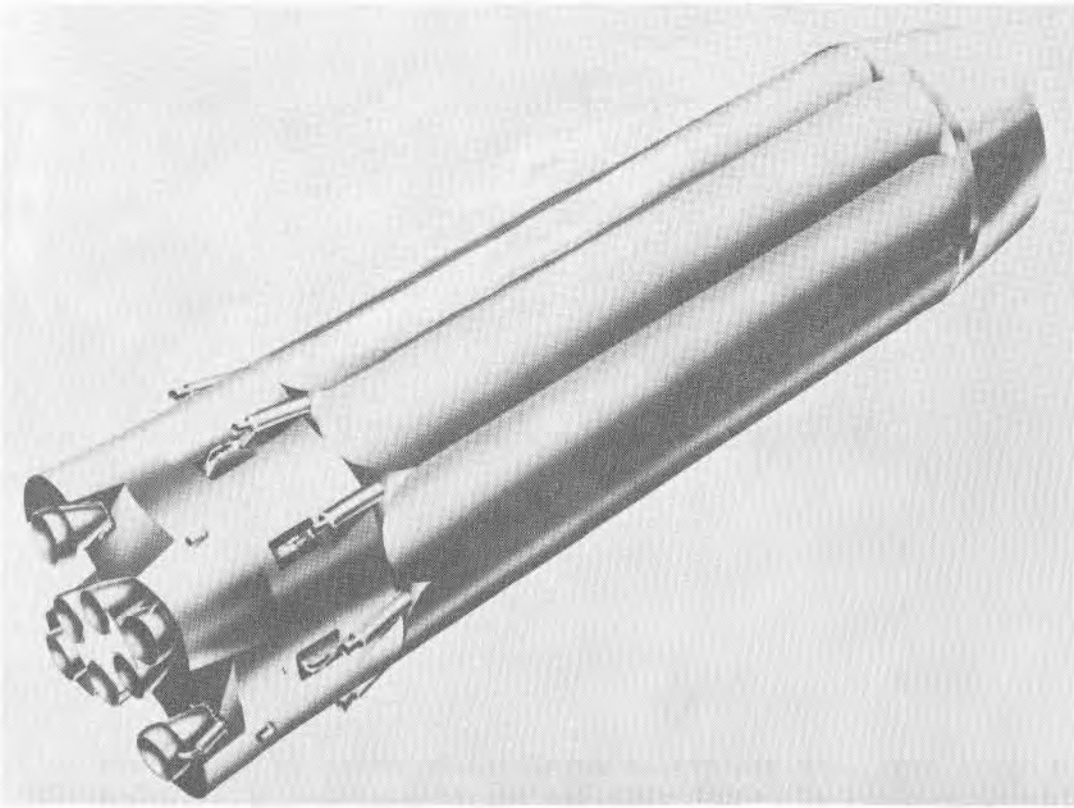


FIGURE 1. PROPOSED CONFIGURATION OF A CLUSTERED BOOSTER

a number of available rocket engines would be clustered. The feasibility of this design (Fig. 1), would be demonstrated by a full-scale static firing by the end of 1959.

Previous studies had shown that the liquid oxygen (LOX) and fuel tanks developed for the REDSTONE and JUPITER missiles could, with some modification, be used for the tanks of the proposed booster. It was also determined that an existing engine, the S-3D, used on both the THOR and JUPITER missiles (Fig. 2), could be modified to produce an increased thrust of 188,000 pounds. Certain of the tools and fixtures developed for the REDSTONE and JUPITER programs could also be used with comparatively little modification (Fig. 3). Thus, it was possible to begin booster development with certain well-tested hardware of proven reliability. As a result, the time for design and development of some important booster components and tooling was significantly shortened, and the cost of hardware development and retooling reduced.

As an immediate step toward development of the clustered booster, a contract was awarded Rocketdyne Division of North American Aviation,

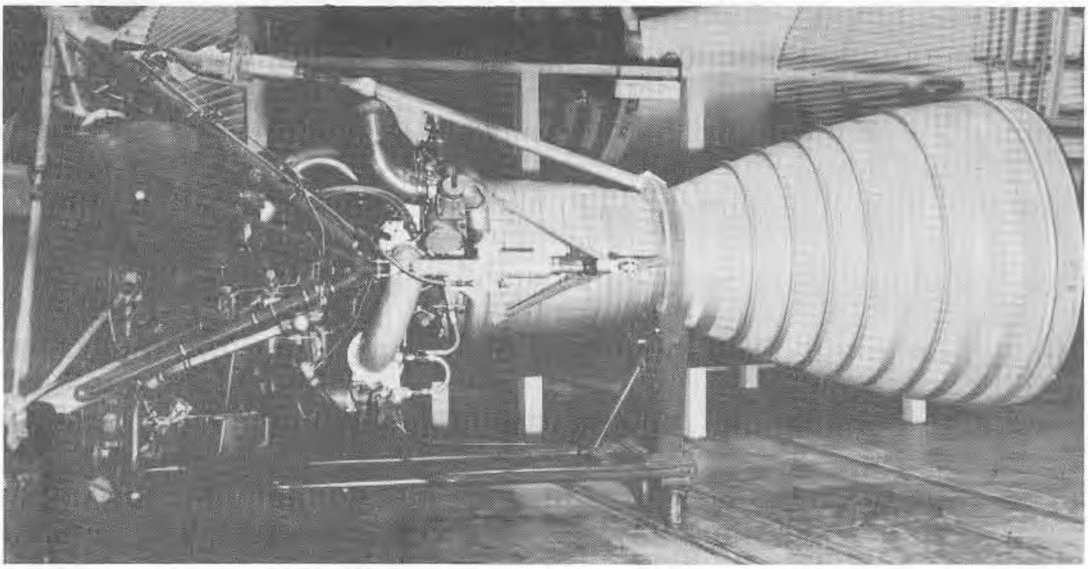


FIGURE 2. THOR-JUPITER ENGINE

September 11, 1958, to up-rate the THOR-JUPITER engine. After redesign, simplification, and modification, the engine would be the H-1 (Fig. 4).

In October 1958, to expand previous program objectives, ARPA Order 14-59 was amended to require the development of a reliable, high-performance booster which would serve as the first stage of a multistage carrier vehicle capable of performing advanced space missions. (The vehicle was tentatively identified as JUNO V.) ARPA also requested a study of a complete vehicle system,

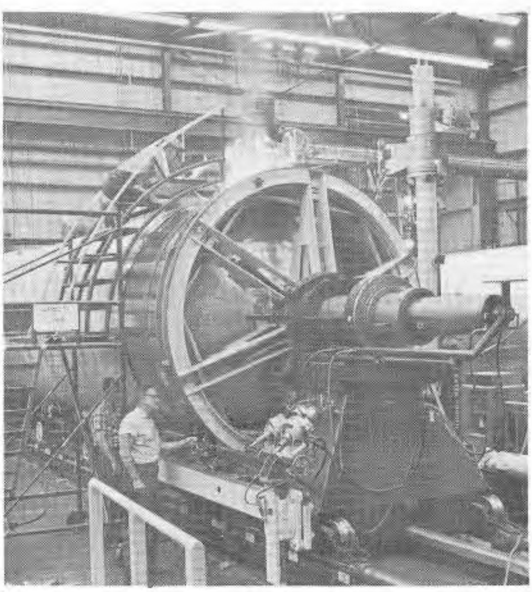


FIGURE 3. BOOSTER TOOLING

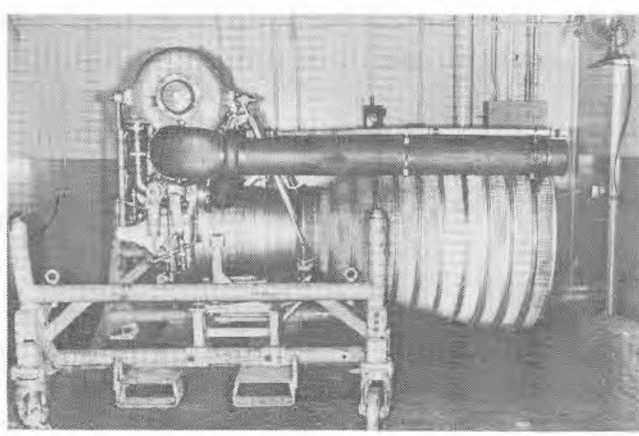


FIGURE 4. EARLY H-1 ENGINE

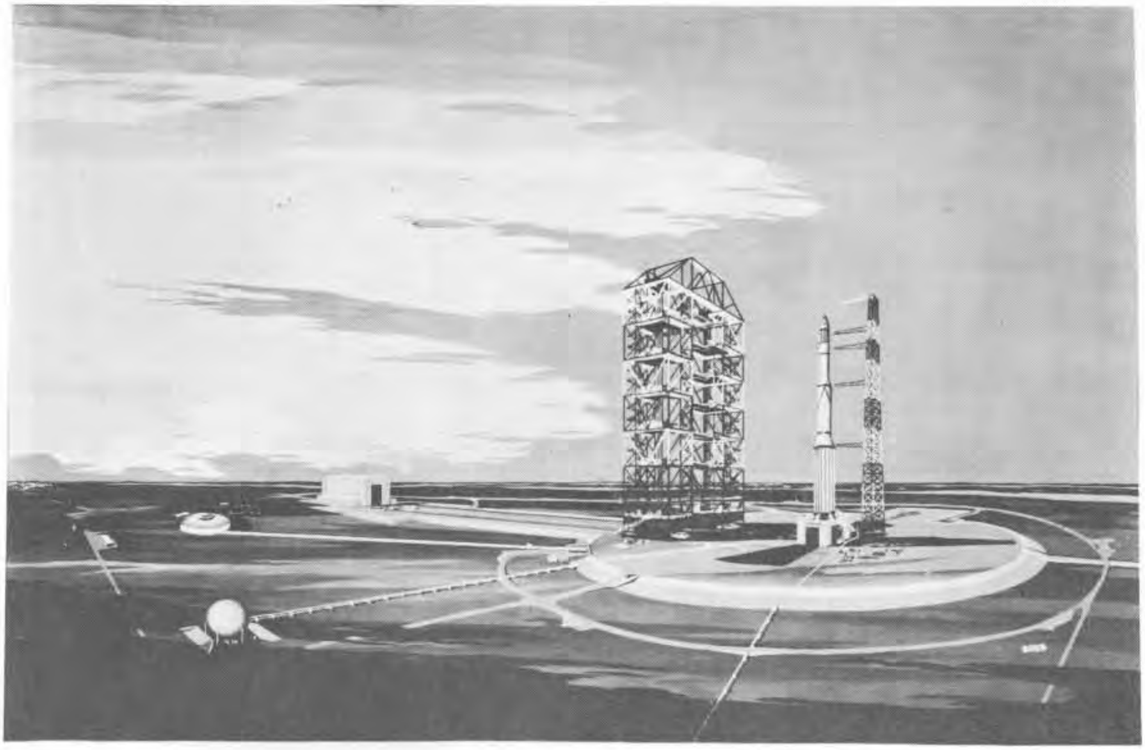


FIGURE 5. PRELIMINARY CONCEPT OF LAUNCH COMPLEX 34, CAPE CANAVERAL

so that upper-stage selection and development could begin, and initiated a study of Atlantic Missile Range (AMR) launch facilities which could accomodate the launch vehicle. Later, December 11, 1958, ARPA Order 47-59 authorized the Army Ordnance Missile Command (AOMC) to begin design, modification, and construction of a captive static test tower and facilities for use in the booster development program. AOMC was also authorized to determine the design requirements for necessary launch facilities (Fig. 5).

During these months, while the booster-vehicle program was being formulated and expanded, development work on the H-1 engine had continued. By the end of the year, December 31, 1958, the H-1 Program had progressed to the first full-power firing at the Rocketdyne facility, Canoga Park, California.

Concurrently with the development program of the H-1 engine, studies had been conducted to determine the feasibility of building a large single-chamber rocket engine capable of producing very high thrust. On January 9, 1959, a contract was awarded Rocketdyne of North American Aviation to design, develop, and test such an engine, designated as the F-1. This engine, burning LOX and RP-1, a kerosene-type fuel, would generate approximately 1,500,000 pounds of thrust.

In response to ARPA Order 47-59 of the previous month, construction of the ABMA static test stand for large boosters began January 10, 1959. At the same time, Army representatives of the ARPA board visited AMR to discuss selection of a site for large vehicle launch facilities at Cape Canaveral. By February 1959, a contract had been awarded for construction of the blockhouse at the site (Launch Complex 34), and a design contract was also awarded for a movable service structure, which would be used to assemble and service the vehicle on the launch pedestal.

On February 3, an ARPA memorandum officially renamed the project SATURN, cancelling the former identification of JUNO V.

ARPA representatives gave a presentation of the proposed National Vehicle Program to the President and the National Aeronautics and Space Council on March 2, 1959. Included at this time were the proposed SATURN B and C vehicle systems (Figs. 6 and 7). On March 13, ABMA submitted to ARPA the results of the SATURN system study. Outlining various upper-stage configurations, this study indicated that either an ATLAS or a TITAN could be used as the second stage of the proposed vehicle (Fig. 8).

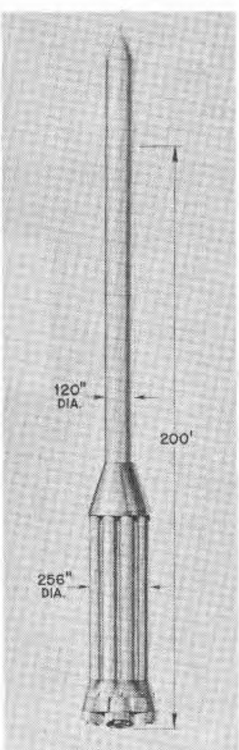


FIGURE 6.
SATURN B

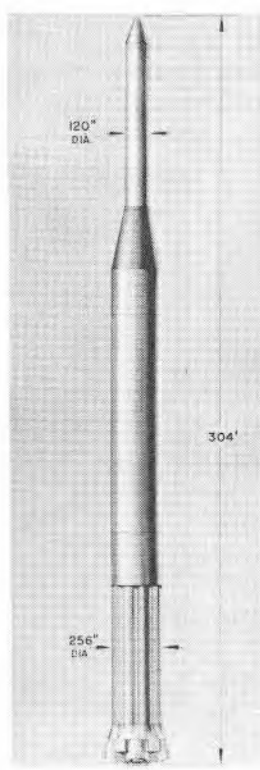


FIGURE 7.
SATURN C

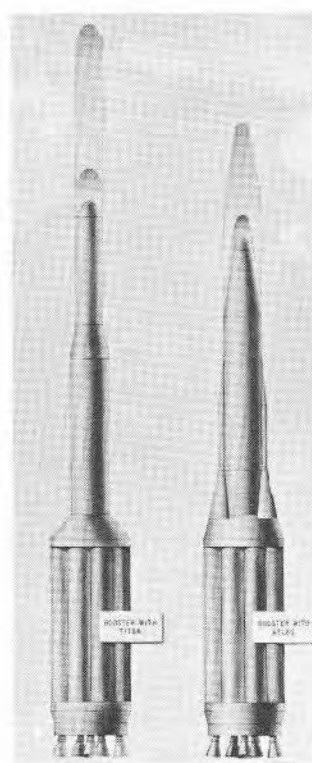


FIGURE 8. VEHICLES USING TITAN AND ATLAS STAGES

In response, ARPA indicated during May, that modified TITAN hardware would be used for the second stage and that the third stage would use a minimumly modified CENTAUR vehicle, which was under development by Convair Astronautics (Fig. 9).

By April 28, the first production H-1 engine (H-1001) had been delivered on schedule to ABMA (Fig. 10). The first firing test of this engine, later used in the first test booster, was performed successfully on May 26, 1959. Shortly after, on July 5, 1959, construction began of the SATURN blockhouse for Launch Complex 34, at Cape Canaveral (Fig. 11).

On July 27, 1959, the date that the last JUPITER airframe was completed at Redstone Arsenal, the Arsenal shops began retooling to support the SATURN project. On the same day, the Director of Defense Research and Engineering sent the Secretary of the Air Force and the Director of ARPA a memorandum stating that as the requirements for the second stage of SATURN and the booster for the proposed DYNA SOAR vehicle were quite similar, ARPA and the Air Force should consider a common development of these projects. Until completion of this review, neither agency was to make firm commitments for the redesign of existing boosters or development of new ones. Immediately after issuing this memorandum, July 29, 1959, ARPA ordered that all AOMC inhouse and contract work, and other expenditures relating to the TITAN second stage, cease immediately. However, permission was granted to continue preliminary work not directly connected with the stage diameter.

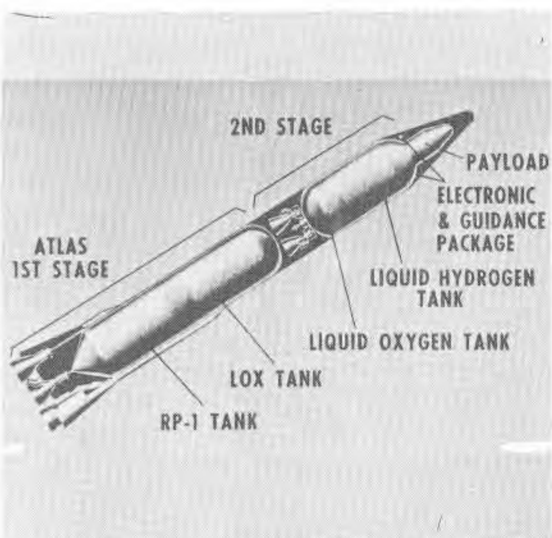


FIGURE 9. ATLAS CENTAUR VEHICLE (CENTAUR SECOND STAGE)

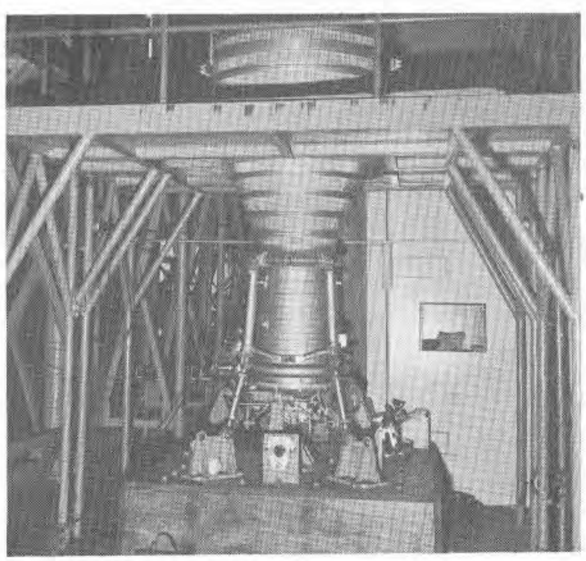


FIGURE 10. H-1 ENGINE IN ALIGNMENT FIXTURE

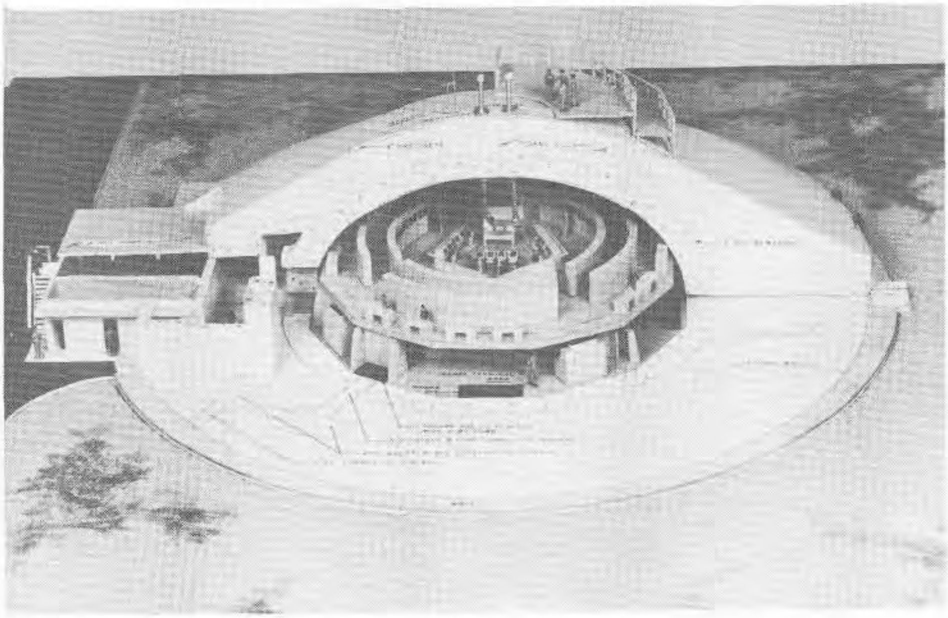


FIGURE 11. MODEL OF BLOCKHOUSE AT LAUNCH COMPLEX 34

While studies of the proposed SATURN-DYNA SOAR combination continued, ARPA, on August 1, authorized ABMA to proceed with captive firing of the SATURN booster early in 1960. In September, a series of presentations on SATURN, NOVA and TITAN C, was made by representatives of AOMC, NASA, and the Air Force, to the Booster Evaluation Committee of the Office of the Secretary of Defense. The purpose of these presentations was to determine which of the three systems would most feasibly promote NASA space objectives. On the basis of these presentations to Dr. York (Director of Research and Engineering, Department of Defense, and Chairman of the Booster Evaluation Committee), the SATURN program was selected because it offered the most immediate advantages of the systems presented. Shortly after this decision, September 24, 1959, ARPA requested that a study be performed to determine the two SATURN configurations which would best increase the vehicle's capabilities to carry NASA payloads.

During the preceding months, studies had been performed to determine the best way of transporting the completed booster. Because of its large size and weight, the booster could not be transported by air or overland, along public highways. As water transportation appeared most feasible, ARPA authorized AOMC, October 23, 1959, to proceed with engineering work for dock facilities. These would be located on the Tennessee River at the southern boundry of Redstone Arsenal. In December, AOMC was further authorized to construct the facilities and to build a barge to transport the booster to Cape Canaveral.

October - December 1959

During October 1959, planning continued of SATURN vehicle configurations. On October 29 and 30, ABMA presented a second SATURN System Study to ARPA and NASA, proposing various upper-stage configurations which offered increased payload capability and growth potential. In December 1959, after evaluation of previous presentations, NASA and ARPA requested that AOMC prepare an engineering study for a three-stage SATURN configuration (later identified as C-1) (Fig. 12).

On November 18, 1959, NASA assumed technical direction of the SATURN project, pending its formal transfer from ARPA. Administrative direction was retained by ARPA until March 16, 1960, when transfer of both administrative and technical direction would become effective.

On December 15, 1959, the SATURN Vehicle Evaluation Committee (the Silverstein Committee), reached a decision on SATURN upper-stage configurations. This committee, composed of representatives from NASA, ARPA, DOD, and AF, recommended a long-range development program for SATURN, including upper-stage engines burning liquid hydrogen and liquid oxygen. The C-1 configuration, selected as the initial vehicle to be developed, was to be a stepping stone to the C-2 vehicle (Fig. 13). The

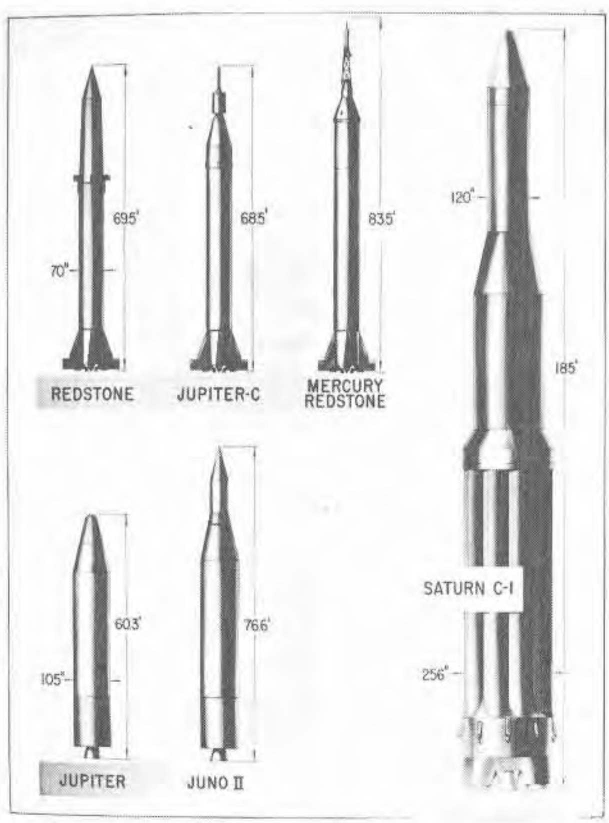


FIGURE 12. C-1 AND EARLIER VEHICLES

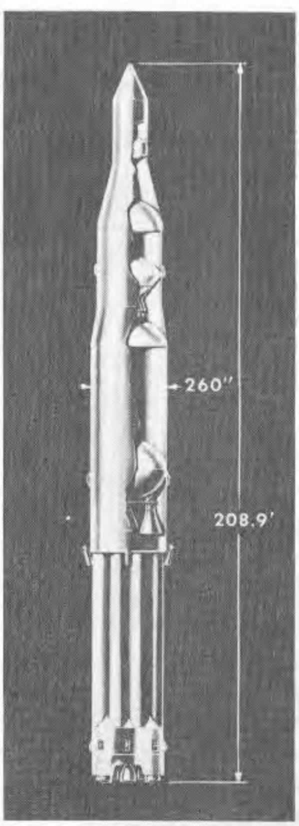


FIGURE 13. PROPOSED C-2

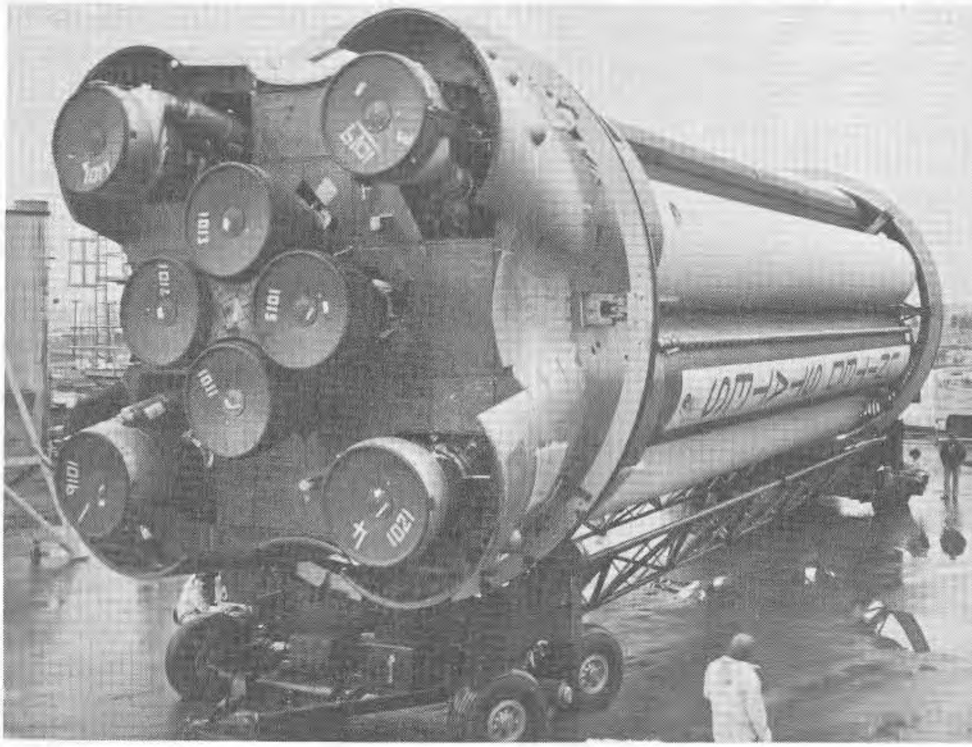


FIGURE 14. BOOSTER STAGE (S-I)

committee also recommended that a high-thrust (150,000 to 200,000 pounds) hydrogen-oxygen engine be developed for use on advanced upper stages. A building-block concept was proposed, as this would yield a variety of SATURN configurations, each using previously-proven developments as far as possible. As these recommendations were accepted by the NASA Administrator, December 31, 1959, a ten-vehicle R&D program was established. The C-1 vehicle configuration included the S-I, the S-IV, and the S-V stages. The S-I stage (Fig. 14) had eight H-1 engines clustered, using LOX/RP-1 propellants capable of producing a total of 1,500,000 pounds of thrust. The S-IV stage (Fig. 15) had four engines, using LOX/LH_2 propellants

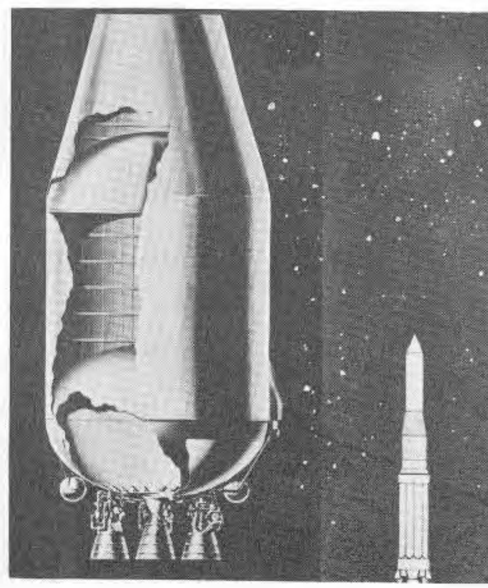


FIGURE 15. SECOND STAGE (S-IV)

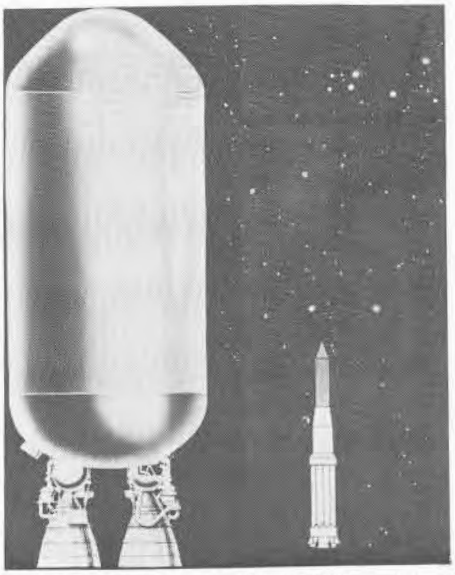


FIGURE 16. THIRD STAGE (S-V)

and producing a total of 80,000 pounds of thrust. The S-V stage (Fig. 16) used two of the same engines as the S-IV stage, producing a total of 40,000 pounds of thrust.

The SATURN project was approved on January 18, 1960, as a program of the highest national priority (DX rating).

As a result of the December decisions, action was taken to procure the S-IV stage. A bidder's conference concerning the stage was held at Huntsville, January 26 and 27, 1960, and, by February 29, 1960, twelve companies had submitted contract proposals.

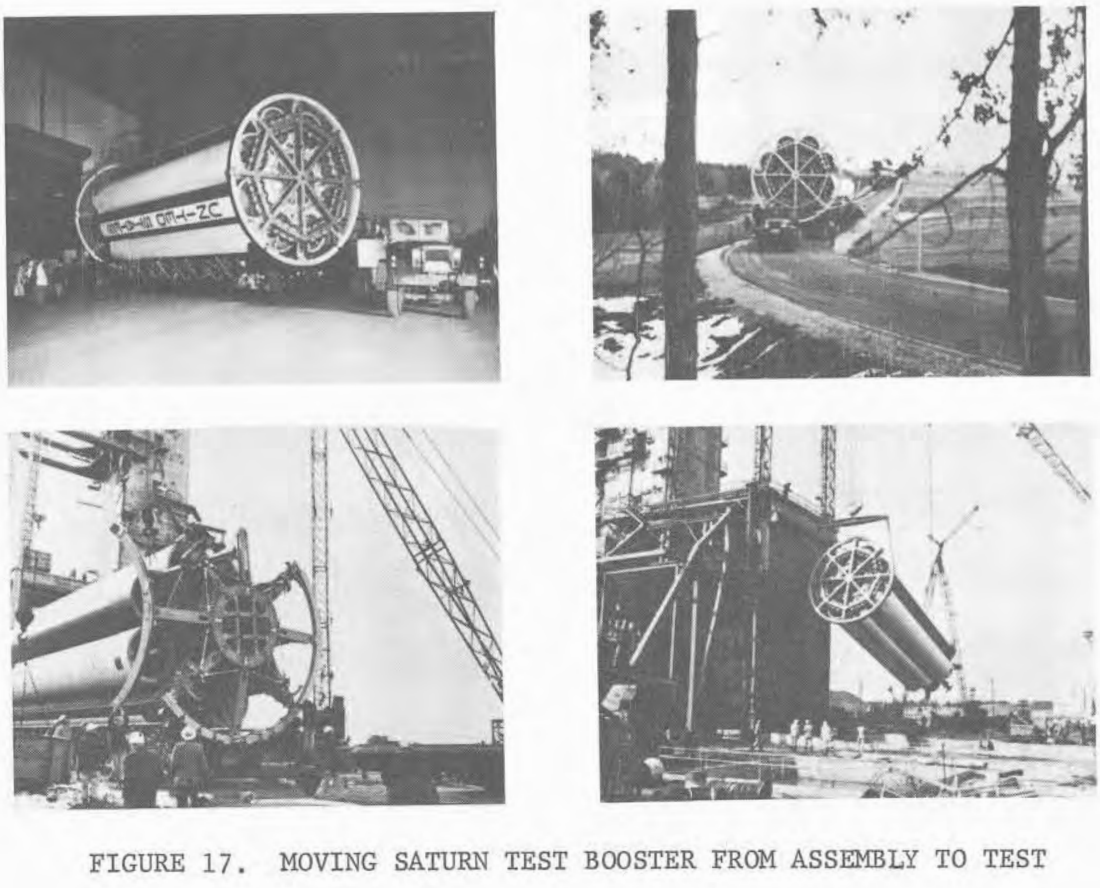


FIGURE 17. MOVING SATURN TEST BOOSTER FROM ASSEMBLY TO TEST

By 1960, the formal test program to prove out the clustered booster concept was well underway at Redstone Arsenal. A mockup of the SATURN booster had been installed in the ABMA test stand on January 4, 1960, to check mating of the booster and stand and to test servicing methods. Structural assembly of a test booster (identified as SA-T) had begun in 1959. Following completion of assembly on January 29, 1960, the booster was moved to checkout. The mockup was removed from the test stand February 1, and SA-T was installed in its place, February 21, 1960 (Figs. 17 and 18).

On February 19, 1960, while preparations for the first series of booster static tests were being made, ABMA received ARPA Order 14-60, Amendment 17. This order authorized NASA to proceed with the preliminary steps leading to contracts for industrial development of the SATURN upper stages. During March 1960, the executive order transferring the SATURN program to NASA became effective. Later in the month, March 28, two of SATURN's eight first-stage engines passed an initial static firing test of approximately eight seconds' duration. This test was identified as number SAT-01 - the first live firing of the SATURN test booster (SA-T). In a second test (SAT-02), on April 6, four engines were successfully static fired for seven seconds. All eight engines of the test booster were successfully fired April 29, 1960, in a test (SAT-03) of eight seconds' duration (Fig. 19). This test was followed, on May 17, by a second eight-engine static firing (SAT-04) of 24 seconds' duration, generating a thrust of 1.3 million

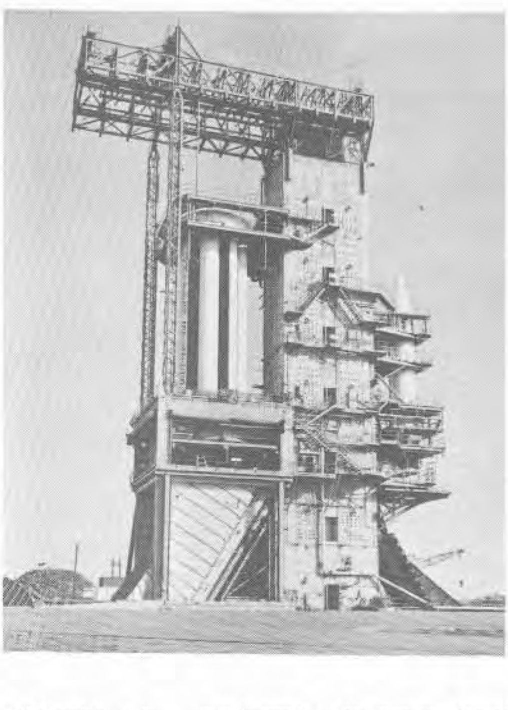


FIGURE 18. BOOSTER IN TEST STAND

FIGURE 19. BOOSTER STATIC FIRING

pounds. On May 26, a third successful eight-engine firing (SAT-05) of 35 seconds' duration was completed.

After review of the S-IV proposals received in February, NASA announced, April 26, 1960, that Douglas Aircraft Corporation had been

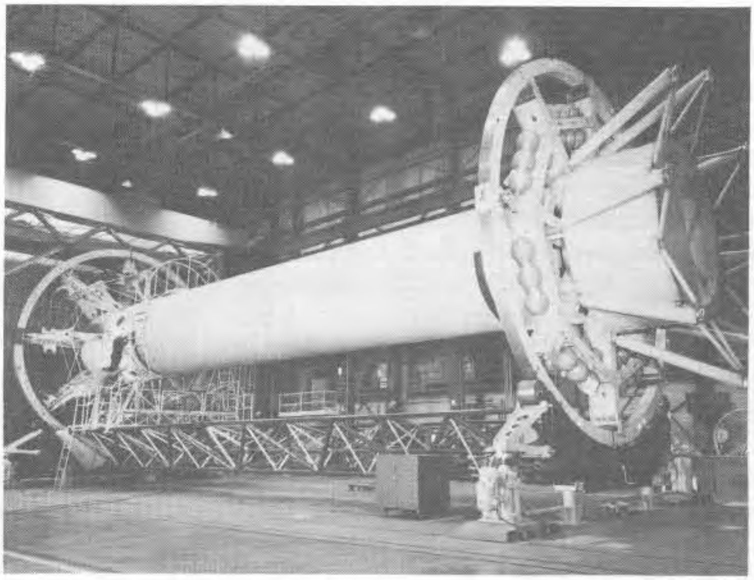


FIGURE 20. ASSEMBLY OF MAIN LOX TANK FOR SA-1 BOOSTER

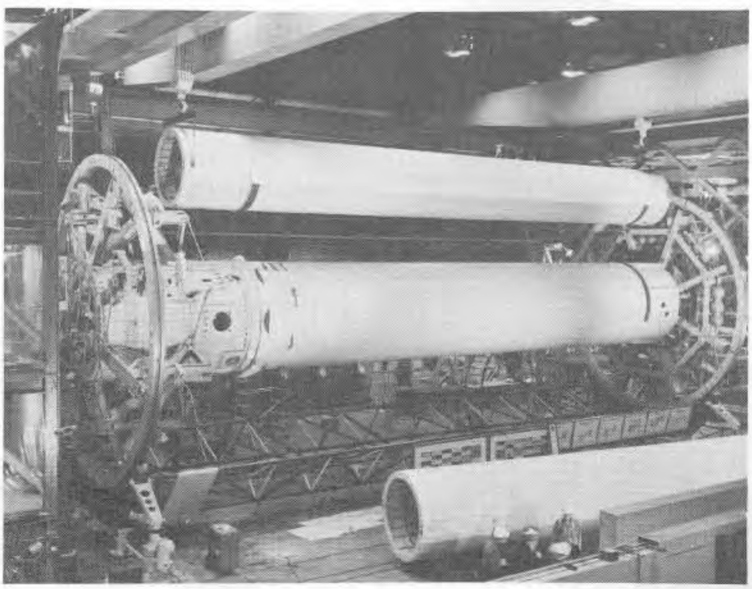


FIGURE 21. ASSEMBLY OF TANKS ON SA-1 BOOSTER

awarded a contract to develop and build the stage. On May 26, 1960, assembly of the booster stage for the first SATURN flight vehicle was begun (Figs. 20, 21, 22, and 23). The flight vehicles would be sequentially numbered, the first being SA-1, the second SA-2, to the SA-10, the prototype of the operational SATURN. Other activity in May included an announcement by NASA that Rocketdyne had been selected to develop the

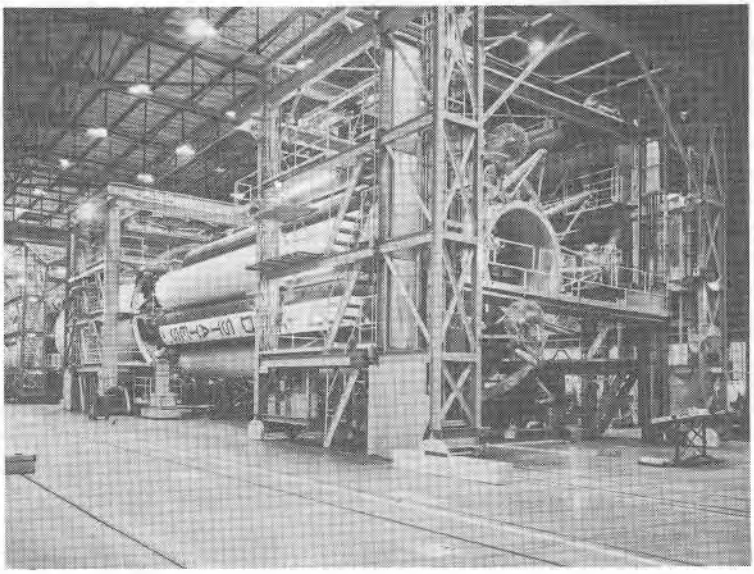


FIGURE 22. STRUCTURAL FABRICATION OF SA-1 BOOSTER

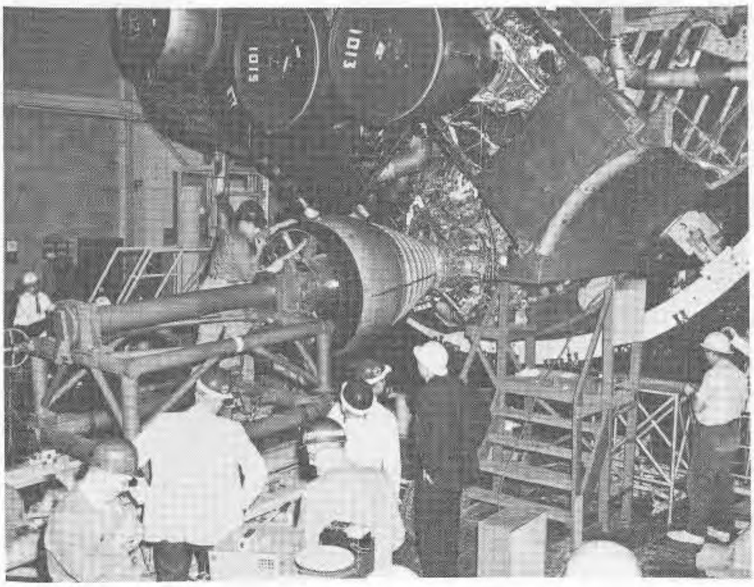


FIGURE 23. INSTALLATION OF ENGINES ON SA-1 BOOSTER

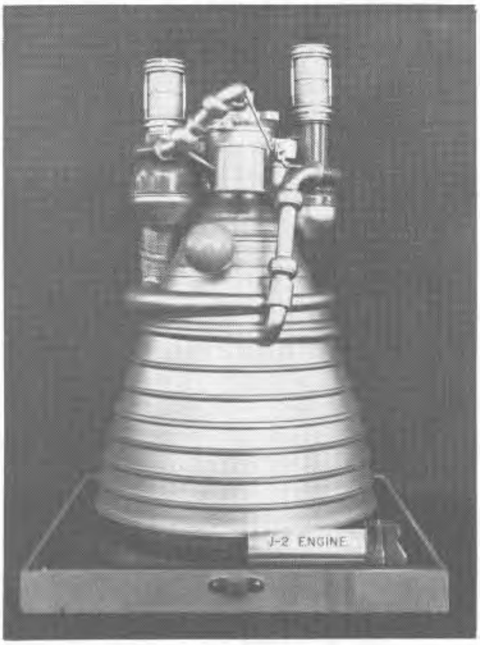


FIGURE 24. MODEL OF J-2 ENGINE

high-thrust J-2 engine (Fig.24). This engine, of the type defined by the Silverstein Committee in December 1959, would burn liquid hydrogen-liquid oxygen, and would be used in an advanced upper stage for the SATURN vehicle.

A second series of booster static tests began June 3, 1960 at MSFC. The eight engines of the stage were successfully fired in a test (SAT-06) of 75 seconds' duration. On June 8, another eight-engine test (SAT-07) was performed in a firing of 111 seconds' duration. A third eight-engine test (SAT-08) of 121 seconds' duration was accomplished on June 15.

On July 1, 1960, the SATURN program was formally transferred to the George C. Marshall Space Flight Center (MSFC).

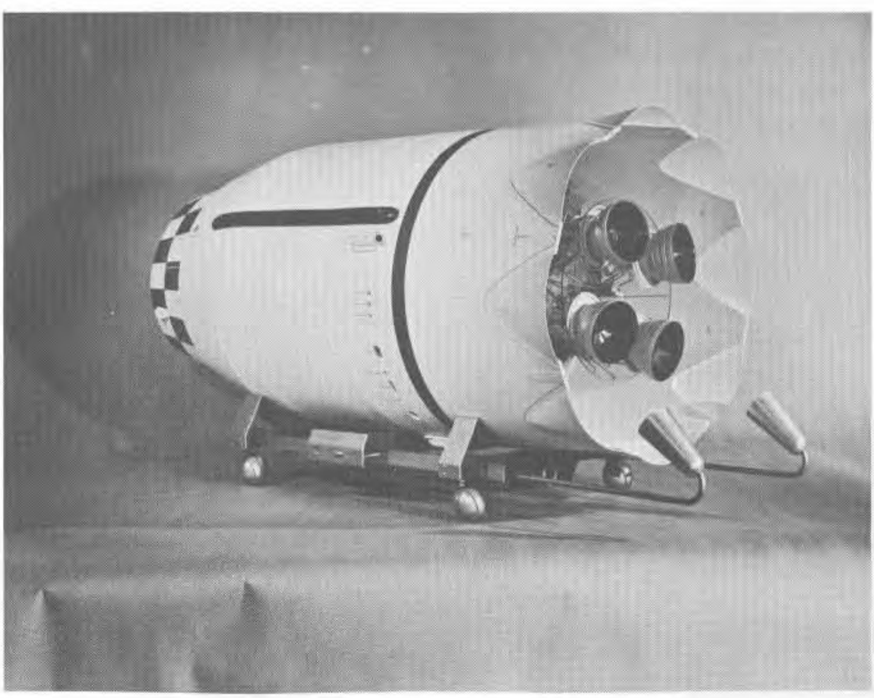


FIGURE 25. INITIAL CONFIGURATION OF THE S-IV STAGE

Formal procurement of the S-IV stage was initiated July 26, 1960, when NAS7-1 Supplemental Agreement was signed with Douglas Aircraft Corporation (DAC). This contract required that DAC design, develop, and fabricate the four-engine S-IV stage (Fig. 25) for the SATURN C-1 configuration. Contracts were also let on August 10, 1960, with Pratt and Whitney (P&W) to develop and produce LR-119 engines; the government would furnish these engines to the contractors responsible for building the S-IV and S-V stages of the C-1 vehicle. The LR-119 engine, an uprated LR-115, was planned to generate 17,500 pounds of thrust.

On August 14, 1960, construction began on the movable service structure for Launch Complex 34 at Cape Canaveral (Fig. 26).

As a result of a request made by the Air Force on August 15, 1960, for NASA assistance in planning the application of SATURN to DYNA SOAR, a meeting was held October 6, between representatives of MSFC and the Air Force. It was agreed that MSFC would provide the Air Force with a preliminary study of the application of SATURN to this program.

FIGURE 26. CONSTRUCTION OF SERVICE TOWER AND PEDESTAL

FIGURE 27. UNVEILING BUST OF GENERAL GEORGE C. MARSHALL

On September 8, 1960, the facilities of the National Aeronautics and Space Administration at Huntsville, Alabama, were dedicated and designated as the George C. Marshall Space Flight Center. Attended by President Eisenhower, Mrs. G. C. Marshall, NASA Administrator T. Keith Glennan, and many other National, State, and local dignitaries, this dedication, (Figs. 27, 28, and 29) was the culmination of events originating in the Presidential Executive Order, dated March 15, 1960.

On October 21, a study contract for a second upper stage (the S-V) was awarded to Convair Astronautics. On October 25, 1960, NASA selected Convair, General Electric, and Martin to conduct individual feasibility studies of an advanced manned-spacecraft as part of Project APOLLO.

The barge, Palaemon, which would transport the booster to the Cape,

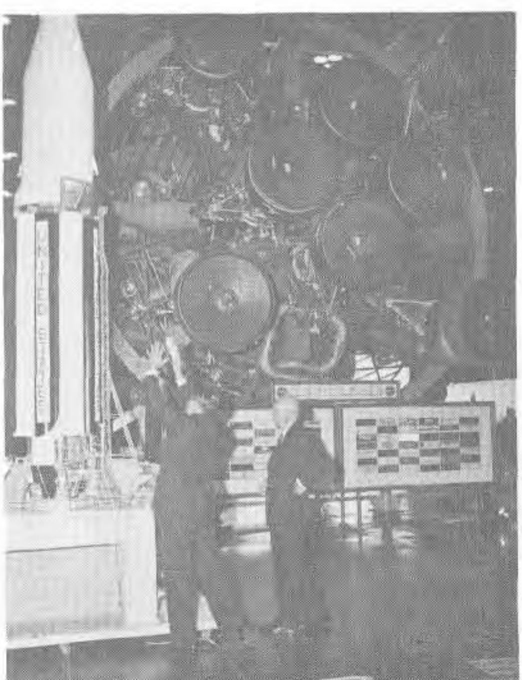


FIGURE 28. DR. VON BRAUN AND PRESIDENT EISENHOWER

FIGURE 29. MR. GLENNAN, PRESIDENT EISENHOWER, AND DR. VON BRAUN

was delivered to MSFC, November 22, 1960.

A new series of static firing tests of the test booster (modified to the SA-1 flight configuration and designated SA-T1) was initiated December 2, 1960, in an eight-engine test (SAT-09) of two seconds' duration. The following week, on December 10, two of the eight engines were static tested (SAT-10) in a firing of six seconds' duration. The series of booster tests was successfully concluded on December 20, 1960, by a 60-second firing of all eight engines (SAT-11). Fabrication of the tanks for the booster stage of the second SATURN flight vehicle (identified as SA-2) was completed during December. Assembly of the booster began immediately.

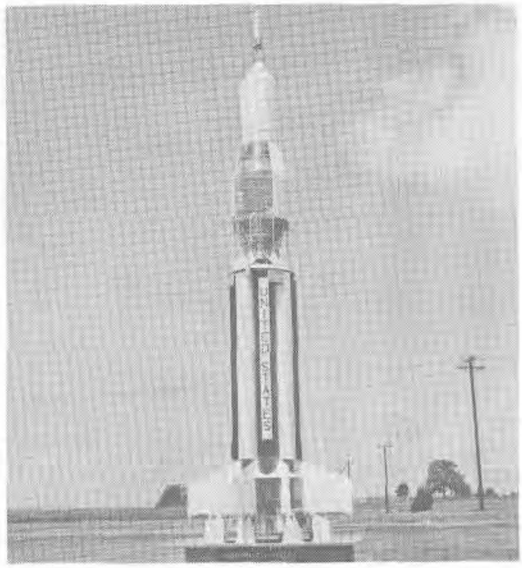


FIGURE 30. PROPOSED SATURN C/1 APOLLO CONFIGURATION

On January 5, 1961, Convair Astronautics submitted a proposal for the development of an S-V upper stage for the SATURN vehicle; however, later in the month, January 26, Dr. von Braun proposed that the C-1 vehicle be changed from a three-stage to a two-stage configuration in support of the APOLLO program (Fig. 30). The change would delete requirements for the S-V stage on C-1 vehicles.

On January 16, the booster stage for the SA-1 flight vehicle was moved from assembly to checkout (Fig. 31). During the month of January, also, wind tunnel testing of a model SATURN booster began at the Arnold Engineering Development Center; the tests were designed to study base heating phenomena of the clustered stage.

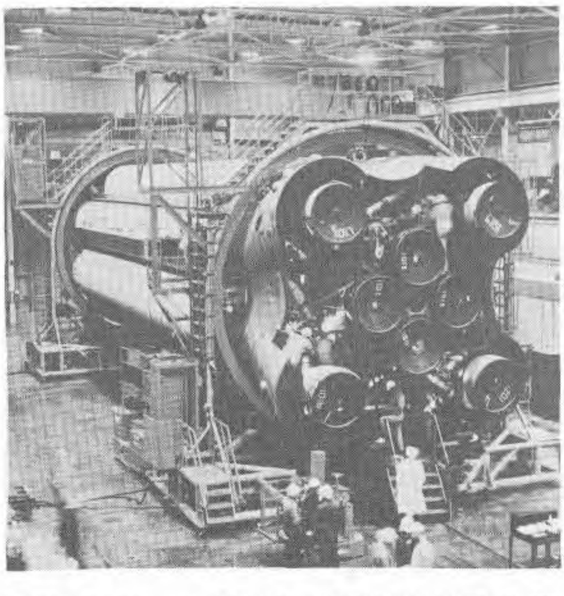


FIGURE 31. FLIGHT BOOSTER CHECKOUT

Two additional studies began in January, 1961, when contracts were awarded North American and Ryan to investigate the feasibility of recovering the S-I booster stage of the flight vehicle by using a

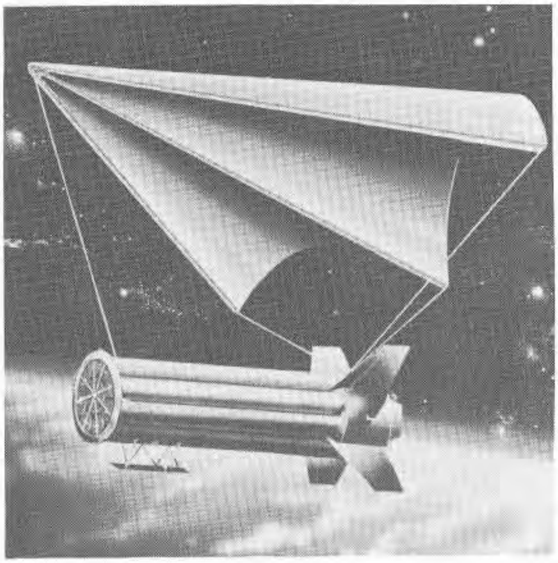


FIGURE 32. SATURN BOOSTER RECOVERY

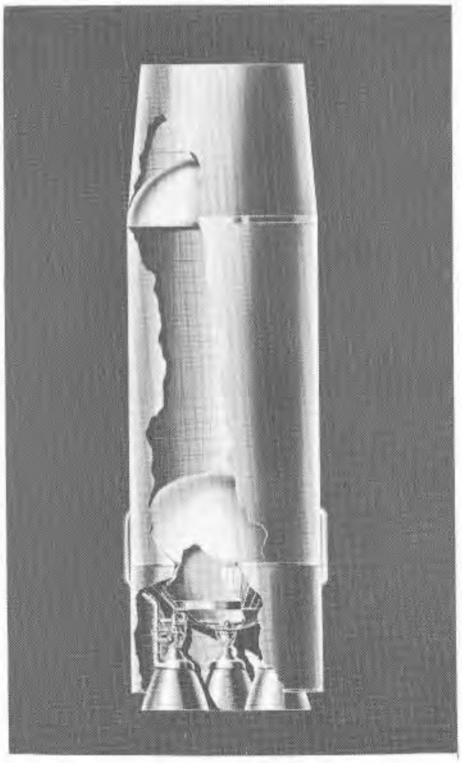


FIGURE 33. C-2 SECOND STAGE CONCEPT

Rogallo paraglider (Fig. 32). A design contract was awarded for equipment which would be used at MSFC to check out the S-1 stage automatically.

On January 25, 1961, a meeting was held at MSFC to study S-II stage requirements for the SATURN C-2 vehicle (Fig. 33). This information was needed so that early S-II stage trajectory, performance, and structural analysis calculations could be completed and made a part of the preliminary SATURN/DYNA SOAR proposal. Two days later, at MSFC, a dummy of the S-IV stage was completed and moved to checkout (Fig. 34).

On January 31, an eight-engine R&D static firing, (SAT-12), of the SA-T1 test booster took place at MSFC. This was a test of 113 seconds' duration.

A dummy S-V stage, built for use on SA-1, was received from Convair on February 8, and mated to the dummy S-IV stage. The first horizontal assembly of the complete C-1 vehicle was accomplished during this month (Fig. 35).

SA-T1 static tests were completed on February 14 in an eight-engine firing of 108 seconds (SAT-13). By February 27, Convair had provided MSFC with a second dummy S-V stage. This stage would first be used during dynamic tests of a complete dummy vehicle; later the dummy S-V would be used on a flight vehicle.

In February, a series of meetings were held at NASA Headquarters and MSFC to discuss difficulties met during LR-119 engine development. As a result of these meetings, studies began early in March to determine

FIGURE 34. MOVEMENT OF DUMMY S-IV STAGE TO CHECKOUT

FIGURE 35. FIRST HORIZONTAL MATING OF THE SATURN VEHICLE

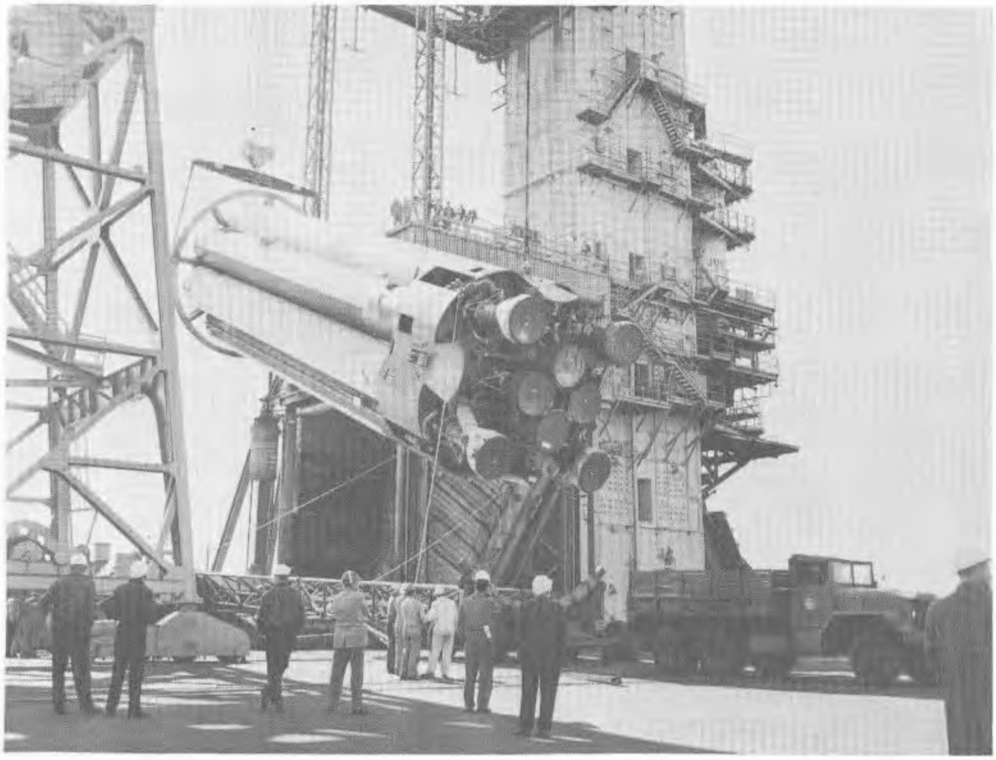


FIGURE 36. REMOVAL OF THE BOOSTER FROM THE STATIC TEST STAND

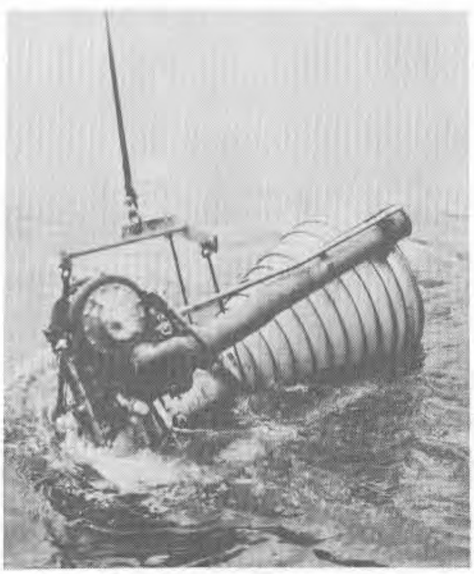


FIGURE 37. SALT WATER TEST OF H-1 ENGINE

the possibility of using the first generation LR-115 type CENTAUR engine on the SATURN S-IV stage, rather than the planned second-generation CENTAUR engine, the LR-119. The booster was removed from the test stand on March 2, (Fig. 36) and loaded aboard the Palaemon for river trials.

Also, on March 2, 1961, as a part of the booster recovery studies, tests began at Cape Canaveral to determine the feasibility of reusing H-1 engines after exposure to salt water (Fig. 37). Construction work at Launch Complex 34 continued to progress satisfactorily, with the service structure, blockhouse, and gas facilities, nearing completion (Fig. 38).

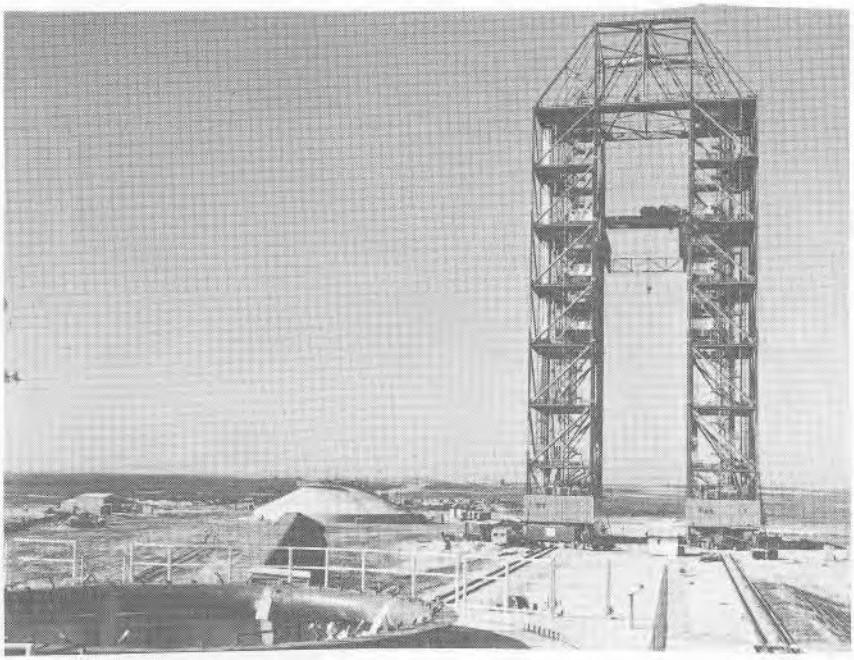


FIGURE 38. FACILITIES CONSTRUCTION AT LAUNCH COMPLEX 34

During the first week of March 1961, preparations began at MSFC for the first flight qualification testing of the SA-1 booster, which, on March 7, was moved to the Marshall Space Flight Center static test stand for preflight checkout.

On March 14, the Palaemon, carrying the SA-T1, left the MSFC dock on its first training trip (Fig. 39). Following its return on March 18, the test booster was returned to the MSFC shops for modification to the SA-T2 configuration. Also during March, construction began at MSFC of a facility to be used in familiarizing personnel with the handling of liquid hydrogen.

At a SATURN Program Review, held March 23, 1961, MSFC presented plans to accelerate the C-2 program and recommended that a prime contractor be selected to develop the S-II stage. Recommendations were

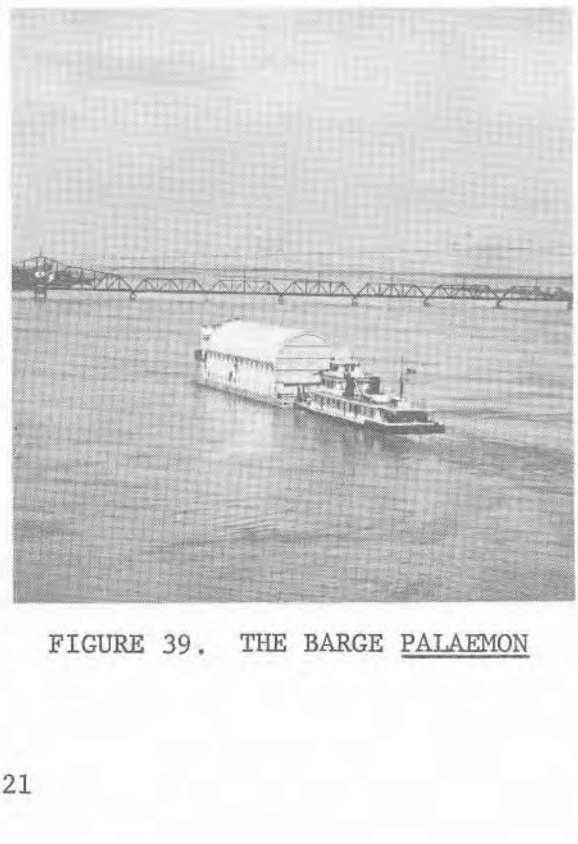


FIGURE 39. THE BARGE PALAEMON

also made to use six LR-115 engines on the S-IV stage instead of four LR-119 engines. Pratt and Whitney would still be the supplying contractor. Also proposed were certain design changes of the S-I stage, including increased propellant capacity, fins (Fig. 40), and increased structural stiffening for later versions of the booster.

On March 29, 1961, MSFC received NASA Headquarters approval for the six-engine configuration of the S-IV (Fig. 41). Stage redesign began immediately afterward at DAC. Additional NASA approval was received March 31, to accelerate the C-2 program and optimize the C-2 vehicle for a three-stage escape mission. MSFC was also authorized to begin a two-phase procurement of an S-II stage. (The S-I stage design changes were authorized later in May, 1961).

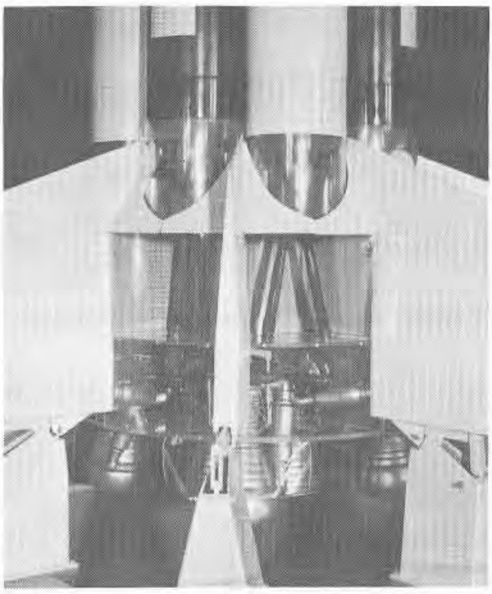


FIGURE 40. REDESIGNED TAIL OF THE SATURN BOOSTER

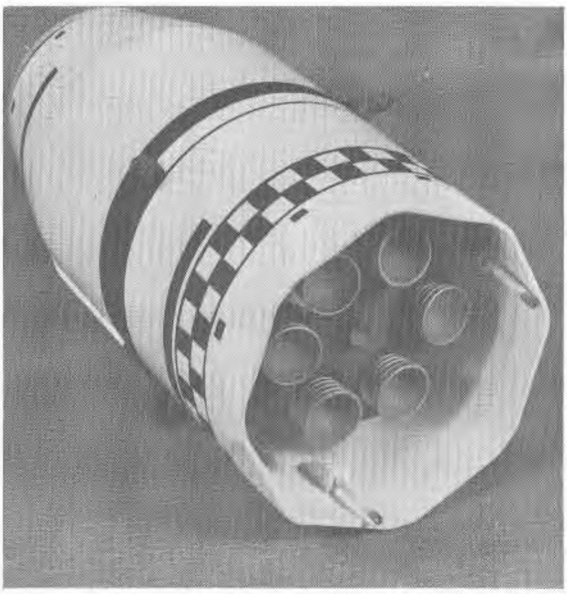


FIGURE 41. SIX-ENGINE CONFIGURATION OF THE S-IV STAGE

During March, further decisions were made concerning engines for the S-IV stage. It was decided to redirect effort from development of the LR-119 to the RL10-A-3, an engine that could be used in common by both the CENTAUR and the S-IV stage.

On April 10, 1961, NASA announced the Project APOLLO objective of developing an orbiting laboratory for the study of effects of radiation and prolonged weightlessness, first with animals and later with a three-man crew (Fig. 42). During April, DAC reported that air transport for the S-IV stage was feasible (Fig. 43). DAC had been authorized in 1960

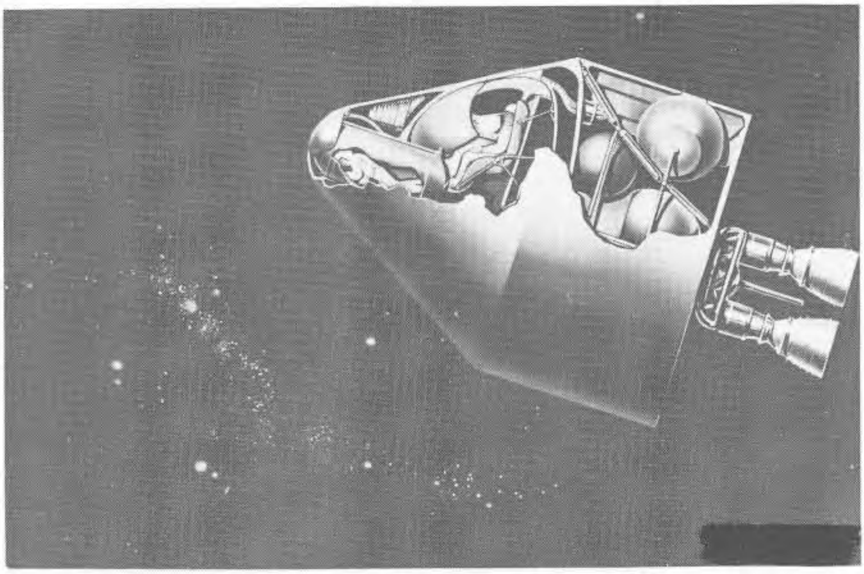


FIGURE 42. ARTIST'S CONCEPT OF APOLLO CAPSULE

FIGURE 43. AIR TRANSPORT OF S-IV STAGE

to study air transportation for the S-IV stage. This mode of transportation would greatly reduce the time required to move the stage by water from California to Marshall Space Flight Center at Huntsville, Alabama, and thence to Launch Complex 34, at Cape Canaveral, Florida. Other modes of stage transportation under investigation during this time included gliders, blimps, and aircraft to carry the stages internally.

April 1961

On April 17, the Palaemon began its first trial run to Cape Canaveral. The barge carried a water-ballasted tank simulating the size and weight of the S-I booster (Fig. 44), plus a dummy S-V stage for the SA-1. The barge reached Cape Canaveral on April 30 (Fig. 45). After rehearsing movement of the booster along roads at the Cape, the simulator was reloaded aboard the Palaemon. The dummy S-V stage remained at the Cape. On May 3, the barge began its return trip, arriving at the Redstone Arsenal dock, May 15 (Fig. 46).

Construction of the dynamic test tower at MSFC had been completed on April 17, the same day that the Palaemon left for Florida. Designed to obtain essential information on the dynamic behavior of the vehicle (Fig. 47), the dynamic tower permits checkout of the mechanical mating of the C-1 vehicle, and aids in determining the vehicle's natural bending characteristics and the effect of simulated flight vibrations.

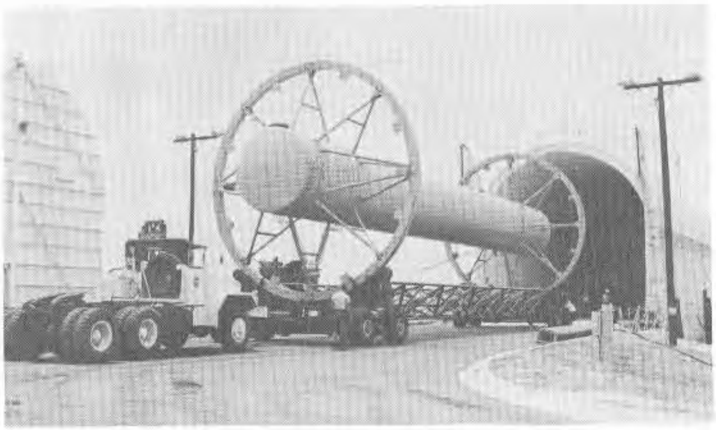


FIGURE 44. BOOSTER SIMULATOR BEING LOADED ABOARD PALAEMON

Acting on the authorization received from NASA Headquarters on March 23, MSFC held a SATURN S-II preproposal conference on April 18; the first phase of S-II procurement was expected to begin during May. On April 21, DAC reported to MSFC that the major problem in S-IV stage development was disposition of hydrogen gas generated during engine chilldown. On April 29, 1961, the first flight qualification test (SA-01) of the SA-1 booster was successfully accomplished in an eight-engine test of 30 seconds' duration. Assembly of the SA-2 flight vehicle continued, and fabrication

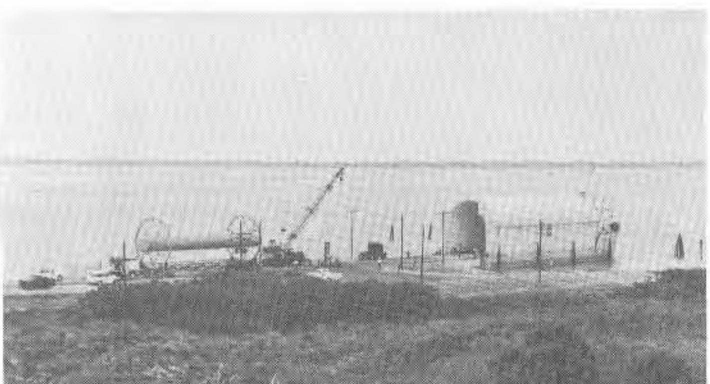


FIGURE 45. UNLOADING SIMULATOR AT THE CAPE

FIGURE 46. ROUTE OF THE PALAEMON TO CAPE CANAVERAL

of the LOX and fuel tanks for the SA-3 vehicle was begun.

A second static firing of the SA-1 booster (SA-02) was accomplished May 5, 1961, in an eight-engine test of 44 seconds' duration. As this test was terminated prematurely (because of a ruptured gas generator pressure transducer which gave a shutdown signal through the fire detection system), a third eight-engine static firing test (SA-03) of the SA-1 booster was performed May 11 (Fig. 48). Results of this test (111 seconds' duration) were satisfactory.

In May 1961, NASA Headquarters accepted MSFC's March proposal to incorporate design changes into the S-I stage of the C-1 vehicle. The changes would permit the C-1 to be used as a two- or three-stage vehicle possessing satisfactory safety requirements for the

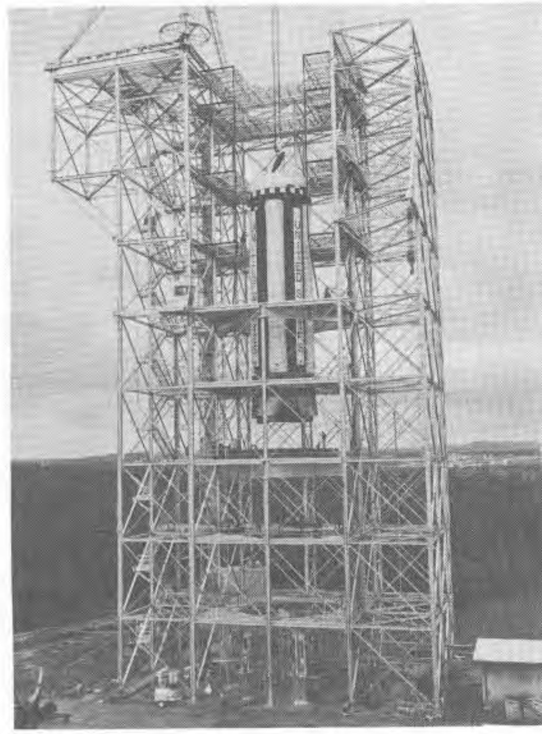


FIGURE 47. INSTALLING DUMMY S-I ON DYNAMIC TEST TOWER

FIGURE 48. POSITIONING FLIGHT BOOSTER IN TEST STAND

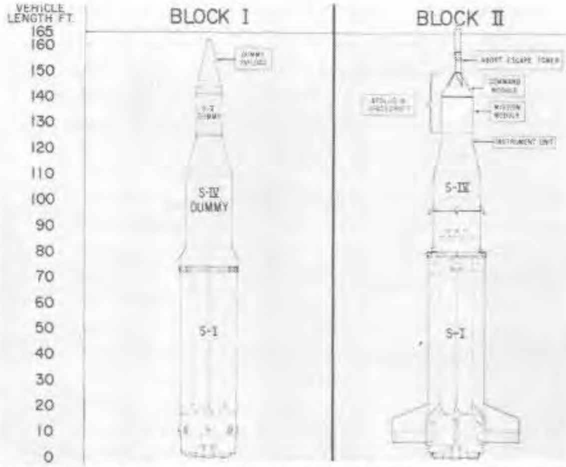


FIGURE 49. CONFIGURATIONS OF SATURN FLIGHT VEHICLES

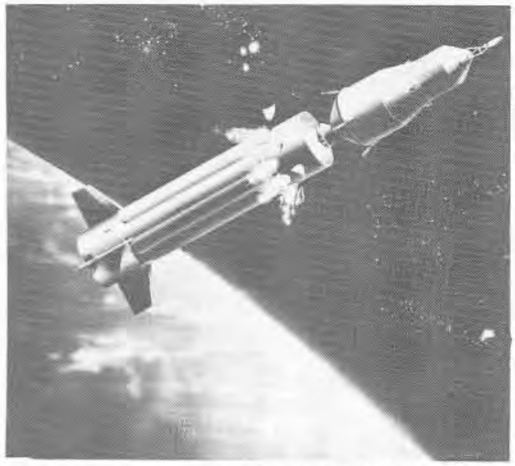


FIGURE 50. SEPARATION OF UPPER STAGES FROM BOOSTER

two-stage manned mission (Figs. 49 and 50) This change eliminated the immediate need for an S-V stage with the C-1, except for possible special missions. Also, during May 1961, MSFC began reexamination of the capabilities of the SATURN C-2 configuration to support lunar circumnavigation missions. Results of this examination indicated that, as lunar mission requirements had increased, a SATURN vehicle of even greater performance would be desirable.

On May 18, the first phase of S-II procurement began, when MSFC requested industry to prepare capability proposals for the design and development of the stage. Also during May, P&W shipped a mockup of the RL10-A-3 engine (Fig. 51) to DAC and Convair for checks to assure that the engine was physically compatible with both the S-IV stage and the CENTAUR vehicle. Among other activities in May, the Martin Company was awarded a contract to study launch vehicle systems which could be used in lunar exploration beyond the initial Project APOLLO flights. (These studies cover transportation systems for a lunar landing and immediate return

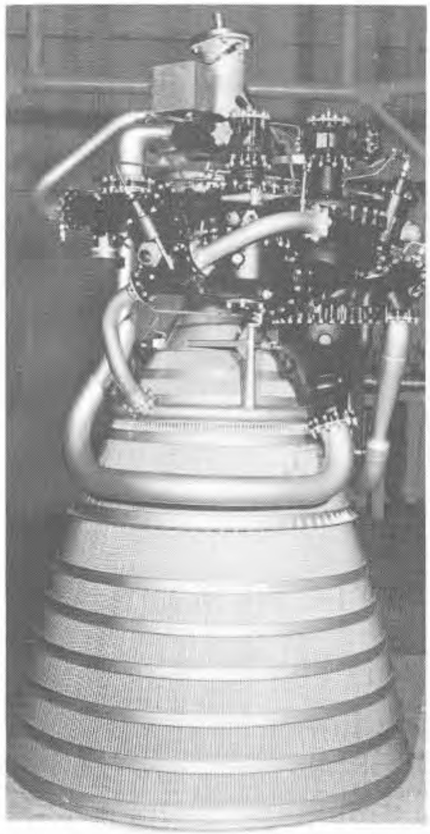


FIGURE 51. MODEL OF THE RL10-A-3 ENGINE

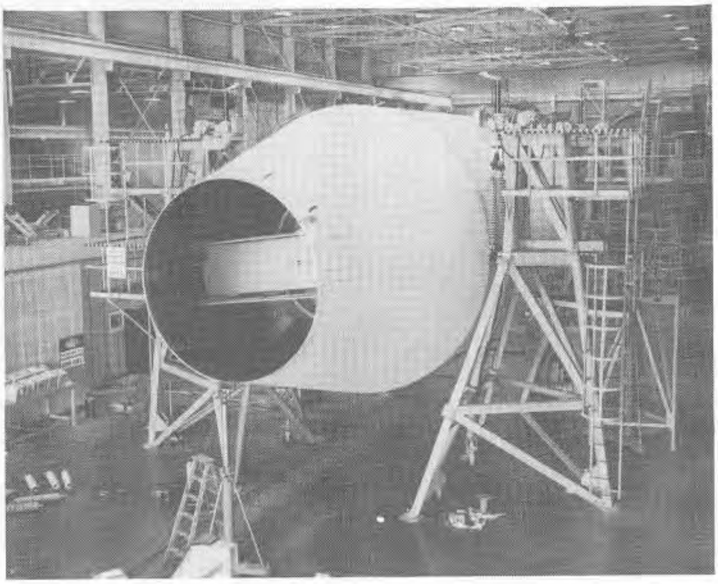


FIGURE 52. TESTING OF DUMMY S-IV STAGE

for three men, a thirty-day stay on the moon for three men, and a permanent moon base to accommodate 10 to 12 men).

At MSFC, tests of the S-IV dummy stage for the SA-1 flight vehicle were performed May 20-25, 1961 (Fig. 52). On successful completion of testing, work began to ready the stage for shipment to Cape Canaveral.

During June, construction of the liquid-hydrogen test site (Fig. 53)

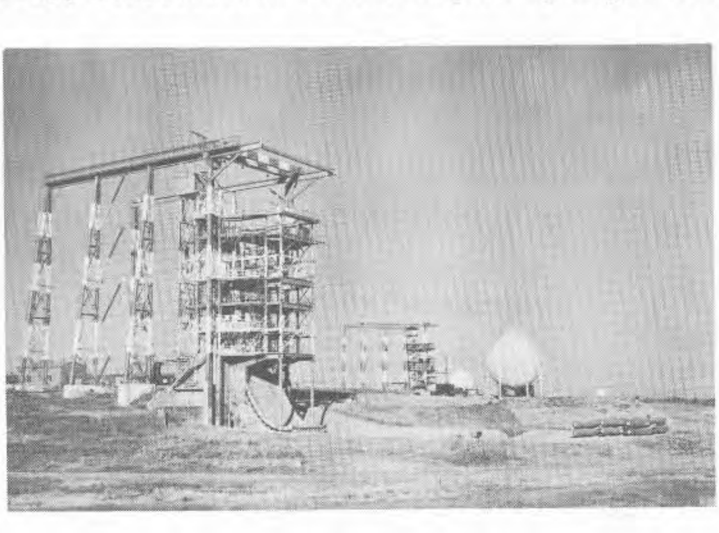


FIGURE 53. SACRAMENTO TEST FACILITY

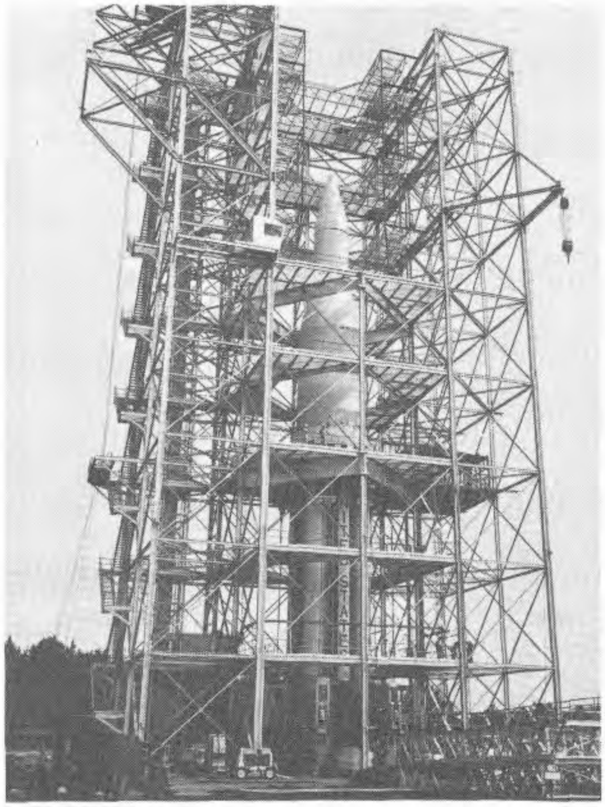


FIGURE 54. DUMMY SATURN VEHICLE IN DYNAMIC TEST STAND

neared completion at Douglas Aircraft's Sacramento Test Facility. Utilizing LOX facilities existing from earlier programs, the site includes two 90,000-gallon liquid hydrogen storage tanks and test stands capable of testing S-IV hardware under a variety of conditions.

Engine gimbal tests performed at MSFC during April and May had indicated the advisability of increasing the stiffness of the engine control support structure in the booster. To investigate this matter further, the control engine support structure of the S-I stage of the dynamic test vehicle was modified and a series of single-engine gimbal tests began on May 29, 1961. As test results were of marginal satisfaction, a new type of actuator servo valve was then installed. Further test results were satisfactory. On completion of these tests, the dummy booster was moved to the dynamic test stand early in June, and, for the first time, vertically mated with dummy S-IV and S-V stages. The assembled vehicle was then readied for dynamic testing (Fig. 54).

During May and June 1961, Douglas Aircraft had continued fabrication of full-scale mockups of S-IV stage sections (Figs. 55 and 56). These

FIGURE 55. TAIL AREA MOCKUP

FIGURE 56. FORWARD INTERSTAGE MOCKUP

mockups are used to check the mating of different sections of the stage and to determine equipment locations.

On June 2, a lock collapsed at the Wheeler Dam on the Tennessee River. All movement of river traffic was halted. As the Palaemon was trapped in the upper river, it was decided to transport the booster in the Palaemon to a point above the dam, unload the stage, and transport it overland to a point below the dam. There, the stage would be reloaded on another barge to continue the trip to Cape Canaveral. To support these plans, MSFC obtained a Navy barge which had been mothballed at Pensacola, Florida. Necessary modifications began so that the new barge (renamed the Compromise) (Fig. 57) could carry the S-I and dummy S-IV stages and dummy payload.

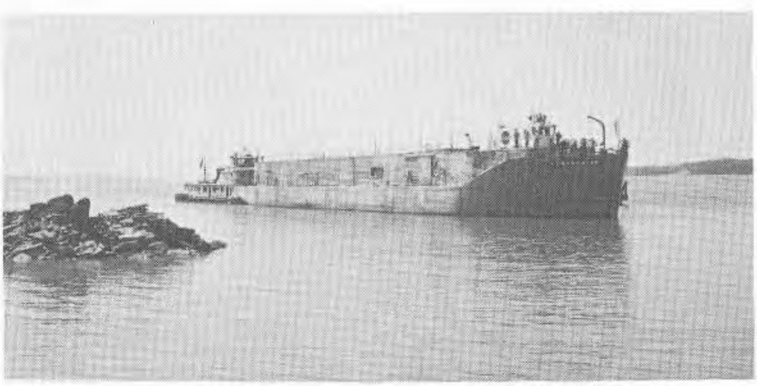


FIGURE 57. THE BARGE COMPROMISE

FIGURE 58. LAUNCH COMPLEX 34, AERIAL VIEW

On June 5, 1961, Launch Complex 34 was dedicated in a brief ceremony and turned over to NASA (Figs. 58 and 59).

Final acceptance testing of the S-I stage for the first flight booster began at MSFC, June 12, 1961, the first operation accomplished

FIGURE 59. LAUNCH COMPLEX 34, BLOCKHOUSE INTERIOR

being the mechanical mating of the S-IV dummy stage. Design work for later SATURN vehicles also continued at MSFC, when, on June 15, 1961, a mockup of the new instrument unit portion of the vehicle was completed; this unit, containing guidance and instrumentation, will be placed above the upper stages of Block II vehicles (Fig. 60).

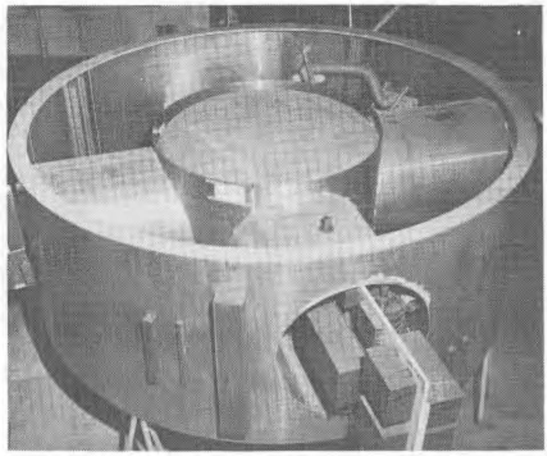


FIGURE 60. INSTRUMENT UNIT MOCKUP

On June 21, Phase II procurement of the S-II stage began. Four companies were invited to attend the Phase II meeting at MSFC and proposals were requested.

At another meeting held in June with DAC, MSFC made the decision that the S-IV stage would be redesigned to incorporate chill-down venting through which accumulated hydrogen gas would be disposed.

As a result of studies initiated at MSFC in May, Dr. von Braun announced, June 23, that further engineering design work on the C-2 configuration would be discontinued, (Fig. 61) and effort would instead be redirected toward clarification of the SATURN C-3 and NOVA concepts

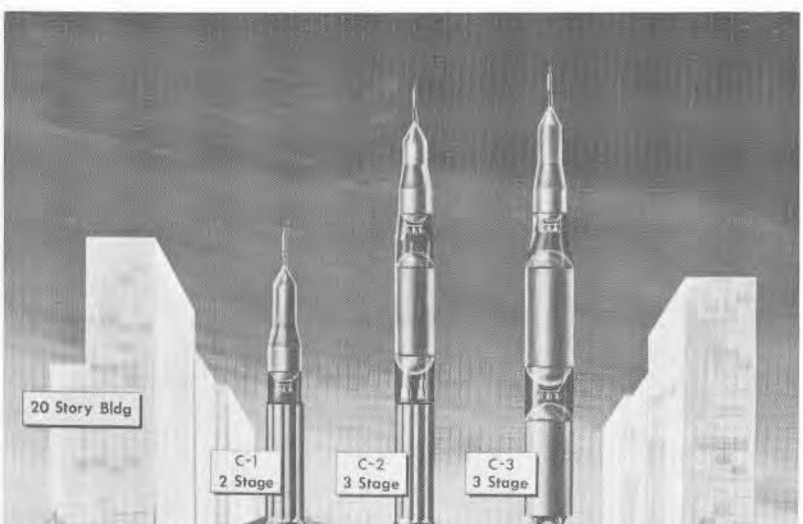


FIGURE 61. COMPARISON OF SATURN CONFIGURATIONS

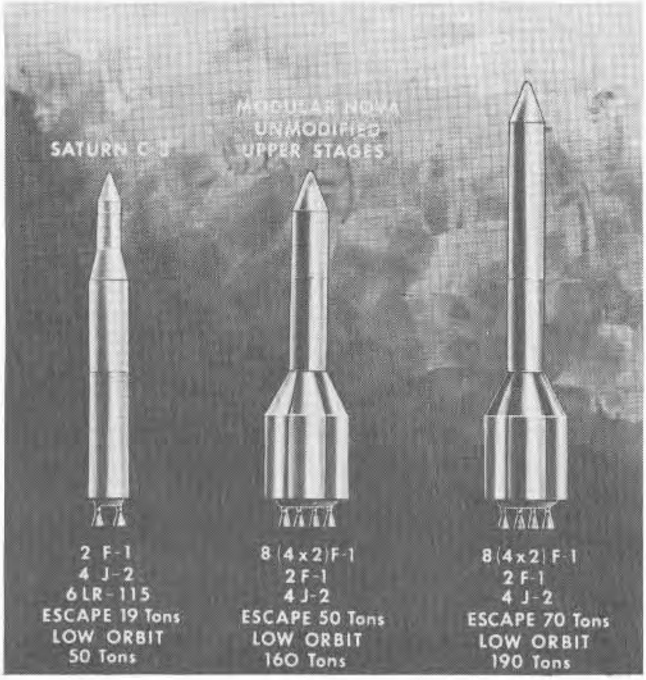


FIGURE 62. POSSIBLE NOVA CONFIGURATIONS

(Fig. 62). Investigations were specifically directed toward determining capabilities of the proposed C-3 configuration in supporting the APOLLO mission (Fig. 63).

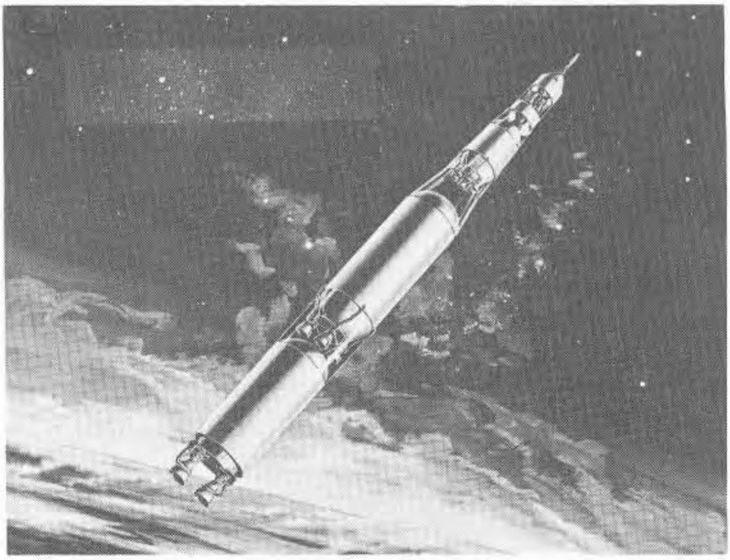


FIGURE 63. PROPOSED C-3/APOLLO CONFIGURATION

FIGURE 64. INSTALLATION OF SA-T2 ON STATIC TEST STAND

FIGURE 65. DR. VON BRAUN, JAMES E. WEBB, AND MAJ. GEN. OSTRANDER

On June 27, the first static test of the SA-T2 booster (the SA-T1 booster modified to the configuration of the SA-2 booster stage) was successfully accomplished at MSFC (Fig. 64). This was an eight-engine test (SAT-14) of 30 seconds' duration to confirm effectiveness of the new actuator servo valve and the stiffening of the control engine support structure.

During the last week in June, a contract was awarded to Chrysler Corporation for performance of qualification and reliability testing on various engine, hydraulic, mechanical, and structural components of the SATURN booster. Another contract was awarded in the same month for preliminary design of a facility to static test the J-2 engine.

To commemorate the first anniversary of Marshall Space Flight Center, an open house was held at the Center on July 1, 1961. Attending were such national figures as the NASA Administrator, James E. Webb; the Director of NASA Launch Vehicle Programs, Major General Don Ostrander (Fig. 65), and numerous other national, state, and local dignitaries. A few days later, dynamic testing of SA-D1 began to investigate the bending modes of the vehicle and to continue studies into tank resonances, initiated by Langley Research Center during June. While dynamic

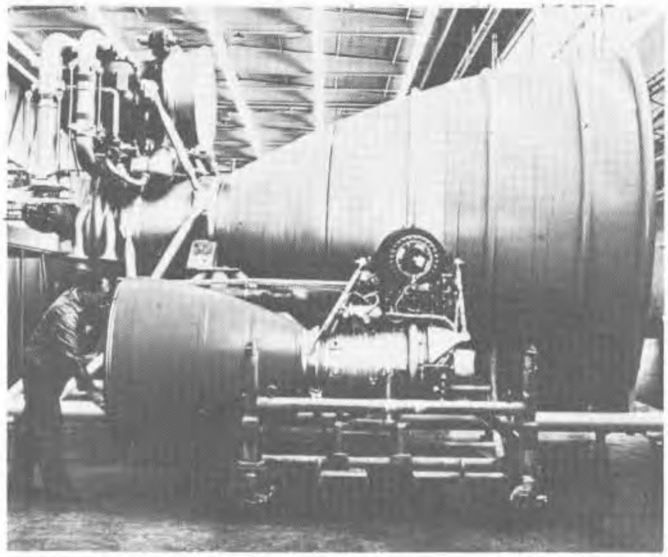


FIGURE 66. H-1 AND F-1 ENGINE COMPARISON (H-1 IN FOREGROUND)

testing proceeded at MSFC, Rocketdyne, in California, began static firing tests of a complete F-1 engine, (Fig. 66). In the course of these tests, the engine would build up to 1.5 million pounds of thrust (Fig. 67).

Early in July 1961, MSFC awarded a contract to Minneapolis-Honeywell for necessary engineering and manufacturing services to adapt the CENTAUR guidance set to SATURN requirements. Also in July, MSFC awarded a six-month contract to the Boeing Company to study the feasibility of creating huge vehicles by joining solid propellant "superboosters" with liquid-propellant upper stages (Fig. 68).

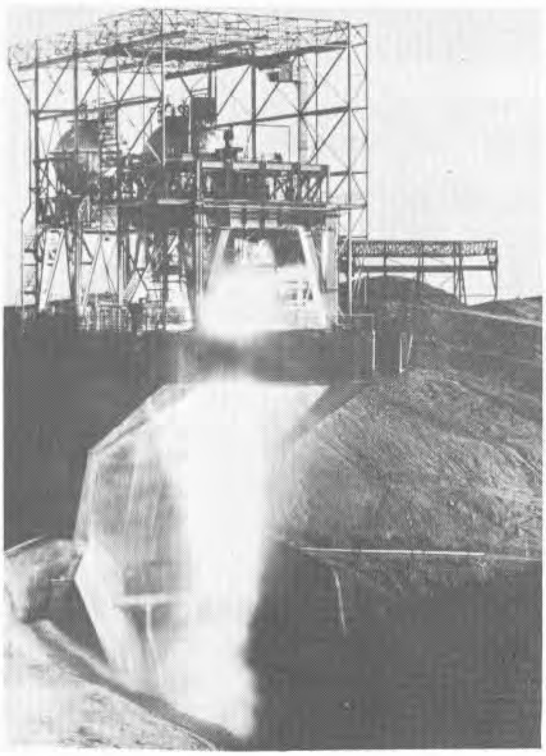


FIGURE 67. STATIC FIRING OF F-1 ENGINE

On July 7, 1961, the second static firing of the SA-T2 test booster was successfully completed at MSFC in an eight-engine test (SAT-15) of 119 seconds' duration (Fig. 69). This test was to evaluate the effect of modifications in reducing engine structure vibration, to evaluate flame curtain materials, and to check out a LOX depletion system similar to that used on SA-1. Results of the testing were satisfactory.

In July, MSFC awarded a contract to the Space Technology Laboratories, Inc., Los Angeles, California, to investigate the relative merits and potential problems of assembling the giant SATURN boosters in horizontal and vertical positions. Other contracts awarded by the Marshall Space

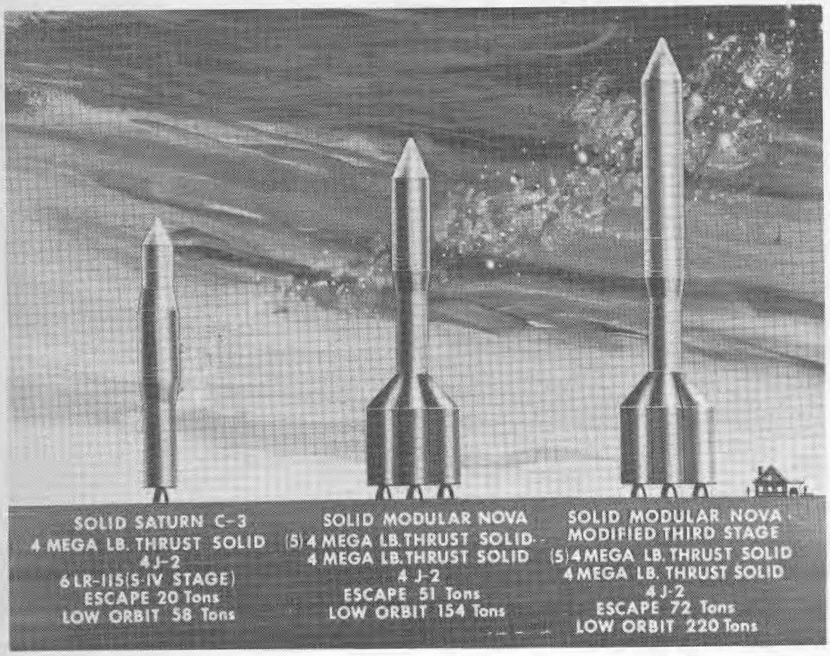


FIGURE 68. PROPOSED SOLID PROPELLANT BOOSTERS FOR LARGE SPACE VEHICLES

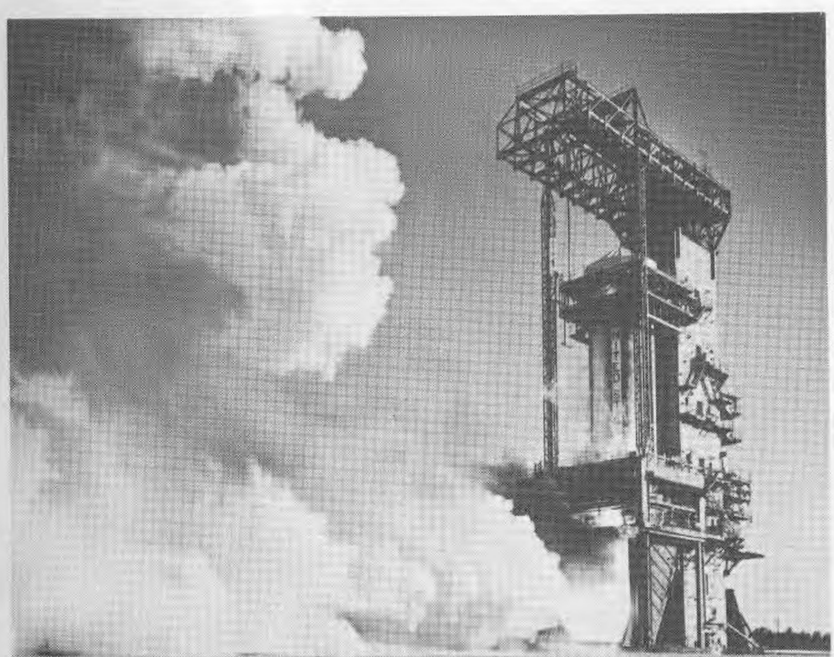


FIGURE 69. STATIC FIRING OF SA-T2

Flight Center, in July included qualification and reliability testing of SATURN ground support equipment, subsystems, and components, and contruction of a special assembly building at Cape Canaveral; this building would provide a protected area for heavy boosters, as well as a servicing area for assembly, handling, checkout, and mating of all stages to the SATURN vehicle.

On July 18, 1961, the third static firing of the SA-T2 booster was successfully completed in an eight-engine static test (SAT-16) of 110 seconds' duration. During this test, the in-flight engine cut-off sequence (shutdown of the inboard engines six seconds before shutdown of the outboard engines) was simulated for the first time. The test also continued investigation of heat shield and engine curtain materials; and testing was performed to support studies of the SA-D1 test vehicle.

Late in July, MSFC awarded a contract for site development of the Center's new static test facility (Fig. 70). This facility would be used for static testing boosters with up to 3,000,000-pounds of thrust, and was scheduled for completion by the end of 1962. Also in July, the Space Task Group invited 12 companies to submit proposals for the manned lunar APOLLO spacecraft (Fig. 71). Study contracts were also awarded

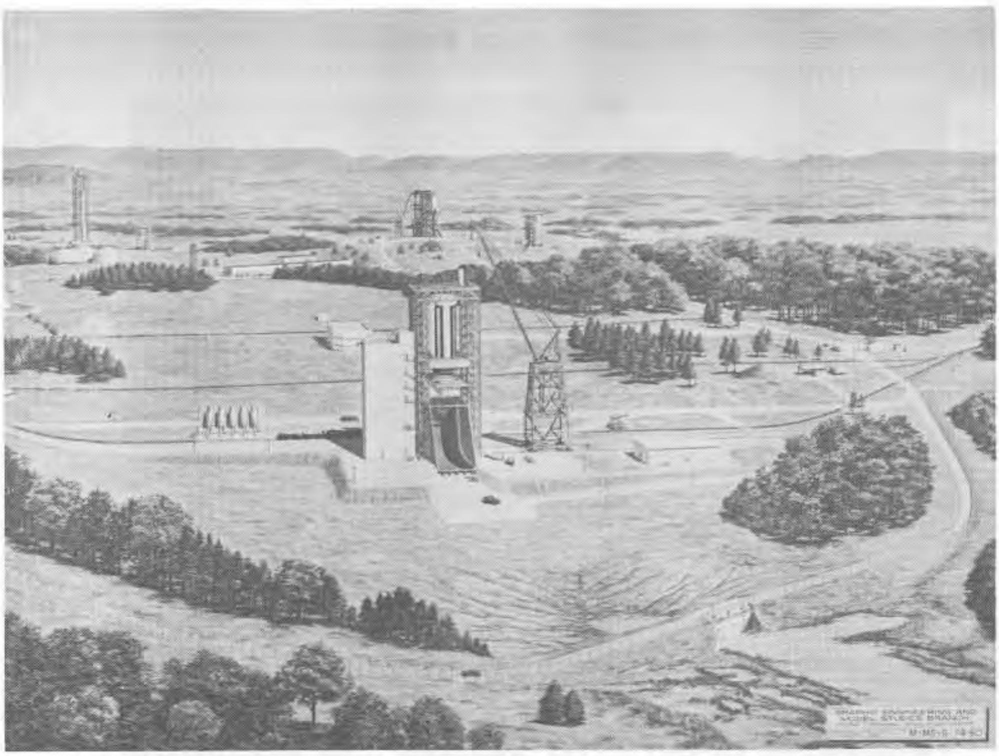


FIGURE 70. CONCEPT OF NEW STATIC TEST FACILITY, MSFC

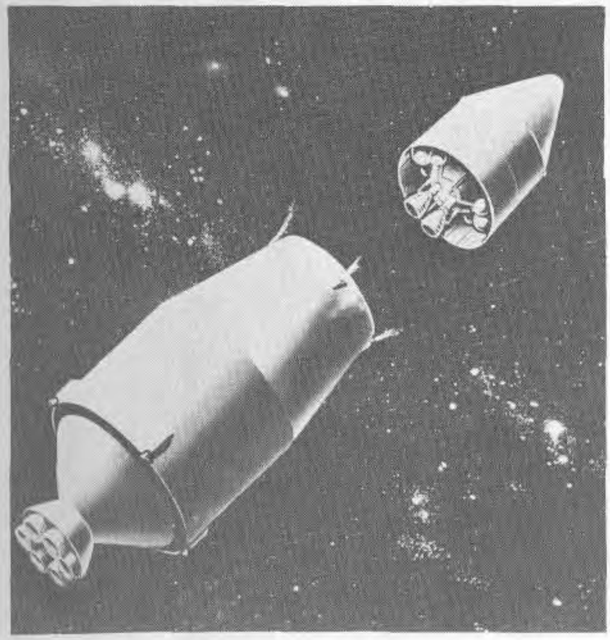


FIGURE 71. ARTIST'S CONCEPT OF APOLLO SEPARATION FROM SECOND STAGE

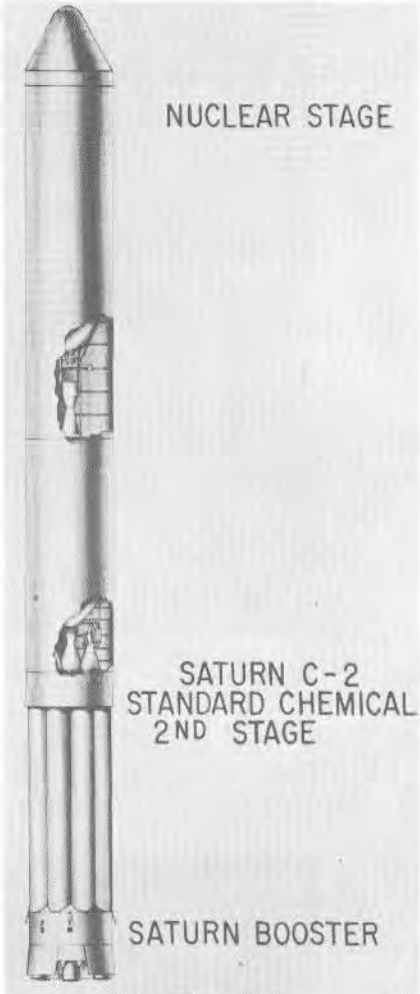


FIGURE 72. CONCEPT OF SATURN WITH NUCLEAR POWER STAGE

by MSFC to General Dynamics-Astronautics, Douglas Aircraft Company, Lockheed Aircraft Company, the Martin Company, for a six-month RIFT (Reactor in Flight) design analysis for a nuclear-powered SATURN upper stage (Fig. 72).

Assembly of the booster stage for the SA-3 vehicle began on July 31, 1961. The following day, August 1, 1961, the SA-2 booster was transferred from the assembly area to checkout. On August 3, a planned 114-second static test (SAT-17) of the SA-T2 booster was terminated after 1.2 seconds, when instrumentation indicated an unacceptably high temperature of the LOX pump inlet on engine No. 1. The test was therefore rescheduled for the following week. Test SAT-18 was performed on August 7, to accomplish objectives established for SAT-17. The SA-T2 booster was successfully fired in a test of 124 seconds' duration.

Checkout of the flight booster, which had begun in the middle of June, was completed early in August. The booster stage, the dummy S-IV stage, and the dummy payload body were shielded with protective covers and loaded on their respective transporters. The stages and payload

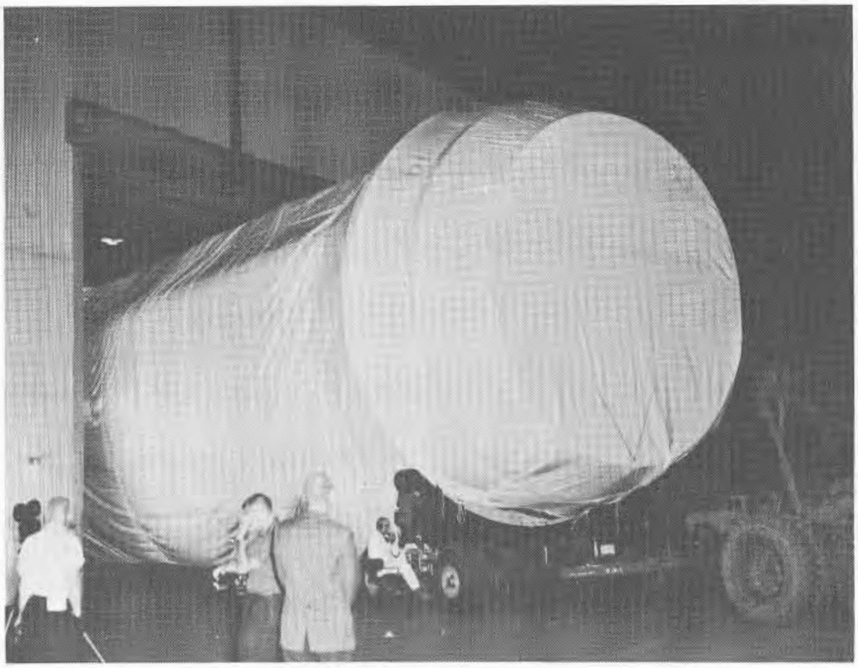


FIGURE 73. BOOSTER MOVEMENT TO DOCKING FACILITY

body were then moved from the MSFC shops (Fig. 73) to the docking facilities on the Tennessee River and loaded aboard the Palaemon. On August 5, the barge began the first leg of the trip to Cape Canaveral. At Wheeler

FIGURE 74. PAYLOAD MOVEMENT AROUND WHEELER DAM

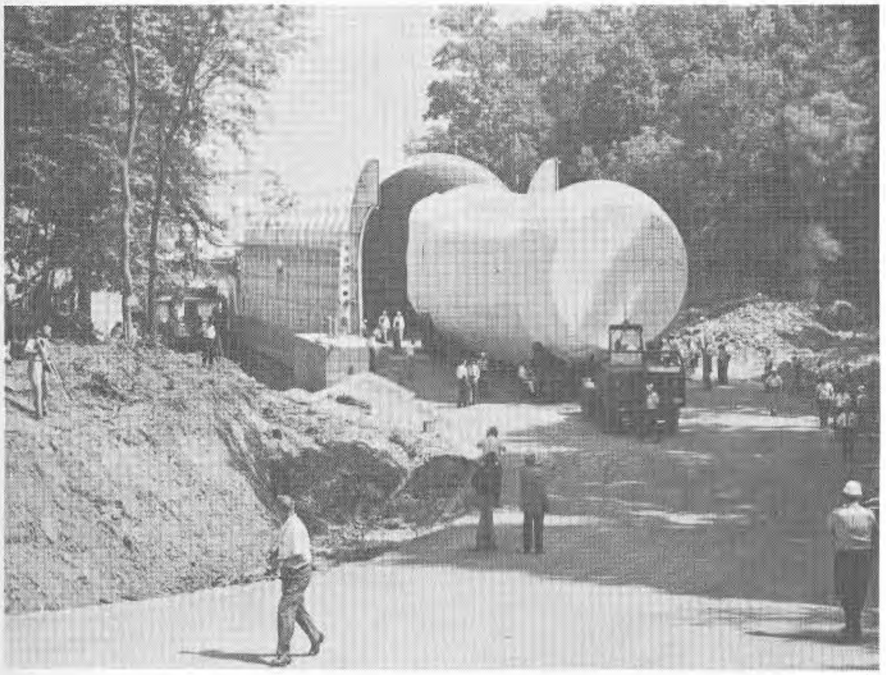


FIGURE 75. BOOSTER MOVEMENT AROUND WHEELER DAM

Dam, the units were unloaded, transported to a dock below the dam (Figs. 74 and 75), and placed on the second SATURN barge, the Compromise, to continue the 2200-mile trip to Florida (Fig. 76). On August 15, the

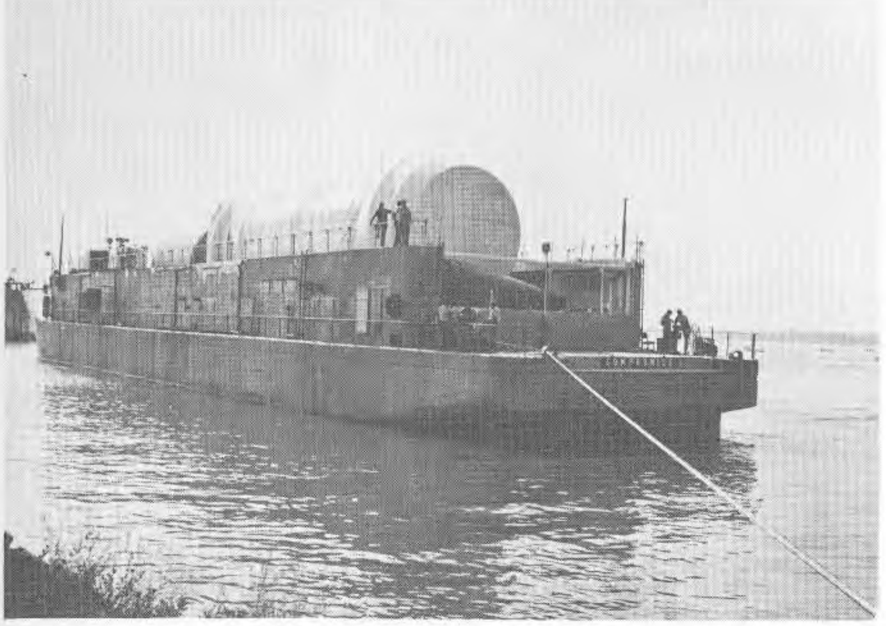


FIGURE 76. S-I AND S-IV STAGES ABOARD THE COMPROMISE

August 1961

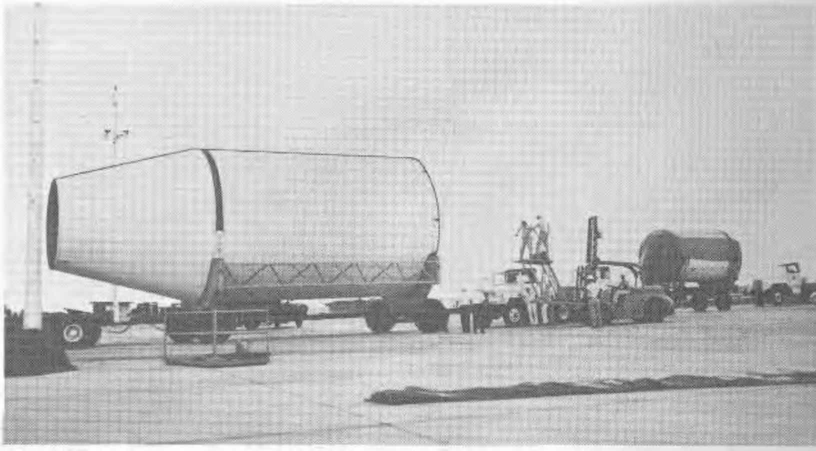


FIGURE 77. UNLOADING COMPROMISE IN FLORIDA

Compromise arrived at the Cape, unloaded her cargo (Fig. 77), and assembly of the first flight vehicle on the launch pedestal began (Figs. 78-80).

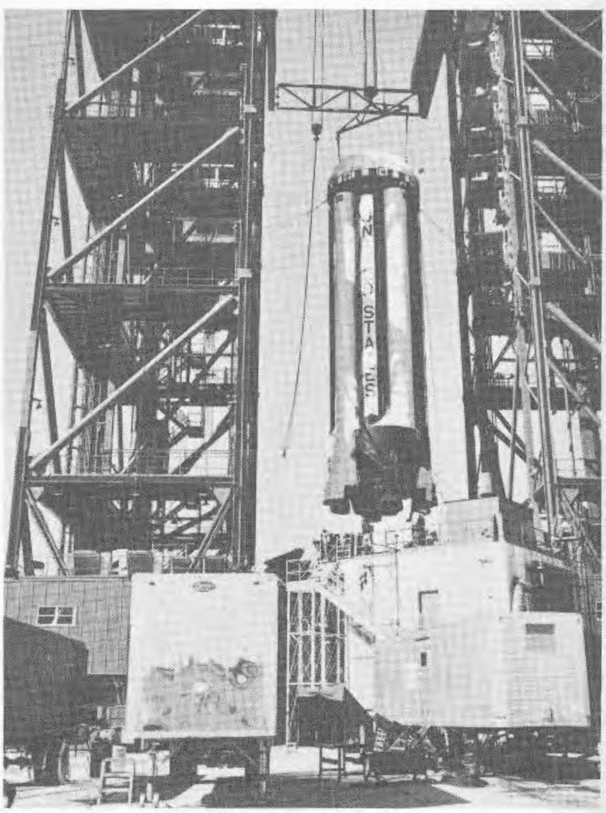


FIGURE 78. BOOSTER ERECTION AT CAPE CANAVERAL

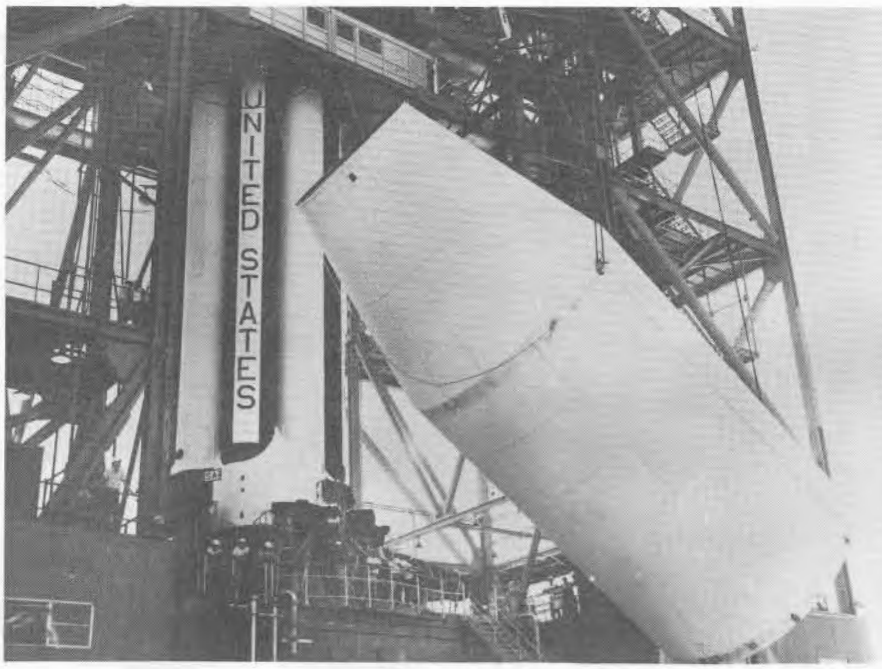


FIGURE 79. S-IV ERECTION AT CAPE CANAVERAL

FIGURE 80. PAYLOAD BODY ERECTION INTO SERVICE STRUCTURE

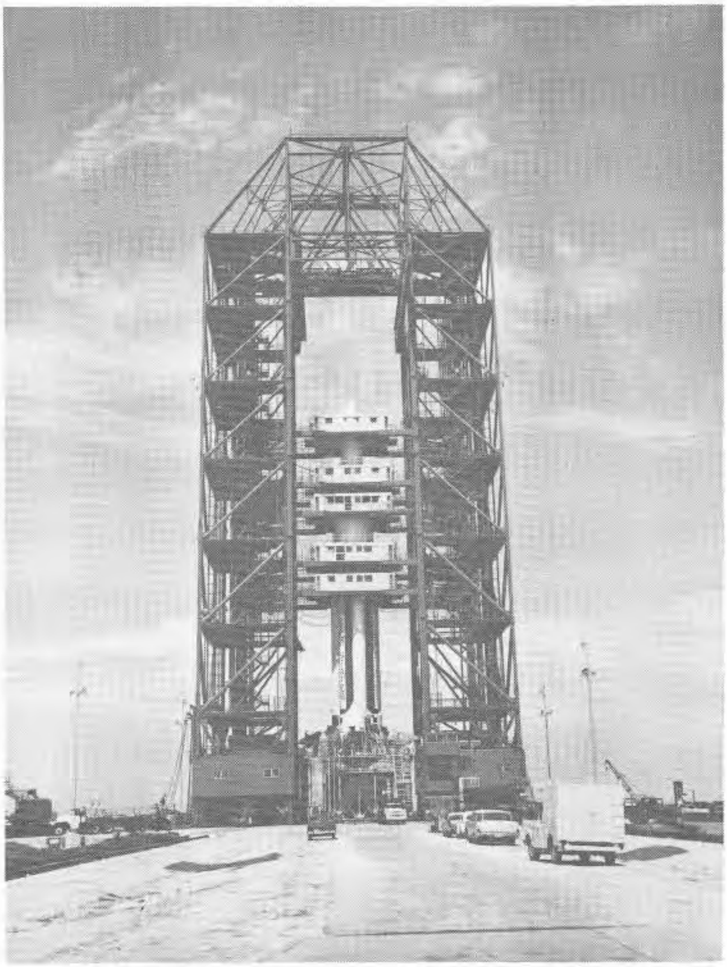


FIGURE 81. ASSEMBLED SA-1 LAUNCH PEDESTAL

After the vehicle was completely assembled on the launch pedestal (Fig. 81), final preparations for the launch began.

Early in August, MSFC invited bids for the construction of a new SATURN launch complex (LC 37) at Cape Canaveral (Fig. 82). Scheduled for completion in late 1962, the new complex would support the high launch rate planned for the SATURN vehicle (Fig. 83).

An F-1 engine was fired on August 16, 1961, at Edwards Air Force Base; although the test was terminated after one and one-half seconds, the engine built up one million pounds of thrust during this time.

On August 24, 1961, NASA announced that Cape Canaveral had been selected as the base for all manned lunar flights and other space missions requiring advanced launch vehicles. An 80,000 acre tract of land

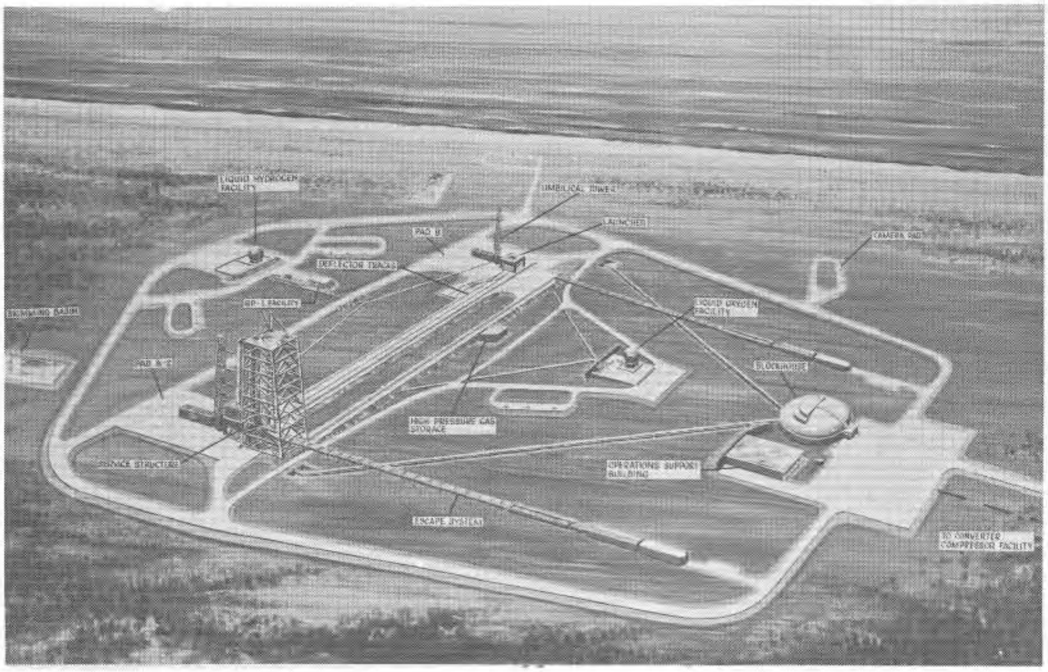


FIGURE 82. SATURN LAUNCH COMPLEX 37, CAPE CANAVERAL

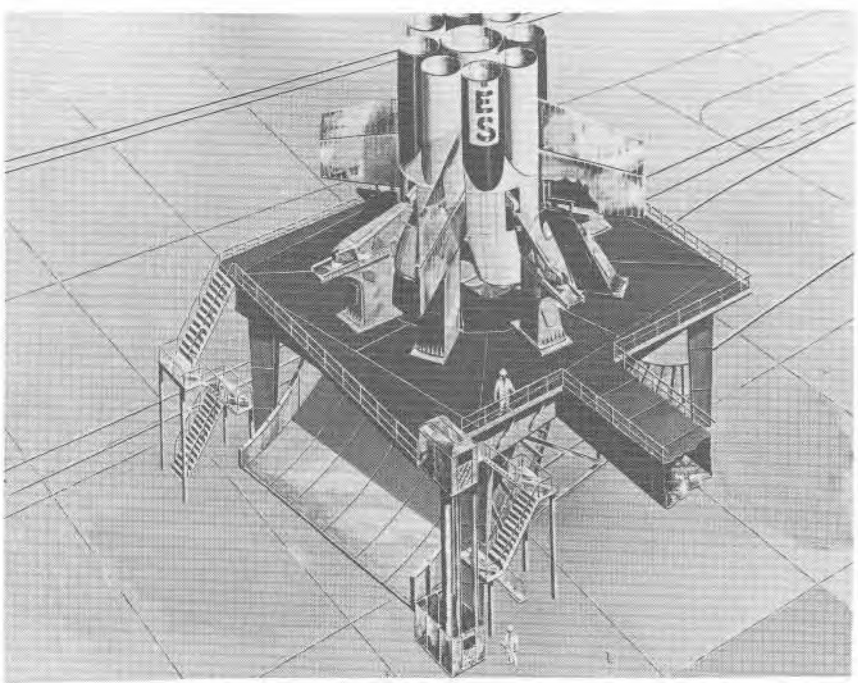


FIGURE 83. ARTIST'S CONCEPT OF LAUNCH PEDESTAL FOR LC 37

would be secured, raising the total area of Cape Canaveral to 97,000 acres. The additional land was needed because of the tremendous vibration and noise expected with later launch vehicles.

On September 7, 1961, the government-owned Michoud Ordnance Plant near New Orleans was selected by NASA as the site for industrial production of the S-I stage (Fig. 84). The plant will be operated by industry under the technical direction of MSFC. Simultaneously, MSFC continued preparations for a conference to secure Requests for Quotations from industry on production of the S-I stage.

North American Aviation was selected by NASA, September 11, 1961, to develop and build the S-II stage for an advanced SATURN launch vehicle. The stage will be used in both manned and unmanned missions.

A contract was awarded by the Army Engineers, on September 13, 1961, for the construction of Launch Complex 37 at Cape Canaveral. The complex will include a mobile steel tower, a blockhouse, and a cable tower on a 120-acre site at the north end of the Cape.

On September 15, 1961, the SA-1 vehicle had been completely assembled on the launch pedestal at LC 34. For the first time, the service structure was moved back, leaving the SATURN standing as it would at launch (Fig. 85).

FIGURE 84. MICHOUD PLANT AT NEW ORLEANS

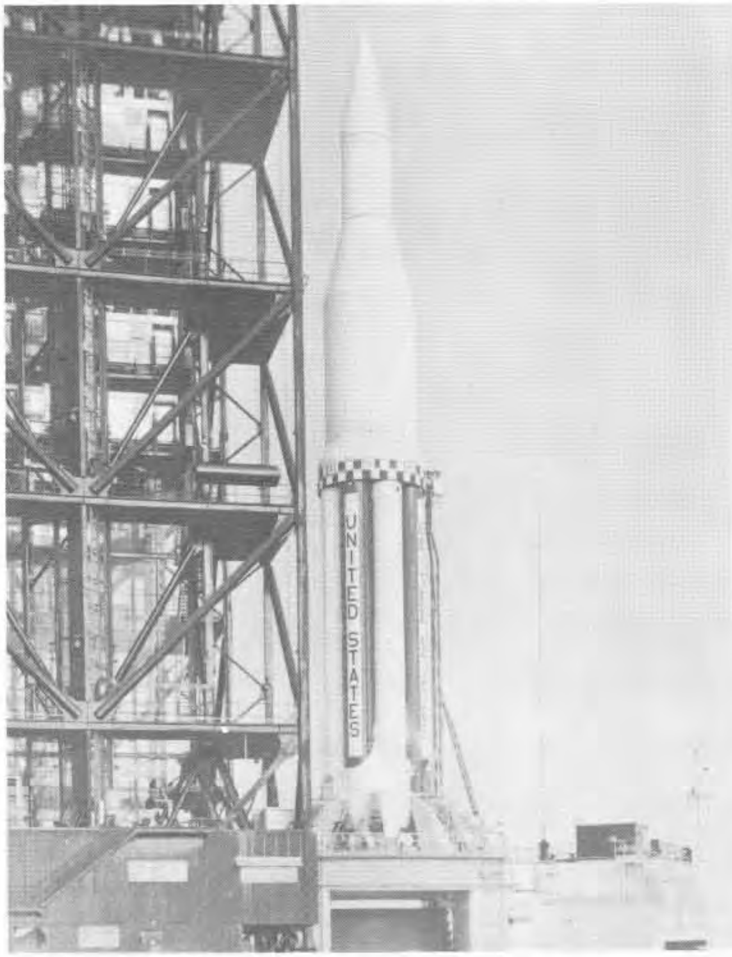


FIGURE 85. SATURN SA-1 FLIGHT VEHICLE ON LAUNCH PEDESTAL

On September 26, a preproposal conference was held at New Orleans to secure bids for industrial production of the S-I stage. Four days later, on September 30, a ground-breaking ceremony was held to begin construction of the Marshall Center's central laboratory and office building.

Testing continued in September and October at the Marshall liquid hydrogen test facility, where problems in the handling and use of liquid hydrogen are studied. The SA-2 flight booster was installed in the MSFC static test tower early in October. On October 10, a successful eight-engine test of 33 seconds duration (SA-04) was performed to check reliability and performance of booster and gimbal systems. Test SA-05 was successfully conducted on October 24 for a duration of 112 seconds. Test objectives included evaluation of the flight cutoff sequence.

Late in October, NASA selected a 13,550-acre site in Mississippi on which to build a facility for static testing of the Advanced SATURN, and NOVA first stages. The site, which will become the Mississippi Test Facility, is only 35 miles from the Michoud Plant where industry will manufacture the S-I and S-IC Stages.

The first launch of the SATURN vehicle took place on October 27, 1961 (Fig. 86). The vehicle, 162 feet high and weighing 460 tons at liftoff, rose to a height of 85 miles during its trajectory. The inboard engines shut down after 109 seconds of burning; the outboard engines cut off six seconds later. The booster stage produced the 1,300,000 pounds of thrust intended for the first four flight tests. (On subsequent tests, the thrust will be increased to 1,500,000 pounds.) At a speed of approximately 3,600 miles per hour, the SATURN followed a precalculated flight path to land within 13 miles of predicted impact, over 214 miles from Cape Canaveral. The launch was considered most successful.

On November 6, 1961, MSFC directed NAA to redesign the S-II Stage to incorporate five J-2 engines, providing a total of 1,000,000 pounds stage thrust (Fig. 87).

Work at the new large booster Static Test Stand at MSFC was interrupted in November for redesign of the stand to accept thrust levels of more than 7.5 million pounds.

On November 10, 1961, NASA received proposals from five firms for the development and production of the advanced SATURN booster.

NASA announced selection of Chrysler Corporation on November 17, to

FIGURE 86. LAUNCH OF SATURN SA-1 FLIGHT VEHICLE

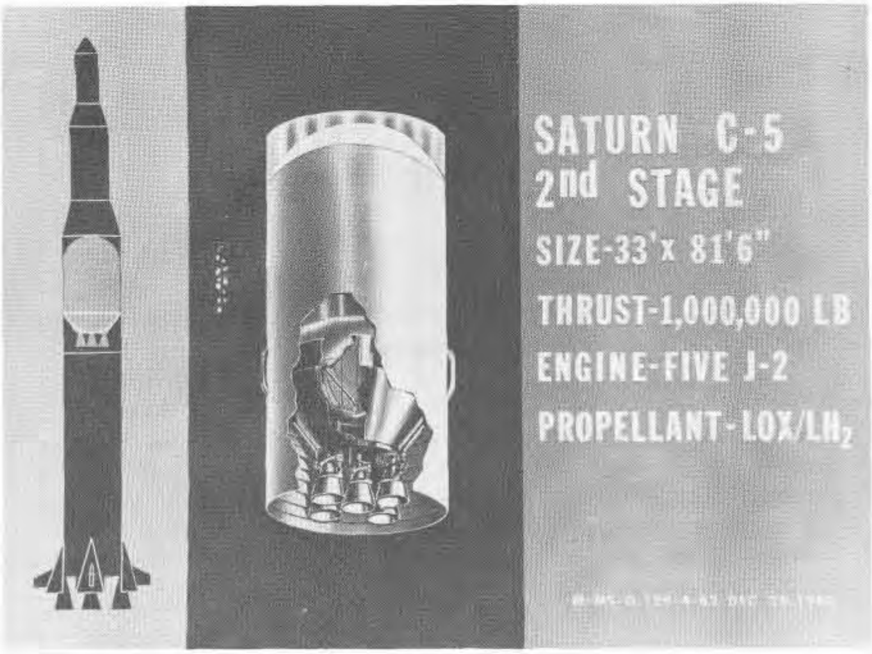


FIGURE 87. S-II STAGE CUTAWAY

negotiate a contract to build, check out, and test twenty S-I boosters. Manufacture will be accomplished at the Michoud Plant. The contract was signed in mid-January 1962.

On November 19, the nation's first liquid hydrogen engine, the RL-10, successfully completed its preliminary flight rating test, producing 15,000 pounds thrust. The engine, designed and developed by Pratt and Whitney, performed about 30 per cent better than engines using hydrocarbon fuels. Six RL-10 engines will power the SATURN S-IV Stage.

On November 29, 1961, NASA awarded North American Aviation, Inc. a contract for the design and construction of a three-man APOLLO spacecraft. The APOLLO project will be divided into three basic missions: earth orbital flights, circumlunar flights, and manned landings on the moon. The two-stage SATURN C-1 will support earth orbital flights of prototype APOLLO command modules during the 1964-1965 period. The advanced SATURN C-5 would support re-entry and circumlunar APOLLO flights. Previous to the contract award, the Marshall Space Flight Center and the Manned Spacecraft Center met to jointly plan toward the use of the C-1 R&D vehicles for vehicle-payload compatibility test and early R&D systems test of the APOLLO spacecraft.

The SA-T3 test stage was installed in the test stand and, on November 30, 1961, Test SAT-20 was conducted to investigate flight cut off sequencing, to perform an "engine out" test, and to study fuel and LOX tank levels. The test was prematurely cut off at 95 seconds by the automatic fire detection system. No hardware damage occurred. This was the first of a series of tests to verify SA-3 design improvements.

The last of the SATURN 70-inch tanks to be manufactured by MSFC was completed the week of December 4. Future 70-inch tanks will be built by Chance-Vought in Dallas, Texas, and shipped initially to MSFC and later to Michoud for the Chrysler assembled stages.

MSFC awarded a design contract on December 6 to Maurice H. Connell and Associates for modification to the west side of the Center's existing static test tower. The design was completed in April 1962. The tower, scheduled for completion by the summer of 1963, will be used for acceptance testing of Chrysler S-I stages.

On December 5, 1961, AEC-NASA Space Nuclear Propulsion Office selected the Aetron Division of Aerojet-General Corporation proposal as the basis for negotiating an architect and engineering contract for a NERVA engine test stand. The NERVA would be used in nuclear stages with a reactor derived from the Kiwi-B test series.

A preproposal conference was held on December 7, at Huntsville, Alabama, to select a prime contractor for the reactor-in-flight test (RIFT) stage launch vehicle. On January 29, 1962, NASA selected three firms to submit final proposals. The RIFT vehicle is planned for use as an upper stage of a SATURN vehicle.

At the Douglas Sacramento Test Facility, prototype S-IV Stage tankage was installed and propellant loading tests begun on December 11, 1961 (Fig. 88).

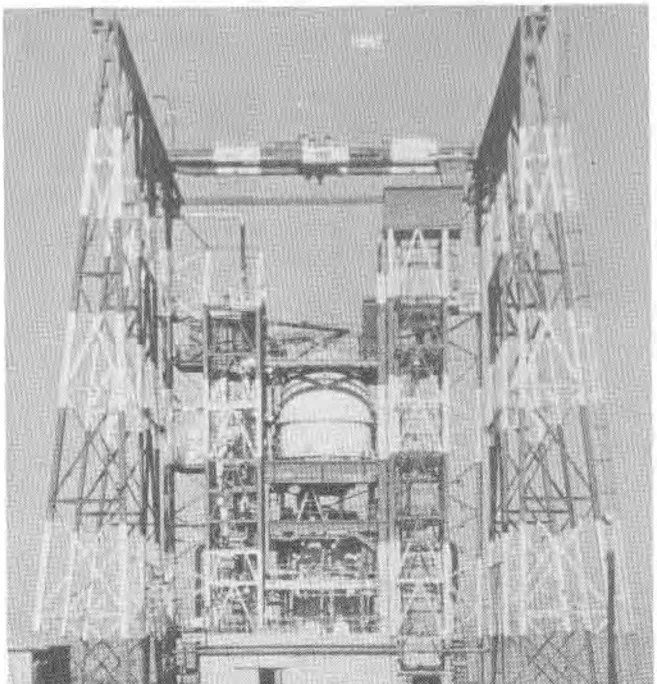


FIGURE 88. S-IV TANKAGE AT SACTO TEST FACILITY

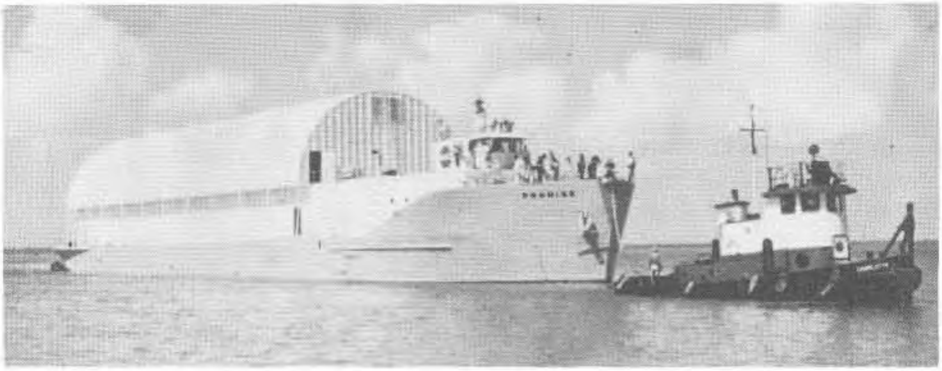


FIGURE 89. BARGE PROMISE

Modifications to the SATURN barge Compromise were completed on December 14, 1961 (Fig. 89). The barge, renamed Promise, was readied for movement to Wheeler Dam, where it would receive stages of the SA-2 flight vehicle. On the same day, another F-1 engine test was performed at the Rocketdyne test facility (Fig. 90.) The engine reached its rated 1.5 million pounds thrust in a short mainstage firing.

The Boeing Company was selected for negotiations, on December 15, as a possible prime contractor for the first, or S-IC Stage, of the Advanced SATURN vehicle. The S-IC, powered by five F-1 engines,

FIGURE 90. F-1 ENGINE AND TEST STAND

will be 33 feet in diameter and about 140 feet high (Fig. 91). The manufacturing program at Michoud was planned to consist of 24 flight stages and one for ground test.

The second static test (SAT-21) on SA-T3 vehicle was performed at MSFC on December 19. Prematurely terminated after 68 seconds duration, the test was rescheduled for mid-January.

Douglas Aircraft was selected by NASA on December 21, 1961, to negotiate a contract to modify the SATURN S-IV stage by installing a single J-2 Rocketdyne engine of 200,000 pounds thrust (Fig. 92). The modified stage, identified as the S-IVB, would be used as a third stage of the advanced SATURN C-5 configuration.

Later in December, MSFC awarded a contract to the Mason-Rust Company to perform housekeeping and other administrative services at the New Orleans Michoud Plant.

Assembly of the SA-4 flight booster began January 2, 1962. The SA-3 booster successfully completed functional and pressure engine tests and entered pre-static checkout on January 8, 1962. Later in

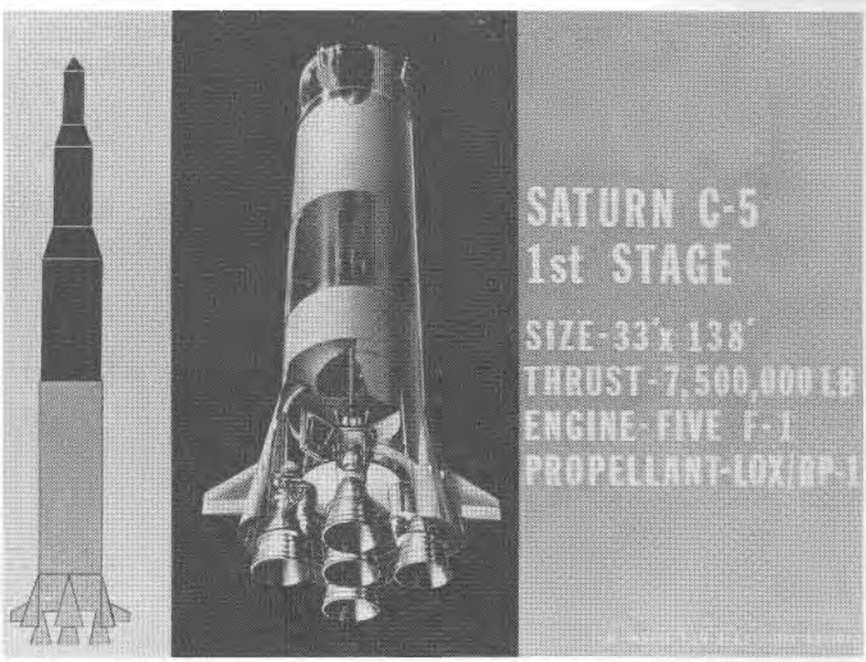


FIGURE 91. S-IC STAGE

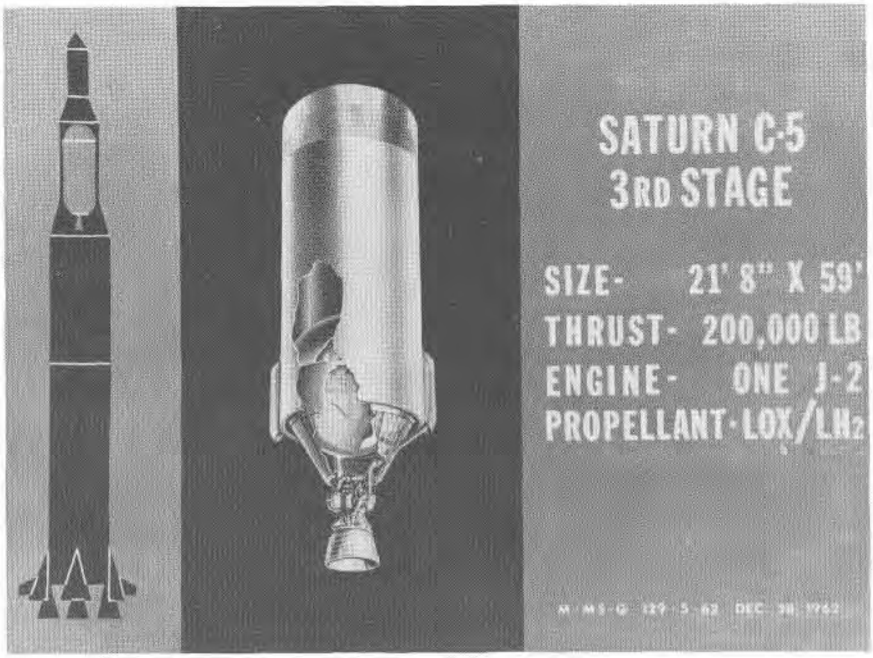


FIGURE 92. S-IVB STAGE CUTAWAY

the month, on January 18, 1962, a 122-second test (SAT-22) was successfully conducted with SA-T3 test booster.

NASA announced on January 24, that Aerojet-General Corporation has been selected for design and development of a new, 1,200,000-pound thrust liquid hydrogen engine. The engine, known as the M-1, will be used to power the second stage of the NOVA launch vehicle.

MSFC awarded a contract to Consteel-Ets-Hokin late in January for the construction of the umbilical tower for Launch Complex 34 at Cape Canaveral. The tower is to carry the electrical, pneumatic, and hydraulic connections used in fueling and servicing SATURN upper stages.

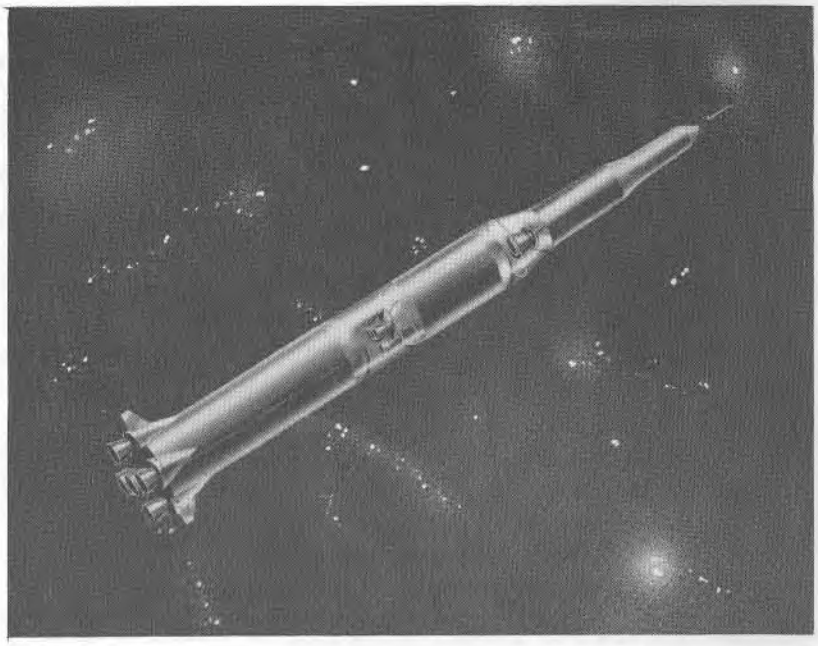


FIGURE 93. SATURN C-5

On January 25, 1962, NASA approved development of the 3-Stage SATURN C-5 vehicle under the direction of MSFC. The vehicle will

FIGURE 94. SA-2 ERECTED ON LAUNCH PEDESTAL

FIGURE 95. REGIONAL MAP SHOWING MISSISSIPPI TEST FACILITY

support manned circumlunar flights and manned landings by earth or lunar orbit rendezvous method. The C-5 (Fig. 93) will be capable of placing 120 tons in low earth orbit or escaping 45 tons to the vicinity of the moon.

On February 6, 1962, a 46-second C-1 booster test firing (SAT-23) was successfully conducted at MSFC. On February 9, a preliminary contract was awarded the Space and Information Systems Division, North American Aviation, to design, develop, and fabricate the S-II Stage of the C-5 vehicle. MSFC signed a preliminary S-IC development contract with Boeing Company on February 14.

Stages of the SATURN SA-2 flight vehicle departed Huntsville on February 16, for Cape Canaveral. The vehicle arrived at Cape Canaveral on February 27, 1962 and, by March 1, the vehicle was erected on the launch pad of LC 34 (Fig. 94).

A static firing of the SA-T3 booster was conducted on February 20, 1962. The test (SAT-24) scheduled for LOX depletion cutoff, was terminated at 55 seconds, due to fire indication at Engine No. 6. No damage resulted.

On March 4, NASA selected Sverdrup Parcell Company to provide design criteria and initial planning for the test facilities at the Mississippi Test Facility (Fig. 95).

The SA-T3 test booster was removed from the MSFC static test stand on March 15, for inspection, repair and modification. On March 19, the booster for the SA-3 flight vehicle was installed in the test tower, and preparations begun for the first flight qualification test.

On March 19, 1962, the Seal Beach, California, site was reconfirmed as the location of the S-II Stage major manufacturing and assembly activities. Testing of prototype stages will be performed at Santa Susana, California. Stage acceptance testing will be conducted at the Mississippi Test Facility.

At Douglas Aircraft, structural assembly of the first All-Systems vehicle was completed in March 1962 (Fig. 96). The All-Systems vehicle, a heavily instrumented configuration of the S-IV flight stage, will be used to check out all operating S-IV systems.

FIGURE 96. S-IV ALL SYSTEMS VEHICLE

Late in March, a construction contract was awarded for construction of a second launch area at the SATURN Launch Complex 37, Cape Canaveral. Construction began early in April (Fig. 97).

On April 10, 1962, the SA-3 booster successfully performed its first flight qualification test (SA-06) in a static firing of 31 seconds' duration. On the same day, representatives of 13 companies attended a pre-proposal conference at MSFC concerning the NOVA launch vehicle designs. Submittal of bids was required late in the month.

The J-2 liquid hydrogen engine, which will be used in the SATURN S-II and S-IVB Stages, reached 90 per cent sea-level thrust in its

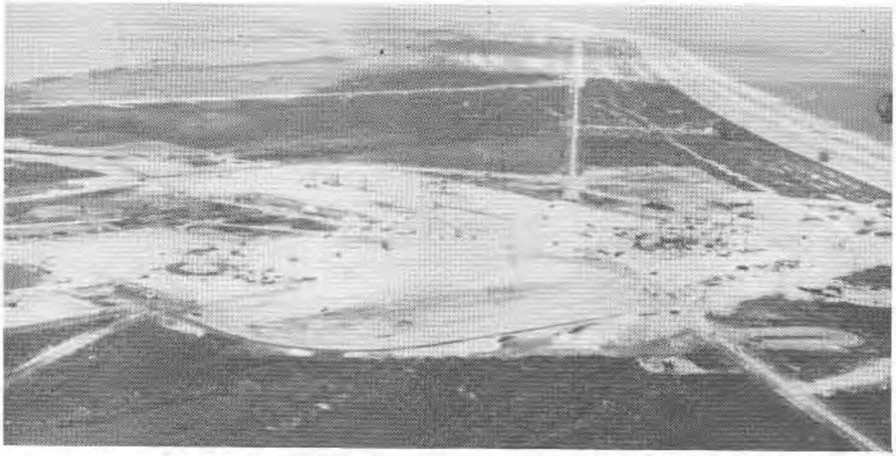


FIGURE 97. CONSTRUCTION OF LAUNCH COMPLEX 37

initial hot firing tests, April 11, 1962. On the same day the F-1 engine, being developed to power the S-IC Stage, performed a successful 150 seconds' static firing.

One week later, reconstruction of the Wheeler Dam Lock on the Tennessee River was completed; transportation of SATURN flight stages could be made without land detour.

NASA Headquarters announced on April 18 that the highest national priority (DX) had been approved for the APOLLO, SATURN C-1, and SATURN C-5. The priority includes all stages, engines, facilities, and related construction for production, test, research, launch, and instrumentation.

The second flight vehicle, the SA-2, was successfully launched from Cape Canaveral on April 25 (Fig. 98). As with the SA-1, the vehicle was launched

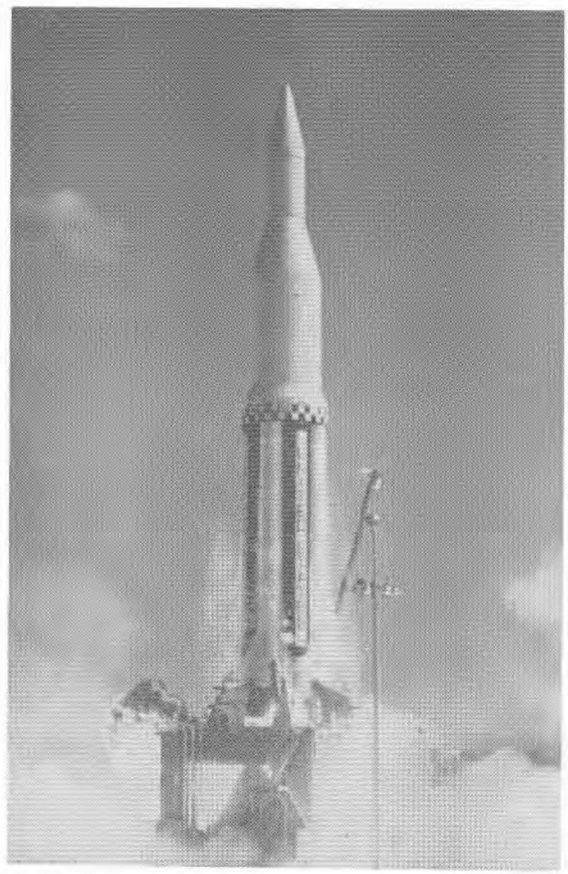


FIGURE 98. LAUNCH OF SATURN SA-2 FLIGHT VEHICLE

without a technical hold during the 10-hour countdown. This vehicle had a secondary mission. After first stage shut-off, at 65 miles altitude, the water-filled upper stages were exploded, dumping 95 tons of water in the upper atmosphere. The massive ice cloud produced rose to a height of 90 miles. The experiment, called Project High Water, was to investigate the effects on the ionosphere of the sudden release of such a great volume of water. This experiment did not interfere with the major goal of the flight, which was achieved when the first stage engines burned out 116 seconds after launch. Every phase of the launch was considered most successful.

A 31-second duration eight-engine test (SA-07) of the SA-3 flight booster was conducted on May 17, with excellent overall performance. The final SA-3 booster acceptance firing test (SA-08) was performed on May 24, for a duration of 119 seconds. The booster was removed from the test tower on May 31, 1962.

On May 26, 1962, Rocketdyne successfully conducted the first full-thrust, long-duration F-1 engine test (Fig. 99). On the same day, SA-4 booster fabrication was completed.

FIGURE 99. STATIC FIRING OF F-1 ENGINE

In mid-May, MSFC directed DAC to use a 260-inch diameter for the S-IVB (an increase of 40 inches from the initial diameter) permitting development of a more optimum sized stage. Also during May, the S-II Stage length was increased from 75 feet to 81.5 feet, and the S-IC Stage was decreased in length from 141 feet to 138 feet.

A contract was awarded to Greenhut Construction Company on June 5, to modify the SATURN C-1 booster static test stand at MSFC. The stand, originally built to test the REDSTONE and JUPITER missiles and later modified for SATURN testing, will provide test positions for two C-1 first stages (Fig. 100).

On June 9, Pratt and Whitney completed preliminary flight rating tests of the RL10A-3 engine with all test objectives successfully met.

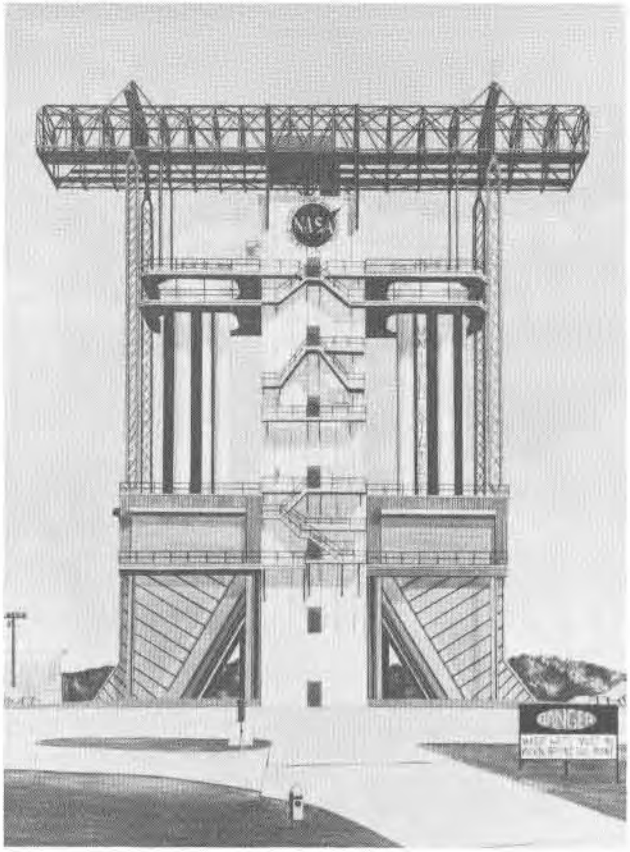


FIGURE 100. C-1 FIRST STAGE TEST STAND

At MSFC, the first SA-T4 test booster static firing (SAT-25) was successfully conducted on June 18, for a duration of 31 seconds.

During June, bids were requested for construction of a static test stand to captive fire the SATURN C-5 booster. The stand, to be located at MSFC, will provide handling equipment and thrust restraint for boosters up to 178 feet in length, 48 feet in diameter, and with thrust of up to 7.5 million pounds. Including a crane at the top, the tower will stand 405 feet high, more than twice as tall as the present SATURN C-1 booster test stand.

Three letter contracts were signed on July 2, by NASA and the Rocketdyne Division of North American Aviation, for further development and production of the F-1 and J-2 engines. The contracts, extending through 1965, cover long lead-time items in F-1 engine R&D and early production effort on F-1 and J-2 engines. On July 7, SA-5 flight booster assembly began at MSFC.

FIGURE 101. SATURN C-1B VEHICLE

NASA announced on July 11, that a new, two-stage SATURN-class vehicle (Fig. 101) would be developed for manned earth-orbital missions with full-scale APOLLO spacecraft and associated equipment. The C-1 booster and C-5 third stage would be adapted to provide a vehicle capable of performing these mission. This vehicle was identified as the SATURN C-1B. Simultaneously, NASA announced selection of lunar orbit rendezvous as the method for performing the manned lunar landing. A special lunar excursion module (the "Bug") would be developed to perform the actual landing, instead of the entire APOLLO spacecraft, as originally considered. The lunar rendezvous mode requires the use of only one SATURN C-5 vehicle to inject the spacecraft into an earth-lunar trajectory.

On July 12, the second static test (SAT-26) of the SA-T4 stage was manually terminated after 12 seconds when a broken ground instrumentation wire caused an erroneous pressure drop indication. Pressure measurement loss caused a premature cutoff after 20 seconds of a third SA-T4 static test (SAT-27), conducted on July 13. A fourth firing (SAT-28) of 120 seconds' duration was conducted on July 17; overall performance was excellent. The stage was removed from the MSFC test stand on July 20, and work was begun to uprate the engines to 188K thrust level. The stage was redesignated as the SA-T4.5.

On July 21, NASA Headquarters announced construction plans for Complex 39, SATURN C-5 launch facilities (Fig. 102). The 350-foot high vehicle will be erected and checked out vertically in a special 48-story assembly building. Following checkout, the SATURN will be moved to a launch pad by a 2,500-ton crawler vehicle (Fig. 103).

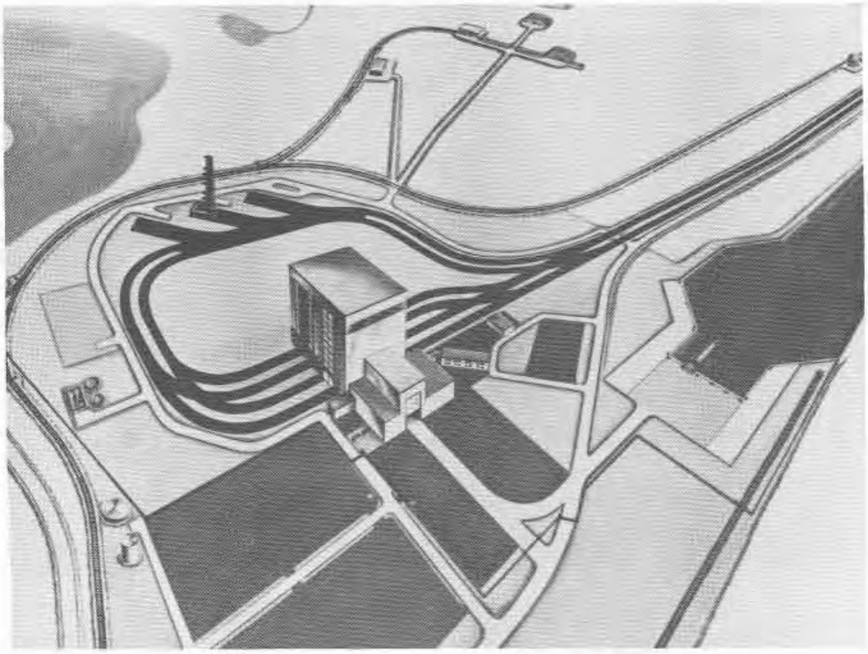


FIGURE 102. SATURN LAUNCH COMPLEX 39, CAPE CANAVERAL

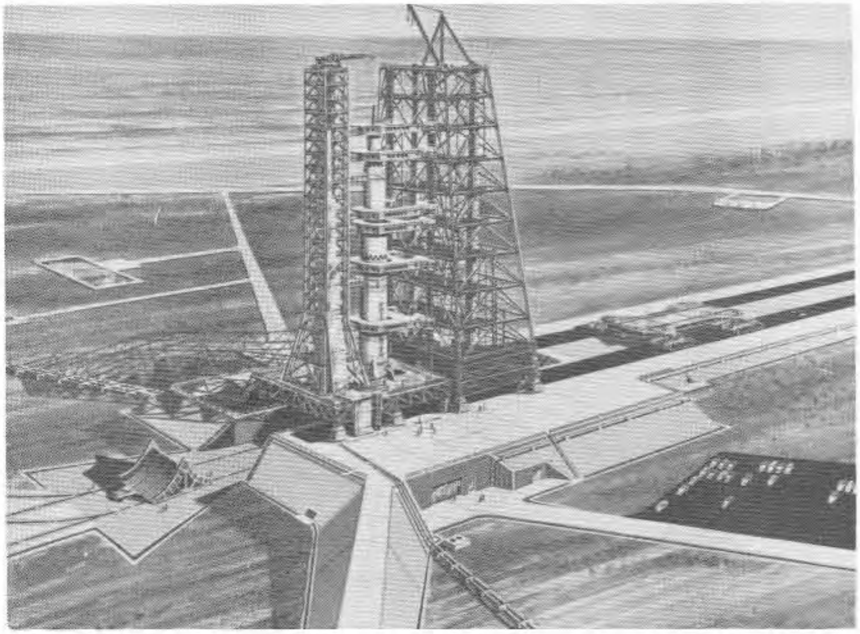


FIGURE 103. SATURN C-5 LAUNCH PAD

FIGURE 104. NASA COMPUTER CENTER, SLIDELL, LOUISIANA

In July, NASA announced that a computer center (Fig. 104) would be established at Slidell, Louisiana, to service the Michoud Operations. The center, to be one of the nation's largest, will perform engineering calculations necessary in the development, building, and static testing of the SATURN C-1 and C-5 boosters.

In July, MSFC awarded a contract to Maurice H. Connell and Associates, Inc., to design a 360-foot high dynamics test tower (Fig. 105) at MSFC to accommodate the SATURN C-5 launch vehicle. The vehicle will be suspended in the tower and vibrated by mechanical and electrical means to simulate free-flight conditions, and determine the vehicle's natural bending modes.

On August 6, 1962, NASA and Chrysler Corporation signed a contract for production of 21 C-1 boosters, with delivery to be made between late 1964 and early 1966. The stages would be produced by Chrysler at the Michoud Plant near New Orleans. On the same date, NASA announced that the Boeing Company had received a supplementary contract from MSFC for work leading to design, development, fabrication, and test of the C-5 booster.

A contract for design, development, fabrication, and test of SATURN S-IVB Stage was awarded Douglas Aircraft Corporation on August 8. The contract calls for 11 of the C-5 upper stages; five for ground tests (two of which would be used later as inert flight stages) and six stages for powered flight.

On August 13, MSFC selected the C-5 instrument unit design. The cylindrical unit will measure 260 inches in diameter and stand 36 inches high. All vehicle guidance and control equipment will be mounted on panels fastened within the structure.

On August 15, 1962, NASA awarded Rocketdyne Division of North American Aviation a two-year contract to continue H-1 engine research and development. The C-1 booster will be powered by a cluster of these engines.

On August 17, the first S-IV battleship static firing (Fig. 106) was successfully conducted at the Sacramento Test Facility in California. The Douglas Aircraft Corporation-produced second stage for the C-1 launch vehicle developed approximately 90,000 pounds of thrust for a planned 10 seconds' duration; all test objectives were met. The first successful full 420

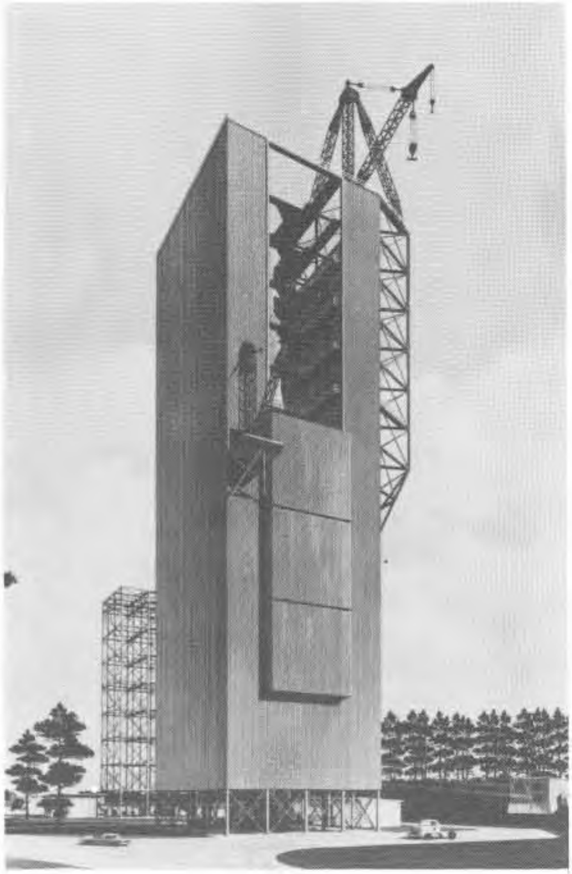


FIGURE 105. C-5 DYNAMIC TEST TOWER

FIGURE 106. S-IV BATTLESHIP STATIC FIRING

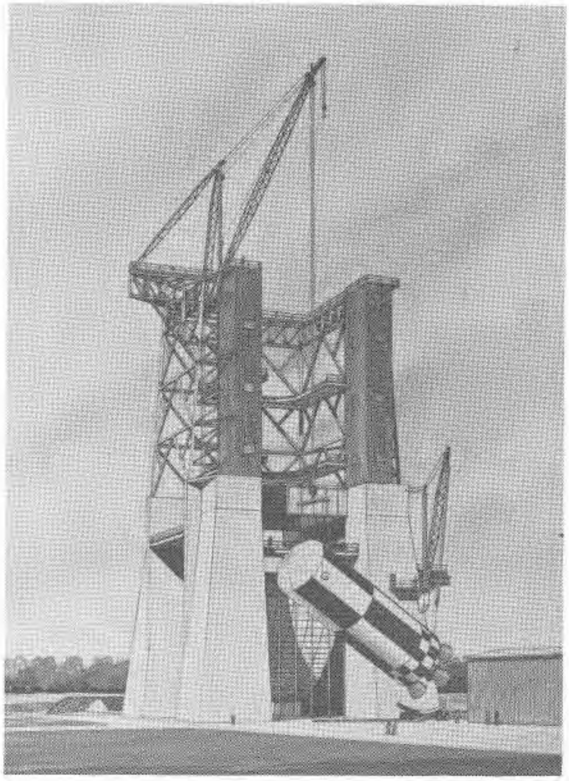


FIGURE 107. S-IC STATIC TEST STAND

seconds' duration firing was performed on October 4. In the final phase of testing, a total of 11 tests were conducted, the last one on November 8.

MSFC, on August 31, awarded a contract to Ets-Hokin and Galvan, Inc., for construction of the S-IC static test stand superstructure, less the flame deflector (Fig. 107). During August, Phase I construction of the Launch Complex 34 umbilical tower was completed at AMR. Also in August, MSFC received the DAC preliminary proposal for S-IVB stage application to the C-1B vehicle.

The SA-3 flight booster was shipped to Cape Canaveral on September 9, arrived on September 19, and was erected on the launch pad on September 21. By September 24, the inert upper stages and payload had been erected on the booster.

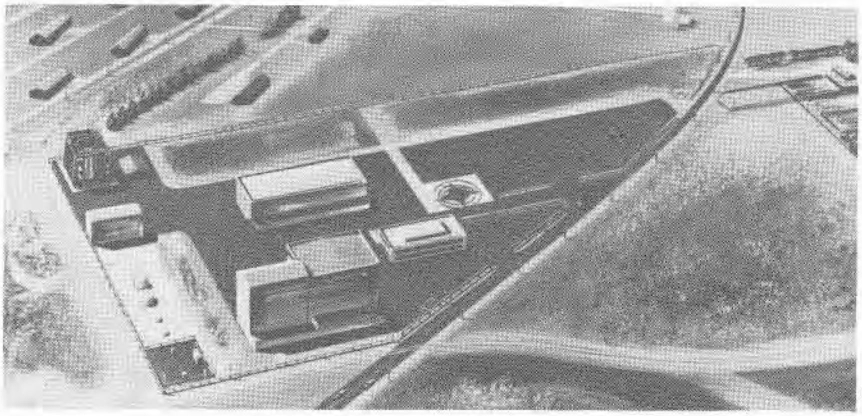


FIGURE 108. S-II STAGE ASSEMBLY AND TEST FACILITY

Early in September, ground breaking ceremonies were held at Seal Beach, California, where assembly and test facilities for the second (S-II) Stage of SATURN C-5 will be located. The S-II facility (Fig. 108) will be constructed by the U. S. Navy and operated by NAA, S&ID.

FIGURE 109. PRESIDENT KENNEDY VISITS MSFC

On September 11, President Kennedy and Vice President Johnson, with other key government officials, visited MSFC (Fig. 109) as part of a two-day tour of four U.S. space centers.

On September 15, installation of a 42-foot boring mill (Fig. 110), the largest known, was completed at Michoud for use in C-5 production.

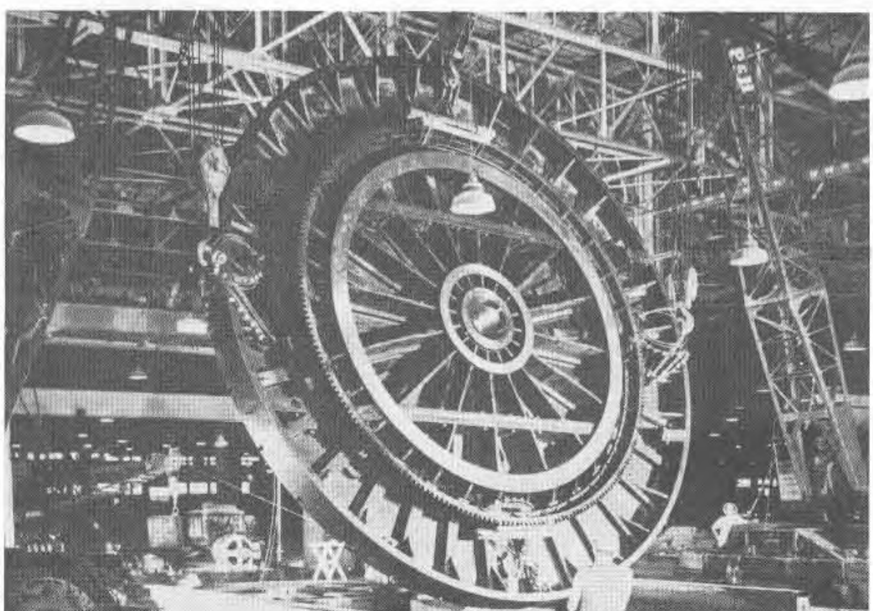


FIGURE 110. INSTALLATION OF 42-FOOT BORING MILL

September 1962

In mid-September, the first SA-4 booster flight qualification static test (SA-09) was successfully performed for a planned 30 seconds' duration. Also, in mid-September, MSFC provided Douglas Aircraft Corporation 90-day program authorization to investigate minimum changes necessary to adapt C-5/S-IVB to C-1B/S-IVB, plus stage separation and S-IVB attachment to C-1 booster.

FIGURE 111. MISSISSIPPI TEST FACILITY

On September 25, assembly began of the SA-6 flight booster. The following day, preliminary plans were completed for development of the Mississippi Test Facility (Fig. 111). First phase of the three-phase program included two each test stands for static firing the C-5 booster and second stage, and about 20 service and support buildings. The stages will be transported by water from Michoud to MTF, necessitating improvement of about 15 miles of river channel and construction of about 15 miles of canal within the test facility.

All objectives were met during the second SA-4 booster flight qualification static firing (SA-10) on September 26. A record burning time was set when the inboard engines operated for 121.5 seconds, and the outboard engines for 127.43 seconds. The SA-4 booster was removed from the static test tower on October 1, in preparation for post-static checkout. On the same day, MSFC let a contract for construction of the vertical assembly building foundation at Michoud (Fig. 112).

FIGURE 112. VERTICAL ASSEMBLY BUILDING AT MICHOUD

On October 4, fabrication was begun at Michoud of the first of 21 C-1 boosters to be produced by Chrysler Corporation Space Division (Fig. 113).

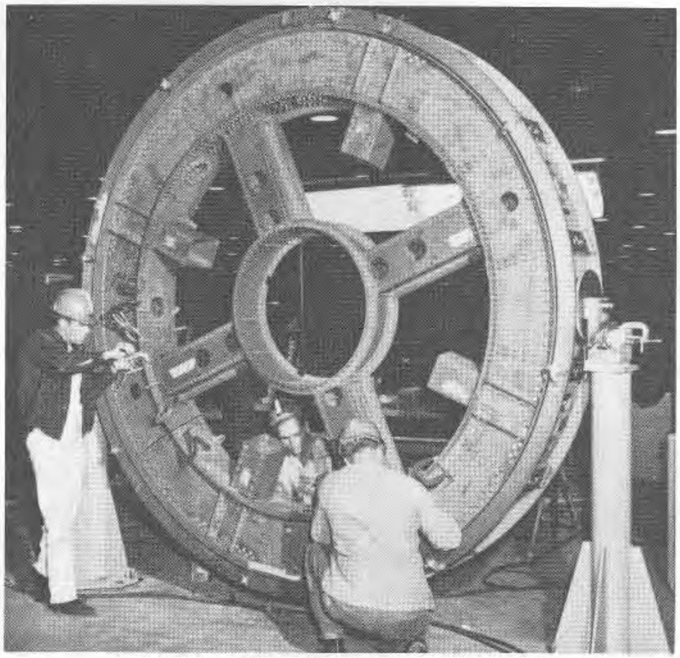


FIGURE 113. SA-8 BOOSTER THRUST RING

Two J-2 engine full-thrust firing tests of 50 and 94 seconds' duration, respectively, were successfully performed prior to the long-duration static firing on October 4. The long-duration engine test conducted by Rocketdyne was satisfactory throughout the scheduled 250 seconds operation. A second long-duration test of 220-seconds was

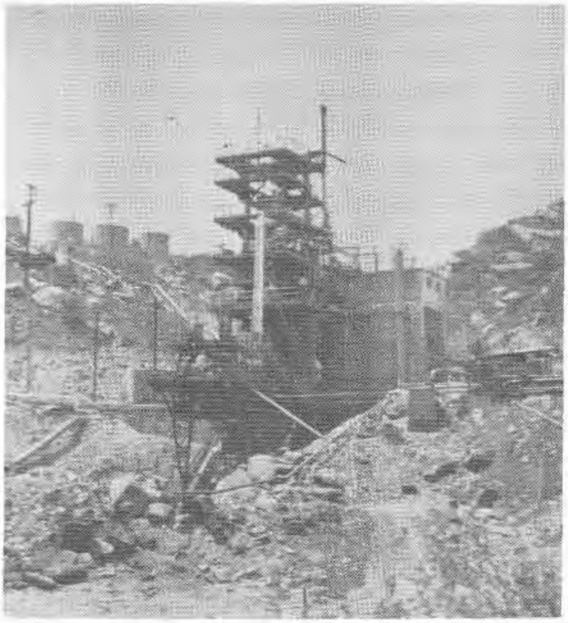


FIGURE 114. J-2 TEST FACILITY

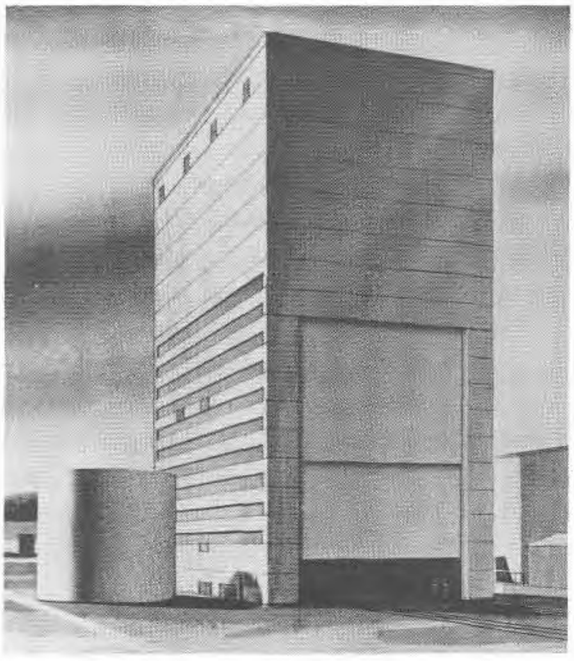


FIGURE 115. S-IC STAGE FACILITY

successfully conducted on October 6, at the Santa Susana Test Facility (Fig. 114).

The SA-T4.5 test stage was installed in the MSFC test tower on October 4, and a series of static tests begun to check the integrity of the propulsion system and effect of the 188K engines on the flame deflector. The following day, MSFC awarded a contract for construction of a combined C-5 booster vertical assembly building and hydrostatic test tower at MSFC (Fig. 115). The facility will permit hydrostatic testing of C-5 booster tanks in the assembly fixture.

The S-II Stage long-term R&D contract, signed by S&ID on September 24, was approved by NASA Headquarters on October 12.

On October 15, 1962, NASA Headquarters approved the SATURN C-5 vehicle development schedule, Plan V. The plan includes funding and test program adjustments, assembly of the first S-IC flight stage at MSFC, and launch and ground test schedule changes.

On October 26, a contract was let for construction of a flame deflector for the MSFC C-5 booster test stand. On the same date, the first static firing test (SAT-29) of the SA-T4.5 test stage with 188K thrust-rated engines, was conducted for a planned duration of 30 seconds. The stage produced 1.5 million pounds of thrust. A second static test (SAT-30) was successfully conducted on November 2, for a duration of 65 seconds.

On November 9, the third and final static test (SAT-31) of the stage was performed for a duration of 125 seconds. The stage was removed from the test tower on November 15, for use at Michoud in checking out facilities.

The S-IV Hydrostatic/Dynamics Stage was completed at Santa Monica and shipped to MSFC by the Victory Ship Smith Builder on October 26. On November 8, the stage was transferred to the barge Promise at New Orleans and delivered to MSFC (Fig. 116) on November 16, for six months of comprehensive dynamic testing.

FIGURE 116. UNLOADING S-IV STAGE AT MSFC

SA-5 flight booster assembly was completed on November 6, and the booster transferred for pre-static checkout. Assembly of the SA-D5 booster for dynamics testing was completed on October 29, and the stage installed in the MSFC dynamics test tower on November 13, 1962. The booster simulates configuration of the booster to be used during later manned flights.

The Launch Operations Center awarded a contract in October to modify the Complex 34 fuel, LOX, and LN_2 servicing systems in preparation for SATURN C-1 Block II vehicle launches.

On November 15, negotiations between MSFC and Boeing began on the cost proposal for the long-term S-IC Stage development and production contract.

November 1962

On November 16, 1962, the third SATURN flight vehicle, SA-3 was successfully launched from Cape Canaveral (Fig. 117). The vehicle, carrying a full propellant load of 750,000 pounds, rose to a height of about 104 miles. Flight range was 268 statute miles, some 65 miles farther downrange than SA-2. Inboard engine cut-off occurred, as planned, after 141 seconds of flight; outboard engine cutoff came eight seconds later. Project High Water was performed as a secondary mission on SA-3 as on SA-2.

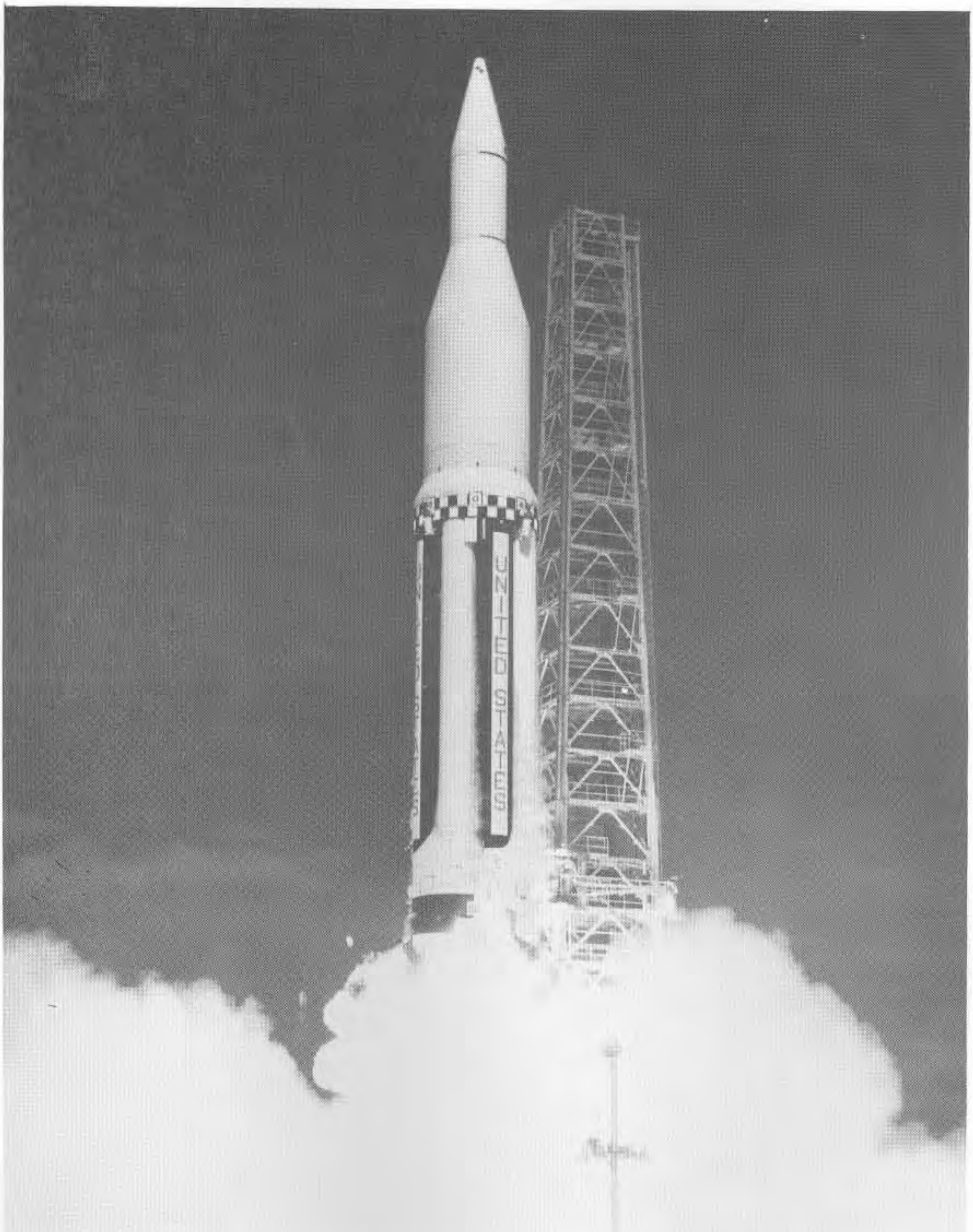


FIGURE 117. LAUNCH OF SATURN SA-3 FLIGHT VEHICLE