MHR-4

May 15, 1965

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

HISTORICAL OFFICE

MANAGEMENT SERVICES OFFICE

SATURN ILLUSTRATED CHRONOLOGY

SATURN'S FIRST EIGHT YEARS

APRIL 1957 through APRIL 1965

Revised and updated by: Evelyn Falkowski

National Aeronautics and Space Administration

NASA

MSFC - Form 454 (Revised September 1961)

This Chronology was originated by

the MSFC SATURN SYSTEMS OFFICE

Updating and revision is by

the MSFC HISTORICAL OFFICE

A GENERAL GUIDE TO SUBJECT MATTER

Appendices

Saturn

Illustrated Chronology

In April 1957 the scientific organization directed by Dr. Wernher von Braun began studies which led to Saturn, America's first rocket developed for space investigation. The team at Redstone Arsenal, Alabama, hoped to design launch vehicles that could carry 20,000-40,000 pound payloads for orbital missions or 6,000-12,000 pound payloads for escape missions. High-thrust booster stages were essential.

In December 1957 the von Braun group, then working with the Army Ballistic Missile Agency (ABMA), proposed a program to the Department of Defense. At that time the United States was considering an integrated missile and space vehicle development program. Creation of a booster with 1,500,000 pounds of thrust was the aim of the proposed program.

To secure this much power ABMA first considered clustering four 380,000 pound thrust Rocketdyne E-1 engines. This initial concept was discarded because of the time required to complete development of this type engine. However, ABMA continued studies to determine if engines already developed could be used.

On August 15, 1958, the Advanced Research Projects Agency (ARPA) formally initiated what was to become the Saturn project. The agency, a separately organized research and development arm of the Department of Defense, authorized ABMA to conduct a research and development program at Redstone Arsenal for a 1,500,000-pound thrust vehicle booster.

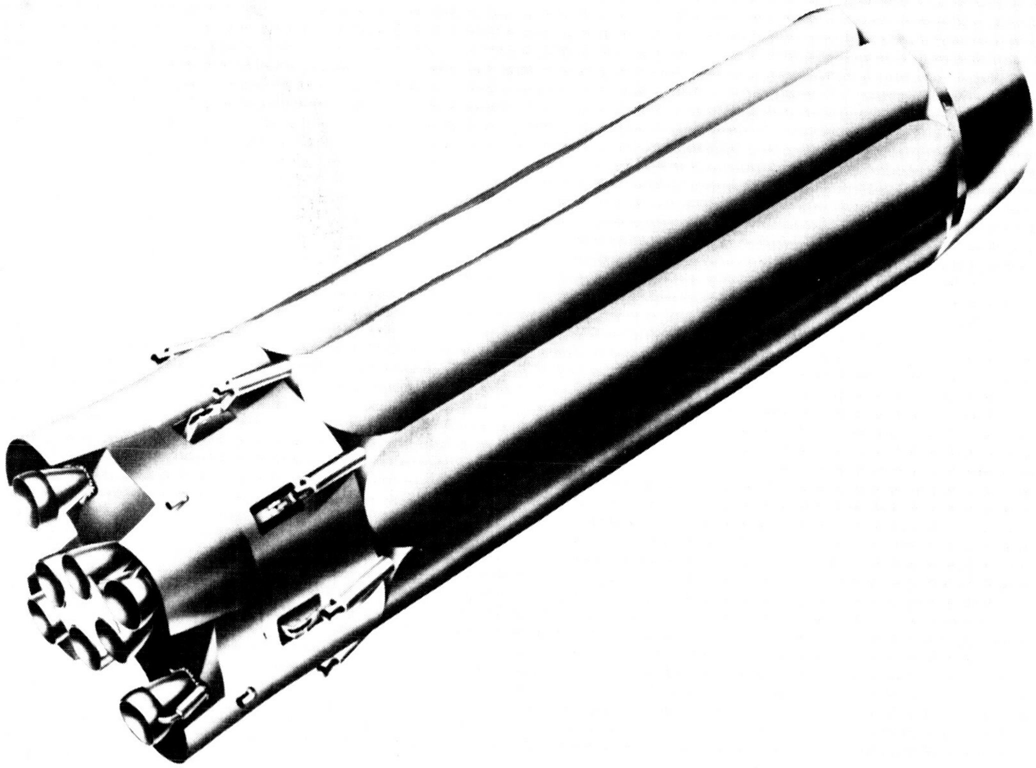


FIGURE 1. PROPOSED CONFIGURATION OF A CLUSTERED BOOSTER

A number of available rocket engines would be clustered. This design (Fig. 1) would be tested by a full-scale static firing by the end of 1959.

The liquid oxygen (LOX) and fuel tanks developed for the Redstone and Jupiter missiles could be modified for use in the proposed booster. 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. Numerous 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 hardware of proven reliability. Time for design and development of some important booster components and tooling could be significantly shortened and cost reduced.

As an immediate step a contract was awarded Rocketdyne Division of North American Aviation on September 11, 1958, to up-rate S-3D, the Thor-Jupiter engine. After redesign, simplification, and modification, the engine would be the H-1 (Fig. 4).

In October 1958 ARPA expanded its program objectives. A multistage carrier vehicle capable of performing advanced space missions would be built. The vehicle was tentatively identified as Juno V. ARPA requested Redstone personnel to study a complete vehicle system so that upper-stage

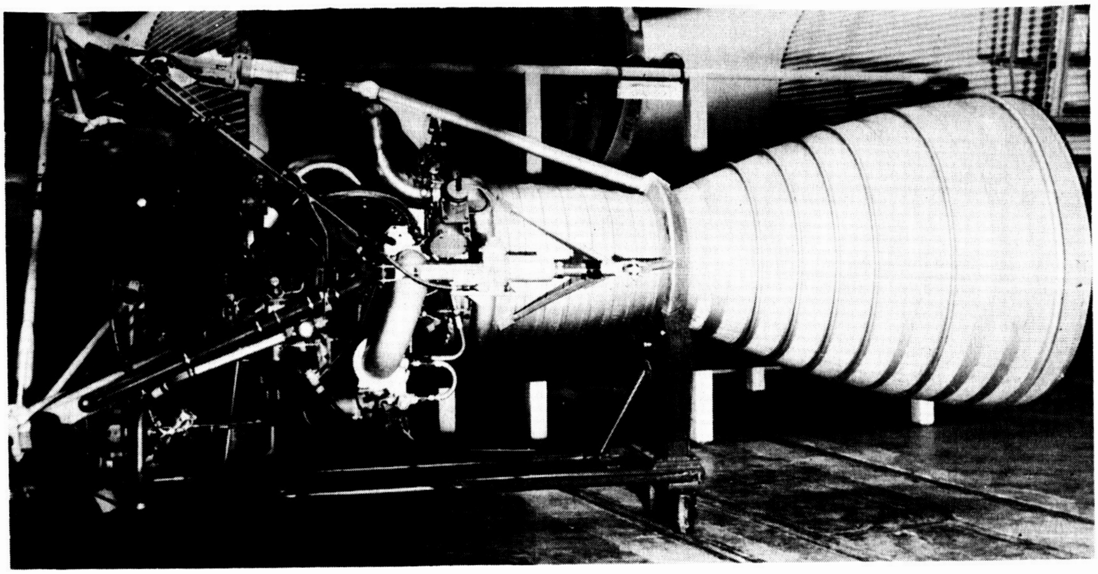


FIGURE 2. THOR-JUPITER ENGINE

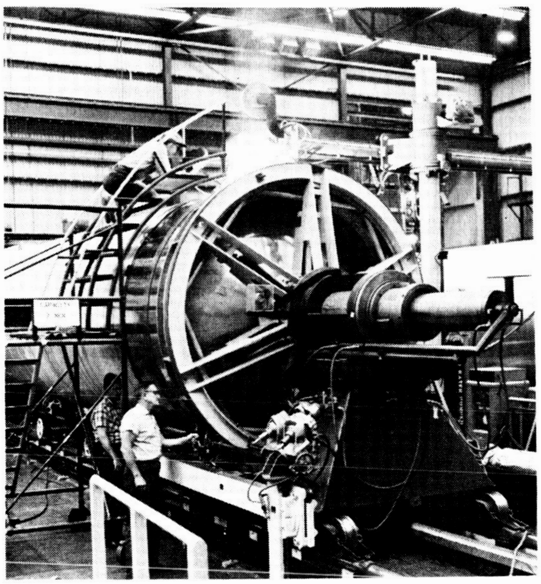


FIGURE 3. BOOSTER TOOLING

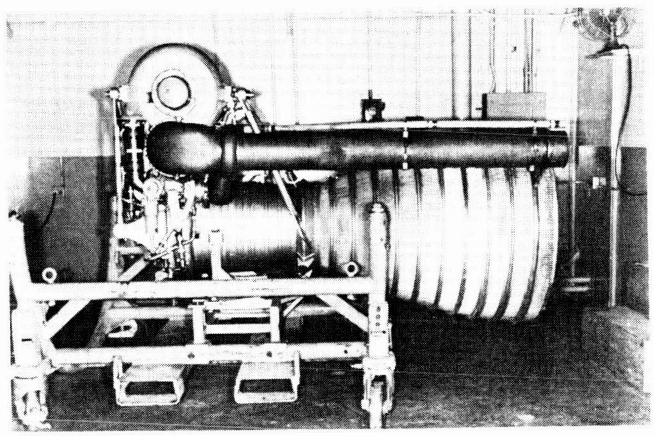


FIGURE 4. EARLY H-1 ENGINE

selection and development could begin, and initiated a study of Atlantic Missile Range (AMR) launch facilities which could accommodate the launch vehicle. Later, on December 11, 1958, ARPA 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

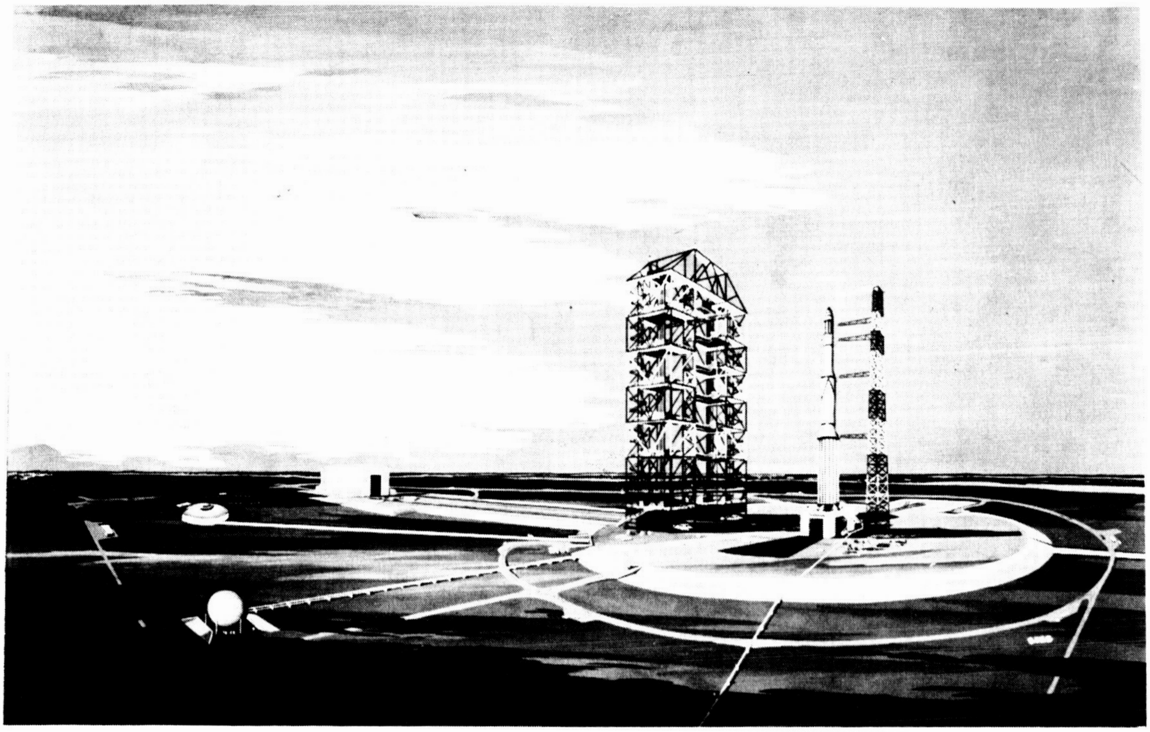


FIGURE 5. PRELIMINARY CONCEPT OF LAUNCH COMPLEX 34, CAPE CANAVERAL

program. AOMC was also to determine the design requirements for necessary launch facilities (Fig. 5).

While the booster-vehicle program was being formulated and expanded, development work on the H-1 engine continued. The first full-power H-1 engine firing occurred in December 1958 at the Rocketdyne facility in Canoga Park, California.

Concurrently with development of the H-1 engine, studies were conducted pertaining to the feasibility of a larger single-chamber rocket engine. On January 9, 1959, Rocketdyne of North American Aviation agreed by contract 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 a very high thrust - approximately 1,500,000 pounds.

Construction of the ABMA static test stand for large boosters began January 10, 1959. Meanwhile, 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). A design contract was also awarded for a movable structure which would be used to assemble and service the vehicle on the launch pedestal.

On February 3 an ARPA memorandum officially renamed the large launch vehicle project Saturn. ARPA representatives presented the proposed National Vehicle Program to the President and the National Aeronautics and Space Council on March 2, 1959. Included 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. This study indicated that

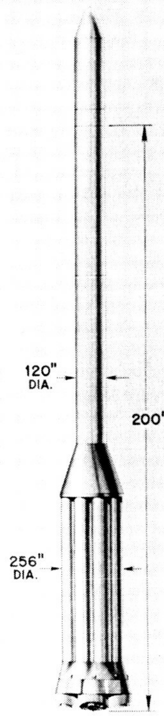


FIGURE 6.
SATURN B

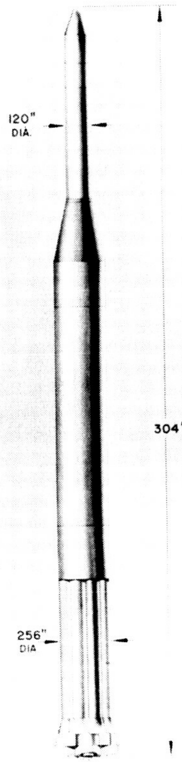


FIGURE 7.
SATURN C

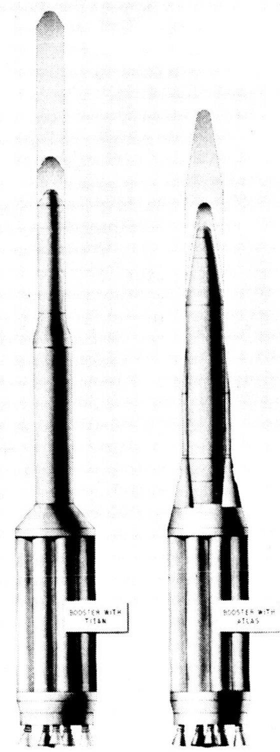
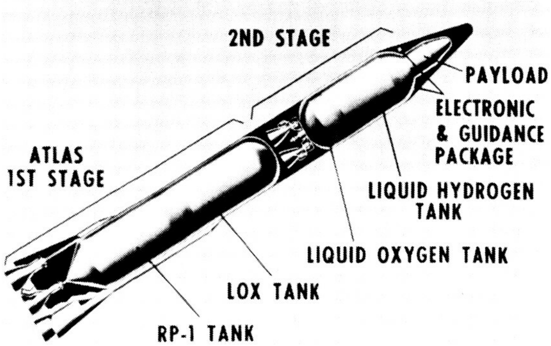


FIGURE 8. VEHICLES USING TITAN AND ATLAS STAGES

either an Atlas or a Titan could be used as the second stage of the proposed vehicle (Fig. 8). During May ARPA decided that modified Titan hardware could be used for the second stage and that the third stage could use a slightly modified Centaur vehicle (Fig. 9).



- FIGURE 9. ATLAS CENTAUR VEHICLE (CENTAUR SECOND STAGE)

April - July 1959

By April 28 the first production H-1 engine (H-1001) had been delivered on schedule to ABMA (Fig. 10). ABMA's first firing test of this engine, later used in the first test booster, was performed successfully on May 26, 1959.

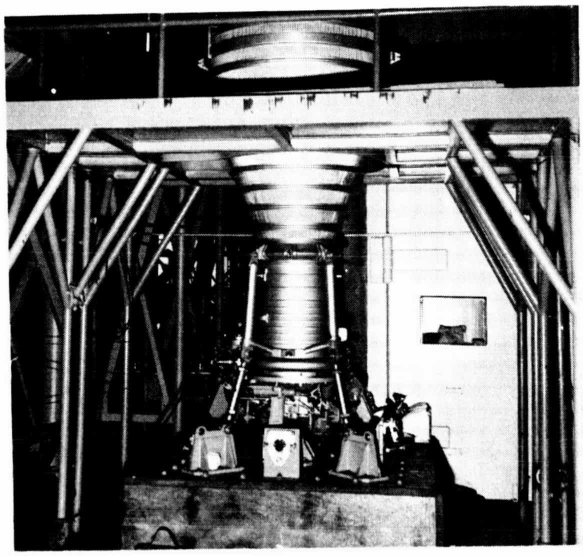


FIGURE 10. H-1 ENGINE IN ALIGNMENT FIXTURE

On July 5, 1959, construction of the Saturn blockhouse for Launch Complex 34 began at Cape Canaveral (Fig. 11). On July 27 when the last Jupiter airframe was completed, Redstone Arsenal shops began retooling to support the Saturn project.

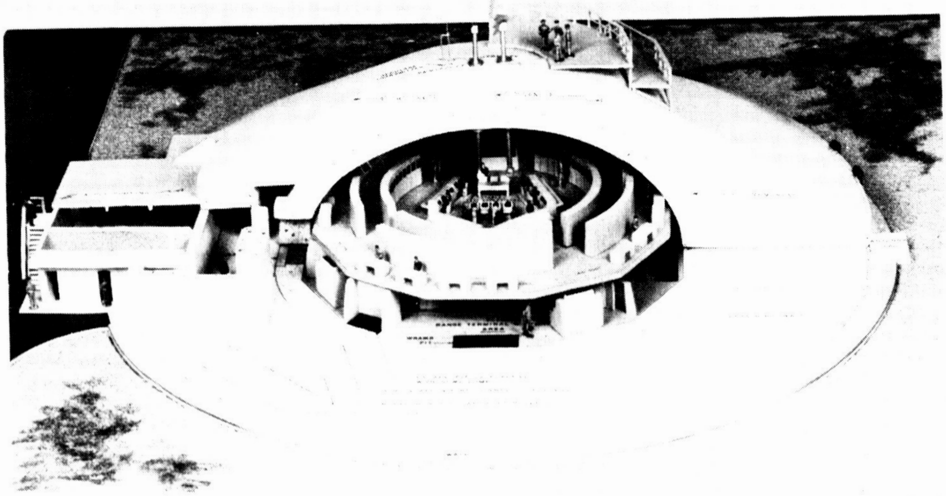


FIGURE 11. MODEL OF BLOCKHOUSE AT LAUNCH COMPLEX 34

Late in July the Director of Defense Research and Engineering notified Air Force and ARPA to consider common development of the Saturn second stage and the booster for the proposed Dyna Soar; requirements for these stages appeared to be similar. Until review of this, neither agency was to make firm commitments for the redesign of existing boosters or development of new ones. ARPA then ordered that AOMC in-house and contractor work relating to the Titan second stage cease. An exception was made of some preliminary work not directly connected with the stage diameter.

Work continued on the Saturn booster stage. While studies of the proposed Saturn-Dyna Soar combination were in progress, ARPA, on August 1, authorized ABMA to proceed toward captive firing the Saturn booster early in 1960.

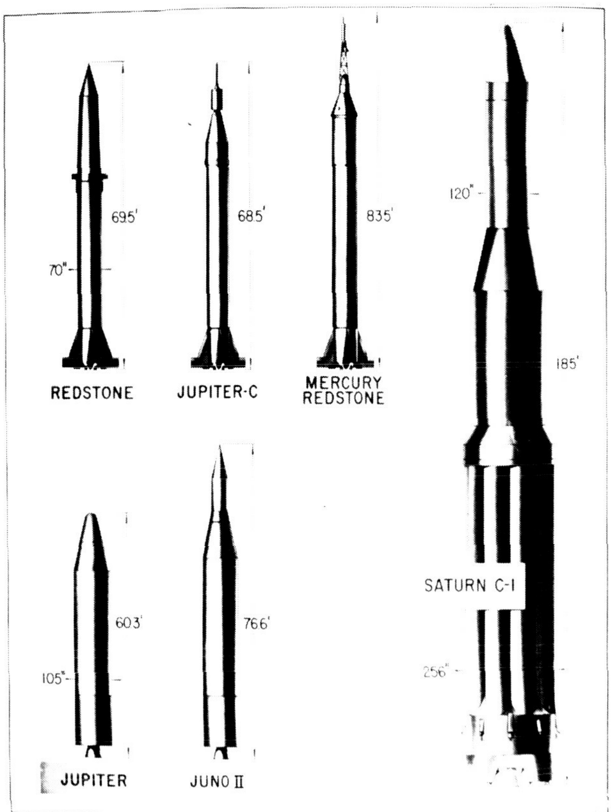
In September representatives of AOMC, NASA, and the Air Force presented Saturn, Nova, and Titan C systems to the Booster Evaluation Committee of the Office of the Secretary of Defense. On the basis of these presentations ARPA chose Saturn. ARPA then requested that Redstone scientists determine the Saturn configurations which could best carry NASA payloads.

During October 1959 consideration of Saturn vehicle configurations continued. 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 (Fig. 12).

Because of its large size and weight the Saturn booster could not be transported by air or land. Water transportation appeared most feasible and ARPA, on October 23, 1959, authorized AOMC to proceed with engineering work for dock facilities. These would be located on the Tennessee River at the southern boundary 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.

On November 18 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 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 a Saturn vehicle with upper-stage engines burning liquid hydrogen and liquid oxygen. The initial vehicle, identified as C-1, was to be a stepping stone to a larger vehicle,



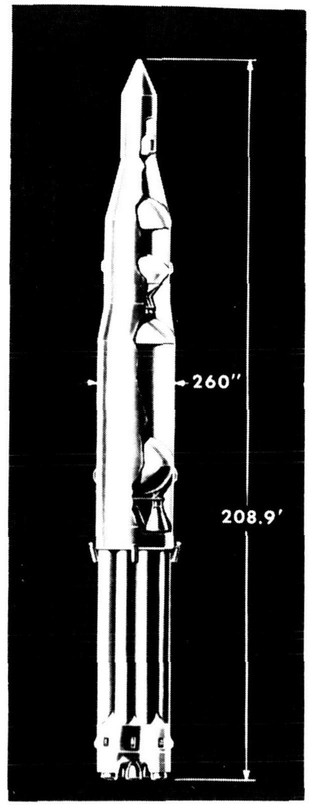


FIGURE 12. C-1 AND EARLIER VEHICLES

FIGURE 13. PROPOSED C-2

the C-2 (Fig. 13). A building-block concept was proposed that would yield a variety of Saturn configurations, each using previously-proven developments as far as possible. These recommendations were accepted by the NASA Administrator. On 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) would have eight H-1 engines. Fueled by LOX/RP-1, the engines clustered were expected to produce a total of 1,500,000 pounds of thrust. The S-IV stage (Fig. 15) was conceived of as a four-engine liquid oxygen-liquid hydrogen fueled unit capable of producing a total of 80,000 pounds of thrust. The S-V stage (Fig. 16) would use two of the same engines as the S-IV stage and this stage would provide an additional 40,000 pounds of thrust.

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

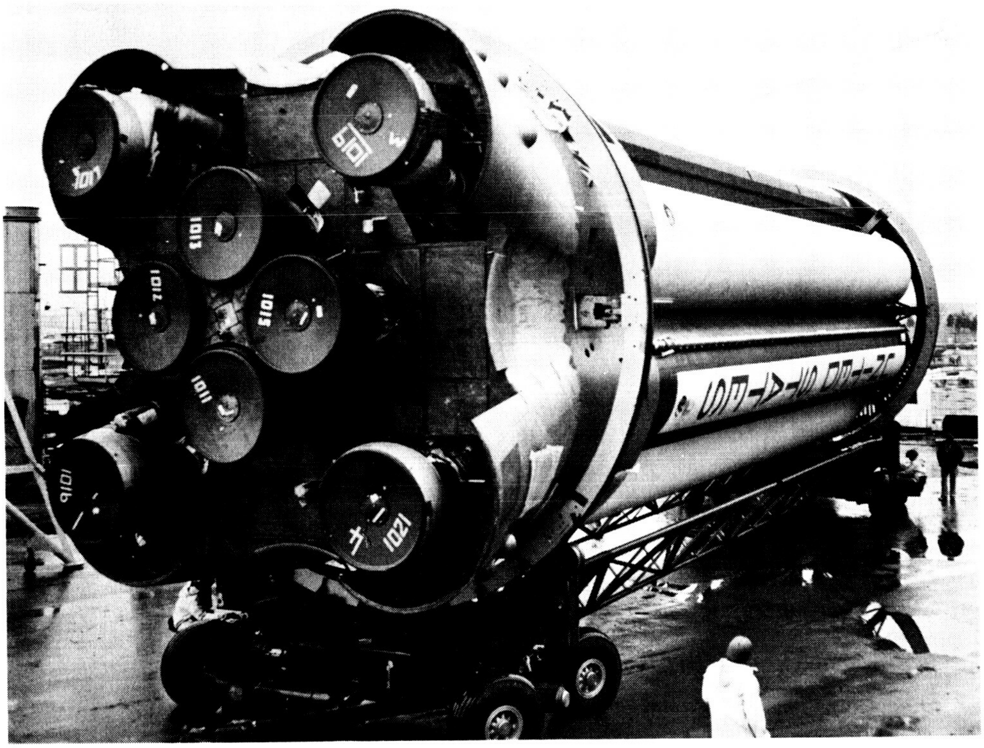


FIGURE 14. BOOSTER STAGE (S-I)

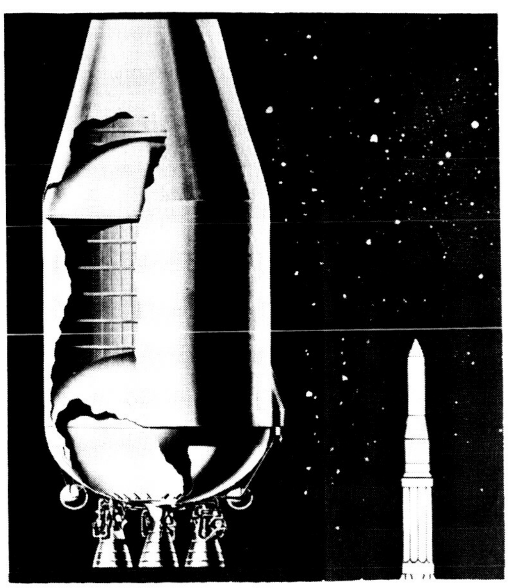


FIGURE 15. SECOND STAGE (S-IV)

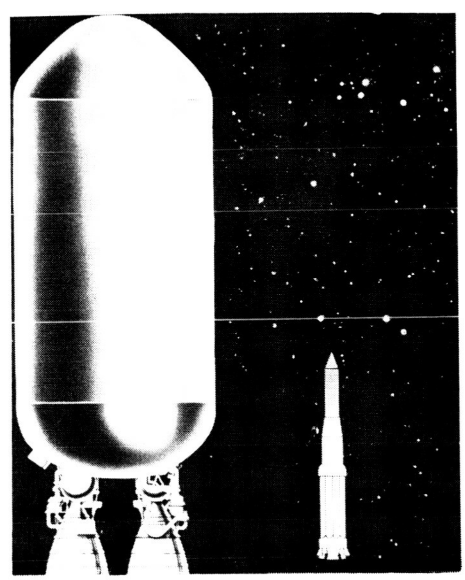


FIGURE 16. THIRD STAGE (S-V)

To develop the second stage of Saturn C-1, NASA sought a contractor. A bidder's conference concerning this S-IV stage was held at Huntsville, January 26 and 27, 1960. By February 29 twelve companies had submitted contract proposals.

Redstone Arsenal scientists started to work on the first stage. By 1960 the formal test program to prove out the clustered booster concept was well underway. A mockup of the Saturn booster was installed in the ABMA test stand on January 4, 1960, to check mating of the booster and stand and to test servicing methods. This mockup was removed from the test stand and the completed test booster, SA-T, was installed in its place during February 1960 (Figs. 17 and 18).

During March the executive order transferring the Saturn program to NASA became effective. Later in the month 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). It occurred on March 28. 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 on April 29 in an eight-second test (Fig. 19).

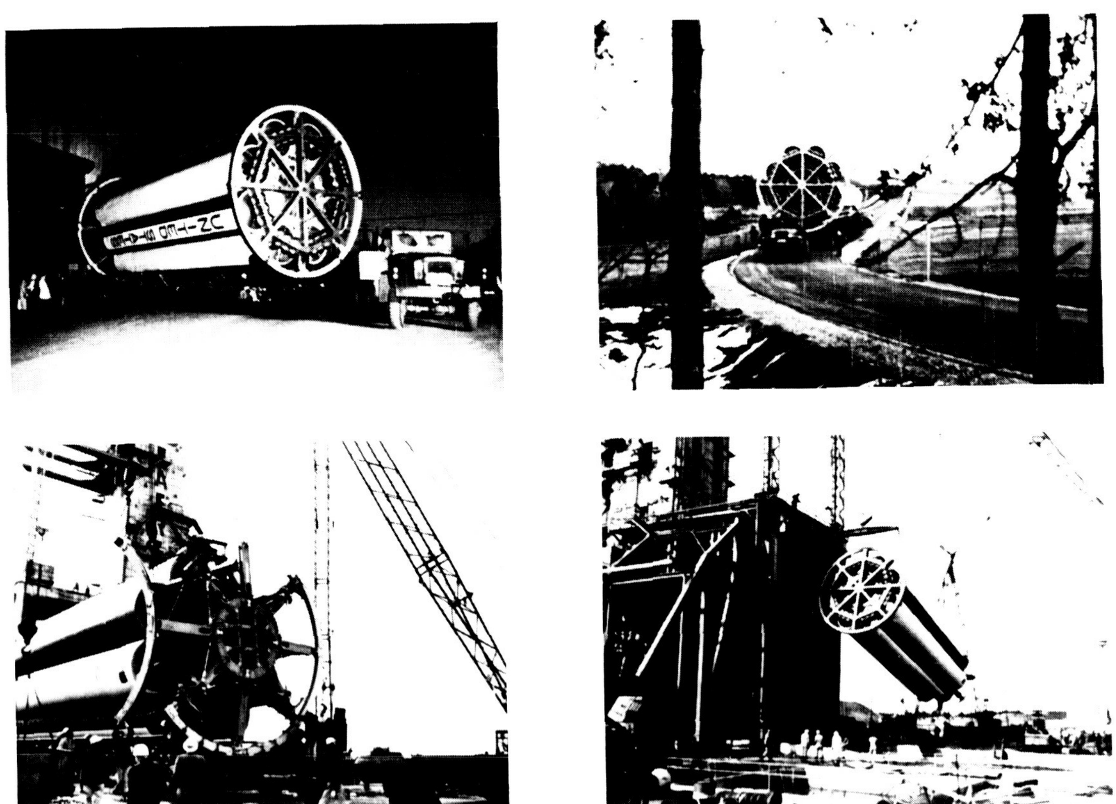


FIGURE 17. MOVING SATURN TEST BOOSTER FROM ASSEMBLY TO TEST

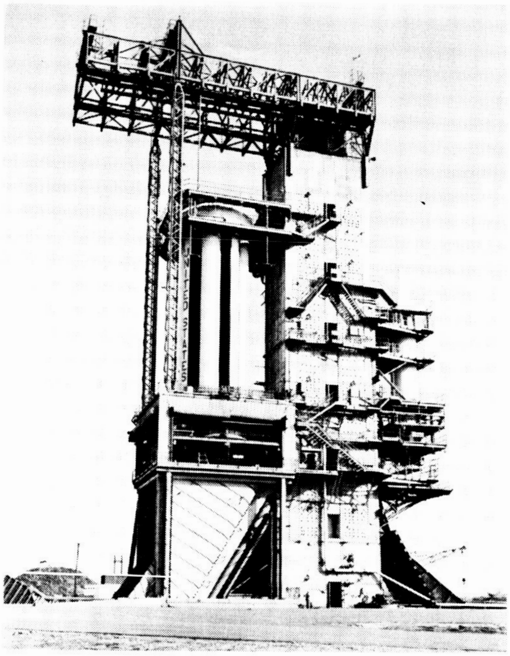


FIGURE 18. BOOSTER IN TEST STAND

FIGURE 19. BOOSTER STATIC FIRING

On May 17 a second eight-engine static firing of 24 seconds' duration generated a thrust of 1.3 million pounds. The third successful eight-engine firing lasted 35 seconds.

Meanwhile, NASA reviewed the S-IV proposals received in February. On April 26 NASA awarded Douglas Aircraft Company a contract to develop and build the second stage.

During May NASA announced that Rocketdyne had been selected to develop the high thrust J-2 engine (Fig. 20). This engine, of the type defined by the Silverstein Committee in December 1959, would burn liquid hydrogen-liquid oxygen. It would be used in an upper stage of an advanced Saturn vehicle.

The first ten Saturn flight vehicles would be numbered from SA-1 to SA-10. SA-10 would be the prototype of the operational Saturn.

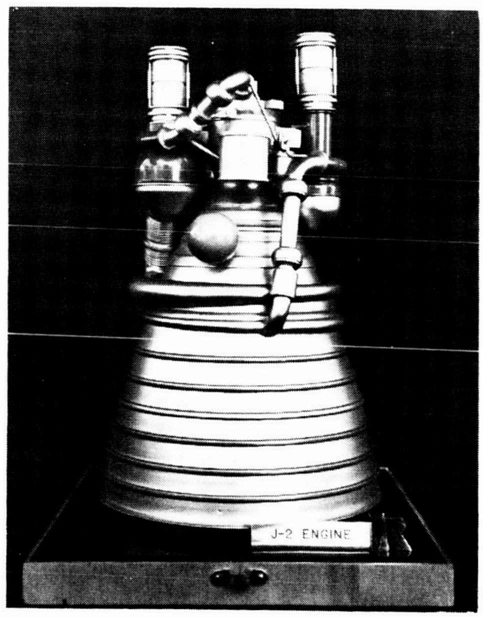


FIGURE 20. MODEL OF J-2 ENGINE

On May 26, 1960, assembly of the booster stage for the first Saturn flight vehicle began in Huntsville (Figs. 21, 22, 23, and 24).

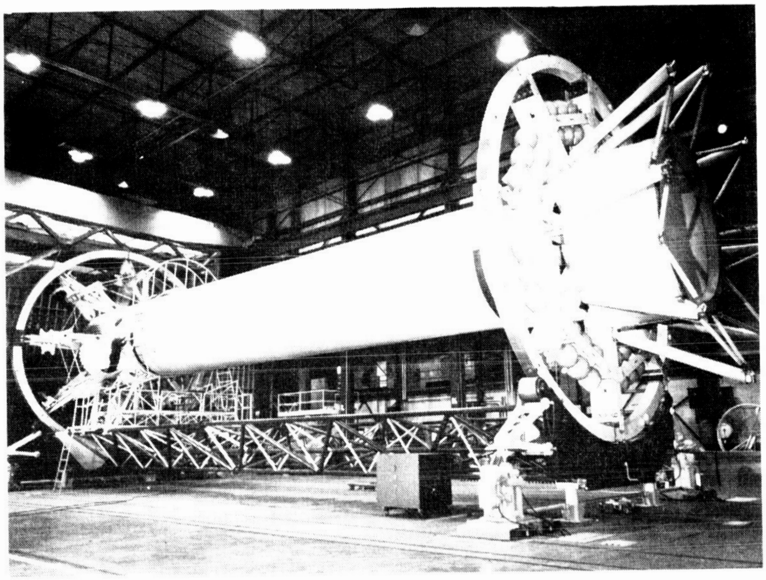


FIGURE 21. ASSEMBLY OF MAIN LOX TANK FOR SA-1 BOOSTER

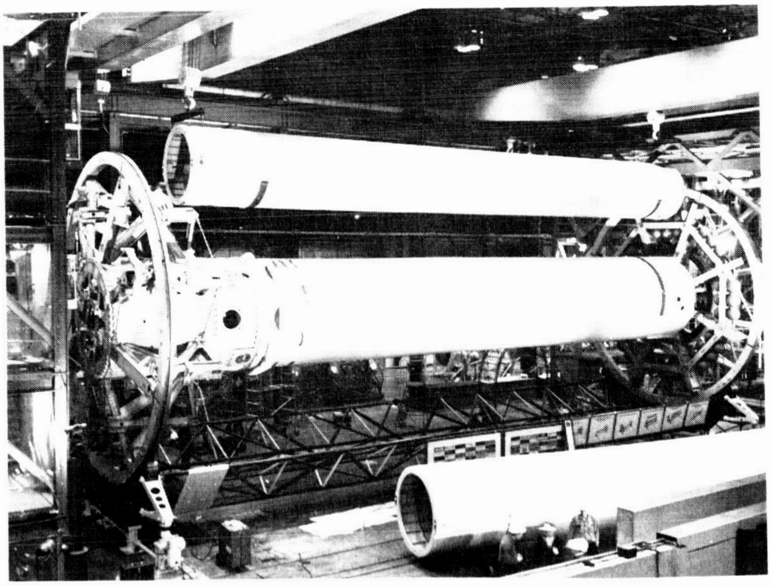


FIGURE 22. ASSEMBLY OF TANKS ON SA-1 BOOSTER

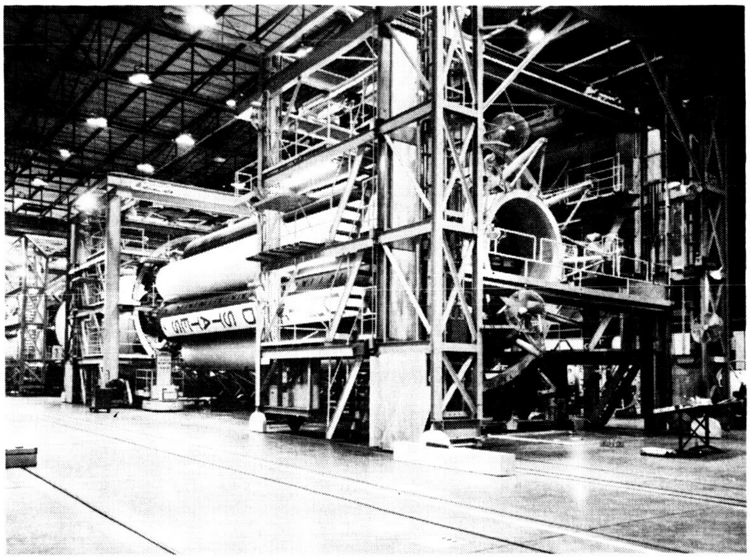


FIGURE 23. STRUCTURAL FABRICATION OF SA-1 BOOSTER

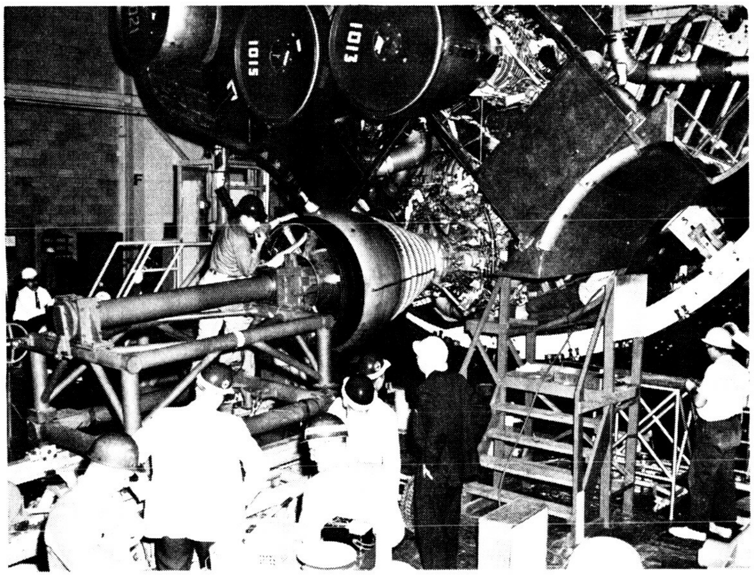


FIGURE 24. INSTALLATION OF ENGINES ON SA-1 BOOSTER

On July 1, 1960, the Saturn program was formally transferred to the George C. Marshall Space Flight Center (MSFC). A second series of static tests had just been successfully completed on the first stage of Saturn C-1.

On July 26 NASA signed a supplemental agreement with Douglas Aircraft Company (DAC) covering the second stage. DAC would design, develop, and fabricate the four-engine S-IV stage (Fig. 25).

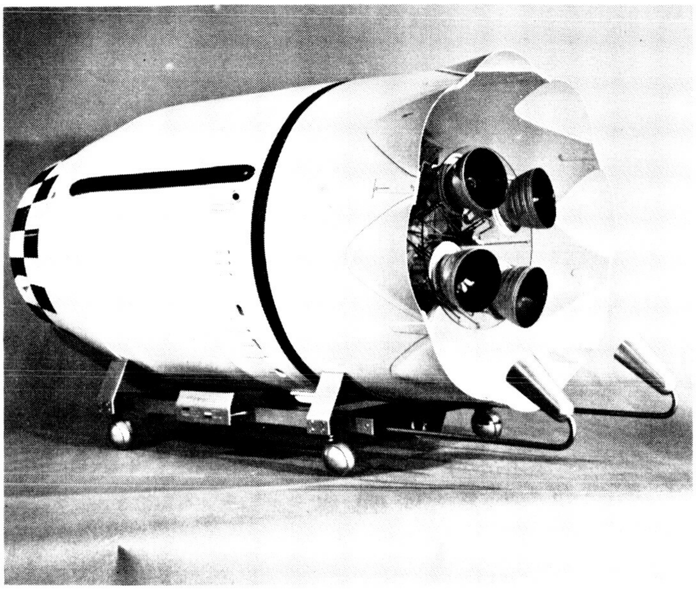


FIGURE 25. INITIAL CONFIGURATION OF THE S-IV STAGE

Contracts were also let on August 10, 1960, with Pratt & 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, an up-rated LR-115 engine, was expected 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).

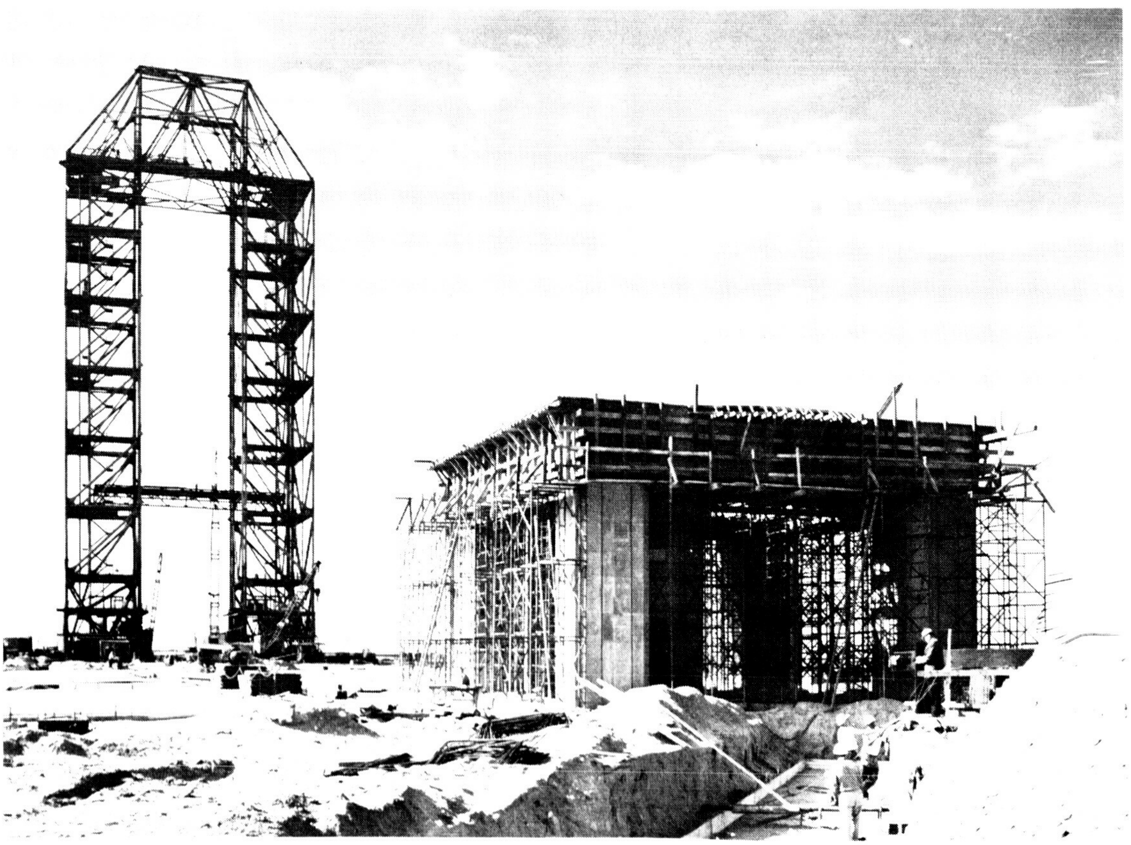


FIGURE 26. CONSTRUCTION OF SERVICE TOWER AND PEDESTAL

FIGURE 27. UNVEILING BUST OF GENERAL GEORGE C. MARSHALL

On August 15 the Air Force requested NASA assistance in planning the application of Saturn to Dyna Soar. After conferring with Air Force, MSFC agreed on October 6 to provide a preliminary study.

On September 8 the facilities of the National Aeronautics and Space Administration at Huntsville, Alabama, were dedicated and designated as the George C. Marshall Space Flight Center. President Eisenhower, Mrs. George C. Marshall, NASA Administrator T. Keith Glennan, and many other national, state, and local dignitaries participated in the ceremony (Figs. 27, 28, and 29).

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

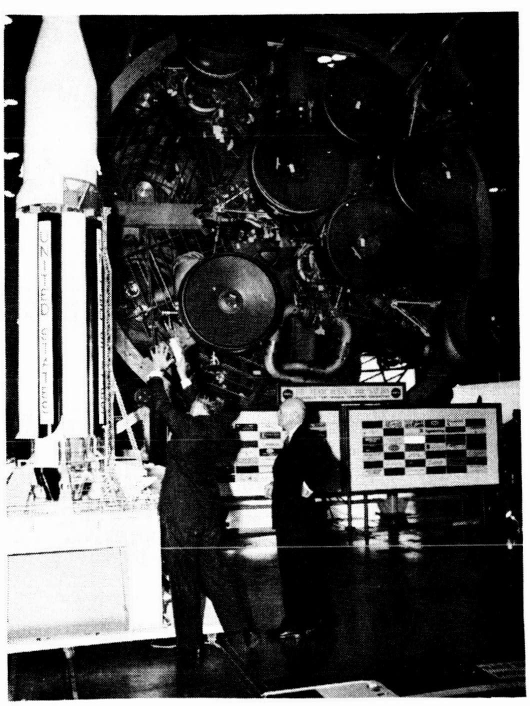


FIGURE 28. DR. VON BRAUN AND PRESIDENT EISENHOWER

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

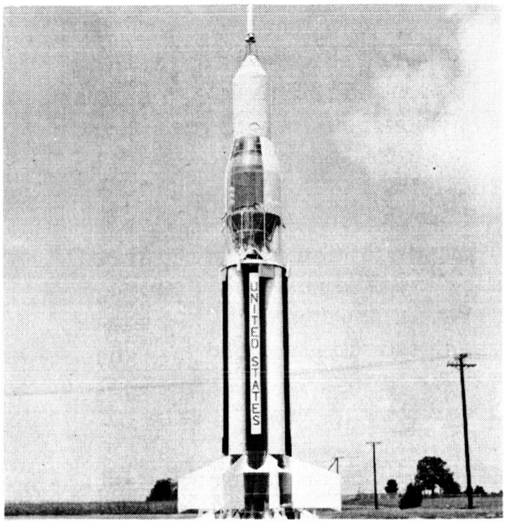


FIGURE 30. PROPOSED SATURN C-1 APOLLO CONFIGURATION

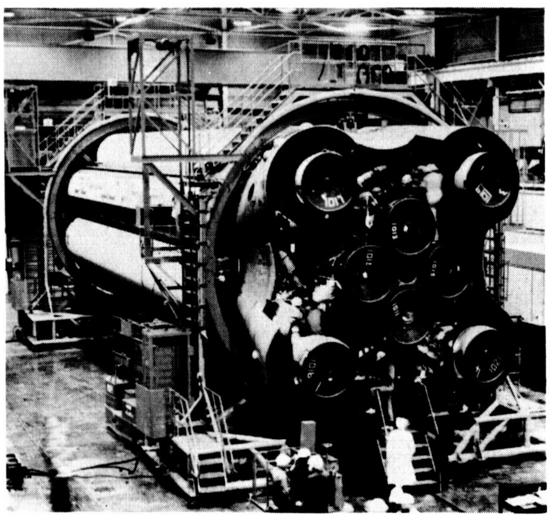


FIGURE 31. SA-1 CHECKOUT

MSFC started a new series of static firing tests of the test booster (modified to the SA-1 flight configuration and designated SA-T1) on December 2, 1960. An eight-engine test lasting two seconds was first. The next week a test of two engines was conducted in a six-second firing. The series of booster tests was successfully concluded on December 20, 1960, by a 60-second firing of all eight engines. 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.

In January Convair Astronautics submitted a proposal for an S-V upper stage for the Saturn vehicle; however, later in the month 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). NASA decided to 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 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.

Two additional studies began in January 1961. NASA awarded North American and Ryan contracts to investigate feasibility of recovering the S-I booster stage after the vehicle flight by using a Rogallo paraglider (Fig. 32). A design contract was awarded for equipment which would be used at MSFC to check out the S-I stage automatically.

On January 25 a meeting was held at MSFC to study S-II stage requirements for the Saturn C-2 vehicle (Fig. 33). S-II stage trajectory, performance, and structural analysis calculations were completed and made a part of the preliminary Saturn/Dyna Soar proposal.

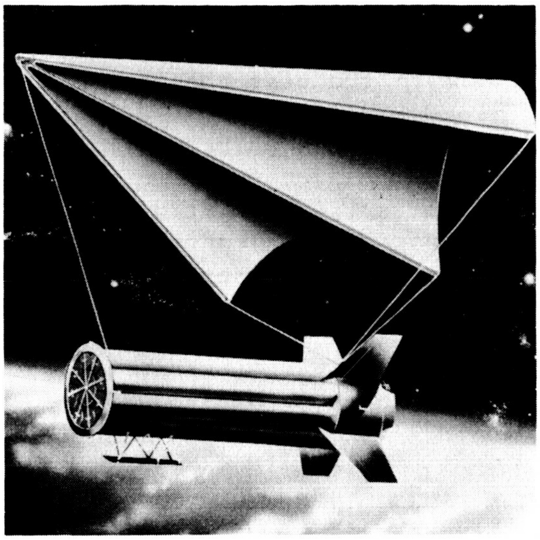


FIGURE 32. SATURN BOOSTER RECOVERY

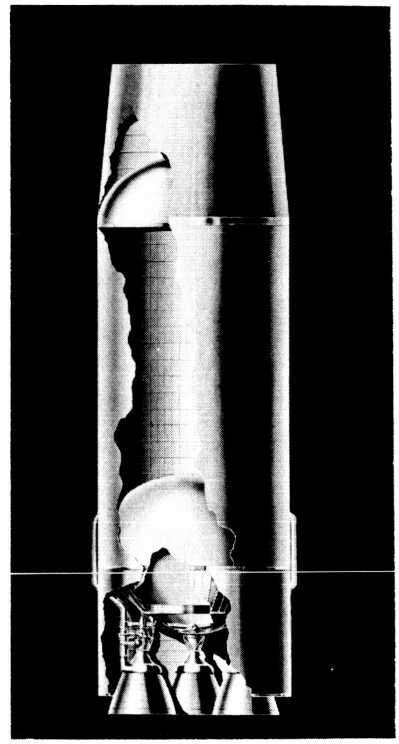


FIGURE 33. C-2 SECOND STAGE CONCEPT

During January a dummy of the S-IV stage was completed at MSFC and moved to checkout (Fig. 34). On January 31 MSFC static fired all eight engines of the SA-T1 test booster for 113 seconds.

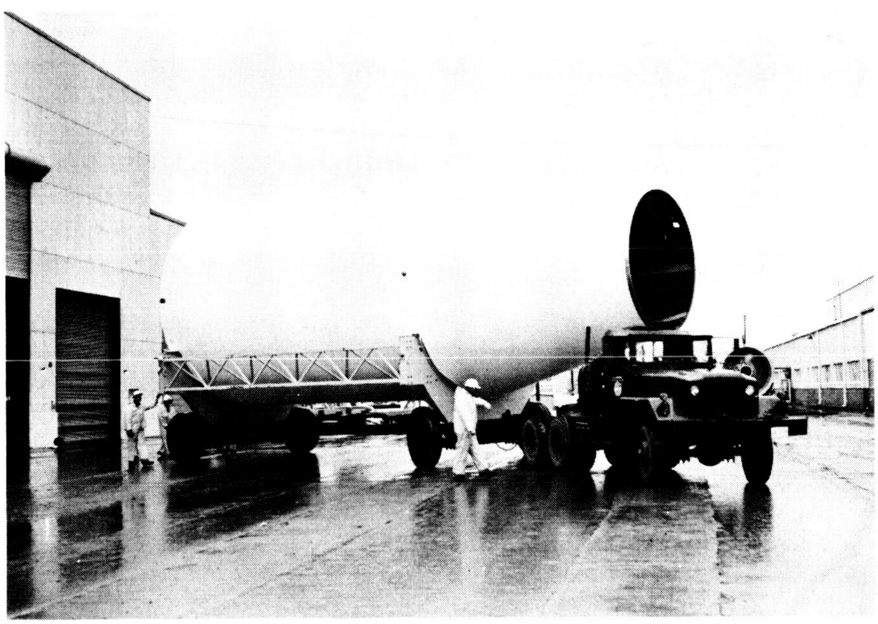


FIGURE 34. MOVEMENT OF DUMMY S-IV STAGE TO CHECKOUT

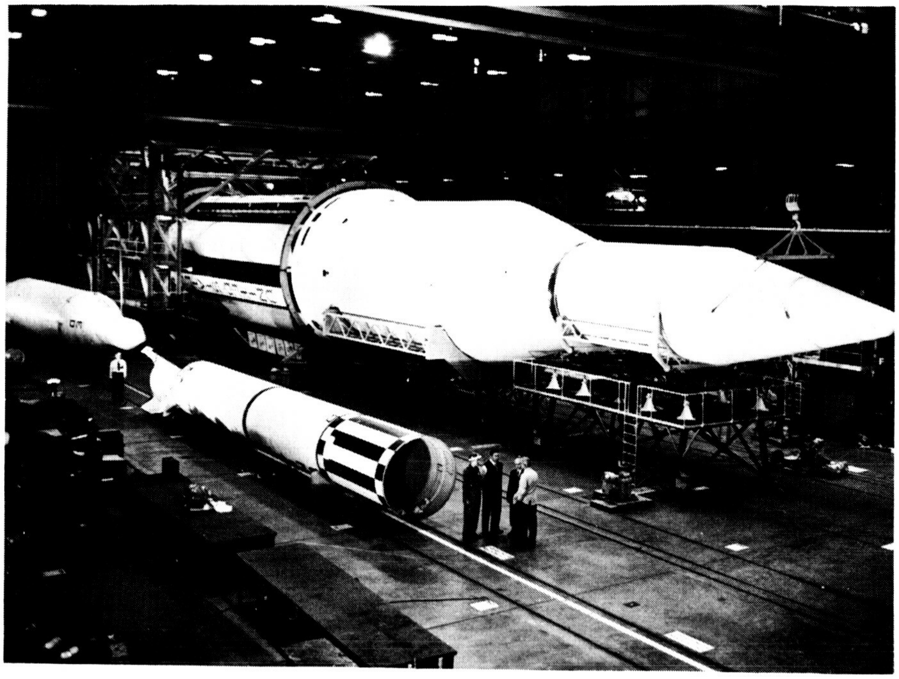


FIGURE 35. FIRST HORIZONTAL MATING OF THE SATURN VEHICLE

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 February (Fig. 35). MSFC completed SA-T1 static tests on February 14. 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.

Liquid hydrogen engine development problems led to studies early in March to determine the possibility of using the first generation LR-115 type Centaur engine on the Saturn S-IV stage, rather than second-generation Centaur engine, the LR-119.

Meanwhile, 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).

On March 7 the SA-1 booster was moved to the Marshall Space Flight Center static test stand for preflight checkout. On March 14 the Palaemon,

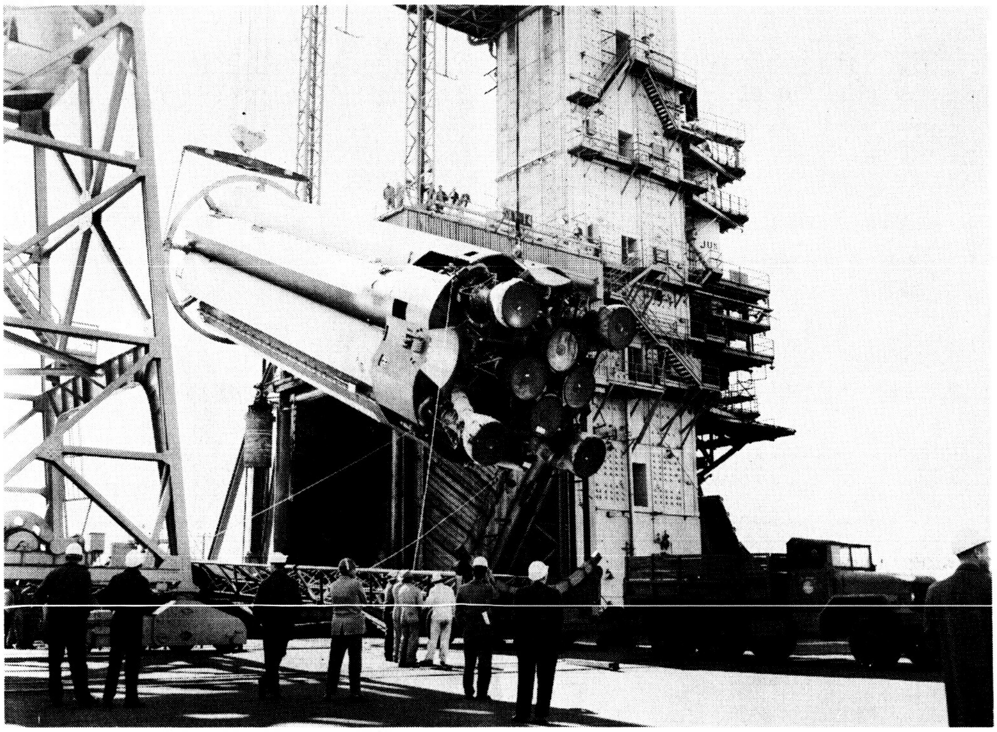


FIGURE 36. REMOVAL OF THE BOOSTER FROM THE STATIC TEST STAND

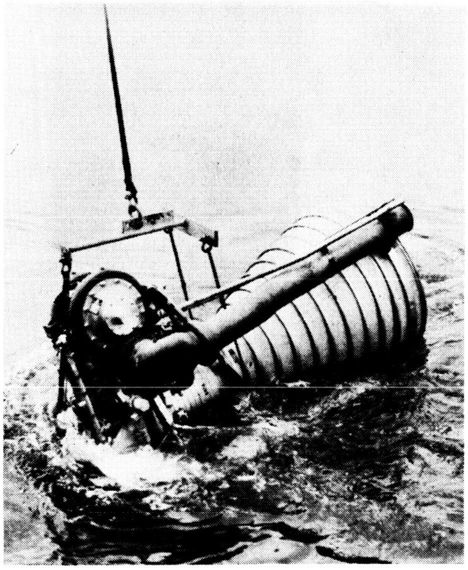


FIGURE 37. SALT WATER TEST OF H-1 ENGINE

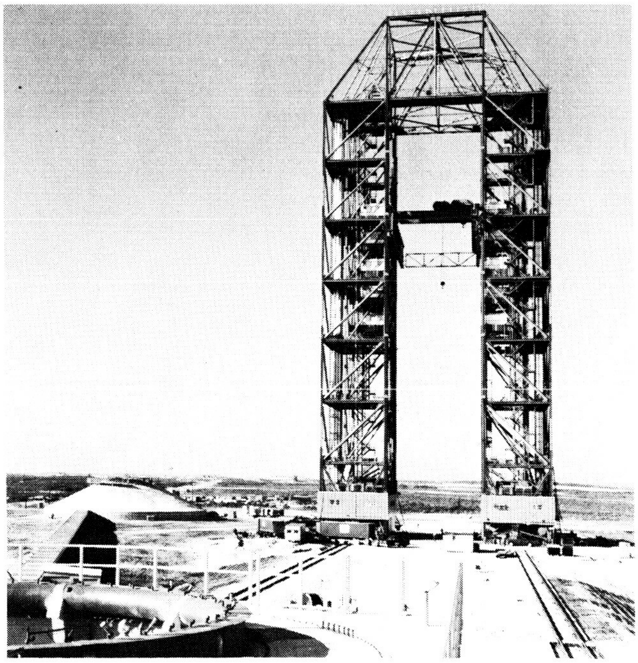


FIGURE 38. FACILITIES CONSTRUCTION AT LAUNCH COMPLEX 34

carrying the SA-T1, left the MSFC dock on its first training trip (Fig. 39). Following its return the test booster went to MSFC shops for modification to the SA-T2 configuration. Looking beyond the booster, MSFC began construction in March of a facility to be used in familiarizing personnel with the handling of liquid hydrogen.

MSFC presented plans on March 23 to accelerate the C-2 program and recommended that a prime contractor be selected to develop the S-II stage. MSFC also recommended use of six LR-115 engines on the S-IV stage instead of four LR-119 engines. Pratt and Whitney would still be the supplying contractor. MSFC then proposed certain design changes in the S-I stage including an increase in propellant capacity, the addition of fins (Fig. 40), and increased structural support for later versions of the booster.

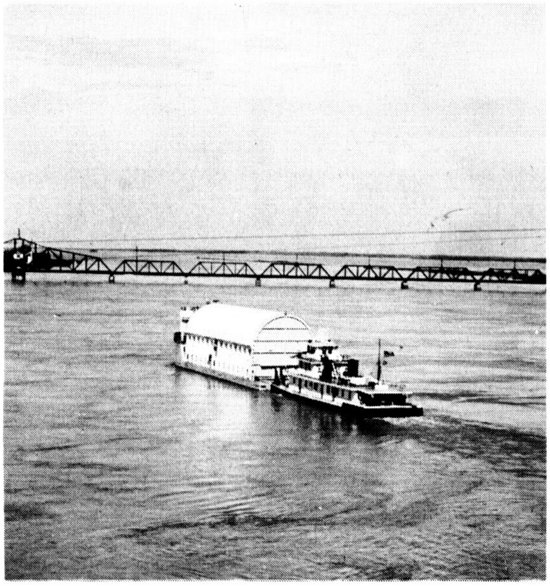


FIGURE 39. THE BARGE PALAEMON

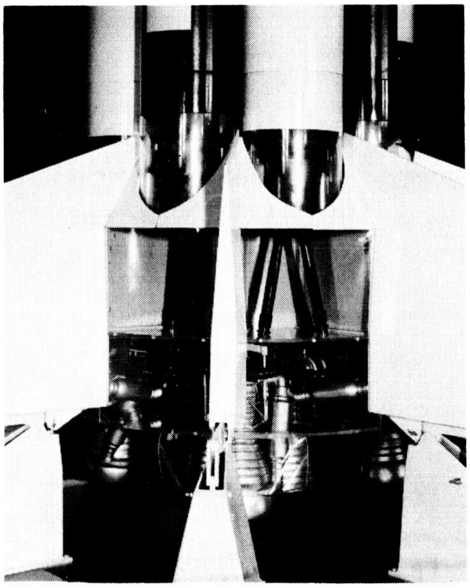


FIGURE 40. REDESIGNED TAIL OF THE SATURN BOOSTER

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. NASA approved on March 31 acceleration of the C-2 program and development of the C-2 vehicle for a three-stage escape mission. MSFC was authorized to begin a two-phase procurement of an S-II stage.

During March further decisions were made concerning engines for the S-IV stage. MSFC decided to redirect effort from development of the LR-119 to the RL10-A-1, an engine that could be used in common by both the Centaur and the S-IV stage.

On April 10 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 to study air transportation for S-IV stages. This would greatly reduce the time which would be required if the stages were moved by water from California to MSFC at Huntsville, and thence to Cape Canaveral, Florida. The use of gliders, blimps, and aircraft to carry the stages was also considered.

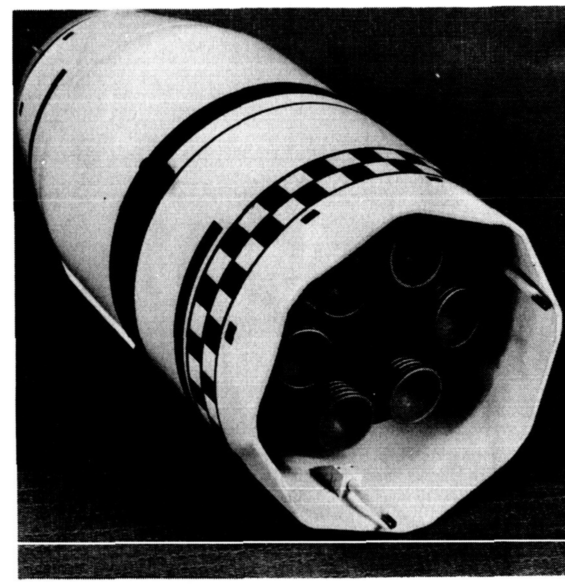


FIGURE 41. SIX-ENGINE CONFIGURATION OF THE S-IV STAGE

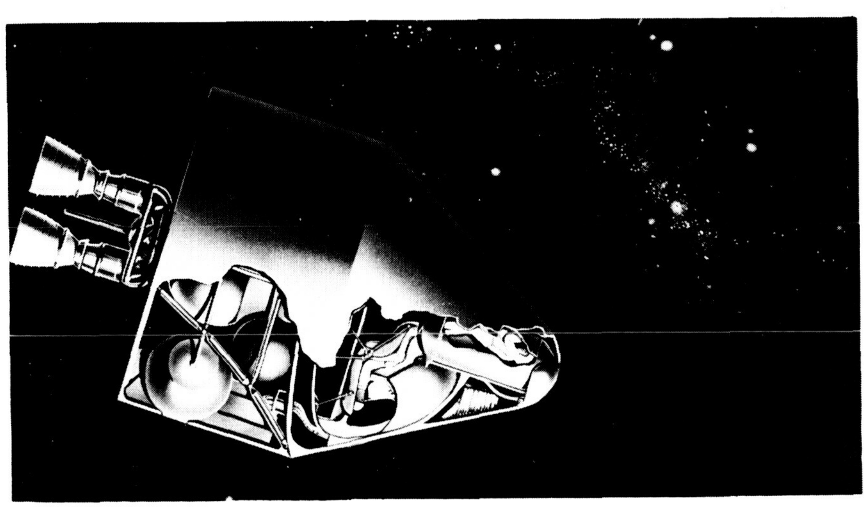


FIGURE 42. ARTIST'S CONCEPT OF APOLLO CAPSULE

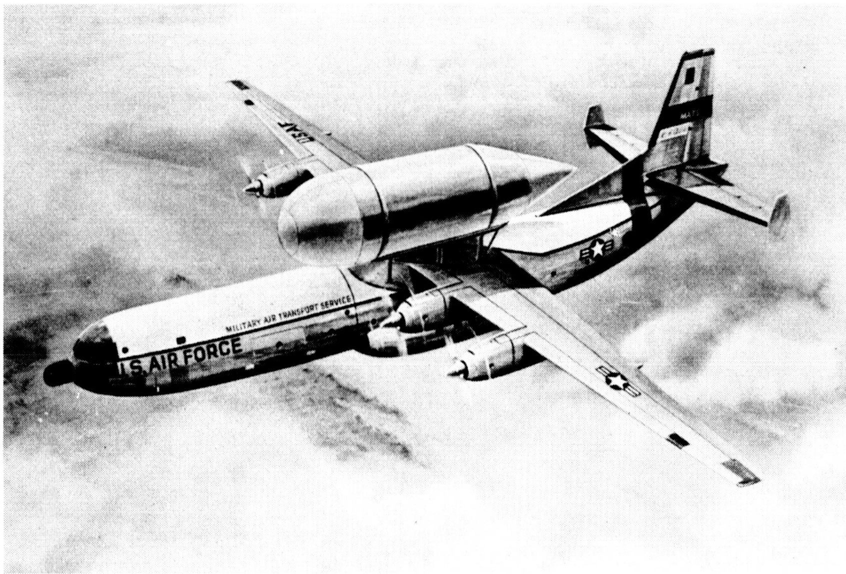


FIGURE 43. AIR TRANSPORT OF S-IV STAGE

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).

MSFC completed construction of the dynamic test tower on April 17, the same day that the Palaemon left for Florida. The dynamic tower (Fig. 47) permits check-out 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.

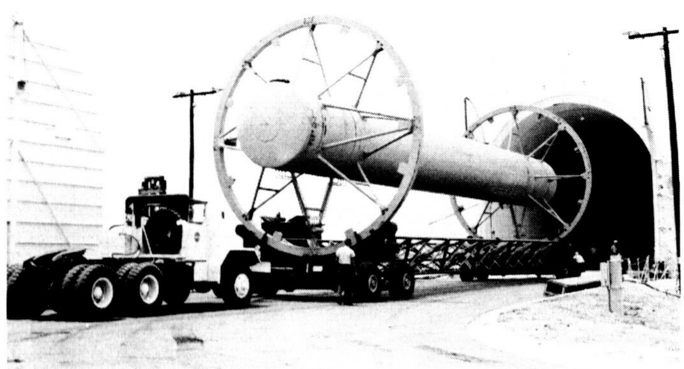


FIGURE 44. BOOSTER SIMULATOR BEING LOADED ABOARD PALAEMON

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

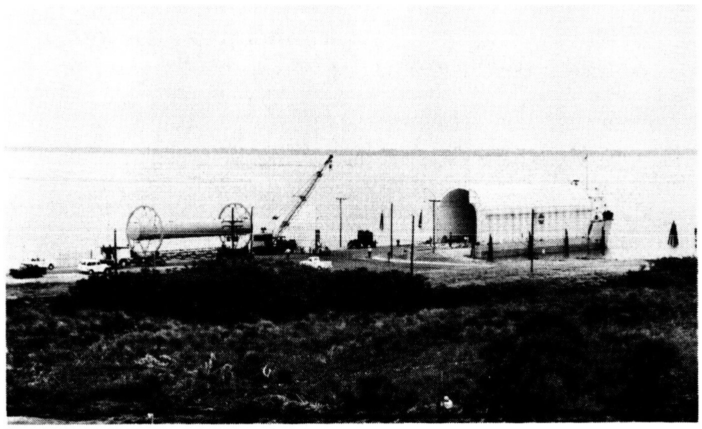


FIGURE 45. UNLOADING SIMULATOR AT THE CAPE

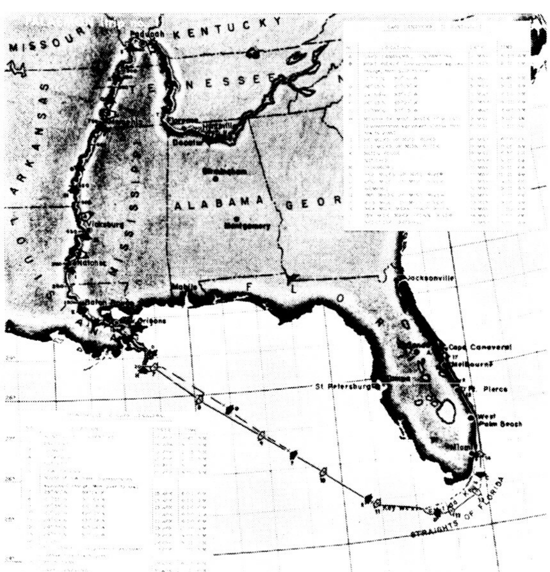


FIGURE 46. ROUTE OF THE <u>PALAEMON</u> TO CAPE CANAVERAL

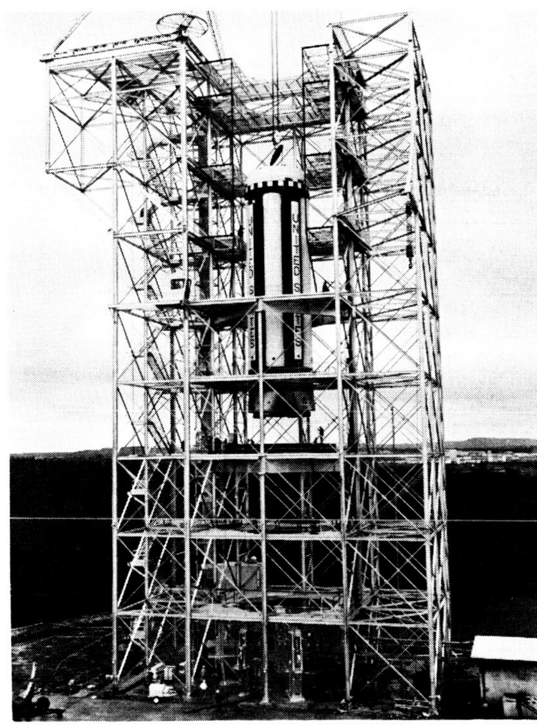


FIGURE 47. INSTALLING DUMMY S-I ON DYNAMIC TEST TOWER

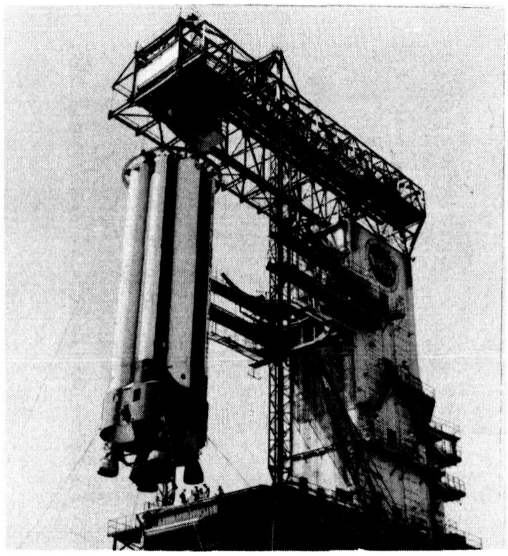


FIGURE 48. POSITIONING FLIGHT BOOSTER IN TEST STAND

development was disposal 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. A second static firing of the SA-1 booster, May 5, 1961, was terminated prematurely because of a problem which caused a shutdown signal through the fire detection system. A third eight-engine static firing test of the SA-1 booster, performed May 11 (Fig. 48) lasted 111 seconds and was satisfactory. Meanwhile, assembly of the SA-2 flight vehicle continued, and fabrication of the LOX and fuel tanks for the SA-3 vehicle was begun.

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 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 re-examination of the capabilities of the Saturn C-2 configuration to support lunar circumnavigation missions. Results of this examination indicated that a Saturn vehicle of even greater performance would be desirable.

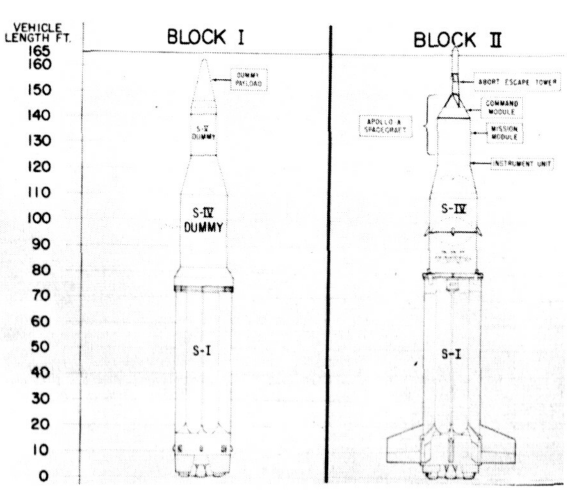


FIGURE 49. CONFIGURATIONS OF SATURN FLIGHT VEHICLES

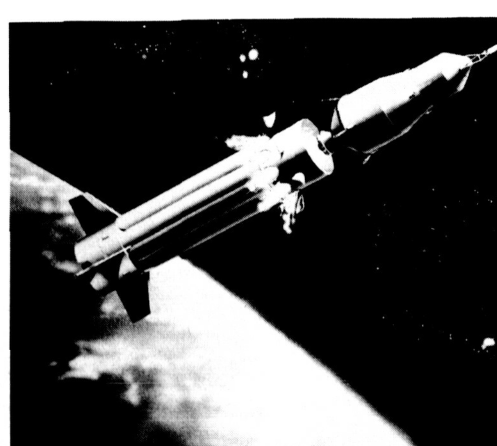


FIGURE 50. SEPARATION OF UPPER STAGES FROM BOOSTER

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 Mav 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 included transportation systems for a lunar landing and immediate return for three men, a thirty-day stay on the moon for three men, and a permanent moon base to accommodate 10 to 12 men.

MSFC tested the S-IV dummy stage for the SA-1 flight vehicle May 20-25, 1961 (Fig. 52). After successful testing the Center began to ready the stage for shipment to Cape Canaveral.

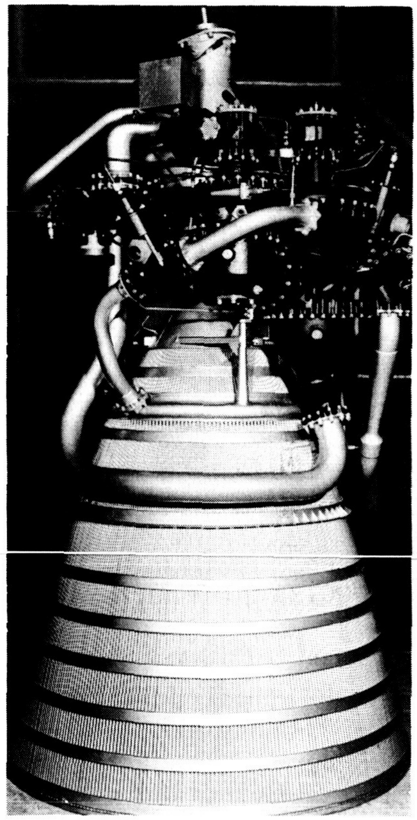


FIGURE 51. MODEL OF THE RL10-A-3 ENGINE

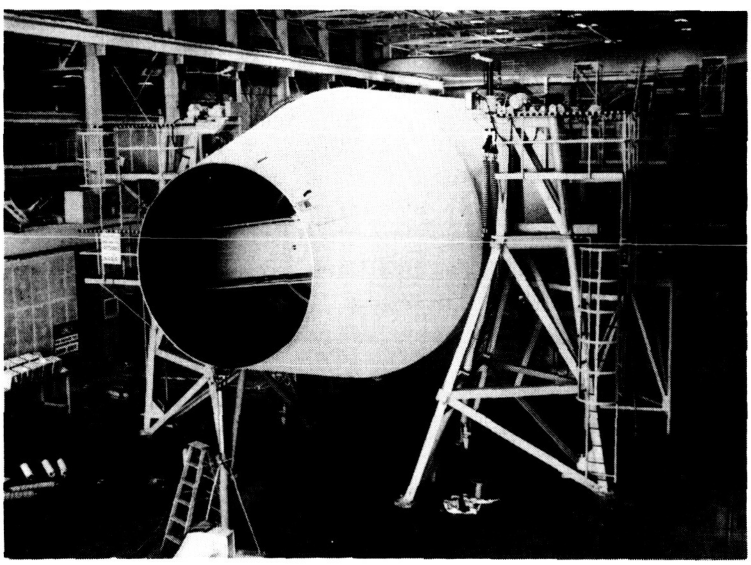


FIGURE 52. TESTING OF DUMMY S-IV STAGE

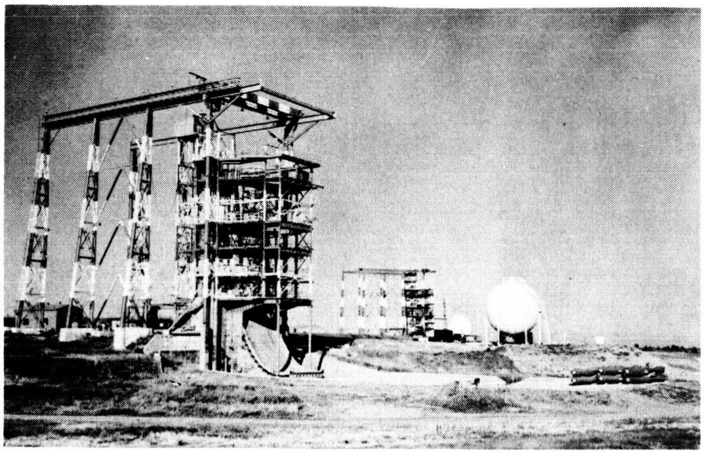


FIGURE 53. SACRAMENTO TEST FACILITY

During June construction of the liquid-hydrogen test site (Fig. 53) 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 installed. Further test results were satisfactory. 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 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. Because the Palaemon was trapped in the upper river, MSFC decided to transport the booster in 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 this

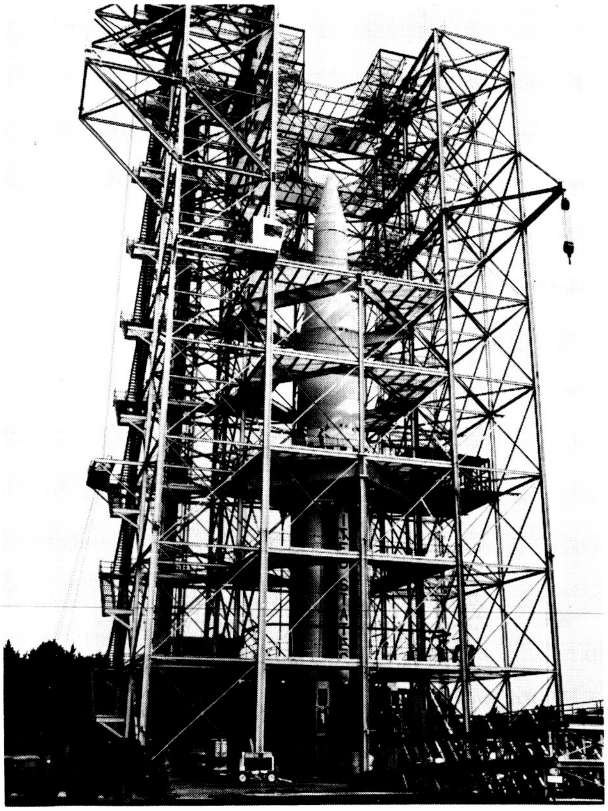


FIGURE 54. DUMMY SATURN VEHICLE IN DYNAMIC TEST STAND

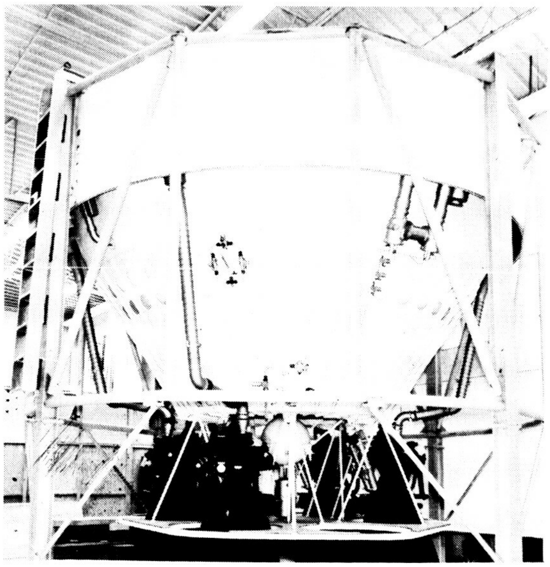


FIGURE 55. TAIL AREA MOCKUP

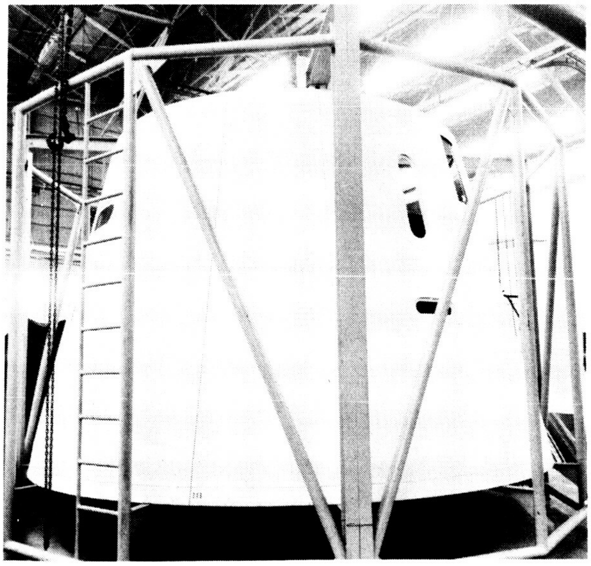


FIGURE 56. FORWARD INTERSTAGE MOCKUP

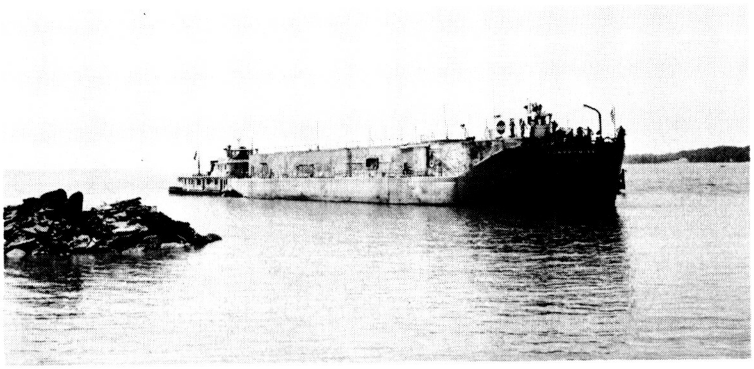


FIGURE 57. THE BARGE COMPROMISE

plan 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.

On June 5, 1961, Launch Complex 34 at Cape Canaveral was dedicated in a brief ceremony and turned over to NASA (Figs. 58 and 59). In Huntsville final acceptance testing of the S-I stage for the first flight booster began on June 12, 1961. The first operation accomplished was the mechanical mating of the S-IV dummy stage. Design work for later Saturn vehicles also continued at MSFC. On June 15, 1961, a mockup of the new instrument unit portion of the vehicle was completed; this unit, containing guidance and instrumentation, would fly above the upper stages of the last five Saturn C-1 vehicles (Fig. 60).

FIGURE 58. LAUNCH COMPLEX 34, AERIAL VIEW

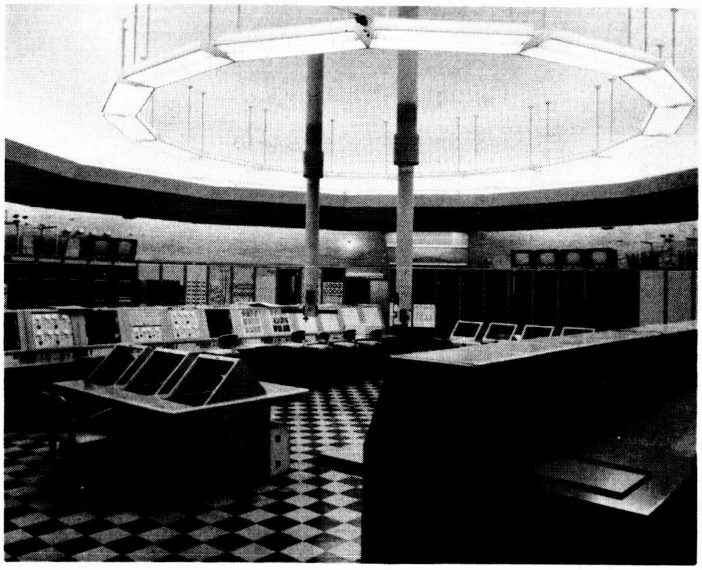


FIGURE 59. LAUNCH COMPLEX 34, BLOCKHOUSE INTERIOR

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 submit proposals.

After a meeting held in June with DAC, MSFC directed that the S-IV stage be redesigned to incorporate chilldown venting through which accumulated hydrogen gas could be disposed.

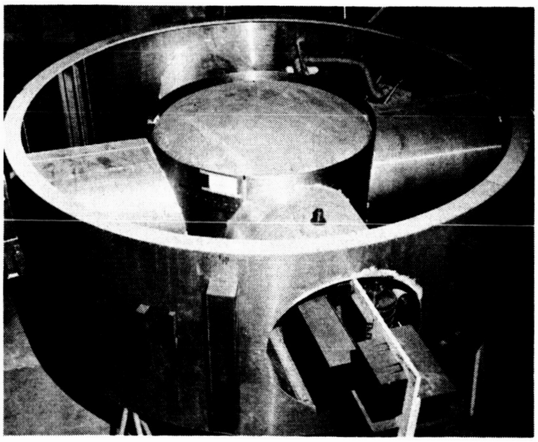


FIGURE 60. INSTRUMENT UNIT MOCKUP

Dr. von Braun announced on June 23 that further engineering design work on the C-2 configuration would be discontinued (Fig. 61); effort would instead be redirected toward clarification of the Saturn C-3 and Nova concepts (Fig. 62). Capabilities of the proposed C-3 configuration in supporting the Apollo mission (Fig. 63) would be determined.

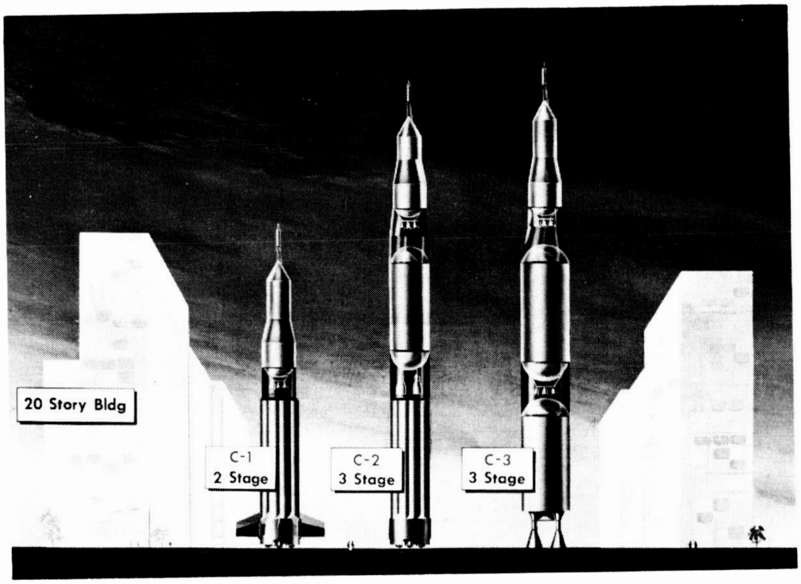


FIGURE 61. COMPARISON OF SATURN CONFIGURATIONS

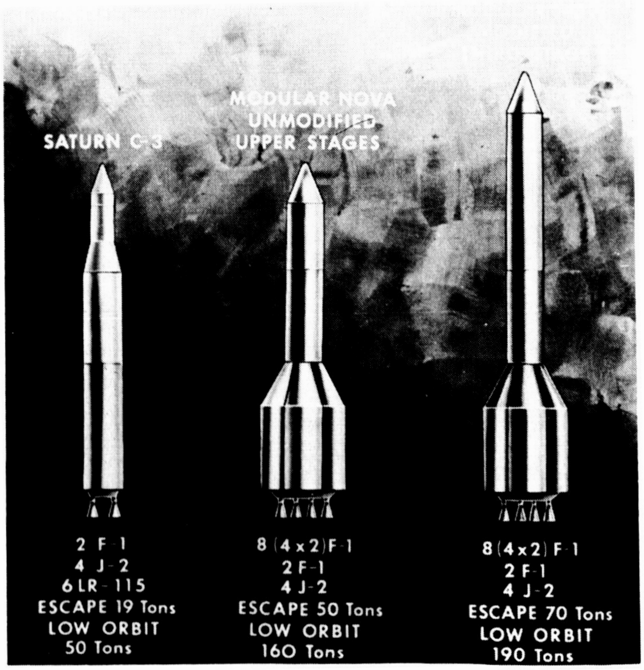


FIGURE 62. POSSIBLE NOVA CONFIGURATIONS

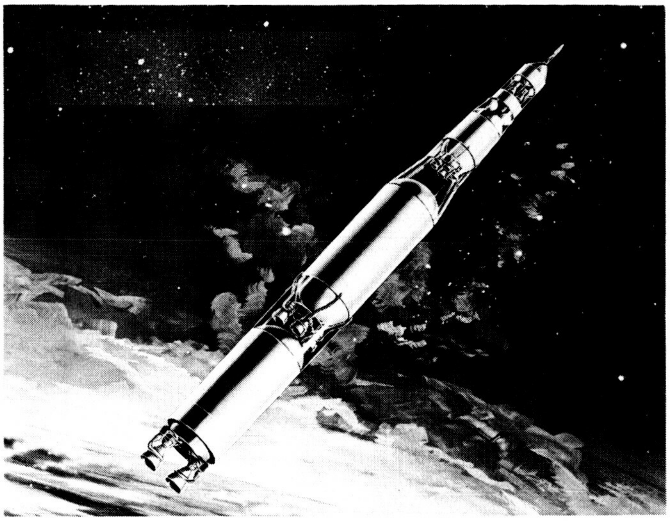


FIGURE 63. PROPOSED C-3/APOLLO CONFIGURATION

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 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.

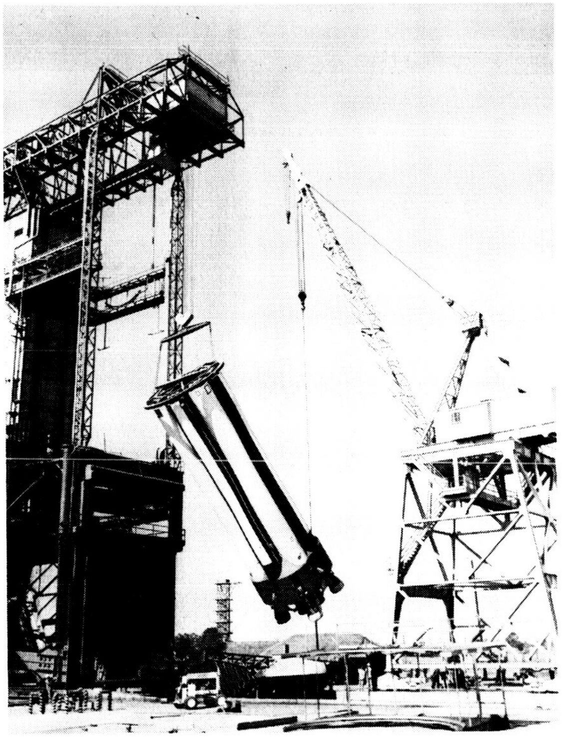


FIGURE 64. INSTALLATION OF SA-T2
ON STATIC TEST STAND

July 1961

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.

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

A few days later dynamic testing of SA-D1 began for the purpose of investigating the bending modes of the vehicle and also to continue studies into tank resonances initiated by Langley Research Center during June. While dynamic testing proceeded at MSFC, Rocketdyne in California began static firing tests of a complete F-1 engine (Fig. 66). The engine would build up to 1.5 million pounds of thrust (Fig. 67) when perfected.

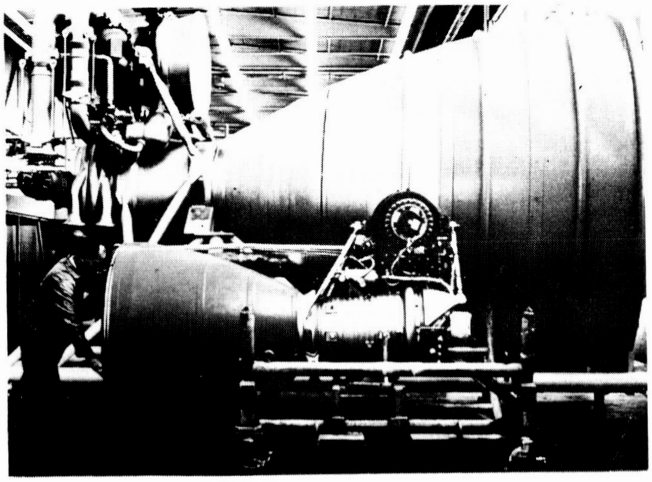


FIGURE 66. H-1 AND F-1 ENGINE COMPARISON (H-1 IN FOREGROUND)

Early in July 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).

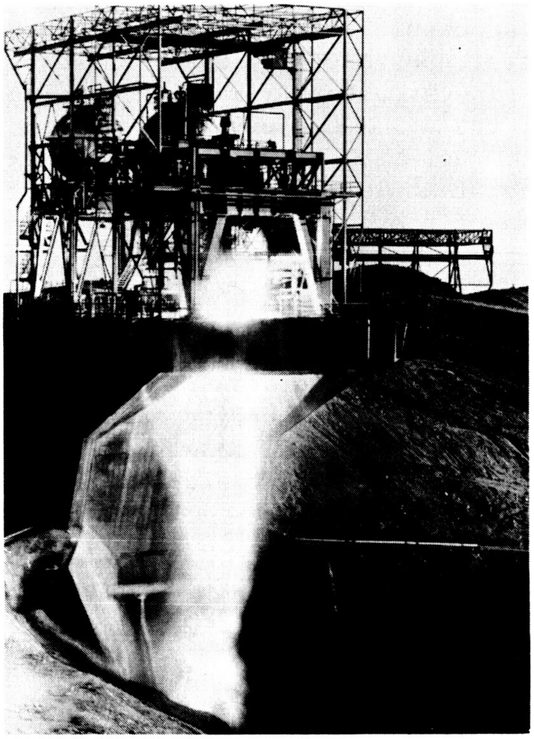


FIGURE 67. STATIC FIRING OF F-1 ENGINE

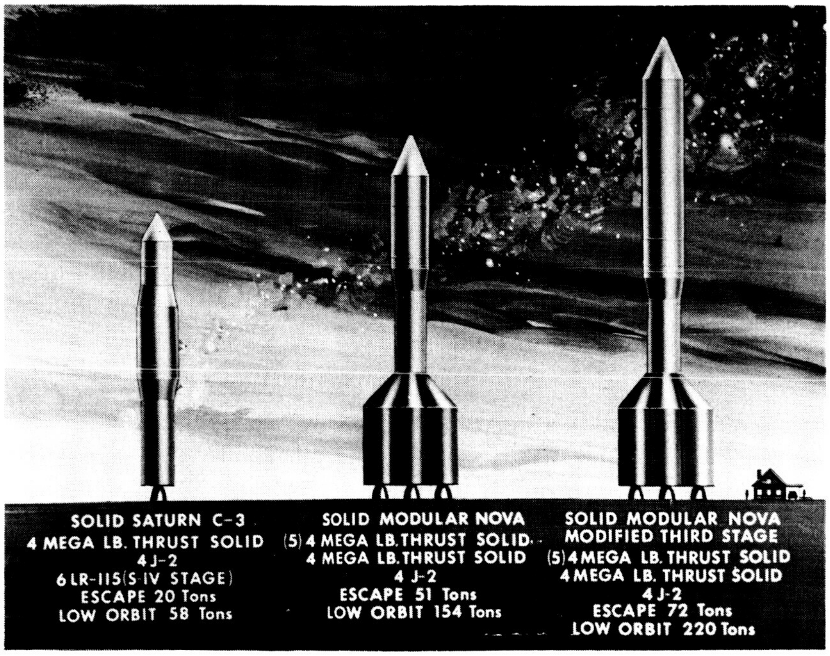


FIGURE 68. PROPOSED SOLID PROPELLANT BOOSTERS FOR LARGE SPACE VEHICLES

During July MSFC successfully completed the second and third static firings of the SA-T2 test booster (Fig. 69). These tests evaluated modifications to reduce engine structure vibration, evaluated flame curtain materials, and checked out a LOX depletion system similar to that used on SA-1. During the third test MSFC simulated for the first time the in-flight engine cut-off sequence, that is, shutdown of the inboard engines six seconds before shutdown of the outboard engines.

MSFC awarded a contract to the Space Technology Laboratories, Inc., Los Angeles, California, during July, to investigate the relative merits and potential problems of assembling the giant Saturn boosters in horizontal and vertical positions. Other contracts awarded by the Center in July included qualification and reliability testing of Saturn ground support equipment, subsystems, and components, construction of a special assembly building at Cape Canaveral, and site development for the Center's new static test facility in Huntsville (Fig. 70).

Also in July NASA's Space Task Group invited 12 companies to submit proposals for the manned lunar Apollo spacecraft (Fig. 71). Meanwhile, the Center contemplated a nuclear-powered Saturn upper stage (Fig. 72) and awarded contracts for a six-month RIFT (Reactor-in-Flight Test) design analysis to General Dynamics/Astronautics, Douglas Aircraft Company, Lockheed Aircraft Corporation, and the Martin Company.

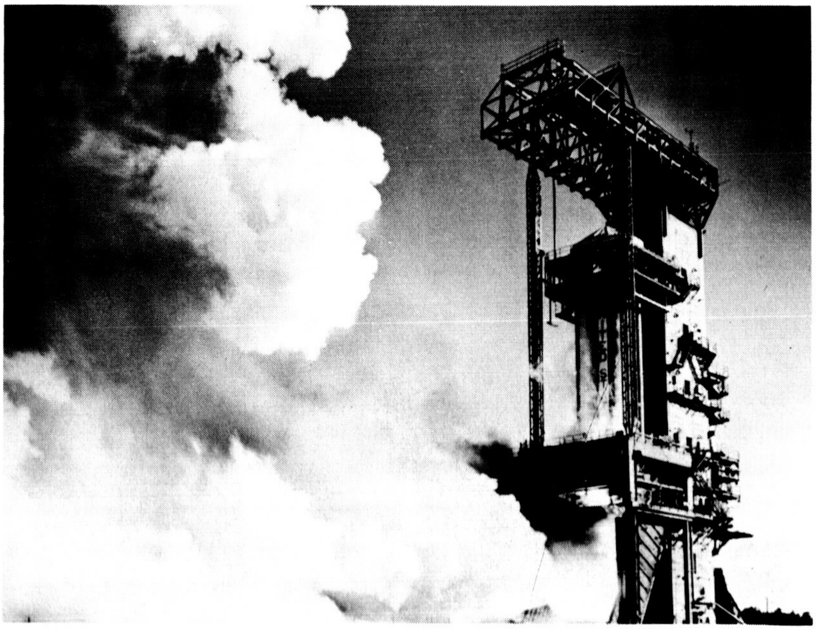


FIGURE 69. STATIC FIRING OF SA-T2

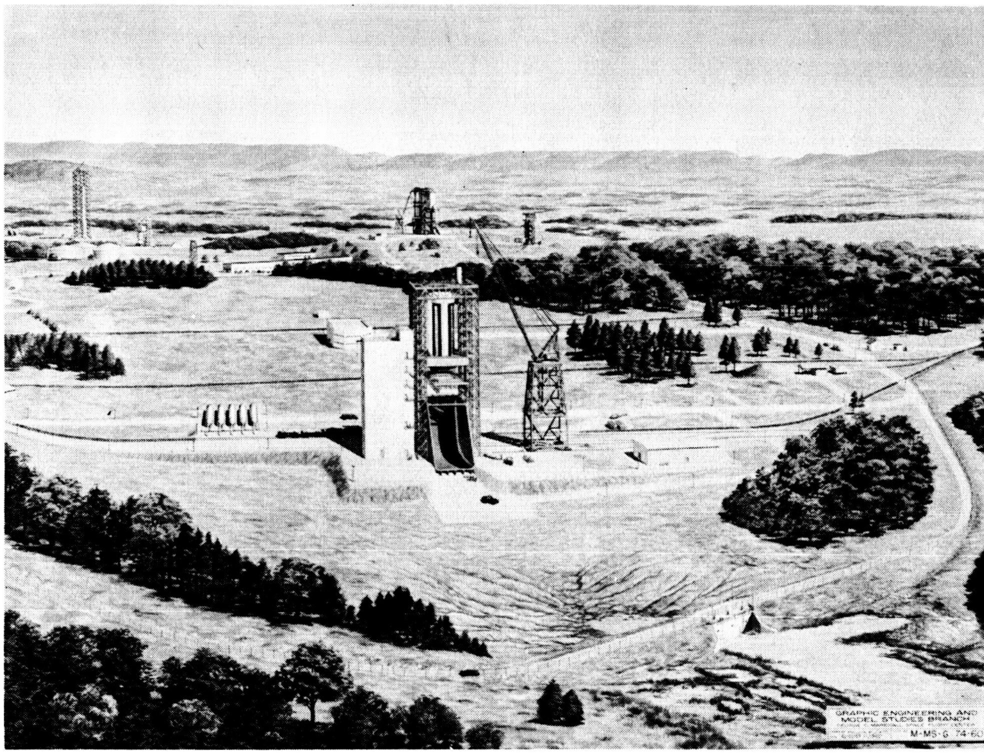


FIGURE 70. CONCEPT OF NEW STATIC TEST FACILITY, MSFC

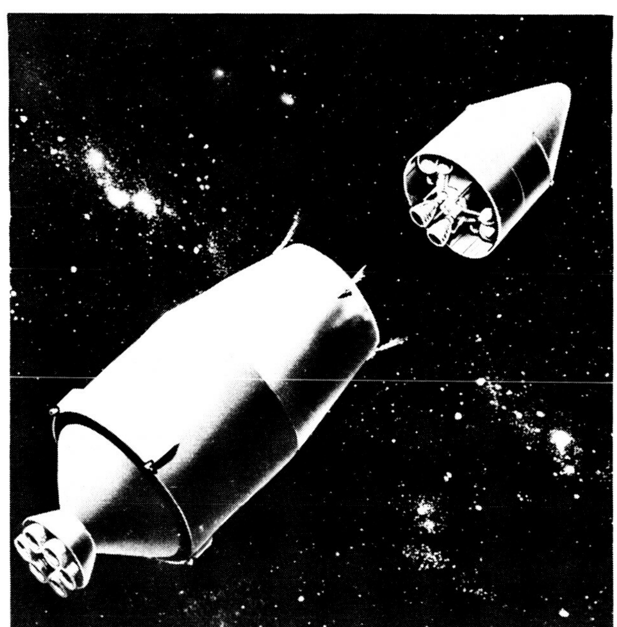


FIGURE 71. ARTIST'S CONCEPT OF APOLLO
SEPARATION FROM SECOND STAGE

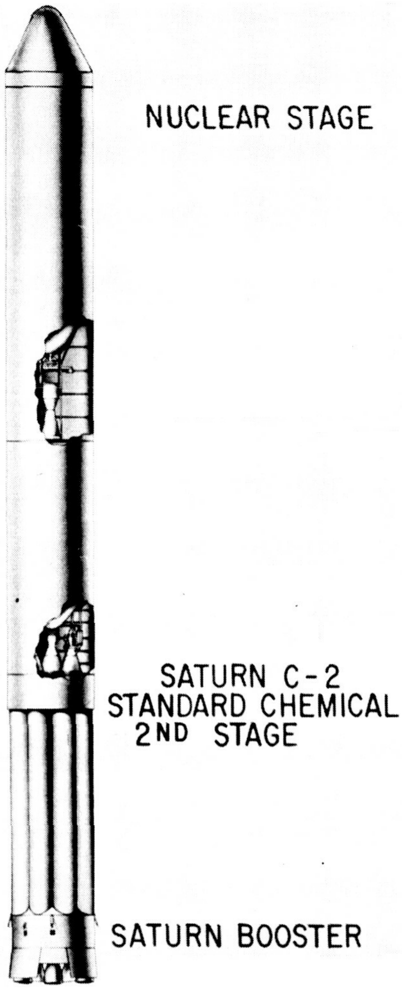


FIGURE 72. CONCEPT OF SATURN
WITH NUCLEAR POWERED STAGE

Assembly of the booster stage for the SA-3 vehicle began on July 31, 1961. The following day the SA-2 booster was transferred from the assembly area to checkout. On August 3 a planned 114-second static test 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 rescheduled for the following week. On August 7 the SA-T2 booster was successfully fired in a test of 124 seconds' duration.

Checkout of the SA-1 flight booster, started in 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

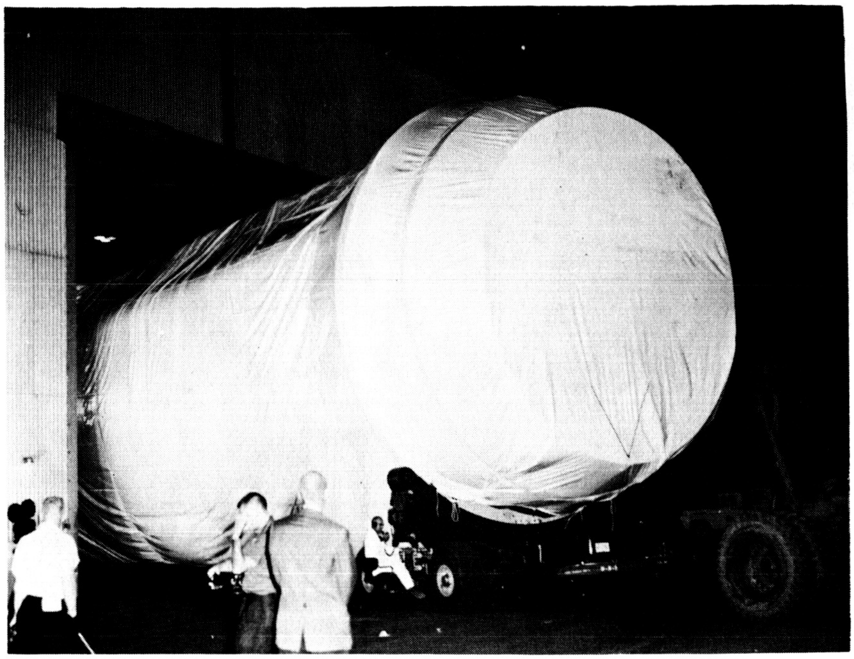


FIGURE 73. BOOSTER MOVEMENT TO DOCKING FACILITY

their respective transporters. The stages and payload 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 Dam the

FIGURE 74. PAYLOAD MOVEMENT AROUND WHEELER DAM

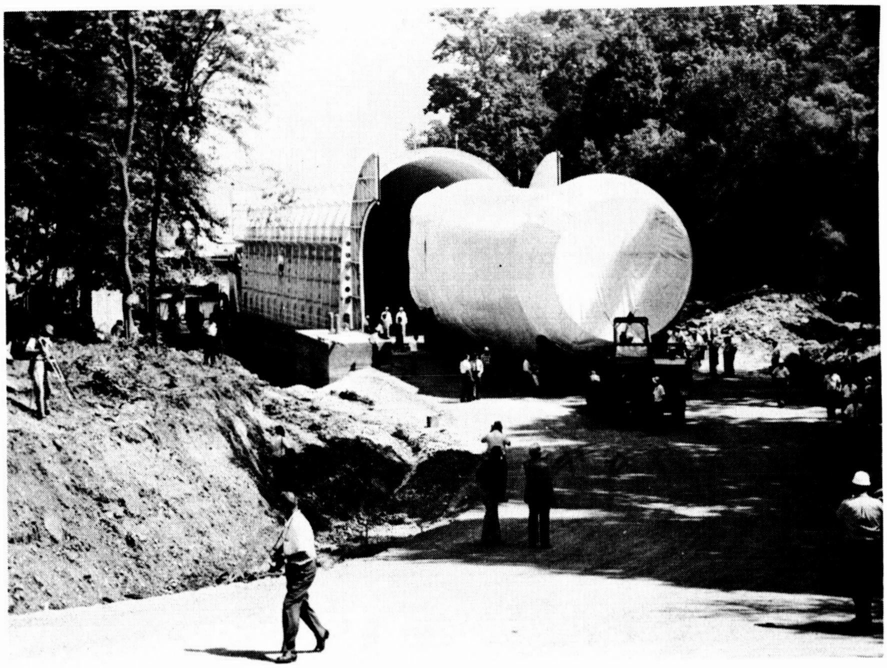


FIGURE 75. BOOSTER MOVEMENT AROUND WHEELER DAM

units were unloaded, transported to a dock below the dam (Figs. 74 and 75), and placed on the second barge, the Compromise, to continue the 2200-mile trip to Florida (Fig. 76). On August 15 the Compromise arrived at the Cape and unloaded her cargo (Fig. 77): MSFC began assembling the first flight vehicle on the launch pedestal (Figs. 78-81).

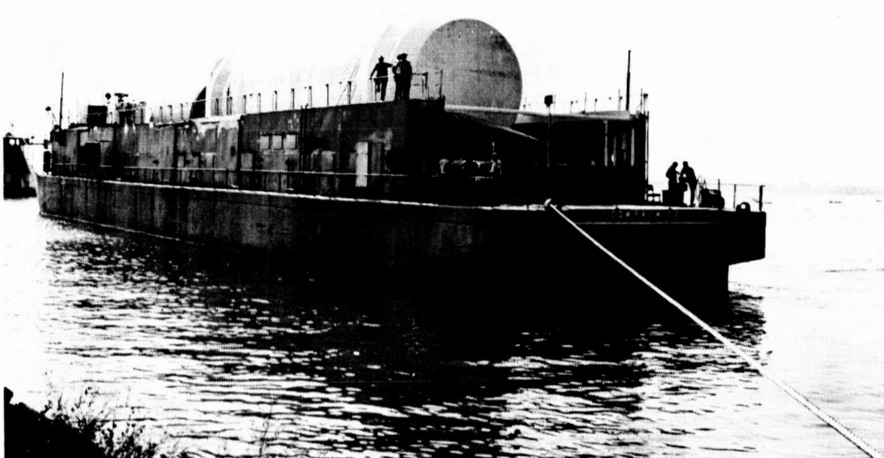


FIGURE 76. S-I AND S-IV STAGES ABOARD THE COMPROMISE

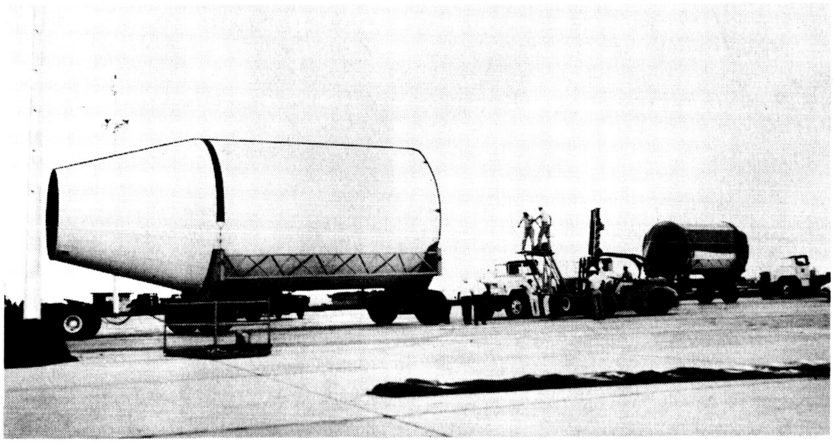


FIGURE 77. UNLOADING COMPROMISE IN FLORIDA

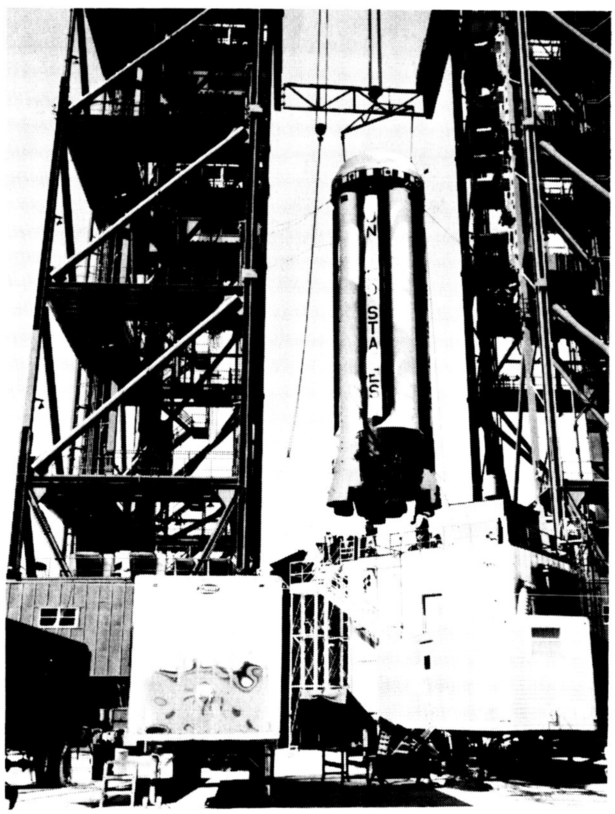


FIGURE 78. FIRST SATURN BOOSTER
ERECTION AT CAPE CANAVERAL

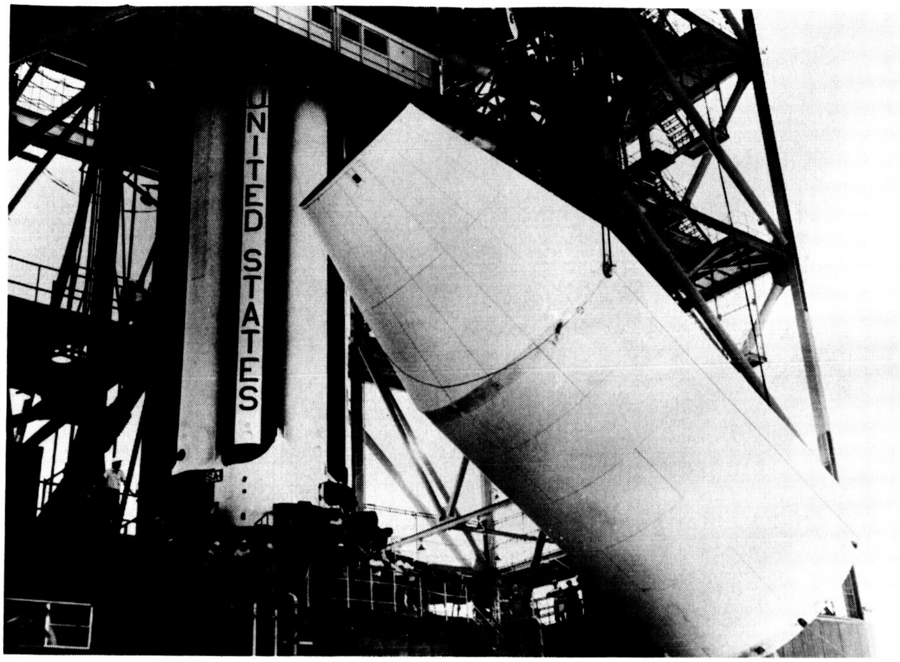


FIGURE 79. S-IV ERECTION AT CAPE CANAVERAL

FIGURE 80. PAYLOAD BODY ERECTION INTO SERVICE STRUCTURE

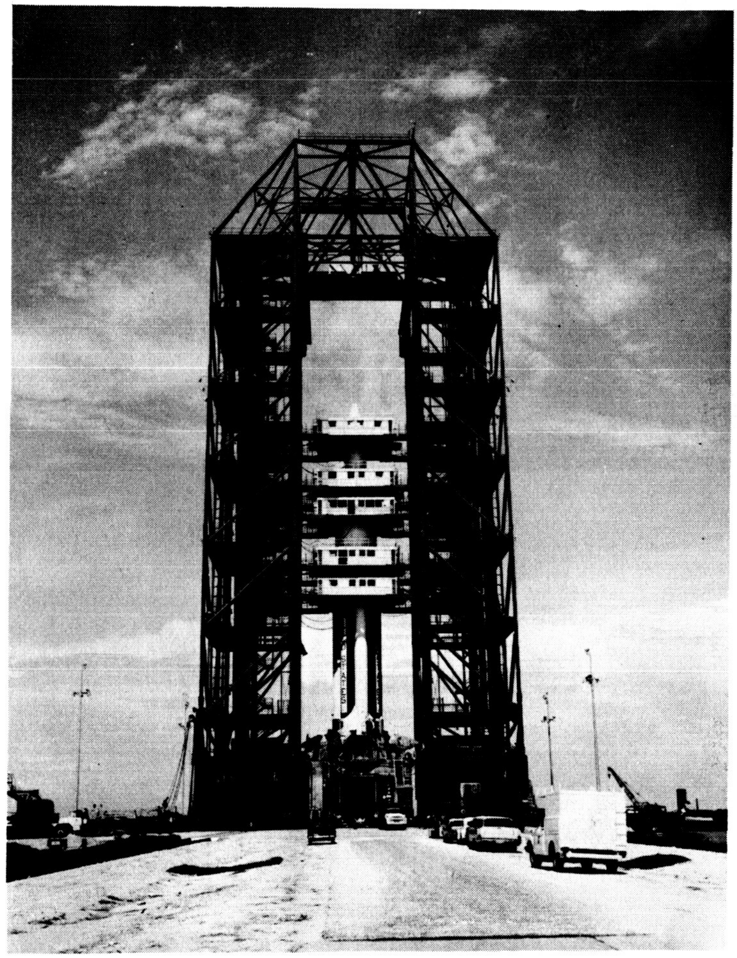


FIGURE 81. FIRST SATURN ASSEMBLED ON LAUNCH PEDESTAL

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).

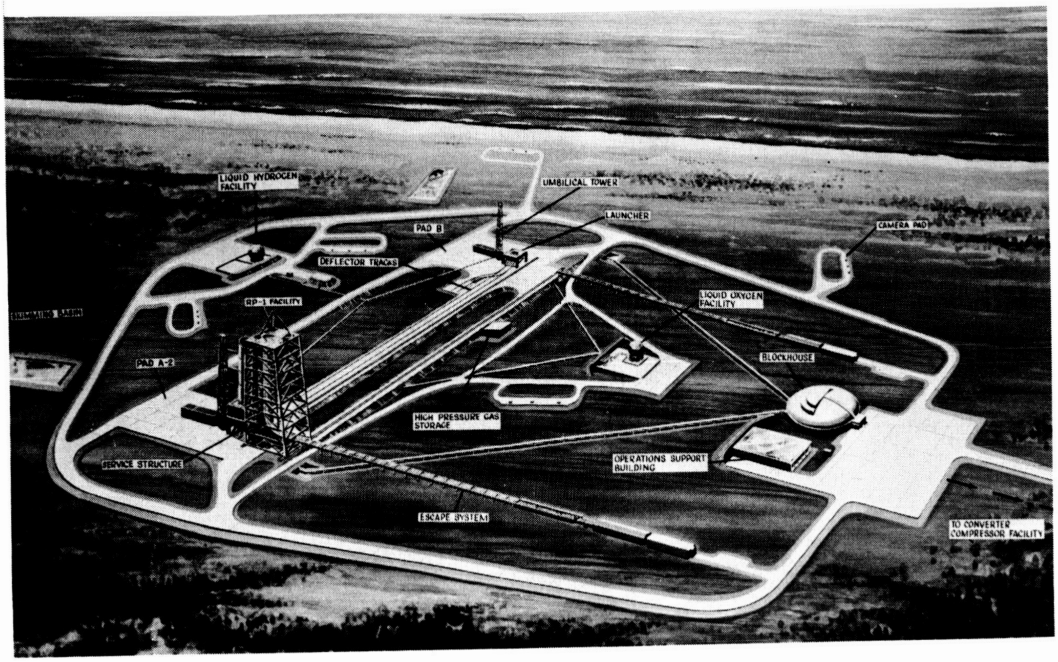


FIGURE 82. SATURN LAUNCH COMPLEX 37, CAPE CANAVERAL

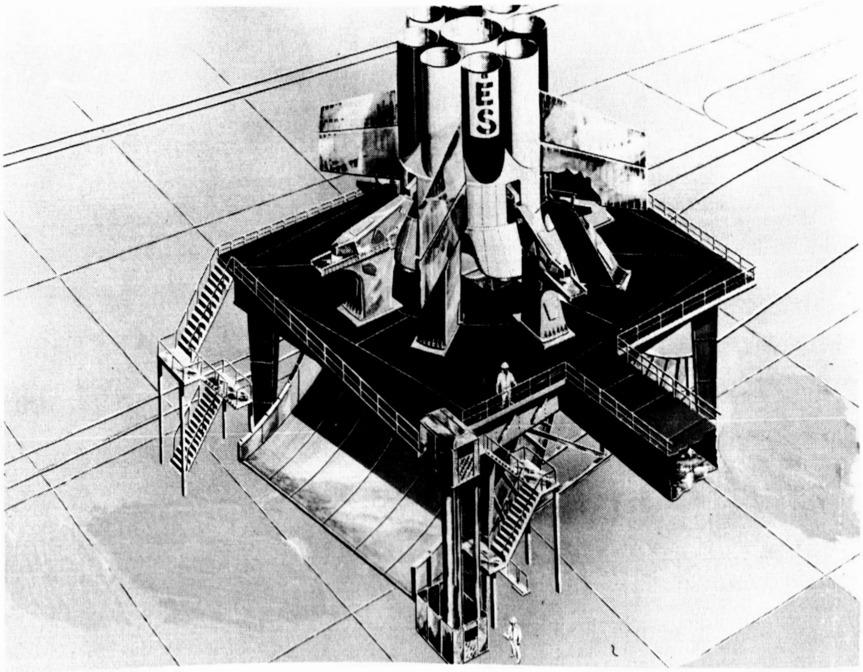


FIGURE 83. ARTIST'S CONCEPT OF LAUNCH PEDESTAL FOR LC 37

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

On August 24 NASA designated Cape Canaveral as the base for all manned lunar flights and other space missions requiring advanced launch vehicles. NASA would secure an 80,000-acre tract of land, increasing its total area in the vicinity to 97,000 acres. The additional land was needed because of the tremendous vibration and noise expected with later launch vehicles.

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

On September 11 NASA selected North American Aviation, Inc. 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.

Army Engineers awarded a contract on September 13 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.

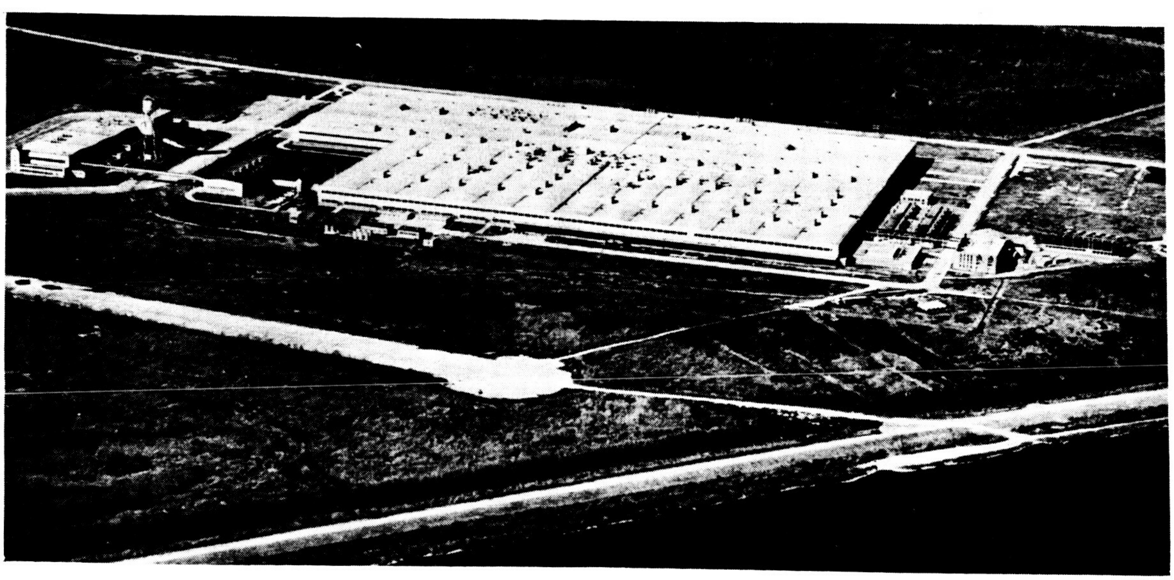


FIGURE 84. MICHOUD PLANT AT NEW ORLEANS

By September 15, 1961, the SA-1 vehicle was completely assembled on the launch pedestal at LC 34. The service structure was moved back, leaving the Saturn standing as it would at launch (Fig. 85).

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.

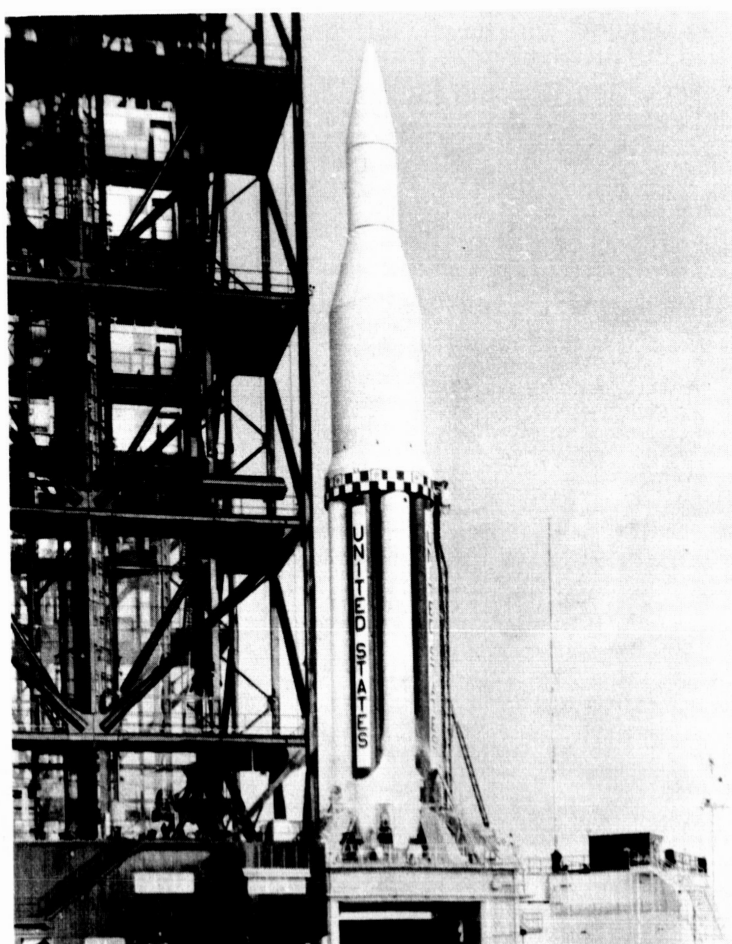


FIGURE 85. SATURN SA-1 FLIGHT VEHICLE ON LAUNCH PEDESTAL

Late in October NASA selected a 13,550-acre site in Mississippi on which to build a facility for static testing Advanced Saturn and Nova first stages. This location of the Mississippi Test Facility is only 35 miles from the Michoud Plant where industry would 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 journey. 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 would 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 almost flawless.

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 negotiate a contract to build, check out, and test twenty

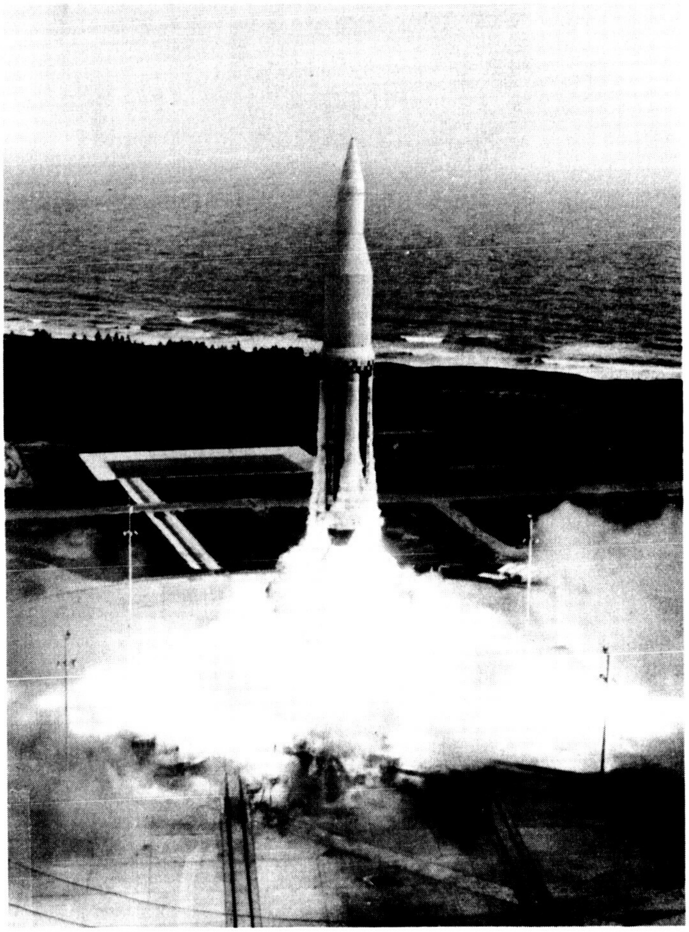


FIGURE 86. LAUNCH OF SATURN SA-1 FLIGHT VEHICLE

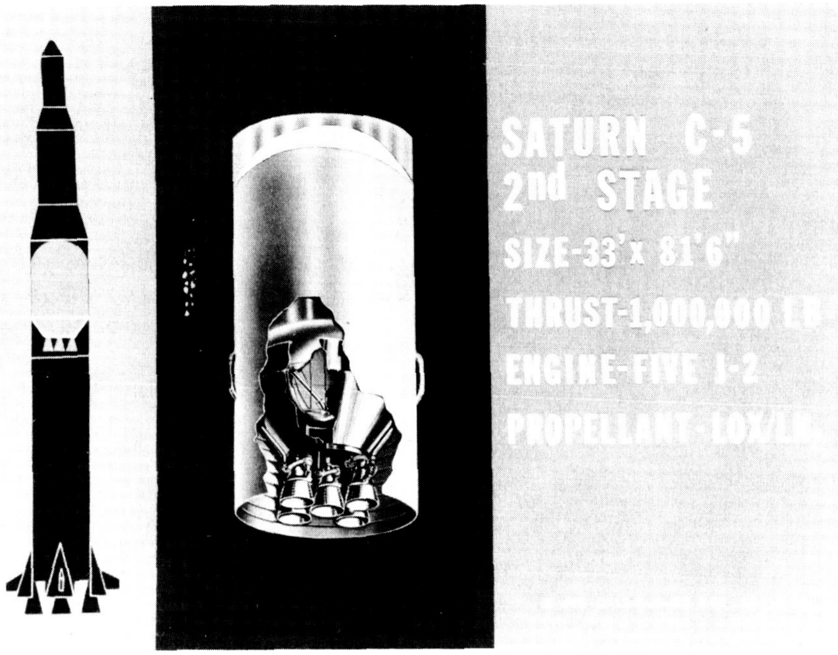


FIGURE 87. S-II STAGE CUTAWAY

S-I boosters. These boosters would be manufactured 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 such engines would power the Saturn S-IV Stage.

After this progress in arranging for development of a large launch vehicle NASA, on November 29, 1961, awarded North American Aviation, Inc. a contract for the design and construction of its payload, a three-man spacecraft.

Marshall Space Flight Center and Manned Spacecraft Center planned to use the C-1 R&D vehicles for vehicle-payload compatibility tests and early systems tests of the spacecraft. The spacecraft was designated Apollo, also the name of the Saturn vehicle missions project.

The Apollo project would be divided into three basic missions: earth orbital flights, circumlunar flights, and manned landings on the moon. The two-stage Saturn C-1 was to 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.

Meanwhile, the SA-T3 test stage was installed in the test stand. On November 30, 1961, MSFC conducted a test to investigate flight cut off sequencing, perform an "engine out" test, and 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 would be built by Chance-Vought in Dallas, Texas, and shipped initially to MSFC and later to Michoud for the Chrysler assembled stages.

On December 5, 1961, AEC-NASA Space Nuclear Propulsion Office selected the Aetron Division of Aerojet-General Corporation's proposal as the basis for a Nerva engine test stand contract. The Nerva would be used in nuclear stages with a reactor derived from the Kiwi-B test series. Two days later a preproposal conference was held at Huntsville, Alabama, to select a prime contractor for the reactor-in-flight test (RIFT) stage launch vehicle. The Rift vehicle, planned for use as an upper stage of a Saturn vehicle, would be powered by the Nerva nuclear engine.

MSFC awarded a design contract on December 6 for modification to the west side of the Center's existing static test tower. The tower, scheduled for completion by the summer of 1963, would be used for acceptance testing of Chrysler S-I stages.

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

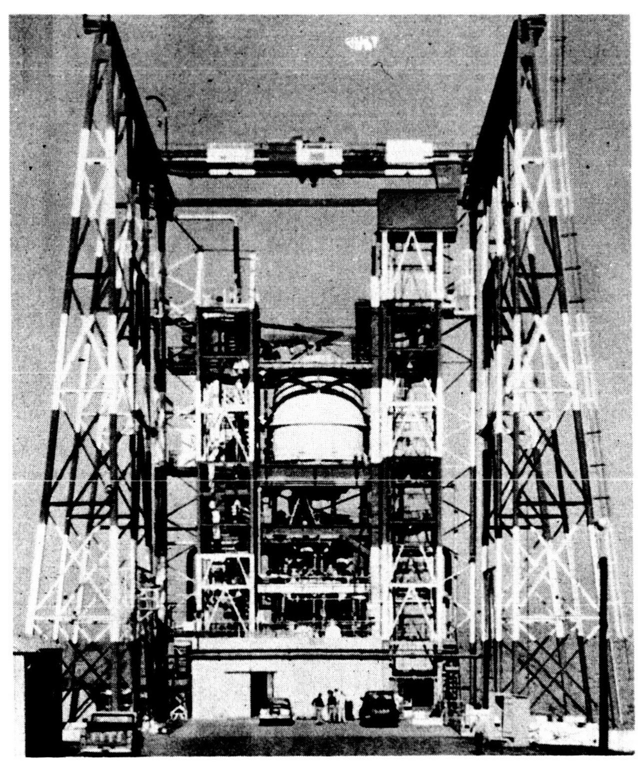


FIGURE 88. S-IV TANKAGE AT SACTO TEST FACILITY

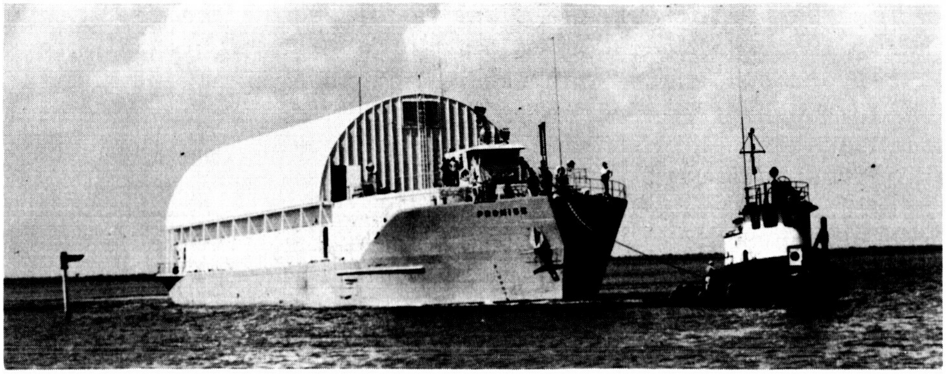


FIGURE 89. BARGE PROMISE

MSFC completed modifications to the Saturn barge Compromise 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.

NASA selected the Boeing Company 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, would be 33 feet in diameter and about 140 feet high (Fig. 91). The manufacturing program at Michoud was to produce 24 flight stages and one ground test stage. In December

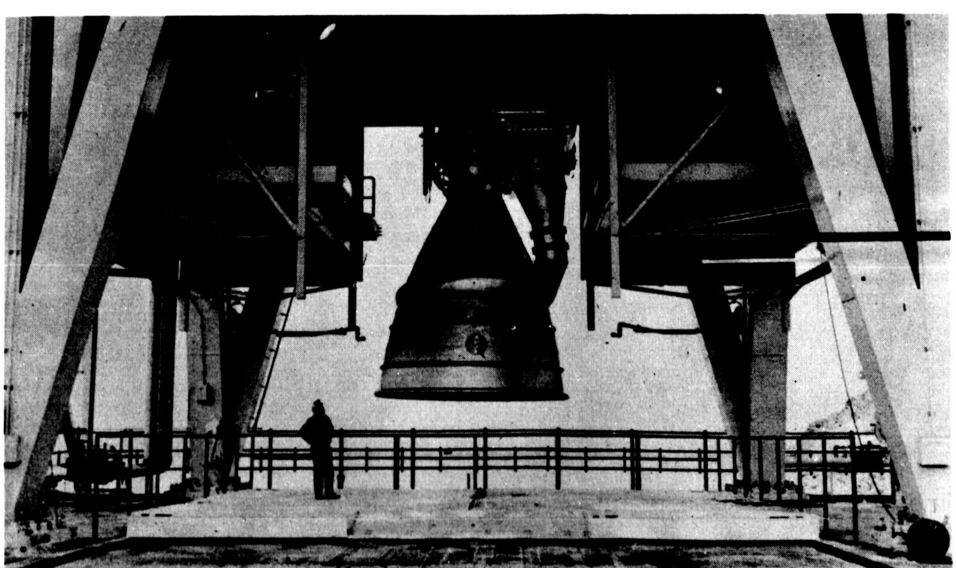


FIGURE 90. F-1 ENGINE AND TEST STAND

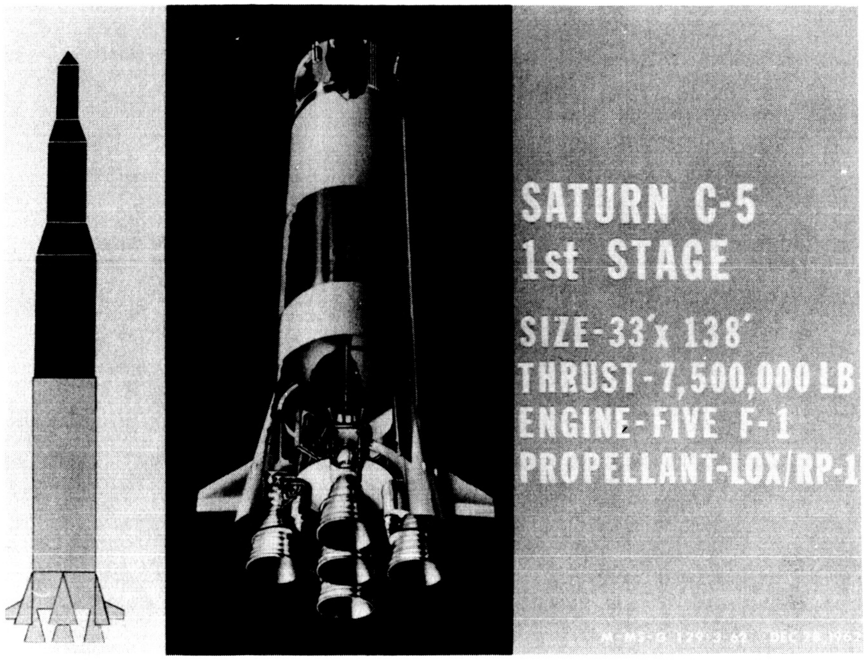


FIGURE 91. S-IC STAGE

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

NASA selected Douglas Aircraft 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.

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.

NASA announced on January 24 that Aerojet-General Corporation had been selected for design and development of a new liquid hydrogen engine. The engine, known as the M-1, was to power the second stage of the Nova launch vehicle. Its thrust would be 1,200,000-pounds.

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 would carry the electrical, pneumatic, and hydraulic connections used in fueling and servicing upper stages.

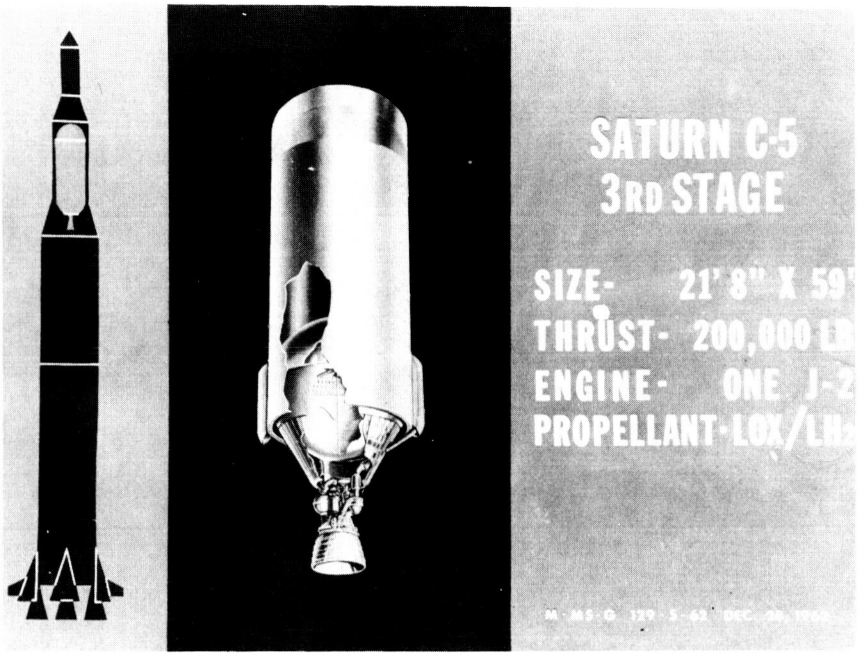


FIGURE 92. S-IVB STAGE CUTAWAY

On January 25, 1962, NASA approved development of the 3-stage Saturn C-5 vehicle under the direction of MSFC. The vehicle would support manned circumlunar flights and manned landings by earth or lunar orbit rendezvous method. The C-5 (Fig. 93) was expected to 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 was successfully conducted at MSFC. 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, scheduled to last until LOX depletion cutoff, was terminated at 55 seconds due to fire indication at Engine No. 6. No damage resulted.

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.

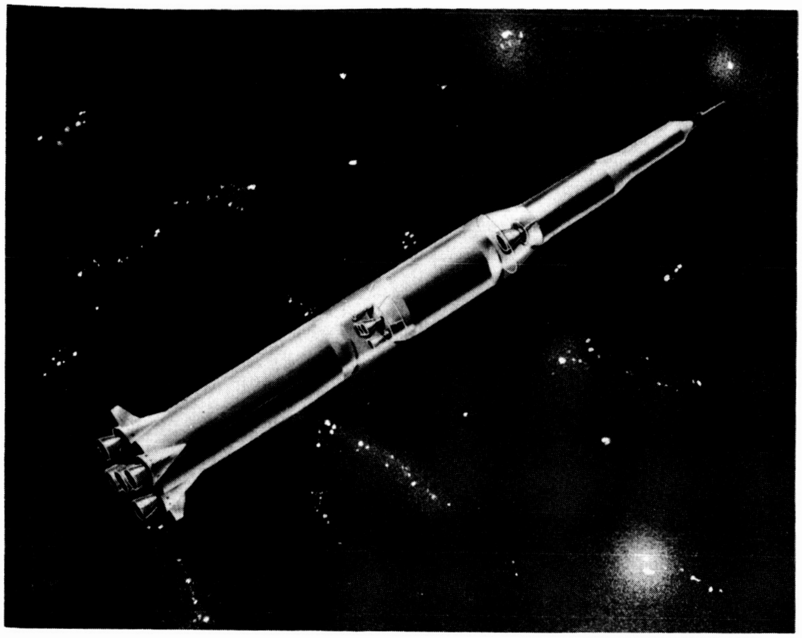


FIGURE 93. SATURN C-5

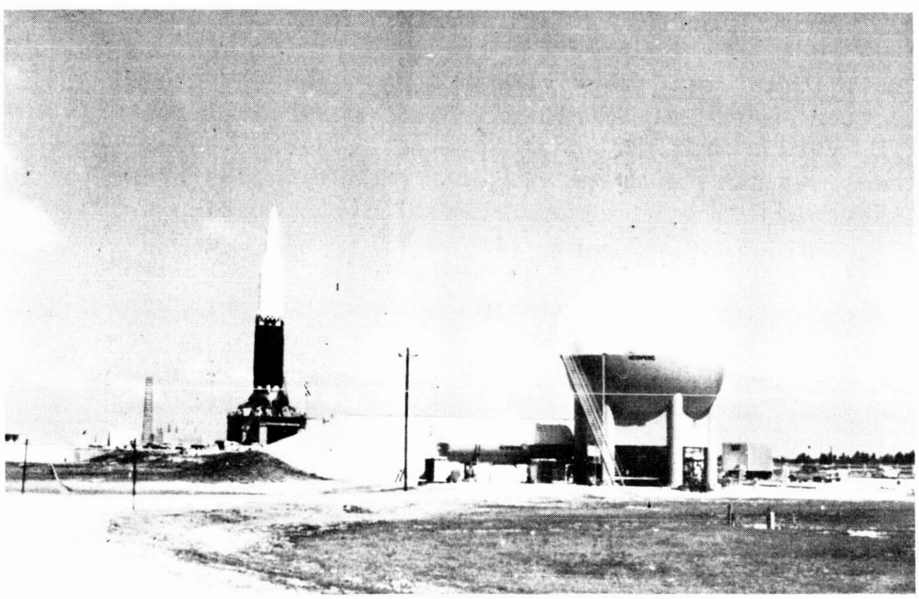


FIGURE 94. SA-2 ERECTED ON LAUNCH PEDESTAL

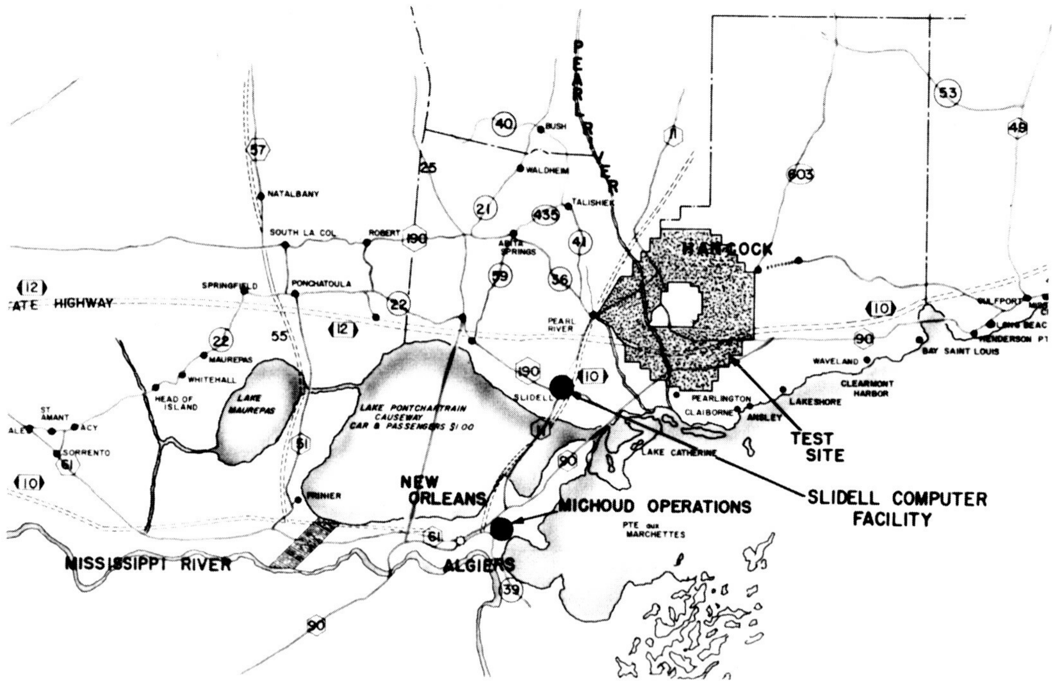


FIGURE 95. REGIONAL MAP SHOWING MISSISSIPPI TEST FACILITY

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).

On March 19 the booster for the SA-3 flight vehicle was installed in the test tower, and preparations were begun for the first flight qualification test. 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 second (S-IV) stage would be used to check out all operating S-IV systems.

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 would be performed at Santa Susana, California. Stage acceptance testing would be conducted at the Mississippi Test Facility. 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 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.

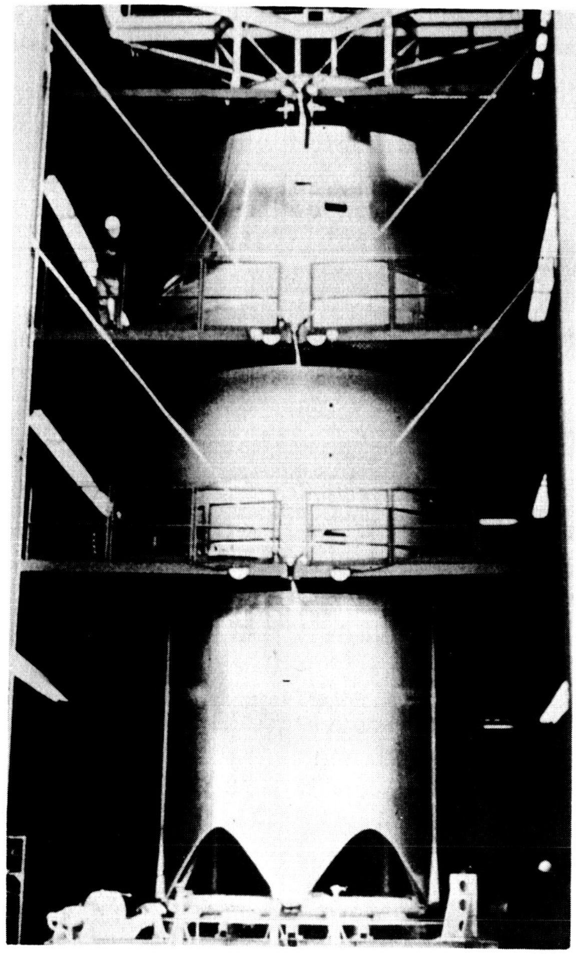


FIGURE 96. S-IV ALL SYSTEMS VEHICLE

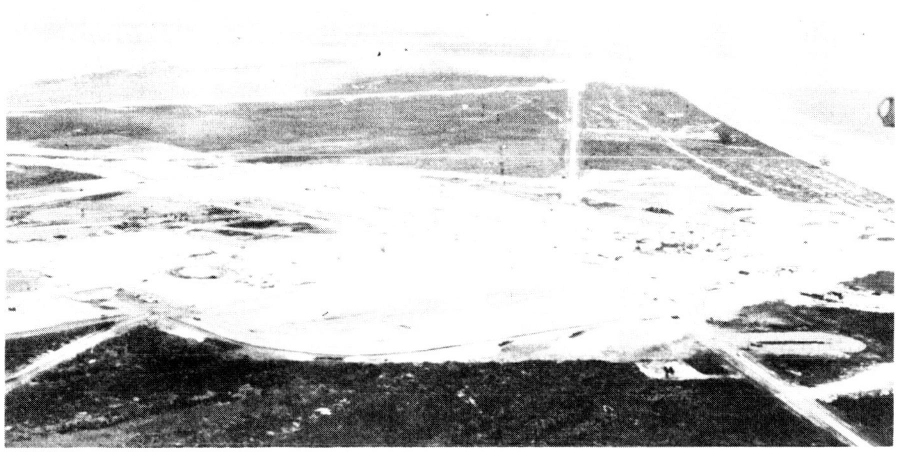


FIGURE 97. CONSTRUCTION OF LAUNCH COMPLEX 37

The large liquid hydrogen engine, J-2, which would power the S-II and S-IVB stages for advanced Saturn vehicles, reached 90 per cent sea-level thrust in its initial hot firing tests on April 11. On the same day the huge F-1 engine, being developed to power the S-IC stage, performed a successful 150-second static firing.

In mid-April 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 included all stages, engines, facilities, and related construction for production, test, research, launch, and instrumentation.

NASA launched the second Saturn flight vehicle, the SA-2, from Cape Canaveral on April 25 (Fig. 98). As with the SA-1, the vehicle was launched 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 performed 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 flight was considered successful.

A 31-second duration eight-engine test of the SA-3 flight booster was conducted on May 17 with excellent overall performance. The final SA-3 booster acceptance firing test was performed on May 24 for a duration of 119 seconds.

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.

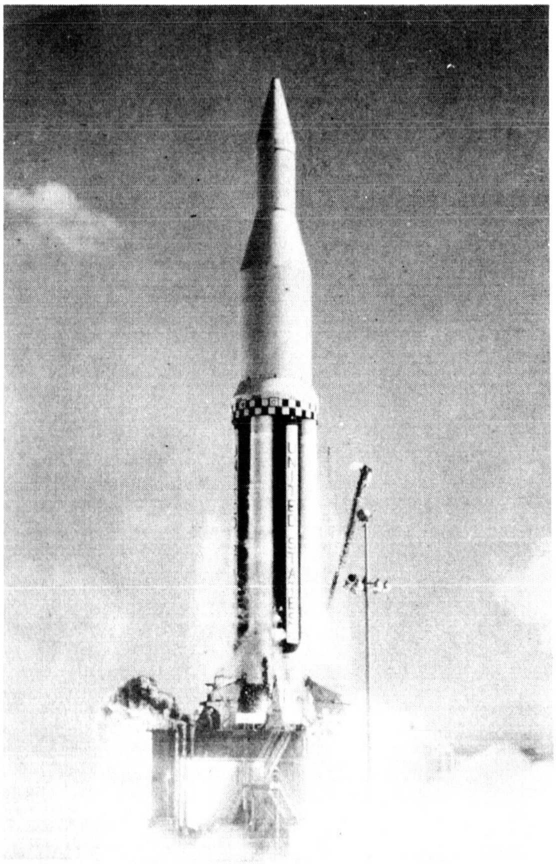


FIGURE 98. LAUNCH OF SATURN SA-2 FLIGHT VEHICLE

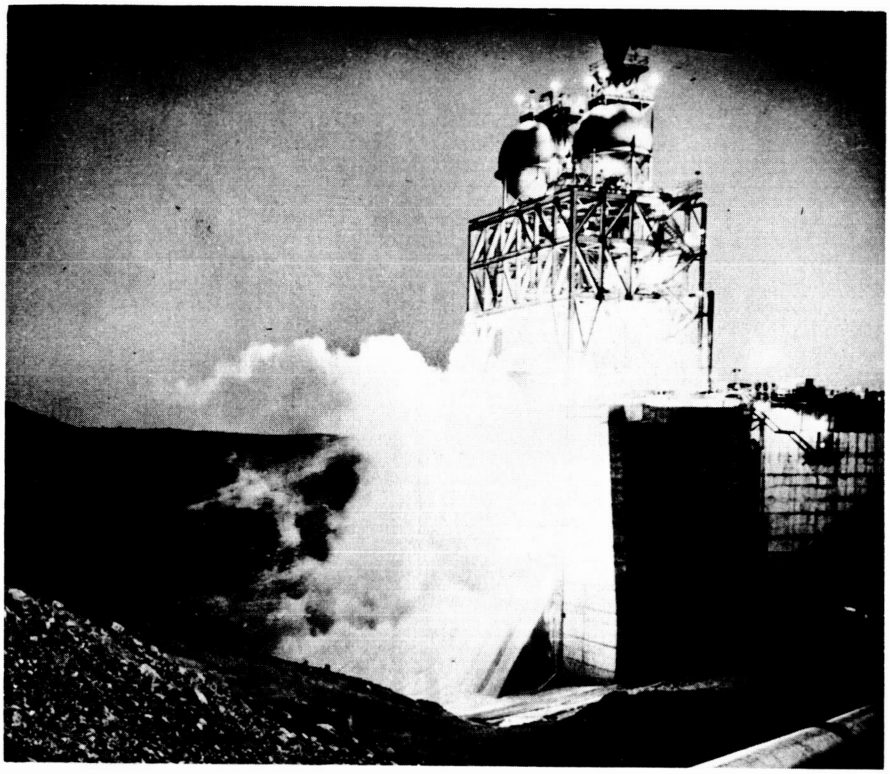


FIGURE 99. STATIC FIRING OF F-1 ENGINE

In mid-May MSFC directed DAC to produce a 260-inch-diameter S-IVB stage. The increase of 40 inches over the initially planned diameter permitted development of a more optimum sized stage. Also during May the Center decided to increase S-II stage length from 75 feet to 81.5 feet and decrease the S-IC stage length from 141 feet to 138 feet.

On June 5 MSFC contracted 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, would 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 for the Saturn C-1 second stage. All test objectives were successfully met. At MSFC the first SA-4 test booster static firing 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, would 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

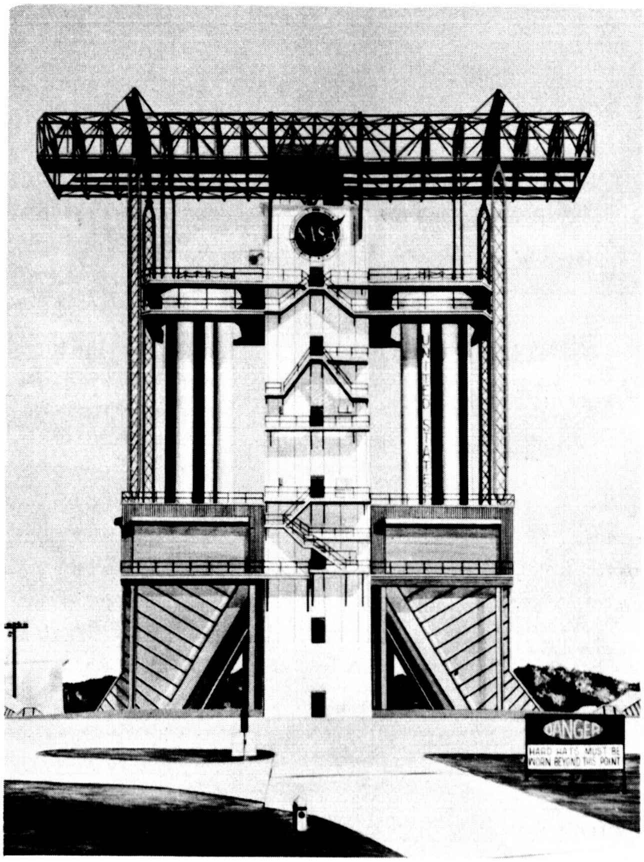


FIGURE 100. C-1 FIRST STAGE TEST STAND

would stand 405 feet high, more than twice as tall as the present Saturn C-1 booster test stand.

NASA and Rocketdyne Division of North American Aviation signed letter contracts on July 2 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.

A new Saturn vehicle was needed. 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. The Saturn would be known as the Saturn C-1B. Simultaneously, NASA announced selection of lunar orbit rendezvous as the method for performing the manned lunar landing. This lunar rendezvous mode would require the use of only one Saturn C-5 vehicle to inject the spacecraft into an earth-lunar trajectory. The entire Apollo spacecraft would not land on the moon after its separation from the launch vehicle's third stage. Rather, one unit of the spacecraft, a lunar excursion module, or "bug", would land and later rejoin the rest of the orbiting Apollo.

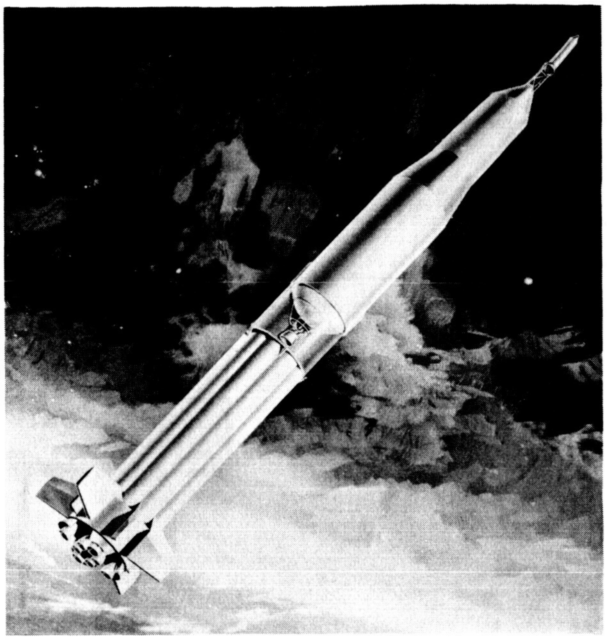


FIGURE 101. SATURN C-IB VEHICLE

Meanwhile, progress on Saturn C-1 continued. On July 12 the second static test of the SA-T4 stage was manually terminated after 12 seconds; a broken ground instrumentation wire had caused an erroneous pressure drop indication. Pressure measurement loss caused a premature cutoff of a third SA-T4 static test conducted on July 13. A fourth firing of 120 seconds duration was conducted on July 17; overall performance was excellent. The stage was removed from the test stand on July 20, and MSFC began uprating the engines to 188K thrust level. The uprated stage was redesignated 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

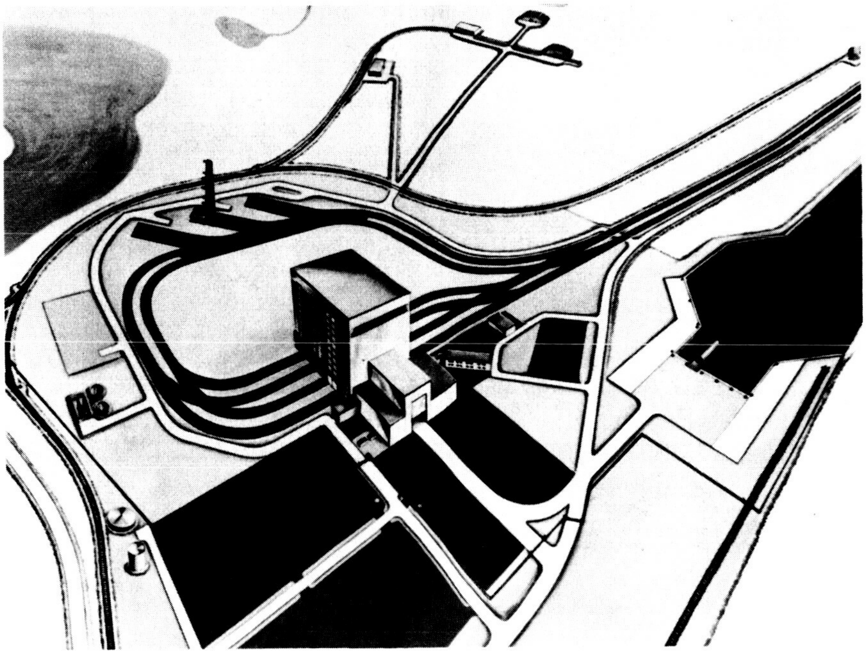


FIGURE 102. SATURN LAUNCH COMPLEX 39, CAPE CANAVERAL

vehicle would be erected and checked out vertically in a special 48-story assembly building. Following checkout a 2,500-ton crawler vehicle would move the Saturn C-5 to its launch pad (Fig. 103).

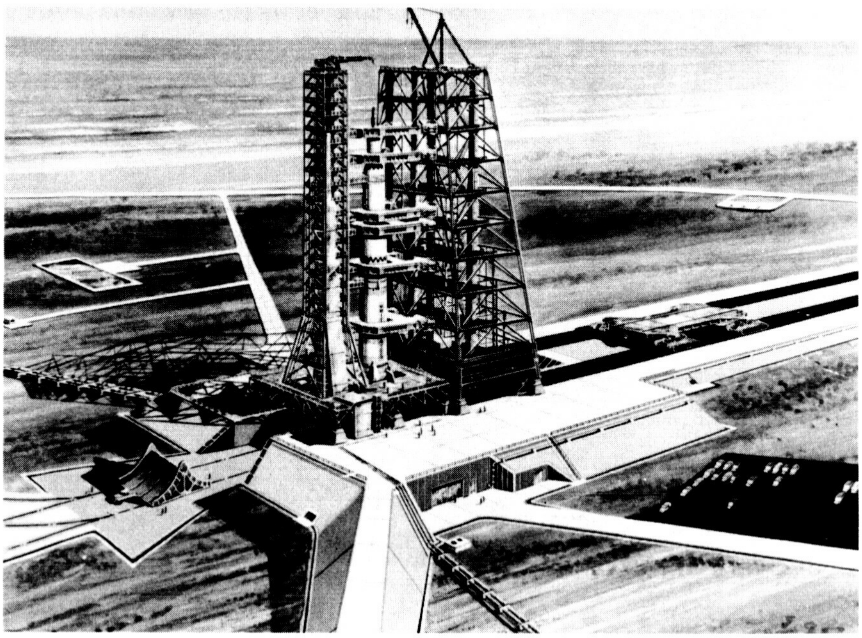


FIGURE 103. SATURN C-5 LAUNCH PAD

In July NASA announced that a computer center (Fig. 104) would be established at Slidell, Louisiana, to service the Michoud Operations.

FIGURE 104. NASA COMPUTER CENTER, SLIDELL, LOUISIANA

The Center, to be one of the nation's largest, would perform engineering calculations necessary in the development, building, and static testing of the Saturn C-1 and C-5 boosters.

To assure C-5 strength, MSFC awarded a design contract in July for a 360-foot-high dynamics test tower (Fig. 105). The Saturn C-5 launch vehicle would be suspended in the tower and vibrated by mechanical and electrical means. This simulation of free-flight conditions would 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, to be delivered 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 C-5 second stage contract for design, development, fabrication, and testing of the S-IVB stages was awarded DAC on August 8. The contract called for 11 of the stages: five for ground tests (two of which would be used later as inert flight stages) and six for powered flight.

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

On August 15 NASA awarded Rocketdyne Division a two-year contract to continue H-1 engine research and development. These first Saturn booster engines would also be used in Saturn IB boosters.

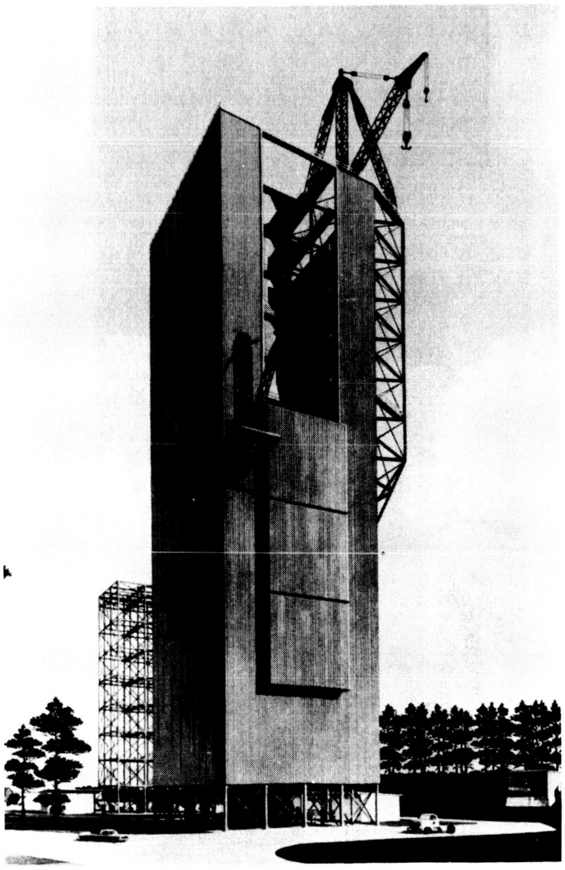


FIGURE 105. C-5 DYNAMICS TEST TOWER

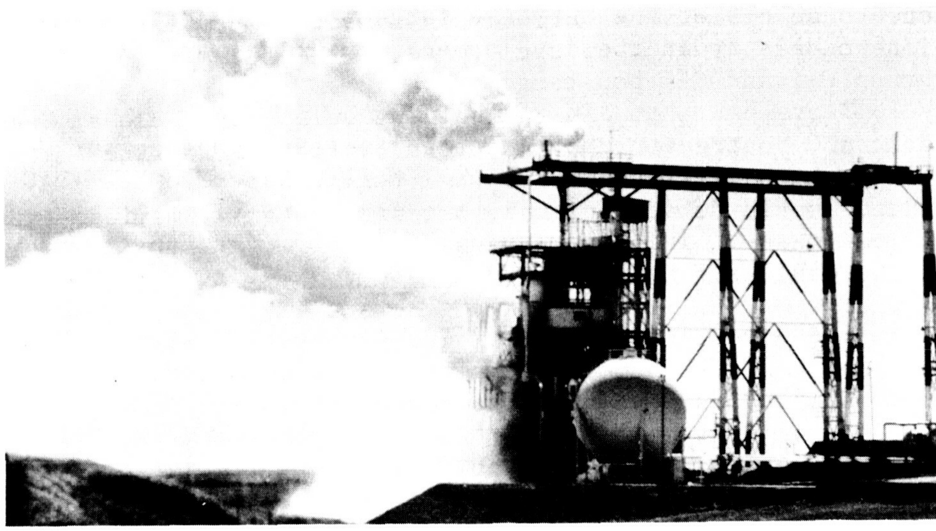


FIGURE 106. S-IV BATTLESHIP STATIC FIRING

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

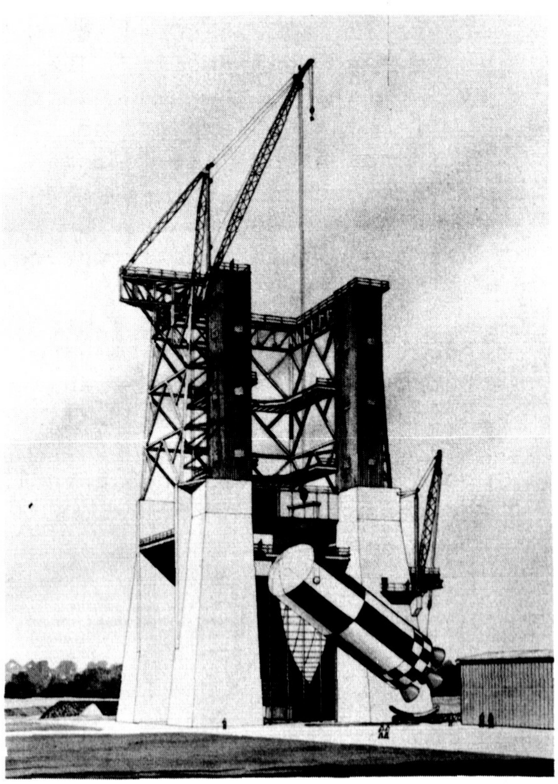


FIGURE 107. S-IC STATIC TEST STAND

MSFC on August 31 awarded a contract for construction in Huntsville of the S-IC static test stand super-structure (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 covering modification of the S-IVB stage for use in 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.

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 would be. The S-II facility (Fig. 108) would be constructed by the U. S. Navy and operated by North American Aviation's S&ID.

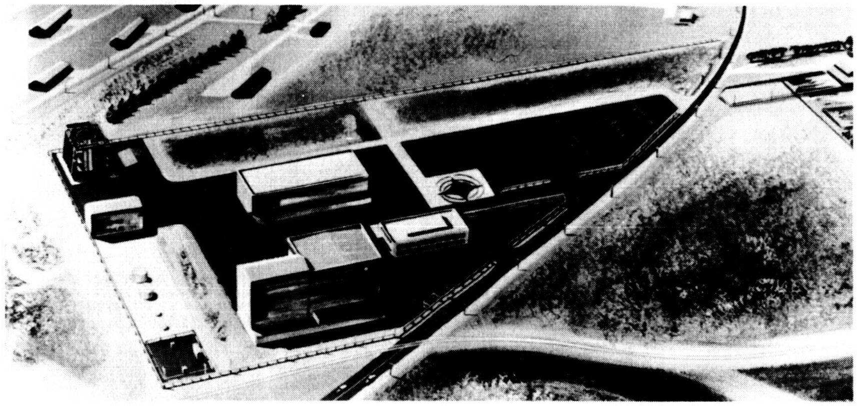


FIGURE 108. S-II STAGE ASSEMBLY AND TEST FACILITY

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.

FIGURE 109. PRESIDENT KENNEDY VISITS MSFC

September 1962

On September 15 Michoud technicians installed a 42-foot boring mill (Fig. 110), the largest known, for use in C-5 production. Also in mid-September MSFC provided DAC 90-day program authorization to investigate minimum changes necessary to adapt C-5 second stages to C-IB. DAC would also study attachment of the S-IVB stages to the C-1 booster, as well as separation during flight.

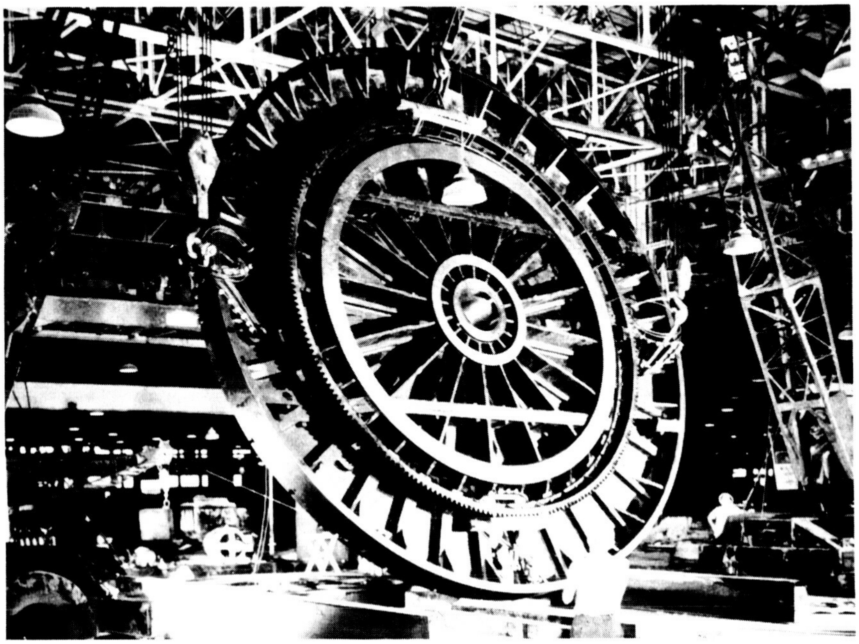


FIGURE 110. INSTALLATION OF 42-FOOT BORING MILL

On September 25 assembly began of the SA-6 flight booster. Meanwhile, preliminary plans were completed for development of the Mississippi Test Facility. First phase of the three-phase program included building two test stands each for static firing the S-IC and S-II stages (Fig. 111) and about 20 service and support buildings. Improvement of approximately 15 miles of river channel and construction of a canal within the test facility would permit transportation of stages from Michoud to MTF test stands.

All objectives were met during the second SA-4 booster flight qualification static firing 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; post-static checkout began. On the same day MSFC let a contract for construction of the vertical assembly building foundation at Michoud.

During September MSFC directed S&ID to develop a plan for C-5 dual plane separation (Fig. 112). In dual plane separation, S-IC separation would be followed by separation of the S-II interstage.

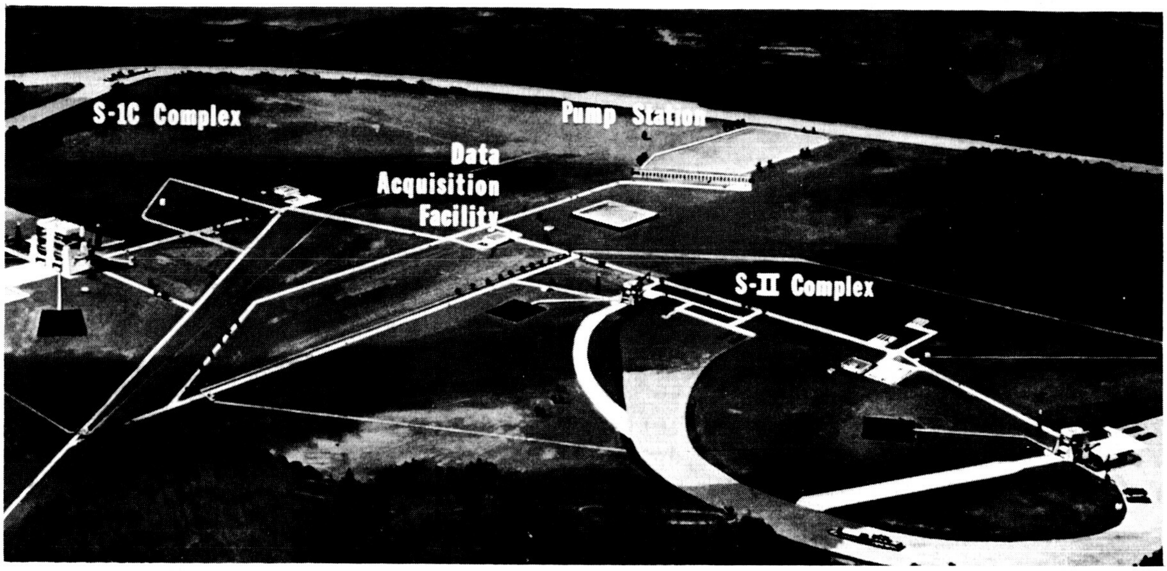


FIGURE 111. MISSISSIPPI TEST FACILITY

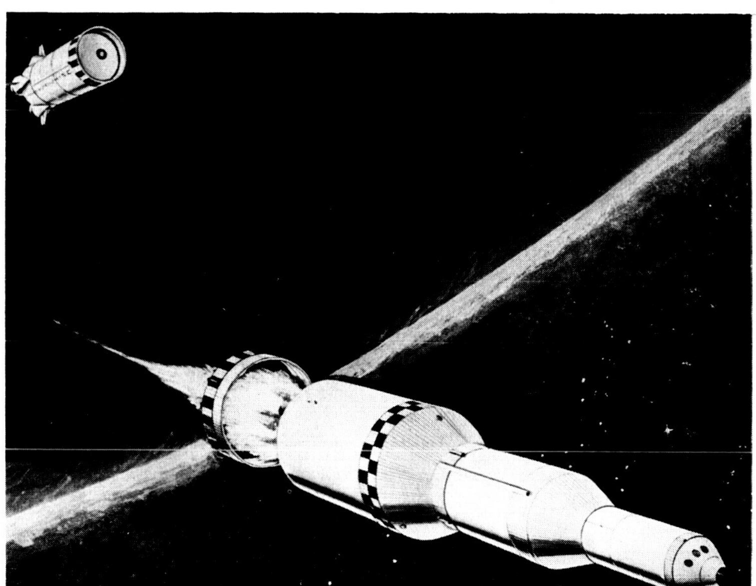


FIGURE 112. DUAL PLANE SEPARATION

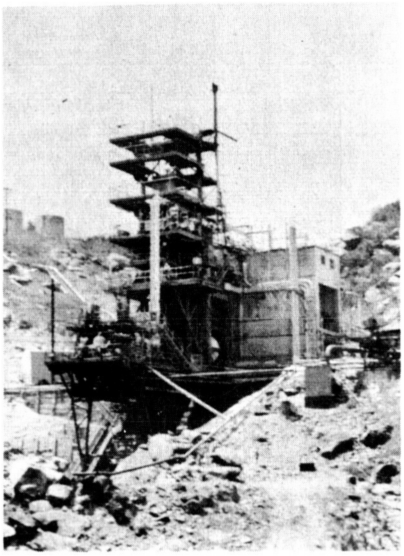


FIGURE 113. J-2 TEST FACILITY

The first industry-produced booster was started October 4 at Michoud when Chrysler began fabrication of S-I-8, the first of 21 Saturn C-1 boosters it was scheduled to produce.

Two J-2 engine full-thrust firing tests, of 50 and 94 seconds duration respectively, were successfully performed prior to a 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 successfully conducted on October 6 at the Santa Susana Test Facility (Fig. 113).

During October MSFC began tests on the C-1 uprated test stage SA-T4.5. Tests were to check the integrity of the propulsion system and effect of the 188K engines on the flame deflector. After tests were successfully concluded the stage went to Michoud for use in checking out facilities.

MSFC awarded a Saturn C-5 contract on October 5 for construction in Huntsville of a combined S-IC stage vertical assembly building and hydrostatic test tower (Fig. 114). NASA Headquarters approved on October 12 the Saturn C-5 second stage (S-II) long-term R&D contract with S&ID.

On October 15 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.

In October NASA arranged to dredge an access channel to the Saturn C-5 Complex 39 Vertical Assembly Building and Launch Pad area at Merritt Island, Florida.

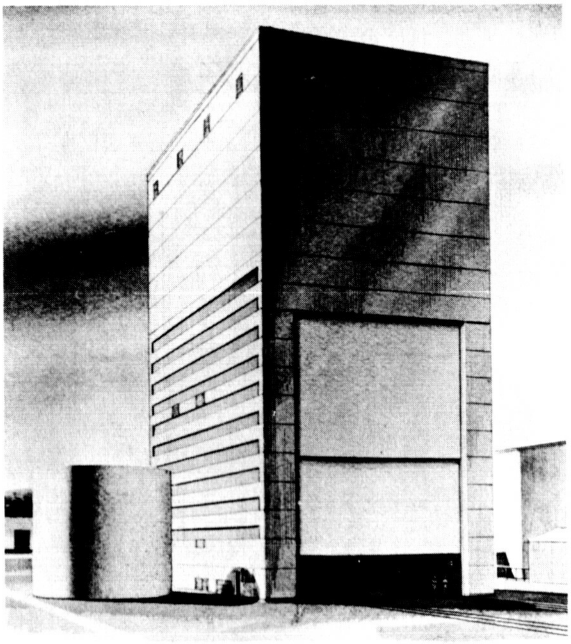


FIGURE 114. S-IC STAGE FACILITY

On October 2 MSFC contracted for construction of a flame deflector for the MSFC Saturn S-IC test stand.

During October MSFC decided to fly a Jupiter-type payload with the fifth Saturn flight (Fig. 115). Saturn C-1 second stage progress included completion of the S-IV Hydrostatic/Dynamics Stage at Santa Monica. It began its trip to MSFC via the Victory Ship Smith Builder on October 26, 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.

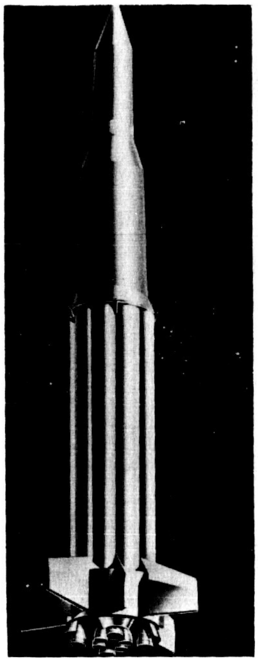


FIGURE 115. SA-5 CONFIGURATION

FIGURE 116. UNLOADING S-IV STAGE AT MSFC

The Launch Operations Center awarded a contract in October to modify the Complex 34 fuel, LOX, and LN servicing systems in preparation for Saturn C-1 Block II vehicle launches. SA-5 flight booster assembly was completed on November 6 and the booster transferred for prestatic check-out. Assembly of the SA-D5 booster for dynamics testing was completed on October 29. This stage was installed in the MSFC dynamics test tower on November 13, 1962. The SA-D5 booster simulated configuration of the final Saturn C-1 boosters which were expected to be used for manned flights.

During November DAC awarded subcontracts for development of the S-IVB's 1750-pound thrust ullage motors and 150-pound thrust attitude control motors.

On November 8 the last S-IV battleship test with RL10A-1 engines was completed at SACTO; eleven tests totaling 1137.6 seconds were accomplished. The A-1 engines were then removed and installation began of RL10A-3 operational-type engines for the next phase of battleship hot firing tests.

Cost negotiations between MSFC and Boeing began on November 15 for the long-term S-IC stage development and production contract.

The third Saturn flew on November 16 (Fig. 117). SA-3 was successfully launched from Cape Canaveral, carrying a full propellant load of 750,000 pounds. It rose to a height of about 104 miles. Flight range was 131 statute miles. Inboard engine cut-off occurred as planned after 141 seconds of flight; out-board engine cut-off came eight seconds later. Project High Water was performed as a secondary mission on SA-3 as on SA-2.

On December 13 a contract was awarded for the construction of the Michoud S-IC Hydrostatic Test and Vertical Assembly Building (Fig. 118). Also at Michoud, Chrysler Corporation began fabrication of the tenth and final R&D Saturn booster, S-I-10.

In December design of Marshall's C-5 Dynamic Test Tower was completed; Douglas awarded a contract for fabrication of the S-IVB Battleship

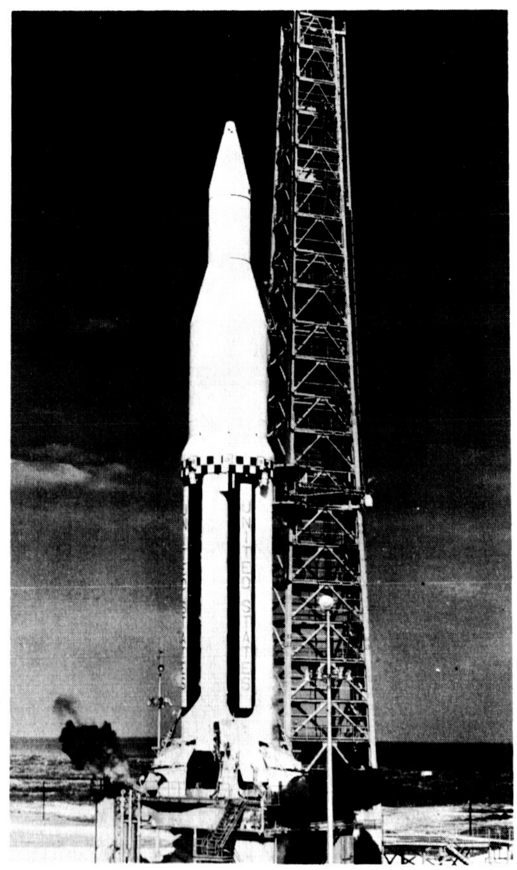


FIGURE 117. LAUNCH OF SA-3 FLIGHT VEHICLE

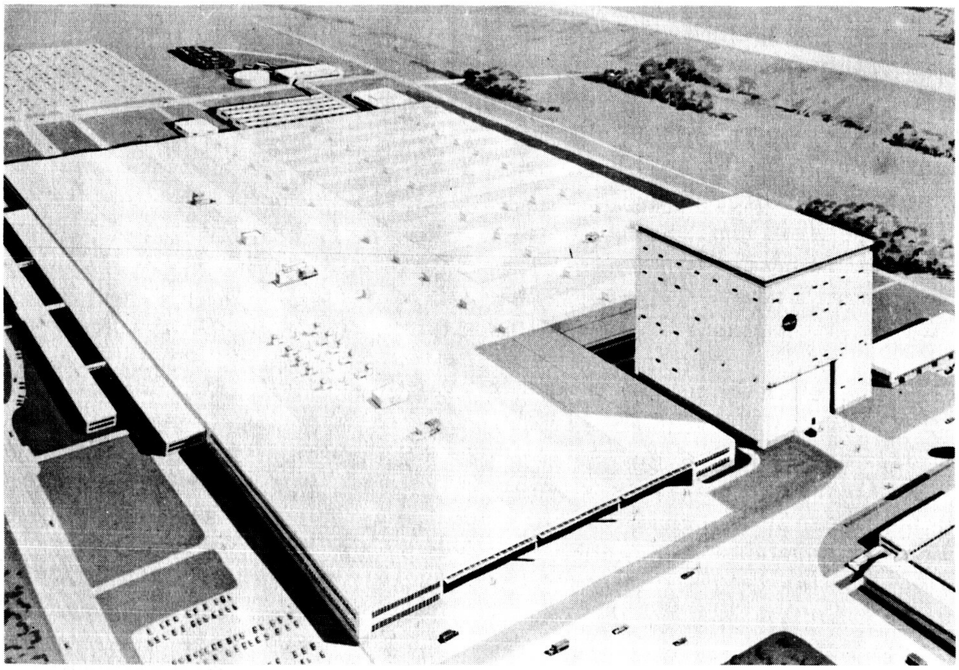


FIGURE 118. VERTICAL ASSEMBLY BUILDING AT MICHOUD

tank; and, at Cape Canaveral, the Corps of Engineers awarded a contract for design of the Launch Complex 39 Vertical Assembly Building (Fig. 119).

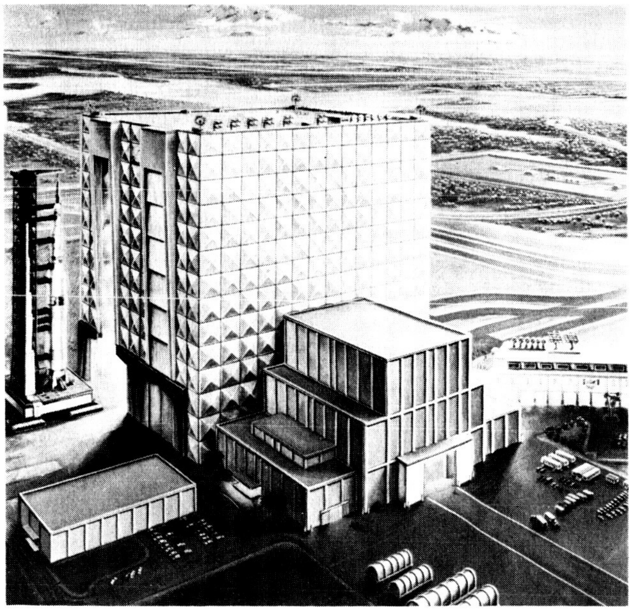


FIGURE 119. LC-39 VERTICAL ASSEMBLY BUILDING

Initial checkout of the S-IV all-systems vehicle began at Santa Monica in late December. DAC began fabrication of S-IV-111, the first production S-IV flight stage.

Rocketdyne studied causes of F-1 engine combustion instability, first encountered during June 1962. Testing with modified engine hardware began in the latter part of 1962 and was scheduled to continue during 1963.

During early January 1963 construction began at the Huntington Beach Assembly Facility where Douglas

Aircraft Company will assemble S-IVB stages.

In January MSFC began dynamics tests of the SA-D5 vehicle configuration (Fig. 120). The Center finished expansion of its static test tower for Saturn C-1 Block II first stages.

DAC completed checkout of the S-IV dynamic/facilities vehicle at Santa Monica and, during January sent this vehicle to Cape Canaveral (Fig. 121) for use in checkout of Launch Complex 37B facilites.

MSFC shipped by barge the complete SA-4 vehicle from Huntsville to Cape Canaveral. The complete vehicle was erected on Launch Complex 34 by February 5 (Fig. 122).

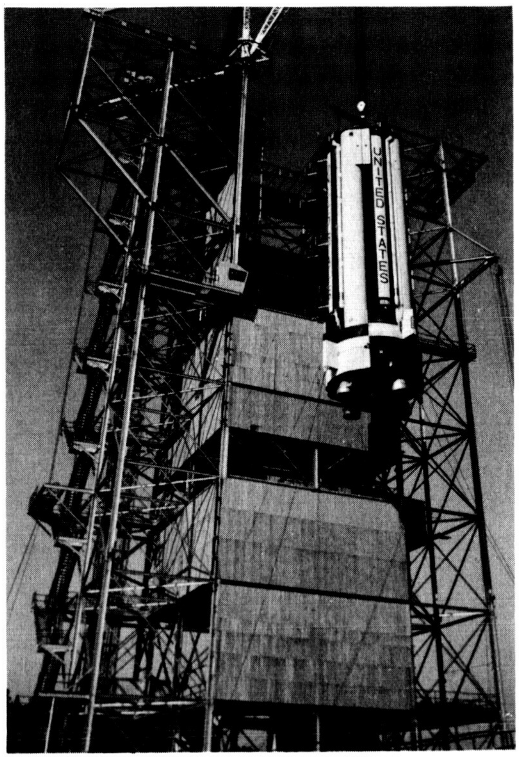


FIGURE 120. SA-D5 BOOSTER

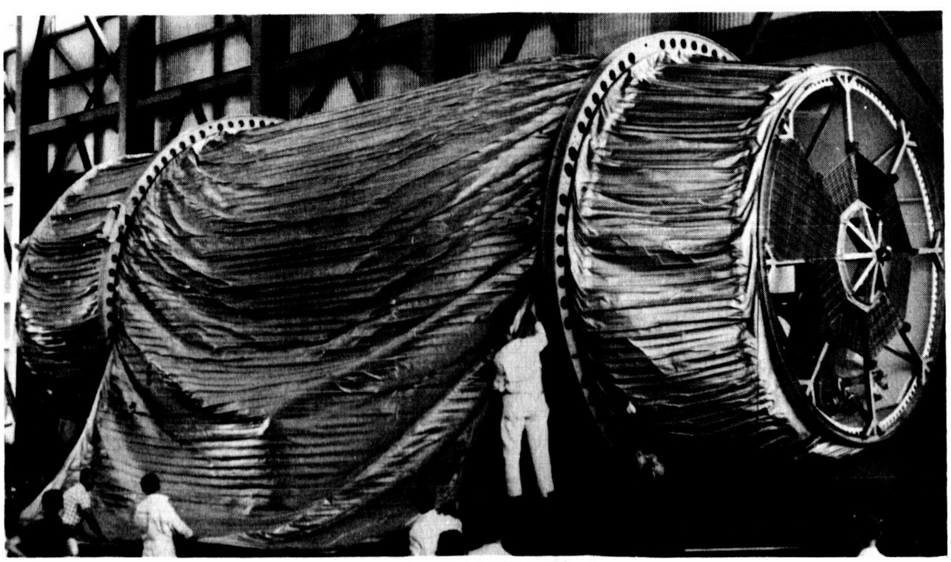


FIGURE 121. S-IV DYNAMIC/FACILITIES STAGE AT CAPE CANAVERAL

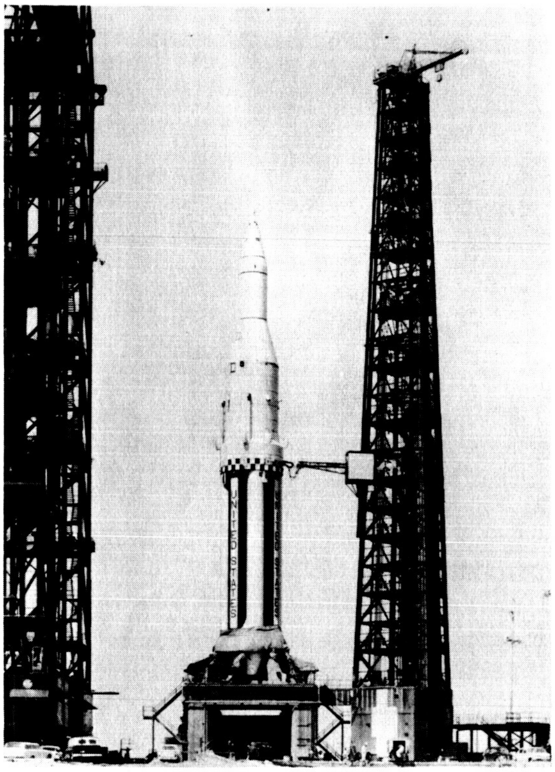


FIGURE 122. SA-4 ON LC-34

On January 26 at SACTO, DAC static-fired the RL10A3 powered S-IV battleship vehicle. Test duration was 468 seconds. On February 1 DAC shipped the S-IV all-systems vehicle from Santa Monica to SACTO for testing. At Launch Complex 37B the Launch Control Center, Automatic Ground Control Station, and Umbilical Tower were completed on January 30.

During the first week of February NASA Headquarters announced a change in Saturn vehicle nomenclature. Saturn C-1 became Saturn I, Saturn C-IB became Saturn IB, and Saturn C-5 became Saturn V (Fig. 123).

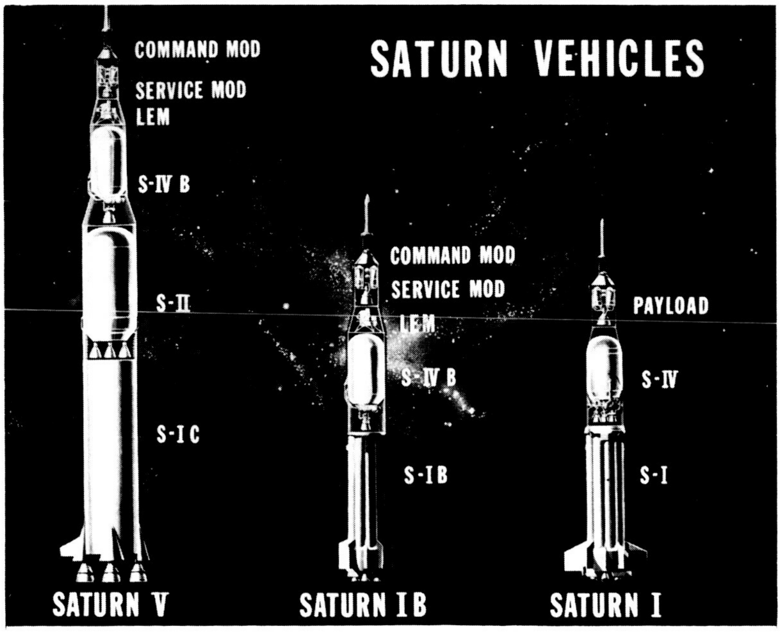


FIGURE 123. SATURN VEHICLES

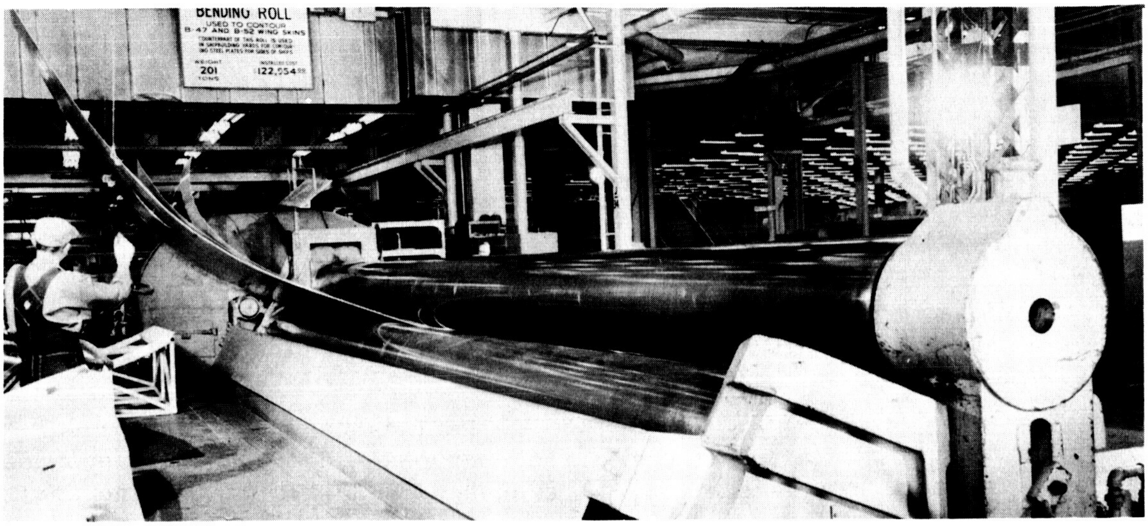


FIGURE 124. S-IC BULKHEAD GORE FORMING

Saturn V hardware development was underway. In early February Boeing began S-IC bulkhead gore-forming operations at Wichita, Kansas (Fig. 124).

On February 4 MSFC decided to modify the west side of the MSFC static test tower for F-1 engine testing. The modification would allow single F-1 engine tests to begin several months earlier than scheduled. The stand would later be reconverted for S-I static testing. On February 8 MSFC awarded a contract for construction of a single F-1 engine test stand superstructure at MSFC (Fig. 125).

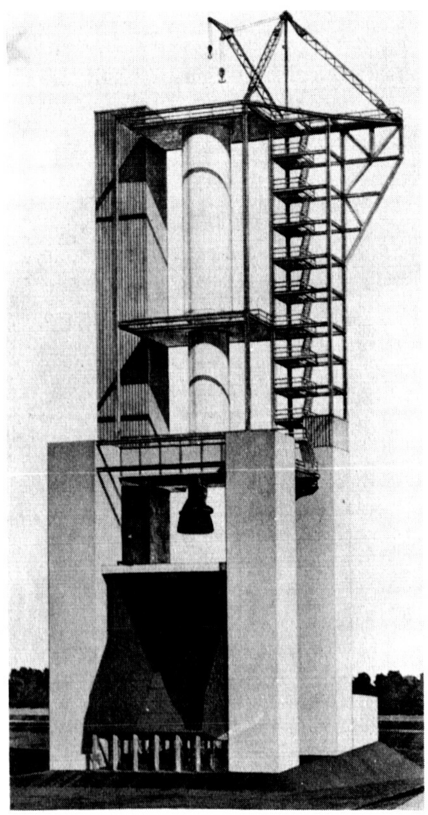


FIGURE 125. F-1 TEST STAND

Early in February S&ID began occupancy of the Seal Beach assembly and test facility (Fig. 126) where Saturn V second stages would be assembled and tested. Also in February S&ID successfully completed S-IC/S-II stage dual plane separation impingement tests.

The first live Saturn I second stage would be powered by liquid hydrogen--still not flight proven. The S-IV battleship stage permitted tests of this new technology. On February 18 and 19 S-IV battleship turbine spinup tests were unsuccessful due to inadequate purge procedures; however, on February 23 a successful spinup test was accomplished. Two days later the second battleship firing testing RL10A-3 engines was terminated after 6.5 seconds when a hydrogen leak caused a fire at engine No. 4. No damage resulted.

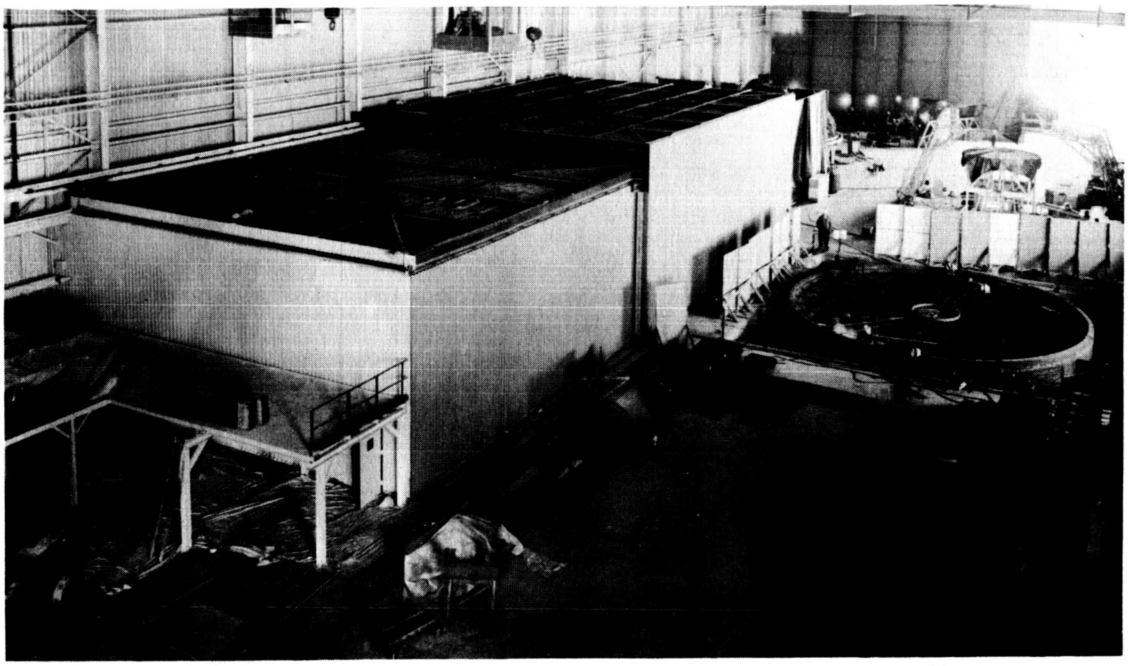


FIGURE 126. S-II SEAL BEACH FACILITY

On February 20 NASA began contract negotiations for design, fabrication, erection, and testing of the Crawler-Transporter (Fig. 127) which

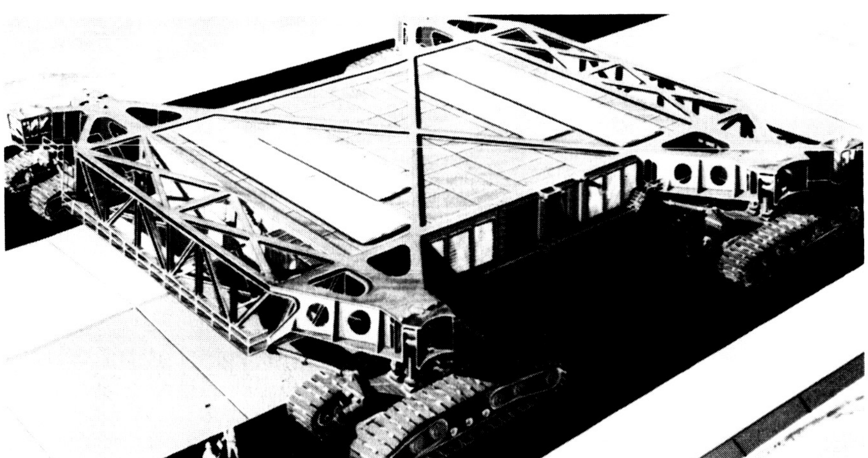


FIGURE 127. CRAWLER-TRANSPORTER

would transport the Saturn V vehicle to the Launch Pad of Launch Complex 39. The contract was signed on March 29, 1963.

NASA Headquarters on February 20 approved the plan for modification of the basic Chrysler contract. The plan provides for redesign of the S-I stage to the S-IB configuration and the delivery of 12 S-IB stages and 8 S-I stages.

For Saturn V, NASA Headquarters approved the Boeing S-IC definitive contract on February 21. Boeing will design, develop, and manufacture one ground test stage and nine flight stages at the Michoud Plant in New Orleans. On February 27 the Corps of Engineers awarded a design contract for the Saturn V test facilities at the Mississippi Test Operations.

MSFC awarded a contract in February for construction of three micrometeoroid satellites (Fig. 128), two for flight and one for backup.

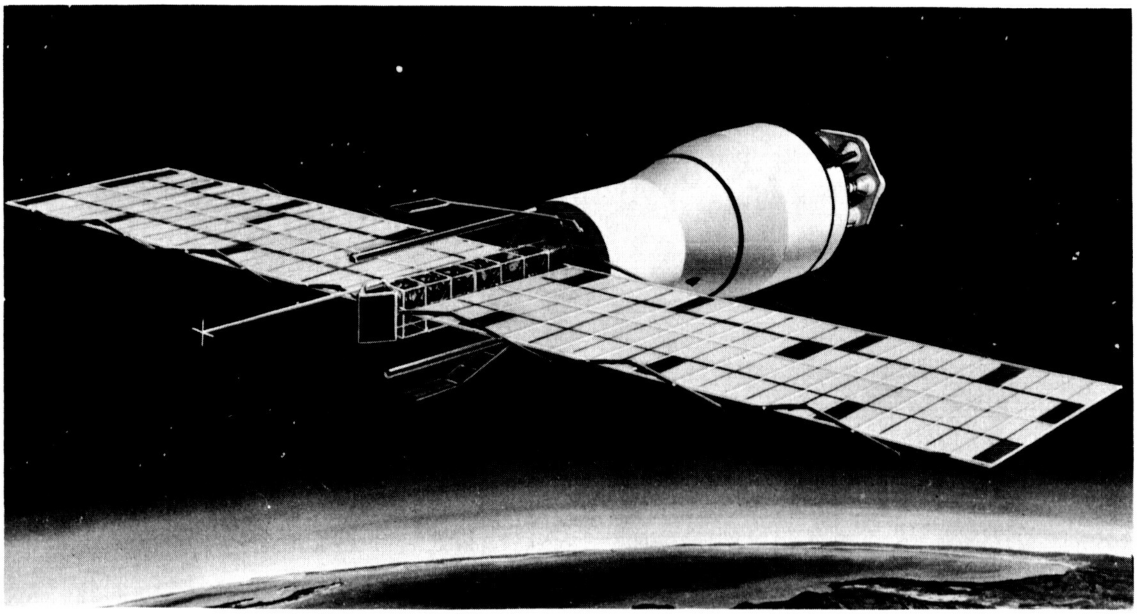


FIGURE 128. MICROMETEOROID SATELLITE

The satellites, secondary payloads for Saturn I vehicles SA-8 and SA-9, would be used to obtain data on frequency and penetration of micrometeoroids in low earth orbits and to relay the information back to earth.
On February 27 the first S-I-5 flight qualification static test (SA-11) was successfully conducted at MSFC for a planned duration of 32 seconds (Fig. 129).

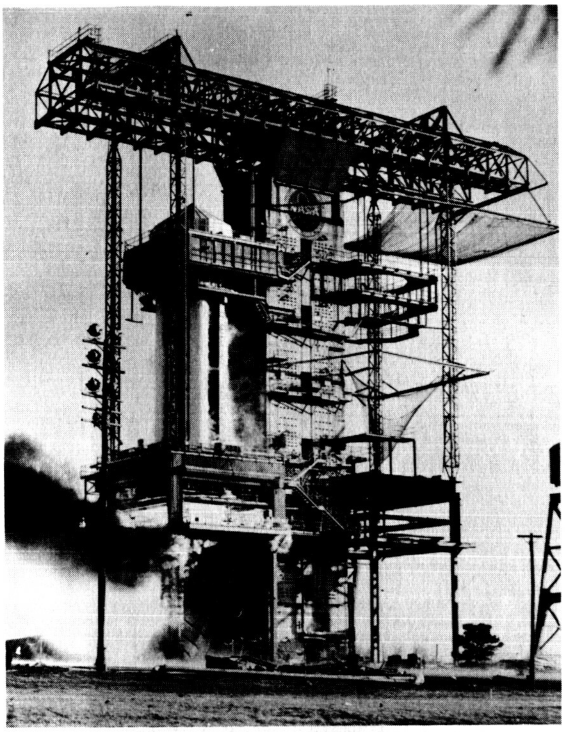


FIGURE 129. STATIC FIRING OF S-I-5

On February 19 at the Michoud Plant, Boeing completed the first Y-ring (Fig. 130) for the S-IC test fuel tank; on March 4 the Y-ring was delivered to MSFC where the fuel tank would be assembled. Also at Michoud during February a contract was awarded for design and construction of the Engineering Building.

During February, construction of Test Stand 2B at SACTO was completed and the propellant pneumatic systems were installed and checked out.

On March 1 Rocketdyne successfully gimballed an F-1 engine during a hot firing test in California. On the same day qualification of explosive forming dies for S-II gore segments began at North American's El Toro facility (Fig. 131).

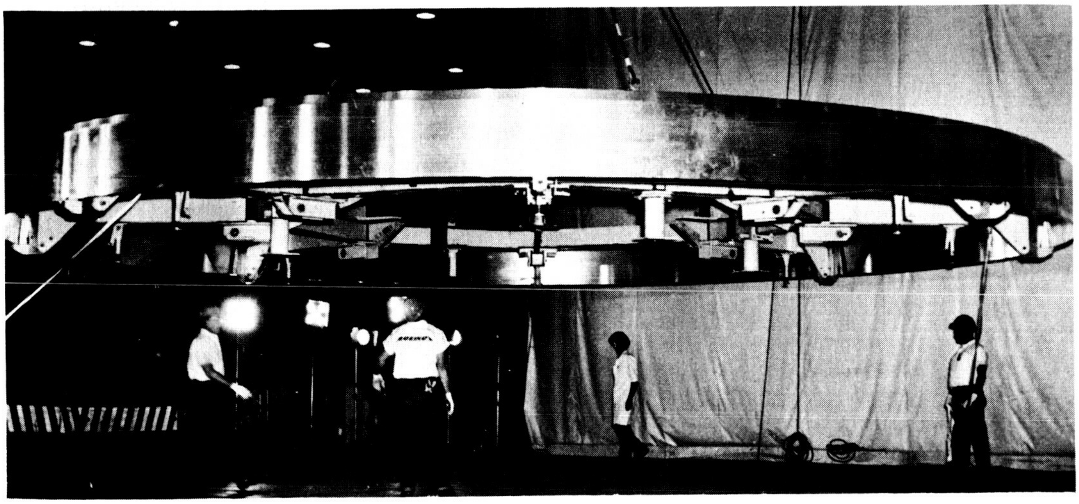


FIGURE 130. COMPLETED Y-RING AT MICHOUD

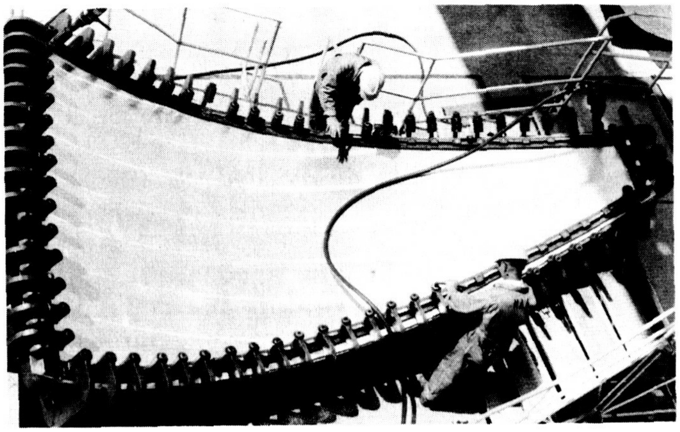


FIGURE 131. EXPLOSIVE FORMING DIES

S&ID awarded a construction contract for the electro-mechanical mockup at Downey, California, on March 1; the mockup will be used for design and engineering verification of various S-II systems. On March 8 MSFC awarded a one-year contract to industry for operation of the Slidell Computer Facility at Slidell, Louisiana.

Dynamic testing of the SA-D5 vehicle was completed on March 7. On March 13 a second flight qualification static firing of S-I-5 was conducted for a planned period of 143 seconds. Subsequent analysis revealed propulsion system irregularities, and a third static firing was conducted on March 27 to confirm corrections. This test, successfully conducted for a duration of 144 seconds, concluded S-I-5 flight qualification testing.

NASA Headquarters approved MSFC procurement plan for four additional S-IVB stages on March 22. On the same day, at MSFC, checkout of the SA-5 Instrument Unit was begun (Fig. 132).

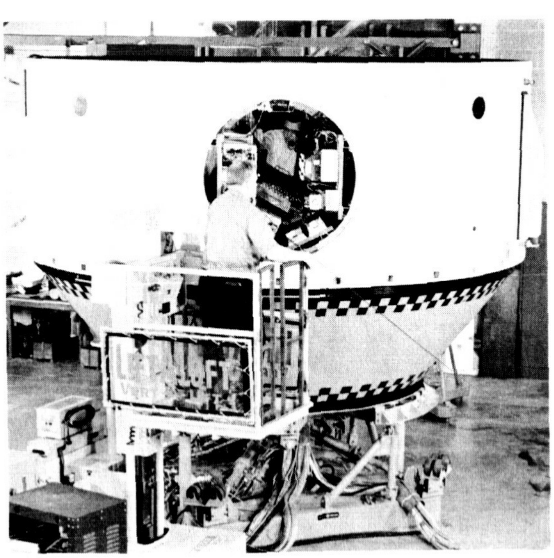


FIGURE 132. SA-5 INSTRUMENT UNIT

Saturn SA-4, the fourth and last of the single-powered-stage, Block I vehicles, was successfully launched on March 28 from Launch Complex 34 (Fig. 133). The vehicle, carrying several Block II components for test, reached an altitude of 80 statute miles. Range was 218 statute miles and peak velocity 3660 miles per hour. As a secondary mission the No. 5 inboard engine was cut off at 100 seconds to test the vehicle engine-out capability. Overall performance of the flight was very satisfactory.

As the Saturn I project entered its final phase, work on the larger Saturns proceeded. On March 12 DAC, S-IVB stage

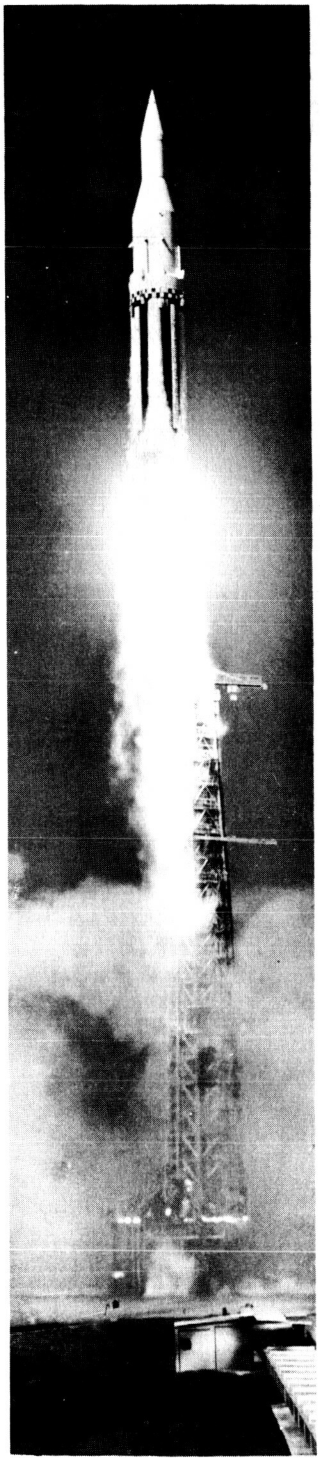


FIGURE 133.
SA-4 LAUNCH

contractor, invited bids for a construction contract for the Beta Complex at SACTO; the contract was awarded in late March. Also in March S&ID placed a contract for the S-II battleship tank structure; fabrication of components began early in April. The first S-IC cylindrical skin segment was completed by Boeing at Wichita during April.

The S-I-D5 stage was removed from the Dynamics Test Tower at MSFC on March 18. The booster was shipped to Cape Canaveral on April 5 for use in facilities checkout of Launch Complex 37B. The stage arrived at the Cape on April 15 and was erected three days later. On April 19 the S-IV Dynamics/Facilities vehicle was erected. Calibration and mechanical checks were begun the week of April 24, followed by propellant loading tests early in May (Fig. 134).

During early April DAC finished checkout of S-IV-5 at Santa Monica (Fig. 135). On April 19 the stage arrived at SACTO and was installed on Test Stand 2B on May 22. Static testing followed modifications and engineering changes.

On April 22 MSFC installed S-I-6 in its static test tower. The first short-duration static firing was successfully conducted on May 15 for a duration of 33.75 seconds.

DAC initiated S-IV all-systems propellant loading tests at SACTO on April 1. Tank bending and insulation cracking halted testing for field repair of the tank. On May 14 another test was performed and a hydrogen leak was detected in the common bulkhead. The vehicle was removed from Test Stand 2B for inspection repair on May 18.

At SACTO DAC completed the S-IV Battleship Test Program with a final LOX depletion firing of 444 seconds on May 4. Sixteen tests totaling 4302.5 seconds were accomplished using the RL10A-3 engines (Fig. 136). The complete Battleship Test Program (including both A-1 and A-3 engines) had a total firing time of 5440.1 seconds. On May 13 a one-engine

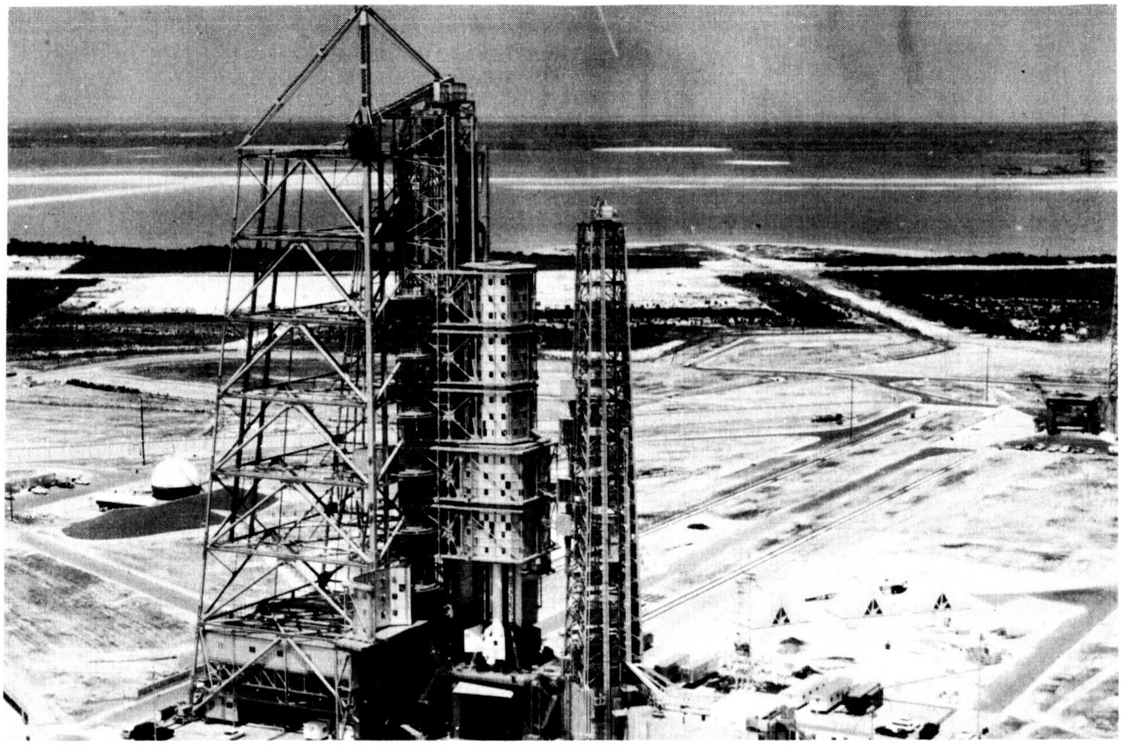


FIGURE 134. FACILITY CHECKOUT OF LAUNCH COMPLEX 37B

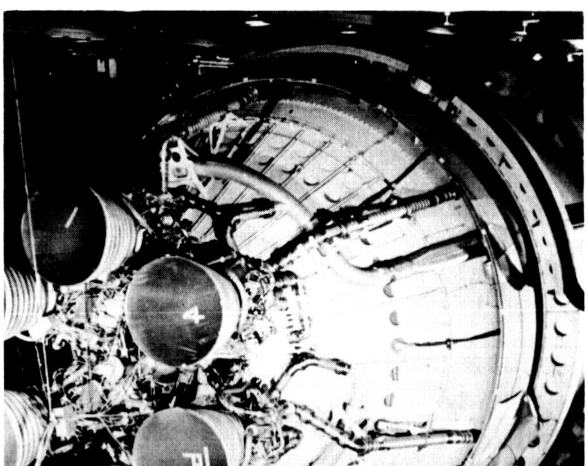


FIGURE 135. CHECKOUT OF S-IV-5

gimbal test was conducted. On May 21 the Battleship tank was shipped from SACTO to MSFC. It was used by the Center for LH_2 slosh test. Five of the six engines were shipped to MSFC and used on the dynamic vehicle for gimballing tests.

During May the S-IVB Huntington Beach fabrication and assembly building (Fig. 137) was completed and construction of the assembly tower begun. Also during May MSFC received the S-IVB forward area mockup (Fig. 138) from Douglas to be used to determine interface requirements between the S-IVB and Instrument Unit.

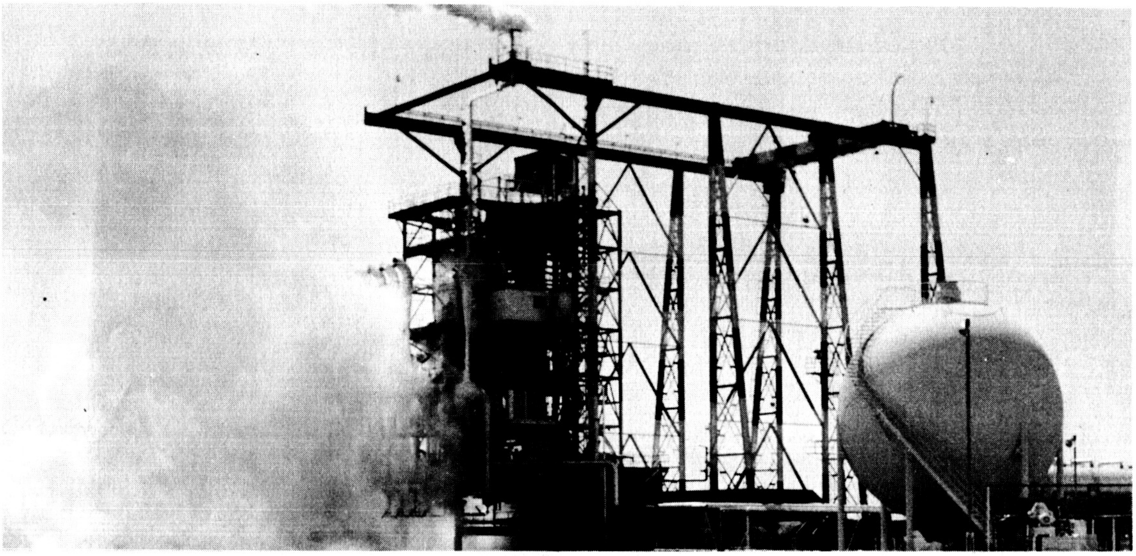


FIGURE 136. COMPLETION OF S-IV BATTLESHIP TEST PROGRAM

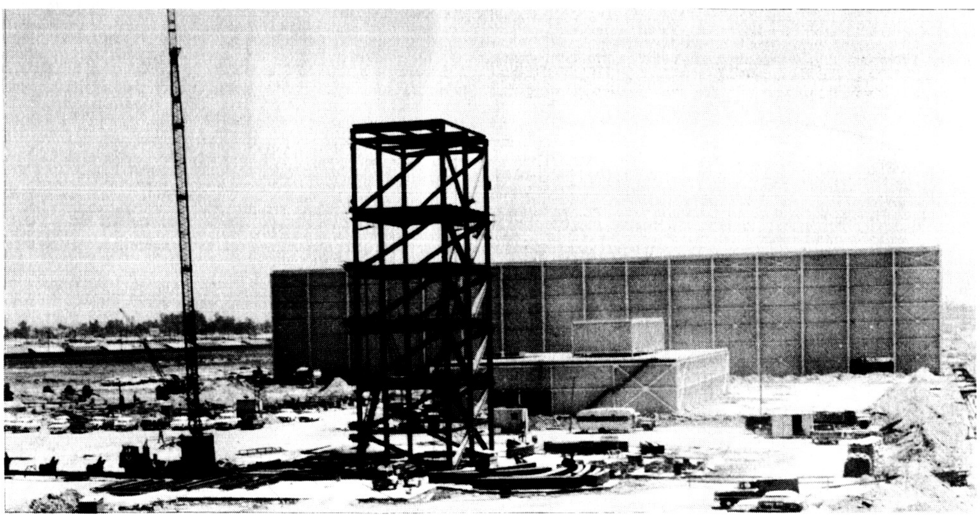


FIGURE 137. DOUGLAS HUNTINGTON BEACH FACILITY

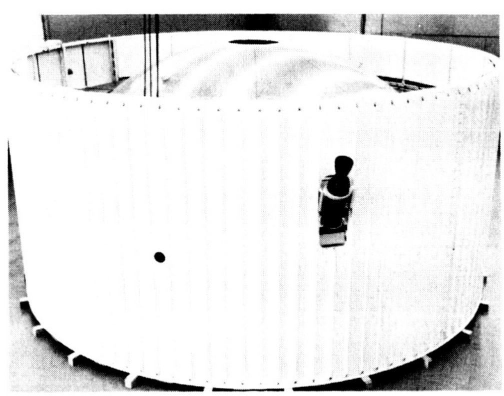
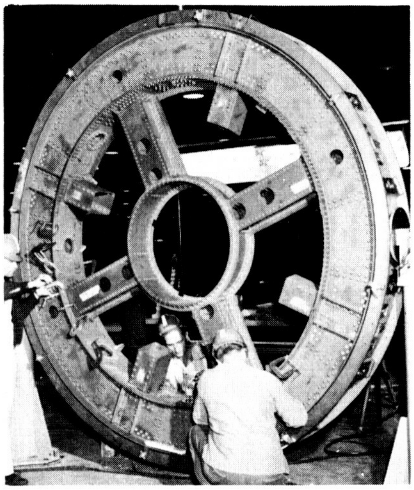


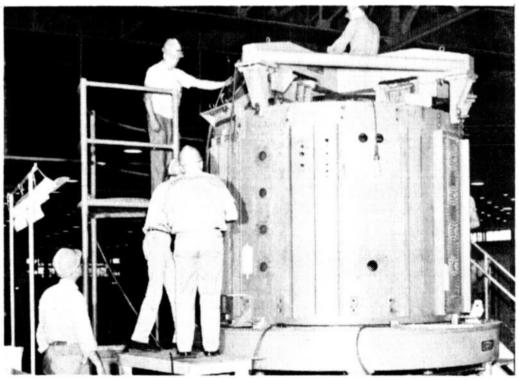
FIGURE 138. S-IVB FORWARD MOCKUP

May 1963

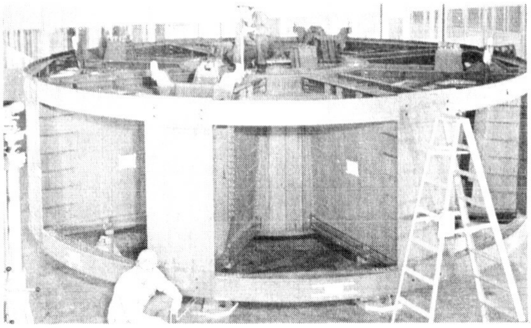
On May 18 at Michoud Chrysler finished clustering of propellant containers for S-I-8 (Fig. 139), the first booster fabricated by industry rather than by federal personnel at MSFC.



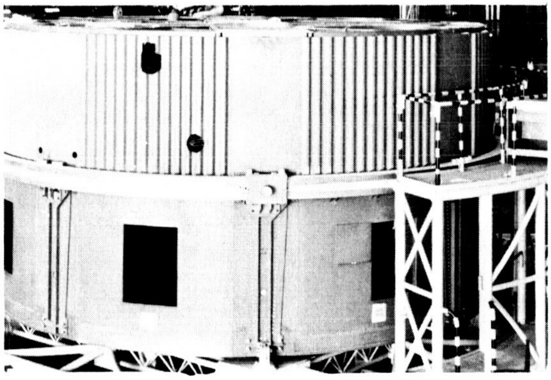
LOWER THRUST RING



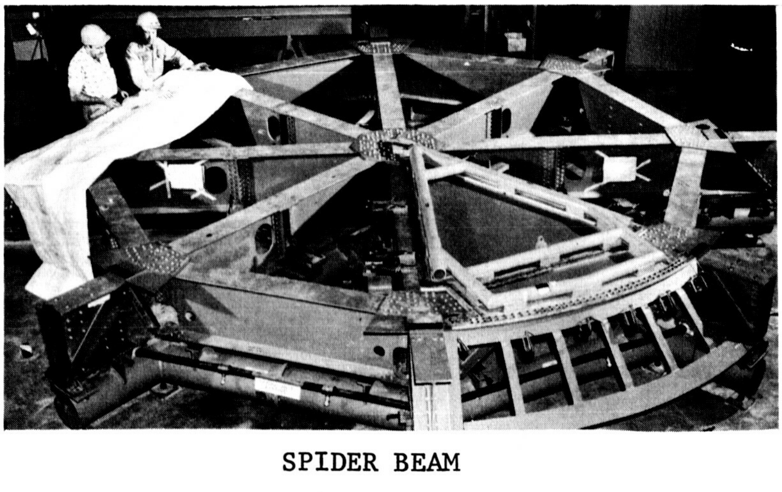
BARREL ASSEMBLY



THRUST STRUCTURE

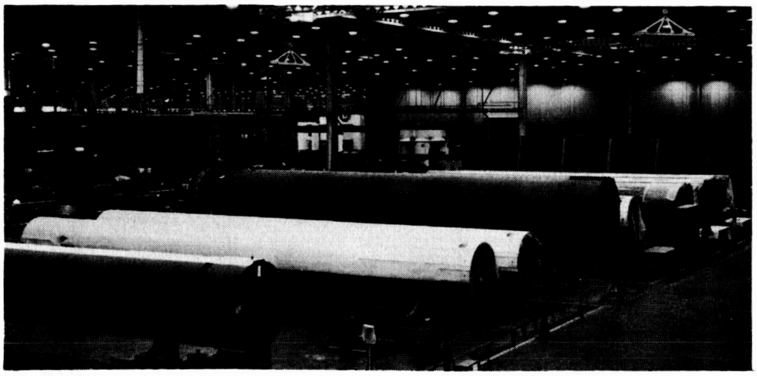


TAIL UNIT

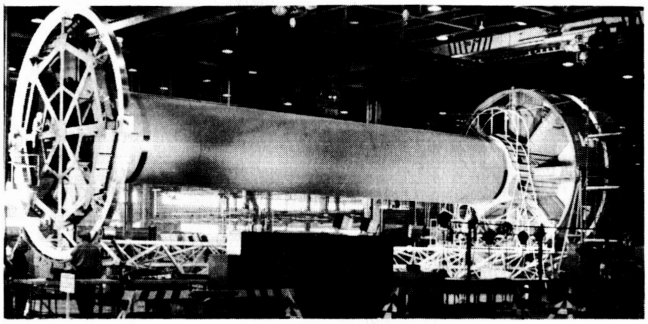


SPIDER BEAM

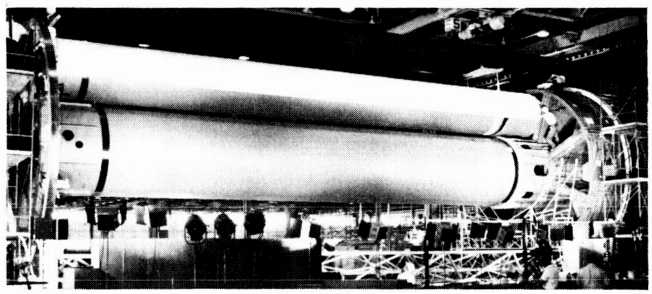
FIGURE 139. FABRICATION AND ASSEMBLY OF S-I-8 AT MICHOUD



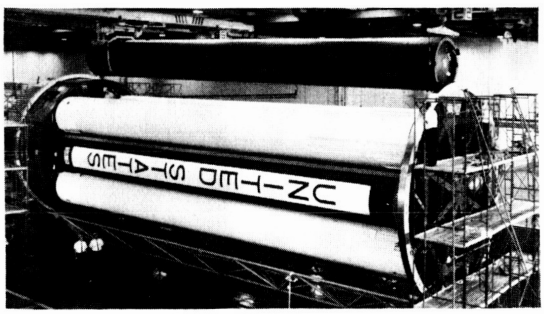
LOX AND FUEL TANKS READY FOR CLUSTERING



INSTALLATION OF CENTER LOX TANK



CLUSTERING 70-INCH LOX TANKS



CLUSTERING 70-INCH FUEL TANKS

FINAL ASSEMBLY

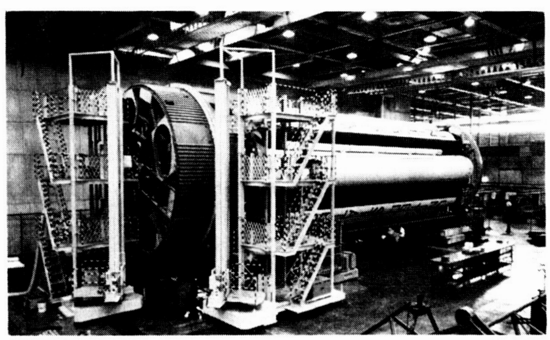


FIGURE 139. FABRICATION AND ASSEMBLY OF S-I-8 AT MICHOUD

During early May the J-2 engine, used on S-IVB and S-II stages, was successfully fired for the first time at a simulated space altitude in excess of 60,000 feet. The engine developed 200,000 pounds thrust; after 20 seconds the test was terminated as programmed.

On May 13 NASA negotiated a firm cost proposal for incorporation of dual plane separation for S-IC/S-II stages with S&ID. During mid-May land clearing at Mississippi Test Operations began in preparation for the dredging of a barge harbor and access channel; a 10.5 mile track of railroad was completed into the test site.

Dynamic testing of the S-IV stage, Instrument Unit, and Jupiter-type payload was completed at MSFC during mid-May. On May 23 the Apollo boilerplate and associated units were installed and testing resumed; this phase of testing was completed on June 16. Also during May MSFC engineers completed the design of the S-IC stage transporter.

On May 28 MSFC awarded a contract for FAA certification flights of a modified B-377 aircraft (Fig. 140). The aircraft would be used for transportation of the S-IV stage and other cargoes. Formal FAA certification was received on July 10.

FIGURE 140. PREGNANT GUPPY AIRCRAFT

During the first of June MSFC personnel began occupancy of the new Central Laboratory and Office Building. Also at MSFC construction of the Saturn V Dynamic Test Tower foundation began in early June (Fig. 141). A full-duration, S-I-6 flight qualification static test was successfully conducted on June 6 for 142.37 seconds' duration. The inboard engines were cut off by LOX low-level sensors at 136 seconds and the outboard engines six seconds later. On June 17 the stage was removed from the stand for poststatic checkout.

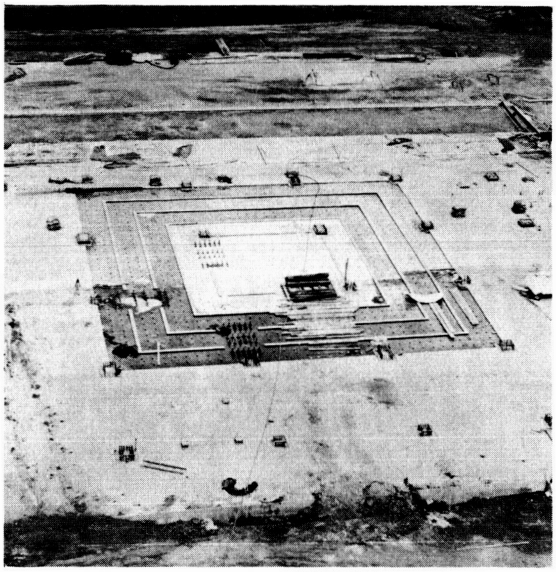


FIGURE 141. SATURN V DYNAMIC TOWER

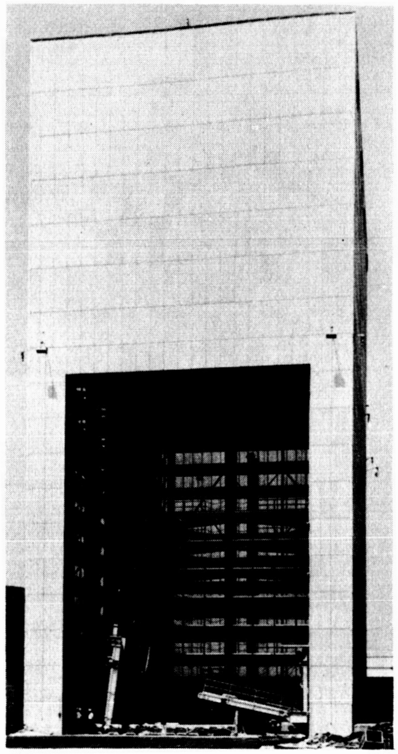


FIGURE 142. S-IC FACILITY

On June 5 limited beneficial occupancy was granted on the S-IC stage Vertical Assembly and Hydrostatic Test Facility at MSFC (Fig. 142). Clustering of tanks for S-I-9, the last Saturn I booster to be fabricated at MSFC, began on June 4 and was completed on June 19; inboard engine installation was completed on July 17 (Fig. 143).

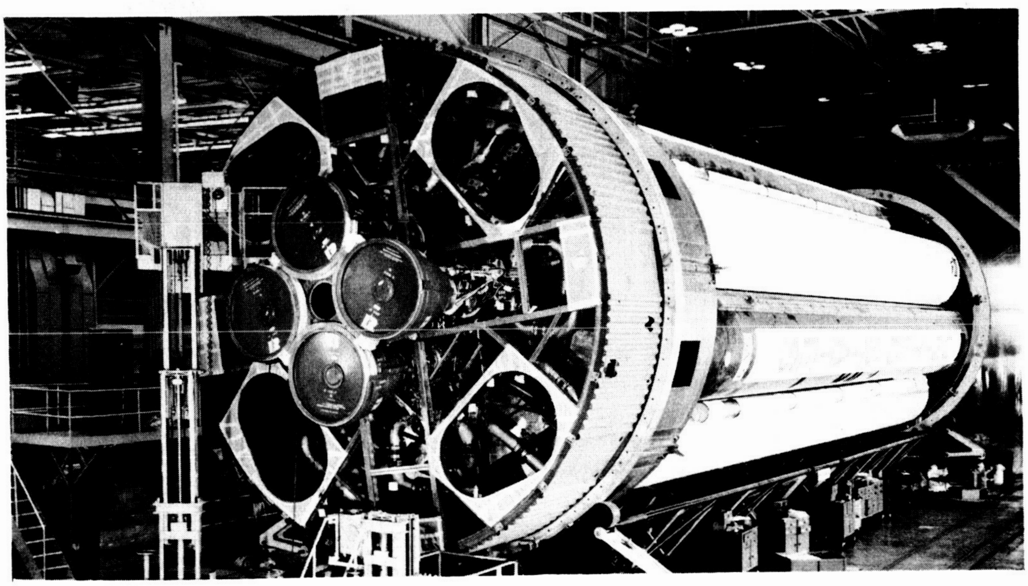


FIGURE 143. ASSEMBLY OF S-I-9 STAGE

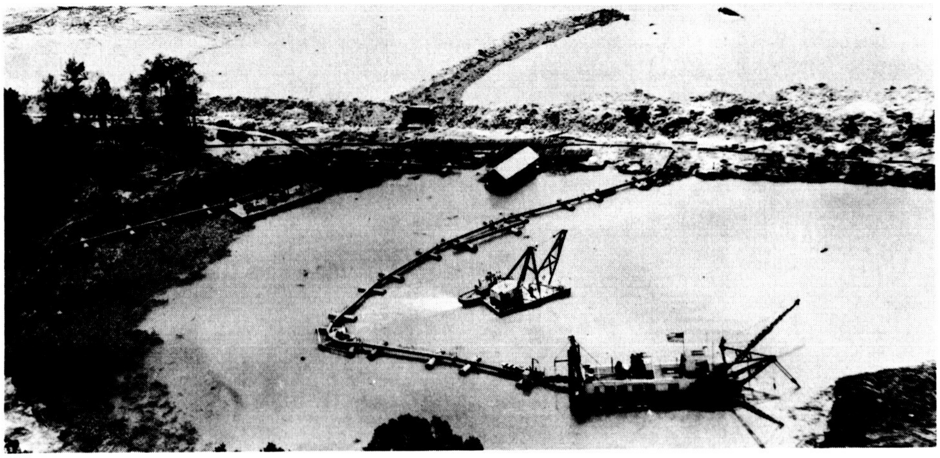


FIGURE 144. DREDGING AT MISSISSIPPI TEST OPERATIONS

On June 17 the Corps of Engineers awarded contracts for excavation for lock and Bascule Bridge, Emergency Service Building, dredging of East Pearl River and clearing of Saturn V complex at the Mississippi Test Operations (Fig. 144). At MSFC gimballing tests on engine No. 1 of the S-IV stage were completed in pitch and yaw directions on June 28. Three days later dynamic tests of the S-IV stage with Apollo boilerplate and launch escape system were completed.

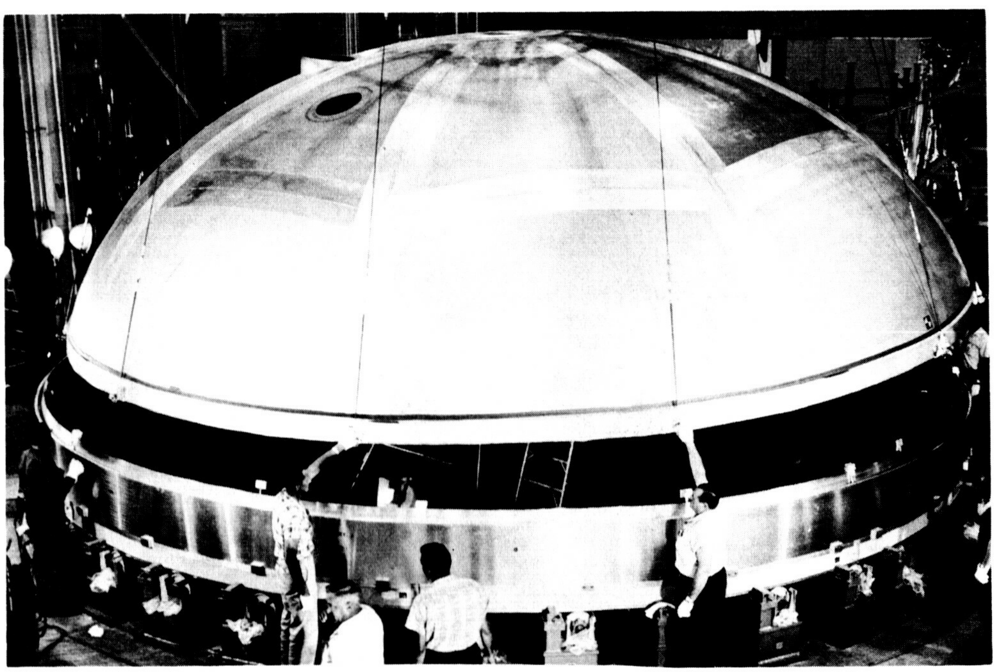


FIGURE 145. MATING BULKHEAD TO Y-RING

Prestatic checkout of the S-IV-5 stage at SACTO began on June 18. During late June repair of the all-systems common bulkhead was completed. On July 6 the vehicle was installed on Test Stand 1 at SACTO. At Santa Monica DAC completed checkout of the S-IV-6 stage on July 19.

During June MSFC welded the upper bulkhead for the S-IC test fuel tank to the Y-ring (Fig. 145). Also during June facility checkout of Launch Complex 37 Pad B was completed at Cape Canaveral. The S-IV Dynamics/Facilities vehicle was flown to the West Coast for Flight Performance Test of the Pregnant Guppy aircraft.

The S-I-D5 stage departed Cape Canaveral on July 1 aboard the barge Palaemon, arriving at MSFC on July 14; the stage was used for additional dynamic testing. On July 9 MSFC directed Chrysler to proceed with fin redesign as part of the S-IB stage redesign effort (Fig. 146).

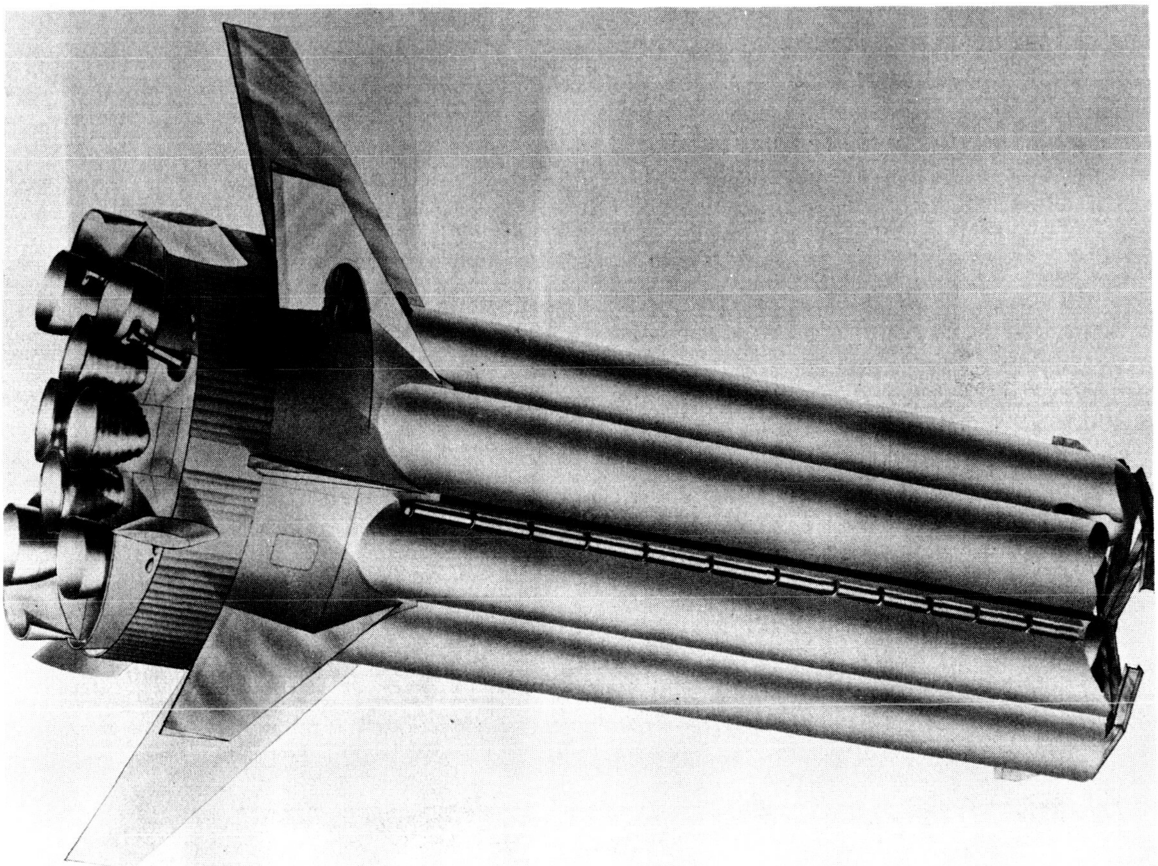


FIGURE 146. S-IB STAGE

On July 25 the Corps of Engineers awarded a contract for construction of S-IC and S-II stage test stand foundations at Mississippi Test Operations. At MSFC during late July the concrete towers for the S-IC Static Test Stand were completed and steel erection begun (Fig. 147). The Center successfully welded the S-IC upper cylindrical skin section to the Y-ring.

FIGURE 147. S-IC STATIC TEST TOWER

During July construction of foundations was completed for Test Stand 1 and 3 at SACTO Beta Complex. Also at SACTO DAC initiated hydrostatic test and calibration of the S-IVB Battleship tank on August 2.

On August 5 NASA completed S-IB contract negotiations with Chrysler Corporation at Michoud. The following day S-IVB/Saturn IB contract negotiations were completed with Douglas Aircraft Corporation at Santa Monica.

On August 6 the Corps of Engineers awarded a construction contract for the Mississippi Test Operations Laboratory and Engineering Building. During August hydraulic dredging and fill operations were completed for the vertical assembly building at Cape Canaveral (Fig. 148). MSFC awarded a contract on August 6 for assembly of two S-IC transporters; assembly began two days later.

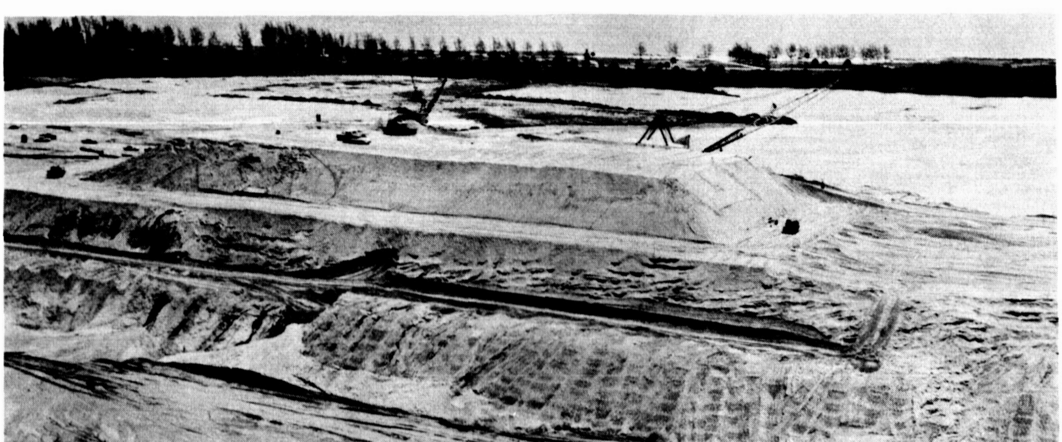


FIGURE 148. CONSTRUCTION AT LAUNCH COMPLEX 39

On August 11 MSFC started the S-I-5, S-IU-5, and Payload toward Cape Canaveral. MSFC installed on the barge Promise a complete dynamics test vehicle of the SA-6 configuration in the Dynamic Test Tower.

Also at MSFC during early August the S-IC aft area mockup was completed, with two F-1 engine mockups attached (Fig. 149).

On August 5 the first attempt to acceptance fire the S-IV-5 stage at SACTO was aborted at 63.6 seconds due to an indication of fire in the engine area; however, inspection revealed an instrumentation

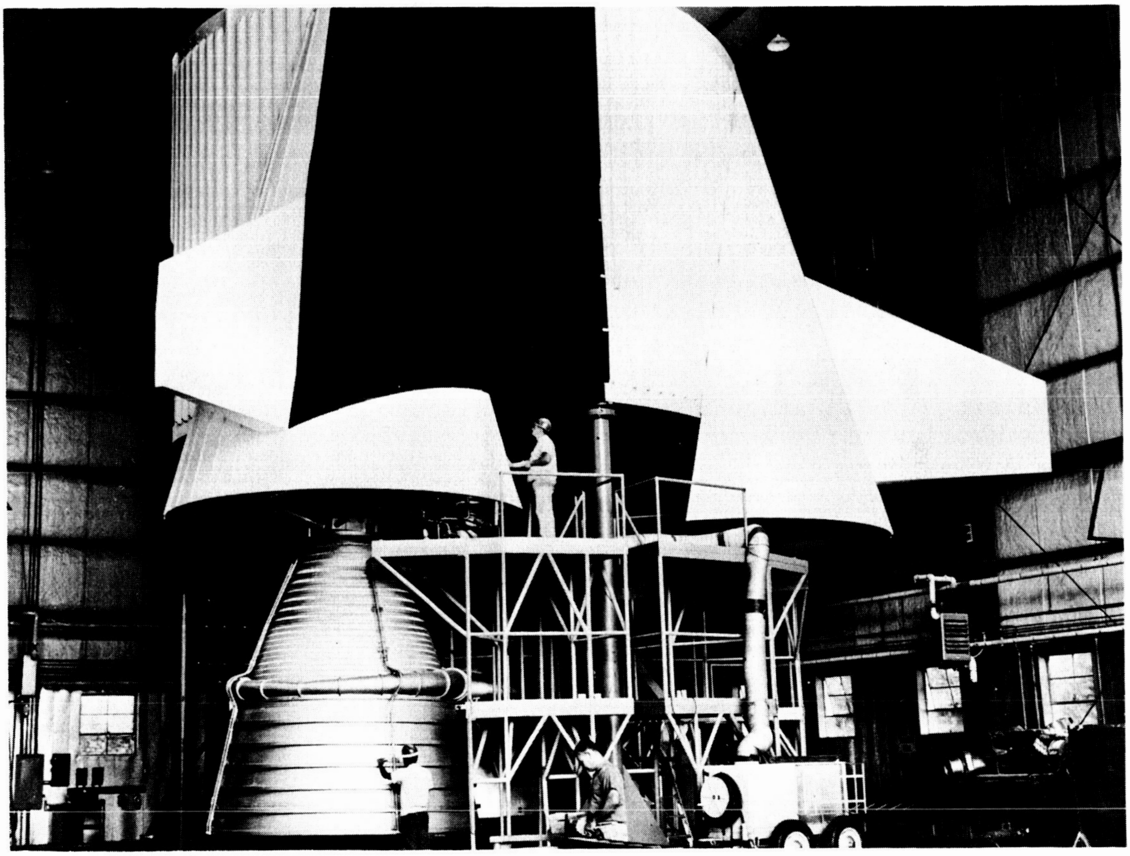


FIGURE 149. S-IC STAGE AFT AREA MOCKUP

malfunction in ground support equipment. On August 12 a successful 477-second, full-duration S-IV-5 flight qualification firing was conducted (Fig. 150). During August the S-I-5 stage, booster for the fifth Saturn flight vehicle, was erected at Cape Kennedy.

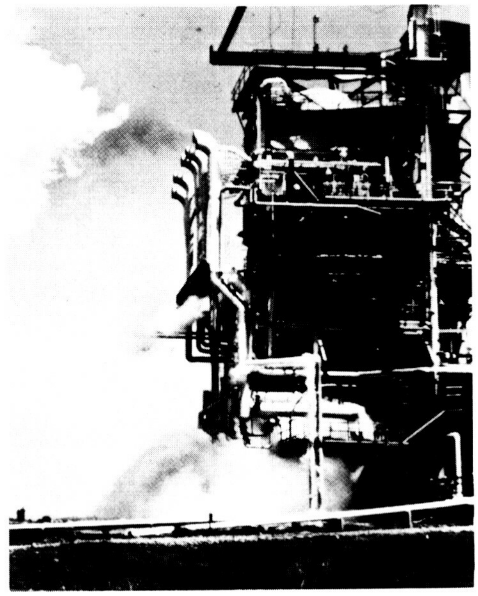


FIGURE 150. S-IV-5 ACCEPTANCE FIRING

On September 1 Dr. Wernher von Braun, MSFC Director, announced a major reorganization of the Center. Progress in the Saturn program, and a rise in industrial participation to approximately 90 per cent of the budget, necessitated the changes. The Center created two major subdivisions -- Research and Development Operations and Industrial Operations. R&D Operations, composed of the nine technical divisions redesignated laboratories, was strengthened for its Huntsville-based operations and for specialized contractor assistance. Industrial Operations was created to direct the portion of the Center's work performed by prime contractors -- mainly the development of stages and engines for the Saturn I, Saturn IB, and Saturn V multi-stage rockets (Fig. 151).

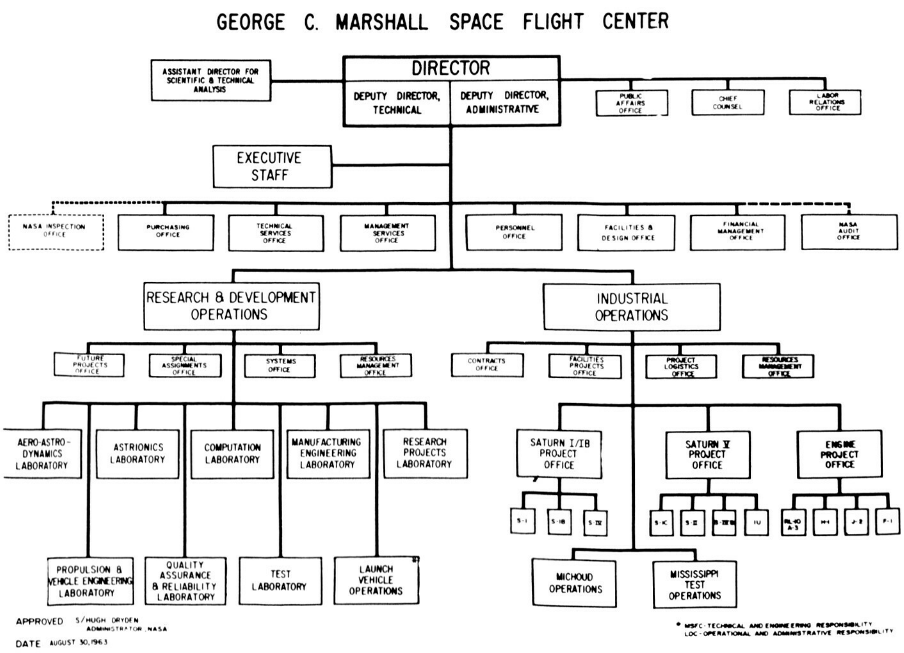


FIGURE 151. MSFC REORGANIZATION

In mid-September DAC flew the S-IV-5 from SACTO to the Cape via the Pregnant Guppy aircraft (Fig. 152). Other Saturn I progress in September included MSFC's final assembly of the S-I-9 and DAC's beginning of pre-static checkout of the S-IV-6 stage.

The Saturn IB second stage contract modification was signed by DAC and submitted to NASA on September 10. In the same month a joint MSFC/Manned Spacecraft Center Ad Hoc safety meeting considered Saturn IB crew safety and developed a "Preliminary Emergency Detection System" specification. DAC began installing insulation on the S-IVB battleship stage, a heavier version for ground tests of the S-IVB flight stage.

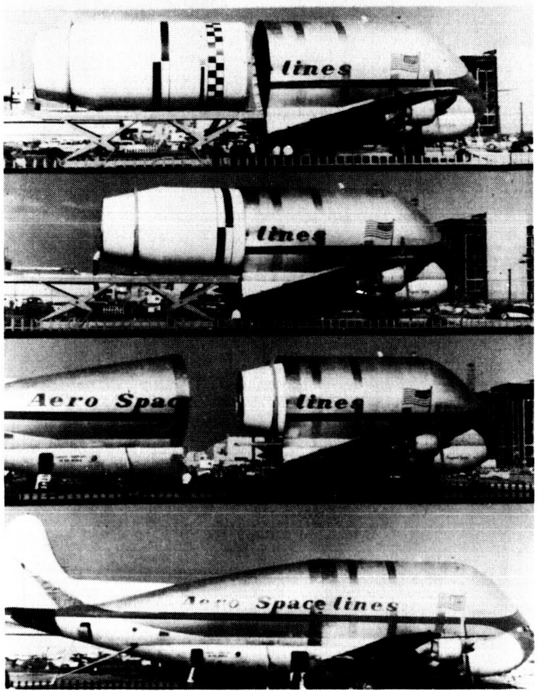


FIGURE 152. LOADING OF S-IV STAGE

During September MSFC completed Saturn V's S-IC forward area mockup and completed the S-IC-T (all systems) intertank assembly (Fig. 153).

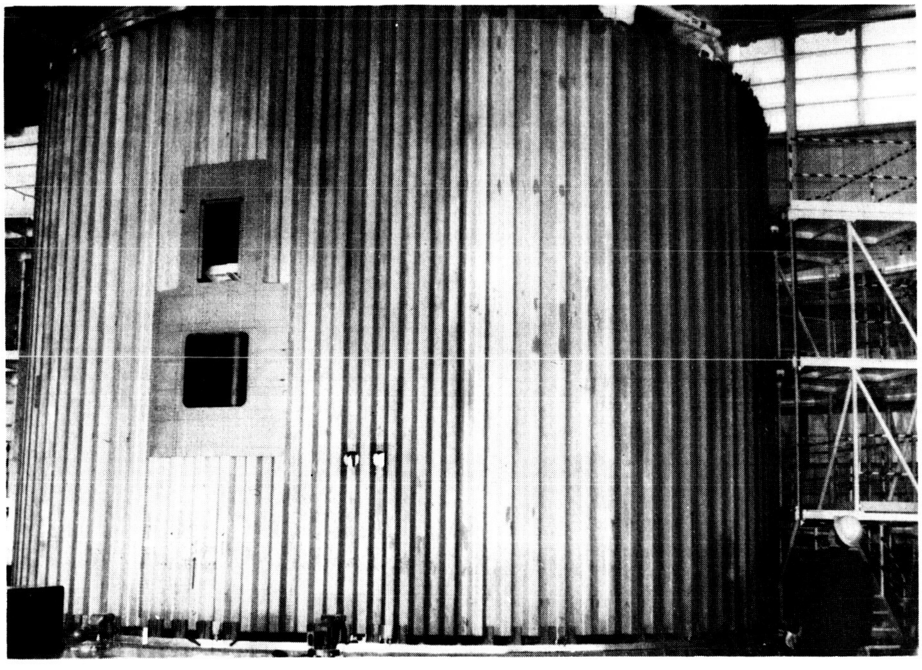


FIGURE 153. INTERTANK FOR S-IC-T

Numerous research activities were underway: MSFC's Test Laboratory studied sound suppression problems (Fig. 154), JPL and Lewis Research Center

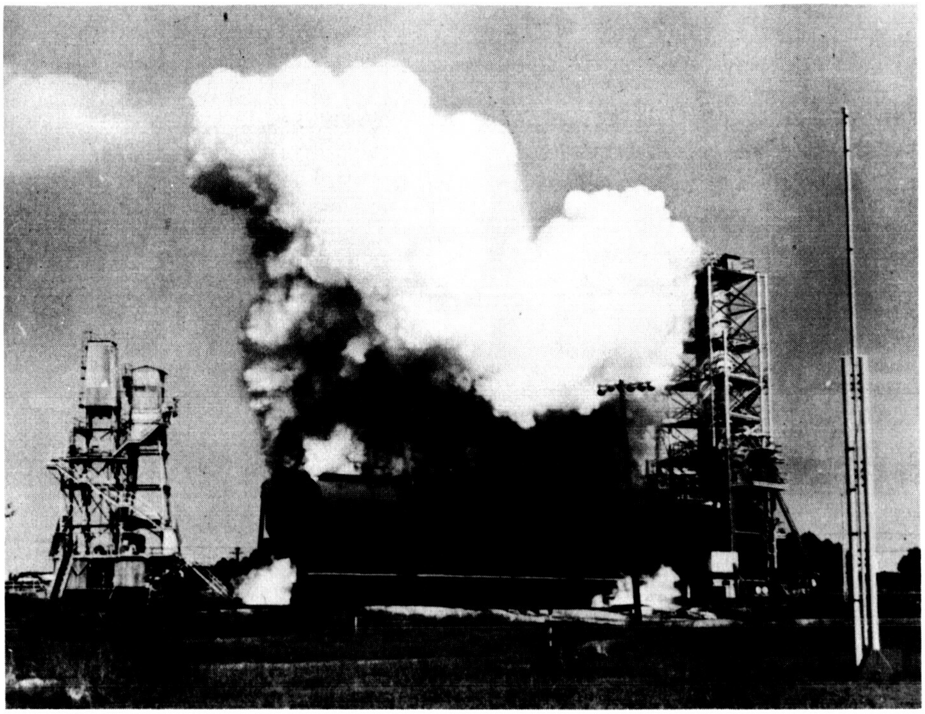
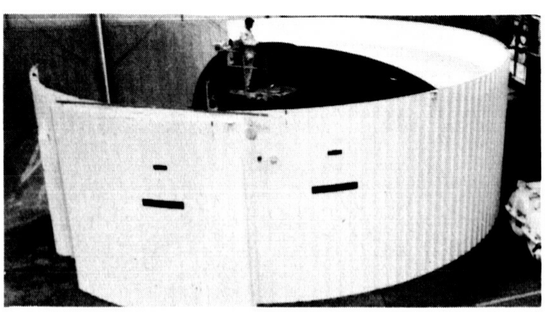
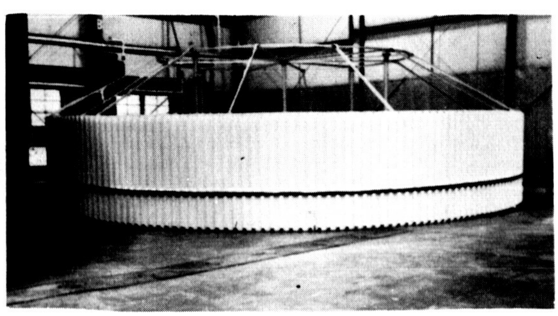


FIGURE 154. EXPERIMENTAL FIRING IN SOUND SUPPRESSOR DEVELOPMENT PROGRAM

began S-IC base heating tests. The contractor for the Saturn V second stage, NAA's S&ID, began PERT reporting at Seal Beach on the S-II program (Fig. 155) with eleven networks reflecting about 8500 activities. On September 23 S&ID sent MSFC the S-II aft and forward interface mating mockups for use in mating tests of the S-IC forward skirt.

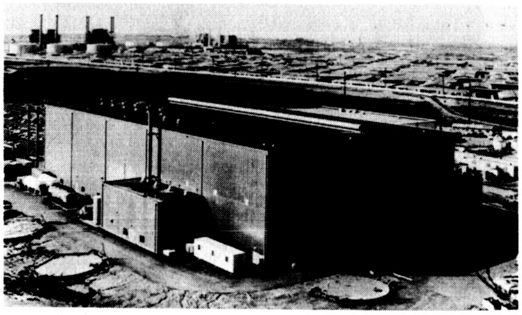


S-II AFT INTERSTAGE MOCKUP

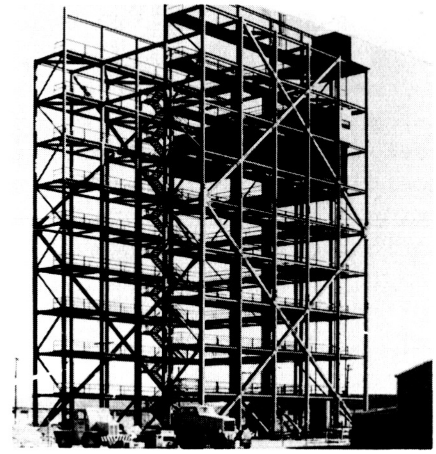


S-II FORWARD INTERSTAGE MOCKUP

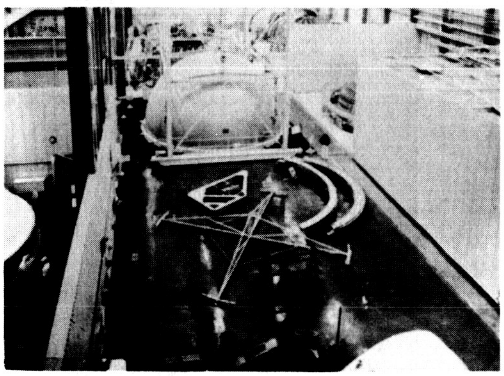
FIGURE 155. S-II STAGE ACTIVITIES



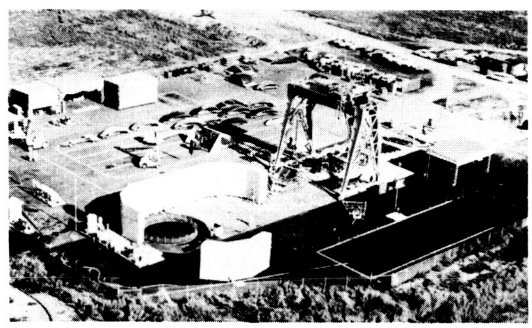
S-II BULKHEAD FABRICATION BUILDING
SEAL BEACH



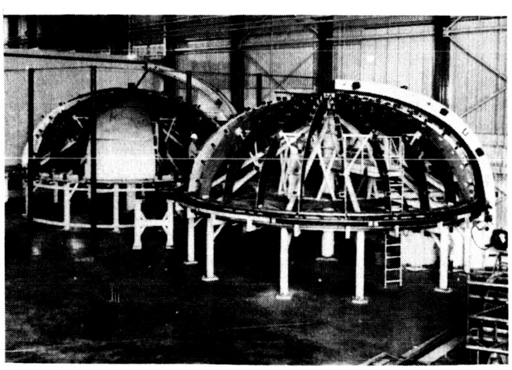
S-II STRUCTURAL TEST TOWER
SEAL BEACH



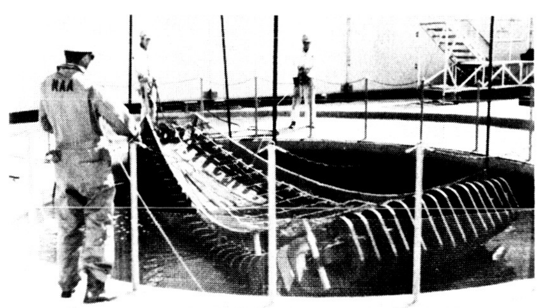
BULKHEAD FABRICATION AREA
SEAL BEACH



GORE FORMING FACILITY - EL TORO



S-II SKATE BULKHEAD WELDERS - SEAL BEACH

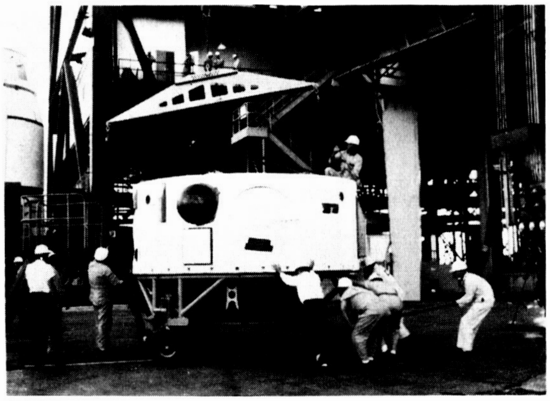


EXPLOSIVE FORMING DIE - EL TORO

FIGURE 155 CONTINUED

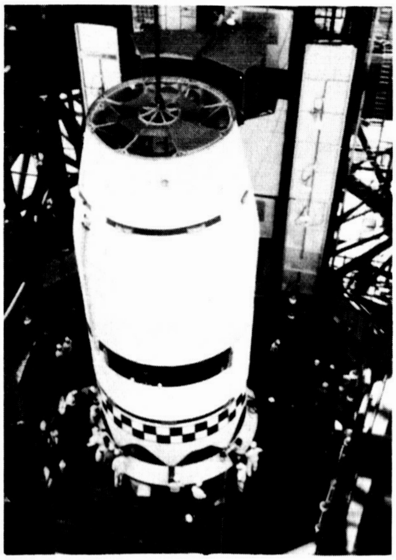
In October technicians at LC-37B joined the S-IV-5 stage, payload, and instrument unit to the S-I stage (Fig. 156). Pre-launch checkout of the SA-5 vehicle continued. In Huntsville MSFC completed the SA-5 flight operational sequence plan, providing for nine-hour completion of launch day tasks.

Progress on the other Saturn I vehicles continued during October. Chrysler completed assembly of the S-I-8 stage at Michoud. MSFC personnel discovered and corrected minor problems in the instrument unit network of the SA-6 vehicle. The Center's Test Laboratory static tested the SA-7 booster for the first time, and on October 22 performed the second and final acceptance test on S-I-7 for a duration of 138.93 seconds. DAC's second stage work at SACTO included initiation of pre-static checkout of the S-IV-6 and start of assembly of the S-IV-10.



INSTRUMENT UNIT

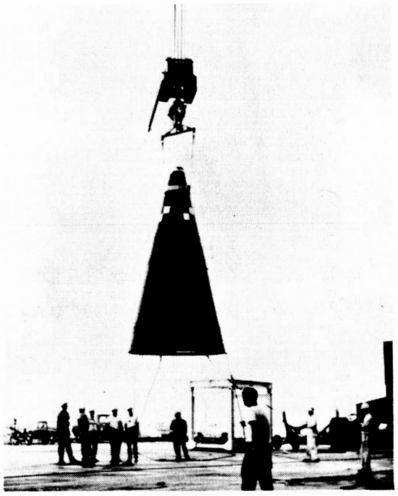
HOISTING INSTRUMENT UNIT



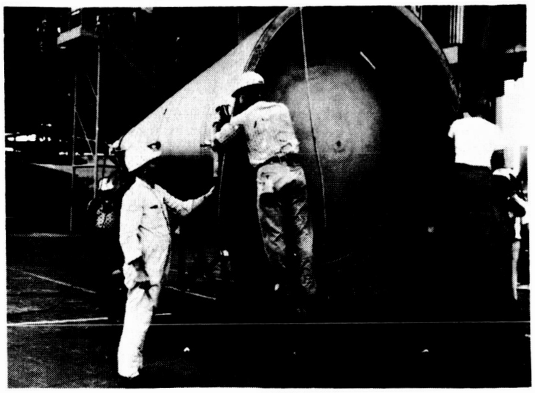
S-IV-5 STAGE

FIGURE 156. ERECTION OF SA-5 AT CAPE KENNEDY

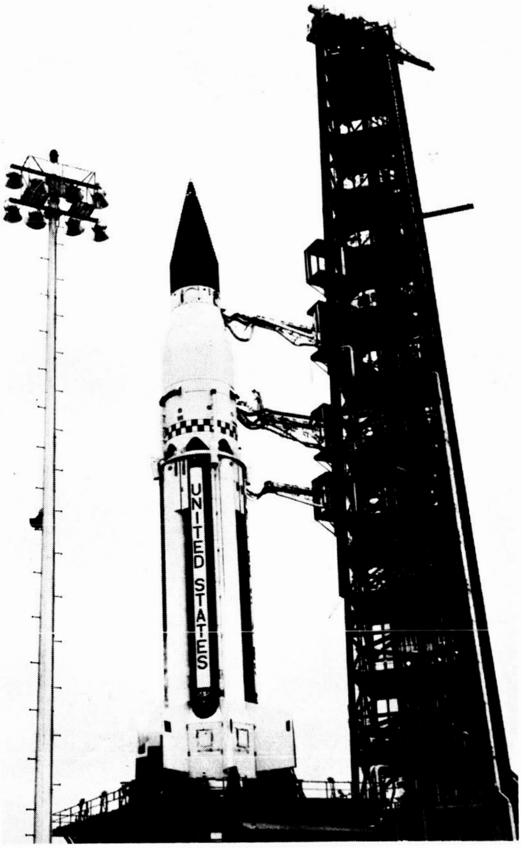
PAYLOAD ADAPTER



HOISTING PAYLOAD



PAYLOAD



SA-5 AT LAUNCH COMPLEX 37B

FIGURE 156 CONTINUED

October 1963

NASA approved a Chrysler contract modification in October that provided for 12 Saturn IB boosters in lieu of operational Saturn I boosters. At Michoud, Chrysler continued design studies on components for these S-IB stages. MSFC approved the design release for the S-IB spider beam and completed the 50 per cent design review of the gaseous oxygen line and diffuser. DAC continued work on hydrostatic and dynamic test equipment for Saturn IB's second stage and began assembly of its S-IVB battleship stage at SACTO. DAC began fabricating an S-IVB liquid hydrogen test tank in Huntsville for use in J-2 engine tests (Fig. 157).

Boeing personnel at Michoud completed the Saturn V booster lower thrust ring assembly in October (Fig. 158). MSFC personnel continued fabrication of the fuel tank and other major components for the S-IC test stage. S&ID continued

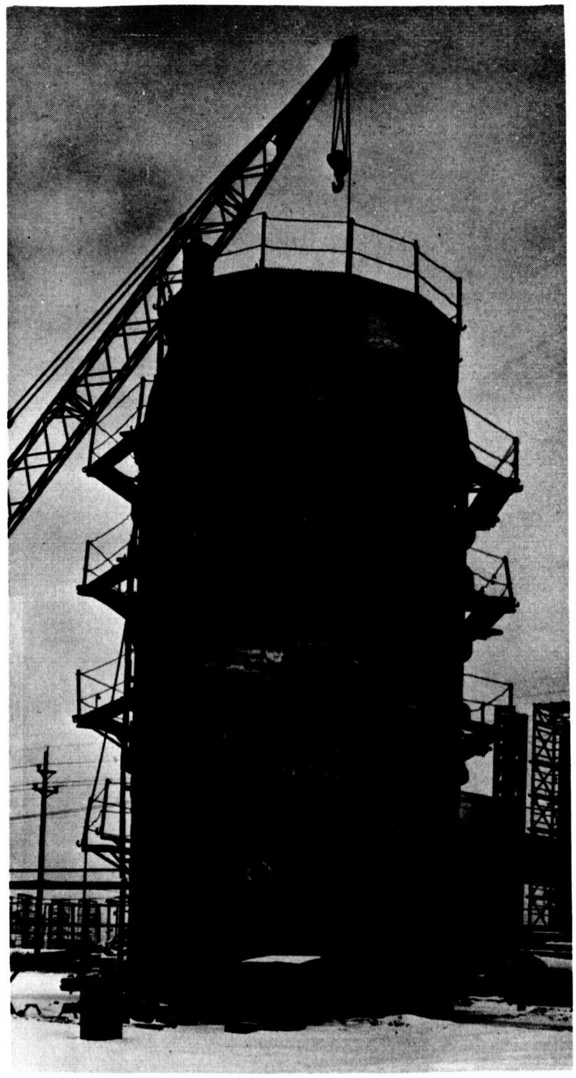
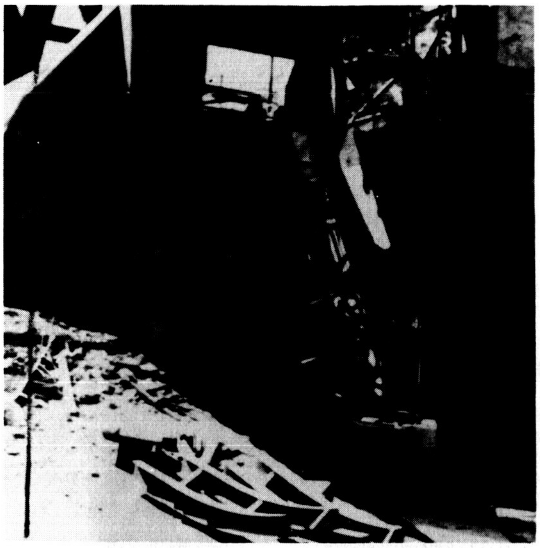


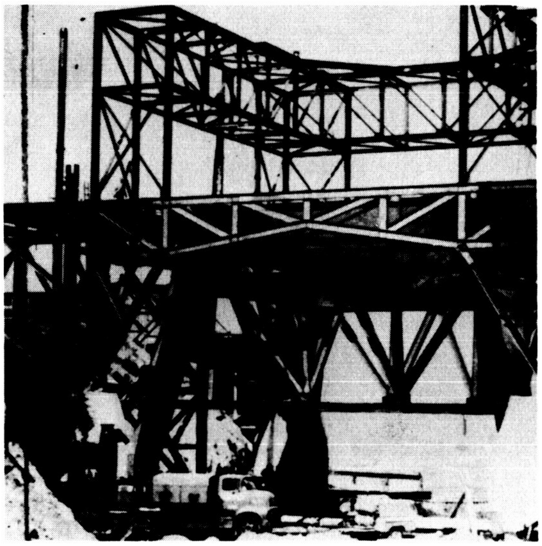
FIGURE 157. S-IVB LIQUID HYDROGEN TEST TANK, MSFC

FIGURE 158. MICHOUD MECHANIC DRILLING HOLES IN THE FIRST S-IC LOWER THRUST RING

fabrication and assembly of ground test S-II stages and construction of test stands (Fig. 159). On October 31 MSFC received from NAA's Rocketdyne Division the first production model of the huge F-1 engine.



FLAME DEFLECTOR IN BATTLESHIP TEST STAND



ALL SYSTEMS TEST STAND

BATTLESHIP TEST STAND

FIGURE 159. S-II TEST STAND CONSTRUCTION AT SANTA SUSANA

NASA announced on October 30 a rephasing of Saturn manned flight missions. Saturn I manned missions were dropped and six Saturn I vehicles thereby deleted. The Saturn I program will terminate with completion of the 10 unmanned flight vehicle R&D program. NASA approved speed-up of Saturn IB development. The more powerful Saturn IB vehicle will launch the Project Apollo manned flights in preparation for Saturn V's manned moon mission. "All-up" testing will be utilized in future Saturn flights. That is, there will be no further flights with dummy stages; development flights will test Saturn vehicles in final configuration.

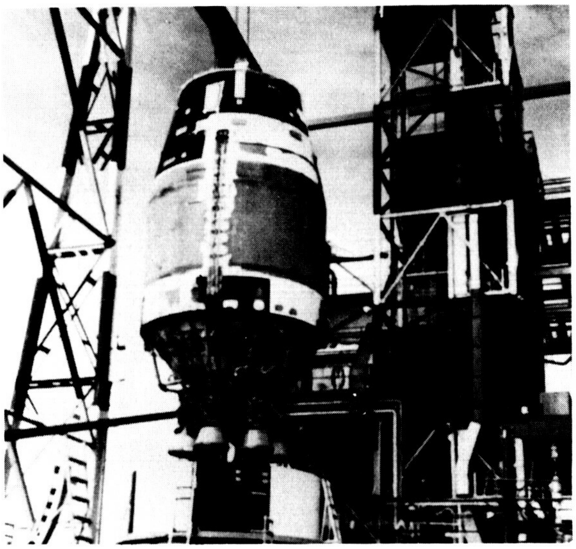


FIGURE 160. SECOND STAGE FOR SA-6 FLIGHT BEING PLACED IN SACTO STAND FOR ACCEPTANCE TESTING

In November NASA postponed the fifth Saturn I flight because of technical problems with the SA-5 vehicle. At SACTO DAC placed the SA-6 vehicle's second stage in a test stand (Fig. 160). On November 22 Douglas conducted a successful 460-second acceptance firing of this S-IV-6 stage. During November DAC finished assembly of another Saturn I second stage, the S-IV-7. The first Chrysler-built booster, S-I-8, was in final checkout.

MSFC and Chrysler completed their study of the use of uprated H-1 engines in Saturn IB's booster stage. On November 8, after Chrysler determined engine load criteria and Saturn IB schedule impact, MSFC directed Rocketdyne to develop the more powerful engine. Douglas occupied its joint Engineering Development Systems Integration Laboratory/Systems Integrations Area facility on November 1. Second stages for Saturn IB (S-IVB) will be assembled and tested in this Huntington Beach facility. At Michoud during the month Chrysler completed a mockup of the S-IB spider beam and began manufacturing the second stage adapter (Fig. 161).

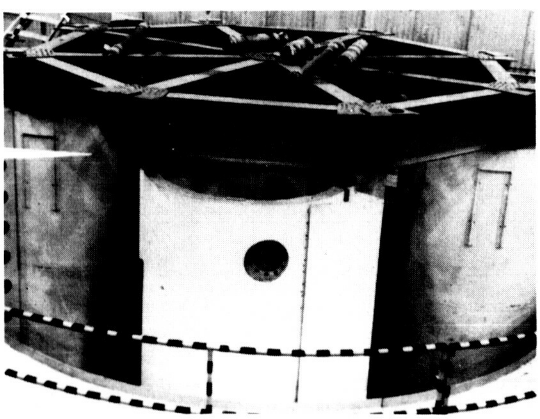
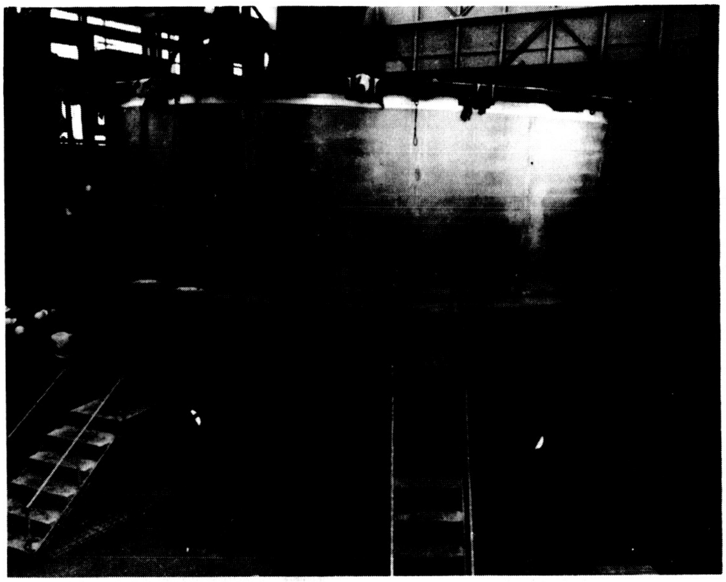
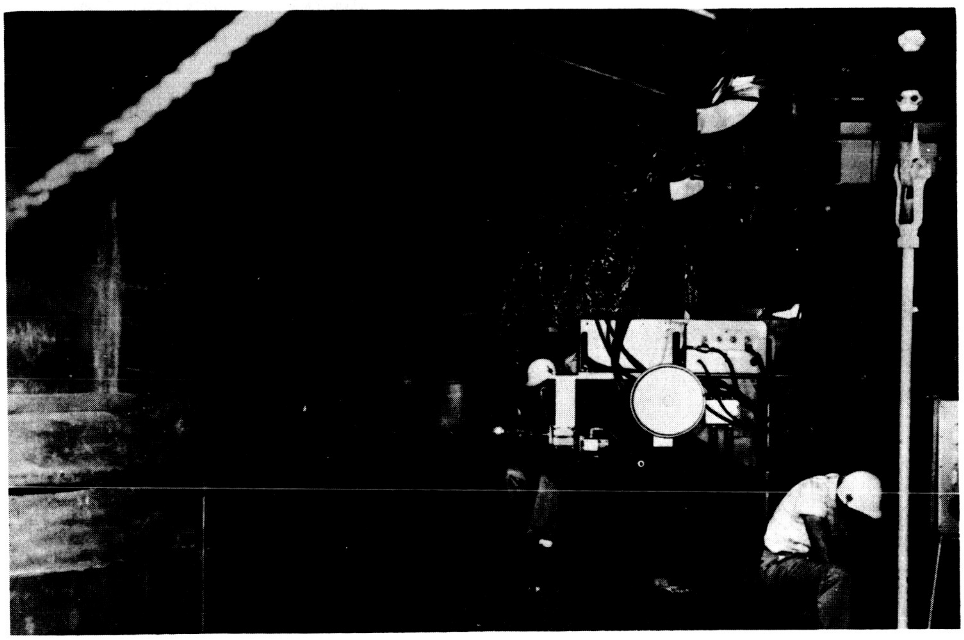


FIGURE 161. SPIDER BEAM MOCKUP FOR SATURN IB'S FIRST (S-IB) STAGE

NASA contracted on November 12 for a Saturn V launch pad at Kennedy Space Center Complex 39. The pad will cost over $19 million. MSFC continued manufacture of Saturn V booster test stage components in November (Fig. 162). The Center began S-IC stage test fuel tank assembly in its new Vertical Assembly Building. Additions to the Saturn V booster contract increased Boeing support to MSFC and raised the total value of the S-IC contract to more than $447 million.



ASSEMBLY OF S-IC TEST FUEL TANK



WELDING S-IC BULKHEAD

FIGURE 162. SATURN V BOOSTER TEST STAGE COMPONENTS

On November 8 MSFC contracted for a $13.4 million test complex at MTO for the Saturn V second stage (S-II). At Seal Beach, S&ID continued assembly of the S-II battleship stage for static tests (Fig. 163).

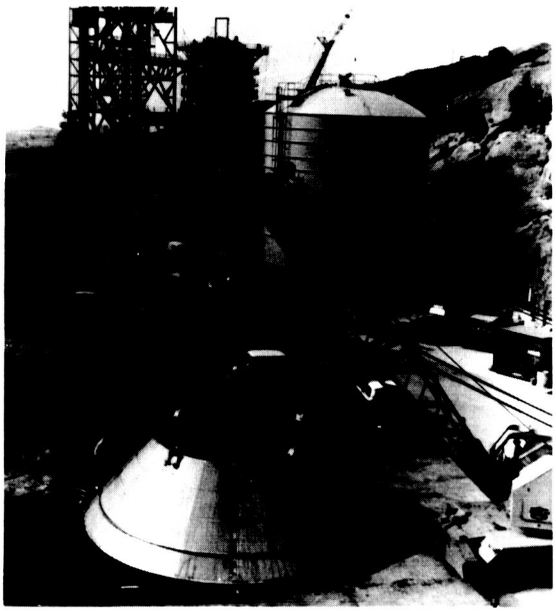


FIGURE 163. ASSEMBLY OF S-II BATTLESHIP

FIGURE 164. FIRST J-2 EXTENDED-DURATION FIRING TEST

An important engine development milestone occurred on November 27 with Rocketdyne's first extended-duration firing test of the J-2 engine (Fig. 164). This successful test of the 200,000-pound-thrust, liquid hydrogen-fueled engine lasted for more than 8 minutes. The J-2 will power upper stages of both the Saturn IB and the Saturn V vehicles.

MSFC in December postponed the SA-5 flight until January 1964 after discovering cracks in fuel line fittings on the S-I-5 stage. MSFC decided to replace critical tubing on it and all remaining S-I stages. On December 13 MSFC accepted from Chrysler at Michoud the first industry-built Saturn I booster (S-I-8).

By the end of December Chrysler had completed and MSFC had approved most of the structural redesign of Saturn IB's first stage. During the month NASA awarded the basic S-IVB contract modification which also accelerated the program for this Saturn IB second stage. Also, DAC completed fabrication of major components for the S-IVB hydrostatic test stage.

Saturn V progress during the month included MSFC's first F-1 engine tests on December 3 and 5. Duration of the first firing test was 1.25 seconds. The second firing lasted ten seconds (Fig. 165). On December 20 NASA updated the Boeing S-IC contract to amend the stage delivery schedule. The contract as changed meant that MSFC rather than Boeing would provide the second S-IC flight booster. On December 27 NASA amended the prime S-II stage contract with S&ID in order to make the first S-II flight stage "live" instead of a dummy. During December NASA signed an agreement with the Military Sea Transport Service (MSTS); by the agreement the USNS Point Barrow would be used for shipment of S-II stages from the West Coast manufacturing site to test and launch sites.

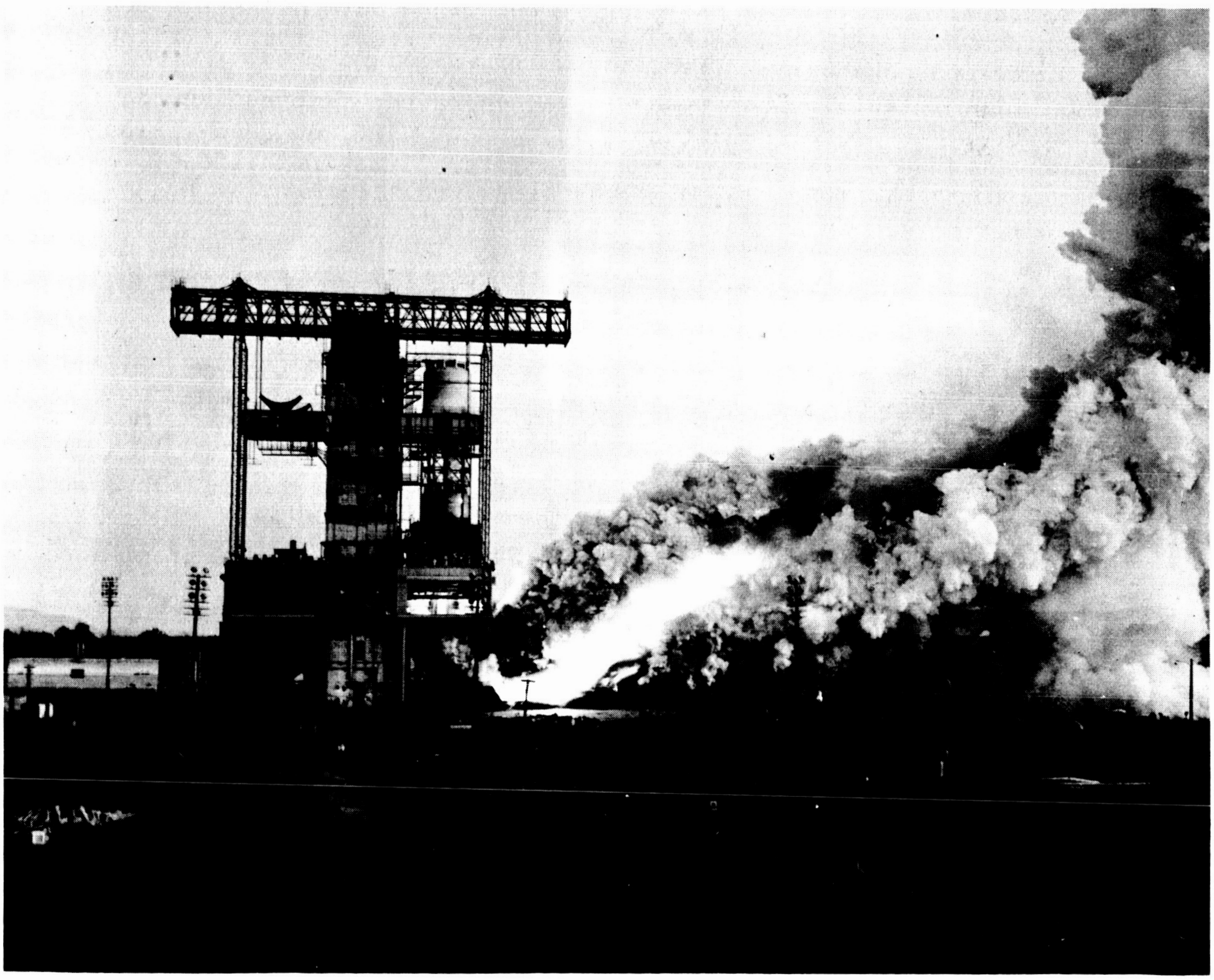
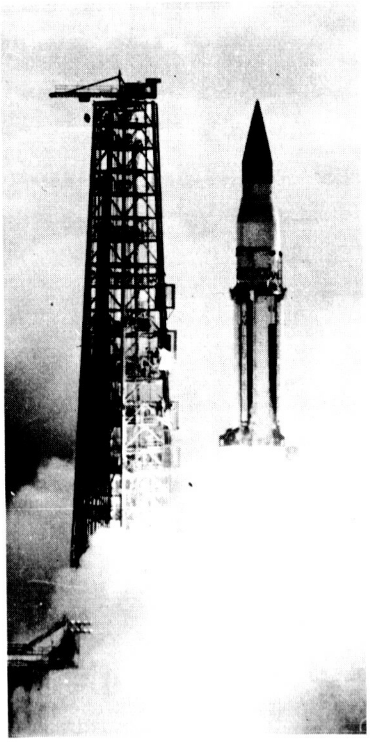


FIGURE 165. MSFC F-1 ENGINE FIRING TEST

January 1964 saw the beginning of the last phase of the Saturn I research and development program. The first four flight vehicles had carried dummy second stages. Now flight testing of second stages began.

Early in January technicians installed new tubing assemblies in the SA-5 booster. On January 24 DAC second stage work underway at SACTO suffered a setback when the S-IV all systems vehicle exploded during an attempt to static fire it. An overpressurized oxidizer tank caused loss of this vehicle as well as damage to the test stand and ground support equipment. On January 27 a blocked fuel line caused a two-day postponement of the SA-5 flight; technicians had failed to remove a flange used in checking the liquid oxygen line.

On January 29, 1964, NASA launched the fifth Saturn I (Fig. 166). The liquid hydrogen-fueled second stage, flight tested for the first time, functioned perfectly. First-stage engines shut off as planned, 147 seconds after liftoff. The second stage separated, ignited, burned for eight minutes, and with the attached instrument unit and sand-filled nosecone attained orbit as an earth satellite. Time from liftoff until orbit was 10.32 minutes. The almost 19-ton satellite was the heaviest ever orbited.



SECOND STAGE SEPARATION (ARTIST'S CONCEPT)

FIGURE 166. THE FIFTH SATURN I FLIGHT

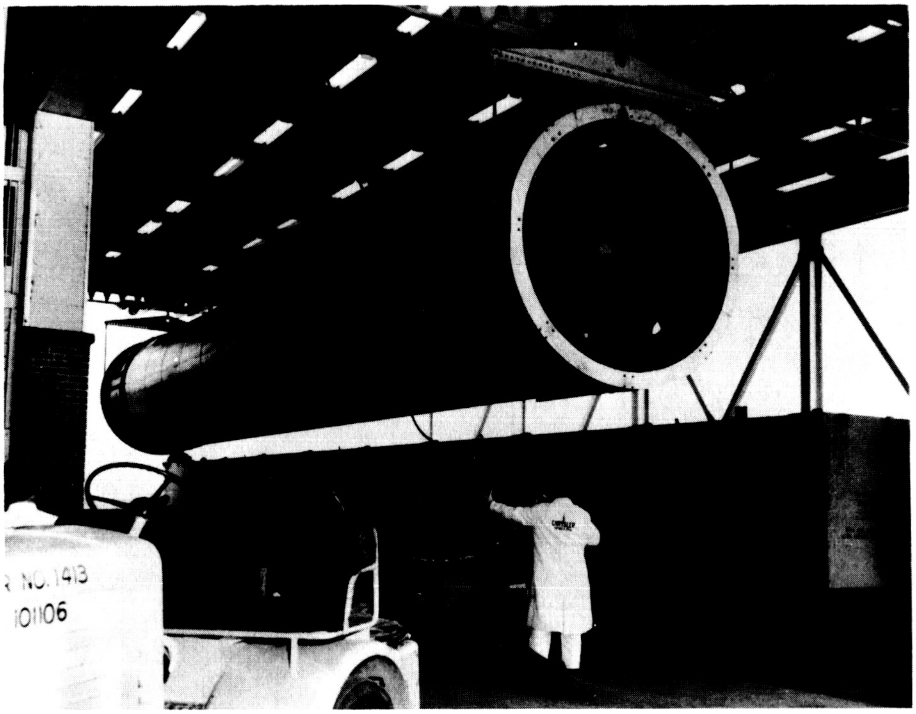


FIGURE 167. SATURN I LOX TANK WHICH WILL BE MODIFIED FOR SATURN IB

Meanwhile, MSFC continued production of test components and expansion of test facilities for Saturn IB and Saturn V multi-stage rockets. NASA announced in January that construction budgets for Saturn IB and Saturn V facilities at Michoud and the nearby Mississippi Test Facility would be \$6,534,000 and \$61,991,000, respectively, for Fiscal Year 1965.

In February MSFC shipped Saturn I's sixth flight booster and instrument unit from Huntsville to KSC; the trip by barge took eleven days. DAC flew the S-IV-6 stage to the Cape. On February 19 MSFC successfully completed meteoroid payload fairing separation tests for SA-8 and SA-9 missions. MSFC decided that the sixth Saturn I vehicle would have an active guidance system.

In February, Chrysler started fabrication of components for the first two Saturn IB boosters (Fig. 167), utilizing some of the components available from cancelled Saturn I vehicles. Second stage accomplishments included DAC's fabrication work on the S-IVB/IB-1 as well as further development of the S-IVB hydrostatic, all systems, dynamic, and battleship test stages. DAC also worked on an S-IVB facilities checkout stage.

Saturn V progress included MSFC's successful hydrostatic testing on February 8 of the first stage (S-IC) test fuel tank (Fig. 168). During

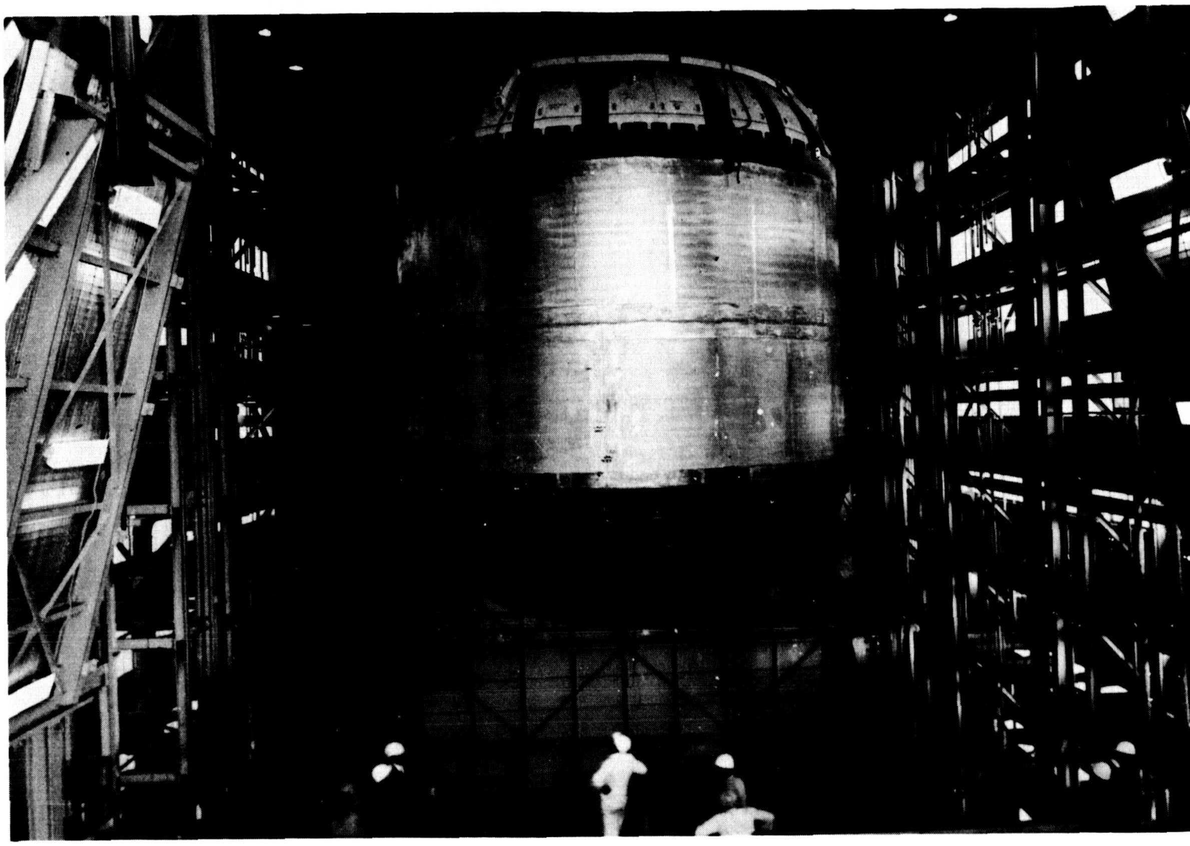


FIGURE 168. SATURN V TEST FUEL TANK

February the Center conducted seven static tests on an F-1 engine. At Edwards AFB an F-1 engine systems test on February 28 ended in an explosion and severe engine damage. Rocketdyne attributed the explosion to structural failure of the LOX pump. Rocketdyne's other systems tests were generally successful. S&ID continued manufacture of the S-II battleship stage thrust structure and aft skirt assembly in its stand at Santa Susana.

During February atmospheric physicists of MSFC's Aero-Astrodynamics Laboratory participated in a wind data study. In the ten-day search for atmospheric jet streams which affect rocket flight they released 161 weather balloons (rawinsondes). This was part of an extensive measuring program in Southeastern United States originated by MSFC to aid Saturn stage structural designers in studies on sound propagation.

In March Kennedy Space Center technicians worked overtime preparing for the sixth Saturn I launching. In Huntsville, MSFC performed vibration tests on the SA-9 instrument unit, S-IU-9, and also began dynamics testing on vehicles in the SA-8, SA-9, and SA-10 configurations. MSFC successfully static fired S-I-9, final booster manufactured by the Center, in a short duration test. DAC continued second stage production (Fig. 169) and started static tests on the S-IV-7 at SACTO. CCSD completed fabrication and replacement of critical tubing assemblies for S-I-10 at Michoud.

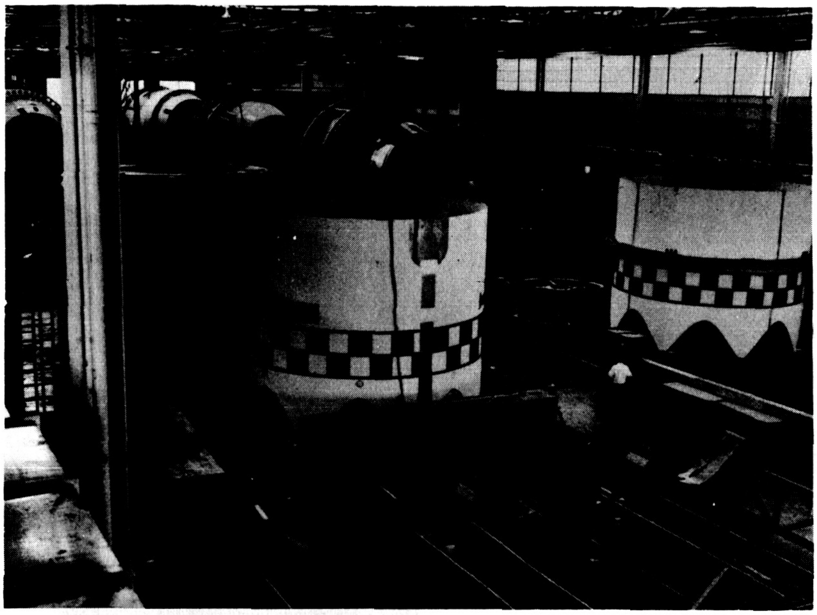


FIGURE 169. SATURN I SECOND STAGE PRODUCTION

Saturn IB activities during March included beginning of fabrication of components for the second S-IVB flight stage, the S-IVB/IB-2. DAC also started assembly of the S-IVB dynamics test stage (Fig. 170) in its assembly tower at Huntington Beach. Early in March the Center awarded a contract to IBM for Saturn IB and Saturn V instrument unit digital computers and data adapters. MSFC also arranged for integrating the eight systems of the Saturn IB and Saturn V instrument units. These systems are: guidance, control, electrical, measuring, telemetry, radio frequency, structural, and environmental. IBM, under a $5.5 million contract, will provide development plans, test plans, and procurement specifications during the five-year first phase of the contract. On March 23 NASA published Saturn IB mission assignments as coordinated with MSFC and MSC.

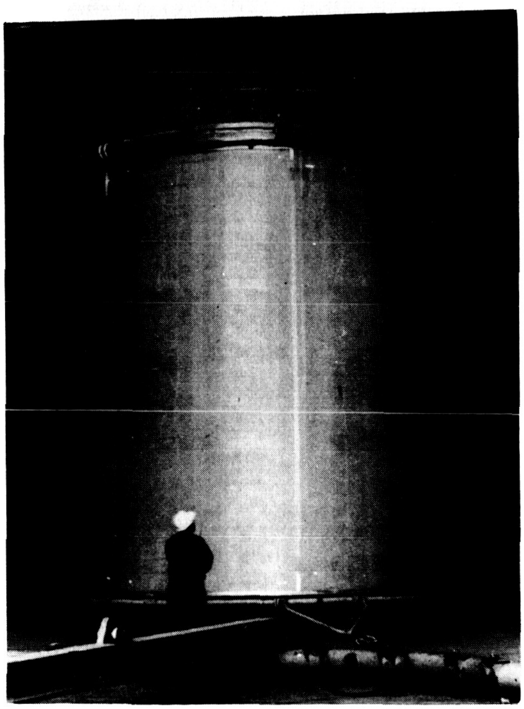


FIGURE 170. S-IVB DYNAMICS TEST STAGE

At Seal Beach, S&ID began assembly of the first Saturn V second stage (S-II) flight hardware. S&ID technicians conducted three successful tests of S-IC/S-II separation techniques. In Huntsville MSFC moved the completed S-IC test fuel tank to its load test facility on March 6. Other MSFC Saturn V activities during the month included construction progress on the $30 million static test facility in the Center's West Test Area. This Saturn V static test facility (Fig. 171) will be used to test four S-IC stages in Huntsville: one flight booster built at Michoud by Boeing, a non-flight MSFC-built stage, and the first two S-IC flight stages, both to be built by MSFC. The Center completed the dynamic test stand superstructure in March.

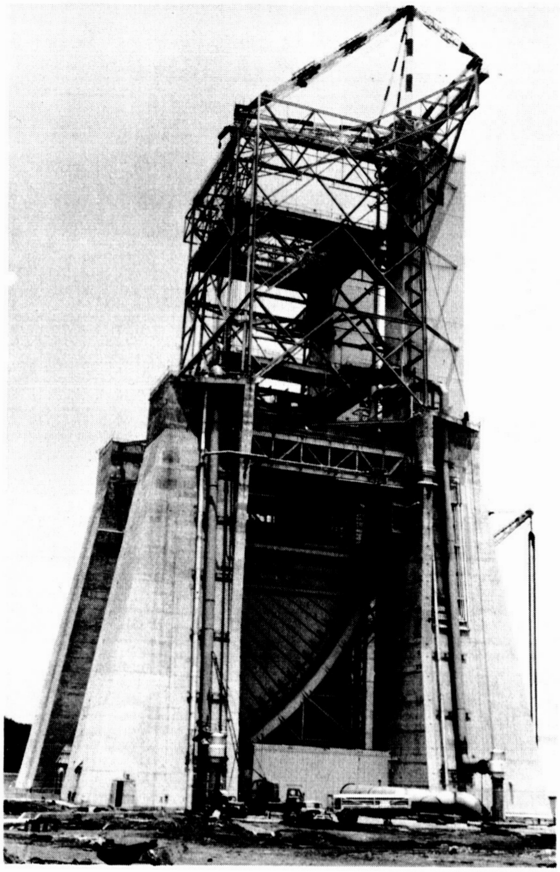
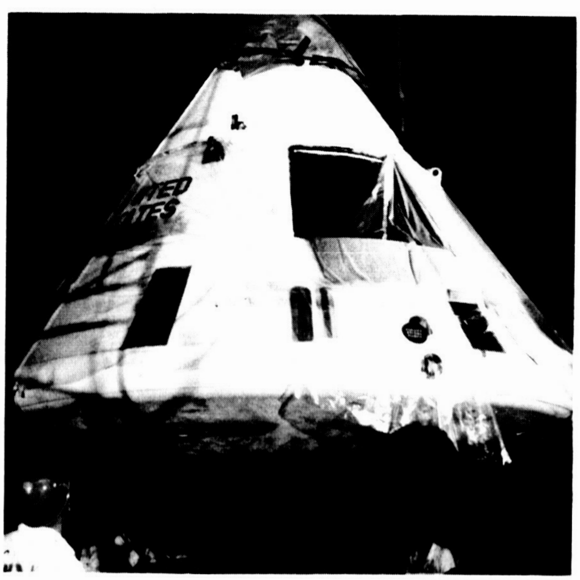


FIGURE 171. MSFC STATIC TEST STAND FOR SATURN V BOOSTER

NASA completed Saturn I second stage negotiations with DAC on April 17; scope changes increased the DAC S-IV contract by $22 million. During April the Apollo command module was mated to the spacecraft. This Apollo payload was then joined to the SA-6 vehicle at Cape Kennedy (Fig. 172). On April 24 the first industry-produced Saturn I booster arrived at MSFC from Michoud (Fig. 173). The Chrysler-built S-I-8 stage went directly to MSFC's static test stand. On April 29 DAC successfully acceptance fired the S-IV-7 stage. During April the Center decided to make minor changes in the S-IU-9 on the basis of vibration test results. MSFC announced that the SA-10 vehicle would carry a meteoroid detection satellite as its payload. This type payload, also to be used for the SA-8 and SA-9 flights, will aid the investigation of hazards from meteoroid particles to both manned and unmanned spacecraft.



MATING COMMAND MODULE

FIGURE 172. JOINING APOLLO TO SA-6

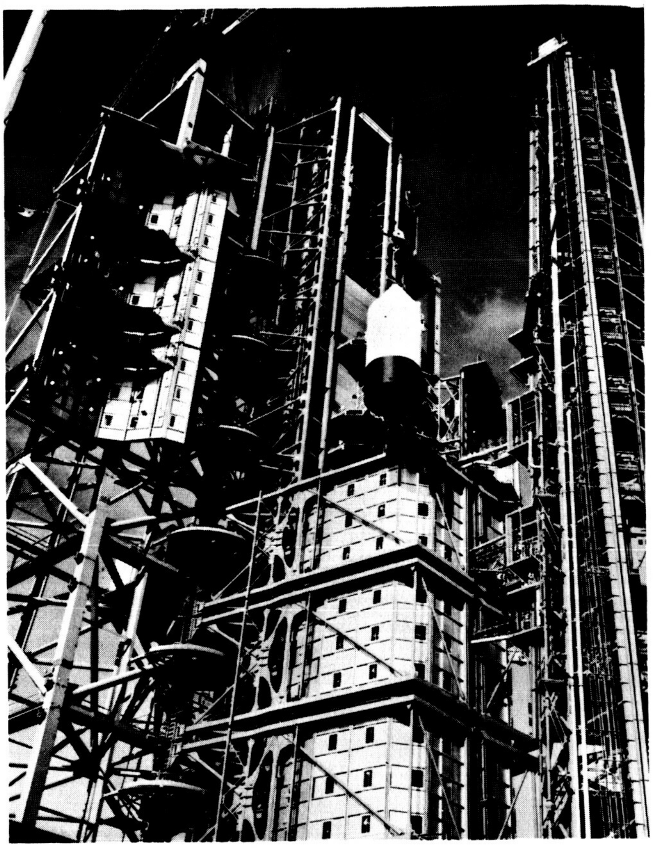


FIGURE 172 CONTINUED -
JOINING APOLLO PAYLOAD TO SA-6

During a Saturn IB procurement discussion early in April, NASA and MSFC discussed the problem of orbital debris. NASA inquired about the possibility of controlled reentry of the S-IVB stage. The Center feared a critical loss of load capability if the S-IVB were redesigned to provide this but study of the problem continued. Early in April DAC completed the S-IVB structural test stage at Huntington Beach. On April 14 the forward dome of the dynamics test stage for Saturn IB second stages was damaged during production proof testing of the propellant tank assembly. At Michoud during April Chrysler progressed in the fabrication and assembly of the S-IB-1, the booster stage for SA-201, the first Saturn IB flight vehicle. Chrysler technicians were putting together two major structural assemblies, the second stage adapter and the thrust structure, for the S-IB-1.

Early in April MSFC negotiated with RCA for 19 ground computer systems to be used in checkout, static test, and launching of Saturn IB and Saturn V vehicles. Cost of these systems and seven ordered last year

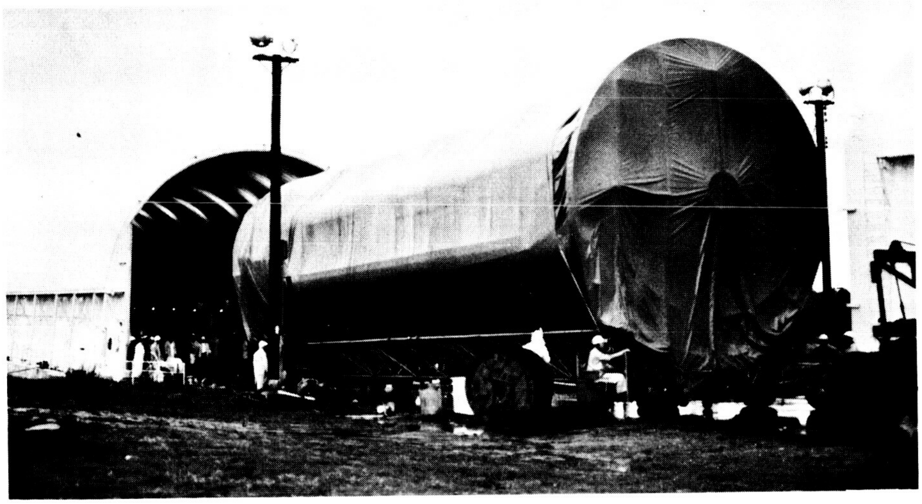


FIGURE 173. S-I-8, FIRST INDUSTRY-PRODUCED SATURN BOOSTER, BEING UNLOADED FROM BARGE AT MSFC

will total more than $47 million. They will be used at Michoud, MTO, and Cape Kennedy Launch Complexes 34, 37, and 39. NASA completed instrument unit (Fig. 174) arrangements for Saturn IB and Saturn V during April. Under a prime contract effective May 1 IBM became lead contractor for work which, together with previous instrument unit assignments to IBM, is expected to cost $175 million over a five-year period. NASA delegated management of this work to MSFC. Meanwhile, Army Engineers requested bids for an MSFC facility to study noise characteristics and sonic environment data independent of full-scale firings. Saturn IB and V upper stage engine production and testing continued at Rocketdyne's Canoga Park and Santa Susana sites. Rocketdyne delivered the first J-2 production engine (Fig. 175) to DAC for the S-IVB battleship during April.

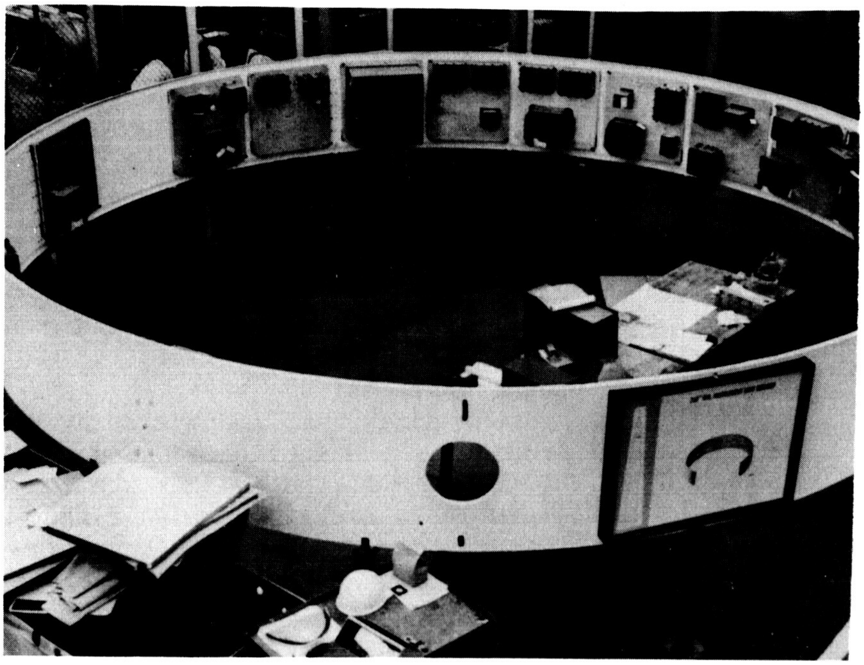


FIGURE 174. MOCKUP OF INSTRUMENT UNIT FOR SATURN IB AND SATURN V

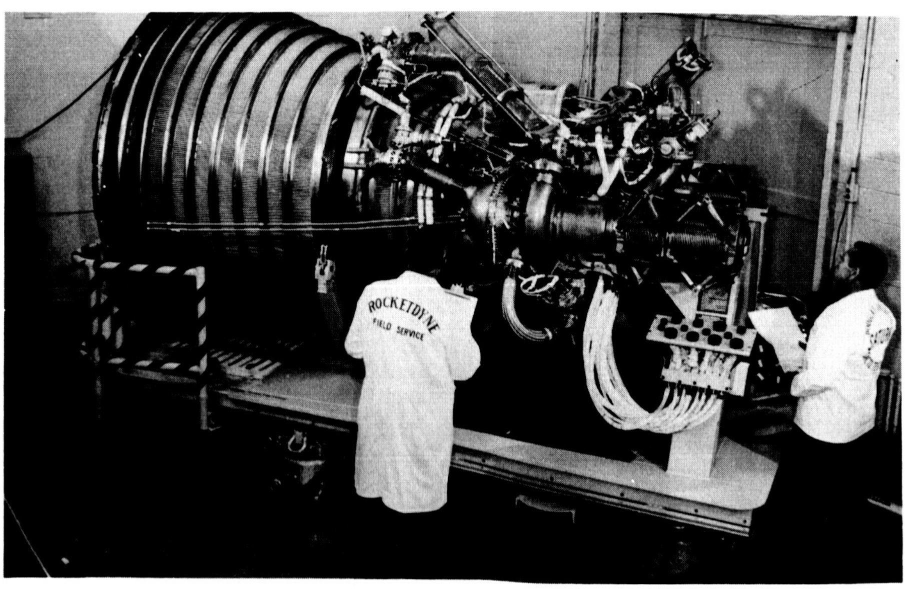


FIGURE 175. FIRST J-2 PRODUCTION ENGINE DELIVERED TO DAC

Saturn V booster facilities in Huntsville continued to expand during April. MSFC awarded a contract worth more than \$2½ million to Sullivan, Long, and Hagerty of Birmingham, Alabama, for a 100-foot-high hangar to house large components of this S-IC stage. NASA provided almost \$6 million additional support for the S-IC booster program at Michoud (Fig. 176) in a contract supplement awarded the Boeing Company for additional research, quality assurance, and mission planning. At Downey, California, S&ID completed fabrication of two giant bulkheads for the Saturn V second stage (S-II). NASA also modified S&ID's contract in April, adding more than \$12 million to provide for vertical checkout of the S-II stages at Seal Beach and at MTO. The Center studied ground support equipment (GSE) needs for Saturn V. On April 22 MSFC held a conference on electrical support equipment (ESE) to be furnished by General Electric. MSFC personnel prepared a preliminary schedule of Saturn V GSE deliveries and installation.

FIGURE 176. MOVING SATURN V BOOSTER TANK BULKHEAD AT MICHOUD

Early in May stress corrosion was discovered in aluminum tube assemblies in the S-IV-6 stage. These were replaced without delay to the SA-6 flight. However, minor problems in fueling the S-IV-6 stage caused a six-day launch delay and GSE compressor trouble held up the flight two days.

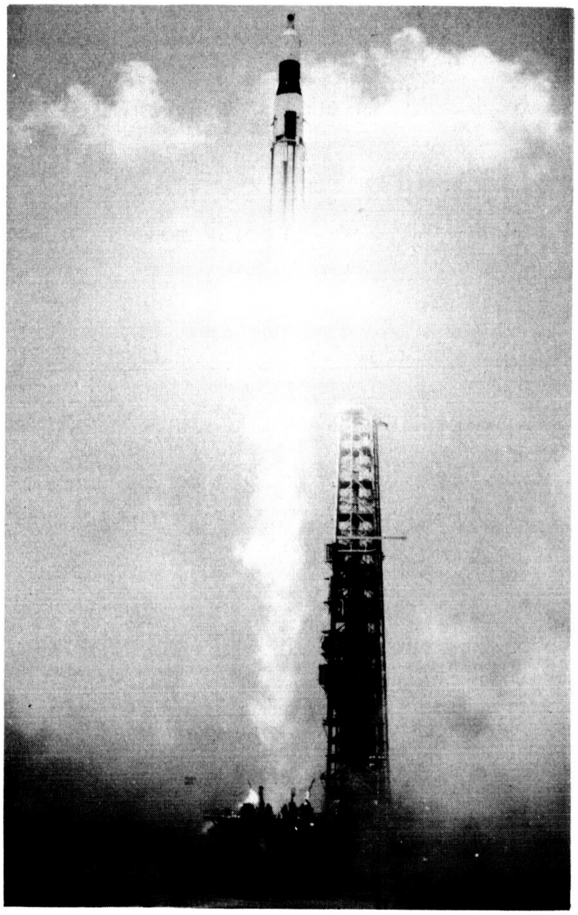


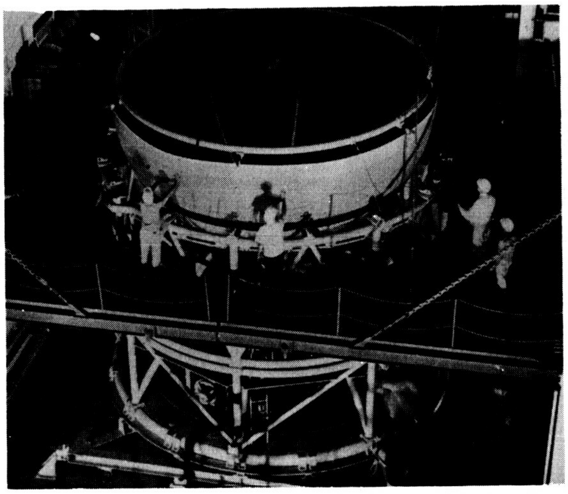
FIGURE 177. SIXTH SATURN I FLIGHT

MSFC negotiated with DAC on May 19 for Saturn IB ground support equipment and additional Saturn IB second stages. On May 27 MSFC and DAC personnel agreed on a DAC program of computer reporting for MSFC on S-IVB/IB status.

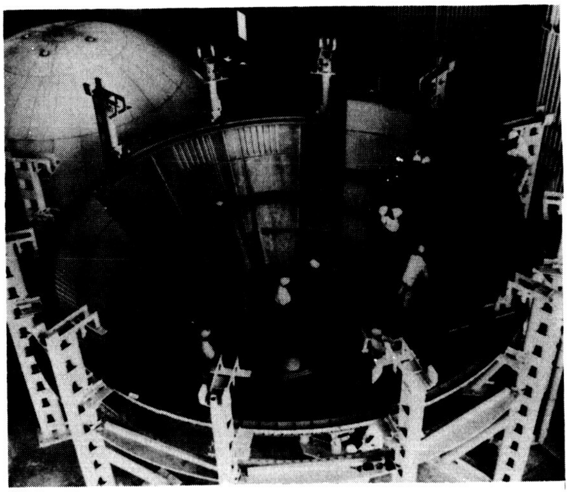
On May 4 Saturn V personnel met in Washington to consider the Apollo reliability and quality assurance program. During the month MSFC completed a plan for integrating computer information from Saturn V systems, stages, and projects. MSFC and MSC continued Saturn/Apollo interface study in meetings during May.

The sixth Saturn I flight occurred on May 28 (Fig. 177). The SA-6 flight was successful, as all preceding flights had been. The vehicle's guidance system, active in this flight for the first time, corrected a deviation from the planned trajectory caused by premature shutdown of one of the engines. The payload, 37,300 pounds and slightly lighter than that of the record SA-5 load, included a boilerplate Apollo spacecraft which reentered the atmosphere and disintegrated as expected after 3.3 days and 50 orbits of the earth. On the day this flight took place, MSFC started the seventh flight booster and instrument unit on the water voyage to Cape Kennedy.

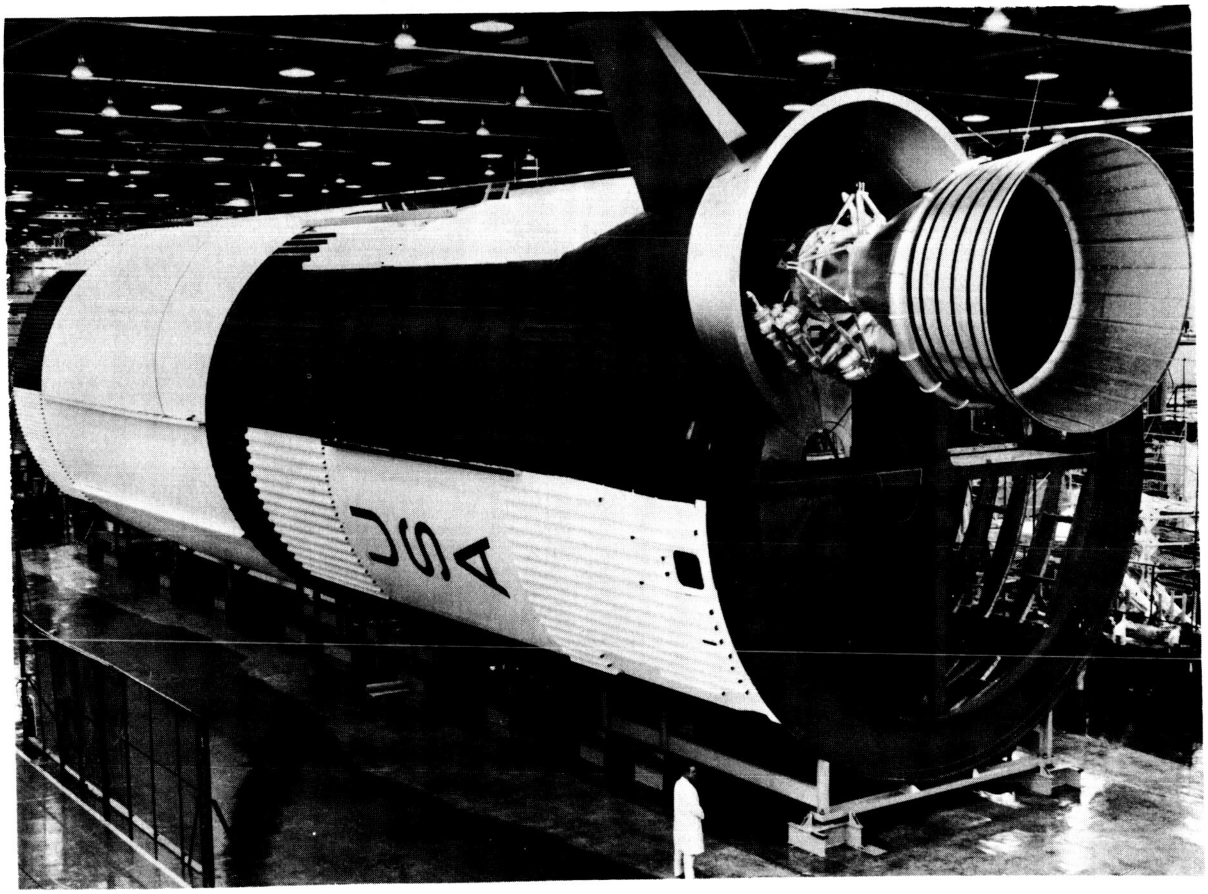
At the end of May 1964 four Saturn I flights remained. Fabrication of stages for the Saturn IB was underway. Saturn V, the launch vehicle for the Apollo mission, began to emerge (Fig. 178). Ground test stages were taking form, and huge facilities that would test them were rising at MSFC, Michoud, MTO, and contractors' sites.



LOX TANK ASSEMBLY FOR S-IVB STAGE, UPPER STAGE FOR SATURN IB AND V



FIRST SATURN V SECOND STAGE (S-II) FLIGHT HARDWARE



SATURN V BOOSTER FULL SCALE MOCKUP AT MICHOUD

FIGURE 178. SATURN IB AND SATURN V PROGRESS AT TIME OF SIXTH SATURN I FLIGHT

During June MSFC, KSC, MSC, and associated contractors evaluated the sixth Saturn I flight. Included in their data were films (Fig. 179) from eight on-board movie cameras recovered after the flight and nearly 1200 performance measurements telemetered to ground stations during the flight. Analysis affirmed success of the on-board guidance system (Fig. 180), severely tested by unexpected shutdown of one of the first stage engines. This ST-124 guidance system became active shortly after second stage ignition and corrected trajectory deviation. After the SA-6 review NASA decided to lighten the S-IV stage on the four remaining flights by reducing fuel reserve.

Other Saturn I activity in June included arrival of SA-7 payload and vehicle major components at Cape Kennedy; MSFC's successful ground firing of S-I-8, the first booster produced by private industry; and start of assembly of S-IU-8, instrument unit for the SA-8 vehicle.

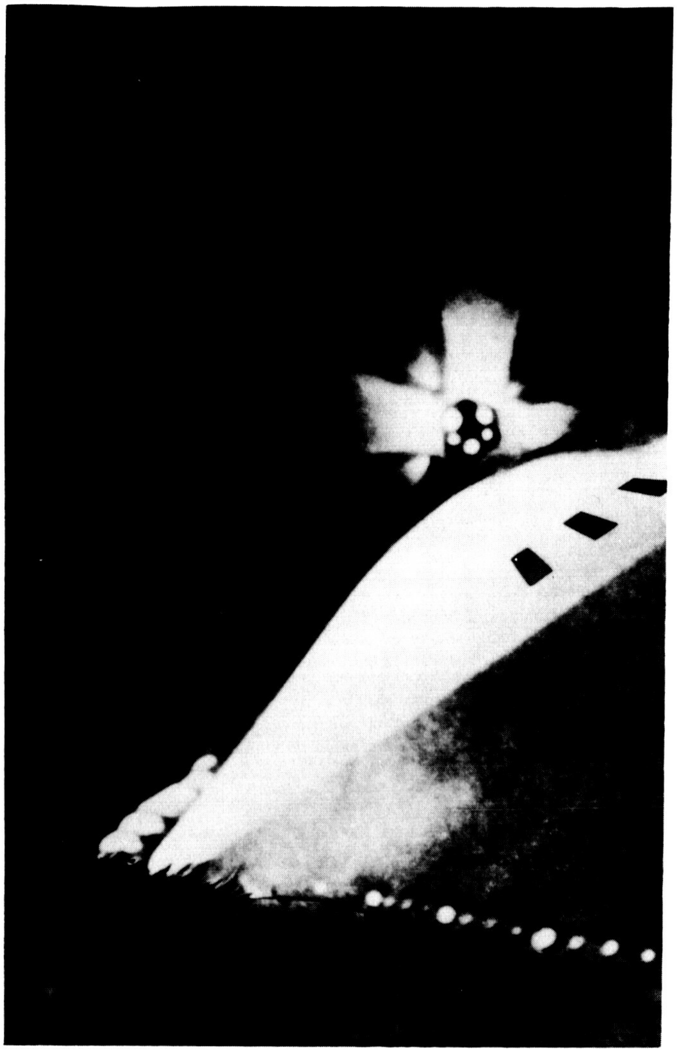


FIGURE 179. ON-BOARD CAMERA PHOTOGRAPH OF SA-6 STAGE SEPARATION

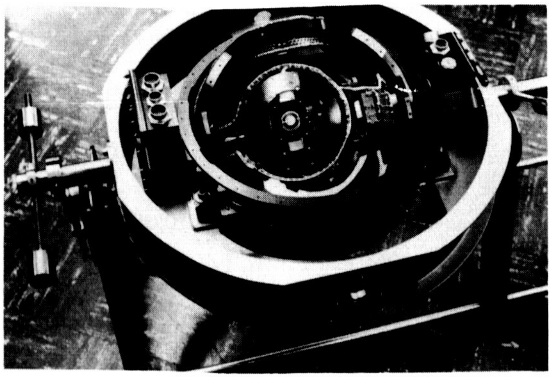


FIGURE 180. ST-124 GUIDANCE STABLE PLATFORM

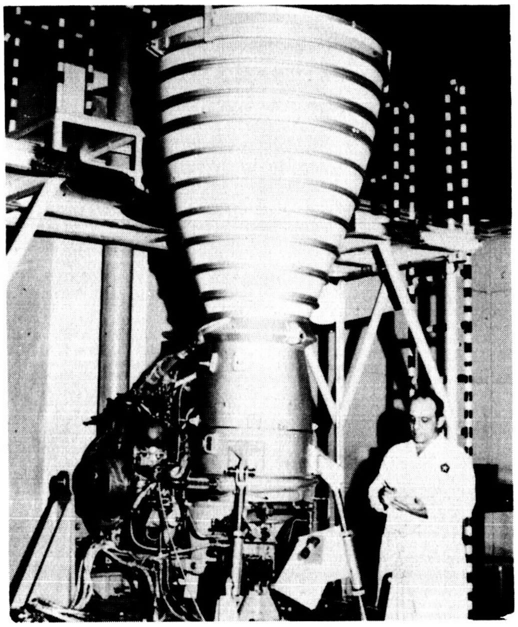


FIGURE 181. H-1 ENGINE, UPRATED FOR SATURN IB BOOSTER

NASA's middle-sized Saturn, Saturn IB, progressed during June to beginning of manufacture of the first flight booster. By mid-June North American Aviation-Rocketdyne had delivered the first four uprated 200,000-pound-thrust H-1 engines to Michoud for the Saturn IB booster (Fig. 181). Chrysler began clustering tanks of the first flight booster, S-IB-1, during June. Douglas continued work at Huntington Beach on the Saturn IB second stages (Fig. 182) and progressed with assembly of a facilities checkout stage. Instrumentation problems delayed cold flow tests on the second stage propulsion test stage, the S-IVB battleship, but Douglas reported successful checkout of the S-IVB structural test stage prior to testing. A ground support equipment development highlight at Huntington Beach was successful checkout of second stage prototype automatic test equipment.

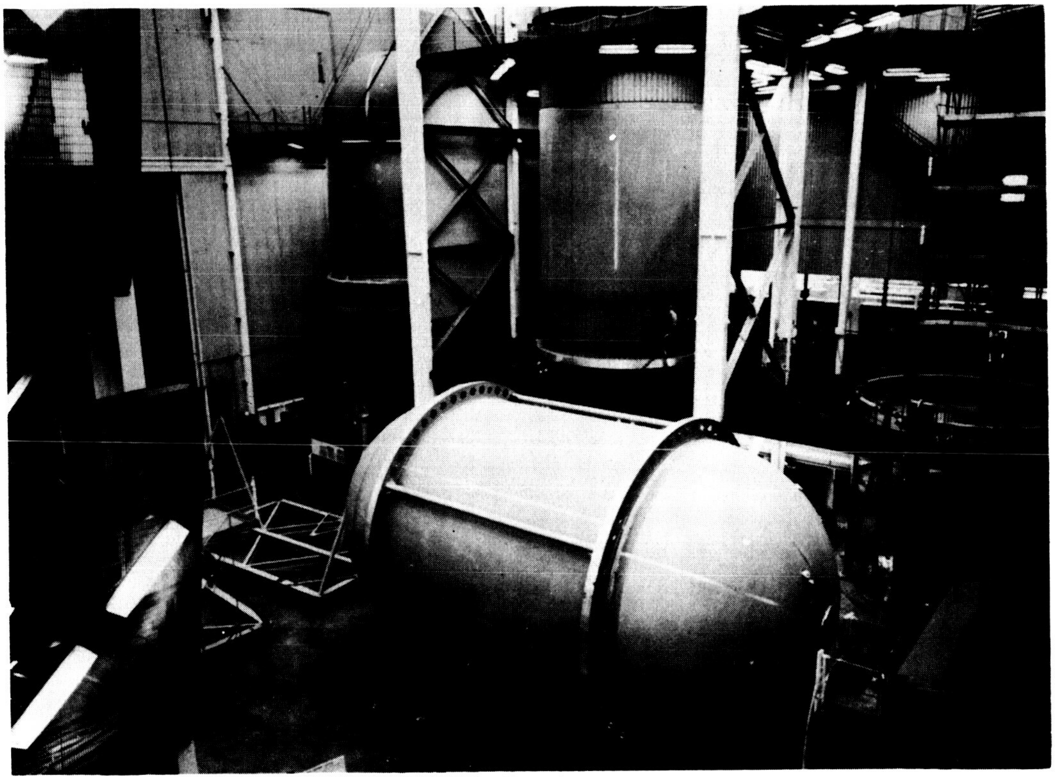
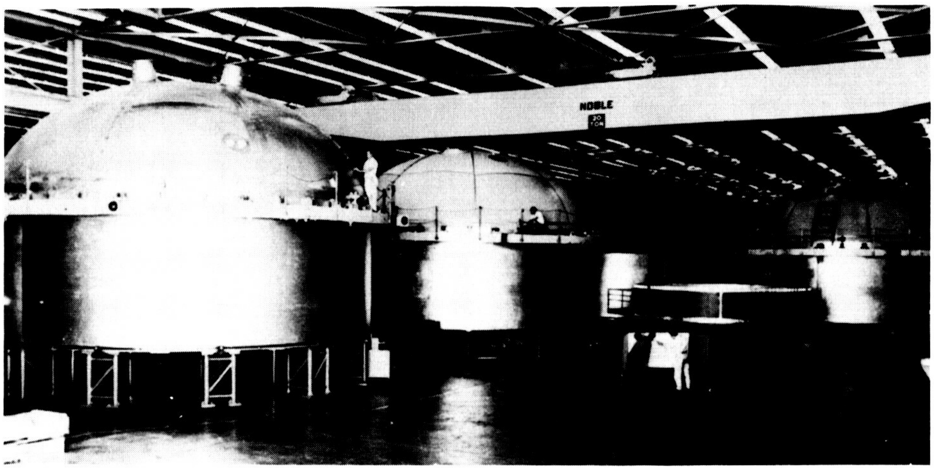
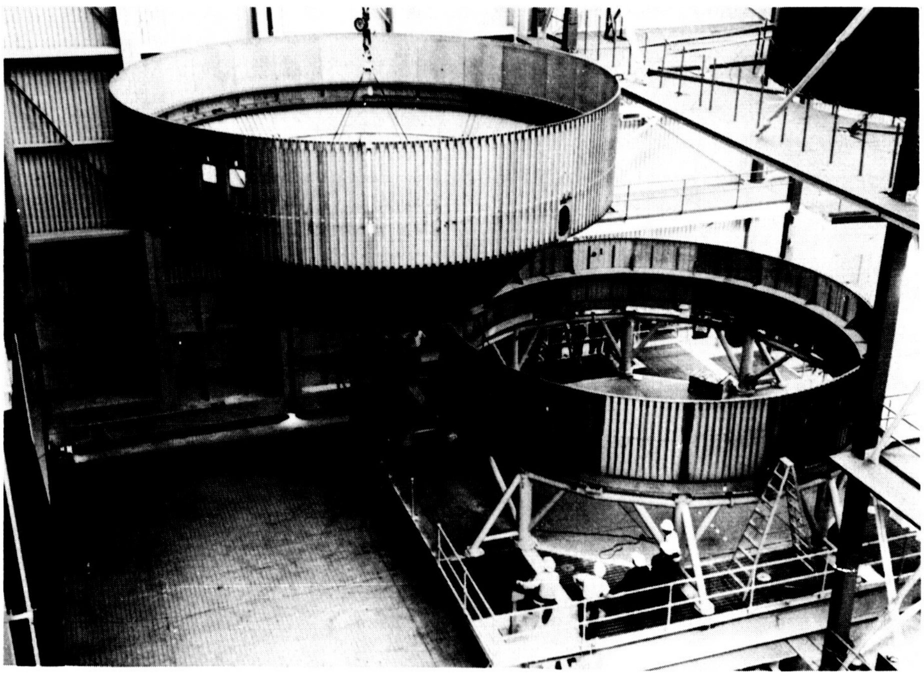


FIGURE 182. SATURN IB SECOND STAGES (S-IVB) IN DOUGLAS COMPANY TOOLING TOWER, HUNTINGTON BEACH, CALIFORNIA



FUEL AND LOX TANKS BEING BUILT IN HUNTSVILLE, ALABAMA, FOR THE SATURN V FIRST STAGE (S-IC)



STRUCTURAL TEST STAGE THRUST UNIT AT SEAL BEACH, CALIFORNIA, FOR THE SATURN V SECOND STAGE (S-II)

FIGURE 183. FABRICATION OF SATURN V

With Saturn V manufacture continuing (Fig. 183), NASA announced during June that it would study the feasibility of increasing the weight-lifting capacity of the vehicle by more than one-third. MSFC sought proposals on which to base contracts for preliminary studies expected to cost about $2 million.

In early July MSFC completed the last phase of the Saturn I dynamic test program with successful tests of the SA-8, 9, and 10 vehicle configuration. MSFC's Saturn I dynamic test stand would now be one of the complex of MSFC Saturn IB and Saturn V test stands (Fig. 184).

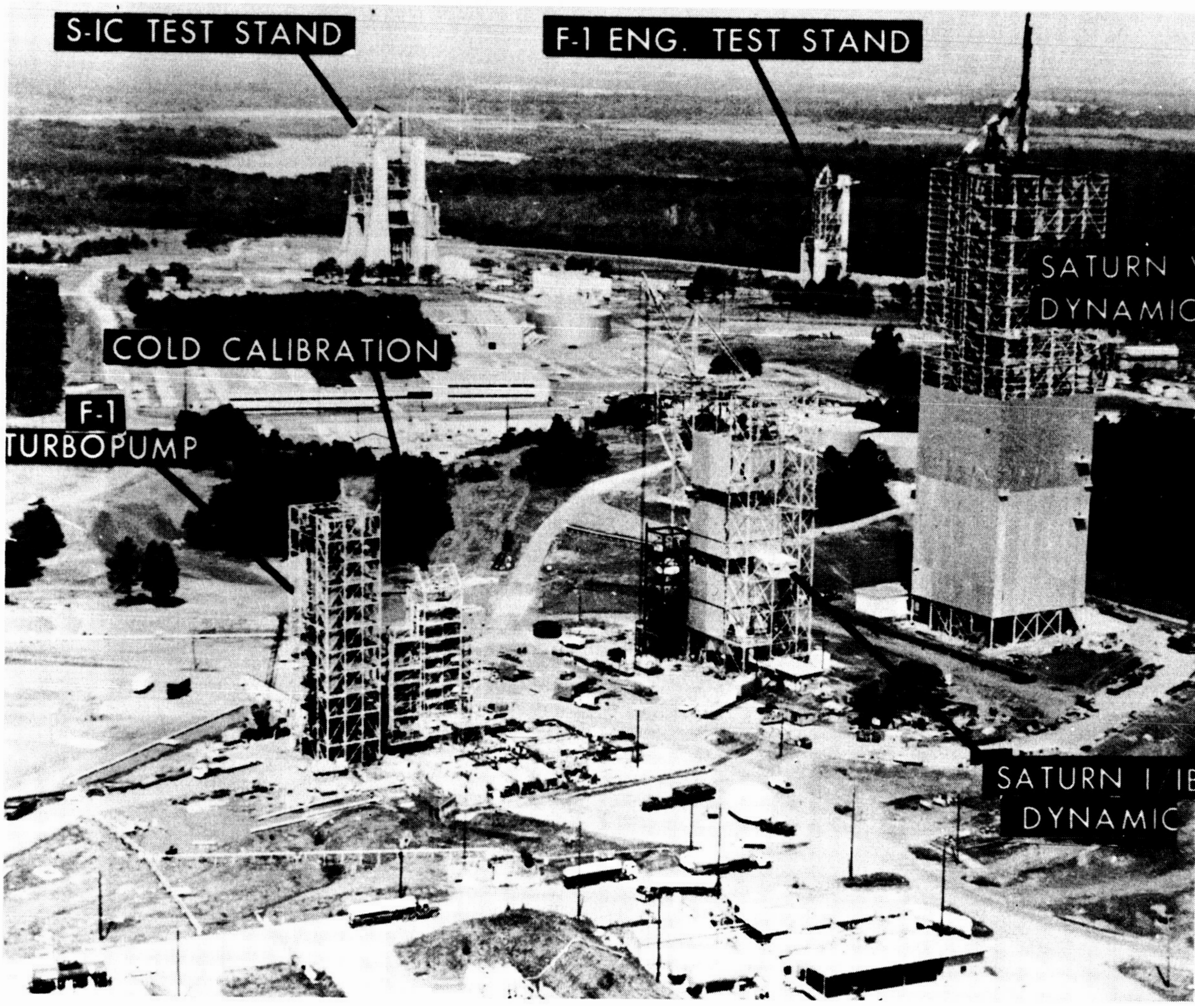


FIGURE 184. AERIAL VIEW OF MSFC SATURN TEST STANDS

Preparation for the seventh Saturn I flight included installation of a non-propulsive propellant tank venting system in the second stage to reduce tumbling of the vehicle's payload in orbit. Also, following discovery of "stress corrosion" cracks, all eight engines were removed from the SA-7 vehicle's first stage and sent back to Rocketdyne where aluminum alloy domes were substituted.

The final three Saturn I vehicles neared completion. Douglas employees at Santa Monica finished inspecting the S-IV-8 stage prior to its delivery to SACTO for static test. Chrysler personnel at Michoud completed prestatic checkout of the final Saturn I booster, S-I-10.

Meanwhile, MSFC personnel at Huntsville conducted checkout of Instrument Unit S-IU-9 (Fig. 185). Besides these events in July, NASA amended its S-IV stage contract with Douglas to add R&D work valued at more than $21 million.

By mid-July Chrysler at Michoud had clustered all tanks for the first Saturn IB booster, S-IB-1, and by the end of the month installed all eight uprated H-1 engines. Chrysler worked on the second booster (S-IB-2) components (Fig. 186) and began the third booster.

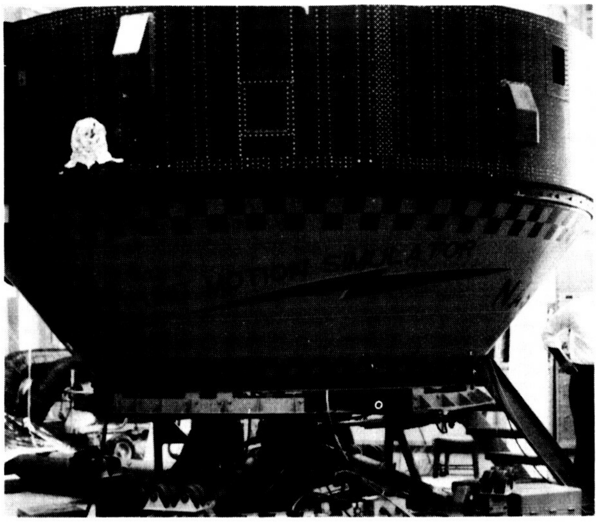


FIGURE 185. S-IU-9 CHECKOUT

FIGURE 186. CHRYSLER PERSONNEL WORKING ON S-IB-2 THRUST STRUCTURE AT MICHOUD

Chrysler personnel also began converting the Saturn I dynamic test booster to a Saturn IB dynamic test stage. After dynamic tests this stage will be used to check out Kennedy Space Center Saturn IB launch facilities. This modified stage was designated S-IB-D/F. Meanwhile, Douglas second stage (S-IVB) progress during July included insulating the dynamic test stage, rework on the battleship stage, and hydrostatic testing for leaks in the liquid hydrogen tank of the structural test stage. Douglas continued work on ground support equipment (Fig. 187).

FIGURE 187. DOUGLAS PERSONNEL WORKING ON GROUND SUPPORT EQUIPMENT AT HUNTINGTON BEACH

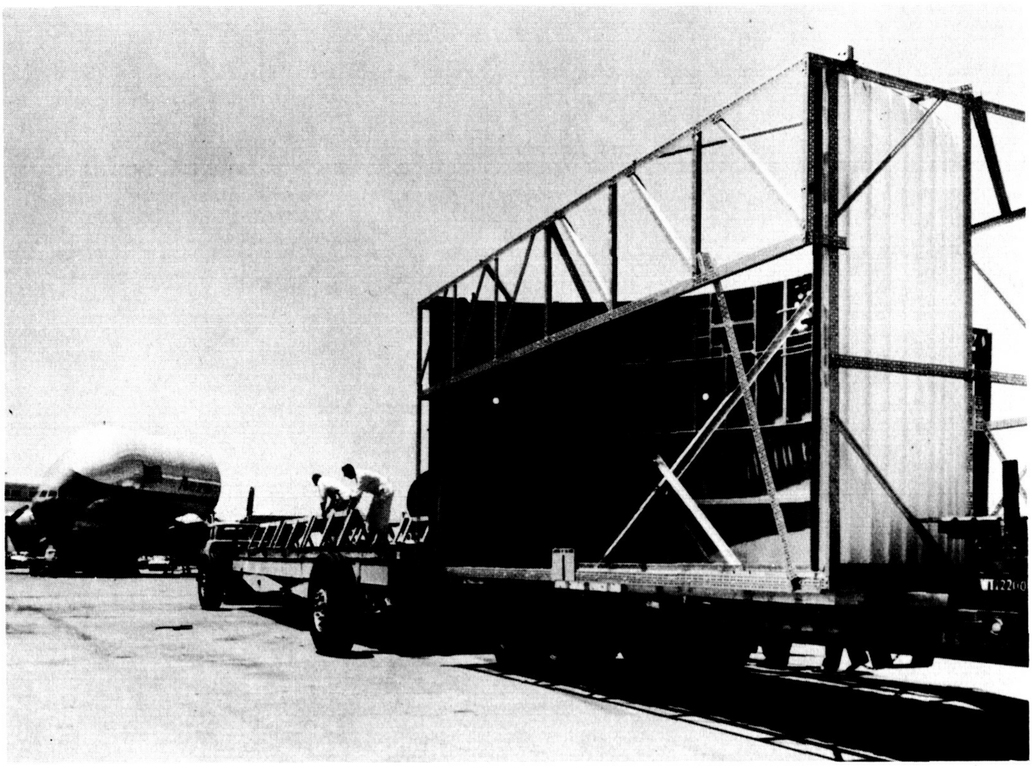


FIGURE 188. FIRST SATURN V HARDWARE FROM DOUGLAS

Saturn V booster production at Michoud was several weeks behind schedule in July; parts shortages accounted for some of the delay. Third stage problems included rupture of the S-IVB hydrostatic test stage because of two faulty weld repairs--tests were considered complete, however, because sufficient information had been obtained.

The first of two test stands for the Saturn V second stage (S-II) was completed by North American Aviation at its Santa Susana Field Laboratory in July. On July 11 Douglas delivered its first Saturn V third stage test hardware to Huntsville (Fig. 188). Flown from Long Beach, California, this S-IVB stage forward skirt would connect the top of that stage to the vehicle instrument unit.

Saturn V contract action included addition of over $22 million to Rocketdyne's F-1 engine contract for acceleration of combustion stability research and a variety of hardware and services, a $3.6 million J-2 facility contract to Rocketdyne, a launch vehicle computer contract with IBM, and two contracts for more than $2 million each to Douglas for S-IVB rocket stage items and S-IVB automatic checkout equipment, respectively. On July 13 Army's Corps of Engineers of Mobile, Alabama, acting as NASA's agent for MTO construction, awarded a contract worth more than $17 million for construction of the first test position on the giant S-IC dual test stand.

On August 6 at Sacramento Douglas personnel successfully acceptance fired S-IV-9, second stage of the SA-9 flight vehicle (Fig. 189). During

FIGURE 189. BLOCKHOUSE ACTIVITY AT SACRAMENTO TEST FACILITY DURING S-IV-9 ACCEPTANCE FIRING

August the Fairchild Hiller Corporation continued work on meteoroid detection satellites to be orbited by the last three Saturn I vehicles. Each satellite, soon after second stage separation and orbit, would extend its wings to a span of 96 feet. During the month NASA named the satellites "Pegasus" after the winged horse of ancient mythology. Problems with their development threatened the schedule of the last three Saturn I launches.

NASA launched its seventh Saturn I from Cape Kennedy on September 18 (Fig. 190). The two-stage rocket placed approximately 37,000 pounds of payload into an orbit similar to the interim orbit for future three-man Apollo lunar missions (145-mile apogee, 112-mile perigee). Boilerplate Apollo spacecraft command and service modules, instrument unit, and the spent S-IV stage comprised the satellite. All major test objectives were met: final development testing of Saturn I propulsion, structural, guidance and flight control systems; development testing of Apollo spacecraft structure and design; demonstration of physical compatibility of launch vehicle and spacecraft; and test-jettisoning of spacecraft launch escape system. Cameras ejected after the flight were abandoned because of Hurricane Gladys, but some were later unexpectedly recovered. After this flight Saturn I was declared operational--achieving its goal three vehicles early.

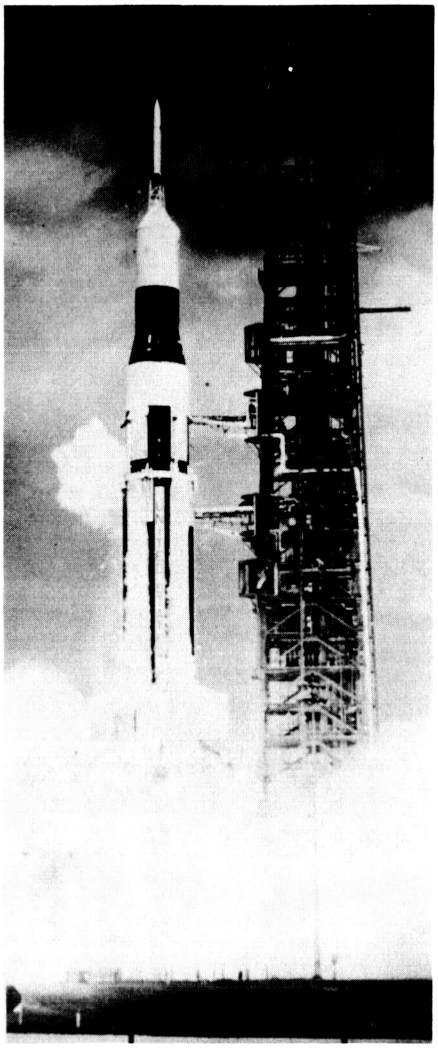


FIGURE 190. SA-7 RISES

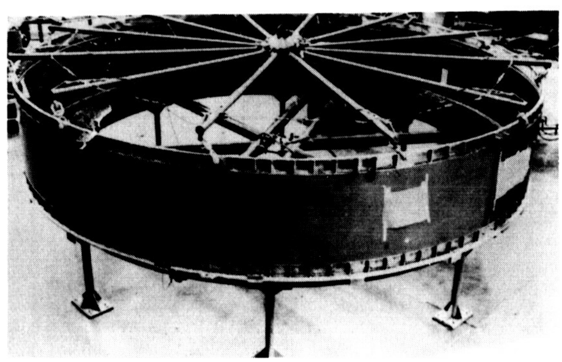


FIGURE 191. SATURN IB NON-FLIGHT INSTRUMENT UNIT

Saturn IB accomplishments by late September included MSFC's strengthening of the structure and start of component assembly for S-IU-200V (Fig. 191), a non-flight Saturn IB instrument unit. At Michoud Chrysler personnel were modifying the dynamic test stage, S-IB-D/F (Fig. 192), using modified flight tail section (Fig. 193), and other Saturn I test stage components, with a new spider beam (Fig. 194). Douglas had completed propellant loading in an S-IVB propulsion test stage, the S-IVB battleship. A Saturn IB program assessment had caused MSFC to extend the test period for this stage and to terminate the all systems test program. The S-IVB all systems test stage became a facilities checkout stage. MSFC was reviewing the S-IVB battleship test program on a daily basis, having found that problems with propulsion testing were affecting the Saturn IB second stage development schedule.

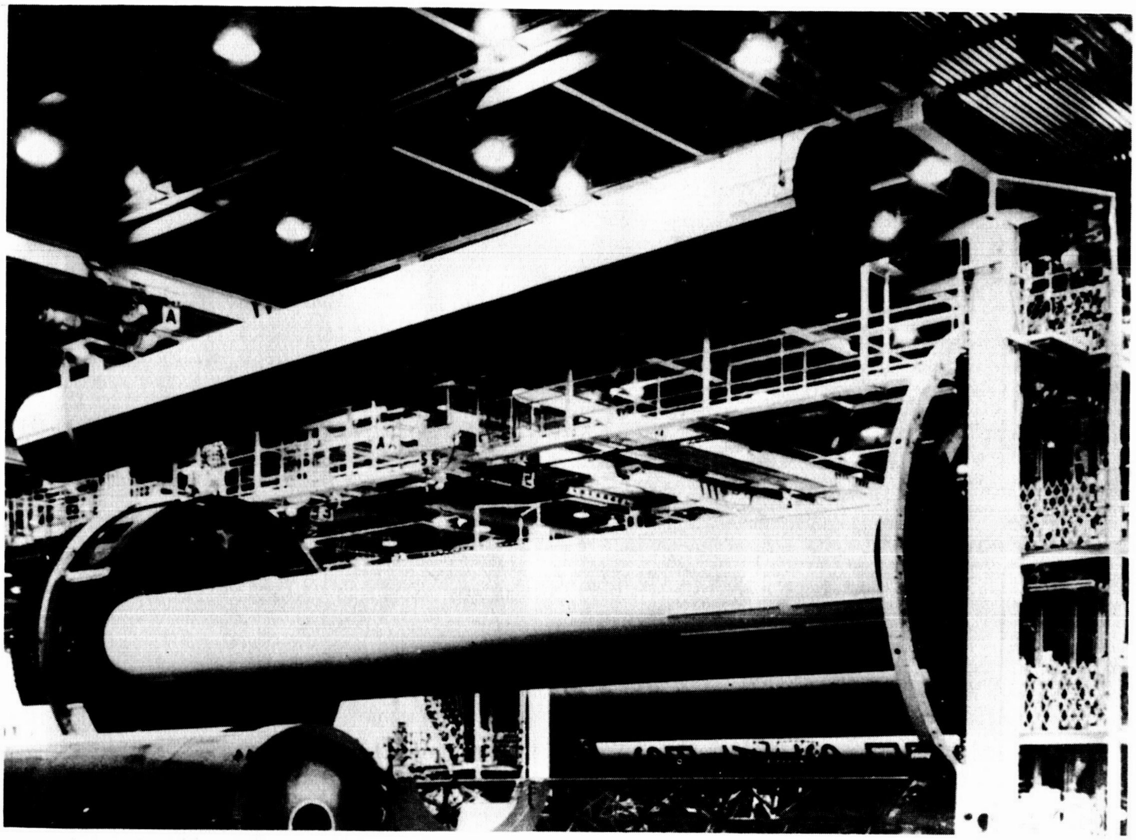


FIGURE 192. CLUSTERING SATURN IB DYNAMIC TEST STAGE AT MICHOUD

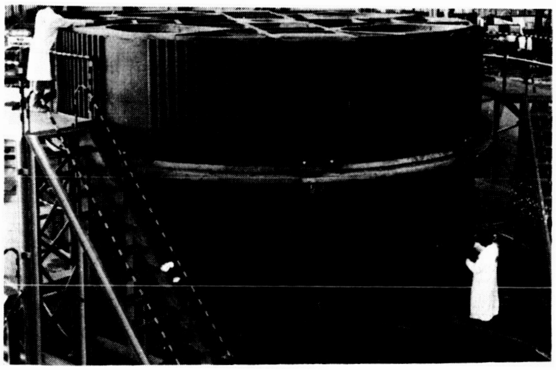


FIGURE 193. S-IB TAIL SECTION

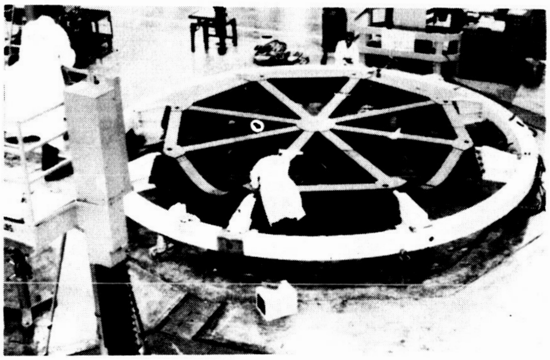
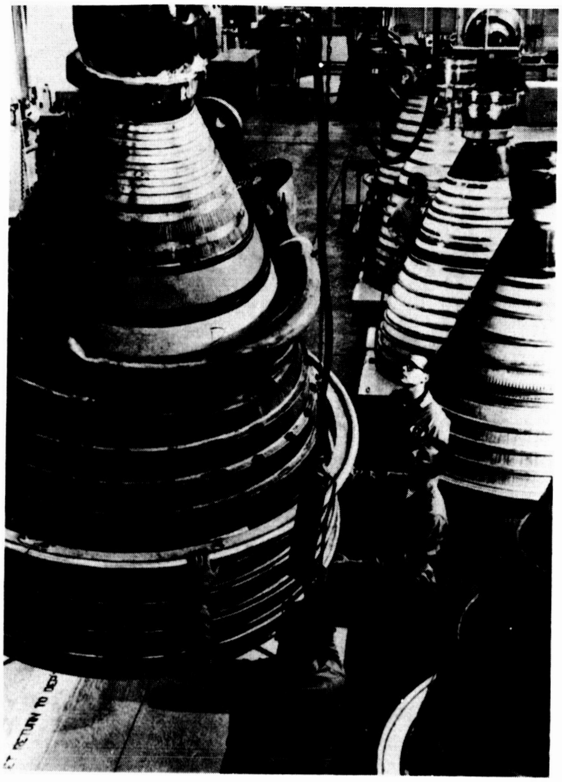


FIGURE 194. S-IB SPIDER BEAM

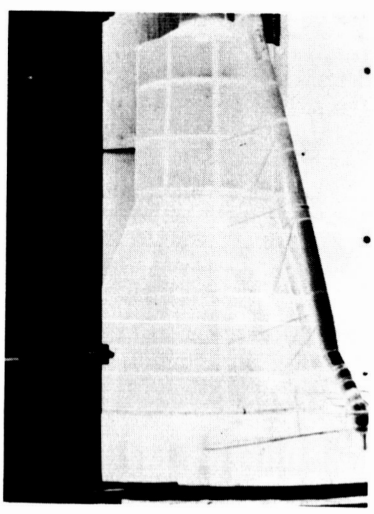
Progress on both Saturn V engines was substantial by the end of September (Fig. 195). MSFC had conducted a number of F-1 firing tests, and Rocketdyne was testing F-1 engine systems at Edwards. Four J-2 engines had been tested, accepted, and delivered to stage contractors.

North American Aviation-S&ID announced completion of a 33-foot-wide bulkhead for the hydrogen-powered Saturn V second stage (S-II) during September (Fig. 196). The Electro-Mechanical Mockup (Fig. 197) for the S-II stage was completed at Downey, California, but not fully instrumented. Douglas personnel began fabricating the first flight version of the Saturn V third stage, the S-IVB/V-1.

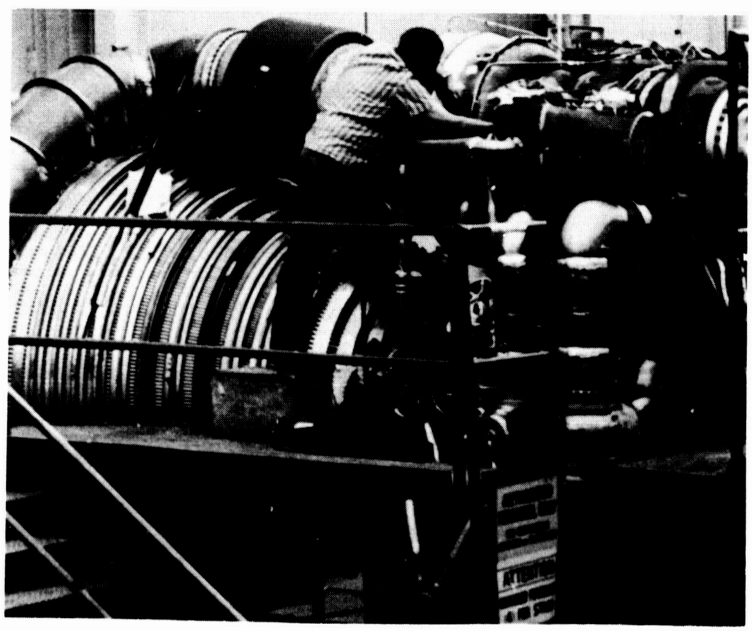
NASA had completed negotiations with Bendix Corporation for the Saturn V instrument unit guidance platforms by the end of the month.



J-2 ENGINE ASSEMBLY



F-1 FURNACE BRAZING OPERATION



F-1 ENGINE ASSEMBLY

FIGURE 195. SATURN ENGINE MANUFACTURING BY ROCKETDYNE AT CANOGA PARK, CALIFORNIA

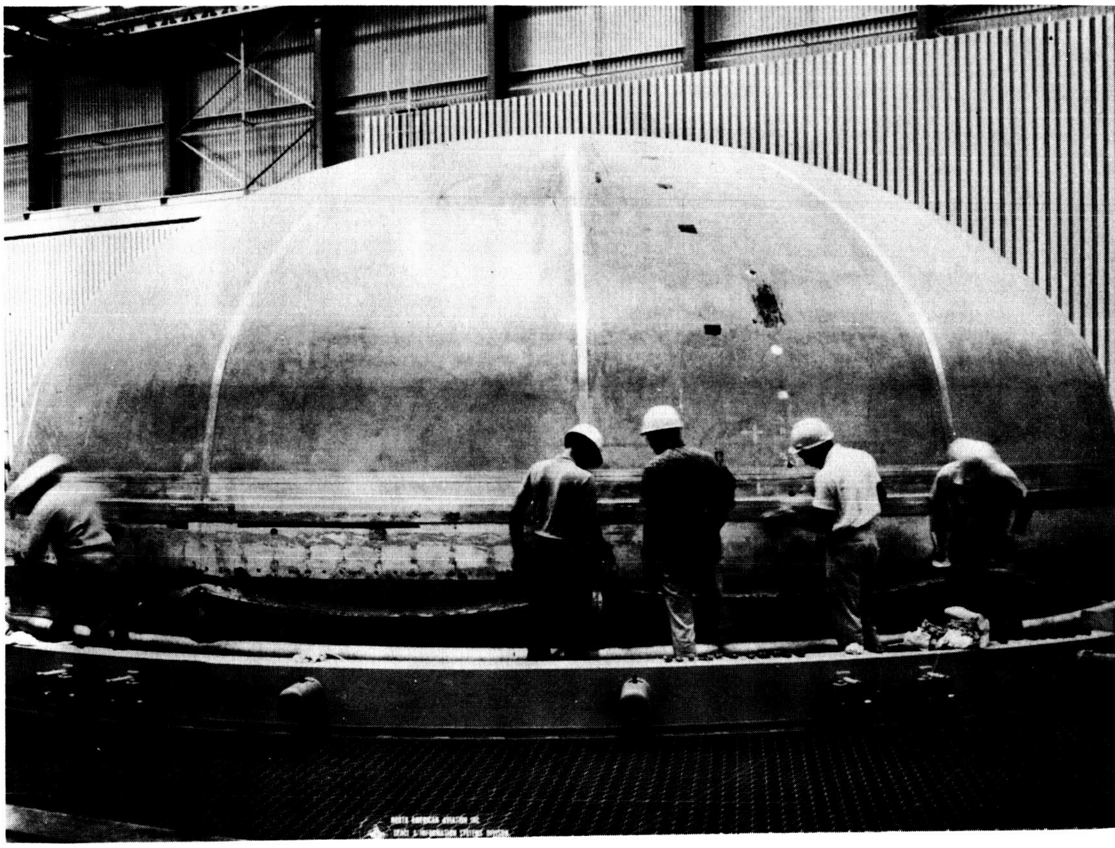


FIGURE 196. BULKHEAD FOR SATURN V SECOND STAGE

FIGURE 197. ELECTRO-MECHANICAL MOCKUP FOR SATURN V SECOND STAGE (S-II)

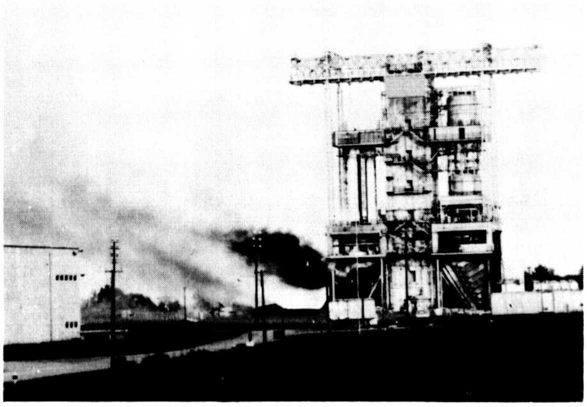


FIGURE 198. LAST SATURN I BOOSTER GROUND TEST

On October 6 MSFC concluded $3\frac{1}{2}$ years of Saturn I first stage static testing with a test of the final booster (Fig. 198). The 156-second test indicated that the S-I-10, manufactured by Chrysler at Michoud, was satisfactory. The major units of the SA-9 vehicle went to the Cape in October, and the other two Saturn I vehicles neared completion. Development of the Pegasus satellites to be carried by the last three Saturn I vehicles proceeded. During October Fairchild Hiller Company conducted tests on a canister designed to provide power, communication, and data electronics for these meteoroid measurement satellites. An adapted Apollo spacecraft service module would protect each satellite from aerodynamic heat prior to its injection into orbit and operation (Fig. 199).

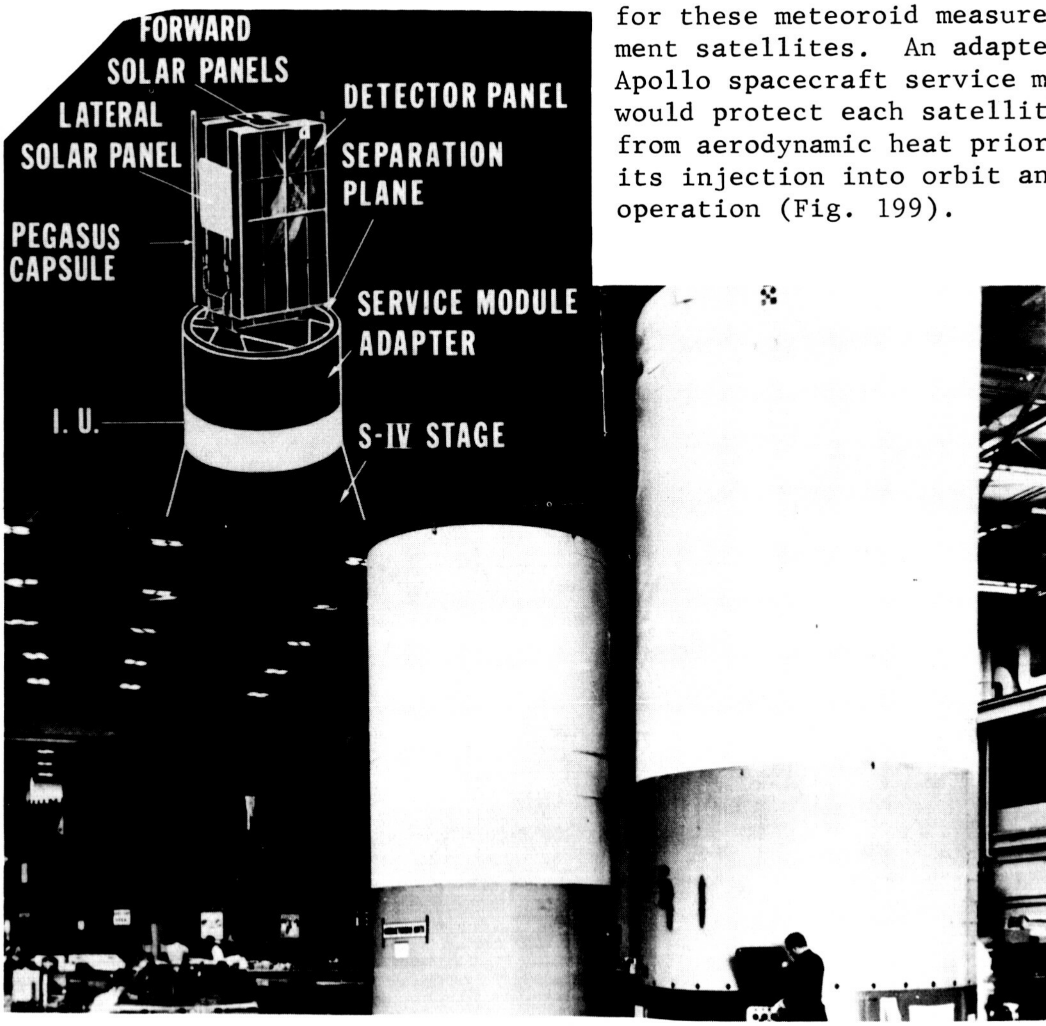


FIGURE 199. TWO OF THREE PEGASUS SATELLITES FOR LAST SATURN I FLIGHTS HOUSED INSIDE ADAPTED SERVICE MODULES

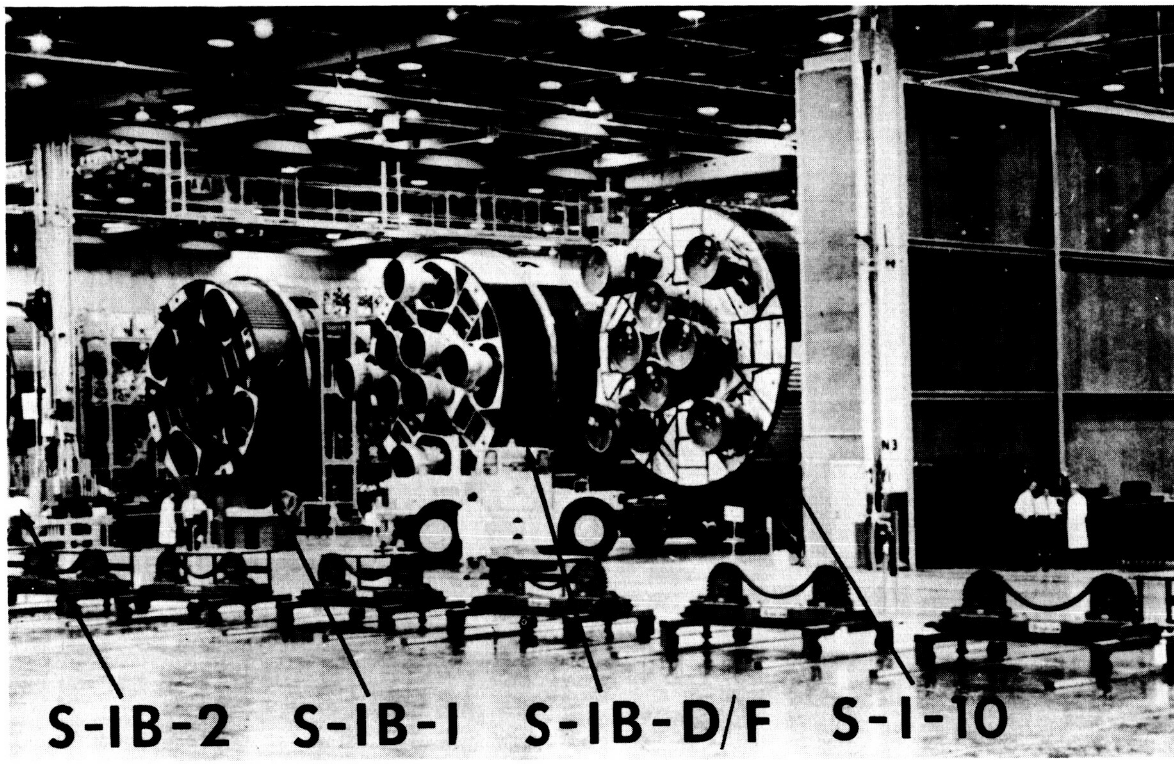


FIGURE 200. CHRYSLER SATURN IB BOOSTER WORK

Two flight booster stages for the Saturn IB were visible in the Chrysler Final Assembly Area at Michoud in October (Fig. 200). The first, S-IB-1, was ready for inspection prior to ground test firing. Tank clustering of the S-IB-2 was complete and other assembly operations were underway. Also near completion was S-IB-D/F, dynamic test stage converted from Saturn I. Meanwhile, Douglas had four Saturn IB second stages underway (Fig. 201). As these S-IVB flight stages were being manufactured, Douglas was conducting tests of the propulsion subsystems and of engine childown procedure prior to full-duration static firing of the J-2 engine-powered S-IVB battleship.

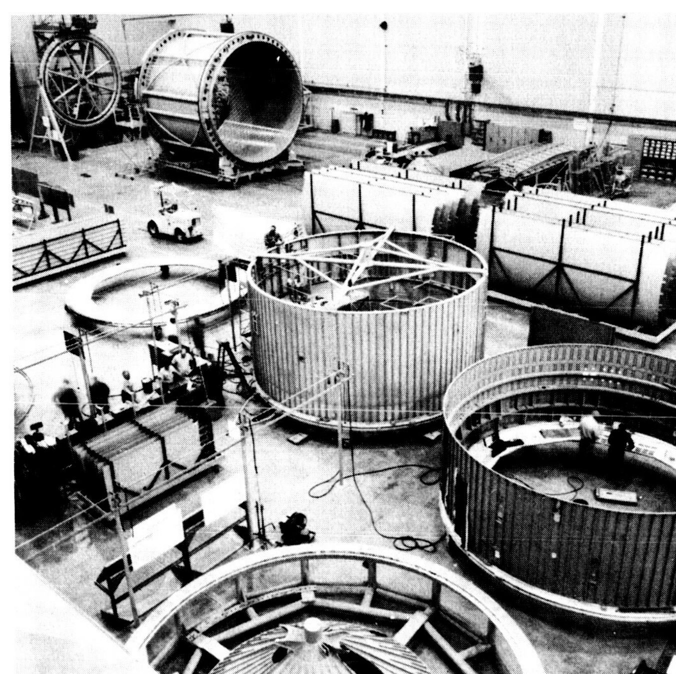


FIGURE 201. DOUGLAS S-IVB STAGE FABRICATION AREA

Progress on Saturn V test facilities was substantial in October. Personnel at the Rocket Engine Test Site at Edwards, California, conducted four consecutive full-duration F-1 engine test firings and approved the operational readiness of the new stand (Fig. 202). Dr. von Braun assigned operation of the site to Rocketdyne after officially accepting it on behalf of NASA. The MSFC Saturn V test complex, Mississippi Test Operations, observed its third anniversary. MTO (Fig. 203) will conduct final ground firings of the two lower stages of Saturn V. Testing of the other stage, S-IVB, will occur at facilities in California. S-IVB will have been flight-proven in modified form in Saturn IB flights prior to its use in Saturn V.

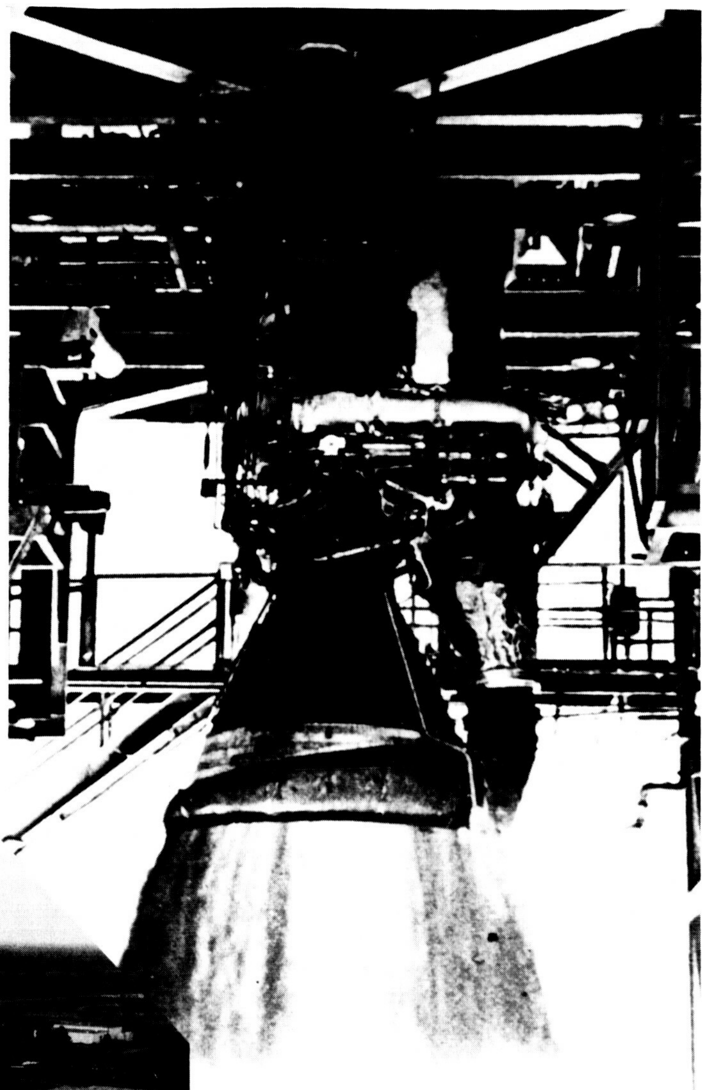
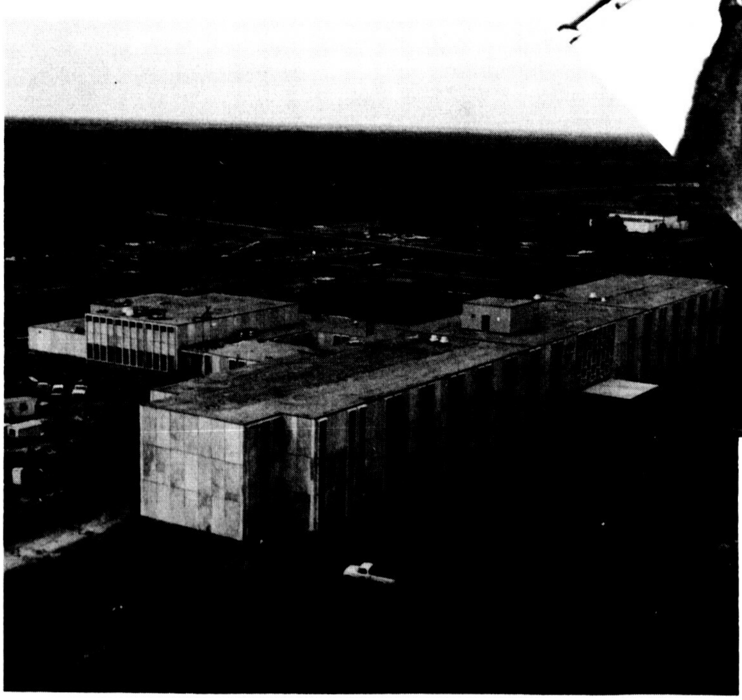


FIGURE 202. F-1 ENGINE TEST AT ROCKET ENGINE TEST SITE, EDWARDS, CALIFORNIA



LABORATORY AND ENGINEERING BUILDING

FIGURE 203. MISSISSIPPI TEST OPERATIONS (CONTINUED ON NEXT PAGE)

TEST STAND FOR SECOND SATURN V STAGE (S-II)

TEST STAND FOR FIRST SATURN V STAGE (S-IC)

FIGURE 203. MISSISSIPPI TEST OPERATIONS

A surprising recovery of films from the seventh Saturn I flight took place in November. Almost two months after the flight, two barnacle-encrusted capsules, each containing 100 feet of color motion-picture film in good condition, were found, one on a beach of an island in the Bahamas, the other in San Salvador in Central America (Fig. 204). Hurricane weather had thwarted recovery efforts after the flight.

FIGURE 204. RECOVERED CAMERAS

Other Saturn I activity in November included erection of the SA-9 on the launch pad at Cape Kennedy. The SA-8 vehicle, to fly after SA-9, progressed; poststatic checkout of the S-I-8 stage neared completion, instrument unit checkout was underway, and the S-IV-8 stage was acceptance fired. Stages of SA-10, the final vehicle, were manufactured; Chrysler was making minor modifications and repairs in the S-I-10 stage prior to poststatic checkout, Douglas transferred the S-IV-10 stage to the Sacramento facility (Fig. 205) where it would be acceptance fired, and in Huntsville MSFC was assembling the S-IU-10 components on schedule. Development problems on the Pegasus satellite, payload for remaining Saturn I vehicles, were being solved, and there was considerable test activity on parts of the prototype satellite.

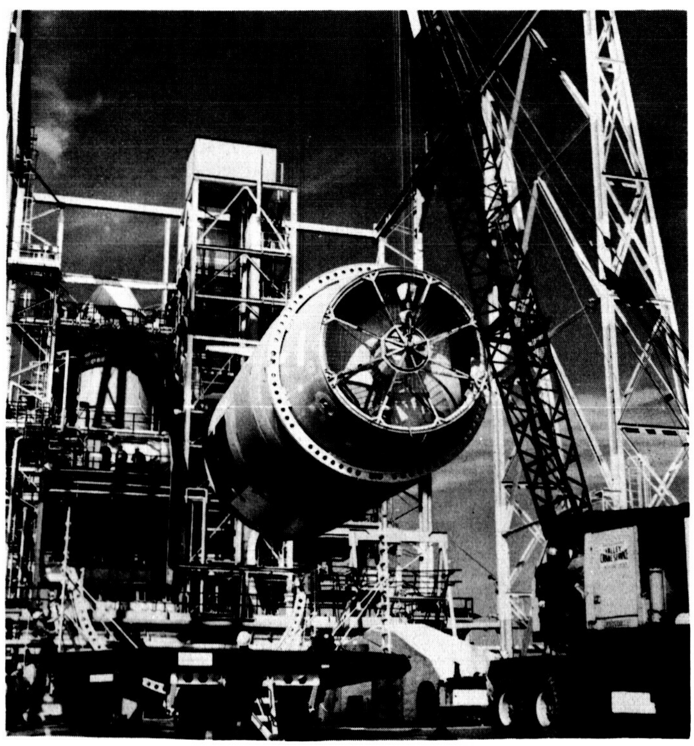


FIGURE 205. S-IV-10 BEING MOVED TO TEST STAND AT SACTO

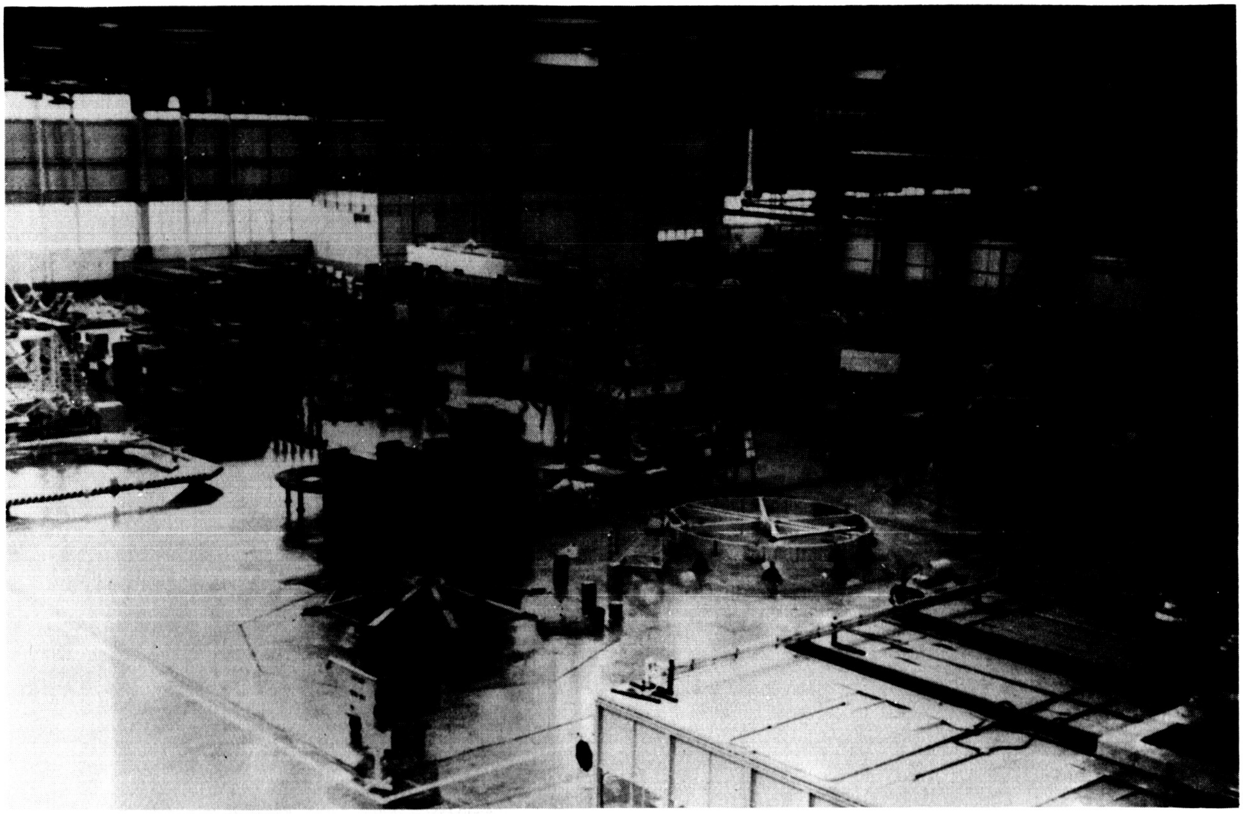


FIGURE 206. CHRYSLER SATURN IB FABRICATION AND ASSEMBLY AREA AT MICHOUD

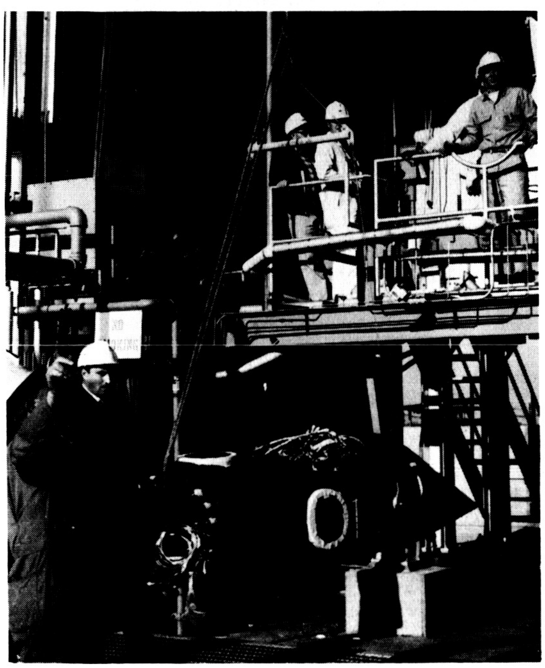


FIGURE 207. AUXILIARY PROPULSION SYSTEM FOR SATURN IB SECOND STAGE

With the first Saturn IB booster complete, Chrysler continued manufacture and assembly of the next three during November (Fig. 206). Technicians removed engines from the first booster, S-IB-1, and shipped them to Neosho for LOX dome retrofit. Engines would be re-installed at Michoud before delivery of the stage to MSFC for static test. At SACTO Douglas employees test fired, for the first time, the Auxiliary Propulsion System (Fig. 207) for the Saturn IB second stage, S-IVB. This system consists of six 150-pound thrust engines which provide attitude control after the main engine (J-2) shuts down and the S-IVB stage enters into the coast phase of flight. In Huntsville MSFC finished assembly of a non-flight Saturn IB instrument unit, S-IU-200V. On November 24 a successful S-IVB battleship firing occurred (Fig. 209).

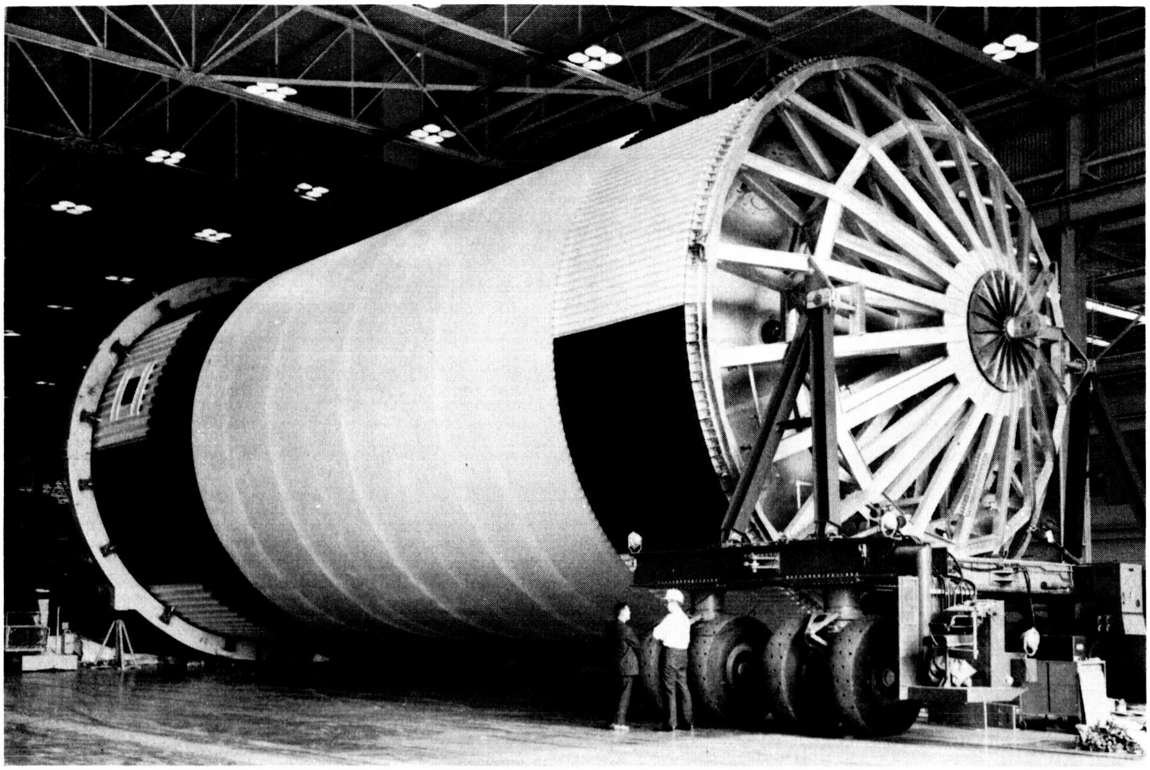


FIGURE 208. FIRST SATURN V BOOSTER, A NON-FLIGHT VERSION FOR STATIC TESTS

NASA provided for construction of Pad B of NASA's Saturn V Complex 39 at Merritt Island, Florida by an almost $20 million firm-fixed-price contract awarded in November. At MSFC the first Saturn V booster stage, S-IC-T, a non-flight version, was partially assembled (Fig. 208); the Center used parts primarily from the Boeing Company. Douglas was checking out the S-IVB dynamics test stage, manufacturing S-IVB flight stages, and conducting propulsion systems tests. On November 24 a successful S-IVB battleship firing took place (Fig. 209). The Saturn V second stage (S-II) activity by North American Aviation included, on November 9, a successful single engine ignition S-II battleship test,

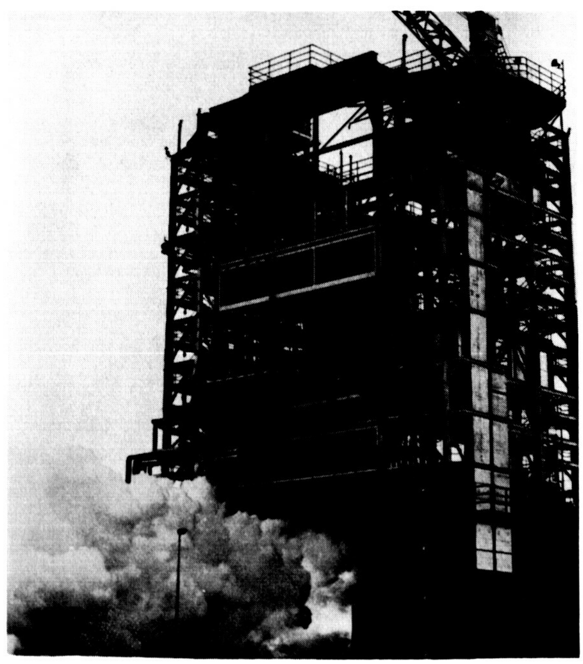


FIGURE 209. FIRST SHORT-DURATION S-IVB BATTLESHIP FIRING

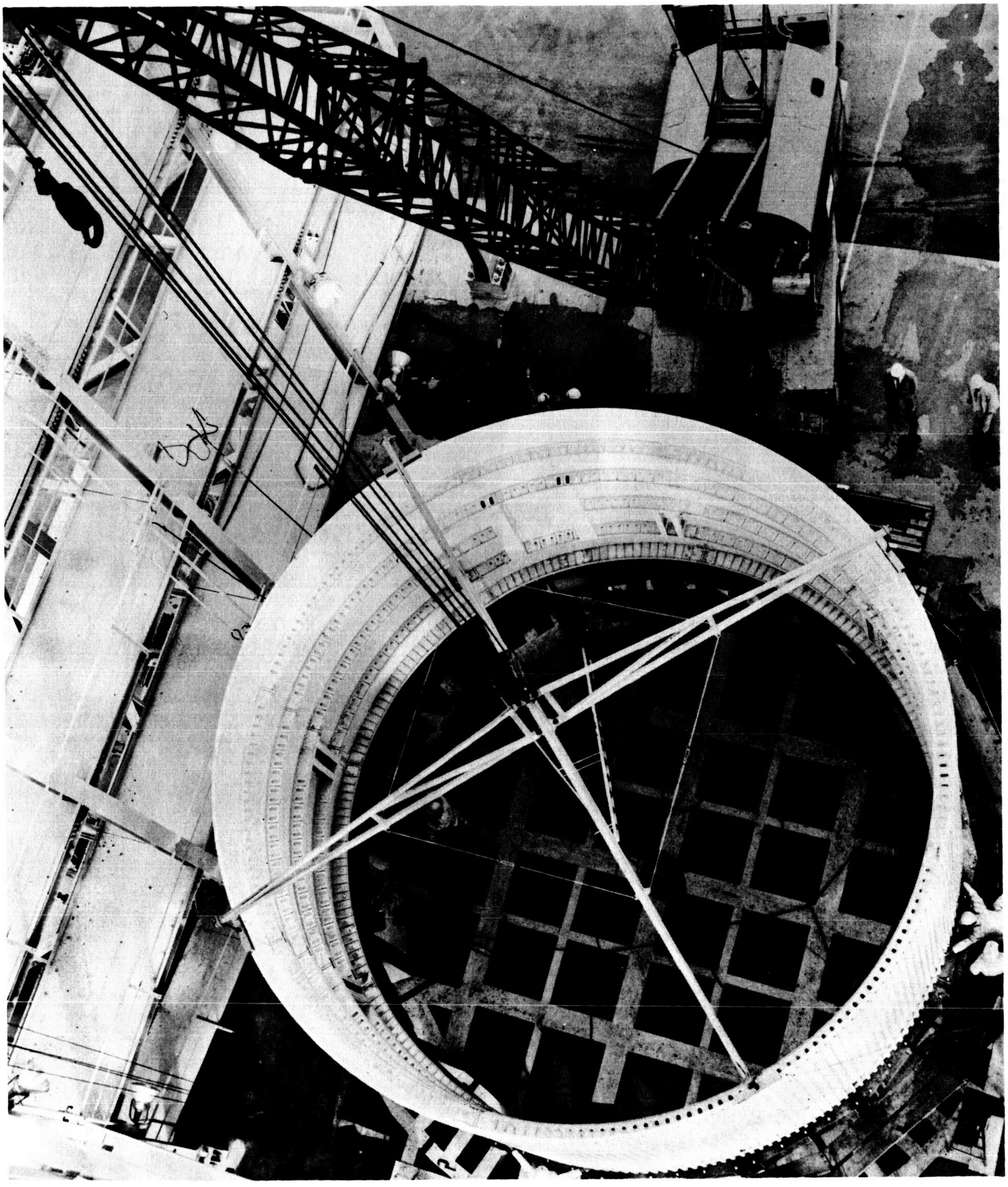


FIGURE 210. BUILDUP OF SATURN V SECOND STAGE (NON-FLIGHT VERSION FOR TESTS)

hydrostatic tests of the common bulkhead test tank which certified repairs, and buildup of the structural test vehicle, S-II-S (Fig. 210).

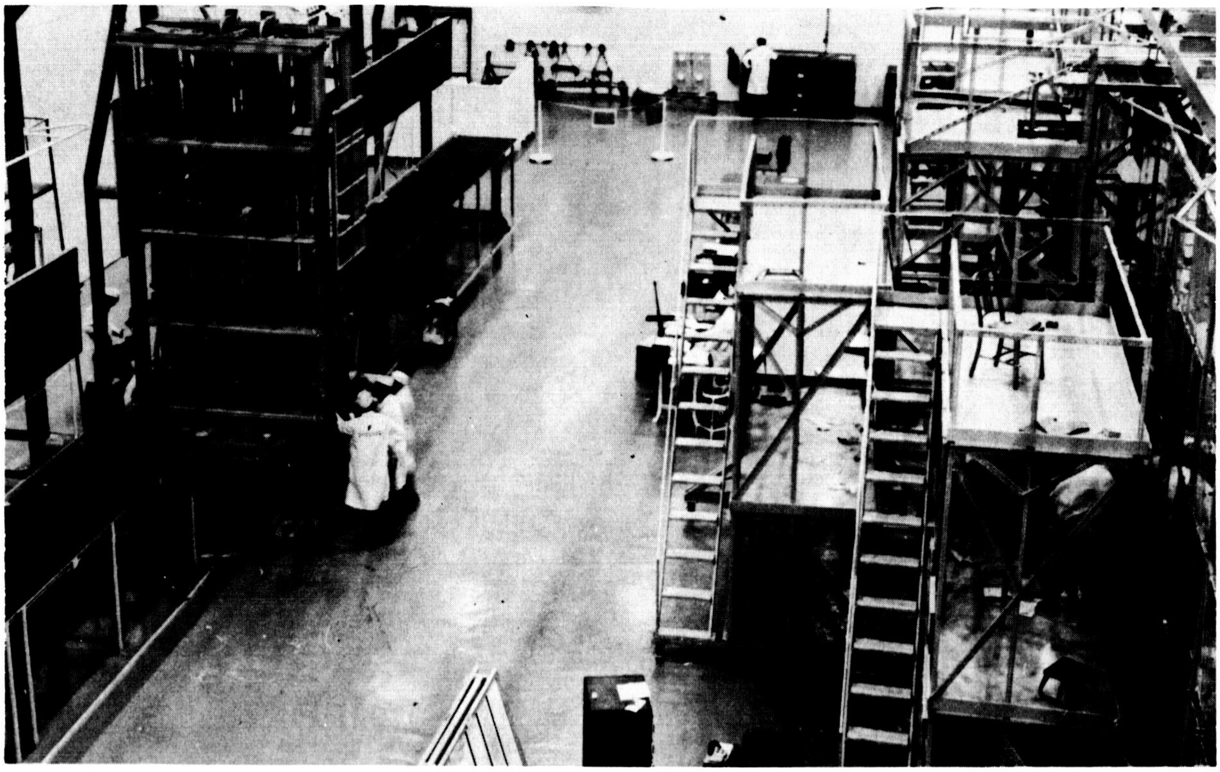


FIGURE 211. PEGASUS B (FOLDED, AT LEFT) AND PEGASUS PROTOTYPE IN SPACECRAFT INTEGRATION AREA OF FAIRCHILD HILLER COMPANY, HAGERSTOWN, MARYLAND

By the end of December Saturn I launch preparations at Cape Kennedy were proceeding on schedule toward the established SA-9 flight date. The S-I-8 stage was ready for shipment but would be stored for a brief period prior to February shipment to the Cape since SA-9 would fly ahead of SA-8. Fairchild Hiller was fabricating Pegasus B (Fig. 211). General Electric Company had finished vibration and vacuum tests on Pegasus A. On December 29 Pegasus A, the first meteoroid detection satellite, arrived at Cape Kennedy from where the SA-9 would boost it into space and orbit of the earth.

Saturn IB's first flight stage booster, S-IB-1, was in prestatic checkout in December. Chrysler was completing installations in assembled S-IB-2 units and assembling

FIGURE 212. SATURN IB TEST FIRST STAGE BEING READIED FOR SHIPMENT

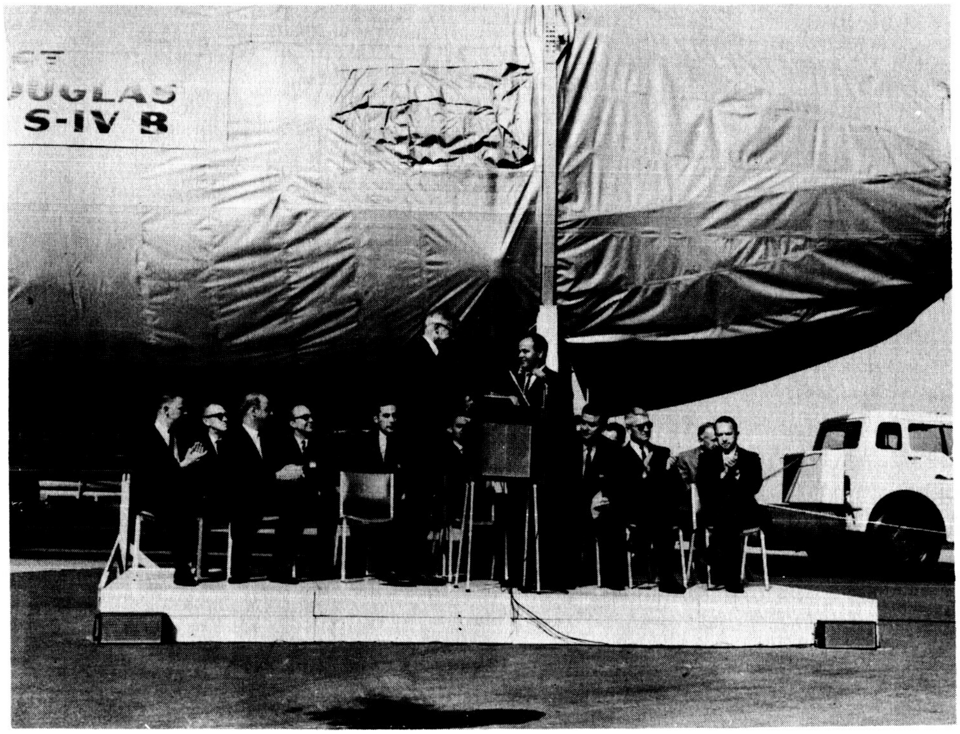


FIGURE 213. FIRST SATURN IB TEST SECOND STAGE (S-IVB-D) AT TURN-OVER CEREMONY AT DOUGLAS AIRCRAFT COMPANY, HUNTINGTON BEACH

spider beam for S-IB-3. Others began assembling the S-IB-4 tail section. Meanwhile, test booster S-IB-D/F was modified, reclustered, prepared for shipment (Fig. 212), and on December 22 departed New Orleans for Huntsville for dynamic testing. Douglas shipped the first completed S-IVB stage, S-IVB-D, a structural replica of the flight stage (Fig. 213) from Huntington Beach on December 8. First and second Saturn IB stages and an Apollo spacecraft were scheduled to be united for complete vehicle tests in MSFC's 200-foot-tall dynamic test stand.

During December Douglas accomplished a series of test firings of the S-IVB battleship stage at SACTO. On December 23 a full-duration (415-second) firing of the battleship occurred.

Contract for a new Saturn V test stand was signed in December. This second S-II test stand at Mississippi Test Operations will cost over $8 million. The U. S. Army Corps of Engineers, Mobile District, construction agent for NASA's MTO facilities, awarded the contract to Malon Construction Company of Koppers Company, Inc. In Huntsville MSFC prepared for the first single engine firing of the Saturn V test booster S-IC-T and perfected ground support equipment. MSFC's Manufacturing Engineering Laboratory manufactured and assembled the LOX bulkhead of structural test stage S-IC-S in less than a month, setting a new record for building a bulkhead.

From Michoud Boeing shipped to MSFC a 33-foot-diameter S-IC stage thrust structure (Fig. 214) for structural testing. Other Boeing work included building the first Saturn V fin constructed away from Marshall Center (Fig. 215). North American Aviation-Rocketdyne accomplished Flight Rating Tests (FRT) of the F-1 engine; five of these would power the Saturn V first stage. Saturn

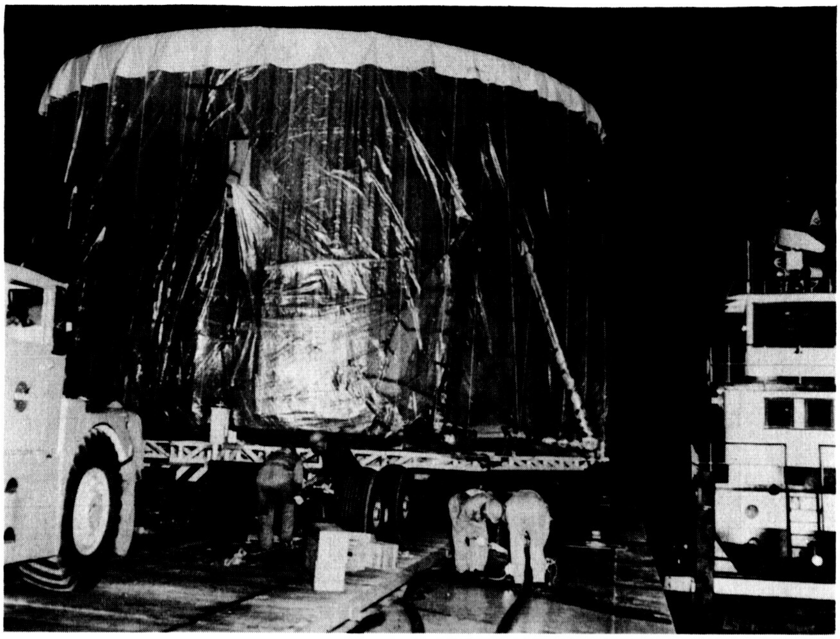


FIGURE 214. S-IC-S THRUST STRUCTURE ON BARGE AT MICHOUD

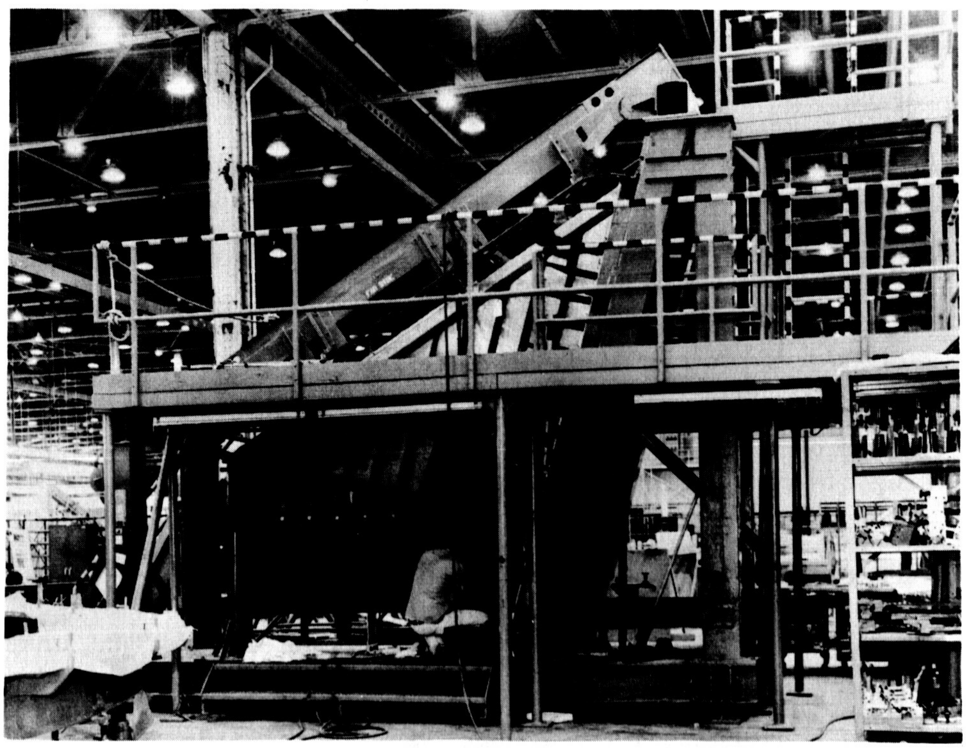


FIGURE 215. INTERNAL RIBS OF FIRST BOEING-BUILT SATURN V FIN, ASSEMBLED AND READY FOR ATTACHMENT OF SKINS

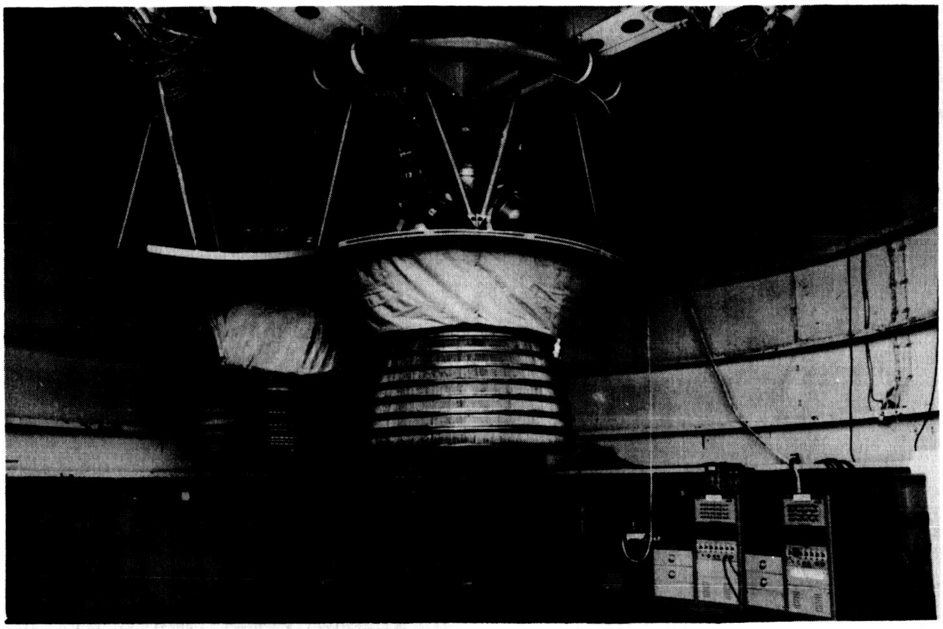
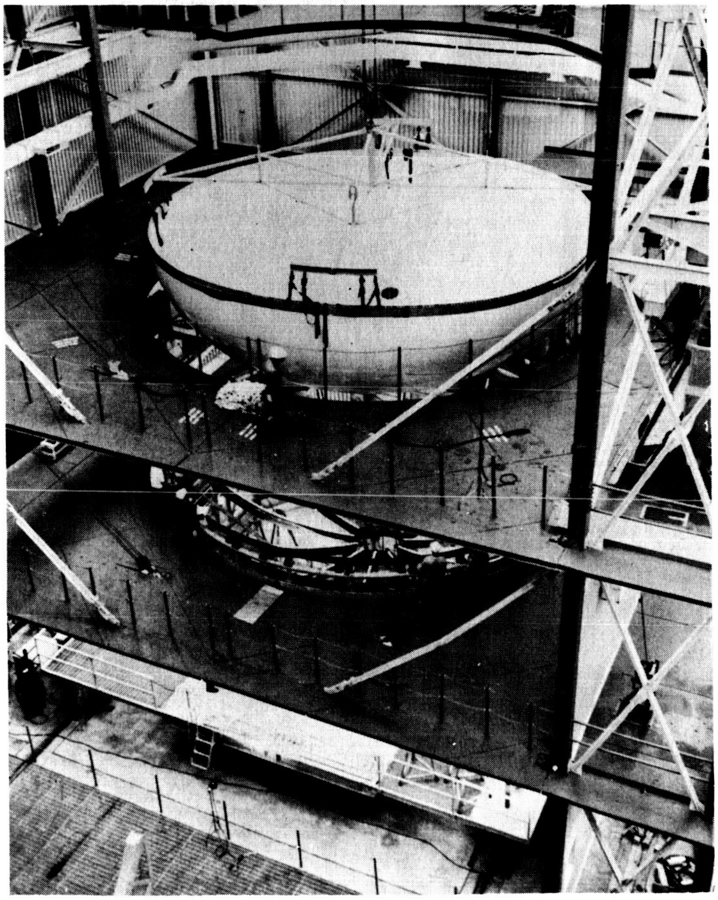


FIGURE 216. J-2 ENGINE GIMBALLING TEST



V second stage accomplishments included North American Aviation-S&ID's testing of J-2 engine gimballing on the Electro-Mechanical Mockup at Downey, California (Fig. 216); replacement of LOX bulkhead of the S-II-S; a load and pressure test S-II stage (Fig. 217); and completion of S-II battleship single engine firings. A major milestone during December was North American Aviation-Rocketdyne's completion of Preliminary Flight Rating Tests (PFRT) of the J-2 engine; five of these would power each Saturn V second stage and one would power the third stage.

FIGURE 217. REPLACEMENT OF S-II-S BULKHEAD

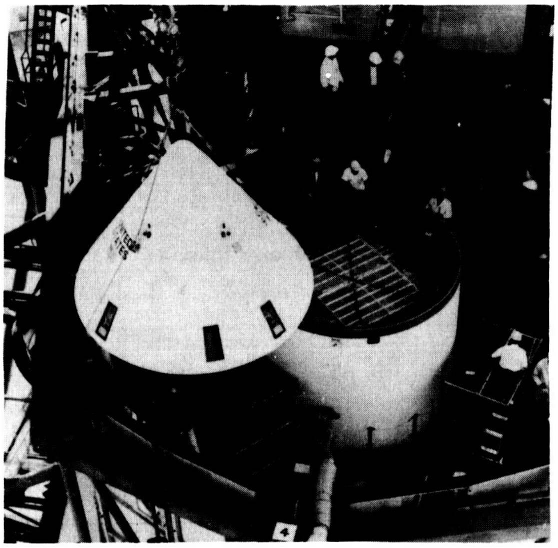


FIGURE 218. INSTALLING PEGASUS SATELLITE INTO SA-9 VEHICLE

Saturn I activity in January 1965 included minor modifications and prelaunch tests on the SA-9 vehicle at Cape Kennedy. On January 12 NASA completed installation in the Apollo service module of the first Pegasus (Fig. 218), and the next day mated the payload to the top of the SA-9. Work on the last two flight vehicles included MSFC's completion of checkout of the S-IU-8 instrument unit and completion of assembly of the S-IU-10. Chrysler at Michoud was preparing the S-I-8 stage for shipment to the Cape. At SACTO poststatic checkout of the S-IV-8 was completed. Douglas finished prefiring inspection of S-IV-10 (Fig. 219) and static fired the stage for 7 minutes, 59 seconds on January 21. This firing concluded all Saturn I stage static firing tests.

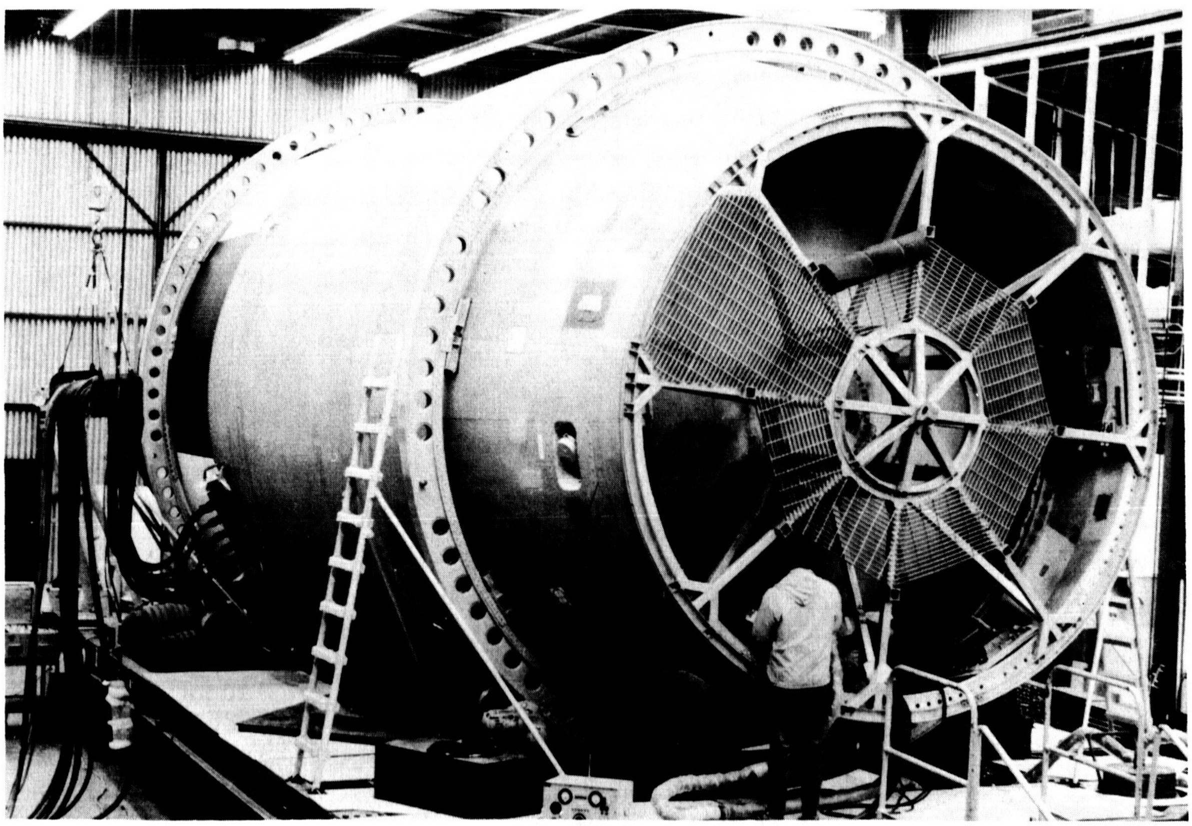


FIGURE 219. SATURN I PRESTATIC CHECKOUT (S-IV-10 PROPELLANT UTILIZATION CALIBRATION)

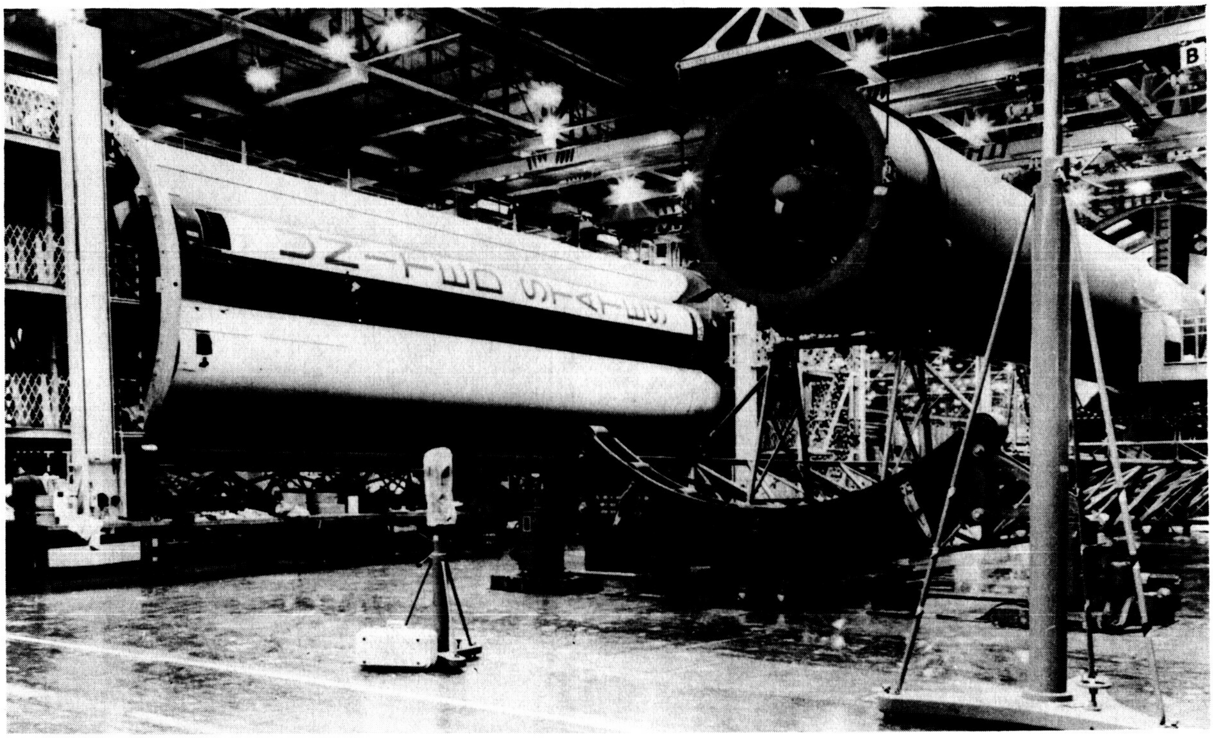


FIGURE 220. LOX TANK BEING INSTALLED IN THE SATURN IB S-IB-3 TAIL SECTION (S-IB-2 STAGE AT LEFT)

Chrysler began clustering tanks of the third Saturn IB flight booster, S-IB-3, at Michoud during January (Fig. 220). The first flight booster was in prestatic checkout, the second in final assembly, and the fourth in fabrication (Fig. 221). At MSFC Saturn IB test stages, S-IB-D/F and S-IVB-D, were installed in the dynamic test stand. At Huntington Beach the first flight upper stage of Saturn IB, S-IVB/IB-1, awaited automatic checkout in a Douglas checkout tower.

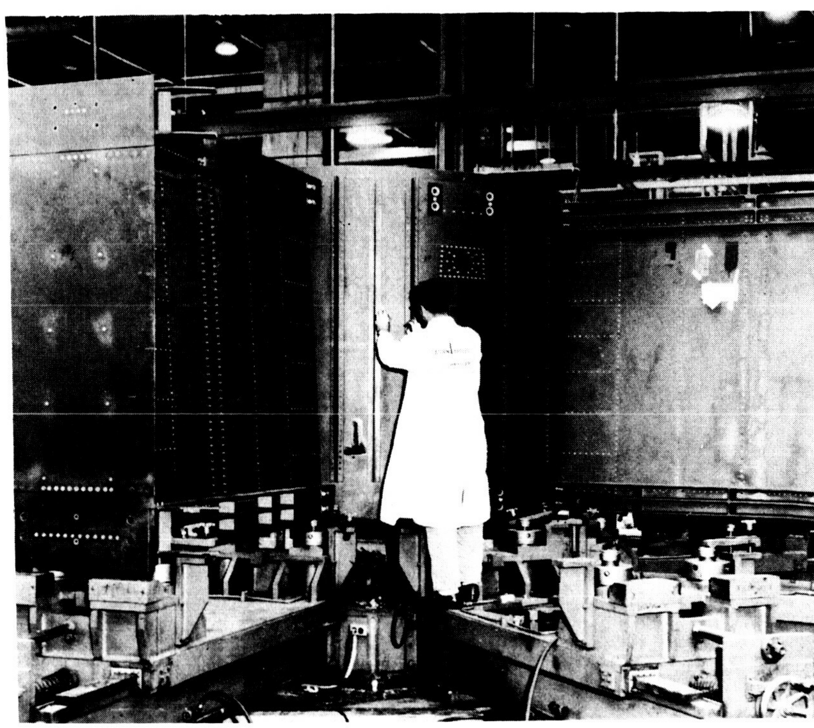
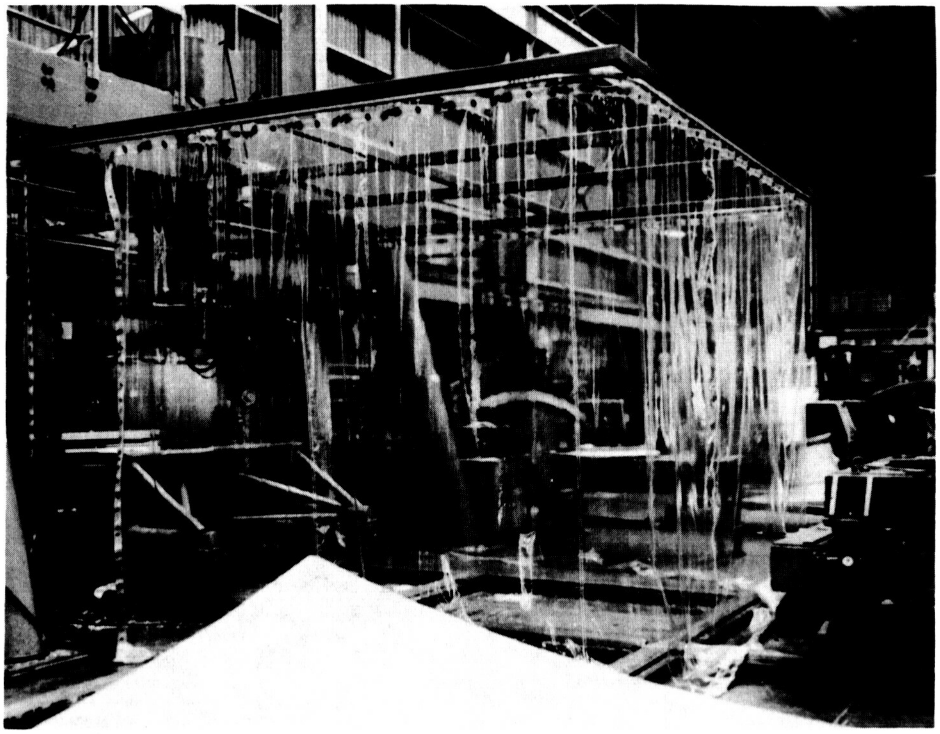
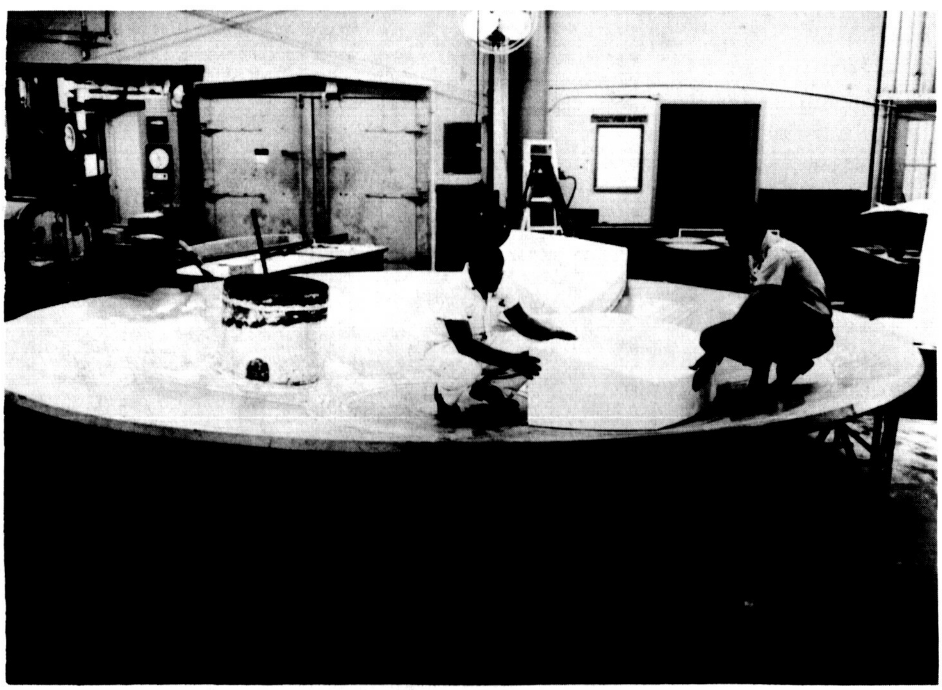


FIGURE 221. TAIL SECTION ASSEMBLY OF SATURN IB BOOSTER (S-IB-4)



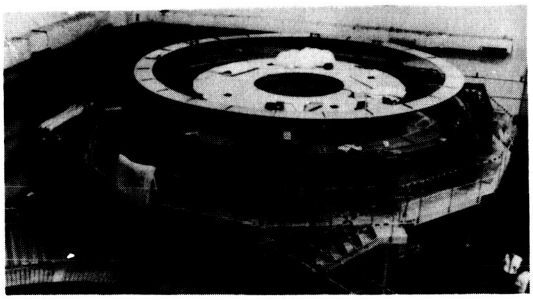
"CLEAN ROOM" FOR S-IC FABRICATION

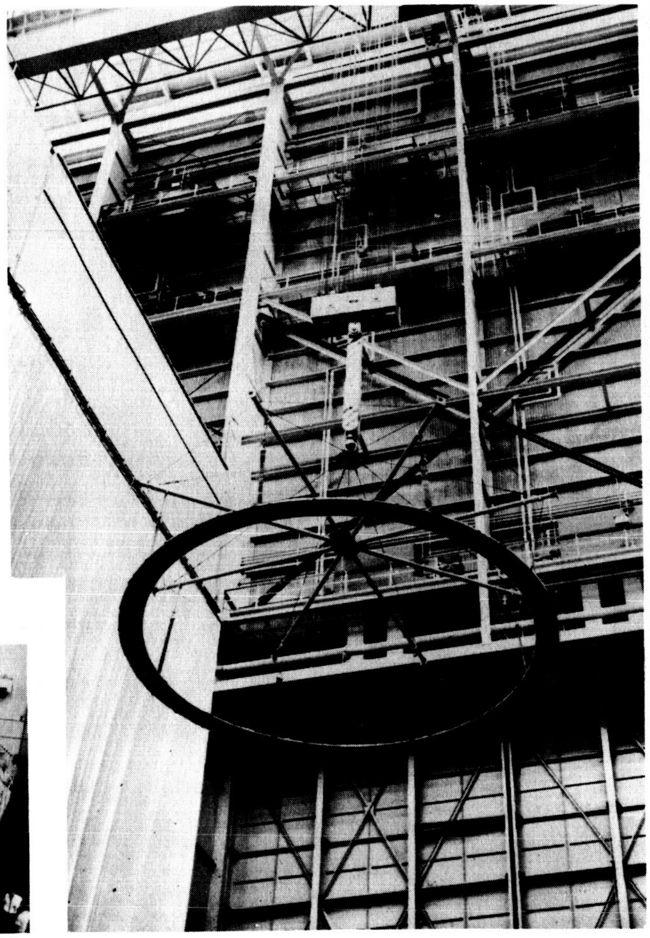


WORKERS FITTING SEGMENTS USED IN S-IC FABRICATION

FIGURE 222. SATURN V MANUFACTURE AT MARSHALL CENTER

MSFC's Manufacturing Engineering Laboratory proceeded with Saturn V booster fabrication in January (Fig. 222). At Michoud the Boeing Company worked on a test stage, S-IC-D (Fig. 223). North American Aviation-S&ID completed fabrication of a second bulkhead for an S-II stage test tank (Fig. 224); and Douglas worked on the aft and forward domes and tank skins (Fig. 225) for the first flight Saturn V S-IVB stage, S-IVB/V-1.





PLACING RING ON TANK SKIN

RING BAFFLE FOR FUEL TANK

FIGURE 223. BOEING WORK ON S-IC-D STAGE

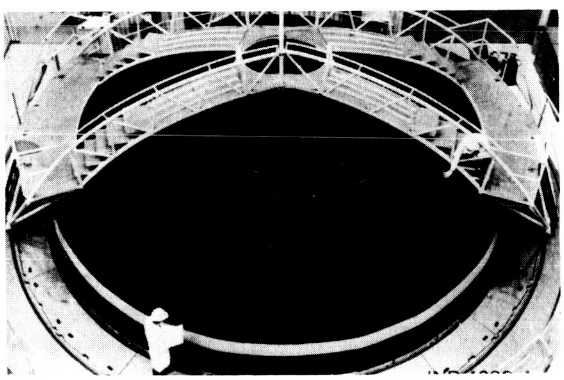


FIGURE 224. NORTH AMERICAN-S&ID INSULATION OF S-II BULKHEAD

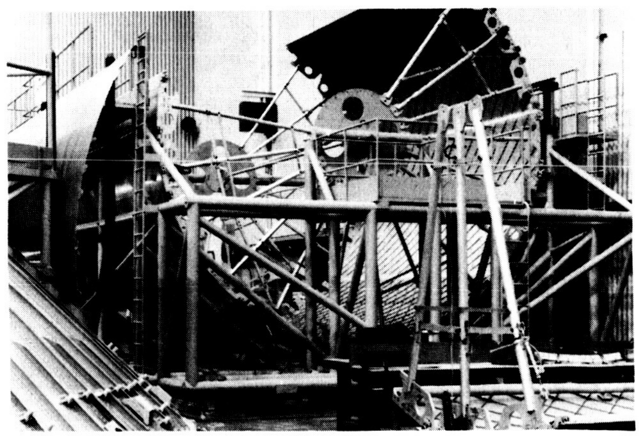


FIGURE 225. DOUGLAS WORK ON TANK SKINS OF FIRST SATURN V FLIGHT S/IVB STAGE

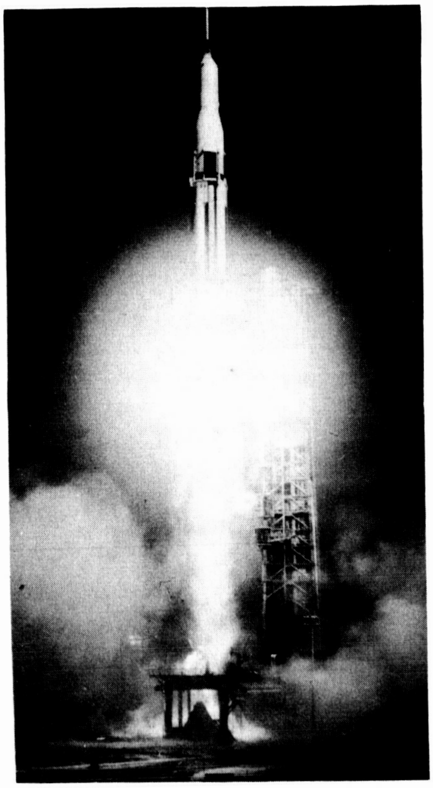


FIGURE 226. SA-9 LAUNCH

Saturn I highlight for February was another successful flight--the eighth. NASA launched the SA-9 vehicle (Fig. 226) on February 16, 1965, testing the booster stage for the eighth time and the second stage for the fourth time.

SA-9 also orbited the first Pegasus satellite. This meteoroid technology capsule was shrouded by boilerplate Apollo command and service modules which were ejected after shutdown of the S-IV stage. The Pegasus, still attached to the S-IV stage, then deployed its "wings" to a span of 96 feet (Fig. 227) and began its function of counting meteoroid punctures.

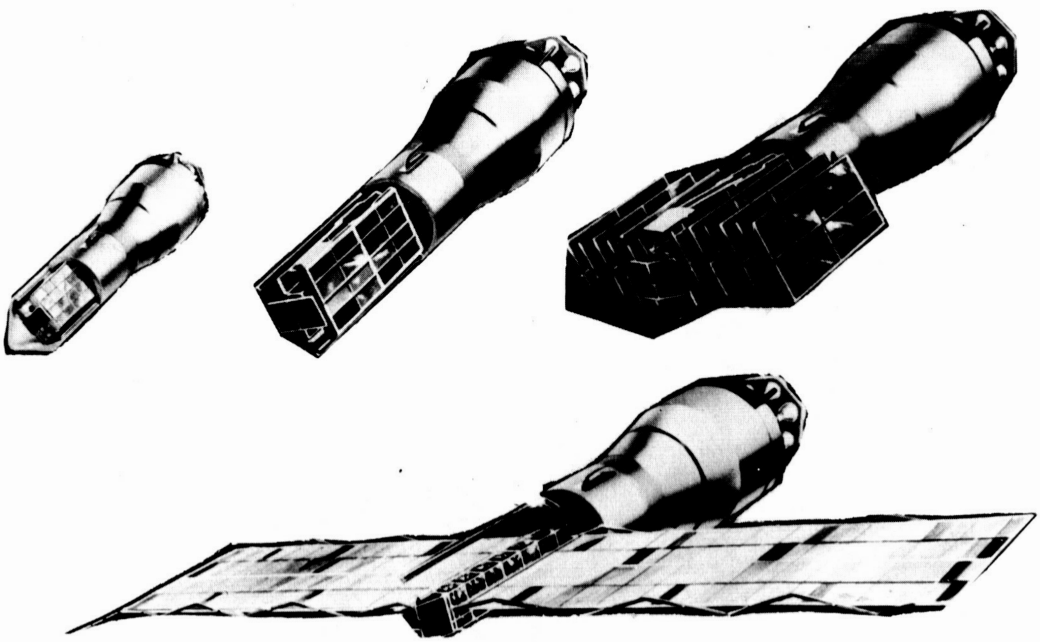


FIGURE 227. PEGASUS SATELLITE EXPANDING WINGS (DEPLOYMENT SEQUENCE CLOCKWISE)

Chrysler delivered to the Cape in February the S-I-8 stage. This first industry-built Saturn booster (Fig. 228) was designated for the next-to-the last Saturn I flight vehicle.

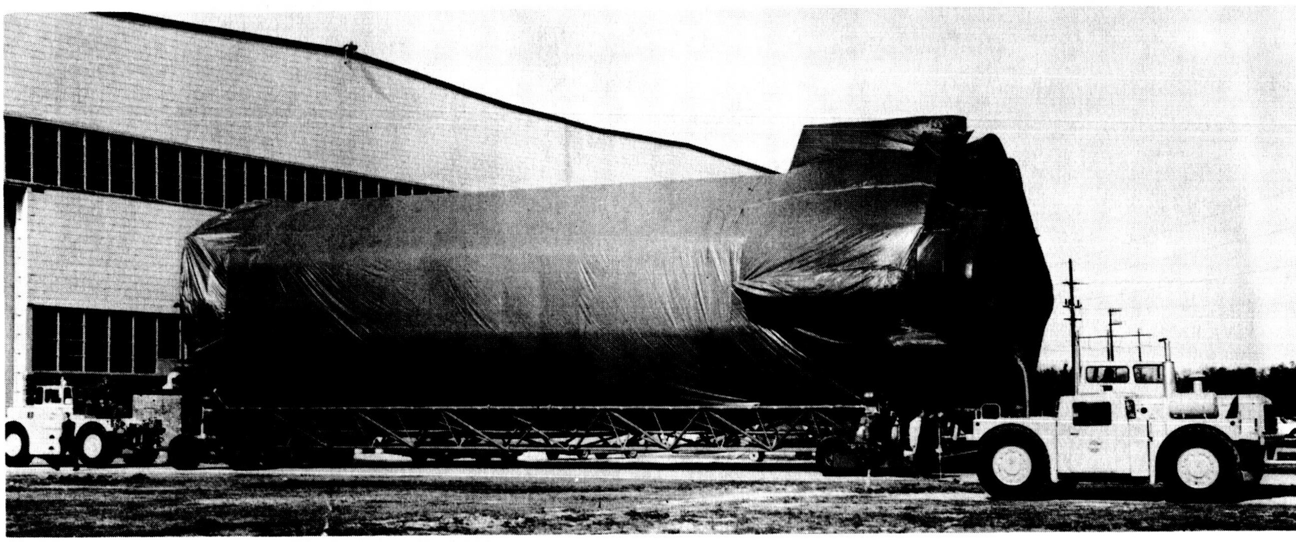


FIGURE 228. FIRST INDUSTRY-BUILT SATURN BOOSTER, S-I-8, READY TO LEAVE MICHOUD FOR CAPE KENNEDY

Chrysler finished prestatic checkout of the first Saturn IB flight booster, S-IB-1, in February and began reinstalling uprated H-1 engines and readying the stage for shipment to Marshall Center. Chrysler completed assembly of S-IB-2 and continued work on S-IB-3 and S-IB-4. Meanwhile, at Huntington Beach Douglas was structurally revising minor portions of the first Saturn IB second stage, S-IVB/IB-1, having installed J-2 Engine No. 2012. Douglas transferred the flight-weight Saturn S-IVB stage, S-IVB-F, from Huntington Beach to Sacramento during the month; there it was mounted in a new test stand (Fig. 229). The facilities stage would test areas of stage design as well as ground test and launch facilities. Engine chilldown tests started on a flight configuration engine in the S-IVB battleship stage.

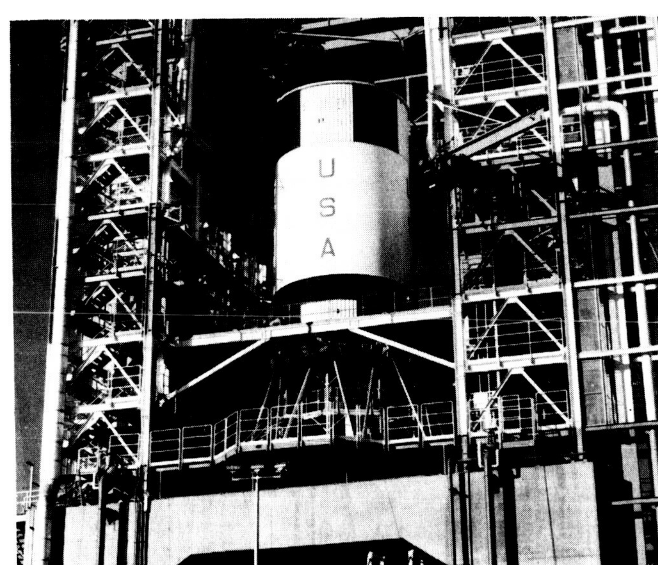


FIGURE 229. FACILITIES CHECKOUT SATURN S-IVB STAGE (S-IVB-F)

During February at Michoud (Fig. 230) Boeing completed its first Saturn V booster fuel tank--for test stage, S-IC-D. NASA awarded Douglas

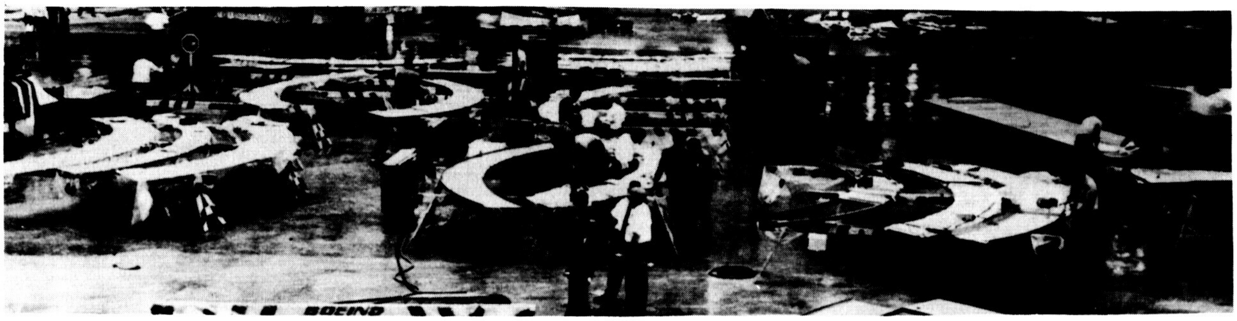


FIGURE 230. BOEING'S SATURN V ~~BOOSTER LOX &~~ FUEL TANK SUBASSEMBLY AREA AT MICHOUD

a contract addition in the amount of almost $6 million for a simulated S-IVB flight stage. MSFC will use the stage to verify Saturn V ground support equipment compatibility and to train launch operations personnel. North American-S&ID at Seal Beach essentially completed the S-II stage common bulkhead test tank.

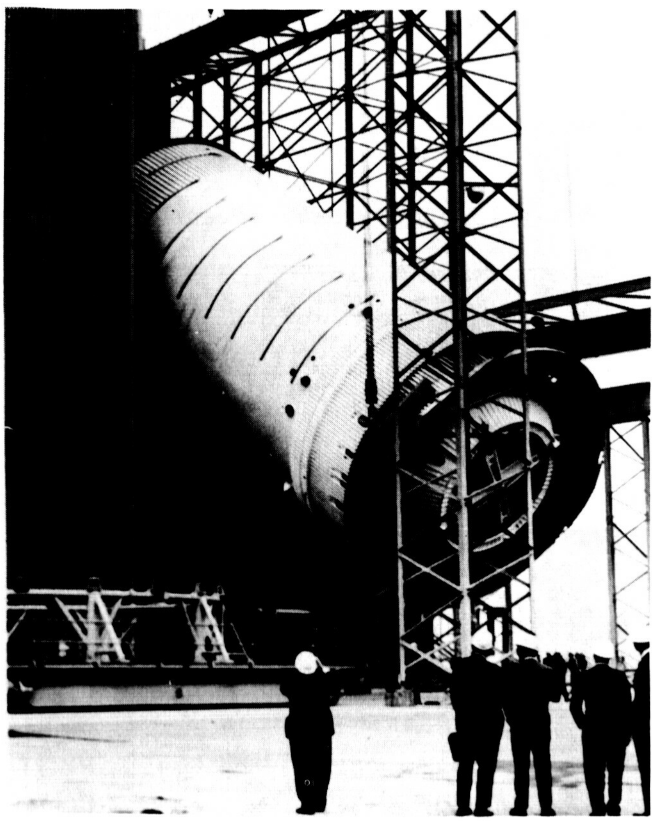
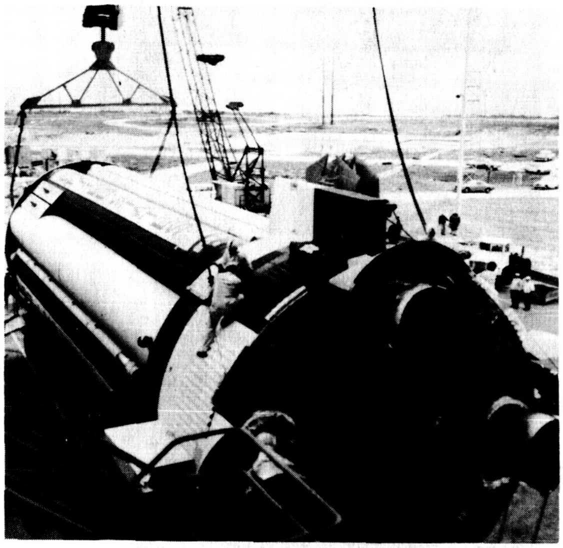


FIGURE 231. FIRST FLIGHT WEIGHT SATURN V SECOND STAGE, S-II-S

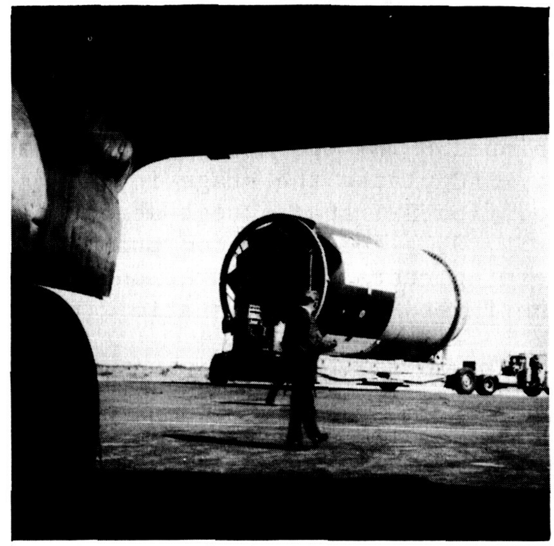
By the end of February MSFC and contractors had completed ground firing versions of all three stages for Saturn V. Last completed was the first stage, S-IC-T, built at MSFC where it would be static-fired. Test firing of the other two stages had begun in November but only single engine firings had been conducted on the S-II.

Other completed test stages for Saturn V included a structural test second stage, S-II-S (Fig. 231), at Seal Beach and a facilities checkout third stage, S-IVB-F (Fig. 229), moved from Huntington Beach to Sacramento test site during February. These two flight-weight stages will undergo non-firing tests. Tests on the S-II-S will include simulation of launch weights of the third stage and Apollo spacecraft on the stage during its maximum flight acceleration. The S-IVB-F tests will include checkout of Saturn IB and Saturn V test and launch facilities.

Saturn I activity in March included erection of the SA-8 vehicle on Launch Pad 37 at Cape Kennedy (Fig. 232). Checkout of this vehicle for the ninth Saturn flight led to removal of gas generators and LOX purge



FIRST STAGE



SECOND STAGE

FIGURE 232. PREPARING TO ERECT VEHICLE FOR NINTH SATURN FLIGHT

lines from the S-I-8 stage and return of these to Michoud for cleaning and reservicing. Personnel at Kennedy Space Center were also performing pre-flight inspection and making necessary minor adjustments on the S-IV-8 stage and on the instrument unit. The camera which would photograph Pegasus satellite deployment was returned to MSFC for modifications.

MSFC and the Pegasus contractor, Fairchild Hiller, considered modifications that might be made on Pegasus B and C. Pegasus satellites contain 416 detector panels (208 on each wing), and the incidence of early panel failure was higher than expected in Pegasus A. Experiments were conducted for the purpose of improving detection panels (Fig. 233). Meanwhile, the orbiting first Pegasus satellite launched by SA-9 on February 16, 1965, was still sending to ground stations information concerning the presence of meteoroids in near-earth space. This satellite was expected to be active for approximately one year.

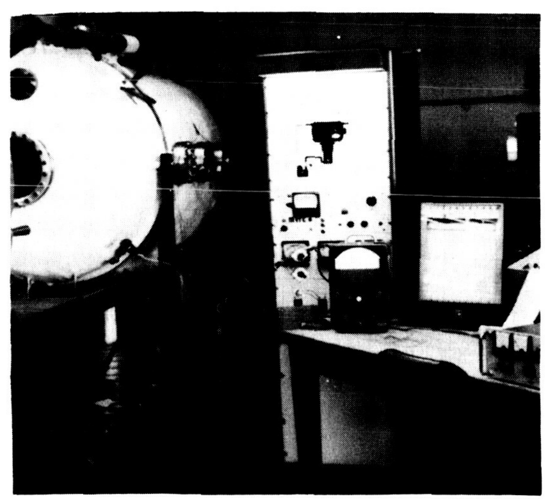


FIGURE 233. EXPERIMENT ON PEGASUS DETECTOR PANEL AT MSFC

The two stages and instrument unit of the final Saturn I, SA-10, were ready for shipment to the Cape except for completion of poststatic checkout.

By March Chrysler at Michoud was fabricating S-IB-5, the fifth Saturn IB flight booster. S-IB-4 was in the final phase of fabrication; S-IB-3 was in final assembly; and S-IB-2 was completely manufactured and in prestatic checkout. During March Chrysler shipped S-IB-1 to MSFC. Technicians at MSFC placed the stage in the modified S-I static test stand (Fig. 234) and completed propellant loading tests in preparation for the first S-IB stage static firing.

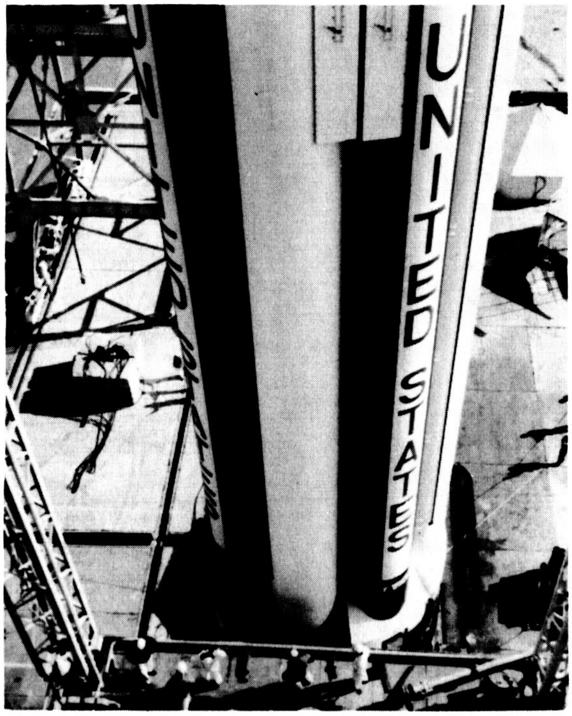


FIGURE 234. FIRST SATURN IB FLIGHT BOOSTER, S-IB-1, BEING LIFTED INTO STAND

On March 30 Douglas terminated prestatic checkout at Huntington Beach of the first Saturn IB flight upper stage, S-IVB/IB-1 (Fig. 235). Later, checkout would resume at SACTO. Other S-IVB stage work included completion of chilldown testing on the battleship stage on March 6, a ten-second battleship firing on March 13, and a successful full-duration battleship firing on March 31. Two semi-automatic firings of the S-IVB/IB Auxiliary Propulsion System occurred during the month, and an automatic firing was scheduled for April.

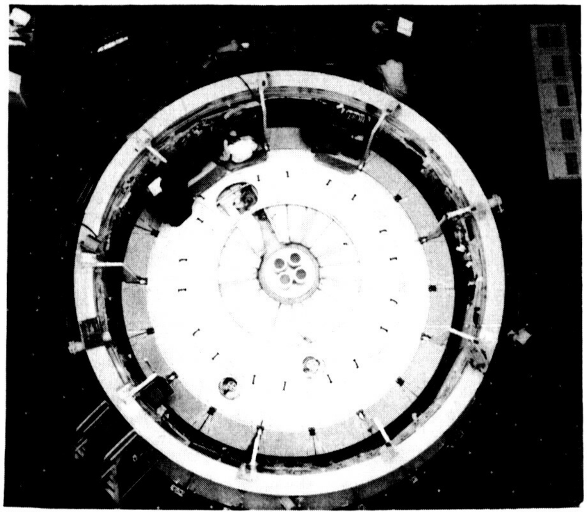


FIGURE 235. FIRST FLIGHT S-IVB STAGE FOR SATURN IB IN PRESTATIC CHECKOUT

Structural fabrication of the first Saturn IB flight instrument unit, S-IU-201, was completed and component assembly began in March. Vibration testing continued on S-IU-200V, a non-flight instrument unit.

MSFC completed dynamic testing of the Saturn IB vehicle SA-203 configuration on March 2. SA-201/202 configuration tests began on March 15. (Numbering of Saturn IB flight vehicles begins with SA-201).

On March 1 MSFC lifted the first Saturn V booster ground test stage into its S-IC test stand (Fig. 236). This stage, S-IC-T, would be used in a series of hot firings to test operation of the engines, related systems, and firing equipment. Testing and checkout of this MSFC-assembled stage

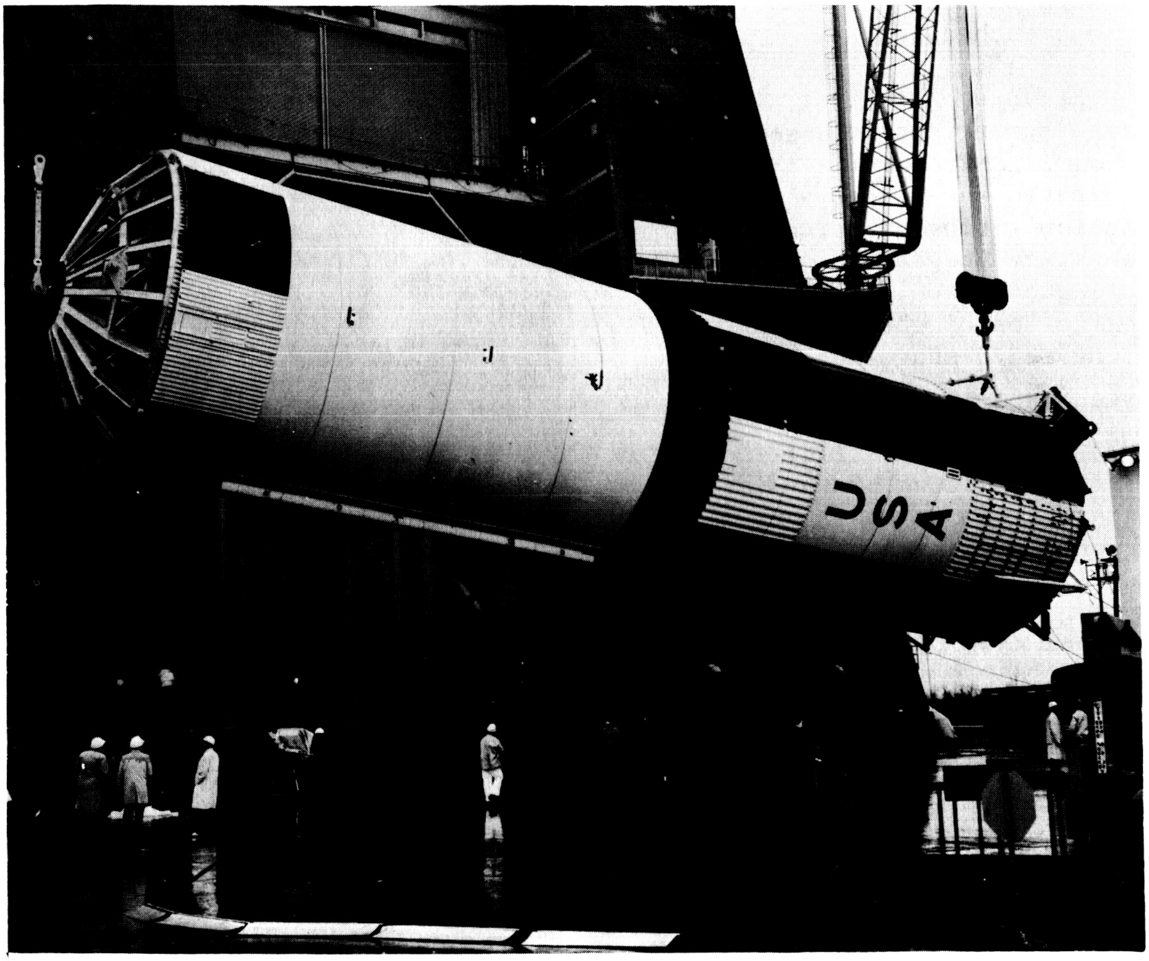


FIGURE 236. FIRST SATURN V STATIC TEST BOOSTER PLACED IN MSFC STAND

proceeded throughout the month. Meanwhile, the Center completed the S-IC-S forward section, an S-IC structural test unit. Boeing continued work on the dynamic test stage, S-IC-D, and began fabricating a bulkhead for the first contractor-assembled flight booster, the S-IC-3.

Saturn V second stage progress in March included vertical assembly operations on S-II-T (Fig. 237) by North American Aviation-S&ID at Seal Beach. S&ID also completed fabrication, assembly, and ultrasonic inspection of the common bulkhead for this all-systems stage during the month. At Santa Susana technicians completed and activated the S-II common bulkhead test facility. NASA studied use of Mississippi Test Operations rather than Santa Susana facilities for the all-systems test program. MSFC started structural testing of S-II-S/D on March 22, ten days ahead of schedule.

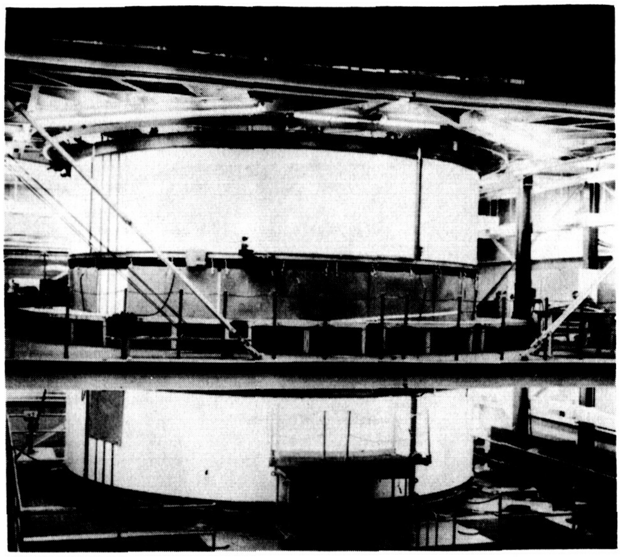


FIGURE 237. SATURN V SECOND STAGE ASSEMBLY (CYLINDERS 3, 4, AND 5 FOR S-II-T)

S-IVB battleship activity for March, summarized in preceding Saturn IB coverage for the month, culminated in a successful full-duration firing on March 31. Meanwhile, Douglas personnel at Huntington Beach worked on the fabrication of the first Saturn V flight S-IVB stage, S-IVB/V-1 (Fig. 238).

MSFC completed longitudinal vibration testing of the instrument unit common to Saturn IB and Saturn V and began preparations for lateral vibration testing. MSFC also finished assembly of S-IU-200S/500S for use in the instrument unit structural test program. IBM Owego shipped the first aerospace systems test and evaluation console (ASTEC) to MSFC on March 24. This instrument unit checkout console successfully combined computer, data adapter, and systems test equipment.

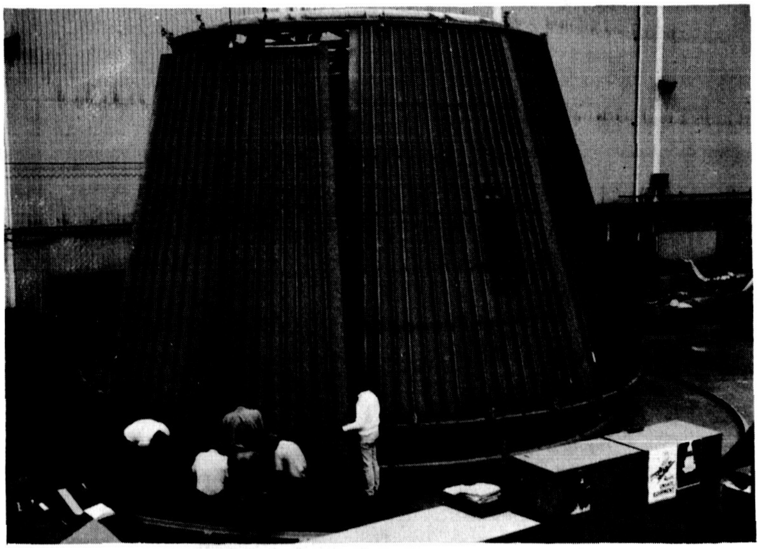


FIGURE 238. FABRICATION OF AFT INTERSTAGE FOR FIRST SATURN V S-IVB FLIGHT STAGE (DESIGNED TO FIT THE WIDER DIAMETER S-II STAGE, THE AFT INTERSTAGE IS THE MAIN VISUAL DIFFERENCE BETWEEN SATURN IB AND SATURN V S-IVB STAGES)

During April preparations for the ninth Saturn I flight proceeded at Cape Kennedy. The SA-8 vehicle, which would perform the flight, was in prelaunch checkout. Near the end of the month technicians at the Cape mated the Pegasus B payload to the vehicle, but--before it could be covered by the Apollo command module--sudden rains soaked the Pegasus capsule. After it dried, the satellite was tested and found to be in satisfactory condition. The SA-8 launch schedule, therefore, was not affected.

The second stage and instrument unit of SA-10, the final Saturn I, were ready for shipment to the Cape. The S-I-10 booster was still undergoing poststatic modifications. NASA expected the last Saturn I to be ready for launching ahead of schedule.

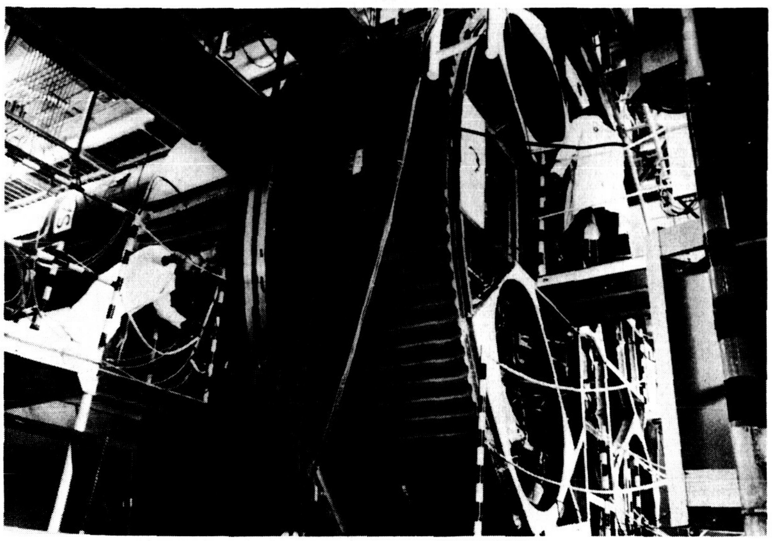


FIGURE 239. PRESTATIC CHECKOUT OF SATURN IB BOOSTER, S-IB-2, AT MICHOUD

The first Saturn IB flight stage was static fired on April 1 in MSFC's test stand formerly used for S-I. Following this short duration firing of the S-IB-1 stage, Chrysler fired the stage, on April 13, for 142 seconds in a long duration test.

At Michoud Chrysler worked on the next five S-IB flight stages. S-IB-2 prestatic checkout was concluded (Fig. 239). S-IB-6 was in very early fabrication.

At Huntington Beach Douglas painted and weighed the first Saturn IB S-IVB flight stage. On April 30 this stage, S-IVB/IB-1, departed by NASA barge for Sacramento where it was scheduled for static firing tests.

During April MSFC worked on the first flight S-IC stage for the Saturn V. The Center completed hydrostatic testing of the fuel tank for this stage and began helium bottle installation in the LOX tank.

Saturn V second stage activity by North American-S&ID included installation and checkout of Electro-Mechanical Mockup systems, beginning of vertical assembly of the S-II-F stage structure, and the first test to ultimate load on S-II-S/D. At Sacramento S&ID accomplished a successful five engine cluster ignition firing of the S-II battleship.

Saturn V third stage work by Douglas included leak and dye tests on the S-IVB/V-1 (first flight stage), propellant loading of facilities checkout stage, S-IVB-F, and full duration firing tests of the S-IVB battleship.

A significant milestone in Saturn V development was reached during April with the first ground firings of an S-IC stage. On April 10 MSFC successfully conducted a 16.73 second single engine firing of this stage, the S-IC-T. On April 16 MSFC successfully fired all five of the stage's powerful 18.5-foot high engines for 6.5 seconds (Fig. 240).

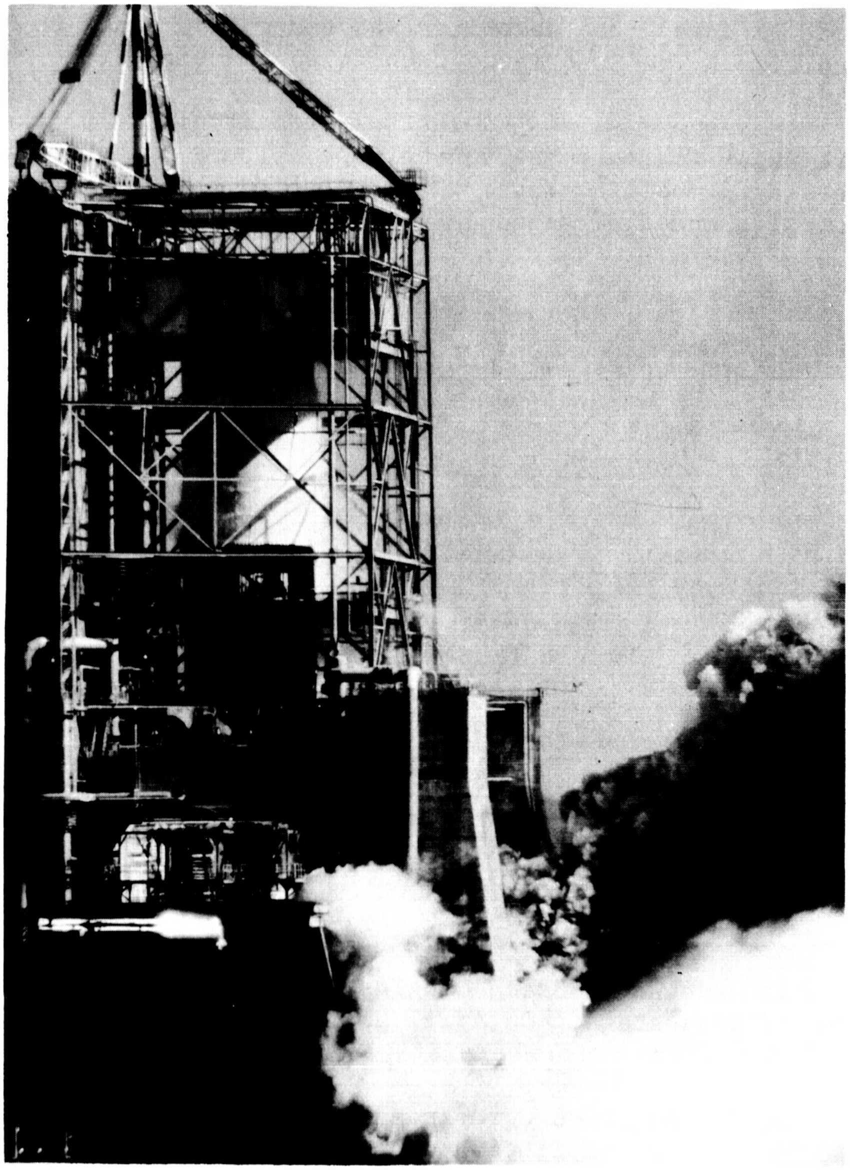
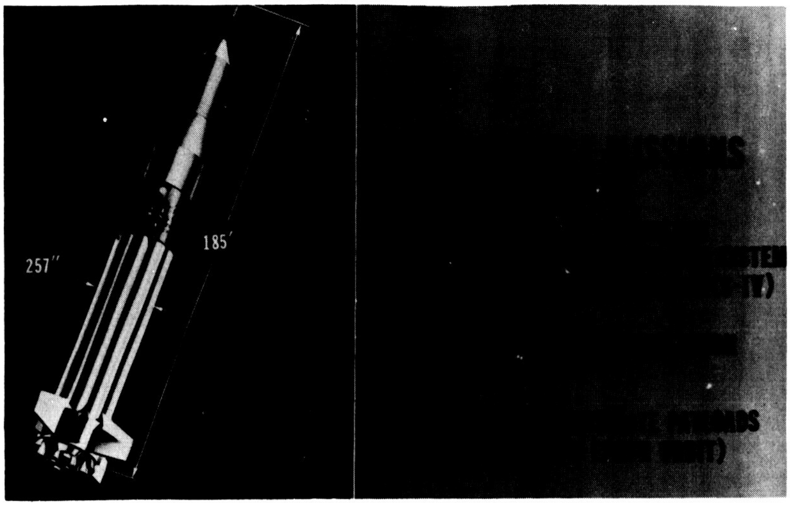


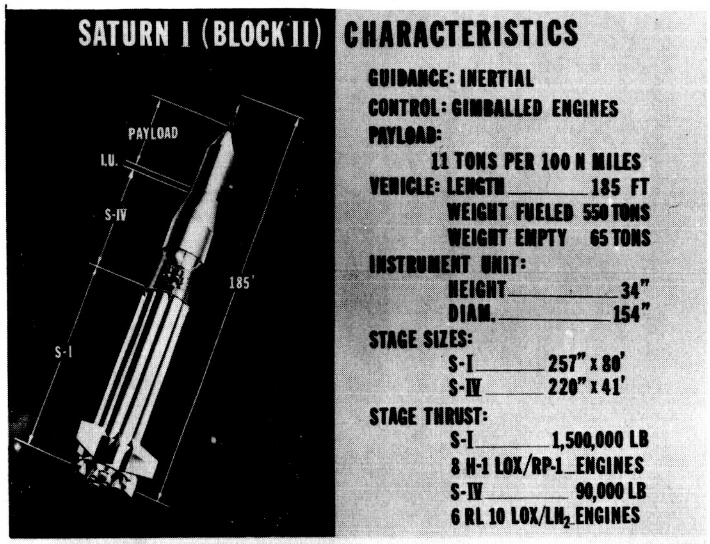
FIGURE 240. FIRST ALL-ENGINE GROUND FIRING OF THE SATURN V BOOSTER

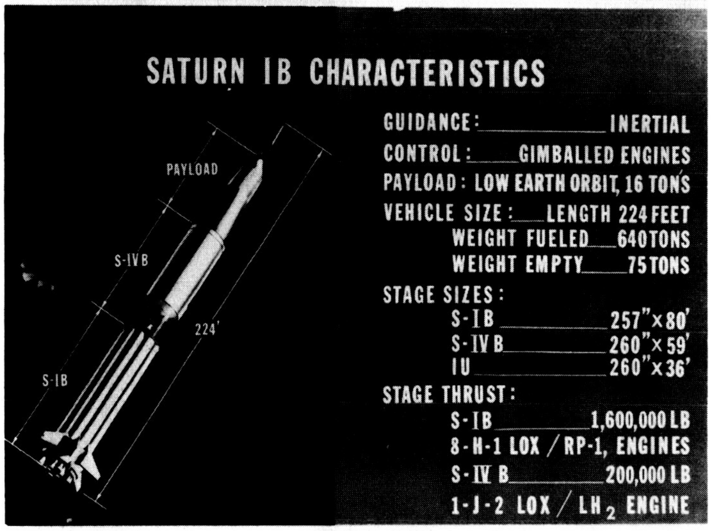
APPENDICES

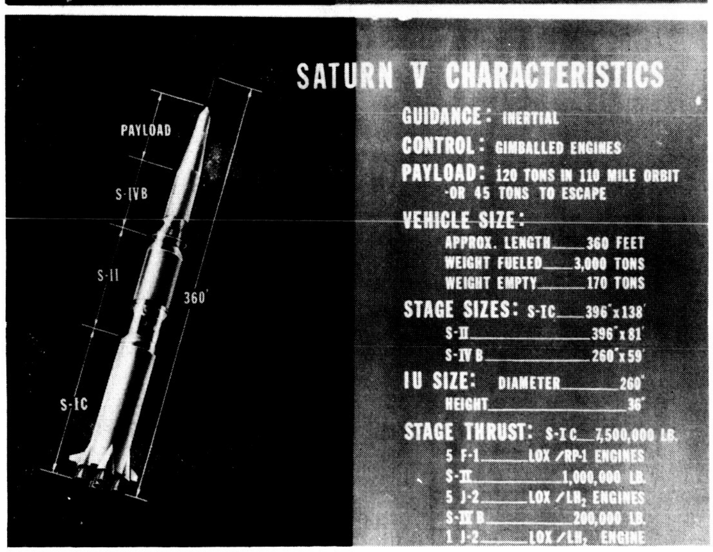
APPENDIX A: SATURN MISSIONS



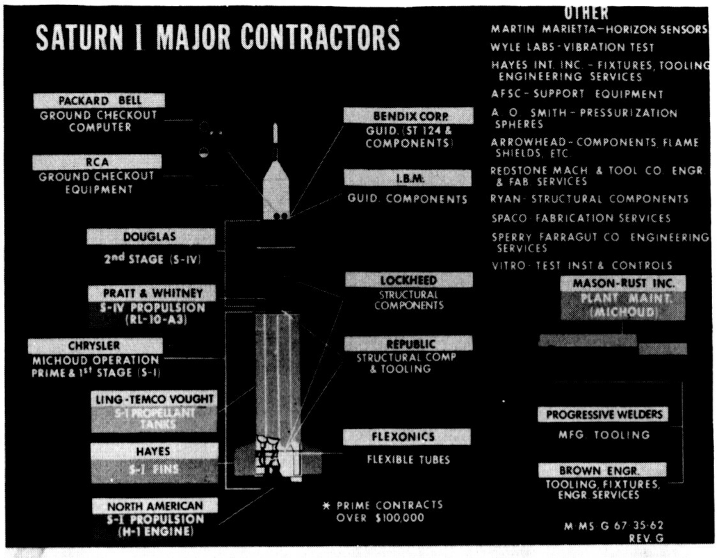
APPENDIX B: SATURN CHARACTERISTICS

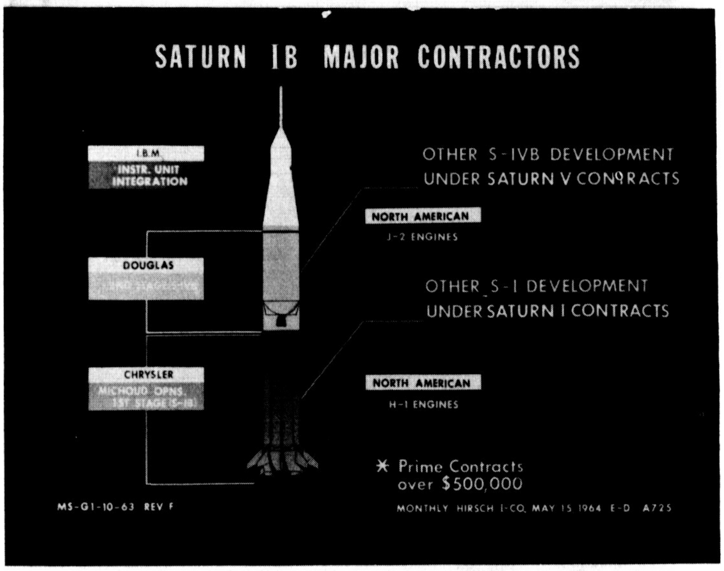


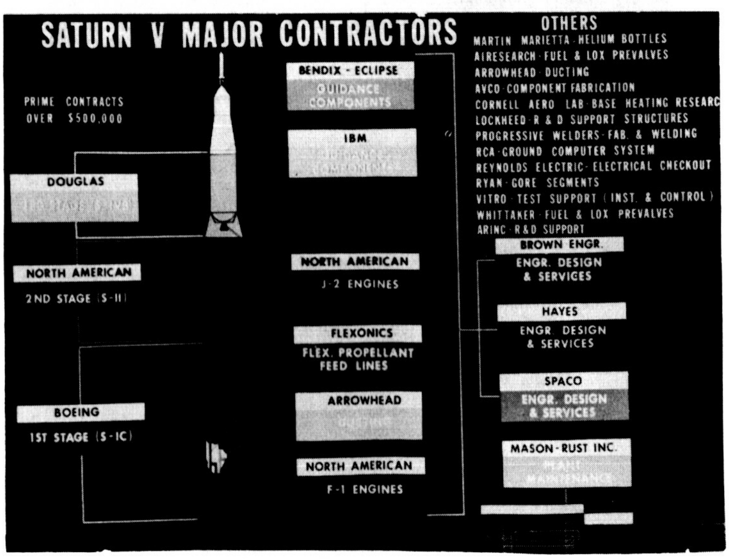


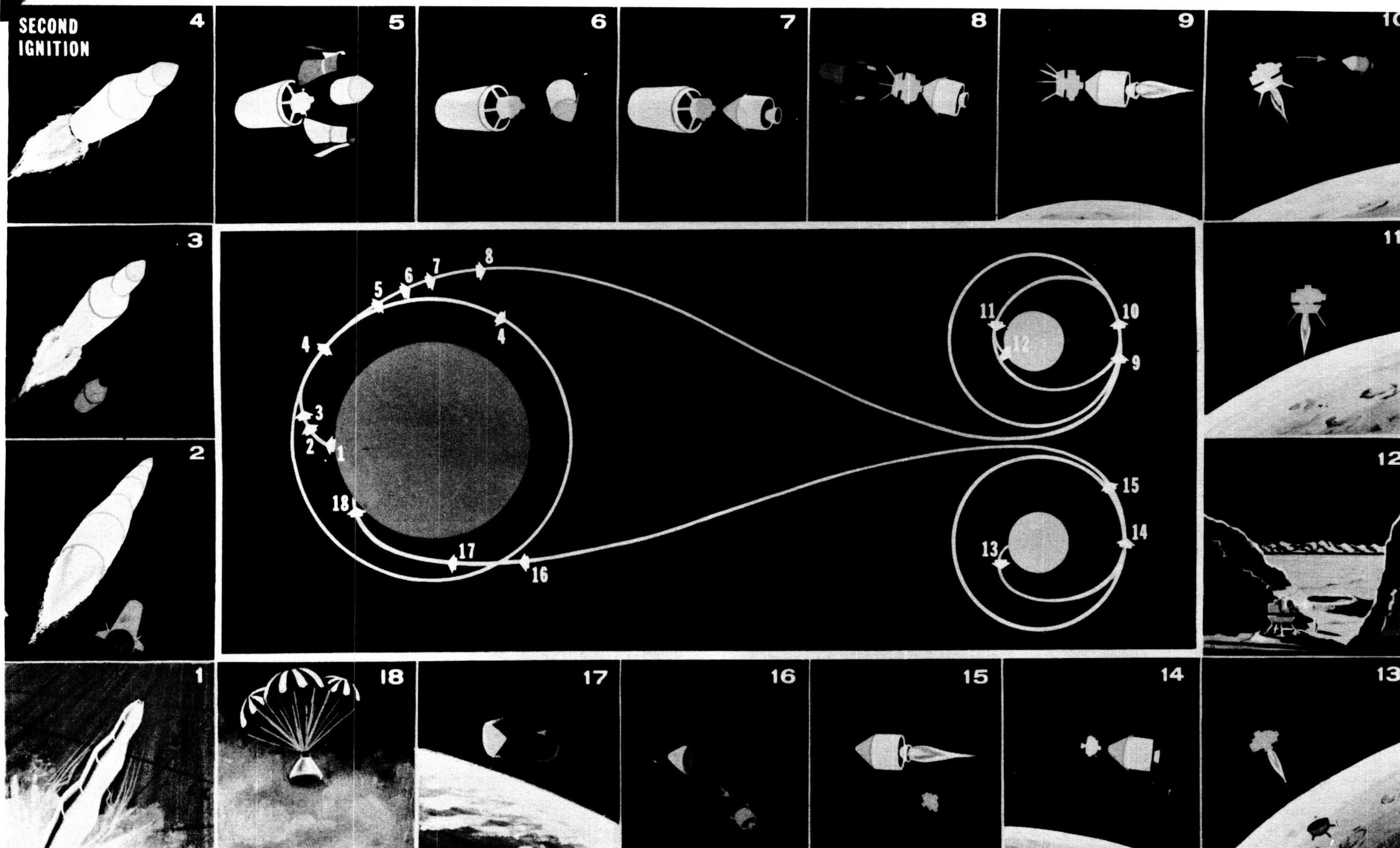


APPENDIX C: SATURN MAJOR CONTRACTORS









APPENDIX D. SEQUENCE FOR SATURN V MANNED LUNAR VOYAGE

GLOSSARY

Defining acronyms, abbreviations, nomenclature, and other terminology used in the SATURN ILLUSTRATED CHRONOLOGY

ABMA - Army Ballistic Missile Agency, now a portion of Army Missile Command (AMC)
AEC - Atomic Energy Commission
Aerojet General Corp. - contractor for M-1 and NERVA
AF - Air Force
All-Systems vehicle - non-flight stage used to checkout flightworthiness of systems
AMR - Atlantic Missile Range
AOMC - Army Ordnance Missile Command
Apollo - project designation for manned lunar landing, also spacecraft for manned lunar landing
ARPA - Advanced Research Projects Agency
Boeing - Boeing Company, contractor for Saturn V's booster, the S-IC stage
"Bug" - lunar excursion module, landing unit of the Apollo spacecraft
C-1 - Saturn C-1, early nomenclature for Saturn I
C-3 - Saturn C-3, Saturn configuration considered but not used
C-5 - Saturn C-5 configuration adopted for lunar landing Apollo flights (renamed Saturn V in February 1963)
C-IB - Saturn C-IB, vehicle selected in 1962 for manned earth orbital flights with full Apollo spacecraft (renamed Saturn IB)
Centaur - vehicle under development for support of unmanned moon probes and other missions
Chance-Vought - Saturn tank manufacturer, Dallas, Texas
CCSD - Chrysler Corporation Space Division
Chrysler - Chrysler Corp., contractor for Saturn I's booster, or S-I stage
Compromise - barge transporter for Saturn booster
Connell, Maurice H. & Associates - MSFC facilities contractor
Consteel-Ets-Hokin - contractor for umbilical tower, Launch Complex 34
Convair - Convair Astronautics, former name for General Dynamics/Astronautics, contractor for dummy S-V stage scheduled but deleted from Saturn C-1
DAC - Douglas Aircraft Corporation, contractor for S-IV and S-IVB stages
DOD - Department of Defense
Downey, Calif. - S&ID S-II stage component fabrication and testing facility location
Dyna Soar - Air Force spacecraft for earth orbital flight featuring "glider re-entry."
DX - highest national priority
Ets-Hokin and Galvan, Inc. - One of MSFC test facilities contractors
Fairchild Stratos Corporation - meteoroid satellites contractor
F-1 - Saturn V booster (S-IC stage) engine
General Dynamics/Astronautics - one of three companies awarded nuclear stage study contracts
Greenhut Construction Company - S-IC static test stand contractor at MSFC
GSE - ground support equipment
H-1 - Saturn I booster (S-I stage) engine
High Water, Project - SA-2 and SA-3 flight experiments in which water from the dummy second stage was released into the ionosphere
Huntington Beach - DAC S-IVB assembly facility in California

J-2 - liquid hydrogen engine for S-IVB and S-II stages
Kiwi-B - nuclear reactor
LC-34 - Launch Complex 34, Cape Kennedy
Lockheed Aircraft Company - nuclear stage contractor
LH_2 - liquid hydrogen
LOX - liquid oxygen
LR-115 - first liquid hydrogen type engine (Pratt & Whitney), early designation of RL10-A3 engine
LR-119 - proposed uprated LR-115 engine (project was cancelled)
Martin Company - nuclear stage study contractor
Mason-Rust Co. - administrative services contractor for Michoud
Michoud - Saturn S-I, S-IB and S-IC stage manufacturing plant in New Orleans
Minneapolis-Honeywell - guidance system components contractor for MSFC
MSFC - George C. Marshall Space Flight Center
MTF - Mississippi Test Facility
MTO - Mississippi Test Operations, rocket ground test site in Hancock Co., Miss.
NAA - North American Aviation, Inc.
NERVA - nuclear engine for RIFT stage
Nova - moon direct flight vehicle deferred in favor of Saturn V
Palaemon - barge transporter for Saturn I first stage and other large vehicle components
P&W - Pratt & Whitney, S-IV stage liquid hydrogen engine contractor
R&D - research and development
RL10-A3 - liquid hydrogen engine for S-IV stage
RIFT - reactor-in-flight test stage (nuclear power)
Rocketdyne - North American Aviation subsidiary responsible for H-1, J-2, and F-1 engines
S-I - Saturn I (originally Saturn C-1) first stage
S-I-5 - fifth Saturn I (SA-5) first stage
S-IC - Saturn V first stage
S-II - Saturn V (originally Saturn C-5) second stage
S-IV - Saturn I (originally Saturn C-1) second stage
S-IVB - Saturn V (originally Saturn C-5) third stage
S-IV Battleship - non-flight S-IV stage replica for engine tests
S-V - Saturn C-1 third stage contemplated but dropped
SA-01 - SA-1 booster's first flight qualification test
SA-1 - Saturn I (originally Saturn C-1), first flight vehicle
SA-2 - Saturn I (originally Saturn C-1), second flight vehicle
SA-D1 - dynamic test of Saturn I (originally Saturn C-1) dummy vehicle
S-IU-5 - Saturn SA-5 instrument unit
SA-T - test booster
SA-T1 - SA-1 test booster
SAT-01 - first live firing of the Saturn test booster
SACTO - Sacramento, California, test facility of Douglas Aircraft Co.
Santa Monica - DAC S-IV stage fabrication facility in Santa Monica, Calif.
Saturn I - first large space vehicle preliminary to the moon flight vehicle
Saturn IB - manned earth orbital flight vehicle preceeding moon flight rocket and composed of Saturn I's first stage and Saturn V's third stage
Saturn V - manned moon flight launch vehicle
S&ID - Space and Information Systems Division, NAA, Downey, Calif.
Seal Beach - NAA S-II stage manufacturing and assembly facility, California
Slidell - NASA computer center, Slidell, Louisiana
Sverdrup Parcell Co. - MTO design contractor