MSFC Historical Monograph No. 9

(MHM-9)

HISTORY OF THE GEORGE C. MARSHALL SPACE FLIGHT CENTER

FROM JANUARY 1 THROUGH JUNE 30

1964

Volume One

by

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Management Services Office
George C. Marshall Space Flight Center
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Huntsville, Alabama

May 1965

MRS. JOHNSON AND DR. VON BRAUN IN SATURN V AREA HERE

MSFC Director Wernher von Braun presents a safety "hard hat" to Mrs. Lyndon B. Johnson, wife of the President, during her visit to this Center on March 24, 1964. Dr. von Braun wears a Texas hat given him by the President in a visit to the LBJ Ranch. This picture was made in the Saturn V mockup area prior to static firings of the S-1 engine and the S-I stage.

FOREWORD

This is the eighth semiannual history of the George C. Marshall Space Flight Center. It covers the period January 1 - June 30, 1964, and records our most important activities in support of the National Aeronautics and Space Administration.

Our principal mission is to develop the launch vehicles for advanced space exploration. The immediate part of this objective is to provide the Saturn vehicles for manned lunar landing and return, a major national goal before 1970.

If it is true that one studies the past in order to know the future, then we are confident that this report will be of interest and help to those engaged in space exploration.

Wernher von Braun
Director

TABLE OF CONTENTS

TABLE OF ILLUSTRATIONS

PREFACE

Entitled Marshall Historical Monograph Number 9, this is the eighth official semiannual history of the George C. Marshall Space Flight Center. In the following pages are described the most historic events at the Center during the period January 1 through June 30, 1964.

The historical background of the Center's scientific group goes back more than three decades prior to activation of MSFC and is related in Marshall Historical Monograph Number 1 (MHM-1), Historical Origins of the George C. Marshall Space Flight Center. The story of the Center's first year of operation is contained in MHM-2, History of the George C. Marshall Space Flight Center: July 1 -- December 31, 1960, and MHM-3, History of the George C. Marshall Space Flight Center: January 1 -- June 30, 1961. The history of the Center's second year of operation is contained in MHM-4, History of the George C. Marshall Space Flight Center: July 1 -- December 31, 1961, and MHM-5, History of the George C. Marshall Space Flight Center: January 1 -- June 30, 1962. The history of the third year of operation is contained in MHM-6, History of the George C. Marshall Space Flight Center: July 1 -- December 31, 1962, and MHM-7, History of the Geroge C. Marshall Space Flight Center: January 1 -- June 30, 1963. MHM-8, History of the George C. Marshall Space Flight Center: July 1 -- December 31, 1963, contains the history of the first half of the fourth year of operation.

Except for MHM-1 our MSFC histories consist of three volumes for each six months of operation. Volume I contains the text plus an appendix of chronological events for all the programs. In Volume II are the unclassified documents that support Volume I. These documents are referenced at appropriate places in the text. Volume III contains classified information and technical progress reports supporting the program histories in Volume I. Volume III is not published for general distribution but is retained in historical archives at MSFC and at NASA Headquarters in Washington, D. C.

In our three-volume histories for each six months the approach is functional: the Center's activities are broken down by major programs. In an organization as large and complex as the Center it is difficult to report separately on the research and development and the administrative functions. However, MSFC's administrative activities are discussed as they relate to the various programs, and in addition the Introduction includes extensive coverage of administrative activities.

Appropriate portions of this history have been read and approved by the Center's Office of Deputy Director, Technical; Office of Deputy Director, Administrative; Offices of the Chief of Management Services, Purchasing, Financial Management, and Public Affairs; Offices of Director, Industrial Operations, and Director, Research and Development Operations; as well as most of the program offices in Industrial Operations and the laboratories in Research and Development Operations. While it is impossible to properly acknowledge every office or organization that provided data for this study, the MSFC Historical Office hopes that the above listing contains the names of most offices that were especially helpful. In the space field, where history changes so rapidly and dynamically, such excellent liaison is vital to an accurate interpretation and recording of space exploration.

May 1, 1964

D. S. A., Chief
MSFC Historian

INTRODUCTION

Development of the three Saturn launch vehicles was the principal mission of the George C. Marshall Space Flight Center (MSFC) during the first six months of 1964, the period covered by this semiannual historical report. The three Saturns under development are the Saturn I, the Saturn IB, and the Saturn V. Successful flight tests of SA-5 and SA-6, the first two Saturn I vehicles in the Block II phase of the program,[1] were the outstanding events of this period. Of major significance in these flights was the first live use of the liquid hydrogen S-IV second stage. As Saturn I research and development (R&D) passed its peak and approached completion, emphasis at MSFC shifted to Saturn IB and Saturn V R&D.

Vehicle Development Progress

The two Saturn I launches in this period were the fifth and sixth Saturn R&D flights. The flights in January and May demonstrated performance of the complete vehicle system. SA-5 orbited the largest payload (37,700 pounds) ever launched by any nation, and the SA-6 placed in orbit the first Apollo boilerplate spacecraft. The two vehicles met all assigned objectives. The flights brought almost to completion the launch vehicle technology phase of the Saturn I program. The four subsequent

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1. Saturn I research and development (R&D) was divided into two phases, Block I and Block II. Block I R&D consisted of development and flight of the first stage and vehicle structure. Block II consisted of development and flight of the complete launch vehicle, including live upper stage, instrumentation systems, and payload.

flight vehicles will perform primarily operational missions in orbiting boilerplate Apollo payloads as well as three micrometeoroid measurement (Pegasus) experiments.

Other Saturn I accomplishments during the first six months of 1964 included preparation for launch of SA-7, the seventh flight vehicle. MSFC and contractors completed assembly of SA-9 and SA-8 vehicles for the eighth and ninth flights, respectively. The booster for SA-10, the final flight vehicle, was complete, and assembly of the S-IV stage and instrument unit for SA-10 was in progress. Concentration of effort was on development of Pegasus and adaptation of the boilerplate Apollo to accept this new payload.

Saturn IB program participants completed vehicle specifications and coordinated vehicle.mission assignments. MSFC and contractors also completed and certified all major tooling, built mockups, assembled some ground test stages, manufactured components for four flight stages, and redesigned the instrument unit structure. In March MSFC accepted delivery of the first production 200K engine.[2] Delivery of the first production J-2 engine (for the S-IVB battleship) occurred in April. In negotiation at the end of the period was the "lead contract" for the Saturn IB/V instrument unit,[3] as well as a supplement to the S-IVB prime contract covering eight flight stages for the Saturn IB vehicle.

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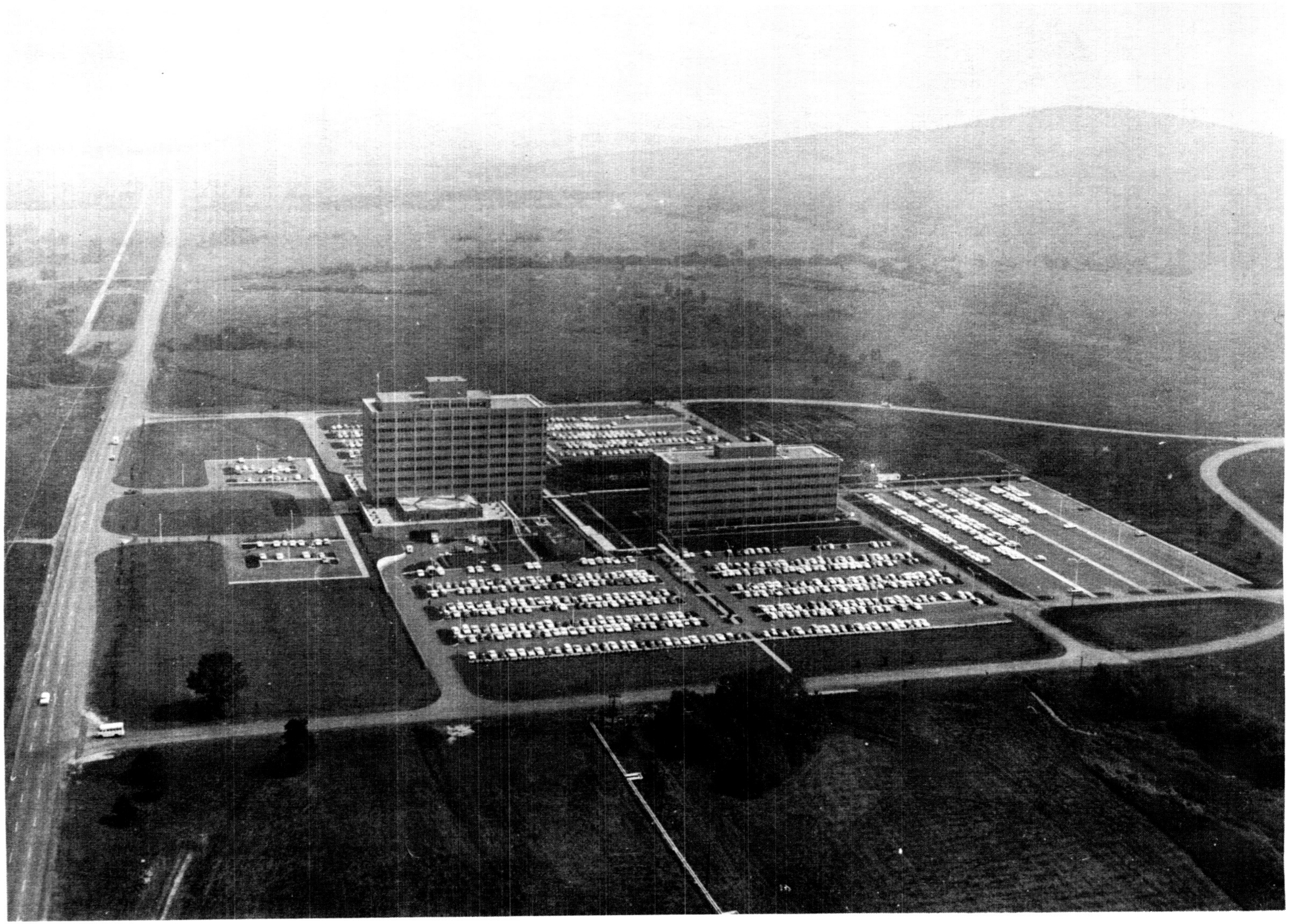
2. The H-1 engine for the Saturn I booster generated 188,000 pounds (188K) thrust. Improvements to the H-1 resulted in a 200K engine for use on the Saturn IB booster.

3. NASA selected International Business Machines Corporation (IBM) to be Saturn IB/V instrument unit "lead contractor," with responsibility for integration of all instrument unit systems.

In the Saturn V program MSFC and industrial contractors proceeded briskly with fabrication and assembly of ground test hardware. The initial design of the launch vehicle for Apollo lunar missions was completed. Manufacturers produced mockups and the first major items of hardware for all three stages plus support equipment. Some S-IC stage subassemblies were ready for structural test. Completed prototypes of the S-II and S-IVB upper stages awaited static firing tests scheduled before the end of 1964. MSFC finalized several instrument unit contracts, initiated action on others, and completed assembly of the first IU. The F-1 and J-2 engine contractor moved steadily toward accomplishment of flight rating tests (FRT) and delivered production models of both engines. Solution of the F-1 combustion instability problem seemed assured. Facilities construction reached a peak at government and contractor locations. Several major facilities became operational and others neared completion in preparation for production, ground testing, and checkout.

Presidential review of the RIFT (reactor-in-flight-test) Project late in 1963 led to cancellation of the project, which was a part of the nation's Nuclear Rocket Program. The project objective was development of a vehicle for flight testing a nuclear rocket engine. Termination of the MSFC prime RIFT contract with Lockheed Missiles and Space Company occurred on February 14, 1964.[4] Thus ended a launch vehicle project which MSFC had managed since its inception in 1962.

4. MSFC Historical Office, History of the George C. Marshall Space Flight Center, July 1 - December 31, 1963, (MHM-8), pp. 213-215, cited hereafter as MSFC Hist. Office, History of MSFC, (MHM-8); and Chief, Financial Management Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Feb. 20, 1964.



MSFC HEADQUARTERS COMPLEX

The two laboratory and office buildings completed at that time are shown in this Spring 1964 photo, looking northeast at MSFC. Building 4200, left, and 4201 will be joined by Building 4202, which will occupy the space between the two structures in this picture. Work on Building 4202 began in May 1964.

Plant Facilities[5]

Building 4201, the six-story Engineering and Administration Building in the Center's headquarters office area, was ready for occupancy during April 1964. Approximately 650 Industrial Operations personnel moved into Building 4201 during April and May, vacating space in Building 4200 and other buildings at the Center. MSFC organizations in other Redstone Arsenal buildings and in downtown Huntsville occupied the space left by the move into Building 4201.

Early in April MSFC sought bids for construction of the third and final building in the headquarters complex, to be erected north of Building 4201 and diagonally behind Building 4200. This new six-story structure, identical to Building 4201, will be designated Building 4202 and used as a Project Engineer Office Building. In the bid opening on April 28 the low bidder was Pearce and Gresham Company. The Center awarded the $2.2 million contract to Pearce and Gresham on May 6, and work began immediately.[6]

Meanwhile, about midway in this period Technical Services Office personnel moved from Buildings 4481 and 4746 into newly constructed Building 4249 near the headquarters complex.

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5. Facilities directly supporting the launch vehicle programs are covered in the applicable chapters of this history.
6. Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Apr. 30, 1964.

MAJOR ADDITION TO COMPUTATION LABORATORY

This July 1964 picture of construction at Building 4663 shows progress of extensions to all three wings of the building.

Work continued on several additions and modification projects at various Center locations. Among these projects was a major expansion of the Computation Laboratory (Building 4663) where construction advanced on a three-story annex that would provide 41,700 square feet of floor space. Work also continued on conversion to office space of portions of Buildings 4471 and 4481.

Toward the end of this report period the Center leased four floors of the 2109 Clinton Building in downtown Huntsville. About 280 personnel formerly occupying office space at the Twickenham Hotel moved into the newly leased offices prior to June 30. Also during this period MSFC's leases expired on the downtown Quick Building, Goldenrod Motel, and Mountain View Motel. Employees from these spaces moved into offices at MSFC proper.[7]

A Redstone Arsenal Railroad relocation project started late in this report period. The project involved moving rail facilities near the Astrionics Laboratory, Building 4487, in order to make space for erection of two new buildings. The new buildings--an Acceleration Test and Calibration Facility and a Hazardous Operations Building--were under construction when the period ended.

At MSFC's Michoud Operations, New Orleans, Louisiana, work proceeded on a number of plant facilities. The principal construction project was the three-story Laboratory and Engineering Building. This new office structure was scheduled for completion in the fall of 1964. Michoud made

7. Chief, Technical Services Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, memo, subject, "Flash Report," May 15, 1964; May 28, 1964; and June 19, 1964; and Deputy Chief, Purchasing Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, memo, subject, "Weekly Activity Report," Apr. 30, 1964.

MTO OFFICE FACILITY

MTO's two-story Laboratory and Engineering Building was at this stage of construction when the January - June 1964 report period ended.

plans for moving about 5,000 contractor and government personnel into the new building in September and October 1964. Renovation of the second floor of the Slidell Computer Facility, near Michoud at Slidell, Louisiana, ended early in this period. Chrysler Corporation and Boeing Company personnel occupied this area the second week of January 1964.[8] Plans were complete for major modification to the air-conditioning system of the computer building when the period ended.

Mississippi Test Operations (MTO), another division of MSFC, continued major facilities construction. In addition to test and support facilities, construction at MTO included completion of site clearance and considerable work on the canal, lock and bascule bridge, roads, rail, and waterway facilities; a warehouse, utilities, and the Laboratory and Engineering Building that will contain offices for government and industrial personnel.[9]

Management and Administration

The MSFC reorganization initiated in the last half of 1963 continued during the current period. The first step of this reorganization, involving a broad realignment of duties and responsibilities within Center management, occurred before the end of 1963.[10]

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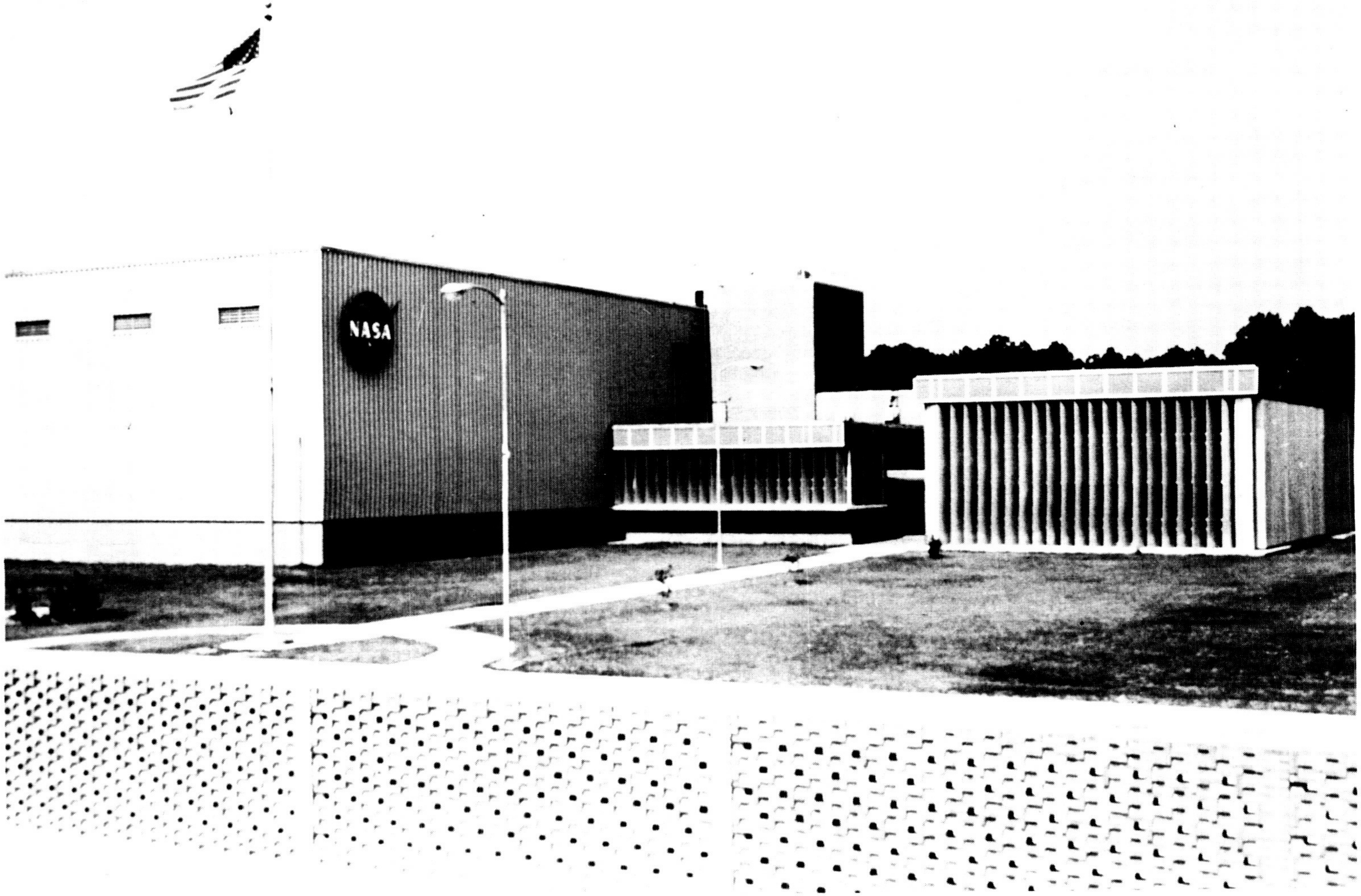
8. MSFC Michoud Operations, Historical Report, Michoud Operations, January 1, 1964 - June 30, 1964, pp. 9 and 41; cited hereafter as MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964.
9. MSFC Mississippi Test Operations, Historical Report, Mississippi Test Operations, January 1, 1964 - June 30, 1964; cited hereafter as MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964.
10. MSFC Hist. Office, History of MSFC, (MHM-8), pp. xxiv-xxxii.



SLIDELL COMPUTER FACILITY

Computer support for MSFC's Michoud Operations is provided at this facility at Slidell, Louisiana.

The Center curtailed internal transportation services by cancelling government taxi service and extending passenger bus routes. Near the end of the period MSFC received approximately 66 government-owned cargo type vehicles to replace contractor-owned vehicles used previously. This economy move completed a vehicle conversion project started in 1962.[13]

On April 16, 1964, MSFC established the Cost Reduction and Value Engineering (CRAVE) office for the purpose of directing the overall MSFC program of cost reduction and control. Col. W. S. Fellows, former Chief of the Nuclear Vehicle Projects (RIFT Project) Office, became Chief of the CRAVE office. NASA assigned the new office the responsibility for monitoring the CRAVE program of 10 major contractors. At the same time the office began development of an in-house cost reduction program.[14]

Responding to a request by the NASA Office of Manned Space Flight (OMSF) to achieve uniformity of titles at all field centers, MSFC changed the titles of principal project offices. The Saturn I/IB, Saturn V, and Engine Project offices became Program offices, and the heads of these offices became program managers instead of project directors.[15]

Effective June 15 MSFC transferred the Meteoroid Measurement (Pegasus) Project Office with its personnel from the Research Projects Laboratory of Research and Development Operations to the Saturn I/IB Program Office of Industrial Operations. Purpose of the transfer was to

13. Chief, Technical Services Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, memo, subject, "Flash Report," Apr. 3, 1964; and April 24, 1964.

14. MSFC Organization Management Manual, Chapter 2-4-08, Apr. 16, 1964; and MSFC Director to Distribution, memo, subject, "Establishment of an MSFC Cost Reduction and Value Engineering Office," Apr. 16, 1964.

15. George E. Mueller, Associate Administrator for Manned Space Flight, NASA, to Dr. Wernher von Braun, Director, MSFC, letter, June 3, 1964.

The second step came in February 1964 when MSFC announced that prime contractors would assume additional responsibilities in the Saturn launch vehicle programs. This transfer of R&D work to private industry represented a continuation of the NASA policy of sharing increased amounts of development and fabrication tasks with Chrysler, Boeing, and other prime contractors. The transfer also signified the eventual taking over by industry of full responsibility for major elements and stages of Saturn vehicles, as spelled out in the various contracts.

The third and final step in the Center's reorganization was the plan announced in March to streamline support service contracts. The plan called for phasing out existing support contracts for services and manpower. In the new arrangement each laboratory or office would have a single contract for all industrial support.[11]

MSFC participated in an intensive program of cost reduction in line with the government-wide economy campaign. At the direction of the President and the NASA Administrator, MSFC Director Wernher von Braun in February outlined a broad economy program designed to cut MSFC administrative and support costs by $4 million this year. Listed for immediate cost reduction were areas including the motor pool, inventories, communications, travel, and overtime. The President's directive extended also to contractors: the NASA Administrator called on major contractor firms to achieve full value for every dollar spent.[12]

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11. David H. Newby, Associate Deputy Director, Administrative, MSFC, Presentation made to in-house contractors March 30, 1964.

12. James E. Webb, Administrator, NASA, to all NASA employees, memo, subject, "The NASA Cost Reduction and Control Program," Dec. 31, 1963.

obtain a closer relationship between launch vehicle and payload management personnel.[16]

A Center-wide job evaluation program began in February. As a first step in the program the MSFC Personnel Office distributed job survey questionnaires to hundreds of Civil Service Classification Act (GS) employees. The goal as the program expanded was that of reviewing all positions and of achieving equity, validity, and simplicity in position classification and salary administration.[17]

NASA appointed Paul L. Styles, Chief of the MSFC Industrial Relations Office, to the newly created position of NASA Labor Relations Director. Styles retained his MSFC office and his Huntsville location.[18]

On March 11 Dr. William A. Mrazek became Deputy Director, Engineering, for both Saturn I/IB and the Saturn V programs. The effect of this assignment by the Center Director was to establish Dr. Mrazek as Chief Engineer for Saturn programs. Replacing Dr. Mrazek as Director of the Propulsion and Vehicle Engineering Laboratory was Fred B. Cline, named Acting Director.[19]

During this report period MSFC established a new organization for employee activities. In June this new employee unit was named Marshall

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16. H. K. Weidner, Director, Research and Development Operations, MSFC; Robert B. Young, Director, Industrial Operations, MSFC; and David H. Newby, Associate Deputy Director, Administrative, MSFC, memo, subject, "Memorandum of Agreement for Transfer of Meteoroid Measurement Project Office from R&D Operations to Industrial Operations," undated.

17. Acting Chief, Personnel Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Feb. 20, 1964, and March 6, 1964.

18. NASA Management Manual, Chapter 2-1-1.5, Jan. 1, 1964.

19. Dr. Wernher von Braun, Director, MSFC, to Distribution, memo, subject, "Assignments for Saturn Project Management," Mar. 11, 1964.

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DEP DIR, ADM	D H NEWBY	876 1763
NT	M I KENT	876-5663
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ATIONS & PROC OFC	F C PERRY	877-2400
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**W A MRAZEK	876-4248

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MGR, RL 10 ENGINE	R D STEWART	876 5023
SPACE ENGINE	J M JACKSON	876 8398

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Athletic, Recreation and Social (MARS) Exchange. MARS will operate under the MSFC Exchange Council.[20]

Personnel

MSFC government personnel on January 3, 1964, totalled 7,262; MSFC contractor personnel as of January 31, 1964, totalled 5,870. On June 30, 1964, at the end of the current report period, government personnel at MSFC numbered 7,731. These 7,731 included 46 military. Assigned to locations other than the Huntsville area were 576 MSFC employees; 279 were at Michoud Operations, 32 at MTO, and the remaining 265 at plants of major industrial contractors and other government organizations. The total contractor support on June 30, 1964, at Huntsville and other locations, numbered 5,801.[21]

In the January 1 - June 30, 1964, period 56 MSFC employees received sustained superior performance awards totalling $19,500. Employees submitted 664 suggestions; the Center adopted 127 of the suggestions for an estimated first-year net savings of $62,586. Suggesters received $5,025 in awards for adopted suggestions. The largest suggestion award was $500. NASA Headquarters approved 11 invention awards totalling $3,950 for Center employees. MSFC presented 284 letters of appreciation

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20. President, Marshall Athletic, Recreation and Social Exchange, and Chairman, MSFC Exchange Council, to Distribution, memo, subject, "Nomination of Candidates for the Marshall Athletic, Recreation and Social Exchange General Assembly," Sept. 9, 1964.

21. MSFC Executive Staff, "MSFC Manpower Status Summary as of January 3, 1964," Jan. 3, 1964; "MSFC Manpower Status Summary as of June 30, 1964," June 30, 1964; "MSFC Contractor Status as of January 31, 1964," Jan. 31, 1964; and "MSFC Contractor Status as of June 30, 1964," June 30, 1964. These documents are in Volume II, Supporting Documents.

and 57 letters of commendation to Center employees during the period. A total of 1,496 NASA honorary service awards went to employees. Of this number 11 were for a 30-year period, 123 for 20 years, 333 for 15 years, 341 for 10 years, and 588 for one year.

During Fiscal Year 1964, extending from July 1, 1963, through June 30, 1964, MSFC presented $59,236 in cash awards, as follows: $7,381 for suggestions, $36,225 for sustained superior performance, $1,230 for group achievement, and $14,400 for inventions. During the year employees submitted 1,094 suggestions of which 191 were adopted. The Center awarded 2,032 honorary service emblems and granted 106 sustained superior performance awards.[22]

Employment at Michoud and MTO continued to increase. In June 1964 Michoud was employing more than 10,000 workers; of this number Boeing had 5,867, Chrysler 2,995, Mason-Rust (support services contractor) 818, Telecomputing Services (computer operations contractor) 124, and NASA 281 employees. Total employment at MTO, consisting of government personnel and construction workers, exceeded 2,000 when this period ended.[23]

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22. James R. Johnson, Chief, Incentive Awards, MSFC, to D. S. Akens, Chief, Historical Office, MSFC, memo, subject, "Incentive Awards Program Data--Historical Report," July 6, 1964.

23. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 10; and MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964, p. 7.

Special Events

In January key NASA and Army officials received an extensive briefing on the centralized Redstone Scientific Information Center (RSIC) at a ceremony marking the formal opening of the new RSIC. The information center, sponsored jointly by MSFC and the Army Missile Command, moved late in 1963 into newly renovated quarters in Building 4484.[24]

Mrs. Lyndon B. Johnson made a one-day visit to MSFC on March 24. It was the first time a President's wife had visited the Center. In the company of NASA Administrator James E. Webb and other officials Mrs. Johnson toured the Center, received briefings at several laboratories, and addressed three groups of employees. She witnessed and described as "fantastic" static firings of a Saturn I booster (S-I-9, the final S-I stage manufactured at MSFC) and an F-1 engine. In presenting eight awards to MSFC employees at a ceremony in Morris Auditorium, Mrs. Johnson emphasized the role of women in government. She attended a luncheon with Alabama relatives and friends and later was guest of honor at a tea attended by several hundred community leaders. Mrs. Johnson departed following a late afternoon speech at the Huntsville Airport.

A mockup of the Saturn V tail section dominated the NASA display in Space Park at the New York World's Fair. The mammoth mockup, 85 feet tall and equipped with a full complement of five F-1 engines, was built for the fair by Boeing at Michoud Operations. Dr. von Braun officially accepted the booster exhibit at the opening of the fair in April.

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24. Chief, Management Services Office, MSFC, to Harry H. Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Report of Weekly Activities - Week Ending January 8, 1964," Jan. 10, 1964.

Another distinguished visitor at MSFC during this period was John W. Macy, Chairman of the Civil Service Commission. Mr. Macy visited on May 28, toured the Center as well as Army activities at Redstone, and addressed MSFC employees in Morris Auditorium.

Funding

During the last six months of Fiscal Year 1964 MSFC committed $663,196,000. Of this sum $517,437,000 was for research and development; $56,508,000 was for administrative operation; and $89,251,000 was for construction of facilities.[25]

25. Information supplied by Louis Snyder, Financial Management Office, MSFC, Mar. 3, 1965.

CHAPTER I: MARSHALL HIGHLIGHTS

The following list contains those items considered most historically significant at Marshall Space Flight Center during this report period.

January--June 1964

January 14 - The service module of the BP-16 Apollo boilerplate spacecraft, scheduled for test during the SA-9 flight, arrived at MSFC. MSFC began modification of the module, adapter, and BP-16 insert to support the first Pegasus capsule.

January 16 - The $66.3 million contract for furnishing and outfitting the Vertical Assembly Building (VAB) at Launch Complex 39 (LC-39), NASA Kennedy Space Center (KSC), went to a joint enterprise of three construction firms.

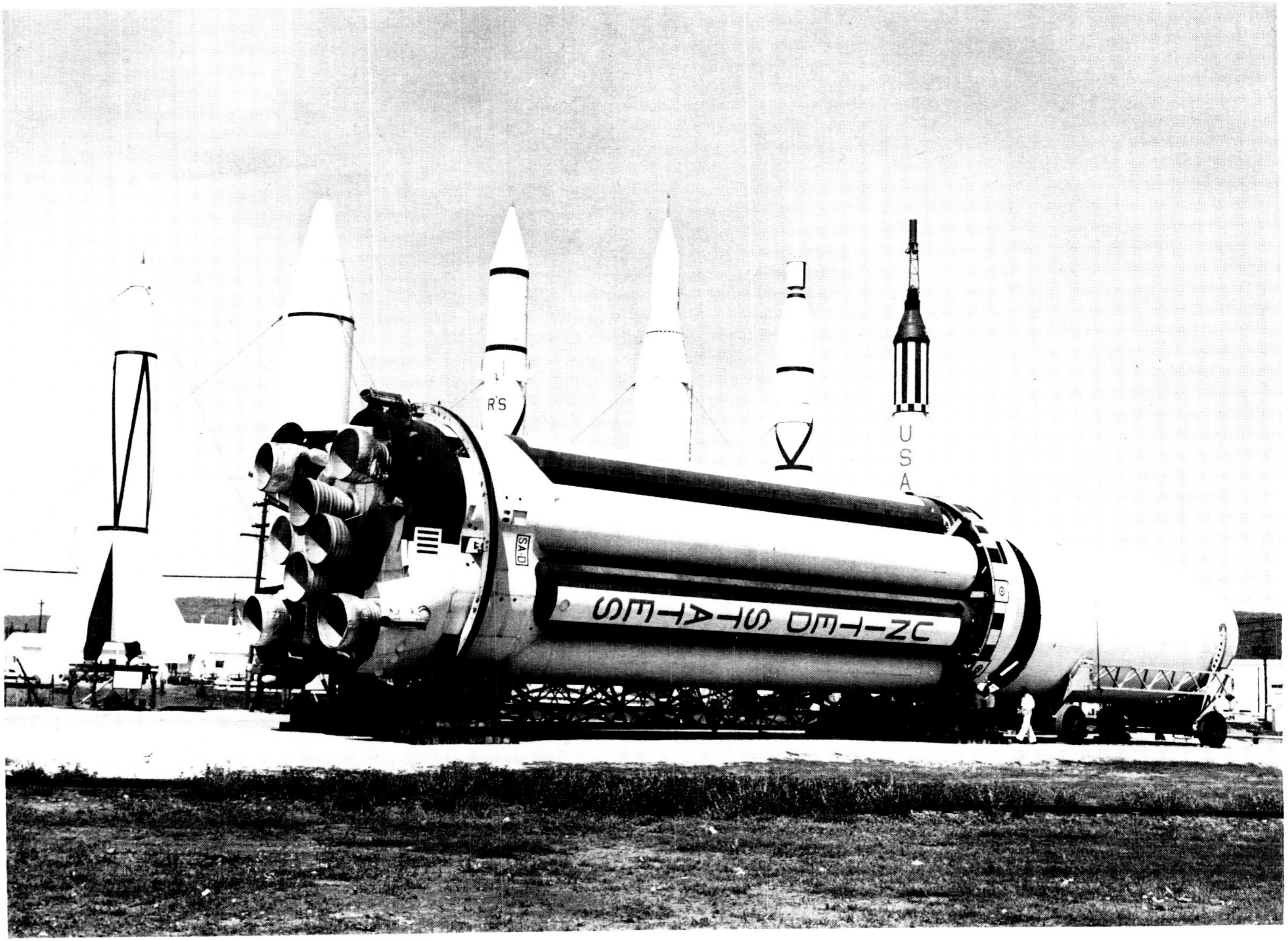
January 24 - During the terminal stages of the countdown for a third attempt to static fire the S-IV All Systems Vehicle (ASV), the vehicle exploded and burned. Investigation showed the immediate cause of explosion to be overpressurization of the stage oxidizer tank.

- In the week ending this date NASA approved extension of letter contracts to International Business Machines Corporation (IBM) through April 22, 1964, for design and development of data adapters and digital computers for Saturn IB and Saturn V vehicles.

January 27 - Rocketdyne Division of North American Aviation, Inc. (NAA), delivered the last of five operational simulator J-2 engines to the S-II stage contractor for use on the S-II electro-mechanical mockup.

January 29 - NASA successfully launched SA-5, the first Saturn to have both first and second stages live. This flight tested the performance of the complete vehicle system and its capability to place an inert payload of 37,700 pounds in an earth orbit.

In January - Workmen finished clearing trees from the 850-acre Saturn V test complex at MSFC's Mississippi Test Operations (MTO).



ROCKET DISPLAY IS AUGMENTED

Workmen move an S-IV second stage into position with the Saturn I booster at the Space Orientation Center here. The rockets and launch vehicles in this exhibit are viewed by thousands of visitors each month.

February 3 - NASA modified by letter a contract with Bendix Corporation to cover procurement of ST-124M platform systems for the first two Saturn IB instrument units (S-IU-201 and 202) and for a test unit.

February 13 - Douglas Aircraft Company (DAC) shipped the SA-7 S-IV stage (S-IV-7) via aircraft to the Sacramento Field Test Station (SACTO) for static testing.

February 14 - The MSFC prime RIFT contract with Lockheed Missiles and Space Company formally ended following cancellation of the nuclear vehicle project by NASA and the Atomic Energy Commission.

February 17 - MSFC installed the SA-9 S-I stage (S-I-9) in the Saturn I Static Test Tower and began preparations for static firing the stage, the last Saturn I booster to be assembled at Huntsville.

February 18 - The barge Promise, which had left Huntsville February 7 carrying the SA-6 S-I stage (S-I-6) and instrument unit (S-IU-6), arrived at the Kennedy Space Center.

- Chrysler Corporation Space Division (CCSD), manufacturer of the final two S-I stages (S-I-8 and S-I-10), completed prestatic checkout of S-I-8.

February 20 - KSC erected the S-I-6 stage on Pad B at Launch Complex 37 (LC-37B).

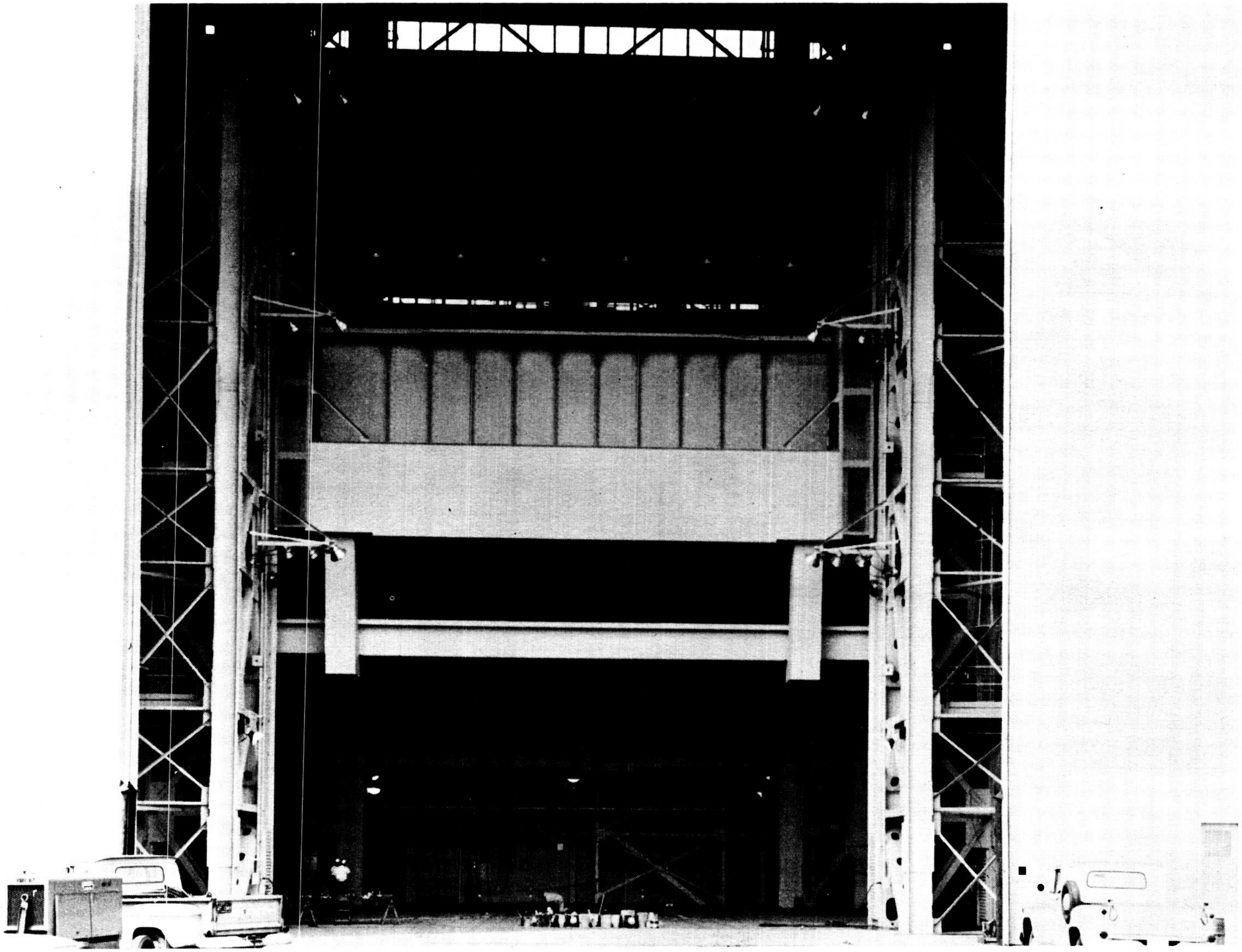
In February - MSFC completed assembly of the first S-IC transporter and modification of the M-26 power unit for the transporter.

- Construction crews at MSFC completed erection of F-1 Engine Test Stand steel superstructure and flame deflector.

- A Center-wide job evaluation program began at MSFC with the aim of reviewing all Civil Service GS positions to achieve equity, validity, and simplicity in position classification.

- In accordance with the government-wide economy campaign instituted by the President, the MSFC Director outlined a program designed to cut Center administrative and support costs by $4 million. Economy measures began immediately.

In February	-	The second step of the MSFC reorganization initiated in 1963 came with the announcement that prime contractors would assume additional research and development (R&D) responsibilities in the Saturn launch vehicle programs.
March 6	-	Technicians moved the S-IC test fuel tank, first major Saturn V component assembled at MSFC, to the Load Test Annex and began preparations for load proof testing.
March 11	-	Dr. William A. Mrazek became Chief Engineer for Saturn programs in his new office of Deputy Director, Engineering.
March 19	-	KSC technicians mated the S-IV-6 stage to the S-I-6 stage at LC-37B.
March 23	-	Activity at LC-37B included mating of the S-IU-6 to the S-IV stage of the SA-6 flight vehicle.
	-	NASA announced that the SA-10 flight vehicle will carry into orbit a third Pegasus capsule in addition to an unmanned Apollo spacecraft.
March 24	-	Mrs. Lyndon B. Johnson made a one-day visit to the Center. Accompanied by NASA Administrator James E. Webb and other officials, Mrs. Johnson toured MSFC, viewed two static firings, and made three speeches.
	-	MSFC test personnel successfully conducted a long-duration (145-second) static firing of the S-I-9 stage.
March 30	-	NASA awarded to Rocketdyne the production contract for 76 F-1 engines. Value of the contract was $158.4 million.
In March	-	NASA approved the award of a $5.5 million contract to IBM covering the first phase of IBM's instrument unit (IU) integration effort for the Saturn IB and Saturn V programs.
	-	Steel erection of the Saturn V Dynamic Test Stand superstructure ended at MSFC.
	-	Rocketdyne selected a promising thrust chamber injector for the J-2 flight rating test (FRT) engine and released the design for production.



INSIDE LOAD TEST TOWER

The MSFC Load Test Annex of the Propulsion and Vehicle Engineering Laboratory was near structural completion at the end of the current report period. Some of the machinery used to exert 30 million pounds of force on Saturn V tanks and other hardware is revealed in this picture.

In March	-	MSFC announced the third and final step in the Center's reorganization. In this move MSFC will streamline support service contracts; each laboratory and office will have a single contract for all industrial support.
April 1	-	The second production F-1 engine, F-1002, arrived at MSFC for use in static firing tests.
April 2	-	KSC technicians mated the Apollo boilerplate (BP-13) to SA-6. Addition of the spacecraft increased the height of the vehicle about 26 feet over that of its predecessor, the SA-5.
April 13	-	MSFC and Rocketdyne began negotiation of the Rocketdyne contract proposal covering production of 55 J-2 engines.
April 16	-	MSFC established the Cost Reduction and Value Engineering (CRAVE) Office to direct the Center program of cost reduction and control. NASA gave this new office the responsibility for monitoring the CRAVE program of 10 major contractors.
April 22	-	A $1.7 million definitive contract calling for Advanced Vehicle Technology studies was awarded to Lockheed Missiles and Space Company following cancellation of the RIFT contract with that firm.
April 25	-	The S-I-8 stage, first industry-built Saturn I booster, arrived in Huntsville from Michoud, and test personnel began preparations for static firing the stage.
April 29	-	DAC successfully static fired the S-IV-7 stage for a duration of 485 seconds. The successful firing followed two abortive attempts on April 21 and 27.
	-	MSFC modification of Bendix Corporation's contract NAS8-5399 made final the purchase of three ST-124M platform systems procured by letter action February 3.
April 30	-	The first hot-firing production J-2 engine, J-2003, was delivered to DAC for S-IVB battleship testing.
In April	-	Building 4201, the second of three buildings in the MSFC headquarters office complex, was completed by builders. Approximately 650 Industrial Operations personnel began moving into this six-story Engineering and Administration Building.

In April - CCSD began assembling the major structural components for the first flight S-IB stage (S-IB-1) at Michoud. DAC began assembling the first S-IVB/IB flight stage (S-IVB/IB-1) in the assembly facility at Huntington Beach, California.

- MSFC instructed General Dynamics/Fort Worth, an IU subcontractor, to redesign the IU structure to permit heavier vehicle loads.

- NASA selected IBM as the "lead contractor" to develop the IU's for Saturn IB and Saturn V vehicles. In this role IBM will have responsibility for integration of all IU systems; MSFC will initially supply components and equipment.

- NASA changed the S-II stage prime contract and increased its value by $12.3 million. Following this change the S-II contract held by NAA Space and Information Systems Division (S&ID) was valued at $337.3 million.

- S-IVB battleship test operations started at SACTO.

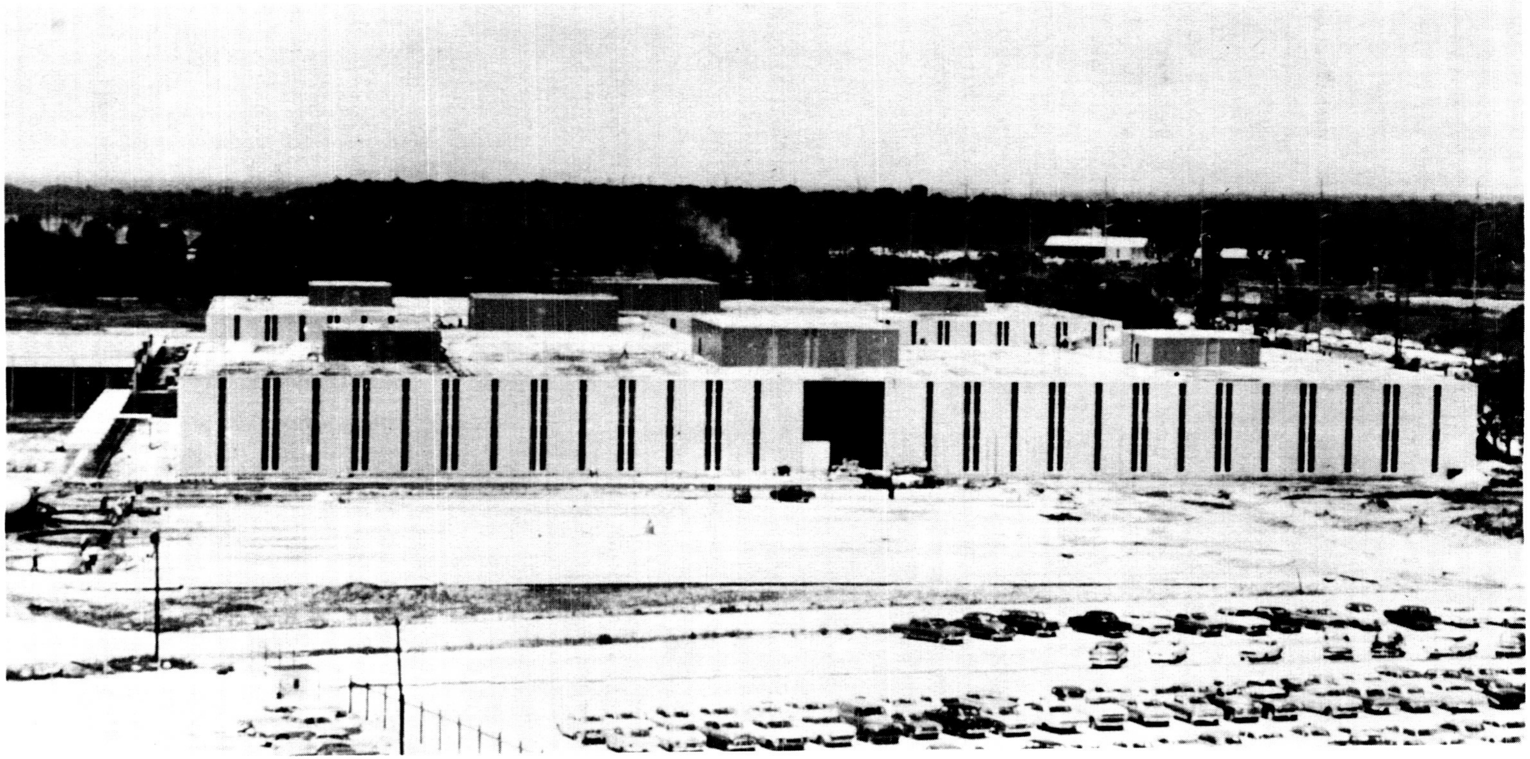
- An F-1 engine liquid oxygen (LOX) pump explosion, the second within three months, halted engine research and development firings at contractor sites and at MSFC while engineers modified the pump.

May 4 - Following completion of assembly CCSD began prestatic checkout of the S-I-10, the booster for the final Saturn I launch vehicle.

May 6 - MSFC awarded a $2.2 million contract for construction of Building 4202, third and final structure in the Center office complex. The six-story building, identical to Building 4201, will be completed in 1965 and used as the Project Engineer Office Building.

May 20 - MSFC began the final series of dynamic tests of the Saturn I configuration. The vehicle undergoing tests simulated the configuration of the SA-9, SA-8, and SA-10 vehicles and included the Pegasus capsule and the Apollo spacecraft.

May 25 - NASA announced that it would negotiate with DAC for an S-IVB stage mockup for use at MSFC.



MICHOUD OFFICE FACILITY

The Engineering and Administration Building at Michoud Operations was near structural completion in this summer 1964 picture. When completed later in the year, the three-story building will accommodate about 5,000 contractor and government personnel.

May 28 - John W. Macy, Chairman of the Civil Service Commission, made an official visit to MSFC and Army organizations at Huntsville.

- NASA successfully launched the second Block II Saturn (SA-6) from LC-37B at Cape Kennedy, thus reaffirming the performance capability of the complete Saturn I vehicle. Also tested was the first closed-loop operation of the SA-6 guidance system. As part of the flight test the SA-6 placed the first unmanned boilerplate model of the Apollo spacecraft into earth orbit.

In May - J-2 engine developers decided to delay flight rating tests from mid-1964 to the end of the year.

June 1 - IBM submitted to MSFC a contract proposal for effort as the lead contractor in development of Saturn IB and Saturn V IU's.

- Workmen completed construction of the foundation for the VAB at Kennedy Space Center's LC-39.

June 7 - The S-I-7 and the S-IU-7 arrived at Cape Kennedy from MSFC. Arriving simultaneously was the Pregnant Guppy aircraft and its cargo of the BP-15 Apollo spacecraft service module and adapter.

June 10 - MSFC requested a quotation from DAC covering manufacture of eight S-IVB/IB stages and a set of ground support equipment.

- S&ID began activation of the S-II battleship.

June 11 - The S-I-8 stage successfully performed a full-duration (145.61-second) firing at MSFC following the first (48.94-second) static test on May 26.

- MSFC contracted with Radio Corporation of America for 19 additional ground computers for use in the Saturn IB and Saturn V programs.

June 12 - The S-IV-7 stage arrived at KSC aboard the Pregnant Guppy aircraft.

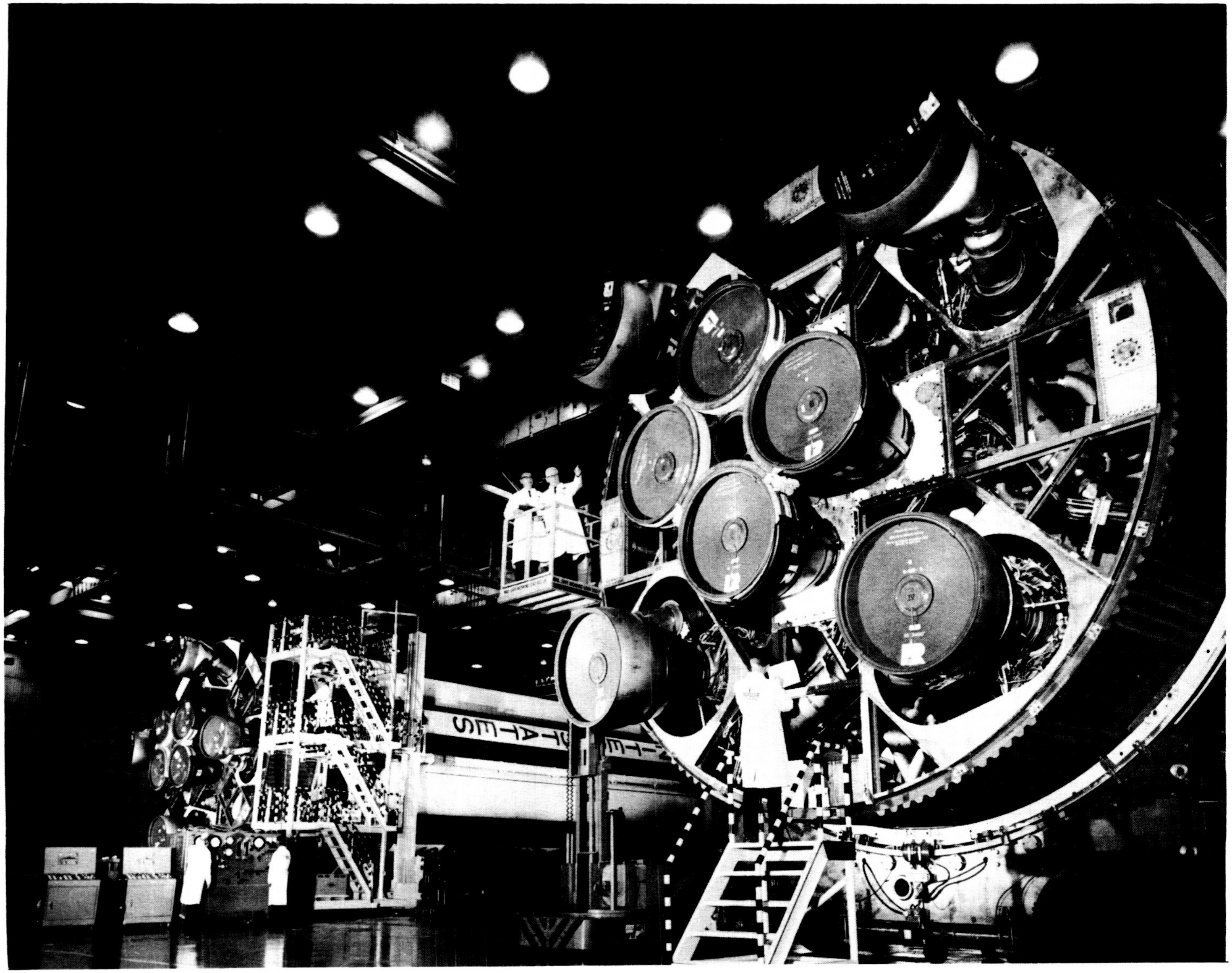
- Rocketdyne delivered the second production J-2 engine, J-2006, to S&ID for S-II battleship testing.

June 15 - MSFC transferred the Meteoroid Measurement (Pegasus) Project Office with its personnel from Research Projects Laboratory to the Saturn I/IB Program Office.

ENGINEERING BUILDING COMPLETED

An addition to Building 4666, the Test Laboratory's Engineering Building, is shown June 8, 1964, just before personnel moved into the new section.

June 19	-	KSC personnel erected S-IV-7 atop the S-I-7 stage on LC-37B.
June 22	-	Test Laboratory personnel moved into the new second addition to Building 4666.
June 23	-	The first firing at MSFC of F-1 engine F-1002 occurred.
June 24	-	NASA approved the J-2 engine production contract with Rocketdyne for 55 engines.
June 30	-	MSFC's leases expired on several downtown Huntsville office buildings, including the Twickenham Hotel, Quick Building, Goldenrod Motel, and Mountain View Motel. Personnel who vacated these spaces moved into offices at the Center and at newly constructed 2109 Clinton Building where MSFC leased four floors.
In June	-	The newly established organization for employee activities adopted the name of Marshall Athletic, Recreation and Social (MARS) Exchange. MARS will operate under the MSFC Exchange Council.
	-	DAC installed a J-2 engine on the S-IVB battleship stage in preparation for static firings.
	-	MSFC awarded a number of study contracts involving Saturn V improvement, planetary probes, and lunar transportation and logistic techniques.



S-I ENGINE ARRANGEMENT

This close-up of an S-I stage tail section at Michoud shows mounting details of the engine system. Note that the four inboard H-1 engines are affixed rigidly to the stage, while the four outboard engines are free to gimbal and thus control the Saturn I vehicle during flight.

CHAPTER II: SATURN I

The Saturn I launch vehicle consists of an S-I first stage, an S-IV second stage, and an instrument unit. It is capable of placing modules of the unmanned Apollo spacecraft[1] into earth orbit. Eight liquid-fueled Rocketdyne H-1 engines, each developing 188,000 pounds (188K) of thrust, power the S-I stage. Six liquid hydrogen/liquid oxygen (LH_2/LOX) Pratt and Whitney RL10A-3 engines, each developing 15K of thrust, power the S-IV stage. The S-I stage attaches to the S-IV stage through the S-IV aft interstage which is bolted to the spiderbeam of the S-I stage.[2] The instrument unit is located between the forward S-IV interstage and the payload adapter assembly; it houses the vehicle control system, a developmental guidance and control system, tracking systems, and power supplies.[3]

During the first phase of research and development (R&D)[4] involving the "Block I" series of vehicles, the Saturn I underwent four vehicle tests. These four flights, all successful, served to prove the launch

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1. The Saturn/Apollo project has as its objective manned lunar landing in this decade. The knowledge, flight experience, and design confidence gained in Saturn I research and development (R&D) will be reflected in the Saturn IB and Saturn V launch vehicles. The Saturn IB vehicle will test the complete Apollo spacecraft which is under development by the National Aeronautics and Space Administration's (NASA's) Manned Spacecraft Center (MSC). The Saturn V will propel the Apollo Spacecraft to the moon.

See NASA, Manned Space Flight - 1963, pp. 4-5 and 12-13.

2. S-I/S-IV separation occurs between the S-IV aft skirt and the S-IV aft interstage. The first actual separation occurred during the SA-5 flight test and is described in the R&D section of this chapter.

3. Dr. F. A. Speer, Aero-Astrodynamics Laboratory (Lab.), MSFC, "Saturn I Flight Test Evaluation," Paper No. 64-322, presented to American Institute of Aeronautics and Astronautics, June 29 - July 2, 1964, hereafter cited as Dr. F. A. Speer, AIAA Paper No. 64-322, June 29 - July 2, 1964.

4. A summary of the past five years of Saturn R&D is contained in the MSFC Historical (Hist.) Office, Historical Origins of the George C.

vehicle design and to advance the state of the art in booster technology. More specifically, the flights of these four vehicles, with only the first stage "live," tested the eight-engine-cluster propulsion system of the first stage. The flights also tested the clustered tank structure, the first stage control system (coping with sloshing and non-rigid body dynamics), and the compatibility between vehicle and launch facility.

In addition to the primary test objectives achieved in the Block I test flights there was a balanced and systematic buildup of test missions in preparation for flight of a vehicle with two live stages (Block II series). A major event in this buildup occurred in the third test flight when engine cutoff was initiated by LOX depletion rather than by timer. The SA-3 flight vehicle also had provisions for full Block II propellant loading. Other SA-3 contributions included tests of retrorockets and umbilical swing arm connections. Each succeeding Saturn flight vehicle carried an increasing amount of passenger guidance equipment in the true flight environment. SA-4 supplemental flight missions included tests of closed-loop accelerometer control and passenger Block II type components such as the ST-124 stabilized platform, S-I retrorockets, and S-I/S-IV interface configuration. The SA-4 provided a demonstration of engine-out capability; the vehicle also had antenna panels added to all four S-I fin positions and kits attached to the inert S-IV to simulate Block II aerodynamic properties.[5]

Marshall Space Flight Center, (MHM-1), December 1960, pp. 58-66; History of the George C. Marshall Space Flight Center, July 1 - December 31, 1960, (MHM-2), pp. 42-74, hereafter cited History of MSFC, (MHM-2); History of MSFC, (MHM-3), pp. 34-53; History of MSFC, (MHM-4), pp. 23-42; History of MSFC, (MHM-5), pp. 7-38; History of MSFC, (MHM-6), pp. 9-44; History of MSFC, (MHM-7), pp. 7-64; and History of MSFC, (MHM-8), pp. 9-56.

5. MSFC Hist. Office, History of MSFC, (MHM-6), pp. 14-21; History of MSFC, (MHM-7), pp. 13-18; and Dr. F. A. Speer, AIAA Paper No. 64-322, June 29 - July 2, 1964.

In the January - June 1964 period the Saturn I entered the Block II phase of R&D flight tests. On January 29, 1964, NASA successfully launched the first Saturn with live first and second stages and an active instrument unit. This flight test served to prove the performance of the complete vehicle system and its capability of placing an inert payload of 37,700 pounds in an earth orbit.[6] A second Block II Saturn I R&D flight test on May 28, 1964, reaffirmed the performance capability of the complete vehicle. In addition, the payload placed in earth orbit by SA-6 included the first unmanned "boilerplate" model of the Apollo spacecraft.[7]

In the current report period MSFC and the stage contractors, Chrysler Corporation Space Division (CCSD) and the Douglas Aircraft Company (DAC),[8] continued to prepare Saturn I vehicles for the four additional Block II test flights (SA-7 through SA-10) scheduled in the remaining Saturn I program.[9]

SA-7 will have flight missions similar to those of SA-6. The assigned missions consist of launch vehicle and spacecraft technology development including LH_2 propulsion test, S-I/S-IV stage separation, and insertion of the spacecraft into earth orbit; developmental test of

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6. MSFC Saturn Flight Evaluation Working Group, Results of the Fifth Saturn I Launch Vehicle Test Flight, (MPR-SAT-FE-64-15), Apr. 1, 1964, p. 5.

7. MSFC Propulsion and Vehicle Engineering (P&VE) Lab., Saturn SA-6 Vehicle Data Book, Flight Report Supplement, p. VI-1.

8. Chrysler Corporation Space Division (CCSD) is the contractor selected by NASA to assist MSFC in designing the S-I stage and to produce the last two R&D flight S-I stages, SA-8 and SA-10. Douglas Aircraft Company (DAC) is the contractor NASA chose to design, develop, and produce the S-IV stages for the Saturn I vehicle.

9. The Saturn I program will end with the R&D test flights, since in October 1963 NASA terminated the Saturn I operational vehicle production and assigned the missions for those vehicles to Saturn IB vehicles.

the launch vehicle guidance in the launch environment; and demonstration of the Launch Escape System under flight conditions. The last three vehicles, SA-9, SA-8, and SA-10, will have the mission of inserting micrometeoroid measurement capsules (Pegasus capsules) into earth orbit to obtain micrometeoroid data in addition to the same missions assigned SA-7.[10]

Research and Development

Saturn I R&D in the first six months of 1964 centered on preparation for and flight testing of the first two Block II vehicles. In this period MSFC and the stage contractors also completed fabrication, assembly, and ground testing of the next two flight Saturns and completed assembly of the SA-10 S-I stage (S-I-10) as well as fabrication of the SA-10 S-IV stage (S-IV-10) and instrument unit (S-IU-10).

Emphasis in the Saturn I program, in addition to flight testing and overall systems improvement, has centered on completion of the design, fabrication, assembly, and testing of the micrometeoroid measurement capsules. Prior to this report period MSFC requested that Fairchild Stratos Corporation (FSC) provide two flight capsules and two backup

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10. MSFC Executive Staff, Managerial Data Center, Management Information, Volume IX, September 1964, p. 2.

SA-9 will fly before SA-8 because assembly of the S-I-8 stage, the first industry-built booster, required more development time than S-I-9, the last booster to be assembled by MSFC.

models of the capsule called Pegasus.[11] In March NASA approved a Pegasus mission for SA-10, and the contractor's requirements increased to delivery of three flight capsules. Difficulties in prototype capsule development caused delay in the development of the Pegasus flight capsules. Delivery of the Pegasus flight capsules thus has become the pacing item in the Saturn flight test program.

In this report period little effort was devoted to facility construction or to related Saturn I studies, two areas of major interest in previous report periods. Curtailment of the Saturn I program cancelled requirements for new facilities. Emphasis on related studies concerning probable vehicle improvement has been shifted to the Saturn IB and Saturn V configurations.

SA-5

The first Block II vehicle included four elements: S-I stage live, S-IV stage live, instrument unit, and payload assembly[12] with adapter.

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11. The micrometeoroid measurement capsule project began in the fall of 1962 under direction of MSFC's Research Projects Laboratory. In June 1964 MSFC reassigned the project management and management personnel to the Center's Industrial Operations. Also during this report period the project unofficially became known as the Pegasus project. NASA officially assigned the title "Pegasus" to the project and capsules in July 1964.

MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16, 1964 - Sept. 30, 1964, pp. 1 and 3; hereafter cited as MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964.

12. The SA-5 payload consisted of an inert Jupiter-type payload ballasted with sand similar to those flown on previous Saturns. Occasionally, the entire orbiting package has been erroneously referred to as the "payload." The SA-5 orbited the burned-out S-IV stage, the instrument unit, payload adapter, and the nosecone.

The vehicle measured 164 feet tall, weighed approximately 1,124,000 pounds at liftoff, and was the most heavily instrumented rocket ever prepared for launch by the United States.

Primarily, the SA-5 differed from previous flight Saturns in that the S-IV stage was live and the pressurized instrument unit was active. The instrument unit housed an adaptive guidance and control system (ST-90S stabilized platform) to steer the vehicle along a predetermined trajectory; a developmental adaptive guidance and control system (ST-124 stabilized platform); six tracking subsystems and four telemetry subsystems; and power supplies. Incorporated in the S-I stage also were certain changes to support the Block II configuration. These changes included elongated propellant tanks, engines rated to full-thrust capacity (188K), and the addition of eight fixed fins.[13]

Personnel on January 27 scrubbed a first attempt to launch SA-5 because a test flange, inadvertently left in the S-I stage LOX replenish line, prevented the flow of LOX to replenish the stage.

Countdown for the second attempt began on January 28 at 11:00 p. m. EST. The second countdown, continuous except for a 20-minute built-in hold and a 73-minute range hold,[14] went through the automatic sequence (firing command beginning at T minus 2 minutes 23 seconds to liftoff at T minus 0) with all functions occurring at or within predicted times.

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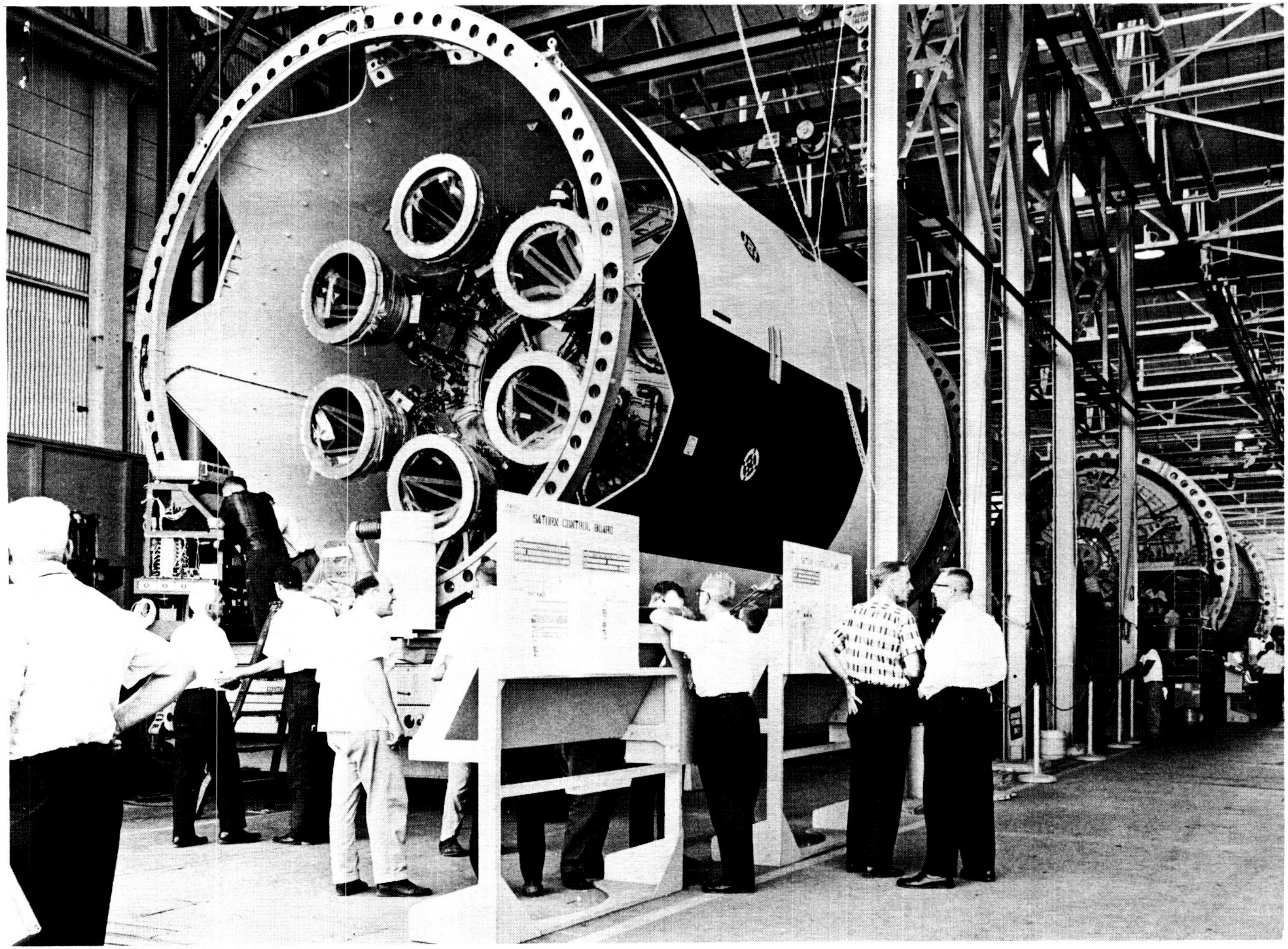
13. MSFC Public Affairs Office (PAO), Press Release, "NASA to Launch Fifth Saturn," Jan. 23, 1964; and Dr. F. A. Speer, AIAA Paper No. 64-322, June 29 - July 2, 1964.

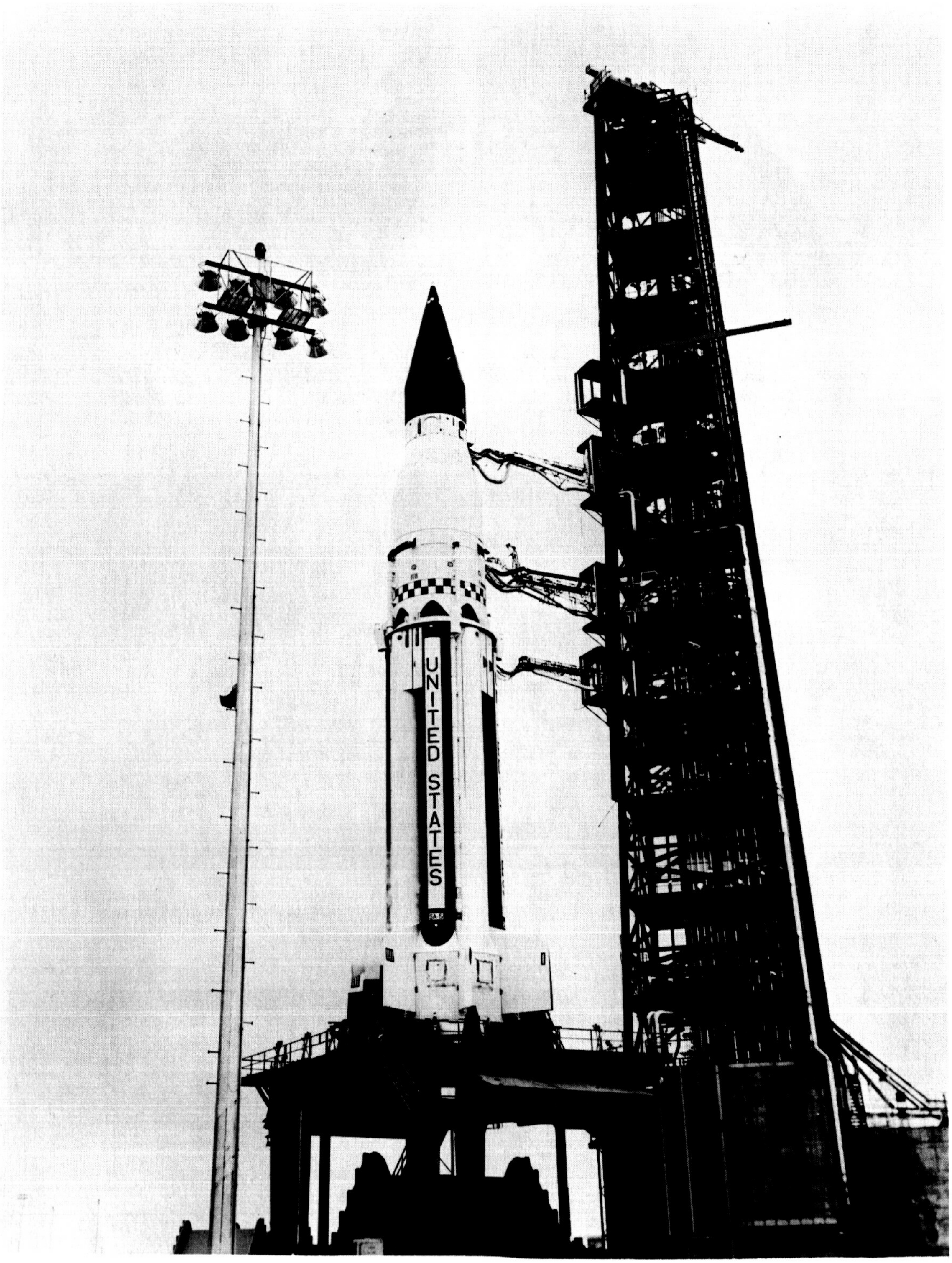
The eight tail fins (four large and four stub) on the S-I stage provide support and holddown points for launch as well as aerodynamic stability during flight.

14. The 73-minute range hold was called at T minus 13 minutes because of RF interference on the C-band radar and the command destruct frequencies.



FIRST "LIVE" S-IV STAGE

S-IV-5, the second stage for the SA-5 flight vehicle, is pictured at DAC's Santa Monica production site prior to captive firing. On January 29, 1964, this stage became the first S-IV to fly live and to carry an inert payload into orbit.



SA-5 POISED FOR FLIGHT

Ready for launch, the SA-5 flight vehicle stands free of the gantry at Cape Kennedy's Launch Complex 37B on January 29, 1964.

Vehicle liftoff occurred at 11:24.01 a. m. EST, January 29, 1964, from Pad B of Launch Complex 37 (LC-37B), the largest and most sophisticated launch facility at Cape Kennedy. The firing successfully demonstrated compatibility between the ground support equipment and the vehicle; the ground support equipment sustained the SA-5 launch with the least damage of any Saturn launch.

The S-I stage flight performance was "exceptionally good."[15] During the S-I stage portion of flight the ST-90S[16] stabilized platform initiated a roll maneuver at 8.78 seconds range time, turning the vehicle into the programmed flight azimuth. The synchronous motor-driven cam located in the ST-90S also caused the vehicle to tilt as programmed.

During first flight operation the LOX/SOX (solid oxygen) disposal system performed satisfactorily. The system prevented inadvertent detonation of the cooldown LOX, SOX, or both that fell from the thrust chambers of the S-IV stage engines during the chilldown period prior to the S-I/S-IV separation.

About 40 seconds prior to S-I/S-IV separation, the hydrogen vent system removed the chilldown hydrogen that began flowing through the S-IV stage plumbing and dumped it into the edge of the jetstream, averting an explosive interstage environment.

The first occurrence during flight of the S-I/S-IV separation sequence proceeded normally. After some 147 seconds of range time, four ullage

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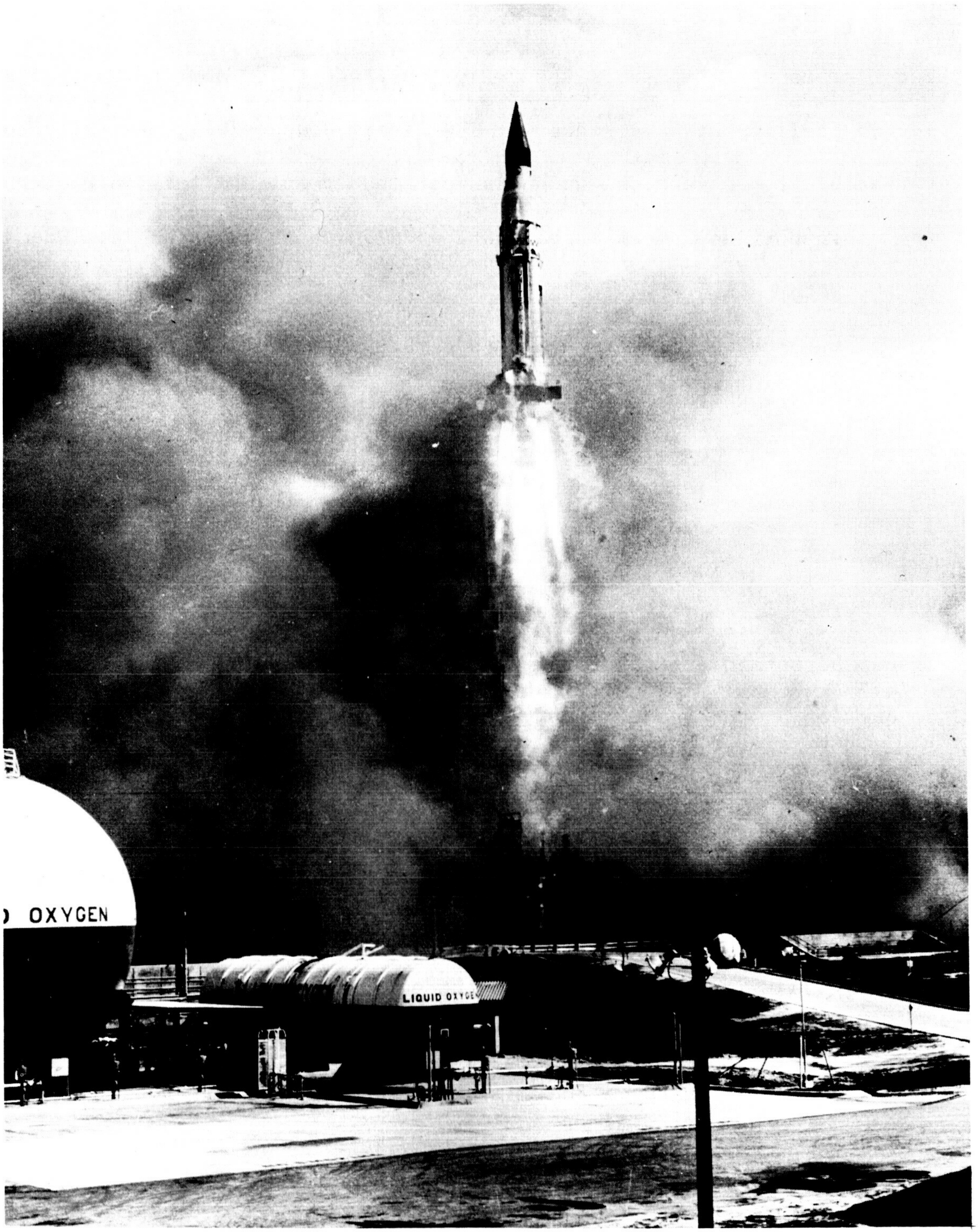
15. MSFC P&VE Lab., Saturn SA-5 Vehicle Data Book, Flight Report Supplement, p. VI-1.

16. The ST-90S stabilized platform system was flown for the first time and was used for attitude control reference. The ST-90S differed from the standard ST-90 system flown on SA-3 and SA-4 in that it included an extended azimuth drive capable of initiating a programmed roll maneuver to turn the vehicle into the flight azimuth defined by the platform.



SA-5 MARKS HISTORIC "FIRST"

The fifth Saturn I flight vehicle leaves the earth January 29, 1964. SA-5, the first Block II vehicle, utilized the first "live" S-IV stage ever flown and was the first Saturn to place a payload in earth orbit. This was another in the series of successful Saturn flights.

rockets on the S-IV stage ignited and four explosive bolt-and-nut assemblies connecting the S-I and S-IV stages fired. Twenty milliseconds later the S-I stage retrorockets ignited and slowed the S-I stage to complete the separation.

The S-IV stage performed within design limits. The engines ignited after approximately 149 seconds of flight and burned to about 629 seconds. The ST-90S platform used for attitude control reference during S-IV stage flight held the control gains constant. As programmed, the vehicle resumed tilting at approximately 175 seconds range time and continued tilting until seconds before insertion into earth orbit.

All components of the instrument unit, including the ST-90S and ST-124 guidance systems, functioned normally during flight. The first flight operation of the guidance system--including the ST-124 stabilized platform, the GPS-24 guidance signal processor, and the ASC-15 digital computer with all functions open loop--was satisfactory.[17] The telemetry systems transmitted 1180 measurements to the ground. Performance of the SA-5 measuring system was 97.4 per cent.

The package, placed into earth orbit after some 640 seconds of flight, included the S-IV stage, the instrument unit, the payload adapter, and a Jupiter-type nosecone filled with 11,500 pounds of sand ballast. The

17. The SA-5 guidance and control system was incomplete because it functioned "open loop." The ST-90S controlled the attitude of the SA-5 vehicle and the vehicle adhered to a predetermined trajectory. The passenger system including the ST-124 stabilized platform, the GPS-24 guidance signal processor, and the ASC-15 digital computer that replaced the prototype system carried on SA-3 and SA-4, was able only to generate steering commands to correct unplanned vehicle movement errors caused by wind or other conditions. This system flown "open loop," could not adapt the vehicle to its steering commands.

SA-5 ARTIFACT

This fiberglas nitrogen bottle found floating in the Atlantic Ocean survived the earthward plunge of the SA-5 booster following its launch, burnout, and flight separation on January 29, 1964. The bottle was the only part of the S-I stage ever found. It is viewed at the MSFC Space Orientation Center by a young visitor.

orbiting package, weighing about 38,000 pounds and facetiously nicknamed the "flying junkpile," was hailed by President Lyndon B. Johnson as "the largest payload ever launched by any nation."[18]

A total of 85 cameras recorded the "close to nominal" flight of SA-5 in which all test objectives were achieved. The cameras were on the launch pedestal around the complex, on board the vehicle, and at various downrange tracking sites. An onboard TV system transmitted good quality pictures back from the S-I stage from liftoff until after separation. Technicians recovered all eight onboard cameras. Four of the cameras that utilized fiber optics provided some qualitative data on the S-I/S-IV interstage area and on the interior of two LOX tanks. Events observed and timed from the recovered film included the blowout panels opening, ullage rocket ignition, and S-I/S-IV separation.[19]

SA-6

In January MSFC completed replacement of critical tubing assemblies[20] in the SA-6 S-I stage (S-I-6), completed mechanical and electrical checkout of the stage, and prepared the stage and the SA-6 instrument unit

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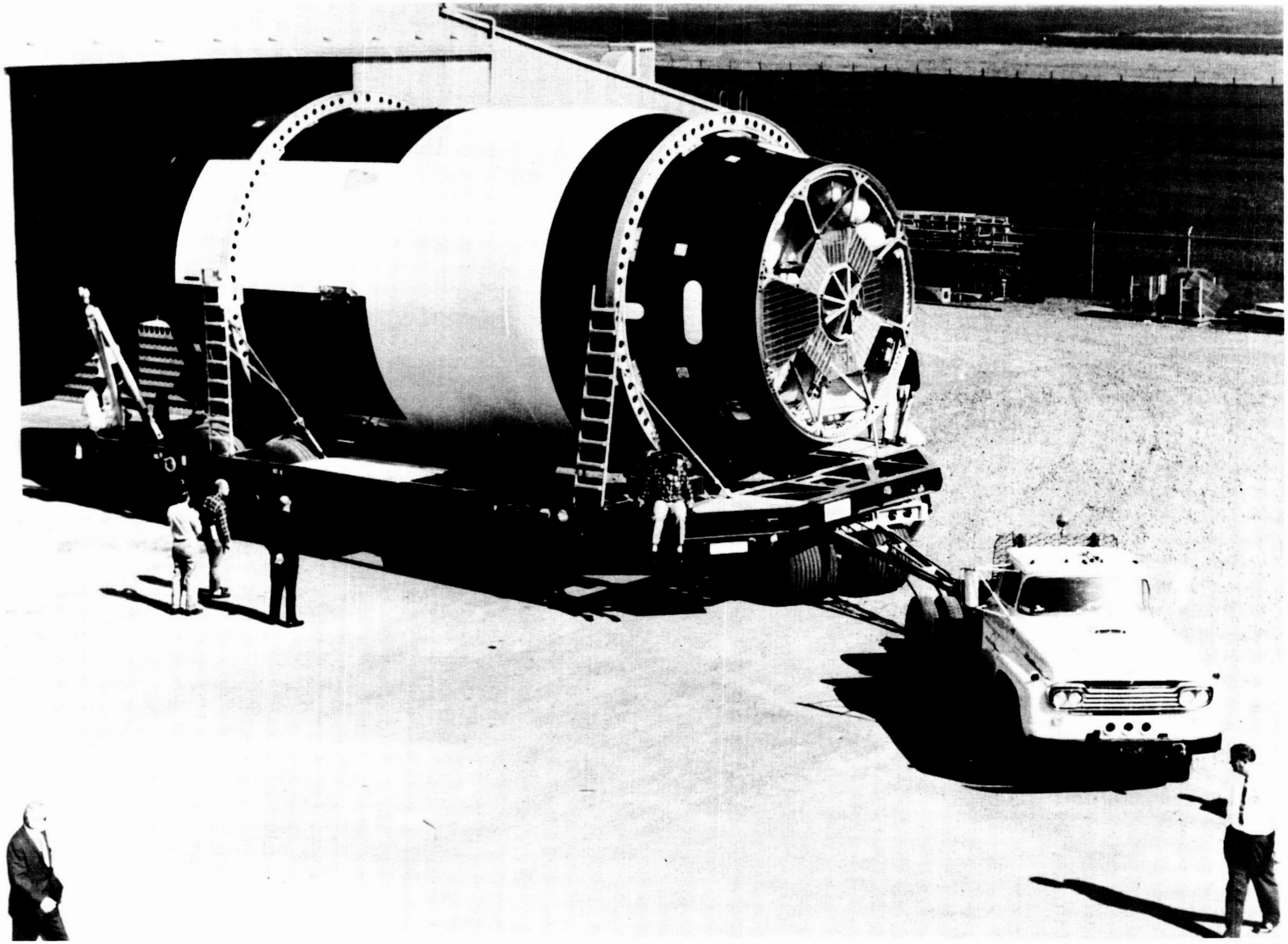
18. MSFC Saturn Flight Evaluation Working Group, Results of the Fifth Saturn I Launch Vehicle Test Flight, Apr. 1, 1964, pp. 1-4, 52, and 248; Dr. F. A. Speer, AIAA Paper No. 64-322, June 29 - July 2, 1964; and Missiles and Rockets, Feb. 3, 1964, pp. 17-18.

The news media nicknamed the orbiting package the "flying junkpile" because no unit of the package had a scientific purpose in orbit.

19. MSFC Saturn Flight Evaluation Working Group, Results of the Fifth Saturn I Launch Vehicle Test Flight, Apr. 1, 1964, pp. 1-5 and 271-273; and Dr. F. A. Speer, AIAA Paper No. 64-322, June 29 - July 2, 1964.

20. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 17-22.

Corroded and cracked tubing assemblies discovered on the SA-5 vehicle prompted the replacement of critical tubing assemblies on the SA-5 prior to launch and on subsequent Saturn I S-I flight stages.



SA-6 SECOND STAGE ON THE WAY

S-IV-6, the second stage for flight vehicle SA-6, leaves the Sacramento static test site en route to Cape Kennedy for May 1964 launching.

(S-IU-6) for shipment to the Kennedy Space Center (KSC). In the January and February interval DAC incorporated Moog actuators[21] into the S-IV-6 stage and performed a final checkout of the stage at the Sacramento Field Test Station (SACTO).

The NASA barge Promise, loaded with the S-I-6 and the S-IU-6, left Huntsville on February 7 and arrived at KSC on February 18. NASA Manned Spacecraft Center (MSC) transported the "boilerplate" Apollo spacecraft (BP-13) and associated equipment from the Space and Information Systems Division (S&ID) plant at Downey, California, where the spacecraft was built, to KSC via three separate USAF aircraft on February 19. The S-IV-6 arrived at KSC aboard the Pregnant Guppy aircraft on February 22, 1964.

Vehicle erection and prelaunch operations at LC-37B began as soon as the vehicle stages arrived at KSC. KSC accomplished the first step, S-I-6 pad erection, on February 20.

Technicians moved the S-IV-6 stage to Hangar AF at LC-37 and entered the LH_2 tank and LOX tank for a check of the cold helium sphere strap tension and for leak checks of the common bulkhead. The leak checks revealed transverse cracks that needed repair in the meridian welds on

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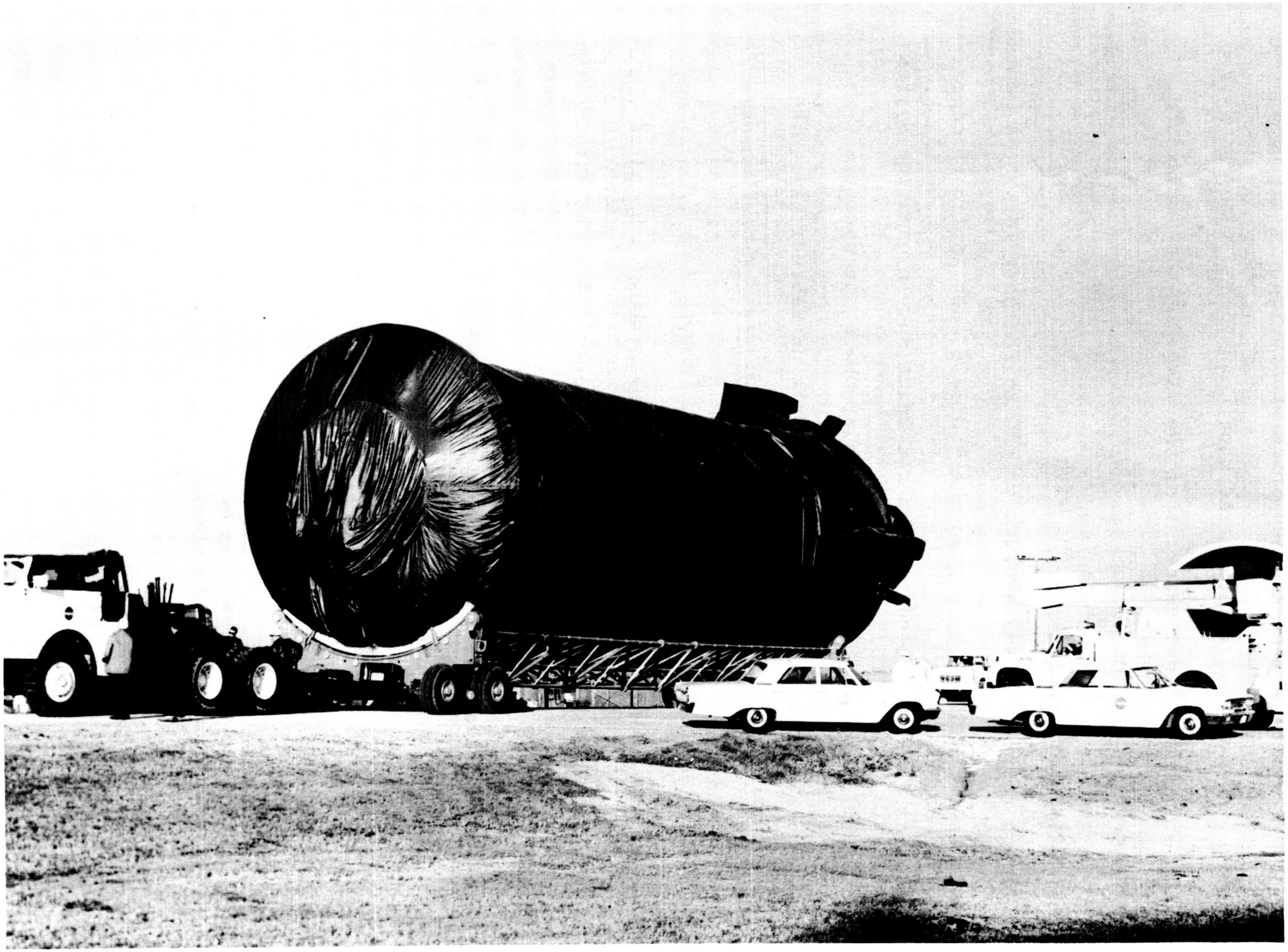
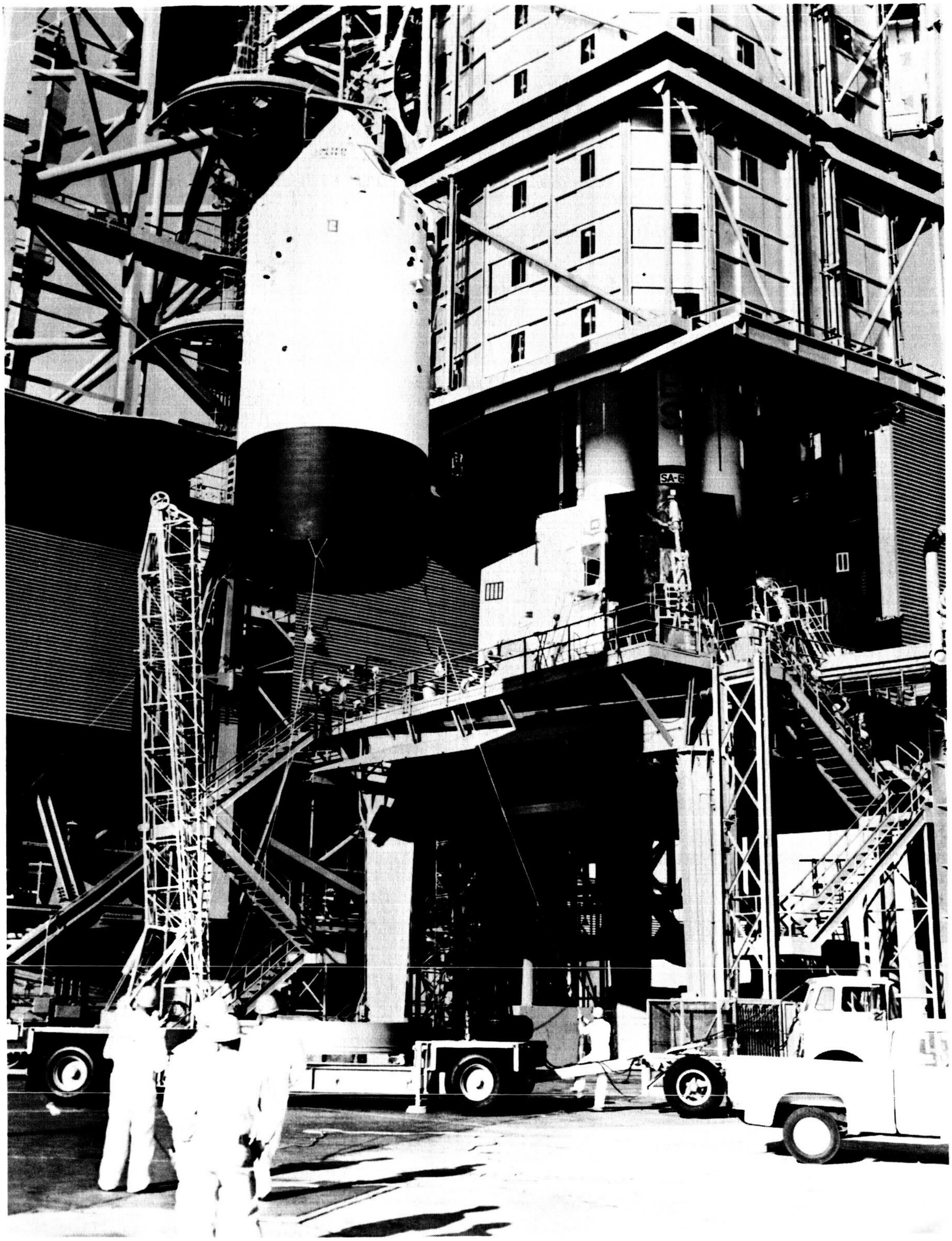
21. Test results of the Moog actuator system in the fall of 1963 indicated the system was more reliable for gimballing the RL10 engines since it was less sensitive to system contamination than the system in use. Thus, MSFC requested DAC to install Moog actuators on all S-IV flight stages.



S-I-6 AT THE CAPE

The SA-6 booster, shipped from MSFC via the NASA barge <u>Promise</u>, is unloaded at Cape Kennedy on February 17, 1964.



BOILERPLATE APOLLO GOES ON SA-6

The boilerplate Apollo command and service modules (BP-13) are hoisted to the top of the SA-6 launch vehicle at Kennedy Space Center's LC-37B.

the LOX side of the common bulkhead. Initial repair by bonding proved unsatisfactory, but KSC repaired cracks by welding patches in place.[22] KSC technicians mated the S-IV stage to the S-I stage on March 19.

Meanwhile, KSC technicians completed installation of S-IU-6 parts shipped separately from the unit. Upon MSFC's decision for a "closed loop"[23] flight for SA-6, workmen made the necessary IU modification. S-IU-6 was mated to the S-IV stage on March 23.

One significant addition to the SA-6 distinguished this vehicle from the SA-5 flight vehicle. This addition was the boilerplate Apollo spacecraft (BP-13), installed for a test of the aerodynamic and structural design of the spacecraft during flight and for a test of the flight vehicle and spacecraft compatibility. Mating of the BP-13 to the Saturn flight vehicle occurred April 2. This addition increased the height of the vehicle by about 26 feet over that of SA-5. The BP-13 was designated a boilerplate because it was a dummy built to simulate external configuration, weight, and balance of the actual spacecraft. The BP-13 contained only limited instrumentation[24] and included a command module, a service module, adapter section, and launch escape system.

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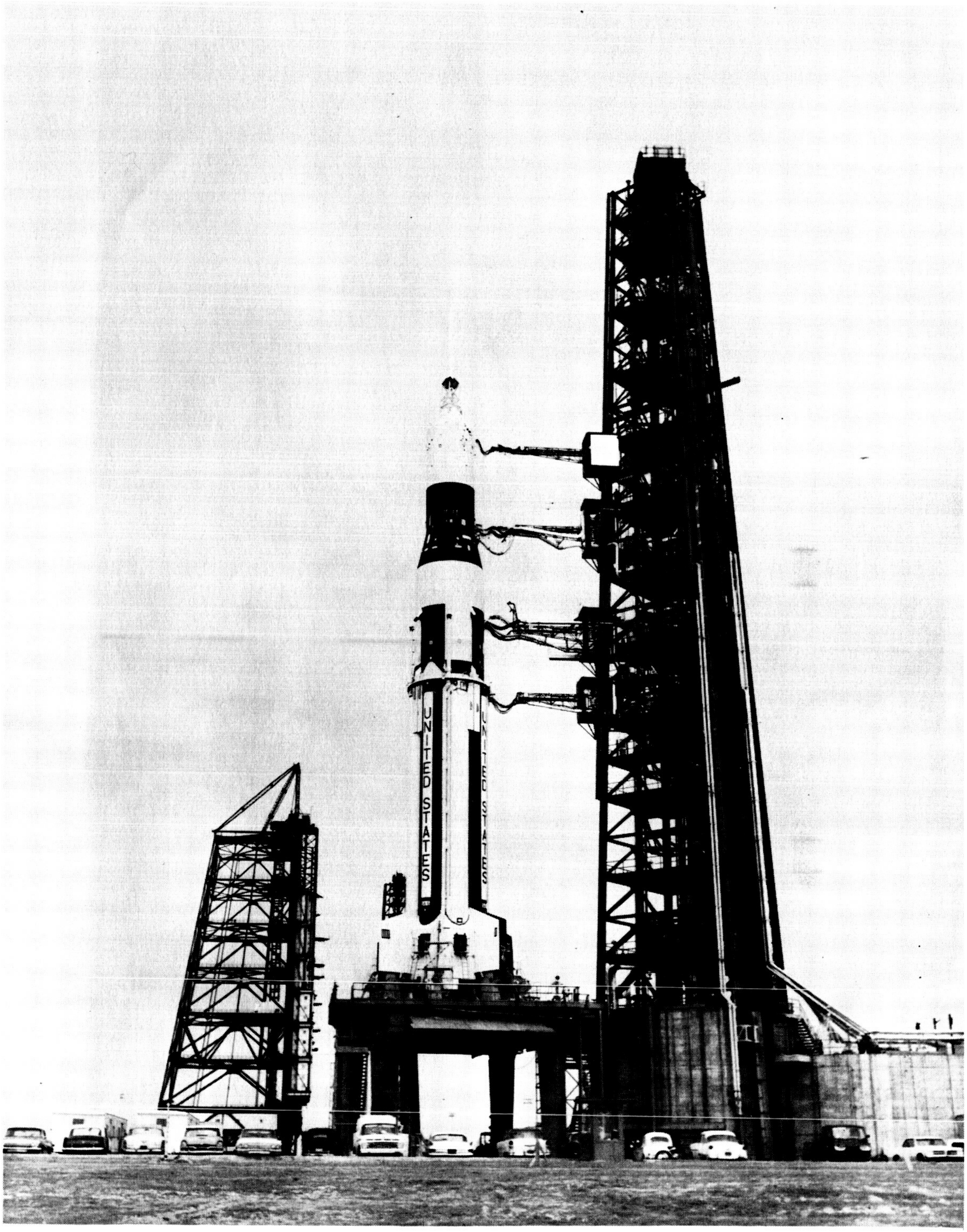
22. MSFC Industrial Operations, Saturn Monthly Progress Report, December 16, 1963 - January 16, 1964, p. 3, hereafter cited MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964; and Jan. 16 - Feb. 16, 1964, p. 3; and Feb. 16 - Mar. 16, 1964, p. 4.

23. The decision to flight test the SA-6 with a closed loop guidance system meant that the SA-6 would have an active guidance system, pitch, adaptive yaw, delta minimum, during the S-IV stage flight. MSFC made the decision in March following the evaluation of the SA-5 flight test.

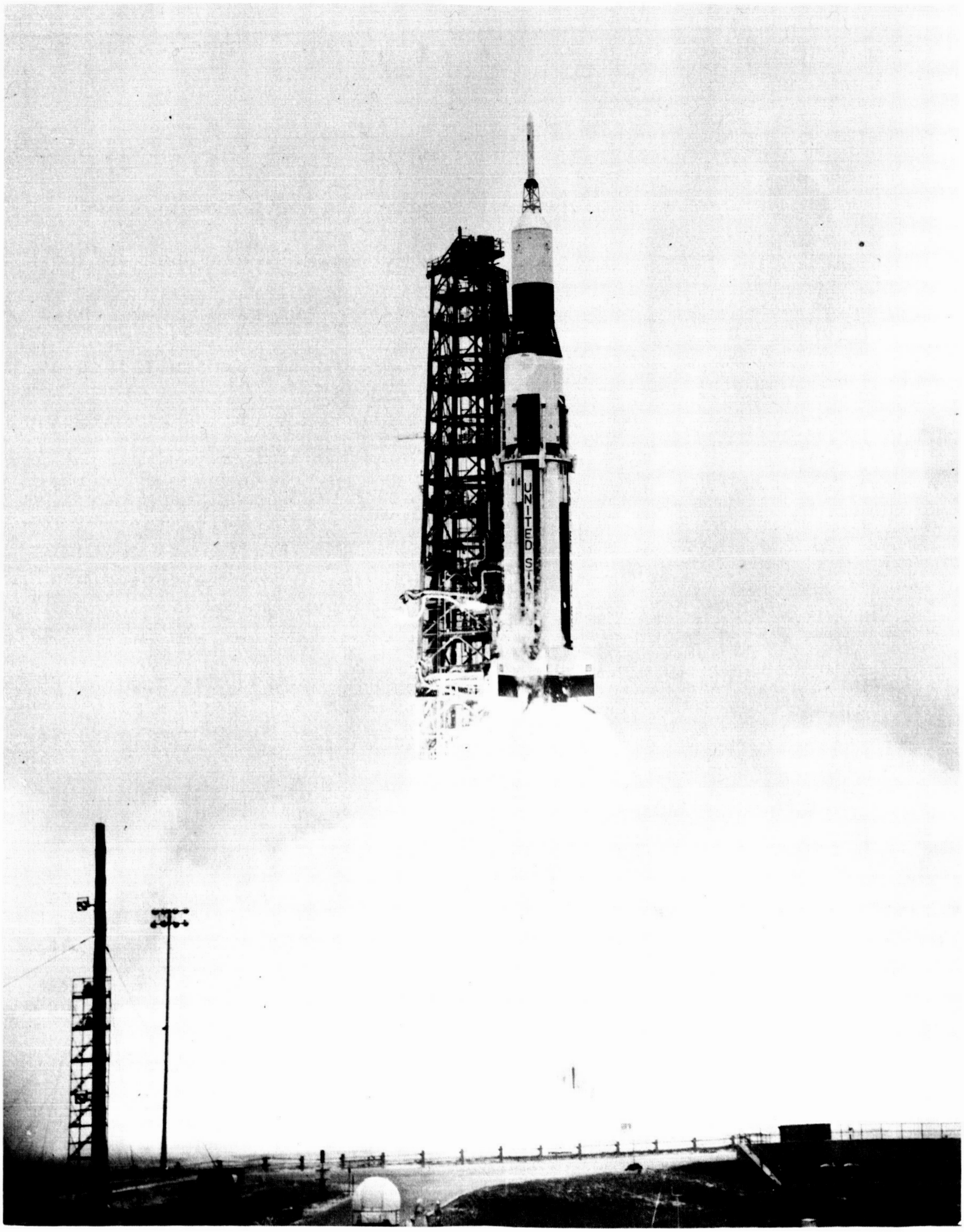
24. The boilerplate Apollo spacecraft (BP-13) instrumentation included three telemetry systems, two C-band radar beacons for tracking, a water glycol cooling system, a power distribution system, and a small sequencing system for jettisoning the launch escape tower. The jettison capabilities of the launch escape system were demonstrated during the flight test.

See Kennedy Space Center (KSC), Press Release, April 2, 1964.



SIXTH SATURN AWAITS LAUNCH

Pictured at Cape Kennedy Launch Complex 37B a few days prior to May 28 launch is SA-6, the second Block II launch vehicle. SA-6 carried the first Apollo boilerplate spacecraft for orbital test.



SA-6 LAUNCHED

The sixth successful Saturn I flight occurred on May 28, 1964, when the SA-6 rose from Cape Kennedy's LC-37B to orbit the first boilerplate model of the Apollo spacecraft.

Also added to SA-6 prior to the flight test were purges to keep clear the lenses of onboard cameras.[25]

On April 3 KSC completed electrical mating of the S-I-6, S-IV-6, and S-IU-6, after which prelaunch checkout began. During propellant loading tests on May 11 the propellant utilization system malfunctioned due to failure of the LOX sump screen mesh in the S-IV-6 LOX tank. The repair involved installation of a reinforced upper screen and screen filter at the LOX umbilical interface and resulted in the rescheduling of SA-6 launch from May 20 to May 26.

On May 26 the SA-6 launch was scrubbed due to an environmental control system compressor malfunction in the ground facilities equipment.

On May 27 at 11:55 p. m. EST the final countdown for the SA-6 launch began. Four holds interrupted the countdown. The first, at T minus 85 minutes, lasted 38 minutes for azimuth alignment of the ST-124 stabilizer. The second, at T minus 70 minutes, lasted 60 minutes for an adjustment of the S-I LOX replenishing valve. The third, a one-minute hold, occurred at T minus 4 minutes because the S-IV LOX pump inlet temperatures were not within specifications. The fourth, at T minus 41 seconds, lasted an hour and 15 minutes because LOX boiloff vapors broke the theodolite beam and caused loss of ST-124 visual alignment. The count, recycled to T minus 15 minutes, resumed at 11:42 a. m. EST May 28 and continued without further holds to liftoff at 12:07 p. m.

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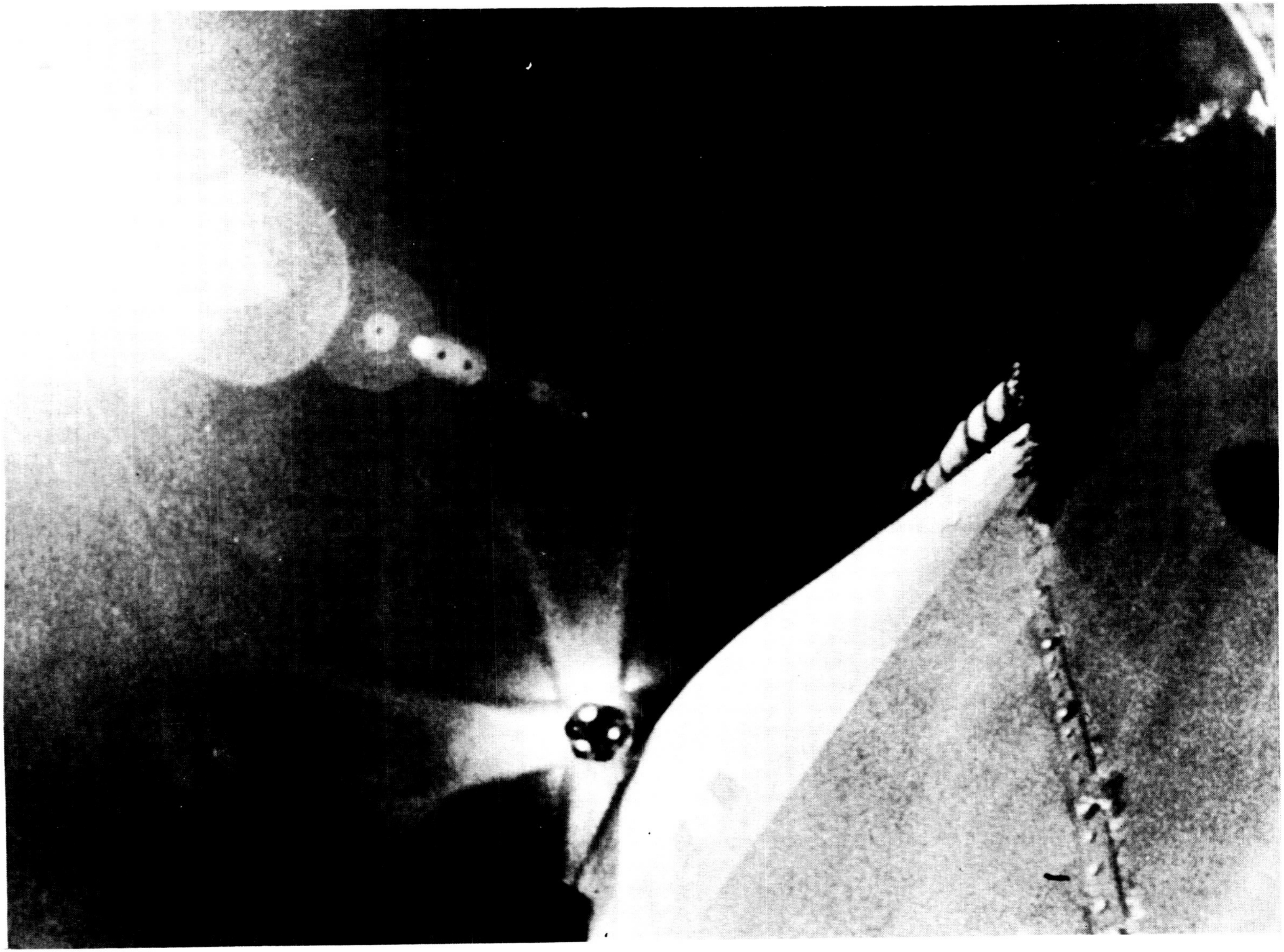
25. MSFC P&VE Lab., Evaluation of Flight Test Propulsion Systems and Associated Systems, Saturn Vehicle SA-6, Aug. 28, 1964, pp. 5 and 156.



FLIGHT SEPARATION PHOTOGRAPHED

This picture, made during the SA-6 flight by an on-board camera that was ejected and recovered from the ocean, shows the S-IV stage following separation. The S-IV stage engines are igniting at this point as the distance increases between the two stages.

At T plus 117 seconds failure of the main gear in the propellant turbopump gearbox caused S-I stage engine Number 8 to shut down 21 seconds prematurely. The remaining seven engines in the S-I stage burned an additional 2.7 seconds past normal cutoff time to partly compensate for the loss of engine Number 8.

The remainder of the flight was normal. The ST-90S stabilized platform guided the vehicle during S-I flight. The S-I/S-IV separation went smoothly. Performance of the S-IV stage propulsion and associated systems were within design limits. Switchover from ST-90S to the ST-124 guidance platform system during the first seconds of S-IV flight was smooth. The first active performance of the ST-124 was "excellent"; the system corrected the larger-than-predicted trajectory deviations caused by the unprogrammed engine-out.

Telemetry and optical data confirmed as successful the first separation of the spacecraft's launch escape system tower under flight conditions. The tower separated on ignition of the explosive bolts and the tower jettison motor about 12 seconds after S-I/S-IV separation. The inert payload inserted in earth orbit included the expended S-IV stage, the IU, and the boilerplate Apollo command and service modules filled with approximately 1500 pounds of ballast to simulate the weight of the operational Apollo payload.

Overall performance of the SA-6 measuring system was 98.9 per cent, a slight gain over that of SA-5. The camera coverage obtained for the sixth successful Saturn flight test was the best ever recorded in the Saturn program.[26]

SA-7

Near the beginning of this report period MSFC halted poststatic checkout of the SA-7 booster (S-I-7) to allow replacement of critical tubing assemblies and to permit S-I-9 work to progress on schedule toward the earliest possible static test date. Replacement of the critical tubing in S-I-7 was completed February 10. Poststatic checkout resumed on February 14 and was completed on May 12.[27]

Because of the good S-IV stage performance during SA-5 and SA-6 flight tests, program participants agreed upon several changes to lighten the stage weight. The helium storage bottles carried as backup for the vehicle helium heater were eliminated to lessen the stage weight about 1,000 pounds. Officials also agreed that on SA-7 and future flights there will be 500 pounds less fuel reserve, since the S-IV propellant utilization system has proved to be more than satisfactory.

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26. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 3-5; MSFC P&VE Lab., SA-6 Vehicle Data Book, Flight Report Supplement, pp. VI-1 - VI-19; MSFC P&VE Lab., Evaluation of Flight Test Propulsion Systems and Associated Systems, Saturn Vehicle SA-6, Aug. 28, 1964, pp. 1-5 and pp. 156-164; and E. R. Matthews, Saturn I Project Office, KSC, to Office of Manned Space Flight, NASA, et al., (teletype), subject, "SA-6 Saturn/Apollo Flash Report Nr. 1," May 28, 1964.

27. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, pp. 1-2; and MSFC Quality and Reliability Assurance Lab., Historical Data, January 1 - June 30, 1964, July 29, 1964, p. 3, hereafter cited as MSFC Quality Lab., Hist. Data, Jan. 1 - June 30, 1964.

DAC completed S-IV-7 prestatic checkout in the vertical checkout tower at Santa Monica during January 1964. On February 13 the contractor shipped the stage via the Pregnant Guppy to SACTO for static testing. At SACTO DAC performed special modification and repair operations on S-IV-7 prior to initiating the static tests.

Personnel installed the S-IV-7 stage in Test Stand 2B at SACTO on February 22. Following two aborted attempts on April 21 and 27, technicians on April 29 successfully static fired the stage for a duration of 485 seconds.[28]

Meanwhile, final checkout of the SA-7 instrument unit (S-IU-7) began at MSFC on February 7. Missing flight components caused a temporary delay in the checkout during April. In May the Center received and installed all the missing flight components except the ST-124 stabilized platform and associated electronics. In order to complete the checkout by May 14 technicians installed a substitute platform; installation of the flight platform would occur at Cape Kennedy.[29]

Manned Spacecraft Center's Apollo spacecraft contractor, North American Aviation (NAA), began Boilerplate Model 15 (BP-15) integrated systems test in May 1964. NAA completed the integrated systems test on May 26 and prepared the spacecraft for shipment to Cape Kennedy.

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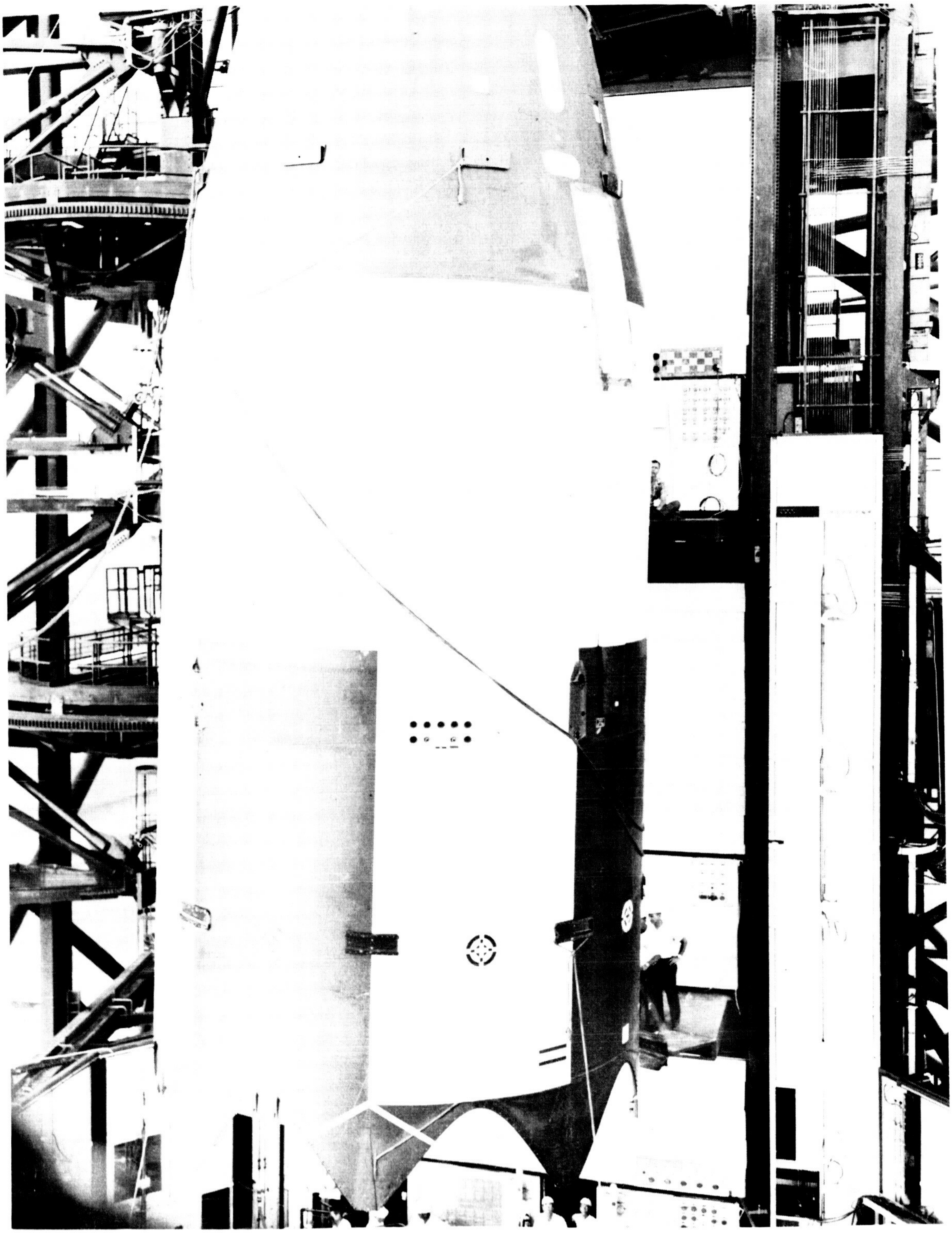
28. MSFC Test Lab., Test Laboratory Monthly Progress Report, February 12 - March 12, 1964, p. 38, hereafter cited MSFC Test Lab., Test MPR, Feb. 12 - Mar. 12, 1964; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.

29. MSFC Quality Lab., Saturn Monthly Progress Report, March 12 - April 12, 1964; and April 12 - May 12, 1964; hereafter cited MSFC Quality Lab., Saturn MPR, Mar. 12 - April 12, 1964; and April 12 - May 12, 1964.



SA-7 SECOND STAGE IS ERECTED

KSC technicians at LC-37B mate the S-IV-7 to the S-I-7 during June 1964 preparation for launch of the seventh Saturn I.

Shipment of SA-7 items to Cape Kennedy from MSFC in Huntsville, Alabama, DAC at SACTO, Sacramento, California, and NAA at Downey, California, occurred during late May and early June. The S-I-7 and S-IU-7 left Huntsville May 28 aboard the barge Promise and arrived at the Cape on June 7. The Pregnant Guppy arrived at the Cape on June 12 with the S-IV stage as cargo. The BP-15's service module and adapter were shipped to Cape Kennedy June 7; the command module on June 17.[30]

KSC technicians erected the S-I-7 on LC-37B on June 9, erected and mated the S-IV-7 to the S-I-7 on June 19, and erected the S-IU-7 on June 22. Electrical mating of the S-I-7, S-IV-7, and S-IU-7 was completed on June 24.

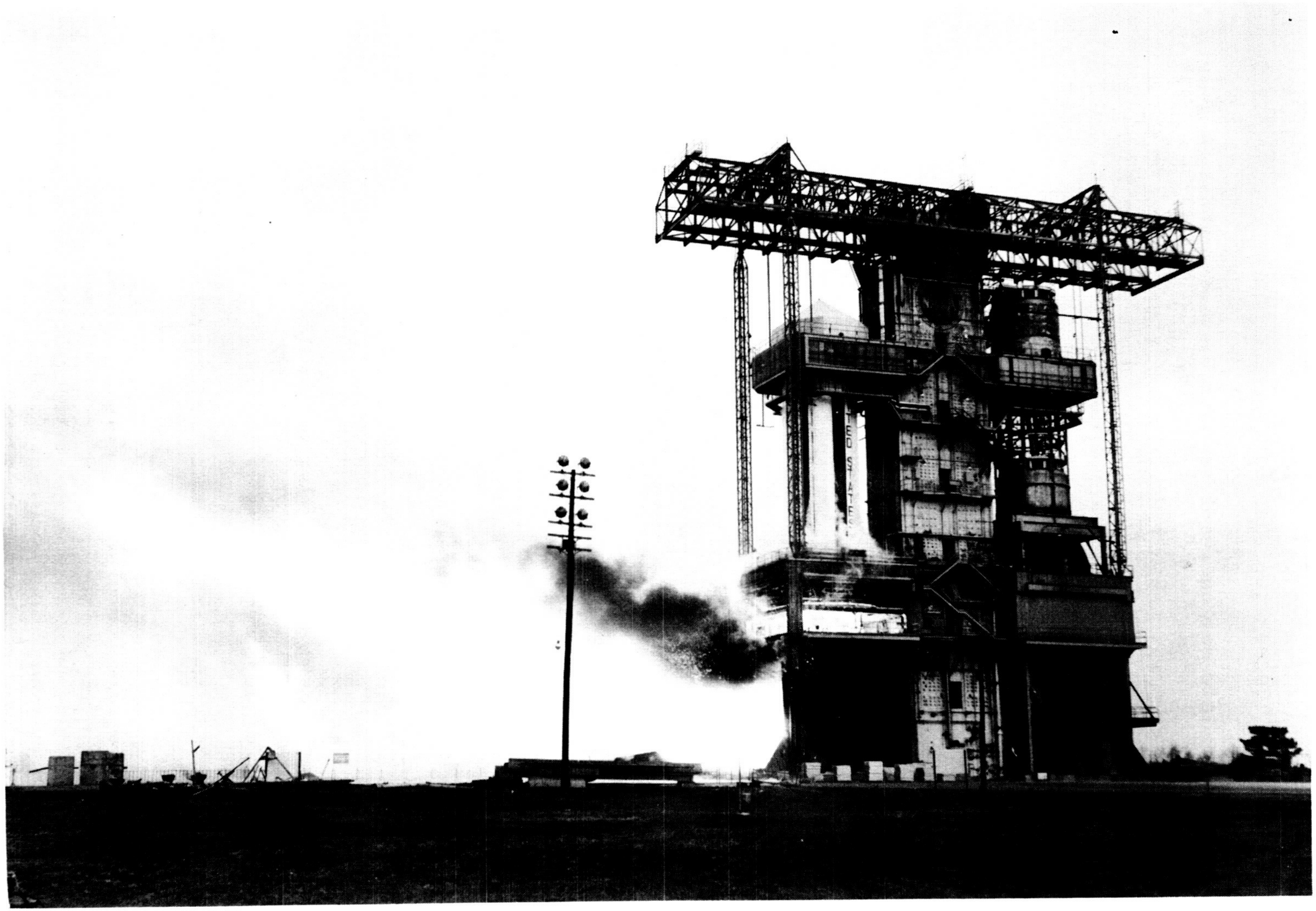
At the close of this report period the SA-7 was in prelaunch checkout. The SA-7 flight test is scheduled to occur in September 1964. SA-7's flight test objectives will be similar to those of SA-6. On SA-7 an ST-124 stable guidance platform will be used during the booster portion of flight.[31] In addition to its guidance function the ST-124 will be used for the first time as attitude reference during flight.

SA-9

The Saturn flight schedule calls for SA-9 to follow SA-7. Assembly of S-I-8, the first of two industry-built boosters, required more development time than the last booster (S-I-9) to be assembled by MSFC.

30. Manned Spacecraft Center (MSC), "Weekly Activity Report, June 7-13, 1964," to Office of Associate Administrator, Manned Space Flight, NASA, p. 3; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.

31. Lee Cropp, Industrial Operations, MSFC, Draft of "Saturn I, IB, and V Quarterly Progress Report, April, May, and June 1964;" and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 11.



FINAL HUNTSVILLE-MADE S-I IS FIRED

The booster for SA-9, the last Saturn S-I stage to be assembled at MSFC, undergoes a static firing during March. Mrs. Lyndon B. Johnson witnessed the full duration firing of this stage during her visit to the Center later the same month.

MSFC completed assembly of S-I-9 in late September 1963. In January 1964 MSFC interrupted S-I-9 prestatic checkout to replace the critical tubing assemblies in the booster. Prestatic checkout resumed January 27 and ended February 11, after which technicians installed the booster in the static test stand. MSFC successfully conducted two S-I-9 static firings: a 35-second, short-duration firing on March 13, and a 145-second, long-duration firing on March 24. Workmen on April 8 removed S-I-9 from the stand and transferred it to the Manufacturing Engineering area for modification and repair operations. Poststatic checkout of S-I-9 began May 5 and is scheduled for completion in August.

DAC completed assembly of S-IV-9 in early February. On February 10 the contractor began the S-IV-9 checkout which extended through April 28. DAC then transported the S-IV-9 via Pregnant Guppy to SACTO and on May 8 installed the stage in Test Stand 2B and began static test preparations. In June the contractor completed the cryogenic loading and weigh system calibrations. A first LOX tank calibration test, attempted June 19, was scrubbed due to a hydrogen leak of the fuel replenishing valve on the valve sled; but the second effort on June 22 was satisfactory. The second test was followed by two fuel tank calibration tests, the first unsuccessful due to fuel leaks and the second satisfactory. A final test of the LOX tank calibration was successful on June 26.[32] The S-IV-9 acceptance firing is scheduled to occur in early August 1964.

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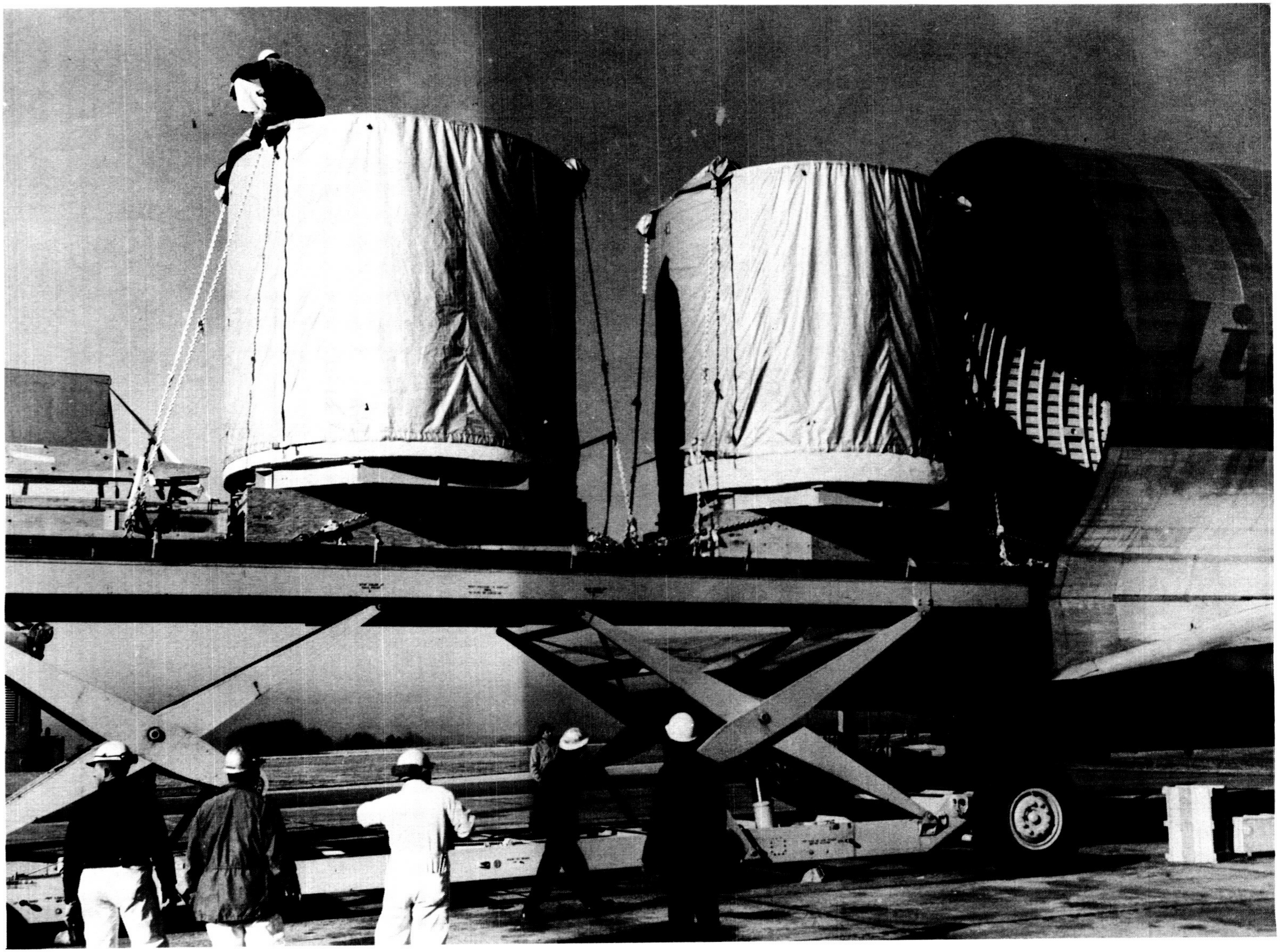
32. MSFC Test Lab., Test MPR, June 12 - July 12, 1964, pp. 38-39.



APOLLO SECTIONS ARRIVE

The two modules of Apollo boilerplate 16, for the SA-9 flight vehicle, arrived at MSFC January 14, 1964, for modification and fitting of the first Pegasus meteoroid payload. The sections came to MSFC aboard the Pregnant Guppy.

In January 1964 MSFC completed structural fabrication of the first non-pressurized instrument unit (S-IU-9) and then stored the structure until March 2. The Center began S-IU-9 assembly on March 2 and scheduled completion of component installation and start of checkout in July.

All Saturn I flight vehicles following SA-7 are scheduled for similar missions. The missions include confirmation of vehicle structure and performance capability, orbiting unmanned Apollo spacecraft, and orbiting Pegasus capsules.

The service module of the Apollo boilerplate spacecraft model (BP-16), scheduled for test during the SA-9 flight, arrived at MSFC on January 14, 1964. Modification of the module, adapter, and BP-16 insert to support the first Pegasus capsule proceeded satisfactorily during the remainder of the report period.

The Pegasus capsules scheduled as bonus missions for Saturn flight vehicles SA-9, SA-8, and SA-10 will weigh more than 3,000 pounds each. The capsule will unfold large "wings" of panels during orbit and its electronics system will record and transmit to earth stations data on meteoroids that penetrate the panels.

In this report period Fairchild Stratos Corporation (FSC), contractor building the capsules, directed effort toward fabrication, assembly, and testing of the prototype capsule and the first flight capsule (Pegasus A). In addition, the contractor, MSFC, and KSC completed activities leading toward establishment of a launch crew and launch support at Cape Kennedy.

In spite of difficulties experienced in developing the prototype capsule, FSC managed during this period to complete and test the prototype capsule components exclusive of the electronics package. Difficulties and delay in development of the prototype capsule slowed the development of the flight capsules and threatened to delay the remaining Saturn R&D flight test program.

While waiting for completion of the prototype electronics package, FSC technicians began fabrication and assembly of the structural and mechanical portions of Pegasus A capsule. The contractor plans completion of Pegasus A component qualification in the fall of 1964; the delivery schedule for Pegasus A will remain dependent upon completion of the prototype.[33]

During the flight tests of SA-9 and subsequent Saturn I vehicles the Pegasus capsules will be housed in the service module of the spacecraft; yet the capsule will also be permanently attached to the S-IV/IU. After attaining orbit the explosive separation nuts will remove the service module, the command module, and restraints on the capsule, permitting the exposed capsule to deploy its wings. During this report period MSFC technicians used a Pegasus water-ballasted dummy in an Apollo

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33. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 4, and Feb. 16 - Mar. 16, 1964, p. 3; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 1-2 and p. 14; as well as Fairchild Stratos Corporation (FSC), Four and Five Quarterly Progress Report, Project Pegasus, April 1964, pp. v-vi and 33-35; and July 1964, pp. vii-viii and 61-62.

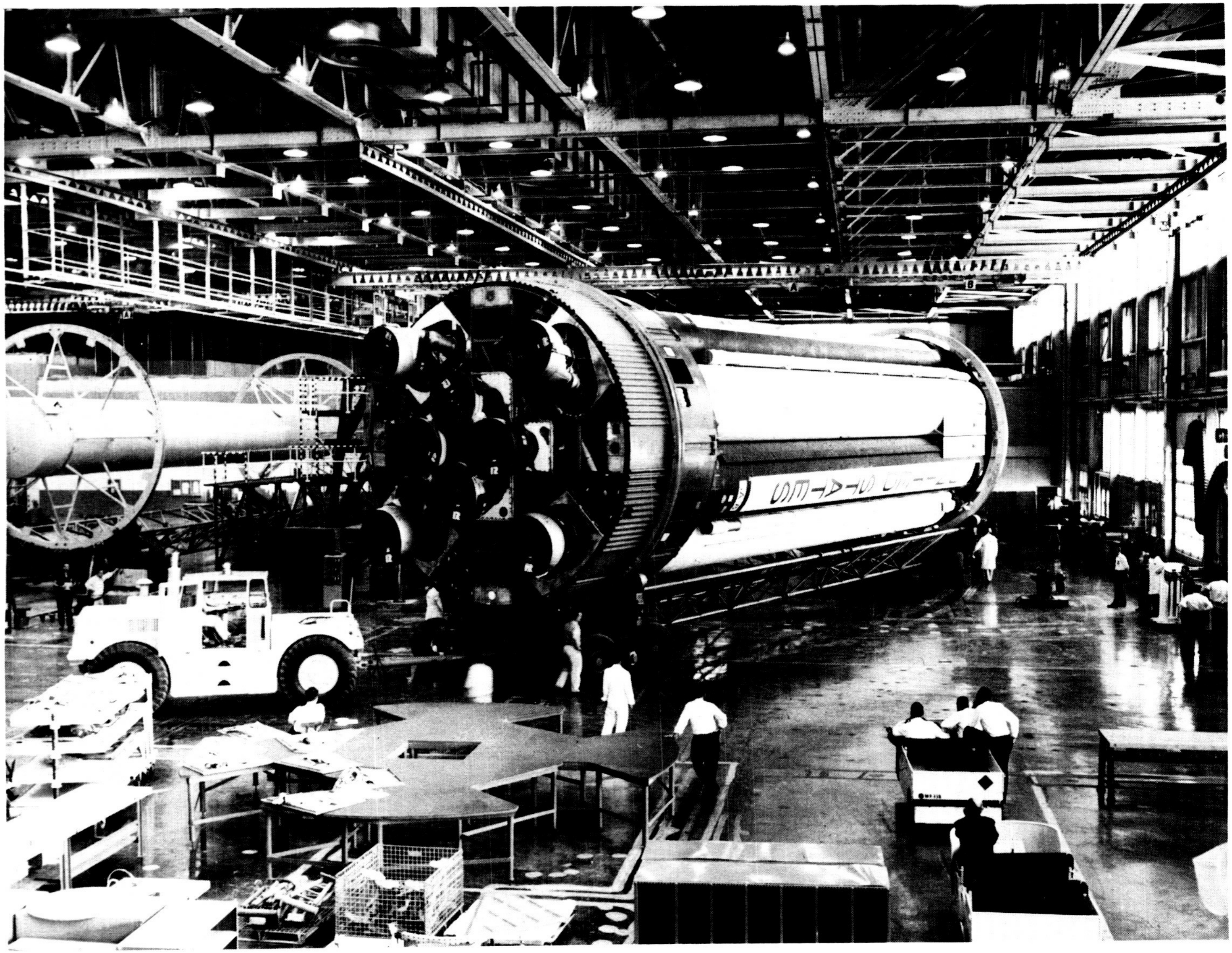
service module attached to an S-IV/IU adapter to complete meteoroid system load and separation tests. The four tests conducted by MSFC indicated that the service module separated from the adapter with the necessary velocity and without damage or unnecessary friction to the Pegasus capsule.[34]

SA-8

CCSD, manufacturer of the final two S-I stages (S-I-8 and S-I-10) in the Saturn I program, completed prestatic checkout of S-I-8 on February 18, 1964. One month later CCSD began cleaning and painting the stage in preparation for its shipment from Michoud Operations to MSFC. The contractor shipped the stage via the barge Promise on April 17, and the stage arrived at MSFC April 25.

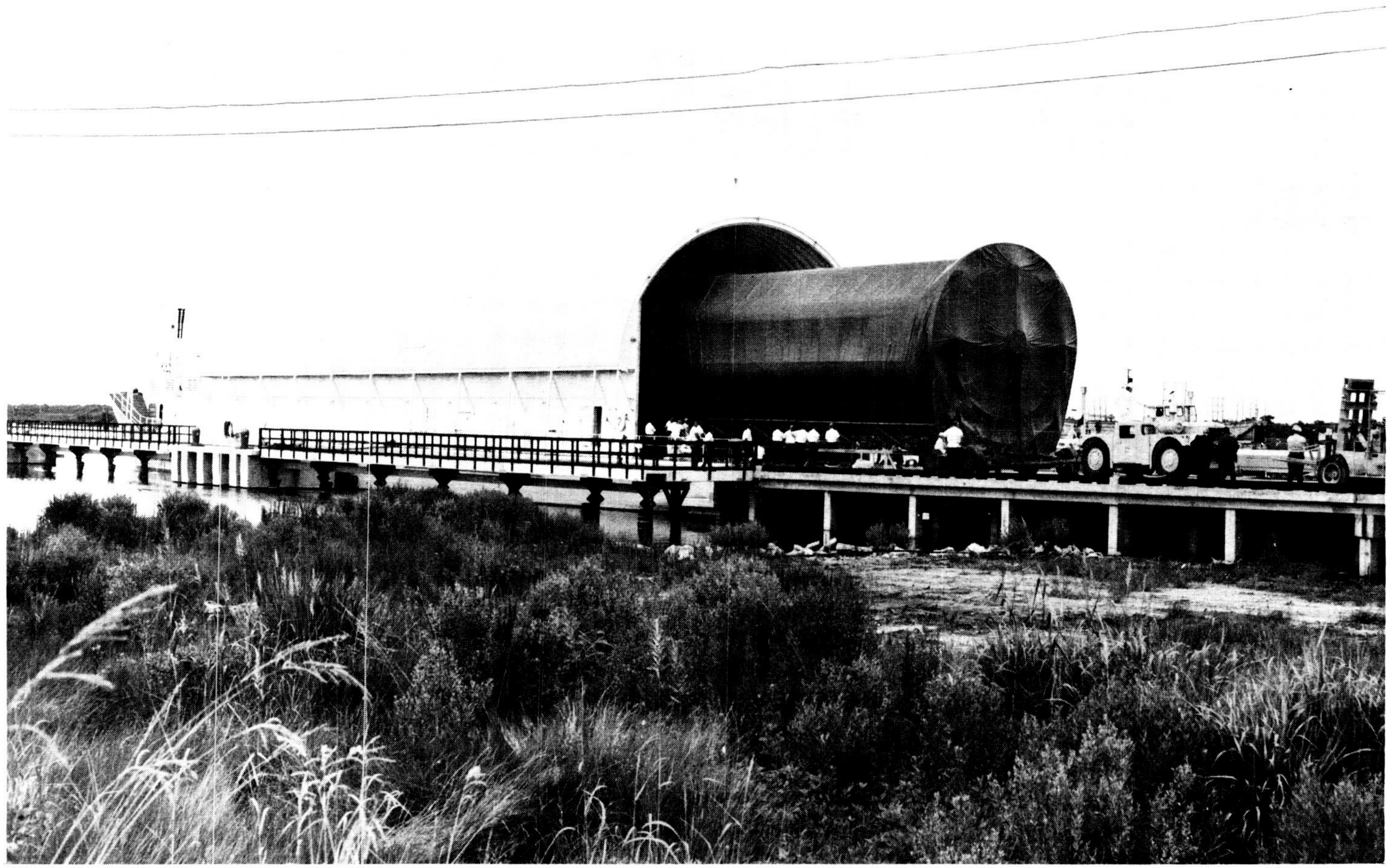
At MSFC, CCSD test personnel erected S-I-8 in the static test stand and completed preparations for testing the stage. They conducted two tests--a short-duration (48.94-second) firing May 26 and a full-duration (145.61-second) firing June 11. Following the static tests CCSD performed a final propellant loading test to investigate difficulties in filling the stage to the reduced ullage of 2.2 per cent required for the SA-9, SA-8, and SA-10 flights.

34. MSFC P&VE Lab., SA-9 Saturn Vehicle Data Book, pp. V-1 and V-5; and D. P. Herd and R. W. Schock, P&VE Lab., MSFC, Micrometeoroid Separation and Ejection Test of Apollo Boiler Module BP-9, July 13, 1964.



FIRST MICHOUD BOOSTER

S-I-8, the first Saturn I booster built by Chrysler at Michoud Operations, is prepared for shipment to MSFC for static firing. This picture was made in March 1964.



S-I-8 BOUND FOR HUNTSVILLE

Chrysler-built S-I-8, the first Saturn booster made entirely by private industry, goes aboard the NASA barge Promise at Michoud Operations in June 1964 for its up-river trip to MSFC for static firing.

CCSD removed the stage from the test stand on June 23. The stage left Huntsville via barge on June 24 and arrived at Michoud Operations June 29. At Michoud CCSD will complete poststatic repair and modification.[35]

In January DAC installed the S-IV-8 stage in the hydrostatic test tower at Santa Monica. The contractor completed leak checks and then began structural modification and assembly of the stage. Stage assembly was completed in April. On April 27 DAC initiated stage checkout, which is scheduled for completion in August 1964.

MSFC completed structural fabrication of the SA-8 instrument unit (S-IU-8) on February 10 and stored the components to await assembly. The Center removed the components from storage June 15 and began assembling the unit. Completion of IU assembly is scheduled in September 1964.[36]

Development of the Apollo boilerplate (BP-26) scheduled for flight test on SA-8 continued satisfactorily during the report period. At Huntsville MSFC continued modification of the BP-26 service module,

35. MSFC Michoud Operations, Historical Report, Michoud Operations, January 1, 1964 - June 30, 1964, pp. 1 and 31, hereafter cited as MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964. This document is contained in Volume II, Supporting Documents.

36. MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, p. 4; Jan. 16 - Feb. 16, 1964, p. 4; and Feb. 16 - Mar. 16, 1964, p. 4; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 14-15.

adapter, and insert to accommodate the Pegasus B capsule. The Center's schedule called for delivery of these modified items to KSC in December 1964.[37]

During this report period FSC began fabrication of Pegasus B capsule. The development and delivery schedule for this second flight capsule depends upon the delivery schedules of the prototype and first flight capsules.[38]

SA-10

CCSD completed assembly of the final Saturn I booster, S-I-10, in the first quarter of this report period. On May 4 CCSD began prestatic checkout of the stage. Following breakout of a small fire on S-I-10 because of an overheated drill MSFC requested CCSD to investigate the use of additives to make fire-safe the polyurethane foam in the S-I-10 torque boxes. The contractor completed the modifications and stage checkout shortly following the close of the period on July 13, 1964.[39]

The S-IV stage contractor completed S-IV-10 leak checks and moved the stage from the hydrostatic tower to the assembly area on April 15. At the end of the report period DAC had completed about 60 per cent of component installation.

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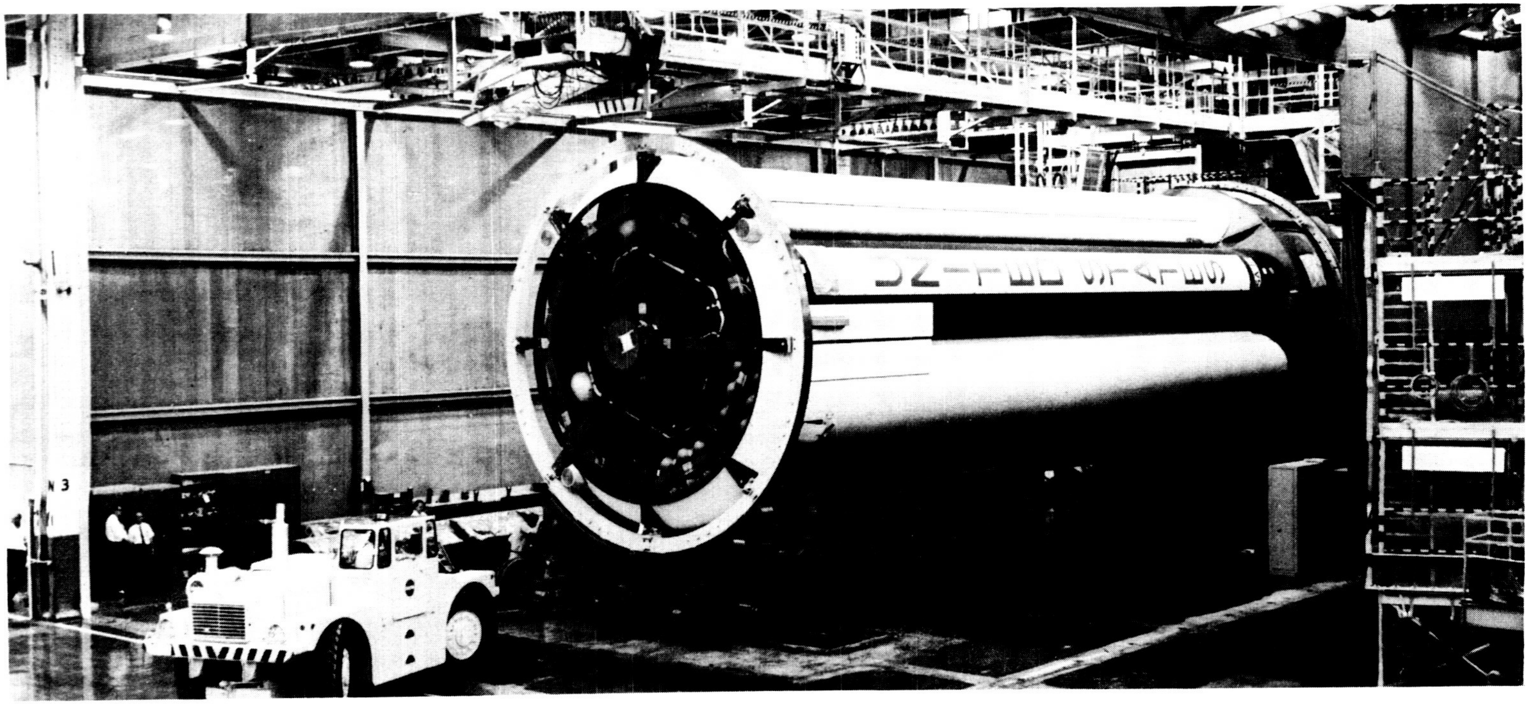
37. MSC, Weekly Activity Report for Office of the Associate Administrator, Manned Space Flight, May 24 - 30, 1964, pp. 4-5; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 16.

38. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 16.

39. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 2.



S-I-10 IN CHECKOUT

The final Saturn I booster is shown at Michoud Operations during prestatic checkout by Chrysler personnel late in this period.

MSFC completed fabrication of S-IU-10 components in March 1964 and stored the unit. The fabricated S-IU-10 remained in storage to the end of the report period. The scheduled assembly date is September 1964.[40]

On March 23 NASA released the official mission assignment for SA-10.[41] SA-10's primary flight mission will be similar to the missions assigned SA-9 and SA-8. As a bonus mission assigned during this period, the vehicle will carry into orbit a third Pegasus capsule experiment. A former backup meteoroid capsule, Pegasus C, will be modified and used as the SA-10 Pegasus capsule. The Pegasus C development and delivery schedule depends upon the timely completion of the prototype and first two flight capsules.

NASA also decided to use the Apollo boilerplate (BP-9) spacecraft as part of the SA-10 payload. The government purchased BP-9 from NAA for use in structural, dynamic, and separation tests at MSC and MSFC. On completion of its use as a test article MSFC will convert the BP-9 to accept the Pegasus C experiment. MSFC will also provide flight qualification and verification of BP-9.[42]

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40. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 5.

41. Prior to this report period a committee investigating "bonus" missions for SA-10 had recommended flight of an Advanced Micrometeoroid Measurement Capsule. NASA did not approve such a mission nor any bonus mission for SA-10 until March 23, 1964.

42. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 18.

Test Vehicles - Status and Testing

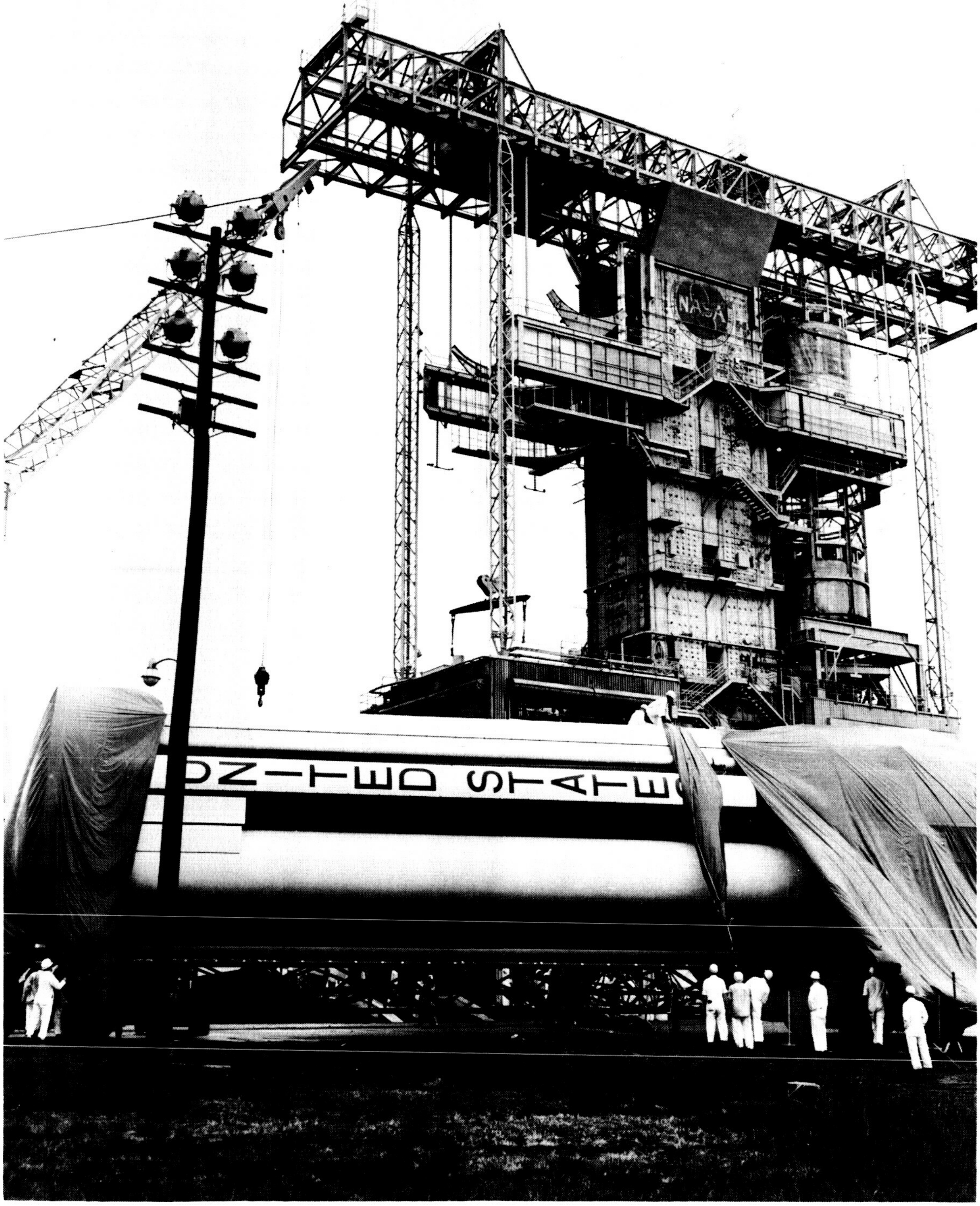
Saturn I ground testing lessened during this reporting period. The tests conducted in this period included S-I static tests, S-IV All Systems Vehicle tests, S-IV static tests, and final Saturn I configuration dynamic tests.

S-I Static Test Program

In this report period CCSD static test personnel, in coordination with MSFC personnel, completed acceptance tests of the last MSFC-built Saturn I booster and also the first industry-built Saturn I booster.

MSFC installed S-I-9 in the East Area Static Test Tower on February 17. On March 2 test personnel put S-I-9 through a simulated flight sequence test; on March 3 the stage underwent a propellant loading test. Technicians aborted the first attempt to static-fire S-I-9 (Test SA-18) on March 12 when the Conax valves inadvertently fired. The next day test personnel conducted a successful short-duration (35-second) firing of S-I-9. Low performance of two S-I-9 engines during the test prompted the reorificing of all S-I-9 engines for uprated performance. On March 24 the S-I-9 performed a long-duration firing of 145 seconds, during which all the engines performed at rated thrust values. MSFC removed the stage from the test tower on April 8.[43]

43. MSFC Test Lab., Test Laboratory Historical Report, January 1, 1964 - June 30, 1964, p. 1, hereafter cited as MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964.



S-I-8 READY FOR STATIC TEST

Arriving at the MSFC Saturn I Test Stand on April 27, 1964, is the first industry-built S-I stage. Workmen later installed it in the left side of the stand for static tests of the stage's eight H-1 engines.

Preparations for testing the S-I-8 stage began April 25. On May 12 static test personnel conducted an S-I-8 propellant loading test. Following the test all LOX prevalves were exchanged for a type modified to relieve pressure buildup between the prevalves and pump. A second propellant loading test conducted May 21 revealed LOX leaks at the center tank lower manhole cover. Following repair of the leaks, technicians conducted a LOX loading test on May 25. This test was considered successful in spite of loading difficulties. Loading was to the nominal ullage of 3 per cent instead of the 2.2 per cent required for SA-9, SA-8, and SA-10 flight tests.

On May 26 static test personnel successfully conducted a 48.94-second short-duration acceptance test. During the test six of the engines produced excessive thrust; following the test these engines were reorificed. On June 11 S-I-8 performed a second static test. The static firing lasted 145.61 seconds. During this test engine Number 8 experienced loss of thrust and engine Number 6 failed to respond to reorificing. Technicians removed engine Number 8 and installed a spare engine. A second spare engine located at Michoud will be shipped to MSFC for single static firing, and then it will be returned to Michoud for replacement of engine Number 6.

Prior to removal of S-I-8 from the test tower, personnel conducted a final propellant loading test to investigate the difficulties experienced in filling the stage to the lower ullage required for the flight test.[44] Technicians removed the stage from the stand on June 23.

All Systems Vehicle Test Program

In January DAC test personnel continued preparations for static firing the first S-IV All Systems Vehicle (ASV). On January 22 DAC postponed the first attempt to static fire the stage due to a LOX umbilical leak. The LH_2 fill and drain valve stuck in a partially open position and resulted in postponement of the second firing attempt January 23. During the terminal stages of the countdown for a third attempt on January 24 the ASV exploded and burned. The explosion resulted in complete loss of the vehicle plus damage to the test stand and ground support equipment (GSE).

Since this was the second known failure[45] involving significant quantities of the LOX/LH_2 propellant combination, an investigation into the causes and damage commenced. Results of the investigation showed overpressurization of the stage oxidizer tank to be the immediate cause of failure. Overpressurization resulted when the primary helium shutoff valve failed in open position and the cold helium was bled through the inoperative helium heater into the LOX tank. On shutoff of the ground

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44. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 1-2; and MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, pp. 1 and 31.

45. The first known failure involving significant quantities of the LOX/LH_2 propellant combination occurred during the boost phase of the first Centaur launch.

helium supply the cold helium from the stage spheres froze the LOX relief valves in a closed position and allowed the pressure to exceed bursting pressure of the tank.

To avoid delay and also to avoid the expense of a second ASV, MSFC recommended that necessary hardware and GSE be provided for accomplishing the major ASV test objectives during acceptance firings of S-IV-7 and subsequent S-IV flight stages.[46]

S-IV Static Test Program

During the report period DAC conducted S-IV static tests on the S-IV-7 stage only. The contractor installed S-IV-7 in Test Stand 2B at SACTO on February 22. The first two attempts to static-fire S-IV-7 were aborted. The first attempt on April 21 failed because a wire omitted in the drawings, and consequently between a relay and the light on the instrument panel, resulted in failure of the panel to indicate "S-IV Ready" at T minus 3 minutes in the countdown. On April 27 a marginal electrical umbilical connection caused abortion of the second attempt after completion of tanking operations. On April 29 DAC test personnel successfully conducted the first and only S-IV-7 static test, for a duration of 485 seconds.[47]

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46. Dr. Kurt Debus, Chairman, Investigating Committee, report, "S-IV All Systems Stage Incident - January 24, 1964," May 11, 1964; J. B. Gayle, P&VE Lab., MSFC, Investigation of S-IV All Systems Vehicle Explosion, Apr. 27, 1964, pp. 1-3; and MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, pp. 1 and 5.
47. MSFC Test Lab., Test MPR, Feb. 12 - Mar. 12, 1964, p. 38; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 1.

On May 8 DAC installed S-IV-9 in Test Stand 2B and began static test preparations. During June test personnel conducted propellant loading tests on the S-IV-9. Acceptance test of the stage is scheduled in August 1964.[48]

Saturn I Dynamic Test Program

Only one series of dynamic tests are necessary for the SA-9, SA-8, and SA-10 configurations because of the similarity of each vehicle and payload.

MSFC began its final series of Saturn I configuration dynamic tests during this report period. In January 1964 MSFC prepared the dynamic test stand for the S-IV dynamic stage (S-IV-D). On February 24 test personnel installed the IU and the Apollo service module and ballasted Pegasus payload atop the S-IV-D in the test tower. Installation of the Apollo command module and launch escape system occurred during the week of March 2. From March 13 to April 4 MSFC performed mechanical and environmental tests of the upper stages of the dynamic vehicle. Included in these tests were the meteoroid system load and separation tests. MSFC also conducted vibration tests on the S-IU-9, S-IU-8, and S-IU-10 type IU during this period.

On April 23 the Center's Test Laboratory began preparing the stand for the complete vehicle configuration tests. Test personnel installed

48. MSFC Test Lab., Test MPR, June 12 - July 12, 1964, pp. 38-39.

the dynamic booster April 29 and the S-IV-D May 6. The Center began the dynamic tests on May 20 and planned to complete the tests July 9.[49]

Facilities

Construction and modification of most MSFC and contractor facilities supporting Saturn I R&D were completed prior to and during this report period.

MSFC

The Center's facility and support activity in this six-month period involved continued modification of facilities to support the Block II configuration. Also involved were testing and delivery of vehicle and launch ground support equipment (GSE).

The C and B Construction Company of Memphis, Tennessee, completed construction of a second addition to the Test Laboratory's Engineering Building (Bldg. 4666). MSFC gained beneficial occupancy of the second floor on June 5 and of the first floor on June 10. Furniture was moved into the building, and personnel began occupying the building June 22.[50]

The Center was unable to complete buildup of the LH_2 slosh test facility in an extension to the west bay of the Saturn I dynamics test stand. An error by the contractor in the construction of the 35,000-gallon LH_2 catch tank resulted in delivery delay of the tank. Problems

49. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 4.
50. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 23.

encountered in redesign and rebuilding of the contractor-supplied vacuum-jacketed piping system also delayed the buildup.[51]

Activities of the Center in the support area included testing and delivery of GSE. MSFC completed acceptance tests of the second set of Block II holddown arms in January and shipped them to KSC. After the SA-5 launch, cracks were discovered in some of the vehicle support blocks and the ball lock separators on the holddown arms of LC-37B. These defective parts were returned to MSFC for determination of the cause for the cracks and for repair. MSFC checked the ball lock separators and returned these in good condition to KSC. In this period the Center also tested a spare set of holddown arms and a third set received from KSC.[52]

MSFC will provide for the Pegasus Project three mobile capsule checkout units (CCU-M) as well as a set of blockhouse GSE for the launch complex. The Center completed the first mobile unit CCU-M-1 during April and delivered it to FSC. The other two mobile units and GSE are scheduled for delivery in November 1964 and January 1965.[53]

During this report period CCSD began stage handling, tiedown, and loading exercises at Michoud to train their personnel for operation of S-I stage transportation by barge. NASA has assigned CCSD responsibility for delivery of the S-I and S-IB (Saturn IB booster) stages from Michoud

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51. MSFC Test Lab., Test MPR, Dec. 12, 1963 - Jan. 12, 1964, p. 11; Jan. 12 - Feb. 12, 1964, p. 11; Feb. 12 - Mar. 12, 1964, p. 11; and May 12 - June 12, 1964, p. 11.

52. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 5.

53. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 18.

to MSFC for static tests, from MSFC back to Michoud for stage checkout, and then to KSC for launching.

In January personnel gave the barge Promise a periodic overhaul in port at MSFC. On February 19 MSFC transferred operation of the barge from the Technical Services Office to the Project Logistics Office of Industrial Operations. An operational and maintenance manual was prepared and an inventory of the vessel completed. On March 5 the Projects Logistics Office completed inspection of the vessel and inventory and assumed operational responsibility.

The Center completed on March 30 contract plans and specifications for modifications to the barge Palaemon. The modifications would include installation of a pilothouse remote control system. The Center did not release the modifications contract before the close of the period.[54]

Michoud

At Michoud throughout this report period the J. A. Jones Construction Corporation of New Orleans continued Phase II construction of the two-story engineering portion of the Engineering and Office Building. Construction of this building remained the only major S-I facility construction or modification at Michoud. This facility will also support the Saturn IB and Saturn V programs at Michoud.

In June the firm of Mason-Rust received a six-month extension to its contract covering support services. This firm has provided support services for Michoud ever since the latter was established.

54. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 27.

During this report period maintenance activities were improved as were all the major utilities. In February the New Orleans Public Service completed an addition to the main electrical substation and provided Michoud with a 110 KV loop by an alternate feeder and switchgear system. This gave Michoud greater reliability and flexibility with the electric power system. On February 3 the Federal Telecommunications System became effective at Michoud Operations, supplementing and ultimately replacing tielines in lieu of telephone toll charges.[55]

Saturn I and Related Studies

In a proposal to use SA-10 to boost a 260-inch diameter Cryogenic Service Propulsion Unit (CSPU) into orbit, the Center considered several methods of adapting the payload to the launch vehicle. The most feasible method involved a command module, a 260-inch diameter IU, and a 260-inch-diameter CSPU adapted to the S-IV stage of SA-10. Use of this configuration as an SA-10 payload, while technically feasible, may be prohibited because of the SA-10 schedule. In April conceptual design drawings were completed for use in a study into the feasibility of using the CSPU as a possible third stage for the Saturn I. This study continued to the end of June.

The only study related to the Saturn I vehicle class which was pending at the beginning of this period was an investigation of a Reusable Ten-Passenger Orbital Carrier vehicle. In its final oral review Lockheed

55. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, pp. 14 and 33-34.

Missiles and Space Company recommended for further study a two-stage, parallel-staged, rocket airplane using horizontal takeoff from a rocket sled. The configuration recommended for further study by a second contractor, North American Aviation (NAA), involved a two-stage (parallel) horizontal takeoff launch vehicle with ground accelerator and with the payload compartment located in the second stage. The Center received proposals for the follow-on effort, "Reusable Orbital Transport Study," on April 30, 1964. The new contract or contracts will be signed in July 1964.[56]

Funding

MSFC committed a total of $65,742,000 for Saturn I during the last six months of Fiscal Year 1964. The breakdown of commitments by program phases was as follows: Saturn S-I stage, $16,112,000; S-IV stage, $39,084,000; RL10A-3 engine, $1,300,000; Instrument Unit, $1,298,000; Ground Support Equipment, $821,000; and Vehicle Support, $7,127,000.[57]

Summary

Most significant accomplishments in the Saturn I R&D program during this report period were the successful flight tests of the first and

56. MSFC P&VE Lab., Monthly Progress Report for Period January 12, 1964, Through February 11, 1964, p. 11; February 12, 1964, Through March 11, 1964, p. 12; March 12, 1964, Through April 11, 1964, p. 13; and April 12, 1964, Through May 11, 1964, pp. 12-13.

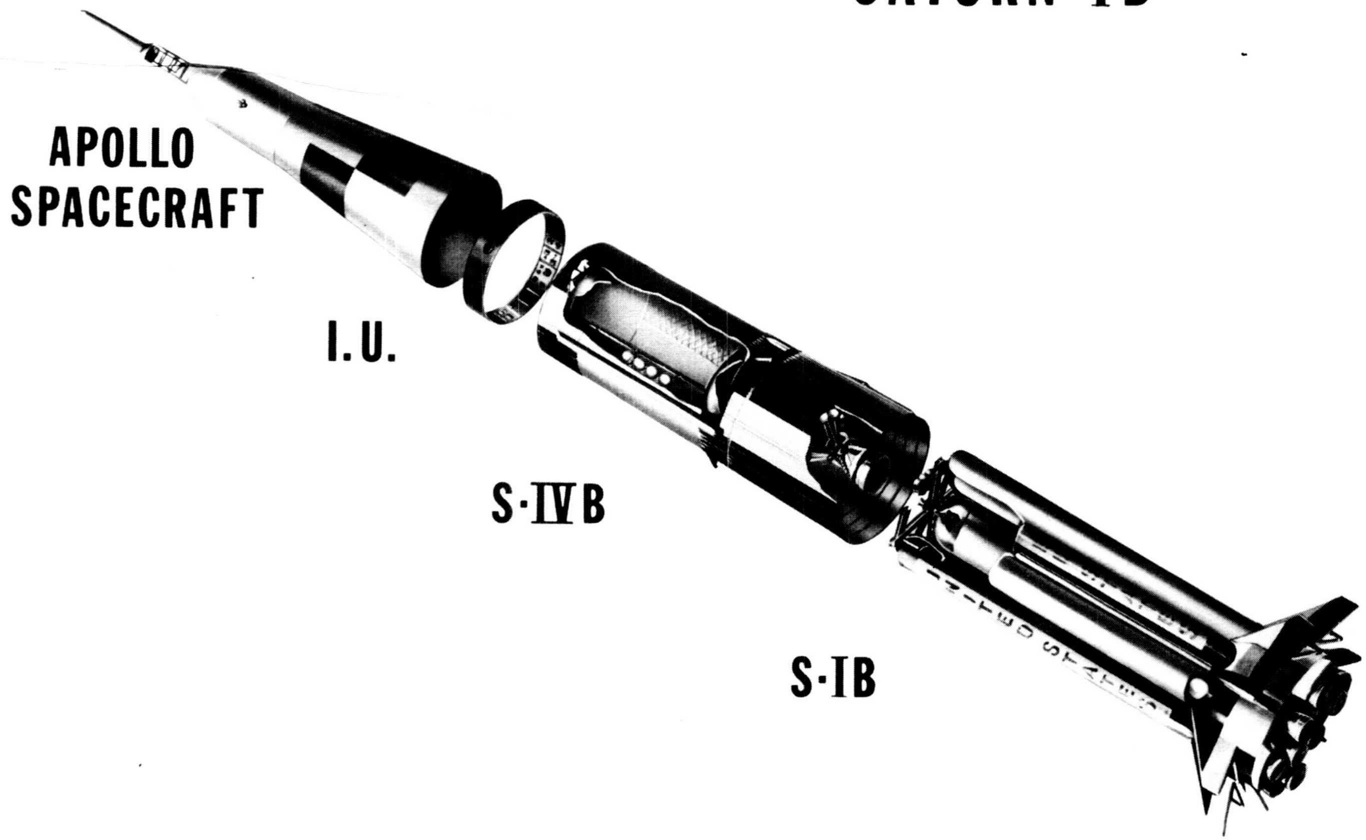
57. Information supplied by Louis E. Snyder, Financial Management Office, MSFC, January 1964.

second Block II R&D vehicles: SA-5 on January 29, 1964, and SA-6 on May 28, 1964.

In this January - June period the S-I and S-IV stage contractors and MSFC completed acceptance tests, checkout, and shipment of the SA-7 vehicle. Preparations at KSC for the SA-7 launch were nearing completion as this period ended. In this period also the contractors and MSFC completed assembly of the SA-9 vehicle stages, the SA-8 vehicle stages, and the S-I stage of the SA-10 vehicle. The SA-10 S-IV stage and instrument unit were fabricated and were entering assembly operations.

The Center and contractors completed a number of tests in this six months, although the volume of the Saturn ground test program diminished as the program entered its final R&D phase. CCSD test personnel assisted MSFC in static testing the SA-9 and SA-8 S-I stages at MSFC during March, May, and June. DAC suffered failure with the All Systems Vehicle test but achieved some of its objectives in the successful acceptance firing of S-IV-7 in April.

SATURN IB



CHAPTER III: SATURN IB

NASA in September 1962 authorized development of a vehicle at that time designated Saturn C-1B and later renamed Saturn IB. The Saturn IB's primary mission has been that of providing payload capability in support of the Earth-orbital missions of the entire Apollo system.[1] Management and directive responsibility for the Saturn IB project has been with MSFC. Since program authorization, specifications for the Saturn IB vehicle have become definitized and stage manufacturing has begun.[2]

The Saturn IB vehicle consists of a Saturn I S-I stage modified and uprated, a Saturn V S-IVB stage, and a Saturn V Instrument Unit. The entire vehicle with payload is 224 feet long. Empty, the vehicle weighs 75 tons: fueled it weighs 640 tons. The eight H-1 engines of the S-IB stage, each uprated from 188,000 to 200,000 pounds thrust (188K to 200K), produce a total of 1,600,000 pounds thrust. When added to the 200K of the one J-2 engine of the S-IVB stage, this thrust provides the Saturn IB with sufficient propulsive power to place 32,500 pounds in a 100-mile Earth orbit. The vehicle's potential thrust power

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1. The Apollo spacecraft consists of three modules: a Command Module, a Service Module, and a Lunar Excursion Module. The spacecraft also has a Launch Escape System.

2. MSFC Historical Office, History of the George C. Marshall Space Flight Center, July 1 - December 31, 1963, (MHM-8), p. 57, hereafter cited MSFC Hist. Office, History of MSFC, (MHM-8).

is sufficient for all presently planned Earth-orbital tasks, including most space-station operations.[3]

The Saturn IB vehicle has the following primary missions: to place Apollo spacecraft in Earth orbit for systems testing; to place manned Apollo spacecraft in Earth orbit for manned flight experience; and to provide flight tests of live systems for the Saturn V S-IVB stage and instrument unit. Other Saturn IB Earth-orbital and escape missions, presently under consideration, are possible with the addition of a Centaur as a Saturn IB third stage. Vehicle improvements now under study will increase the Saturn IB weight-lifting capacity as much as 50 per cent.[4]

In the January - June 1964 period MSFC, the Manned Spacecraft Center (MSC), and NASA's Office of Manned Space Flight (MSF) made significant progress in coordinating Saturn IB mission requirements for the 12-flight vehicle program. NASA issued the first Flight Missions Assignment Document (FMAD) on March 24, 1964. A second and more definitive FMAD will be issued in July 1964.[5]

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3. MSFC Executive Staff, Saturn I & Saturn IB Management Information, June 1964, p. 74; and George E. Mueller, Director, Office of Manned Space Flight, NASA, "Apollo Capabilities," in Astronautics & Aeronautics, (magazine), June 1964.

4. Stanley R. Reinartz, Deputy Manager, Operations, Saturn I/IB Program, MSFC, speech, "Saturn I/IB Launch Vehicle Programs," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964; and George E. Mueller, Director, Office of Manned Space Flight, NASA, "Apollo Capabilities," in Astronautics & Aeronautics, (magazine), June 1964.

5. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16, 1964 - September 30, 1964, p. 19; hereafter cited as MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964.

Research and Development

Prior to January 1964 MSFC completed the preliminary definition of the Saturn IB vehicle and provided the stage contractors with specifications and much of the design data. In the January - June 1964 reporting period the Center continued analysis of the Saturn IB design and prepared additional documentation for the stage contractors. The S-IB stage contractor began fabrication and assembly of the ground test hardware and fabrication of the S-IB flight stages. The S-IVB stage contractor continued fabrication of the first S-IVB ground test stage and the first S-IVB flight stages.[6]

In this report period MSFC completed much of the instrument unit (IU) systems design. The Center also began contract negotiations with a lead contractor to integrate all systems of the IU.[7]

S-IB Stage

The S-IB (first) stage of the Saturn IB vehicle is 80 feet long and 22.8 feet (40.7 feet with fins) in diameter. Its eight H-1 engines, using liquid oxygen (LOX) and kerosene (RP-1), develop 200K each. The S-IB stage is similar to its predecessor, the S-I stage, except for use

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6. MSFC Hist. Office, History of MSFC, (MHM-8), p. 59; and Stanley R. Reinartz, Deputy Manager, Operations, Saturn I/IB Program, MSFC, speech, "Saturn I/IB Launch Vehicle Programs," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964.

7. MSFC Public Affairs Office (PAO), Press Release, Apr. 20, 1964, and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25.

MICHOUD FROM THE AIR

This general view of Michoud Operations at New Orleans, Louisiana, shows dock facilities in the foreground and the sprawling S-I/IB and S-IC manufacturing plant and adjunct facilities in the background.

of uprated engines and weight-saving techniques employed in the S-IB structural design.[8]

Chrysler Corporation Space Divison (CCSD) under MSFC's direction is developing 12 S-IB stages. CCSD develops drawings for all areas for which it has design responsibility; it also uses drawings and specifications furnished by MSFC. CCSD is developing the stage in facilities at Michoud Operations, New Orleans, Louisiana, where it is also completing manufacture of the last two S-I flight stages. The same tooling is employed in the manufacture of both S-I and S-IB stages.

In the January - June 1964 period CCSD's S-I/S-IB stage contract (NAS 8-4016) increased in value from $281,311,809 to $307,643,904. Most of the $26,332,095 increase[9] was for the following purposes: to extend the reliability program through December 1967; to increase Fiscal Year 1964 direct engineering support to MSFC; to extend the logistics spare parts program; to extend and revise the aeroballistics program; to revise the Saturn I mockup to include the Saturn IB inboard engine exhaust ducting; and for facility plant modification and maintenance. The value of CCSD's Saturn I/IB facilities equipment contract (NAS 8-5602-F) increased in this report period from $9,355,819 to $10,419,819.

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8. MSFC Executive Staff, Saturn I & IB Management Information, June 1964, p. 74; and NASA, Apollo Systems Descriptions, Volume II, NASA TM X-881, Feb. 1, 1964, p. 12.5.

9. MSFC Michoud Operations, Historical Report, Michoud Operations, January 1, 1964 - June 30, 1964, pp. 18-19, cited hereafter as MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964. This document is in Volume II, Supporting Documents.

Of the $26,332,095 increase about $5,422,128 provided for Saturn I effort.

Other contract action included an administrative change on January 28, 1964, to provide for design, fabrication, and test of the new fin configuration; this work was previously covered by letter contract. Negotiations to include this work on fins as part of the prime contract continued throughout the remainder of this period.[10]

In this six-month period MSFC and CCSD implemented the first phase of the three-phase S-IB development program, made considerable progress in implementing the second and third phases, and progressed in hardware development.

The first development phase involved structural as well as propellant system redesign of many of the booster's working parts. Included in this phase were the tail area (eight H-1 engines, thrust structure, a shroud with four engine skirts, eight fins, and the majority of the booster's mechanical and electrical systems), the tank cluster, and the spider beam located at the forward end of the tank cluster.[11] In the January - June 1964 period MSFC and CCSD completed necessary redesign and released criteria for all the Saturn IB structural items as well as for some of the instrumentation and electrical systems.

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10. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, pp. 18-20.

11. Chrysler Corporation Space Division (CCSD), pamphlet, "This Is Your Chrysler Saturn Story," September 1964, pp. 12-13; MSFC Hist. Office, History of MSFC, (MHM-8), pp. 62-63; and Stanley R. Reinartz, Deputy Manager, Operations, Saturn I/IB Program, MSFC, speech, "Saturn I/IB Launch Vehicle Programs," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964.

In the second and third development phases MSFC and CCSD continued structural redesign. To meet operational requirements technicians began reducing the weight of instrumentation and electrical systems.[12] Program participants engaged in separate investigations of structural engineering, strength analysis, dynamic and loads, and vibration and acoustic characteristics.[13]

During this report period the Rocketdyne Division of North American Aviation, Inc., the H-1 engine contractor, continued research and development (R&D) of the 200K engine for the S-IB stage. It will be remembered that this is an increase of 12K over the H-1 engine used in the Saturn I. Preliminary testing of the H-1 engine at 200K level provided sufficient engineering information for Rocketdyne to redesign the main oxidizer valve, main fuel valve, and the LOX high pressure ducts.[14] Later Rocketdyne investigated problems encountered with some of the 200K main LOX

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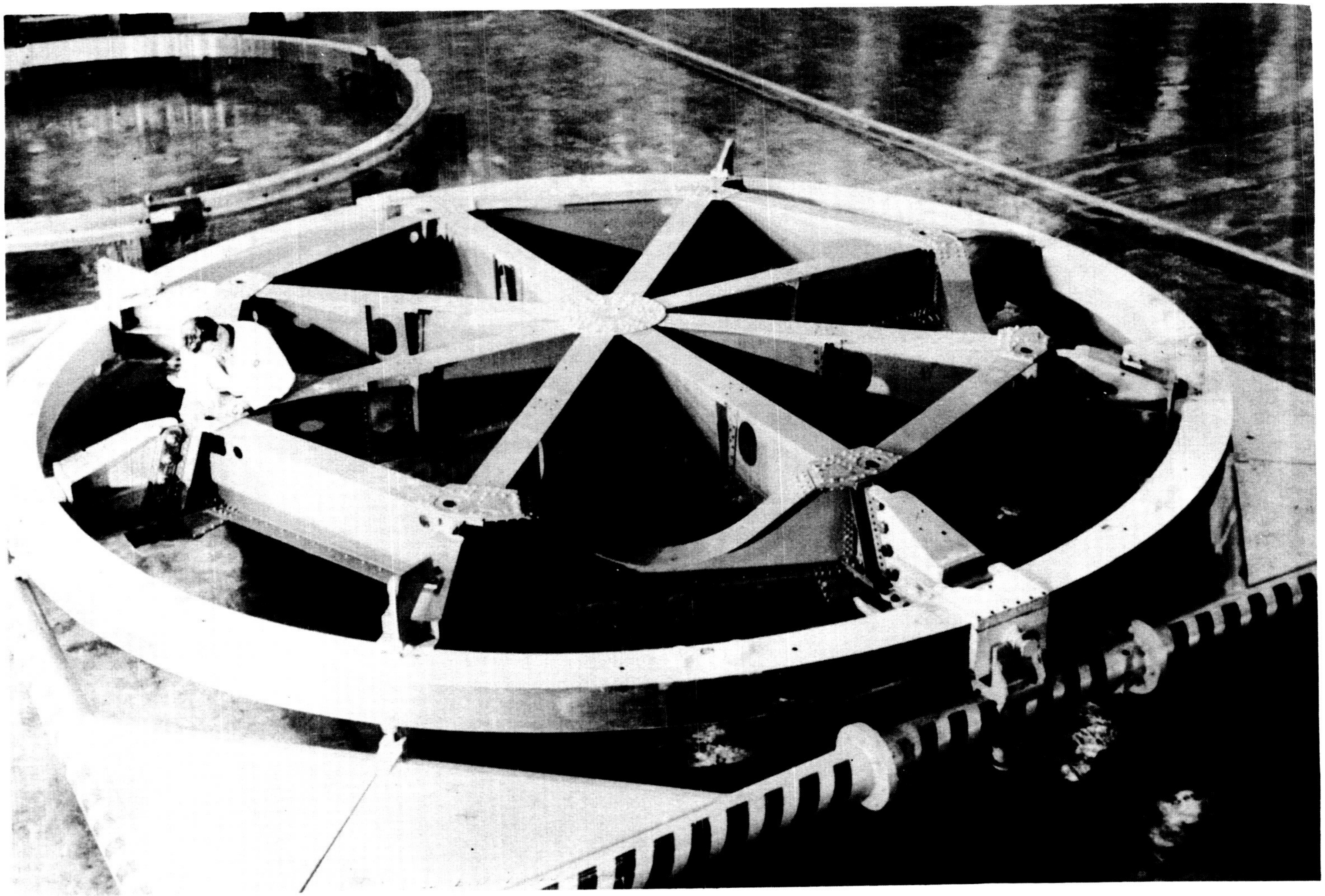
12. MSFC Hist. Office, History of MSFC, (MHM-8), p. 65; and CCSD, Seventh Quarterly Review, Saturn S-I/IB Stage, Saturn I/IB Vehicle Program, Mar. 3, 1964, and Eighth Quarterly Review, Saturn S-I/IB Stage, Saturn I/IB Vehicle Program, June 25, 1964. The latter source is hereafter cited CCSD, Seventh and Eighth Quarterly Review, Saturn S-I/IB Stage.

13. Details on each separate investigation are contained in MSFC Propulsion and Vehicle Engineering Lab., Monthly Progress Reports, beginning with Monthly Progress Report for Period January 12, 1964, Through February 11, 1964, and ending with Monthly Progress Report for Period June 12, 1964, Through July 11, 1964. These reports are hereafter cited MSFC P&VE Lab., MPR for Jan. 12 - Feb. 11, 1964, and MPR for June 12 - July 11, 1964.

14. MSFC Engine Project Office, Monthly Progress Report, F-1, H-1, J-2, and RL-10 Engines, December 16, 1963 - January 31, 1964, p. 61, hereafter cited MSFC Engine Project Office; Engine MPR, Dec. 16, 1963 - Jan. 31, 1964,

The redesigned components will be retrofitted on the 18 production engines for vehicles SA-201 and 202 (16 for use in the stage and 2 as spares). The components will be installed during production on engines for vehicle 203 and subsequent Saturn IB vehicles.



SATURN IB COMPONENT

The spiderbeam, which holds the clustered tanks together at the forward end, is fabricated at Michoud for the Saturn IB vehicle. Engineers redesigned this S-I component for Saturn IB application.

[15] valves and other engine components. Rocketdyne concentrated the balance of the H-1 R&D program in this period on development tests. These tests involved the R&D 200K flight configuration engines, a variety of injectors, and the prototype of a low cost, brazed alloy, stainless steel thrust chamber. In March Rocketdyne delivered the first three 200K production engines; before the end of June the contractor had delivered seven additional production engines.[16]

MSFC and CCSD continued investigating the structural implications and modifications arising from use of the 200K engines in the S-IB. The program participants strengthened the forward and rear tank skirt sections as well as the thrust structure outrigger assemblies to accommodate the increased loads generated by the 200K engines. CCSD redesigned and MSFC approved and released criteria for redesigning the 60-degree fairings and the heat shield. MSFC also authorized CCSD to revise the existing method for ducting the inboard engine turbine exhaust gases to an engine mounted partial aspirator system. This change not only will reduce weight, it will improve aeroballistic characteristics.[17]

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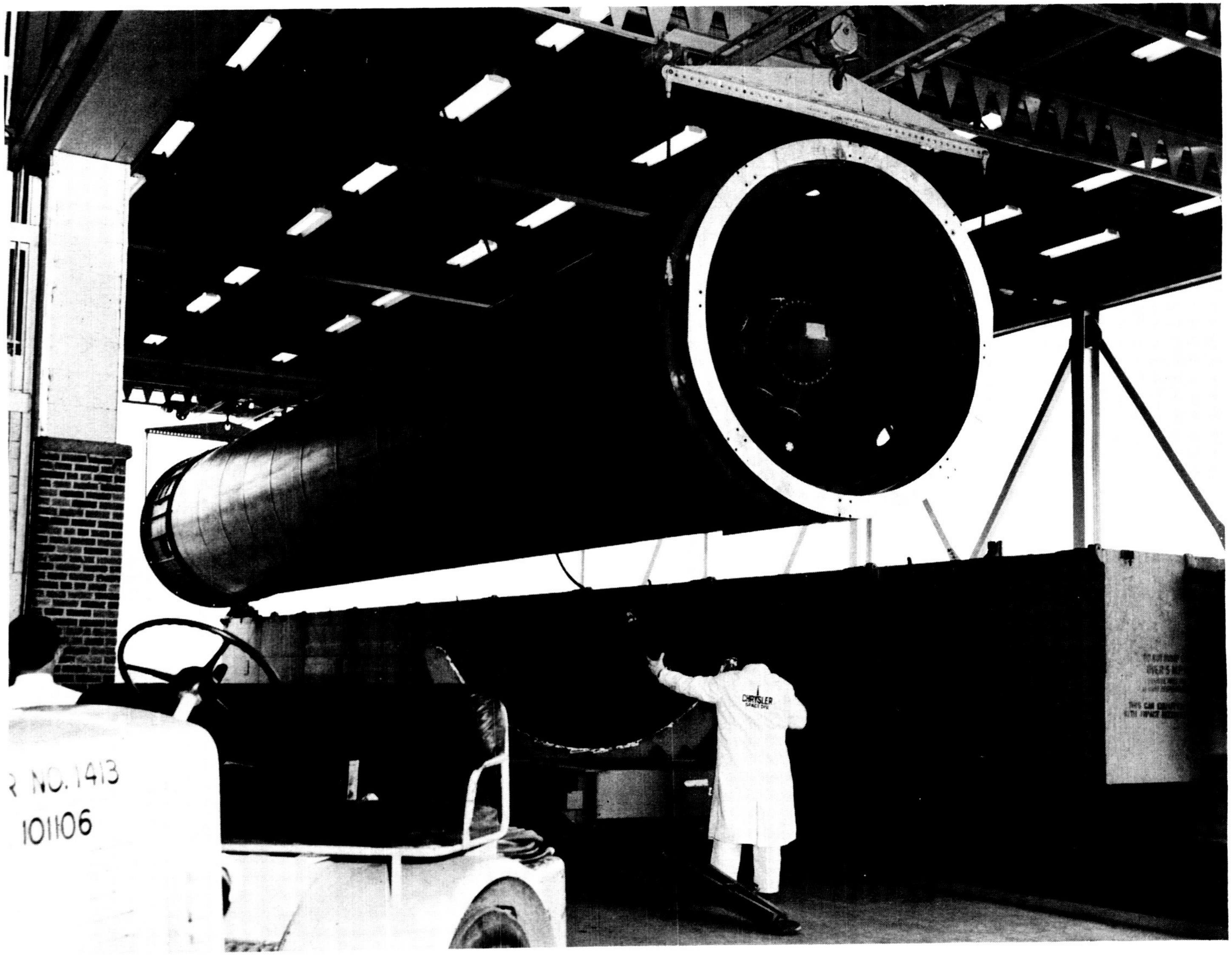
15. MSFC Engine Project Office, Engine MPR, Dec. 16, 1963 - Jan. 31, 1964, pp. 16-18, February 1964, pp. 13-16, March 1964, pp. 1-15, and Quarterly Progress Report, F-1, H-1, J-2 and RL10 Engines, April, May and June, 1964, pp. 21-25. The last document is hereafter cited MSFC Engine Project Office, Engine QPR, April - June 1964.

16. MSFC Engine Project Office, Engine MPR, March 1964, p. 11, and Engine QPR, April - June 1964, p. 21.

17. J. C. Glover, Chief, Design Integration and Criteria Branch, Vehicle Systems Division, P&VE Lab., to Mr. Aberg, Vehicle Systems Division, P&VE Lab., MSFC, memo, subject, "Weight Status Report for the Saturn IB Operational Launch Vehicle," and enclosure 2, subject, "Detail Weight Status," June 1, 1964; Kurt Rothe, Chief, S-IB Office, Vehicle Systems Division, P&VE Lab., MSFC, interviewed May 20, 1964; and CCSD, Seventh and Eighth Quarterly Review, Saturn S-I/IB Stage.



SATURN I COMPONENT CONVERTED FOR SATURN IB

This 105-inch (center) LOX tank, originally manufactured for an operational Saturn I stage (S-I-111), undergoes preparation for modification to the S-IB configuration. The photo was made at Michoud Operations in January 1964.

Additional propulsion system redesign and investigation involved the oxidizer system, the propellant utilization system, the propellant tanks, and tank instrumentation. MSFC authorized relocation of the gaseous-oxygen (GOX) diffuser to the LOX dome of the 105-inch LOX tank. This allowed increased propellant loading and resulted in performance gain. Engine and pump improvements have enabled the S-IB LOX container pressure to be reduced from 60 pounds per square inch absolute (psia) to the 50 psia. On February 18 MSFC authorized CCSD to proceed with redesign of the fuel pressurization sphere. MSFC also authorized replacement of the steel poppet valve in the water quench system with an aluminum butterfly valve. This latter change and selective sizing of lines in the system resulted in reduced weight.[18] Chrysler proposed and MSFC approved an increase in the skin thickness in five skin panels of the 105-inch LOX tank and one in the 70-inch fuel tank to accommodate the 200K engine.[19] Still another design change called for an increase in diameter in the 70-inch LOX tank tension ties to give the S-IB the capability of withstanding 125 mile-per-hour winds while on Launch Complex 34 (LC-34) at Cape Kennedy.[20]

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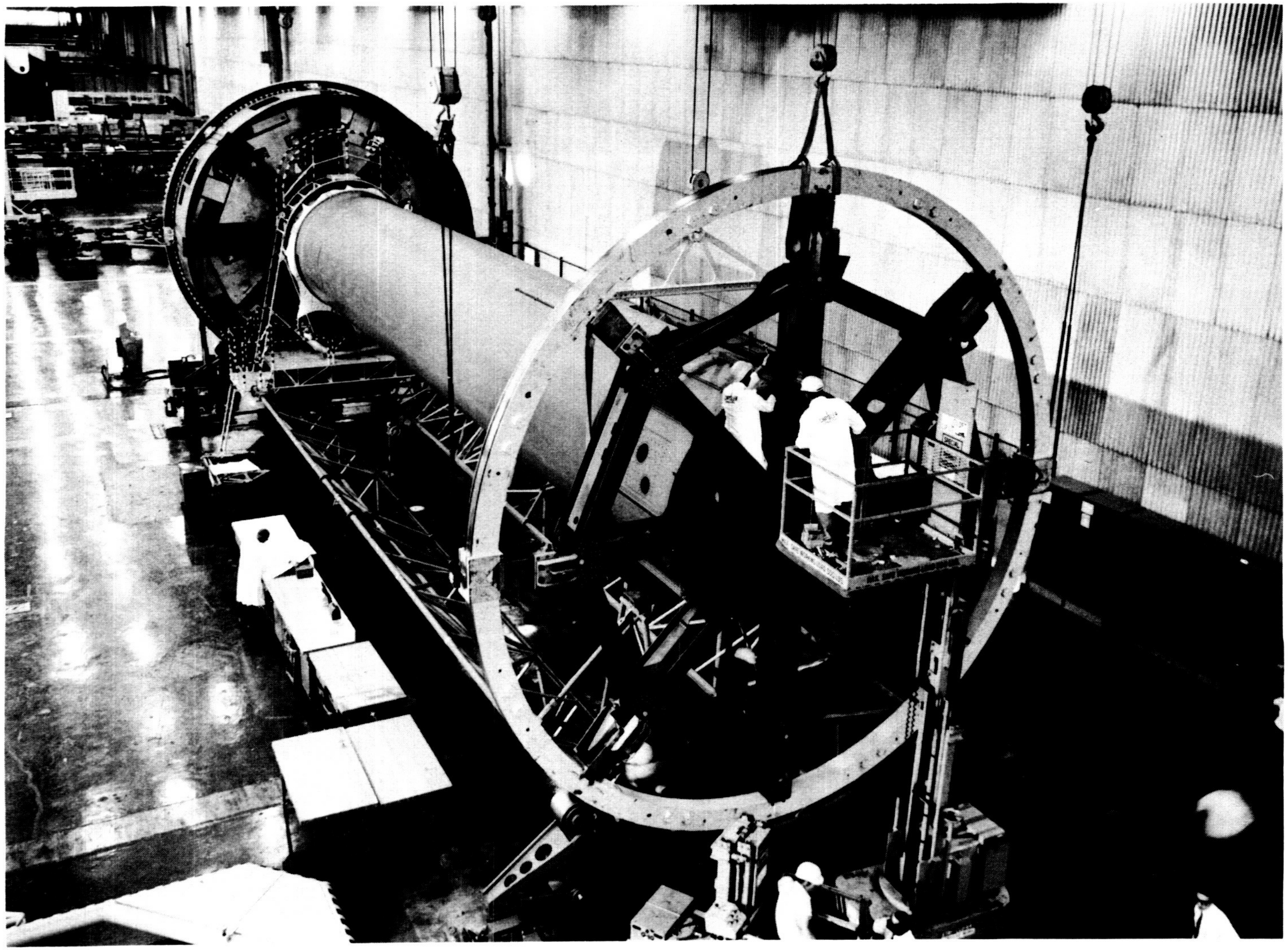
18. CCSD, Seventh and Eighth Quarterly Review, Saturn S-I/IB Stage; Kurth Rothe, Chief S-IB Office, Vehicle Systems Division, P&VE Lab., MSFC, interviewed May 20, 1964; and J. C. Glover, Chief, Design Integration and Criteria Branch, Vehicle Systems Division, P&VE Lab., MSFC, memo, subject, "Weight Status Report for the Saturn IB Operational Launch Vehicle," and enclosures 1 and 2, subject, "Summary Weight Status," and "Detail Weight Status," June 1, 1964.

19. MSFC P&VE Lab., MPR for Feb. 12 - Mar. 11, 1964, pp. 49-50.

20. MSFC P&VE Lab., MPR for Mar. 12 - Apr. 11, 1964, p. 50.



S-IB-1 ASSEMBLY BEGINS

Chrysler workmen at Michoud begin assembly of the first Saturn IB flight booster. The 105-inch center LOX tank shown in place will be circled by a cluster of eight 70-inch LOX and fuel tanks to complete the stage's propellant tankage. The photo was made in June 1964.

In this report period CCSD continued refinement of the S-IB stage fin design and completed documentation concerning fin redesign.[21] On April 20 CCSD completed at Michoud an S-IB mockup fin for use on the tail section mockup as a development fixture. In April MSFC reviewed CCSD's proposal for the S-IB fin design and also the proposal for fin qualification testing. MSFC officially released the criteria for the fin design on April 30.[22]

Prior to this report period CCSD began fabrication and procurement of hardware items common to S-I and S-IB flight stages and began fabrication of some S-IB stage items. In March 1964 the contractor began fabrication of components (other than those already available from the two Saturn I stages, S-I-111 and S-I-112)[23] for the first two S-IB flight stages (S-IB-1 and S-IB-2). In April CCSD began assembling the major structural components for the S-IB-1 stage; the contractor completed the S-IB-1 thrust structure and the second stage adapter in May. On June 19, following erection of these assemblies in the stage assembly fixture, CCSD began clustering the tanks for S-IB-1. On June 22

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21. CCSD completed preliminary design of the fins in the July - December 1963 period. The preliminary design showed eight lightweight, sweptback fins instead of the four large and four stub fins on the S-I stage.

For additional detail see MSFC Hist. Office, History of MSFC, (MHM-8), p. 65.

22. MSFC P&VE Lab., MPR for Mar. 12 - Apr. 11, 1964, p. 50; MPR for Apr. 12 - May 11, 1964, pp. 61 and 63; MPR for May 12 - June 11, 1964, p. 54; and MPR for June 12 - July 11, 1964, pp. 53-54; and CCSD, Seventh Quarterly Review, Saturn S-I/IB Stage, Chart CG-1.

23. When NASA redirected the Saturn I program in October 1963 and cancelled requirements for operational vehicles, CCSD terminated fabrication of components for S-I-111 and S-I-112. The components already fabricated for those stages were allocated for use on S-IB stages.

COMPONENT FOR S-IB FLIGHT STAGE

Chrysler workmen at Michoud put together the thrust structure for S-IB-2, the booster for the second Saturn IB flight vehicle.

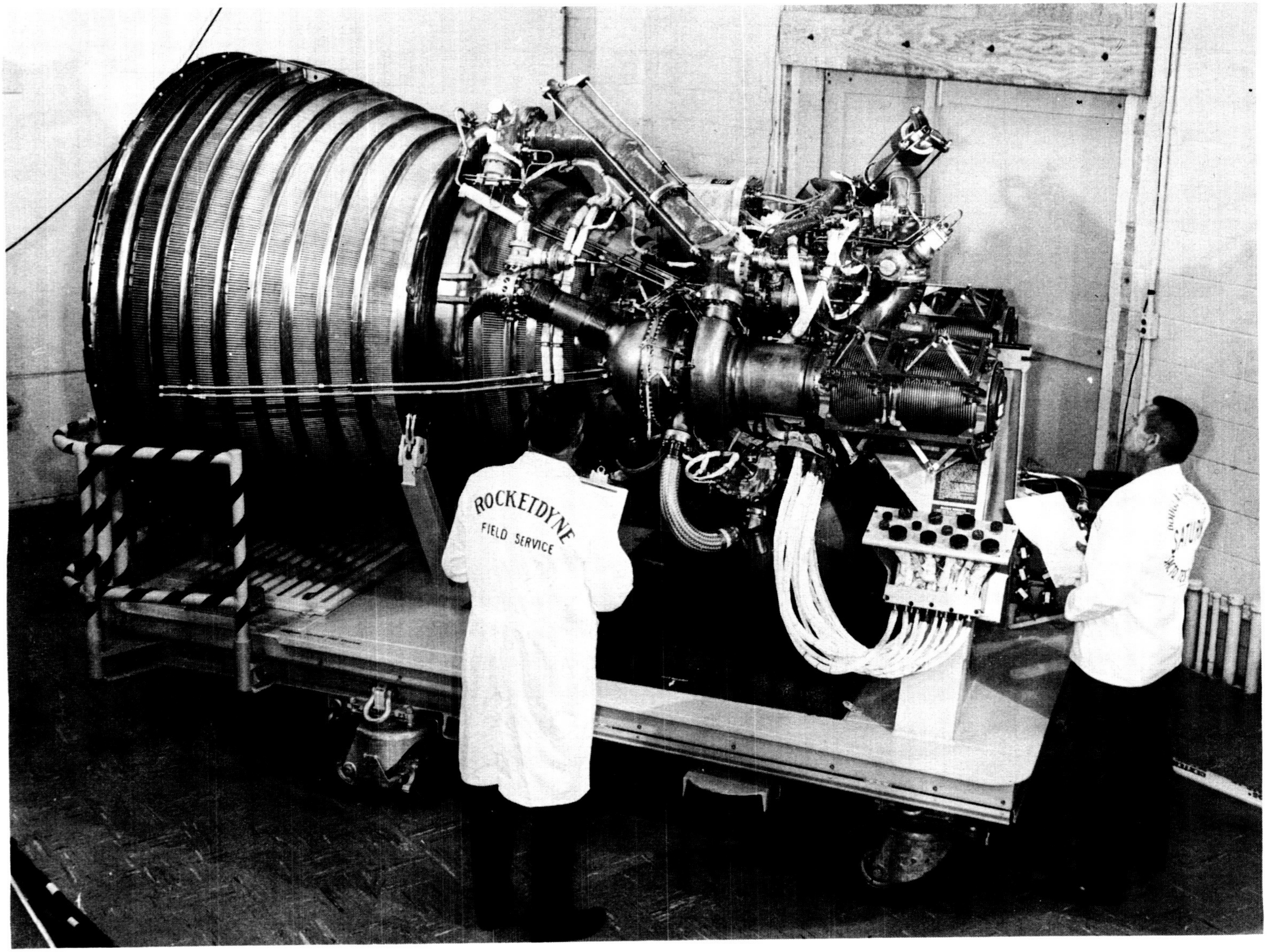
the contractor attached the spider beam to the tanks. S-IB-1 stage assembly is scheduled for completion in November 1964.[24] CCSD began fabrication of components for the second S-IB flight stage also in March and continued S-IB-2 component fabrication throughout this report period. In this period the contractor completed the barrel assembly and began assembling the outriggers to the barrel assembly.[25]

In the January - June 1964 period CCSD formulated qualification test plans for S-IB stage components, and MSFC reviewed and approved most of the proposed plans. In February CCSD and MSFC began work also on the ground rules for the Saturn IB ground test program. MSFC published the rules in June.[26] Only one stage, the dynamic and facilities checkout stage (S-IB-D & F), is required for the S-IB ground test program. On completion of the Saturn I dynamic test program in July 1964, the S-I dynamic stage (SA-D5) will be shipped to Michoud for modification to the S-IB-D & F stage design. The stage will be used first in dynamic tests at MSFC and then in facilities checkout at Cape Kennedy. Near the end of this period CCSD began to plan the static test

24. MSFC Industrial Operations, Saturn Monthly Progress Report, February 16 - March 16, 1964, pp. 1 and 5, hereafter cited MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964; Lee Cropp, Industrial Operations, MSFC, Draft of "Saturn I, IB, and V Quarterly Progress Report, April, May, and June 1964," p. 1; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 19; and MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 2.

25. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 5; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 21.

26. MSFC P&VE Lab., MPR for Feb. 12 - Mar. 11, 1964, p. 22; and June 12 - July 11, 1964, p. 16.



FIRST PRODUCTION J-2 ENGINE

Rocketdyne, as J-2 engine contractor, delivered this first hot-firing production model, J-2003, on April 30, 1964. Delivery was to DAC, for S-IVB battleship testing at Sacramento.

program for the S-IB-1 and subsequent vehicles. CCSD presented the S-IB Stage Static Test Program Plan, Revision 2, to MSFC for review in June.[27]

S-IVB Stage

The Saturn IB S-IVB second stage is 59.1 feet long and 21.7 feet in diameter. It is propelled by one J-2 LOX/LH_2 engine that produces 200,000 pounds thrust at altitude. Dry weight of the stage is 20,000 pounds; stage weight at ground ignition is about 243,000 pounds.[28]

The Saturn IB second stage is designated S-IVB/IB to distinguish it from the Saturn V S-IVB stage (S-IVB/V).[29] The two stages are similar in operation. Both stages, along with the lower stages of their respective vehicles, inject spacecraft into a circular Earth orbit of approximately 105 nautical miles. At this point the S-IVB/IB and S-IVB/V missions change. The S-IVB/IB stage stabilizes the spacecraft's Lunar Excursion Module (LEM) while the remainder of the spacecraft separates from the LEM, turns around and docks, nose to nose, with the LEM. This is referred to as the vehicle's orbital coast mission which lasts about

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27. MSFC P&VE Lab., MPR for June 12 - July 11, 1964, p. 51.

28. The stage weight, based on current estimates, does not include the weight of the S-IB/S-IVB interstage and retromotors, nor does it consider the coast mission.

A more detailed description of the vehicle is contained in NASA, Apollo Systems Descriptions, Volume II, NASA TM X-881, Feb. 1, 1964, pp. 12.5-12.6, published by Office of Manned Space Flight, NASA.

29. The S-IVB stage, slightly modified, serves also as the third stage of the Saturn V vehicle. Douglas Aircraft Company (DAC) performs the S-IVB R&D program for both the Saturn IB and Saturn V programs on a parallel basis. The ground test vehicles are basically the same for both programs. Most of the development progress on the ground test stages and all of the development progress for the Saturn V S-IVB stage is covered in the Saturn V chapter of this report.

4.5 hours and thus ends S-IVB/IB operation. On the other hand, the S-IVB/V stage (following a checkout of crew and space vehicle) burns a second time to inject the spacecraft into a lunar transfer trajectory. It then performs the same mission as S-IVB/IB in stabilizing the LEM during the docking process.

Structurally, the two stages are similar, and both the stages function alike except for the second burn. The primary difference in the two stages is in the weight of various components affected by the mission requirements for their respective vehicles. The S-IVB/IB forward skirt weighs about 180 pounds less; it supports a lighter payload. The S-IVB/IB auxiliary propulsion system (APS) weighs some 1096 pounds less; the attitude control, ullage and venting requirements are less than those for Saturn V. The S-IVB/IB aft skirt is 462 pounds lighter than that of the S-IVB/V because of the lighter payload it helps to support. The most significant weight difference is in the propulsion system. The S-IVB/IB system weighs 1619 pounds lighter because less helium storage is required than with the S-IVB/V which has the orbital restart mission. The S-IVB/IB interstage is 1479 pounds lighter and has a 260-inch diameter, while the S-IVB/V interstage is flared from 260 inches to 396 inches in diameter to accommodate the S-II second stage of the Saturn V. The final difference is in the electrical system: the S-IVB/IB is 349 pounds lighter because more power, resulting in additional weight for the system, is required to provide orbital coast, venting, and restart of the Saturn V.[30]

The Missile and Space Systems Division of Douglas Aircraft Company (DAC) is developing the stage for both the Saturn IB and Saturn V vehicles. The contractor began work on the stage under a Saturn V contract awarded in August 1962. In December 1963 NASA modified the contract to provide for four additional stages, all designated for the newer Saturn IB program.[31] On May 19, 1964, MSFC negotiated cost proposals with DAC for work on one ground support equipment (GSE) set and for additional S-IVB/IB stages and effort in the period June 1 - December 31, 1964. MSFC forwarded to DAC on June 10 a request for quotation (RFQ) for eight additional S-IVB/IB stages and the set of GSE. At the close of this period DAC was preparing its proposal to send to MSFC for review prior to final contract negotiation.[32]

In the January - June 1964 period DAC continued to make progress in the S-IVB/IB program. By the end of the period the contractor had almost completed the initial design phase, had completed manufacture and certification of all major tooling, was manufacturing major components, and had started assembling ground test stages and flight stages.[33]

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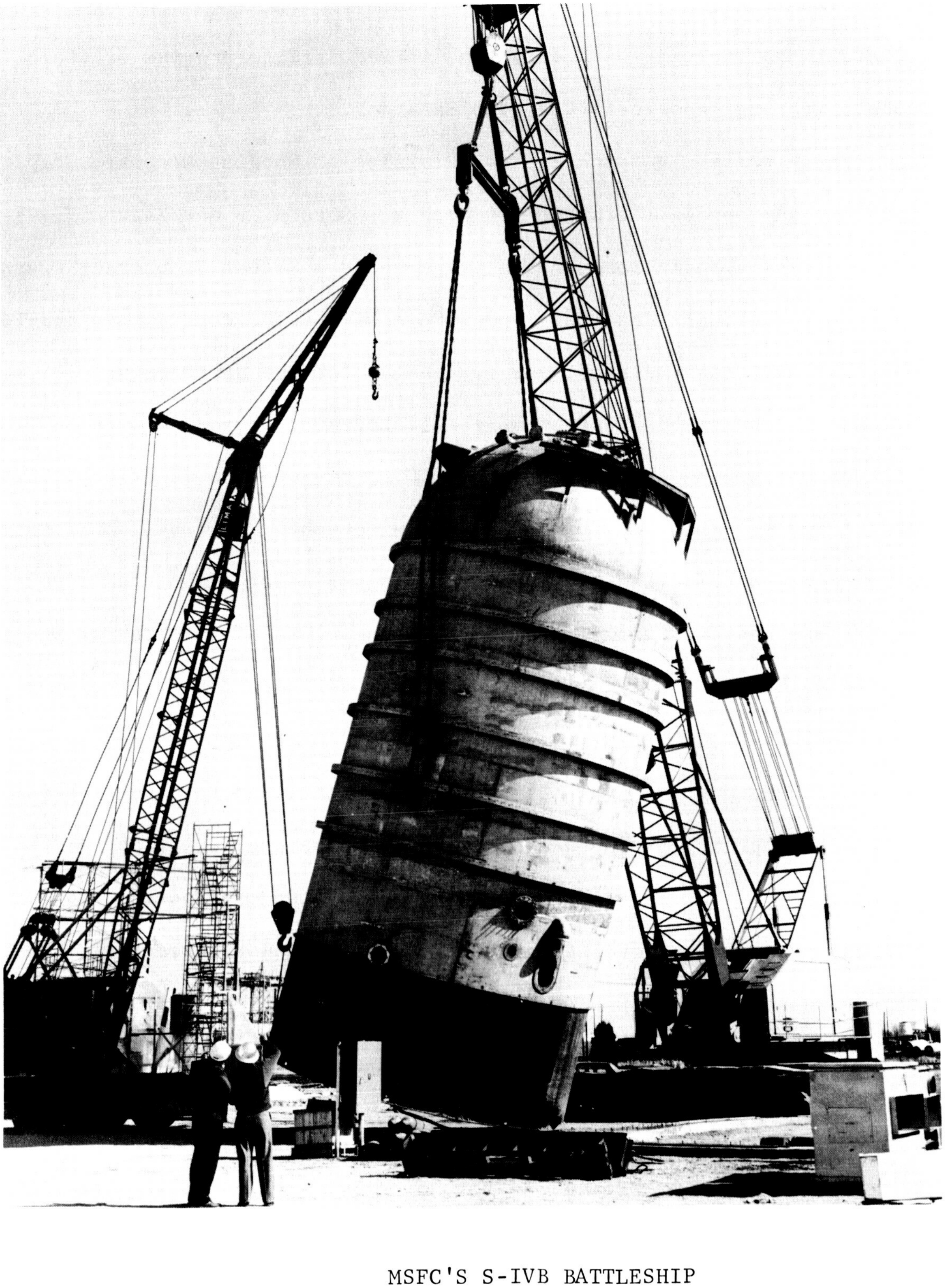
30. These weights are based on estimates as of the June 1964 "Monthly Weight Status" chart.

MSFC Executive Staff, Management Information, Volume I, 2nd Edition, October 1964, p. 104.

31. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 67 and 69.

32. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 21.

33. DAC, Missiles and Space Systems Division, Saturn S-IVB Annual Technical Progress Report, July 1963 - June 1964, pp. 1-3, hereafter cited DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964.



MSFC'S S-IVB BATTLESHIP

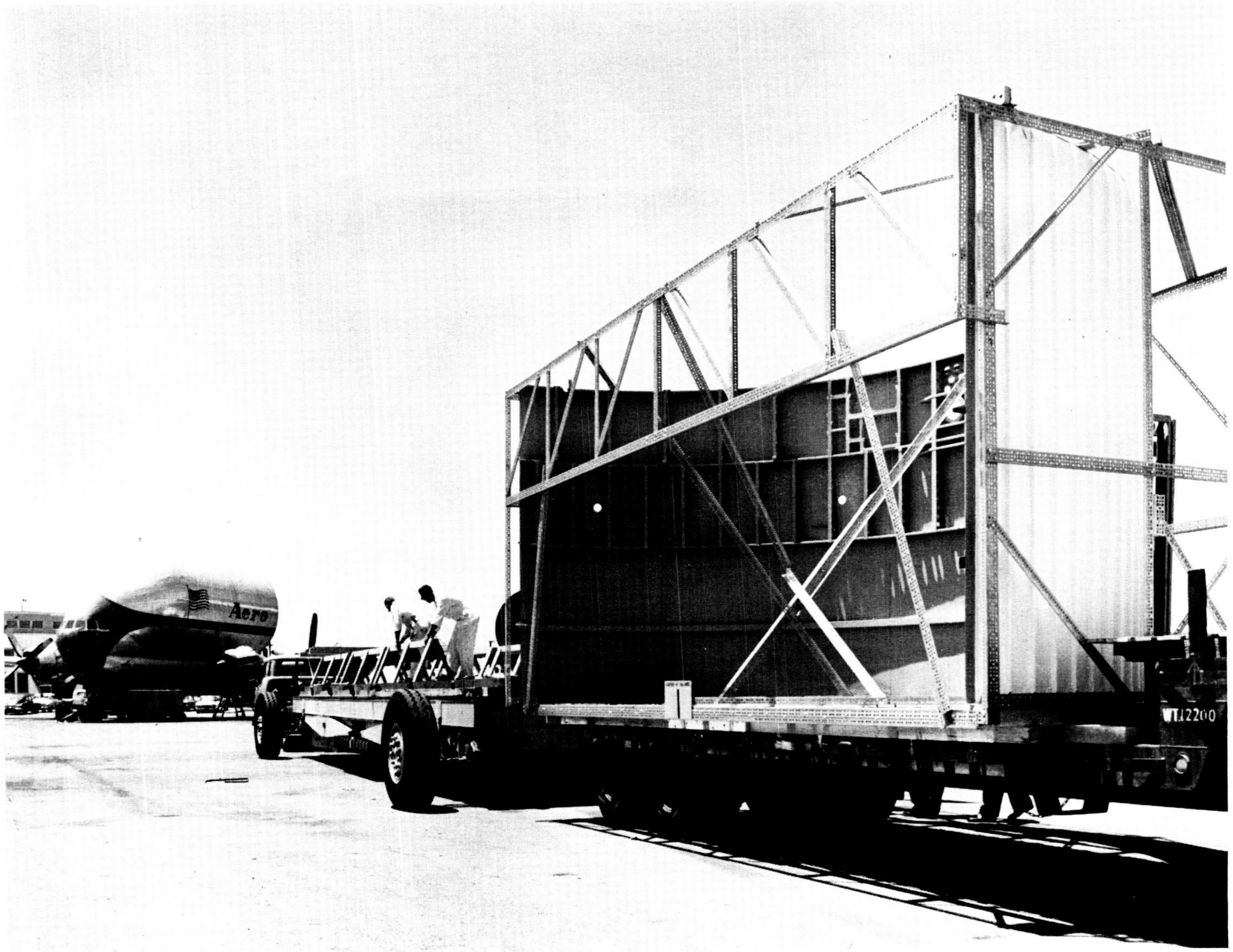
This battleship version of the S-IVB stage for the Saturn IB and Saturn V programs is hoisted in the Test Area during February 1964. Erected at MSFC by a DAC subcontractor, the battleship will be used for firing of the liquid hydrogen J-2 engine.

Major engineering work in the current report period concerned systems improvement and reduction in S-IVB stage weight.

The S-IVB/IB stage weight was reduced during this report period. Approximately 517 pounds of weight loss was attributed to DAC improvement in the thermal performance of the internal insulation. A reduction of the propellant tank (LH_2 tank) operating pressure resulted in a loss of 175 pounds for the S-IVB/IB. An improvement study nearing completion at the end of June involved the operational telemetry. Improvement in this area is expected to yield a 1600-pound weight reduction. Other engineering studies in progress at the end of the period were expected to yield additional reductions in weight. These newest studies concerned low density incapsulating material, trajectory optimization, reduction in skin splice material, use of minimum weight core foam for the internal insulation, and use of solid state sequence.[34]

Engineering activity resulted in systems improvement in several areas. During this period important problems were overcome in the development of the first S-IVB/IB Auxiliary Propulsion System module. Improved also were welding techniques. Near the end of the period DAC completed design of the S-IVB/IB propellant utilization (PU) system and the S-IVB PU inverter based on the design of the S-IV system. The contractor completed prototype tests confirming the PU design; development tests of the PU inverter were in progress. DAC progress in

34. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, pp. 15, 22, and 27-31.



S-IVB HARDWARE DELIVERED

Shown at DAC before loading on the Pregnant Guppy aircraft for shipment to MSFC is half of an S-IVB forward skirt. Shipped in two sections shortly after the end of the current report period, the Saturn IB/V hardware will undergo structural testing at MSFC.

preparing flight stage instrumentation for the S-IVB/IB flight vehicles resulted in the flight instrumentation programs for the first three vehicles.[35]

The S-IVB ground test stages support both the Saturn IB and Saturn V S-IVB development programs. DAC's progress in assembling these stages is presented in the Saturn V Chapter of this history, MHM-9.

In this report period DAC continued development tests to confirm the design concepts and to qualify components prior to the first scheduled S-IVB ground tests. Other development tests concerned items that could affect the design of the S-IVB stage or GSE, qualification of items prior to propellant loading of the facility checkout vehicle at the Sacramento Field Test Station (SACTO), and qualification of components of first vehicle flight. In this period the contractor completed test plans for the Battleship test program and defined detailed test objectives and the instrumentation program required for the All-Systems Test vehicle and the S-IVB/IB flight stages.[36]

DAC proceeded with fabrication and assembly of the first two flight stages (S-IVB-1 and S-IVB-2) during this period. The contractor also began fabrication of S-IVB-3 and S-IVB-4 components. Most advanced of the four stages under construction was S-IVB-1. In the early months of this report period DAC completed fabrication of the common bulkhead aft

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35. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, pp. 25-26, 28-30, 34-35, and 36-37.

36. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, pp. 36-37 and 95-96.

dome and the LOX baffles for the S-IVB/IB-1. The forward bulkhead dome waited installation of the tee-ring.[37] In April the contractor delivered the stage LOX tank to the assembly facility at Huntington Beach, California. There workmen completed the cylindrical tank section seam welds and welded one attach ring in the trim and weld assembly jig. Welding of the LOX tank to the LH_2 cylindrical section occurred in May.[38] On May 14 MSFC and DAC reviewed the contractor's progress during an S-IVB Quarterly Review held at Huntington Beach. DAC proposed and MSFC agreed in May that the forward LH_2 dome of the former S-IVB Facilities Checkout stage be used on the S-IVB/IB-1. This prevented delay in the S-IVB/IB-1 assembly schedule. During the last week of May DAC completed assembly of the LOX tank, the LH_2 cylinder, and the reallocated LH_2 forward dome and joined the three components to form the propellant tank assembly. DAC then moved the stage to the assembly tower and in June completed production proof tests before beginning insulation installation.[39] DAC began fabricating S-IVB/IB-2 at Santa Monica, California, in February. In April the contractor completed the aft common bulkhead except for the dollar

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37. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, pp. 2 and 6, and Feb. 16 - Mar. 16, 1964, p. 5.

38. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 147.

39. Lee Cropp, MSFC Industrial Operations, Draft of "Saturn I, IB, and V Quarterly Progress Report, April, May, and June 1964," p. 9; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 23 and 31.

weld. By early June the contractor had completed all welds on the common bulkhead to the LOX tank and LH_2 tank.[40]

Instrument Unit

The Saturn IB instrument unit is 260 inches in diameter and 36 inches high. Its weight at ground ignition is approximately 3,900 pounds. The Saturn IB IU is almost identical to the Saturn V IU.[41] Its cylindrical, unpressurized structure is composed of three segments joined by splice plates; its structure resists the loads encountered during all vehicle operations through payload separation. The IU is located between the S-IVB stage and the payload. The IU houses the guidance, control, electrical, measuring, telemetry, radio frequency, environmental control, and emergency detection systems.

MSFC and International Business Machines Corporation (IBM) are responsible for designing, testing, procuring, and manufacturing the IU for the Saturn IB and Saturn V programs. The Bendix Corporations and IBM

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40. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 6; Lee Cropp, MSFC Industrial Operations, Draft of "Saturn I, IB, and V Quarterly Progress Report, April, May, and June 1964," p. 10; and DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 148.

41. The only major structural difference between the Saturn IB and the Saturn V IU is in the location of cutouts in the sandwich bonded panels of each segment. The major difference in the Saturn IB and Saturn V IU components is in their location within the unit and vehicle.

NASA, Apollo Systems Descriptions, Volume II, NASA TM X-881, Feb. 1, 1964, pp. 12.6 and 14.9-14.10; and Lee B. James, Director, Saturn I/IB Program Office, MSFC, to Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA, letter and enclosure, subject, "Minutes of Meeting on Instrument Unit, 3 January 1964," Jan. 9, 1964.

manufacture the major guidance components for both IU's. Bendix manufactures the ST-124M stabilized platform and associated equipment; IBM manufactures the launch vehicle digital computer, data adapter, and flight sequencer. Bendix and contractors manufacturing lesser components supply MSFC with the components.[42] MSFC will initially furnish these components to a "lead IU contractor." Later, the lead contractor will be responsible for procuring or manufacturing the components.

In October 1963 MSFC and IBM began contract negotiation covering design and development of the data adapters, production of digital computers, and the total integration and checkout of the Saturn IB IU. Contract negotiation ended in December 1963 and cost negotiation in January 1964. In the week ending January 24 NASA approved extension of letter contracts to IBM through April 22, 1964, for design and development of the data adapters and the digital computers.[43] On March 10, NASA awarded IBM the contract for the digital computer and data adapter for the first Saturn IB IU (S-IU-201) and for subsequent Saturn IU's.[44] In March NASA also approved the award of a $5.5 million contract to IBM covering the first phase of IBM's IU integration effort. No hardware is involved in this phase; involved instead is development of the test plan,

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42. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 76-77, and NASA, Apollo Systems Descriptions, Volume II, NASA TM X-881, Feb. 1, 1964, pp. 12.6, and 14.9-14.10.

43. Garland G. Buckner, Chief, Purchasing Office, MSFC, to H. H. Gorman, Deputy Director, Administrative, MSFC, memo, subject "Report of Activities for Week Ending January 24, 1964," Jan. 24, 1964.

44. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, pp. 2 and 6.

program plan, and procurement specifications to be used in the hardware phase of the program.[45]

In April NASA announced selection of IBM as the lead contractor to assemble, integrate, and checkout the IU's for Saturn IB and Saturn V vehicles. In this role IBM will be responsible for integration of all IU systems; MSFC will initially supply components and equipment. MSFC released the RFQ to IBM on May 1. IBM submitted its contract proposal on June 1, and MSFC began evaluating the proposal.[46] IBM proceeded to build up its personnel and facilities in Hunstville to accomplish the integration effort.

Prior to this report period NASA contracted with Bendix Corporation for four prototype ST-124M stabilized platform systems and associated equipment for use in Saturn IB and Saturn V IU development testing.[47] On January 22, 1964, NASA announced plans for negotiation with Bendix for 29 ST-124M stabilized platforms and associated equipment for Saturn IB and Saturn V flight vehicles. On February 3 MSFC modified an existing Bendix contract (NAS8-5399) by letter to cover procurement of ST-124M platform systems for S-IU-201, 202, and for a test unit (S-IU-500FS). On March 26 MSFC issued Bendix an RFQ for 26 additional platform systems. Modification 9 to contract NAS8-5399, effective April 29, definitized the procurement action of February 3. MSFC on May 26 received Bendix's

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45. MSFC Hist. Office, History of MSFC, (MHM-8), p. 77; Garland G. Buckner, Chief, Purchasing Office, MSFC, to H. H. Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Report of Activities for Week Ending January 24, 1964," and "Report of Activities for Week Ending February 7, 1964;" and MSFC Public Affairs Office (PAO), Press Release, Mar. 31, 1964.

46. MSFC PAO, Press Release, Apr. 20, 1964; MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1 - June 30, 1964, p. 7; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25.

47. MSFC Hist. Office, History of MSFC, (MHM-8), p. 77.

proposal for production of the 26 other platform systems. The Center's evaluation of the proposal was in progress when this report period ended.[48]

In other contract action during this period MSFC procured 62 cold plates for use in IU environmental control systems. The Center completed contract negotiation for the plates with Avco Corporation on April 17. An arrangement of 17 of the cold plates through which ducts circulate a liquid (methanol and water) are required in the environmental control system to maintain the desired range of temperature during ground operations and vehicle flight.[49]

During this report period MSFC continued to make progress in completing design documentation for various IU systems and in preparing qualification test requirements. Design tests of IU systems and components continued throughout the report period at the Center. In April NASA personnel checked out and accepted the breadboard digital computer No. 1 at IBM's Owego, New York, plant. This computer will be used at the contractor's plant in testing, evaluating, and programming units.[50]

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48. MSFC PAO, Press Release, Jan. 22, 1964; MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 7; MSFC Astrionics Lab., Saturn Monthly Progress Report, March 1964, Apr. 14, 1964, p. 4; and John Harlow, Instrument Unit Office, Saturn I/IB Program Office, MSFC, interviewed April 8, 1965.

49. James B. Bramlet, Deputy Director, Operations, Saturn V Program, MSFC, speech, "Saturn V Launch Vehicle Development Program," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964; and MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1 - June 30, 1964, p. 7.

50. MSFC Astrionics Lab., Saturn Monthly Progress Report, April 1964, May 15, 1964, p. 2.

Calculations performed in April to determine the tensile capability for the Saturn IB/V IU revealed that the IU structure required redesign to withstand expected tension loads.[51] MSFC instructed General Dynamics/Fort Worth, an IU subcontractor, to redesign the IU structure to permit heavier vehicle loads. The Center agreed that structural units already delivered would be used in the IU ground test program where the design change would not affect test results. The contractor will deliver the first redesigned structure in November 1964.[52]

In January MSFC completed the floor plan showing the mechanical mockup plus stage mockup and control rooms in the IU Systems Development Breadboard Facility (SDBF).[53] The Center distributed the Operational Plan for the Saturn IB SDBF in February. Before the end of this period MSFC completed the Saturn IB equipment layout reflecting the Saturn IB SDBF. The equipment layout will be updated as required and will form a basis for documentation of equipment within the facility. MSFC also completed the specifications for the Saturn IB SDBF telemetry checkout station. The equipment required to interface between all on-board telemetry and the RCA-110A computer is shown in these specifications.[54]

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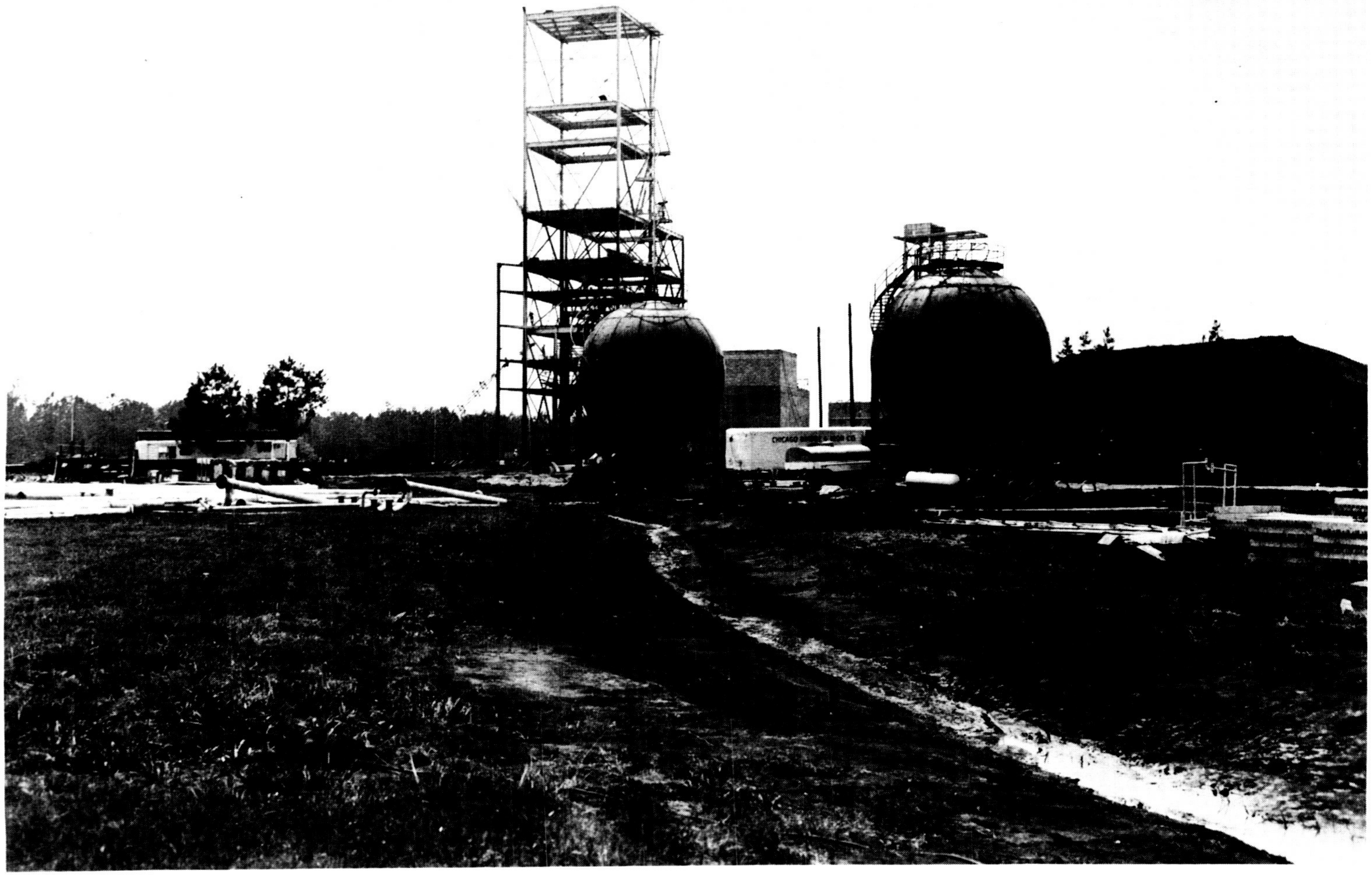
51. The Saturn IB/V IU was initially designed to withstand compression loads only.
John Harlowe, Instrument Unit Office, Saturn I/IB Program Office, MSFC, interviewed April 7, 1965; and MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964, p. 69.

52. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25; and MSFC P&VE Lab., MPR for May 12 - June 11, 1964, p. 53.

53. This facility is for use in design and development operational tests.

54. MSFC Astrionics Lab., Saturn Monthly Progress Report, January 1964, p. 7; February 1964, pp. 6-7; May 1964, pp. 1 and 14; and June 1964, p. 6.



LIQUID HYDROGEN FACILITY

This complex in the East Test Area at MSFC is shown when construction was about 60 per cent complete in June 1964. The facility includes a J-2/S-IVB static test stand and related systems. Completion was scheduled for October 1964.

Fabrication of the Saturn IB IU mockup and test units continued at MSFC during the report period. By May MSFC had fabricated the Saturn IB IU mockup structure and 50 per cent of all components; installation of cold plates and their brackets was in progress.[55] Test unit construction at MSFC involved the unit structures. In April the Center fabricated and inspected the structure for the vibration test unit (S-IU-200V). Technicians then stored the structure pending completion of the redesign effort at General Dynamics. In June MSFC completed fabrication of the structure for the dynamic test unit (S-IU-200D/500D). The Center then decided that the S-IU-200/500D required a new redesigned structure. The first redesigned structural segments delivered by General Dynamics will be used in the fabrication of a new S-IU-200D/500D. The structure already fabricated for the S-IU-200D/500D will be modified and used in another test unit not requiring the redesigned structure.[56]

Facilities and Ground Support Equipment

Facilities and ground support equipment (GSE)[57] supporting the Saturn IB R&D program are located at MSFC in Huntsville, Alabama; Michoud

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55. MSFC P&VE Lab., MPR for Mar. 12 - Apr. 11, 1964, p. 26, and Apr. 12 - May 11, 1964, p. 18.

56. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 33.

57. Ground support equipment (GSE) includes equipment used for test, checkout, handling, transportation, servicing, and auxiliary equipment for all stages and the instrument unit. The GSE is used at all development and test sites where Saturn IB effort is centered. GSE associated primarily with launch support is the responsibility of NASA's John F. Kennedy Space Center (KSC) and is not included in this report.

Operations in New Orleans, Louisiana; DAC in Santa Monica, Huntington Beach, and Sacramento, California; Rocketdyne in Neosho, Missouri, and Canoga Park and Santa Susana, California; and NASA's John F. Kennedy Space Center (KSC) in Cape Kennedy, Florida. Most of the facilities supporting Saturn IB R&D are used in common with the Saturn I and Saturn V R&D programs.[58]

MSFC Huntsville facilities supporting Saturn IB R&D include a vertical structural test facility, component test facility, dynamic test facility, components and subassembly acceptance facility, load test annex, J-2 engine systems development test stands, S-IB static test stand and blockhouse, and other subassembly test facilities. Construction and modification of most of the facilities proceeded throughout the report period. This progress is discussed in the Saturn I and Saturn V chapters of this report. When this report period ended, procurement plans for modification to the west side of the static test stand for Saturn IB and expansion of the blockhouse awaited NASA's approval.[59]

Major MSFC GSE accomplishments in the January - June 1964 period included establishment of a development plan for automation of Saturn vehicle checkout; establishment of the automation techniques; design of much of the electrical support equipment (ESE) for use during checkout,

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58. NASA, Apollo Systems Descriptions, Volume II, NASA TM X-881, Feb. 1, 1964, pp. 17.3-17.31 and 27.3-27.4.

59. MSFC Executive Staff, Saturn I & Saturn IB Management Information, June 1964, p. 82.

static test, and launch of the vehicle (located primarily in the Saturn IB Systems Development Breadboard Facility, an extension of the Saturn I facility); and progress in design of ESE for the IU. The Center contracted with Radio Corporation of America (RCA) on June 11 for 19 additional ground computers for use in the Saturn IB and Saturn V programs. Two of the computers (RCA-110A type) will be used in a tandem mode in the Saturn IB breadboard to permit a data link operation between the Saturn IB and the launch control center.[60] MSFC also completed a plan for standardization of computer programming for space vehicle applications. This included the coordination of automated checkout, static firing, and launch control. An Automation Sub-Board No. 4 was established in March as the R&D management segment responsible for implementation of the plan. By the end of the period both stage contractors had agreed to implement the program in their respective stages. In April DAC agreed to implement the plan effective with S-IVB/IB-2; CCSD agreed to implement the plan effective partially with S-IB-201 and fully on S-IB-205.[61]

Facilities and GSE for Saturn I/IB development work at Michoud Operations are discussed also in the Saturn I Chapter of this report.

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60. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25; Technical Staff, MSFC Automation Board, MSFC Automation Plan, June 1, 1964, pp. 1-13, 37, and 40; MSFC Quality Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 9; and MSFC Astrionics Lab., Saturn Monthly Progress Report, January 1964, pp. 6-7; February 1964, p. 5; March 1964, pp. 5-6; April 1964, pp. 2-4; May 1964, pp. 11-14; and June 1964, pp. 4-6.

61. MSFC Quality Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 9-10.

Modification of these facilities and tooling to support Saturn IB S-IB stage development continued throughout this report period. Completed were modification and construction of the receiving inspection clean rooms, X-ray crane, Phase I and II of the accelerator pit, Phase I of the high pressure test area, Phase II of the tube fabrication clean room, and foundations for the storage tanks.[62]

S-IVB stage development and test facilities and GSE are funded under the Saturn V program, and are discussed also in the Saturn V chapter of this report.

Saturn IB launch facilities are located at the NASA John F. Kennedy Space Center and include Launch Complex 34 (LC-34) as the initial launch facility and LC-37B as a secondary facility. NASA approved in December 1963 modification of LC-34 to support Saturn IB launches. In this period KSC completed most of the criteria for modifying the complex and completed also was the criteria for most of the launch support equipment. Modification of LC-37B to support the Saturn IB launches will not occur until after the SA-10 launch.[63]

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62. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 20.

63. NASA, John F. Kennedy Space Center, Kennedy Space Center Technical Progress Report, Feb. 19, 1964, pp. 4-5, and Mar. 19, 1964, pp. 4-5; and George E. Mueller, Associate Administrator for Manned Space Flight, NASA, to NASA MSFC, letter, subject, "Saturn I/IB Pad Modification and Utilization," Mar. 20, 1964.

Saturn IB and Related Studies

Saturn IB studies in this report period continued to be directed toward investigation of various third stage designs, vehicle improvement, and payload analyses. The major effort centered on possible improvement to the vehicle.

Near the beginning of the report period MSFC initiated in-house surveys of potential growth versions of Saturn IB. The surveys or studies concerned thrust uprating, increased propellant capacities, engine and/or propellant substitutions, and thrust assist takeoff.[64]

Ten different vehicle configurations potentially capable of providing increased payload for the Saturn IB received consideration by MSFC. Five of the configurations consisted of different first stages with the present S-IVB second stage. CCSD and Rocketdyne investigated the possibility of uprating the S-IB stage to 2,000,000 pounds thrust and of increasing the propellant capacity to approximately 1,150,000 pounds. Several industries conducted preliminary investigations of an S-IB stage having a 260-inch-diameter solid motor and an S-IB stage having two 120-inch-diameter solid motors strapped on. However, Boeing Company and Lockheed Missiles and Space Company, under separate contracts with MSFC, performed the major study effort on these configurations. MSFC considered in-house an S-IB stage having 260-inch diameter tandem tanks with two F-1 engines, and an S-IB stage with two strap-on Titan III core stages. Two vehicle

64. MSFC Future Projects Office (FPO), Future Projects Office Bulletin No. 8, April 1964, p. 23.

configurations considered involved the S-IB stage in its present design and S-IVB stages of different design. The different S-IVB stage configurations under consideration employed solid propellant rocket motors. One produced the standard S-IVB thrust and had the same propellant capacity; the other used a 315,000-pound-thrust high chamber pressure engine and had 350,000-pound propellant capacity.[65]

Other methods of improving the payload capacity of the Saturn IB involved use of the Minuteman solid motor vehicle for augmenting the Saturn IB thrust. The solid motors would be attached to the S-IB stage fins. Two configurations were considered. One employing Minuteman strap-ons on a vehicle in which the S-IVB stage had integrated a high pressure propulsion system and an increased propellant load to 350,000 pounds looked most attractive.[66]

In this report period MSFC requested contract proposals from CCSD and DAC for Saturn IB improvement studies. In May MSFC found the technical proposals of both contractors unacceptable and asked the contractors to resubmit proposals. MSFC evaluated and approved the resubmitted proposals toward the end of June. Meanwhile, MSFC continued

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65. MSFC P&VE Lab., MPR for Mar. 12 - Apr. 11, 1964, pp. 3-4; Apr. 12 - May 11, 1964, p. 1; May 12 - June 11, 1964, pp. 1-3; and June 12 - July 11, 1964, pp. 1-3; and MSFC FPO, Orbital Payload Potential: Saturn IB Earth Launch Vehicle Using Solid Propellant Motors, Sept. 10, 1964.

66. MSFC P&VE Lab., MPR for May 12 - June 11, 1964, pp. 2-3; and MSFC P&VE Lab., Saturn IB/Minuteman Strap-Ons (IN-P&VE-A-64-16), Sept. 2, 1964, pp. 1 and 32-33.

in-house analysis of the proposed methods for improving the Saturn IB vehicle.[67]

Near the end of this period MSFC evaluated the performance capacity of several Saturn IB and Air Force Titan III-C stage combinations. The Center also began a preliminary analysis of the Titan III-C launch vehicle to evaluate its capabilities for planetary missions. The data from these evaluations will be of value in forthcoming Saturn IB and Titan III-C launch vehicle comparisons.[68]

MSFC continued to evaluate third stage designs for application to the Saturn IB vehicle. In February the Center performed an analysis of the Saturn IB/Titan III Transtage (S-IB + S-IVB + Transtage) configuration. Also in February MSFC completed a performance analysis of the Saturn IB/Centaur (S-IB + S-IVB + Centaur) orbital payload capability. The results of both analyses were documented. Use of the Centaur as the third stage would provide the Saturn IB with an escape mission capability.[69]

Prior to this report period the Jet Propulsion Laboratory and Space Technology Laboratories, Inc., had completed feasibility studies of the Centaur as a Saturn IB third stage. MSFC's Propulsion and Vehicle

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67. MSFC P&VE Lab., MPR for May 12 - June 11, 1964, p. 1, and June 12 - July 11, 1964, p. 1.

68. MSFC P&VE Lab., MPR for June 12 - July 12, 1964, p. 2; and MSFC P&VE Lab., Titan III-C Launch Vehicle Capabilities for Unmanned Interplanetary Missions, TM X-53103, Aug. 14, 1964, pp. 2 and 19.

69. MSFC P&VE Lab., MPR for Jan. 12 - Feb. 11, 1964, p. 2, Feb. 12 - Mar. 11, 1964, p. 3; and Mar. 12 - Apr. 11, 1964, p. 2.

Engineering Laboratory conducted studies during this period determining the cost, time, and effort required to adapt the Centaur with a 154-inch-diameter shroud as the Saturn IB third stage. When the period ended, MSFC had almost completed a second study concerning adaptation to the Saturn IB vehicle of the Centaur with a 260-inch-diameter shroud (suitable for Voyager missions). Documentation for both configurations was in progress.[70]

MSFC completed a variety of mission application studies for the Saturn IB/Centaur launch vehicle. Missions included Apollo reentry tests, launch of spacecraft including two Surveyors and one Lunar Orbiter and one Surveyor and one Lunar Orbiter, a Voyager, Piggyback payloads, and the Micrometeoroid Measurement Capsule. MSFC also considered use of the Saturn IB/Centaur to launch probes to the planets Jupiter, Saturn, and Mercury.[71]

In March 1964 MSFC initiated a study to determine the possibility of improving the Saturn V escape payload capability by putting part of the payload into orbit with a Saturn IB. This would involve an earth orbit rendezvous prior to a second launch to escape earth orbit. This study was still in progress when the report period ended.[72]

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70. MSFC P&VE Lab., MPR for May 12 - June 11, 1964, pp. 3-4 and 77; June 12 - July 11, 1964, pp. 1, and 54-55; and MSFC FPO, Planning Information and Activity Report, July 1964, p. 40.

71. MSFC P&VE Lab., MPR for Jan. 12 - Feb. 11, 1964, pp. 2-3; Feb. 12 - Mar. 11, 1964, pp. 5, 8, and 14; and May 12 - June 11, 1964, p. 4.

72. MSFC P&VE Lab., MPR for Feb. 12 - Mar. 11, 1964, p. 5; and June 12 - July 11, 1964, p. 3.

In April MSFC awarded the Astran Division of Space Craft, Inc., several payload study contracts. In one study Astran will develop data that will permit NASA to evaluate the usefulness of integrating standard payload modules on the Saturn IB launch vehicles with or without incorporation of a Centaur third stage. The contractor will complete parametric preliminary design of a standard module for installation atop the Centaur third stage to accommodate various experimental payloads. Astran will also analyze the requirements and constraints of the experiments with or without the Centaur third stage, and complete cost and schedule estimates as well as a test and operational plan. In the second study entitled, "The Utilization of Saturn IB Instrumentation Unit to Support Space Experiments," the contractor will determine the usefulness of the standard Saturn IB instrument unit in support of scientific payloads.[73]

Funding

MSFC committed a total of $90,961,000 in the Saturn IB Program during the period January 1 - June 30, 1964. This amount included $22,306,000 for the S-IB stage; $25,756,000 for the S-IVB stage; $5,148,000 for H-1 engines; $4,360,000 for J-2 engines; $10,083,000

73. MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964, p. 1; Astran, a Division of Space Craft, Inc., The Study of the Utilization of the Saturn IB Instrumentation Unit to Support Space Experiments, Monthly Report, July 3 to August 3, 1964, p. ii, and Monthly Report December 1964, Contract NAS 8-11296, A Study of the Integration of Standard Payload Modules on the Saturn IB Launch Vehicle, the Introduction.

for the IU; $6,511,000 for GSE; $1,612,000 for integration support; $6,328,000 for vehicle support; $8,543,000 for checkout; and $314,000 for systems reliability.[74]

Summary

Major progress in the Saturn IB program during the January - June 1964 period involved definitization of vehicle specifications and fabrication and assembly of ground test stages and flight stages. CCSD began fabrication of components for the first two S-IB flight stages in March. Final assembly of S-IB-1 began in June. DAC proceeded with fabrication of S-IVB/IB-1 and S-IVB/IB-2 and began fabrication of S-IVB/IB-3 and S-IVB/IB-4.

In Huntsville, MSFC completed specifications for most of the IU systems. The Center completed structural fabrication of a Saturn IB IU mockup in May and completed fabrication of over 50 per cent of the components for the mockup. Following development tests MSFC instructed General Dynamics/Fort Worth, an IU subcontractor, to redesign the structure to permit heavier vehicle loads. During the period the Center fabricated structures for several IU ground test vehicles and then stored the structures pending completion of the structural redesign. Near the end of the period MSFC initiated contract negotiations with IBM as "lead contractor" to integrate all the IU systems of the IU.

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74. Information supplied by Louis E. Snyder, Financial Management Office, MSFC, January 1965.

Major GSE accomplishments included establishment of a development plan for automated checkout of the Saturn vehicle and implementation of a plan to standardize computer programming for space vehicle applications. The latter involved coordination of automated checkout, static firing, and launch control.

The principal Saturn IB study effort at MSFC in this period involved vehicle improvement. Considerations included thrust uprating, increased propellant capacities, engine and/or propellant substitutions, and thrust assist takeoff. Another area of study concerned the application of the Centaur as the Saturn IB third stage.

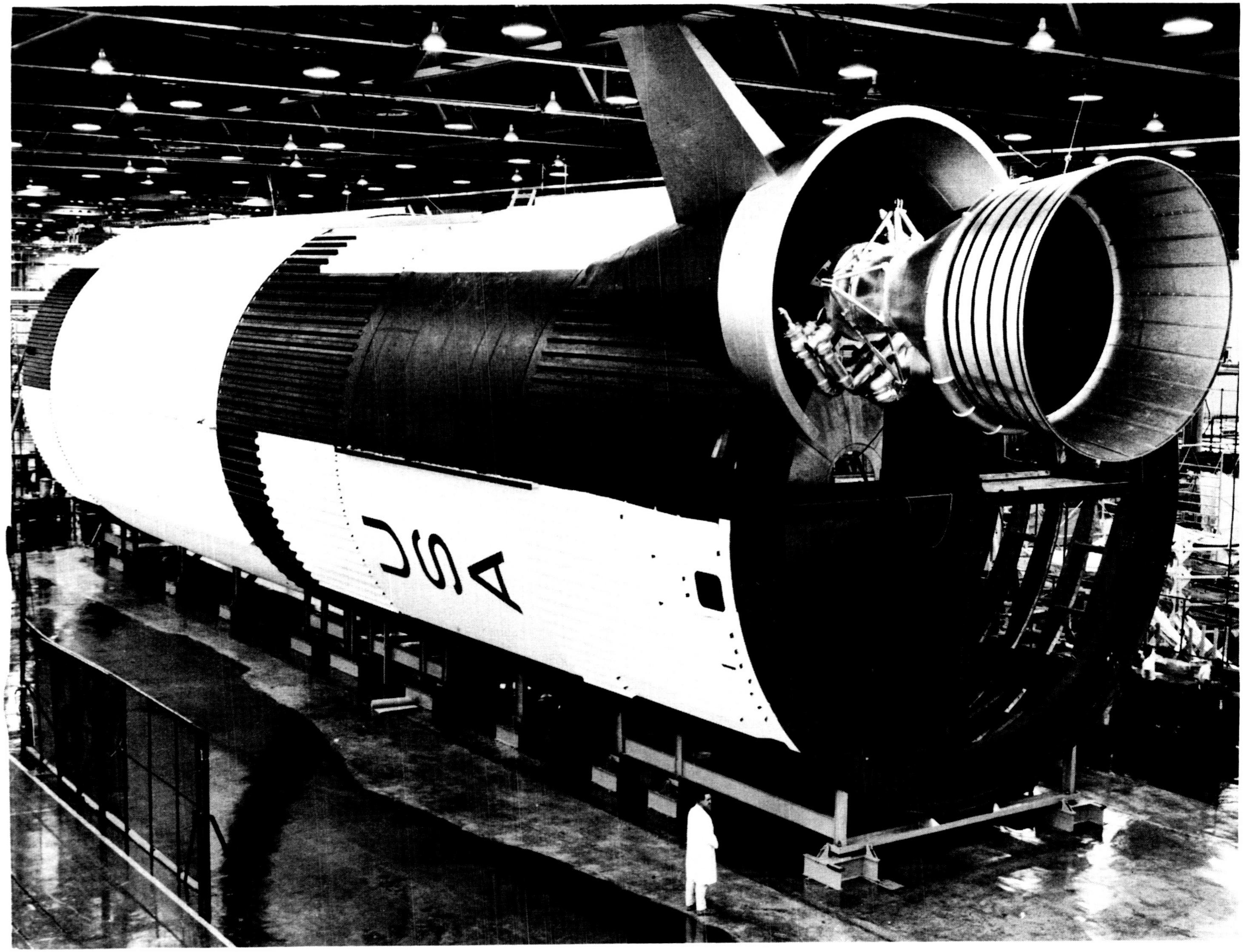
CHAPTER IV: SATURN V

In January 1962 NASA authorized MSFC to design and develop a large launch vehicle, then known as the Saturn C-5 and later redesignated the Saturn V. The Saturn V concept incorporated principles and hardware proven by the Saturn I vehicle.

The major goal of the Saturn V program has become that of providing a launch vehicle for sending a three-man Apollo spacecraft to the vicinity of the moon. A vehicle is needed which can perform the boost portion of the lunar orbital rendezvous (LOR) mission. The vehicle must be able to launch a 95,000-pound Apollo spacecraft through an earth parking orbit into a translunar trajectory. The United States has established a schedule to land a man on the moon before 1970.

A secondary objective of the Saturn V program is the development of a powerful and flexible launch vehicle capable of a variety of missions. The proposed missions include Apollo logistic support, extended lunar exploration from moon encampment, orbiting research laboratories, long-duration space missions including satellite inspection and repair, and planetary probes.

The Saturn V/Apollo space vehicle is about 360 feet high and weighs slightly more than 6 million pounds at liftoff. The launch vehicle consists of three propulsive stages and an instrument unit. The S-IC first stage, or booster, has a propulsion system consisting of five F-1 engines burning liquid oxygen (LOX) and kerosene (RP-1). The S-II second stage is powered by five J-2 engines that burn LOX and liquid



MOCKUP OF SATURN V FIRST STAGE

This S-IC stage mockup is an engineering prototype made by Boeing at Michoud. The full-scale model is shown equipped with one F-1 engine mockup, engine fairing, and tail fin.

hydrogen (LH_2). The S-IVB third stage has one J-2 engine. The instrument unit contains the navigation and guidance equipment necessary to control the flight of the vehicle.[1]

Vehicle Research and Development

Prior to January 1964 the Saturn V program had completed its first major phase (conceptual) and was deep into the second phase (design). Fabrication and assembly of ground test hardware occupied program participants throughout the first six months of 1964, the period covered in this report. Now the program enters a third and crucial phase--that of hardware test, in which drawings and specifications "come to life" through manufacturing, assembly, and test.[2]

S-IC Stage

The S-IC (booster or first) stage of the Saturn V vehicle is 138 feet long and 396 inches (33 feet) in diameter without fins (63 feet with fins). Five F-1 engines provide total sea-level thrust of 7.5 million pounds. Dry weight of the stage is about 300,000 pounds. Propellant capacity is 4.4 million pounds of LOX and RP-1. The stage structure is

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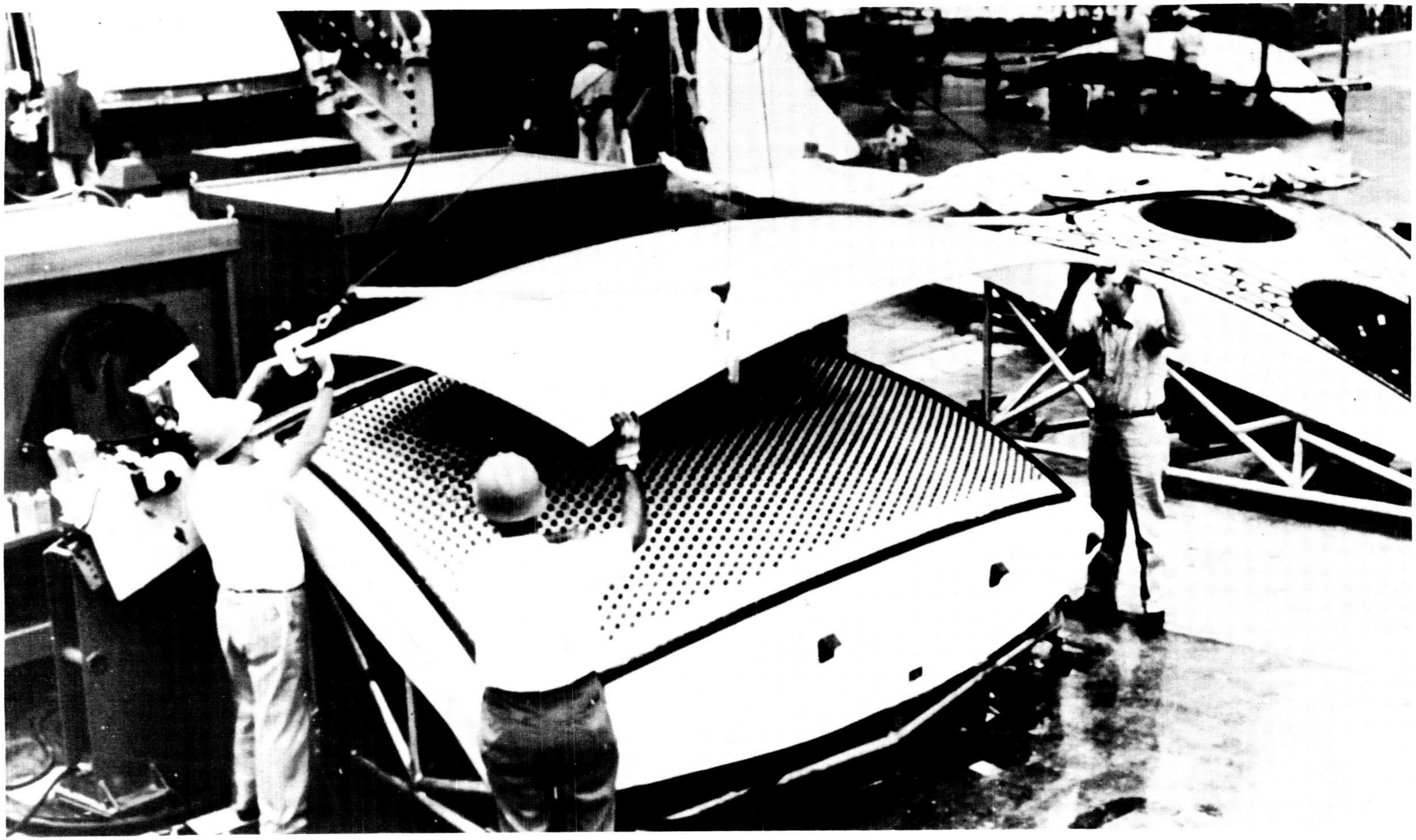
1. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, pp. 1, 4, and 9.

2. MSFC Historical Office, History of the George C. Marshall Space Flight Center, July 1 - December 31, 1963, (MHM-8), pp. 93 and 95, hereafter cited as MSFC Hist. Office, History of MSFC, (MHM-8); and James B. Bramlet, Deputy Director, Operations, Saturn V Program, MSFC, speech, "Saturn V Launch Vehicle Development Program," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964.



SATURN V BOOSTER WORK

Boeing workmen in the Michoud plant fabricate an S-IC gore in a trim fixture. When welded together gores form bulkheads (ends) for the fuel and oxidizer tanks of the 33 foot-diameter S-IC stage.

composed chiefly of aluminum alloys. Principal structural components of the S-IC stage include the following assemblies: forward skirt, LOX tank, intertank section, fuel tank, thrust structure, base heat shield, engine fairings, and fins.[3]

The Boeing Company is under contract to MSFC for the fabrication and manufacture of the S-IC stage. MSFC and Boeing have responsibility for the design, development, test, and procurement of the items needed to build the stage. MSFC is assembling the early ground test and flight stages. Boeing will assemble subsequent S-IC stages at the government's Michoud Operations, New Orleans, Louisiana.[4]

As amended in December 1963, the S-IC prime contract requires Boeing to manufacture and assemble two ground test stages--S-IC-D (dynamic test) and S-IC-F (facilities checkout) as well as eight flight stages, S-IC-3 through S-IC-10. The delivery schedule currently in effect is known as Plan VII. It calls for delivery of the first complete Boeing stage, S-IC-D, to MSFC in August 1965, and the last stage, S-IC-10, to Merritt Island Launch Area (MILA) in June 1968. Boeing also is required to furnish MSFC with certain tooling, components, subassemblies, and manufacturing and test support. MSFC's responsibilities in the S-IC program include assembly of the structural test stage, S-IC-S, the static

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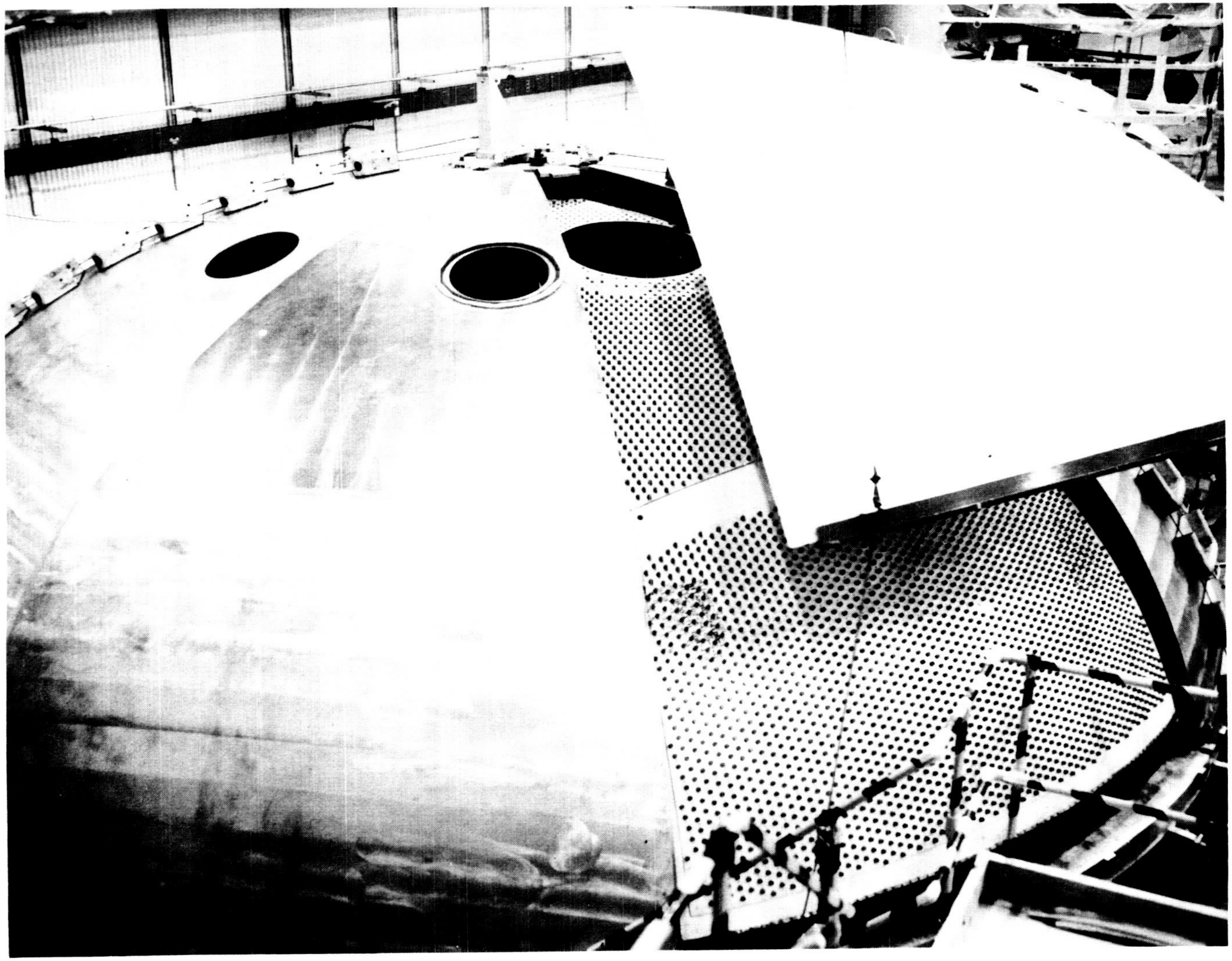
3. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, pp. 9 and 12.

4. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 94.



S-IC TEST BULKHEAD FORMED

This March 1964 picture shows positioning of the final gore segment for welding into the first S-IC test bulkhead on the bulkhead assembly fixture in the Boeing portion of the Michoud plant at New Orleans.

test stage, S-IC-T, and the first two flight stages, S-IC-1 and S-IC-2. The value of the Boeing contract, which was amended 63 times in the January-June 1964 period, increased during the period from $449 million to $504 million.[5]

The S-IC test fuel tank, S-IC-C, is the first structural test component in the Saturn V development program at MSFC. As the current report period opened, technicians were completing assembly of this tank in the MSFC Vertical Assembly Facility. Workmen then cleaned the tank and attached the aft adapter and special half-interstage. On March 6, 1964, they moved the tank to the Load Test Annex of the Propulsion and Vehicle Engineering (P&VE) Laboratory for load proof testing by Boeing.[6]

Assembly of S-IC-T, the static test stage,[7] was several months behind schedule at MSFC when the current period began. Welding problems slowed progress. Other causes of delay on S-IC-T included late releases

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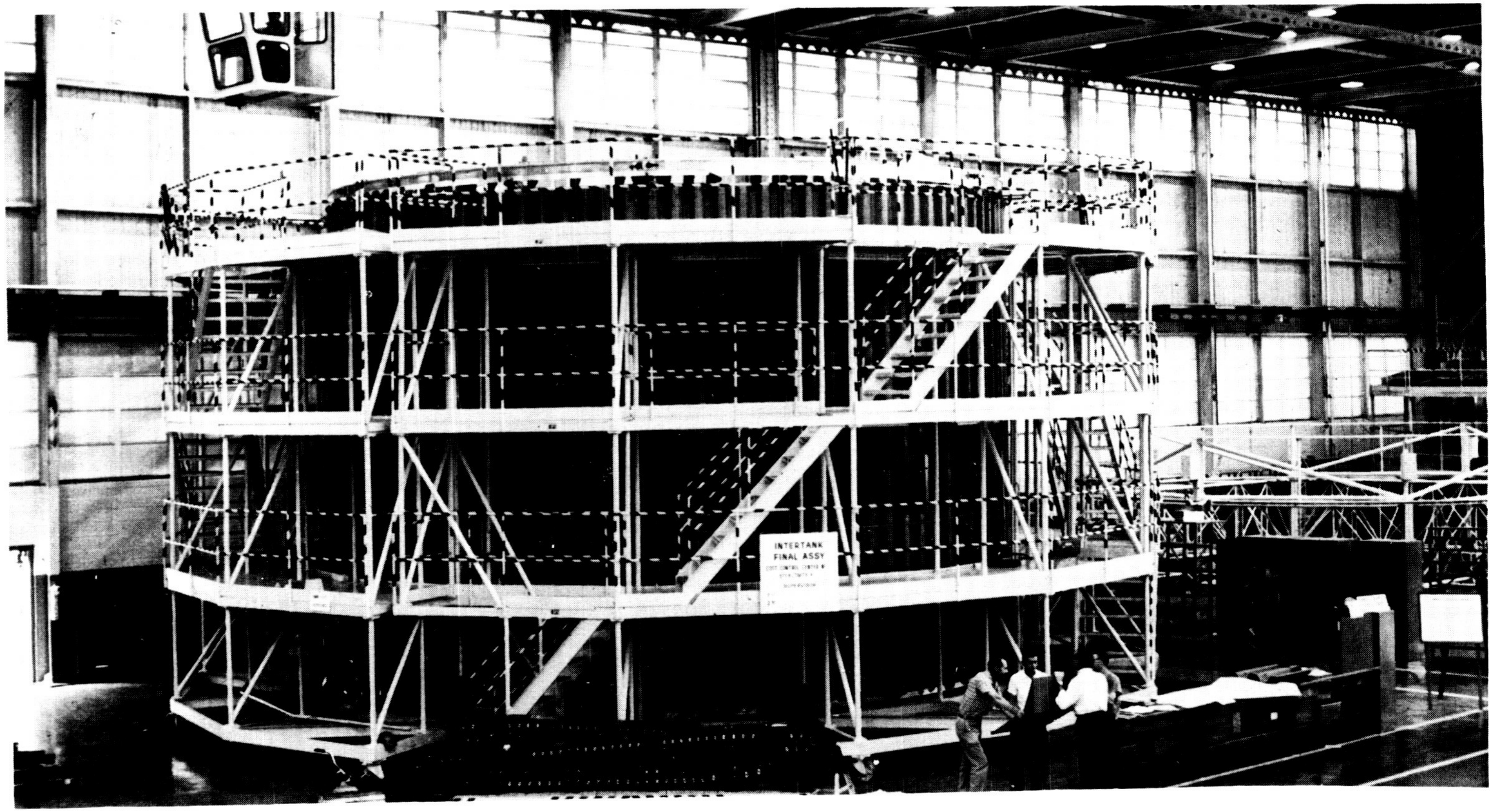
5. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 97 and 101; and MSFC Michoud Operations, Historical Report, Michoud Operations, January 1, 1964 - June 30, 1964, pp. 22-23, cited hereafter as MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964. Latter report is in Volume II, Supporting Documents.

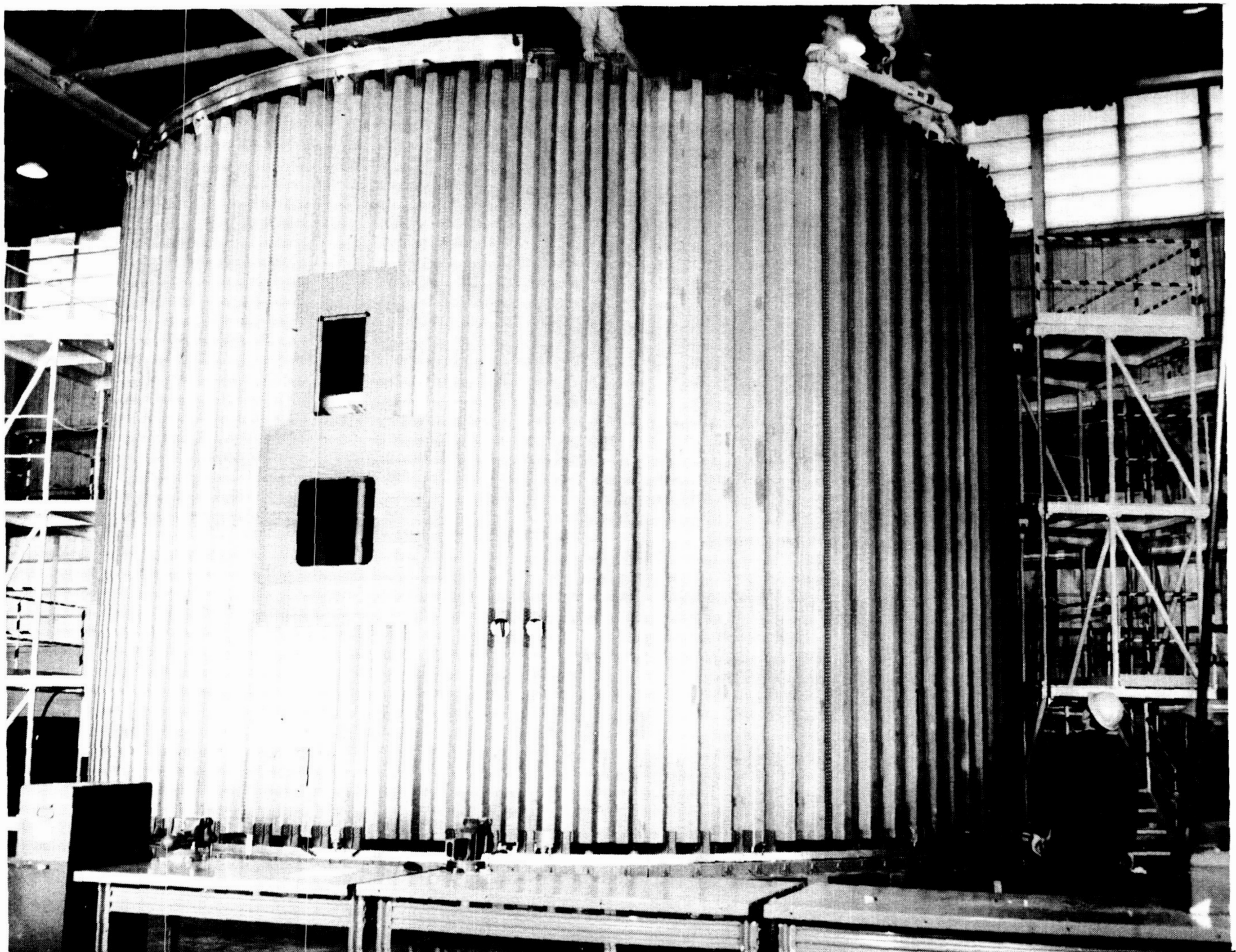
6. MSFC Industrial Operations, Saturn Monthly Progress Report, December 16, 1963 - January 16, 1964, p. 7, hereafter cited as MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964; and Jan. 16 - Feb. 16, 1964, p. 8; and Feb. 16 - March 16, 1964, p. 7. Also see MSFC Manufacturing Engineering (ME) Laboratory, Saturn Monthly Progress Report, December 12, 1963 - January 10, 1964, p. 2, cited hereafter as MSFC ME Lab., Saturn Monthly Progress Report, Dec. 12, 1963 - Jan. 10, 1964; and Saturn Monthly Progress Report, Feb. 12 - March 11, 1964, p. 2.

7. After completion of static firing tests, S-IC-T will be modified and used for all-systems tests. See MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 61.



INTERTANK ASSEMBLY

The intertank assembly for an S-IC stage is shown in production at Michoud Operations. The intertank joins the fuel tank to the LOX tank of the 138-foot stage.



S-IC-T INTERTANK READY

The intertank section for S-IC-T, the static test stage to be fired at MSFC, is shown at Michoud following assembly by Boeing. At this point (February 1964) the section is ready for disassembly and shipment to Huntsville.

of documentation and slow delivery of hardware by Boeing. By mid-March workmen had installed baffles in the fuel tank's upper half and placed the fuel exclusion riser[8] in the tank's lower section. Assembly of the LOX tank also began at the Center in March. At Michoud Boeing proceeded with manufacture of the stage's forward skirt and intertank assemblies, as well as other hardware. A breakdown of automatic welding equipment in the MSFC Vertical Assembly Facility, meanwhile, delayed completion of the fuel tank until late April. The stage's thrust structure moved into the assembly stand on June 18. By the end of the period the fuel tank had completed hydrostatic, calibration, and leak tests; some internal components had been installed in the tank; and the completed LOX tank was in the vertical stand awaiting functional pressure tests. Structural assembly of S-IC-T was several weeks behind schedule at the end of the period, and automatic welding equipment in the assembly facility was still causing delay.[9]

The Manufacturing Engineering (ME) Laboratory began welding bulkheads for the S-IC-S (structural test) stage midway in this report period. Boeing's difficulties in manufacturing acceptable fuel tank fittings and

8. The fuel exclusion riser is a polyurethane foam structure placed in the bottom of the fuel tank to reduce residuals.

9. MSFC Hist. Office, History of MSFC, (MHM-8), p. 103; MSFC ME Lab., Saturn Monthly Progress Report, April 12 - May 11, 1964, p. 4; MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, p. 7; Jan. 16 - Feb. 16, 1964, p. 8; and Feb. 16 - Mar. 16, 1964, p. 7; and MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1 - June 30, 1964, p. 2, cited hereafter as Saturn V QPR, April 1 - June 30, 1964.

gore segments delayed assembly of this stage. The fuel tank for S-IC-S was 10 weeks behind schedule at the end of the period, due to weld defects and to defective and late parts from Boeing.[10]

S-IC-1, the booster for the first Saturn V flight vehicle (SA-501), began to take form at the Center late in this period. Workmen had welded together part of the fuel tank's two bulkheads and were awaiting delivery of fuel suction fittings at the end of the period.[11]

Early in this period ME Laboratory technicians completed the Saturn mockups and installed the necessary systems. Mockups at MSFC include the S-IC tail section, intertank, and forward area; the S-II forward area and interstage; the S-IVB interstage; and the instrument unit.

At Michoud Boeing workmen assembled a full-size mockup of the S-IC stage and installed one F-1 engine mockup on the structure. Boeing started fabrication of S-IC-D in April 1964.[12]

S-II Stage

The S-II (second) stage of the Saturn V is 81.5 feet long and 396 inches (33 feet) in diameter. Its propulsive power is provided by five J-2 engines which develop a total thrust of 1 million pounds at altitude.

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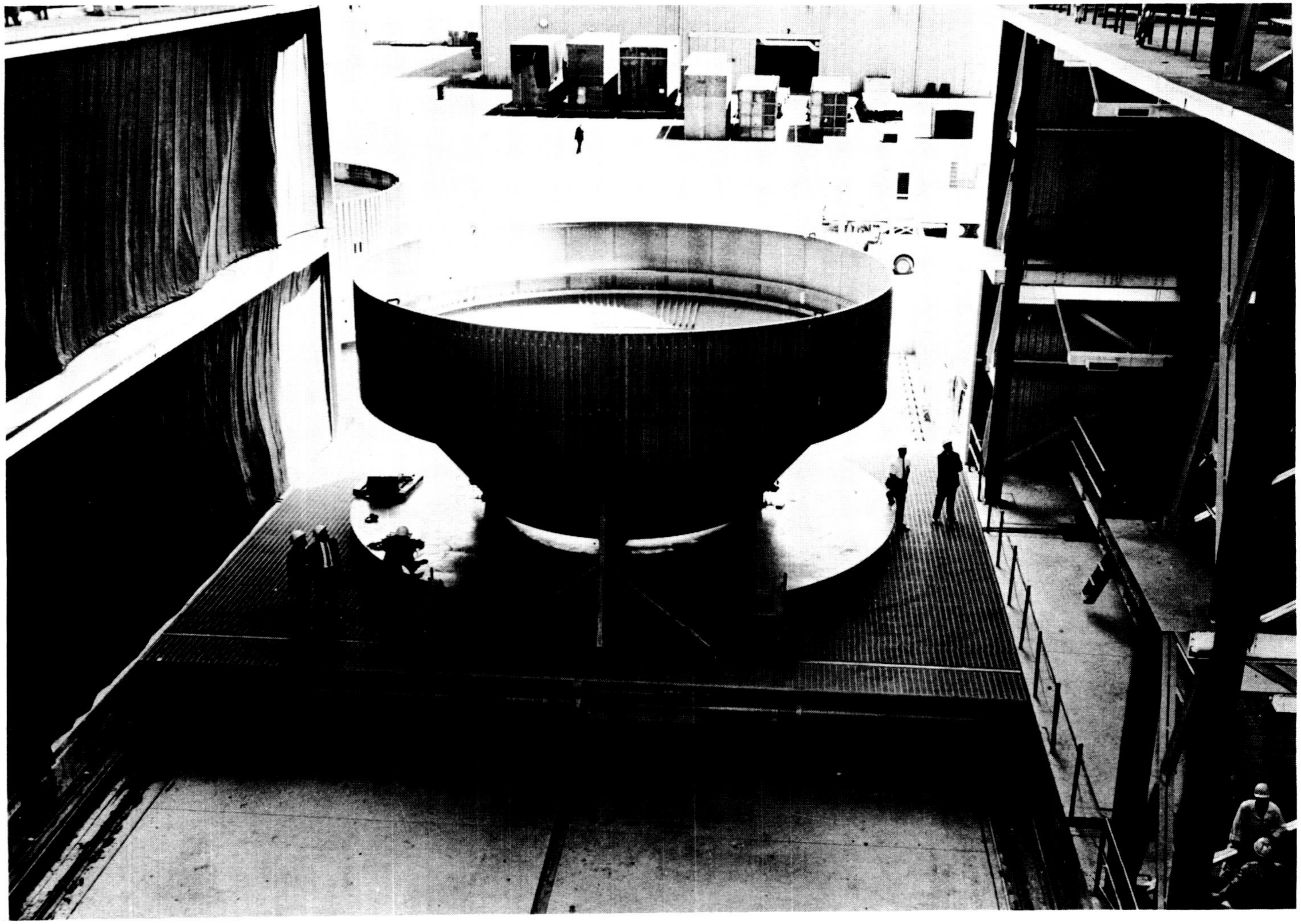
10. MSFC ME Lab., Saturn Monthly Progress Report, March 12 - April 11, 1964, p. 5, and April 12 - May 11, 1964, pp. 5-6; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, pp. 2-3.

11. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 3.

12. Mockups, or engineering prototypes, aid in the manufacture of test and flight vehicles. They are used for engineering studies and placement of components. See MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 9; MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 3; MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 2; and O. E. Moon, Propulsion and Vehicle Engineering (P&VE) Laboratory, MSFC, interviewed Apr. 9, 1965.



S-II THRUST STRUCTURE

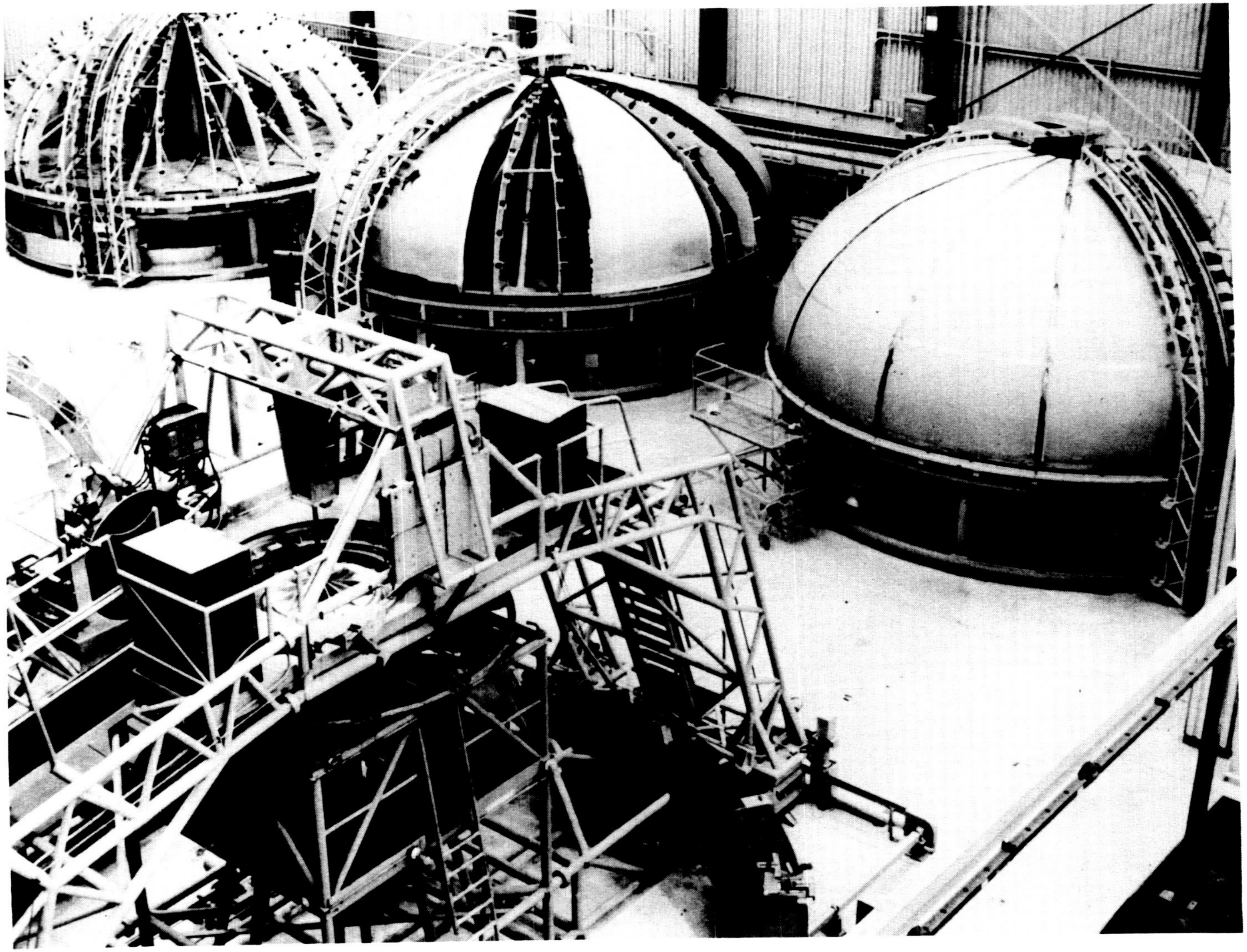
The thrust structure for the S-II structural test stage (S-II-S) is shown in S&ID manufacturing facilities at Seal Beach, California.

The dry weight of the stage is about 80,000 pounds, and its propellant capacity is 930,000 pounds of LOX and LH_2. The structural system consists of the aft interstage, aft skirt, thrust structure, LOX tank, LH_2 tank, forward skirt, and systems tunnel.[13]

The S-II stage prime contractor is the Space and Information Systems Division (S&ID) of North American Aviation, Inc. (NAA). S&ID is responsible to MSFC for research, development, manufacture, and assembly of the S-II stage.[14] S&ID continued during this period the fabrication and assembly of ground test stages. The S-II stage definitive contract, in effect since October 1962, underwent a major change during the current report period. In April NASA changed the contract and increased its value by $12.3 million. Included in the modification were provisions for vertical checkout of the stage at the Seal Beach assembly site and at MSFC's Mississippi Test Operations (MTO), more extensive static firing instrumentation at MTO, and new testing equipment at S&ID locations. Following the modification the S-II prime contract value was $337.3 million.[15]

Assembly of the battleship stage in the Santa Susana Coca I test stand proceeded. Early in this period the battleship firing schedule slipped from June to November 1964 because of delays in activation of the test stand. On January 18 S&ID successfully completed LOX tank

13. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, pp. 23 and 25; and William Marshall, P&VE Lab., MSFC, interviewed Apr. 9, 1965.
14. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 94.
15. MSFC Public Affairs Office (PAO), Press Release, April 16, 1964.



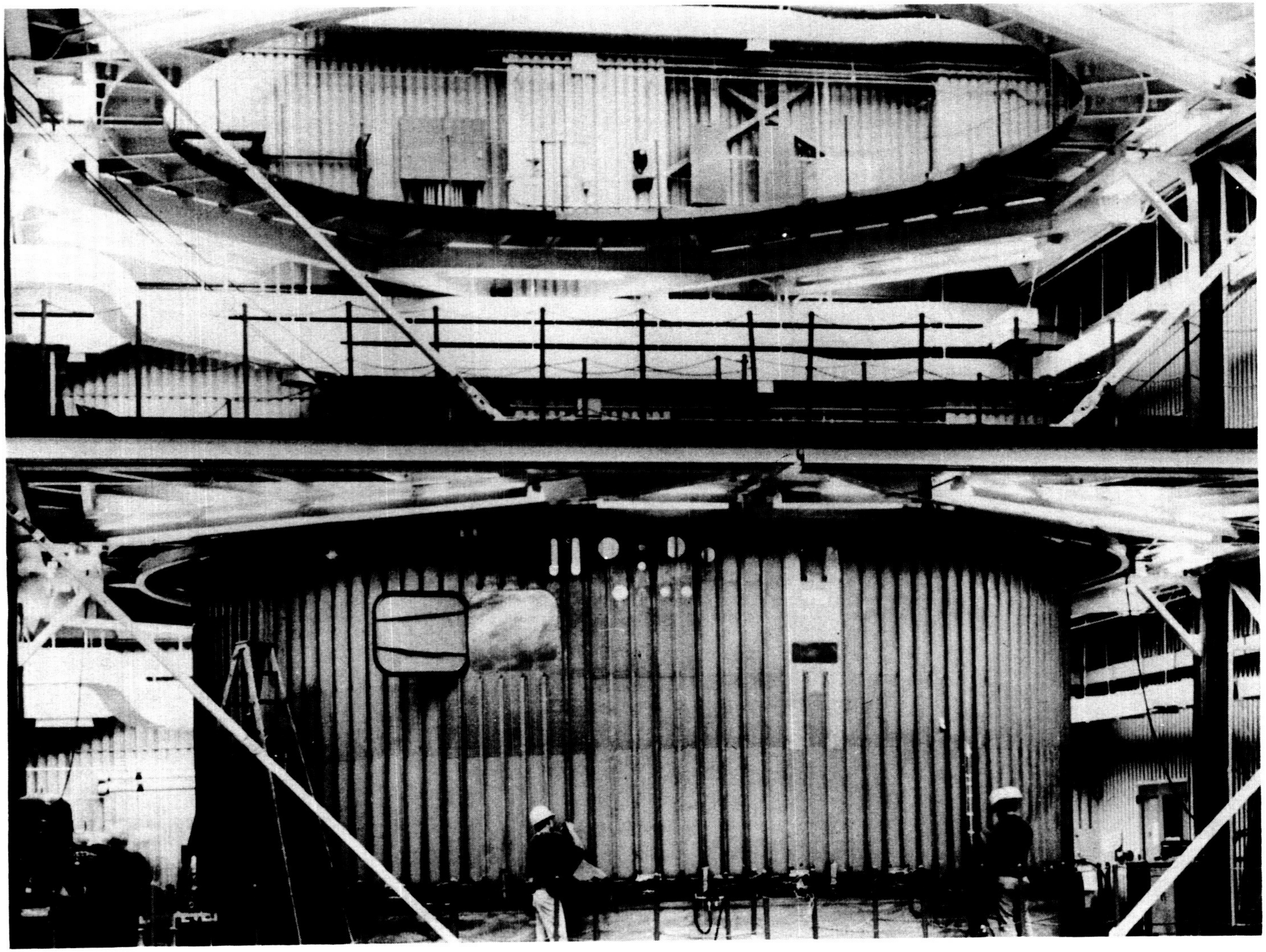
S-II STAGE BULKHEADS

Bulkheads in various stages of completion are seen in the S-II fabrication and assembly facilities at Seal Beach, California.

chill tests on the stage. Late in February workmen installed the thrust structure and aft skirt assembly. During March S&ID aligned the structure and skirt with the stage's propellant tanks in the stand. Final mating ended midway in the report period. S&ID also delivered to Santa Susana 19 production wiring harnesses for the battleship stage. Throughout the remainder of the period fabrication of battleship systems progressed. In May technicians at Seal Beach completed fabrication and subassembly of the pressurization system, thermal control system, and LOX bleed system for the stage. Activation of the battleship began on June 10 but was delayed by slow deliveries of special development devices (SDD) and ground support equipment (GSE).[16]

At Seal Beach in January S&ID completed the first all-welded S-II bulkhead, the aft common bulkhead for the structural static test stage (S-II-S). The stage contractor also received the first complete set of LH_2 tank cylinder panels and forward bulkhead gores. Assembly of the first forward LH_2 bulkhead ended in February. S&ID satisfactorily completed hydrostatic testing of the stage's aft common bulkhead. Assembly proceeded on the common bulkhead and other major components. In May S&ID completed circumferential welding of the first LH_2 cylinder and bulkhead. Mating of the stage's thrust structure and aft skirt assembly was

16. MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, pp. 8-9; Jan. 16 - Feb. 16, 1964, p. 9; Feb. 16 - March 16, 1964, p. 8; and MSFC Saturn V Program Office, Saturn V QPR, April - June 1964, p. 4.



S-II HARDWARE IS FABRICATED

Workmen at an S&ID plant fabricate an S-II stage thrust structure.

completed during June in the Vertical Assembly Building at Seal Beach. S&ID obtained joint occupancy of the static test tower to install instrumentation before this period ended.[17]

During the latter half of the report period S&ID was fabricating portions of the S-II all-systems stage (S-II-T). In manufacture at the end of the period were the thrust structure and interstage for S-II-T.

S&ID started major subassembly work on the facilities checkout stage (S-II-F) late in June.[18]

During February and March S&ID installed the last of the five J-2 simulator engines in the S-II stage electro-mechanical mockup (EMM) at Downey. Mockup GSE manufacture continued. On March 11-12 MSFC conducted a design engineering inspection of the configuration function, status, and operation of the EMM. Test operations began on April 29 with application of power to the flight instrumentation checkout console. Late GSE continued to delay operation of the EMM. Stage systems were generally behind schedule at the period's end.[19]

S-IVB Stage

The S-IVB (third) stage of the Saturn V vehicle is 58.5 feet long and 260 inches (21.6 feet) in diameter. It is powered by a single J-2

17. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 9; Feb. 16 - Mar. 16, 1964, p. 8; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, pp. 4-5.

18. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 5; and Willian Marshall, P&VE Lab., MSFC, interviewed Apr. 9, 1965.

19. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 8; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 4.

S-II ELECTRO-MECHANICAL MOCKUP

The buildup of the S-II stage electro-mechanical mockup at S&ID's Downey, California, plant is shown in this May 1964 photo.

engine which has a thrust of 200,000 pounds at altitude. Dry weight of the stage is about 25,000 pounds, and its propellant capacity is 230,000 pounds of LOX and LH_2. The S-IVB is a self-supporting aluminum alloy structure designed to allow launch preparation with or without payload and with propellant tanks full or empty, pressurized or unpressurized. The basic structure consists of the forward skirt, propellant tank assembly, thrust structure, aft skirt, and aft interstage.[20]

The Missile and Space Systems Division of Douglas Aircraft Company (DAC) is the prime contractor for the design, development, fabrication, and test of the S-IVB stage. The definitive hardware contract, awarded August 7, 1962, authorized DAC to provide five ground test stages and six flight stages for the Saturn V program.[21] On May 25, 1964, NASA announced it would negotiate with DAC for an S-IVB stage mockup to be used with the Saturn V launch vehicle simulator at MSFC in the study of prelaunch, checkout, launch, and flight of the third stage. This mockup was expected to cost about $5 million.[22]

Program progress during the current report period was significant. An extensive weight reduction and performance improvement effort resulted in an increase of approximately 3,500 pounds of payload capability in the

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20. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 34.

21. Since the S-IVB, slightly modified, also serves as the second stage of the Saturn IB vehicle, the R&D program for both versions of the stage proceeds on a parallel basis and the ground test stages for both vehicle applications are basically the same. Development progress of the S-IVB explicitly for the Saturn IB vehicle is covered in the Saturn IB chapter of this report.

22. NASA, News Release No. 64-123.

Saturn V version of the stage. A program to improve the internal insulation accounted for 517 pounds of this weight saving, plus improvement of structural integrity and thermal performance. On April 21, 1964, MSFC issued a contract change order authorizing DAC to redesign the Saturn V/S-IVB venting system and to reorient the configuration of the auxiliary propulsion system (APS) module. This significant program modification changed the LH_2 venting system from a pulse mode to a continuous mode; eliminated the 1750-pound-thrust ullage engine and the 150-pound-thrust ullage engine from the APS module; substituted the Gemini Orbital and Maneuver System (OAMS) engine, derated to 72 pounds thrust; optimized the APS propellant tank capacity to meet mission requirements; incorporated two Thiokol TX-280 solid ullage motors for S-IVB/S-II stage separation; and changed the APS fuel requirements to permit use of hypergolic propellant (monomethylhydrazine). The change also directed DAC to evaluate two types of expulsion tankage--soft bladder and metal bellows--for Saturn V/S-IVB application.

Also during this period DAC completed and certified all major S-IVB tooling. Design verification and qualification testing began, and preparation for battleship hot firing and APS testing began also. Effort intensified to improve S-IVB welding techniques. Testing effort concentrated on developmental testing to confirm design concepts and qualification testing of components prior to start of the battleship test program. DAC manufactured prototype assemblies of a propellant utilization (PU) system based on that of the S-IV stage. Testing of this system proved it to be satisfactory. (MSFC had selected DAC to design the PU system for the S-II stage as well.) Meanwhile, DAC made progress in assembly of S-IVB ground test stages.[23]

The S-IVB battleship test stage, installed in Beta I test stand at SACTO in December 1963, completed water calibration early in the current period. DAC completed and released drawings for the battleship program during January. In February MSFC directed DAC to increase the battleship LH_2 tank pressure to 39 pounds per square inch (psi) in order to meet J-2 engine start requirements. Safety tests of helium spheres ended successfully at SACTO in March. Battleship test operations started in April with integrated checkout of the electrical systems and pneumatic consoles. Also in April Rocketdyne delivered to SACTO the J-2 engine scheduled for battleship testing. DAC completed cold flow of the Beta I LOX valve control complex and also completed the pneumatic consoles as well as inspection and checkout of the battleship J-2 engine. In June workmen installed this engine on the stage. DAC completed the battleship static firing test plan and forwarded it to MSFC. At the end of the period the schedule called for engine chill tests to begin in July, with cold and hot firings beginning in August 1964.[24]

During January the Huntington Beach assembly tower was used for the first time for assembly of the structural and hydrostatic test (S-IVB-S)

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23. Douglas Aircraft Company, Missiles and Space Systems Division, Saturn S-IVB Annual Technical Progress Report, July 1963 - June 1964, pp. 2-3, 30, 36, and 95, hereafter cited as DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964; and Change Order No. 210, Contract NAS7-101, Douglas Aircraft Company, Inc., dated Apr. 21, 1964.

24. MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, p. 6; DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, pp. 9-14; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 6.

stage's LOX tank and cylindrical section. Welding of the forward dome to this assembly in February completed the basic stage structure. The stage was instrumented for hydrostatic testing in March. Installation of instrumentation for structural testing ended in May. At the end of this period the stage was in the hydrostatic test tower, and technicians were preparing to connect instrumentation to the test system.[25]

During January DAC completed the dynamic test stage (S-IVB-D) LOX tank assembly and delivered it to the Huntington Beach assembly tower. In February the stage contractor completed the cylindrical tank section. The LOX tank section and the cylindrical section were welded together during March, and the forward LH_2 dome was welded in place, completing structural assembly of the tankage. DAC also assembled the stage's thrust structure during March. In April workmen moved the stage into the hydrostatic test tower. During testing the LOX tank forward dome wrinkled and had to be repaired and cleaned. Successful proof testing of the stage ended in May. At the end of the period preparation was underway for installation of insulation.[26]

At the start of this report period DAC was about half finished with fitting and bonding of the S-IVB all-systems stage's common bulkhead. This procedure ended in February, and technicians were ready to join the common bulkhead and the aft dome. By the end of March the LOX tank

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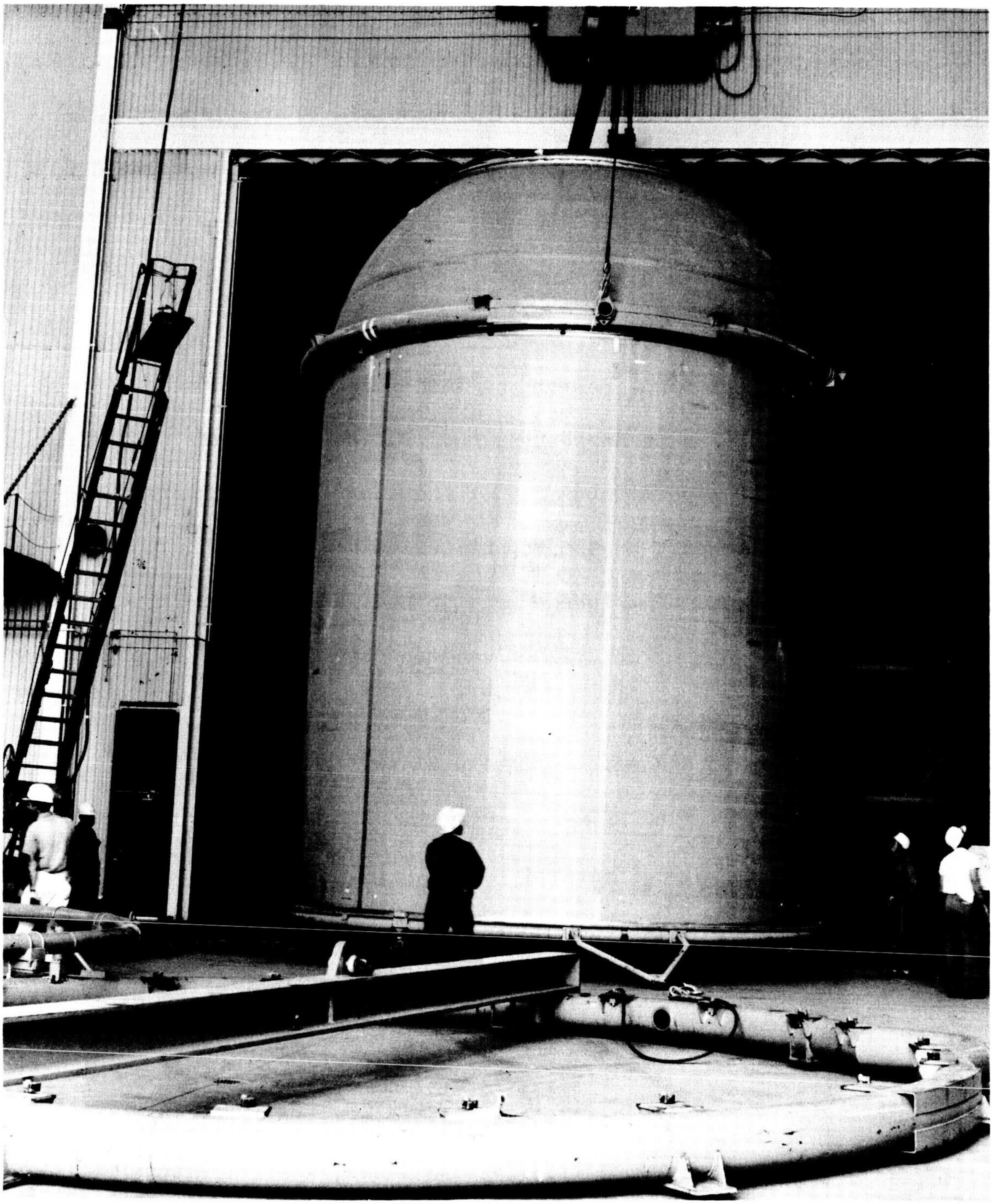
25. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 118; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 5.

26. MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, p. 6; and DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 146.



S-IVB STAGE IN MANUFACTURE

Tankage of the S-IVB dynamic test stage (S-IVB-D) is shown in DAC's Huntington Beach assembly tower during March 1964.

assembly was complete. Welding of the cylindrical section ended in March. In April at Huntington Beach DAC joined the tank sections to the forward dome assembly and completed manufacture of the forward skirt panels. Hydrostatic proof testing of the tank structure occurred in May. Late in this period DAC joined the thrust structure to the tankage and moved the stage to the insulation chamber for start of insulation installation.[27]

Fabrication of hardware for the facilities checkout stage (S-IVB-F) began at Santa Monica in February 1964. DAC completed all cylindrical tank panels during April. Buildup of the tank assemblies proceeded through the latter part of the report period. By the end of June the aft LOX dome and common bulkhead were joined, the forward LH_2 dome was ready and waiting, and the cylindrical tank sections were in process of being joined.[28]

DAC manufactured a set of structural test assemblies for the S-IVB test program during this period. In March and April the contractor completed the special cylindrical tank section and forward skirt assembly. DAC completed the aft skirt assembly in May. The aft interstage and assembly of the thrust structure were nearing completion when this report period ended.[29]

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27. MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, p. 6; DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 147; and MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 6.

28. MSFC Industrial Operations, Saturn MPR, Feb. 16 - March 16, 1964, p. 6; and DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, pp. 146-147.

29. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 148.

Meanwhile, work continued at MSFC on an S-IVB battleship tank for use as a backup to the DAC battleship and for developmental tests of the J-2 engine at the Center. Chicago Bridge and Iron Company was performing this work under a subcontract to DAC. In January DAC shipped to MSFC major items for the MSFC battleship tank, and in February the Center directed DAC to provide propulsion system components for the tank.[30]

Instrument Unit

The vehicle instrument unit (IU) is 260 inches (21.6 feet) in diameter and three feet high. Its predicted weight is 3,500 pounds. The primary structure is a cylindrical assembly composed of three honeycomb panels with equipment mountings and supports. The IU is located between the S-IVB stage and the payload. It contains instruments and systems for navigation, guidance, control, range safety, telemetry, and tracking. MSFC has developed the IU. International Business Machines Corporation (IBM) will assume responsibility for design, test, procurement, and manufacture of the Saturn IB and Saturn V IU, which are almost identical. Since the IU operates in a vacuum, it has a unique thermal conditioning system for cooling the electronic components in both the IU and the S-IVB. IBM and Bendix Corporation provide the major electronic components for the IU. IBM is developing the launch vehicle digital computer and data adapter; Bendix is responsible for the ST-124M stabilized platform and associated equipment.[31]

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30. MSFC Hist. Office, History of MSFC, (MHM-8), p. 76; and DAC, Saturn S-IVB Annual TPR, July 1963 - June 1963, pp. 9-10.

31. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, pp. 43, 45, and 96; and MSFC Hist. Office, History of MSFC, (MHM-8), pp. 117-118.

In January NASA announced it would negotiate with Bendix to provide 29 ST-124M stabilized platform systems and related equipment and services. These systems would be for the Saturn V as well as Saturn IB vehicle. On April 29 MSFC finalized a contract covering the first three of the 29 platform systems--one for Saturn V and two for Saturn IB. On May 26 MSFC received the proposal from Bendix for the 26 other platform systems.[32] Contract negotiations were scheduled for the next report period.

On February 11 MSFC and IBM began contract negotiations for Saturn V prototype and breadboard guidance computers and data adapters. On March 4 IBM submitted its cost proposals for these items.[33] Following MSFC evaluation the contract was expected to be awarded in July 1964.

MSFC received from IBM on January 20 the program plan outlining detailed plans for procurement, integration, and checkout of the Saturn V instrument unit. Late in March the Center awarded this contract to IBM's Federal Systems Division. The $5.5 million contract involved only services, no hardware.[34]

In April 1964 NASA announced selection of IBM as "lead contractor" for development of IU's for the Saturn IB and Saturn V vehicles. As lead contractor IBM will assume full mission responsibility, commencing with the fifth Saturn IB vehicle, for integration of all IU systems, with

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32. MSFC PAO, Press Release, Jan. 22, 1964; and John Harlow, Saturn I/IB Program Office, MSFC, interviewed Apr. 8, 1965.

33. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 10; and Feb. 16 - Mar. 16, 1964, p. 10.

34. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 10; and MSFC PAO, Press Release, Mar. 31, 1964.

MSFC initially supplying components and equipment. MSFC issued the request for quotation to IBM on May 1. IBM submitted its contract proposal on June 1,[35] and MSFC was evaluating the proposal when the period ended.

The IU environmental system utilizes an arrangement of 17 "cold plates" and ducts through which a liquid (methanol and water) is circulated to maintain the desired range of temperature during ground operations and flight. "Black boxes" containing the vehicle's instrumentation equipment are mounted on these cold plates around the periphery of the structure. On April 17 MSFC negotiated with Avco Corporation a $133,000 contract covering production of 62 cold plates for the IU.[36]

Some IU structural hardware, received at MSFC in April, was under test at the end of the period. A prototype heat exchanger for the environmental system also was under qualification testing late in June. Near the end of this period MSFC instructed General Dynamics/Fort Worth, an IU subcontractor, to redesign the IU structure to permit heavier vehicle loads. On July 11 IBM technicians at MSFC completed assembly of the structure for S-IU-200/500D (for the dynamic test vehicle).

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35. MSFC PAO, Press Release, April 20, 1964; and MSFC Saturn V Program Office, <u>Saturn V QPR, April 1 - June 30, 1964</u>, p. 7.

36. James B. Bramlet, Deputy Director, Operations, Saturn V Program, MSFC, speech, "Saturn V Launch Vehicle Development Program," at first annual meeting of American Institute of Aeronautics and Astronautics, Washington, D. C., June 29 - July 1, 1964; and MSFC Saturn V Program Office, <u>Saturn V QPR, April 1 - June 30, 1964</u>, p. 7.

IBM also began work in June on the S-IU-500V structure (to be used for vibration testing). The Center directed that IU's built to the old specifications must be modified and used in the ground test program, and that all future units would be of the new stronger design.[37]

Ground Support Equipment

Saturn V ground support equipment (GSE) includes equipment used for test and checkout, handling and transportation, servicing, and auxiliary equipment for all stages and the instrument unit. This GSE is used at all plants where Saturn V stages are made and at each static test site, as well as at MSFC and Kennedy Space Center (KSC). GSE associated primarily with launch support is the responsibility of KSC and is not included in this report.[38]

The heart of the automated test and checkout complex for the Saturn V vehicle is the RCA 110A computer system. In 1963 after selecting Radio Corporation of America (RCA) to develop and produce the 110A ground computer NASA placed an order for seven of these systems. MSFC announced in April 1964 that it would negotiate with RCA for purchase of 19 additional 110A computer systems for use in the Saturn V and Saturn IB programs. RCA submitted a proposal to the Center the same month.

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37. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16, 1964 - September 30, 1964, pp. 25 and 33.

38. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 56.

Contract negotiations began on June 2 and ended on June 11. Award of the contract was pending at the end of the period.[39]

In February MSFC completed assembly of the first S-IC transporter. Center workmen also completed modification of the first M-26 prime mover that provides power for the transporter. During the latter part of the period MSFC conducted transporter road tests with the S-IC simulator aboard. All systems performed satisfactorily. Fruehauf Corporation continued fabrication of the second and third S-IC stage transporters.[40]

By the middle of this report period American Machine and Foundry Company (AMF), contractor for the S-II stage transporter, had almost completed transporter designs. The first of the S-II transporters was scheduled for delivery to Seal Beach at the end of the period.[41]

Because of their great size the Saturn V stages travel by water for long distance transportation. Early in 1964, following lengthy negotiations, the Secretary of the Navy formally transferred to NASA five YFNB barges. One of these vessels will be modified and used to transport S-IC stages between MSFC, Michoud, MTO, and KSC. The hull of the barge is similar to that of the Saturn I barge Promise. During this period MSFC was drawing plans for converting this YFNB into an S-IC barge. Award of the modification contract was scheduled to be delayed until

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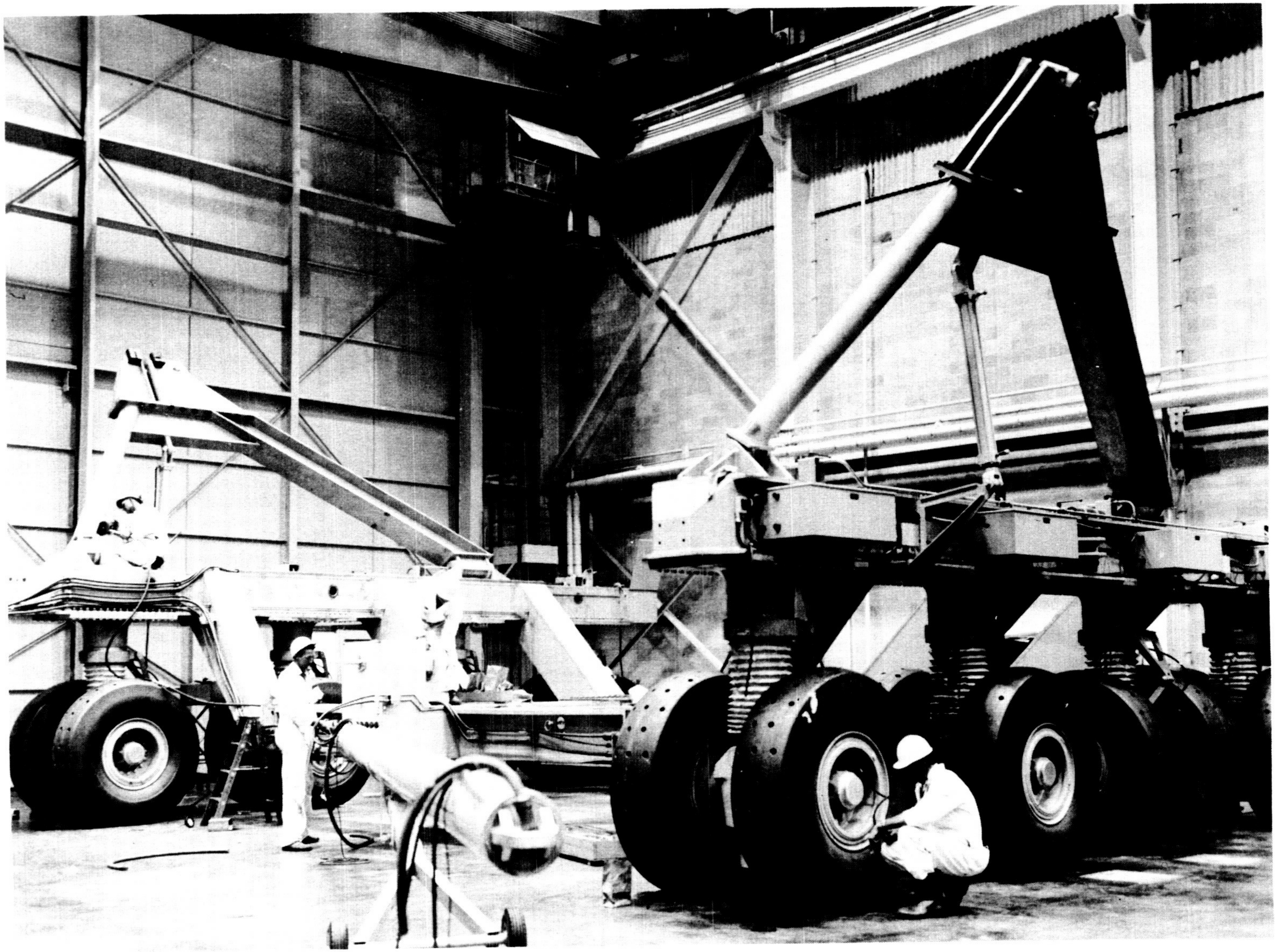
39. MSFC PAO, Press Release, April 14, 1964; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25.

40. MSFC Industrial Operations, Saturn MPR, Feb. 16 - March 15, 1964, p. 10; and Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 8.

41. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 10.



S-IC TRANSPORTER SEGMENTS

Portions of the first transporter for the S-IC stage are shown in an MSFC laboratory during assembly and checkout.

early 1965. NASA earmarked one of the five YFNB's (YFNB 20) for use in moving S-II stages (as well as S-IV stages of the Saturn I vehicle) between contractor sites in California. After a January 1964 bidders' conference for modification of this barge, NASA in February rejected all bids as too high and revised specifications to reduce the scope of work. NASA readvertised for bids in May. Contract action was pending at the end of June. The remaining three YFNB's were scheduled for use as interplant shuttle barges for movement of rocket stages at Michoud-MTO and in the Cape Kennedy vicinity. Design was in progress for these three open-deck shuttle barges when the report period ended.[42]

A Navy LSD (landing ship, dock), the USNS Point Barrow, secured by NASA in 1963, will be used to transport S-II and S-IVB stages from West Coast manufacturing and test sites to Michoud, MTO, and Cape Kennedy. The Military Sea Transport Service (MSTS), which will modify and operate the self-propelled Point Barrow for NASA, started the design for modifications in January 1964. At a design review in March with naval architects NASA approved the proposal and instructed MSTS to proceed with the plans and specifications. Most of the required regulatory agencies had approved the plans by the end of the current period.[43]

Air transport of F-1 engines and other major Saturn V and Apollo hardware is in the special aircraft Pregnant Guppy, leased by NASA from

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42. MSFC Test Lab., Test Laboratory Historical Report, January 1, 1964 - June 30, 1964, pp. 27-29, cited hereafter as MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964; and MSFC Hist. Office, History of MSFC, (MHM-8), p. 173.

43. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 27-28.

Aero Spacelines, Inc. Details concerning this plane, used also for S-IV stage shipment, is contained in the Saturn I chapter of this history. Pallets for movement of Apollo service modules and related general cargo aboard the Pregnant Guppy were under design and construction during this period.[44]

DAC installed S-IVB stage GSE at the Huntington Beach assembly plant during this period. This equipment was undergoing test at the end of the period. Fabrication and delivery of S-IVB battleship GSE to SACTO continued.[45]

Among major GSE accomplishments at MSFC during the report period were establishment of the automation plan, establishment of automation techniques, design of electrical support equipment (ESE) for the S-IC-T stage, and establishment and implementation of the plan for the Saturn V ESE design.[46]

Test Laboratory performed various GSE tests, some of them for KSC, involving such items as the Launch Complex 39 fuel transfer system and a simulated Saturn V holddown arm.[47]

Engine Research and Development

The principal propulsion systems in the Saturn V program consist of the F-1 engine for the first stage and the J-2 engine for the second and

44. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 29-30.
45. DAC, Saturn S-IVB Annual TPR, July 1, 1963 - June 30, 1964, p. 37.
46. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, pp. 8-9.
47. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 9.

third stages. The F-1 engine, which burns LOX and kerosene, generates 1.5 million pounds thrust at sea level. It has been under development since 1958. The J-2 liquid hydrogen engine, which uses LOX as oxidizer, has been in development since 1960. Its rated thrust is 200,000 pounds in the vacuum of space. In spite of numerous development problems both engines have repeatedly achieved rated thrust and duration during static tests. Both are now in production by Rocketdyne Division of North American Aviation, Inc., (NAA), under the technical direction of MSFC. Prior to this report period Rocketdyne had delivered the first production F-1 engine and was conducting acceptance tests on the first hot-firing production unit of the J-2.[48]

F-1 Engine

When this report period opened, Rocketdyne was performing under the F-1 engine research and development (R&D) contract, NASw-16, and a letter contract that called for production of 76 engines. Negotiations to definitize the production contract had ended in August 1963. MSFC awarded this definitive contract, NAS8-5604, to Rocketdyne on March 30, 1964. Value of the 76-engine contract was $158.4 million. It provided for delivery of the engines plus some ground support equipment (GSE), mockups and transporters, and associated support. Near the end of this period MSFC issued four modifications valued at $22.3 million to the R&D and production contracts, covering additional hardware and services.[49]

48. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 124-142.

49. NASA, News Release No. 64-48; NASA Historical Staff, Astronautics and Aeronautics, March 1964, (HHR-17), p. 148; and MSFC PAO, Marshall Star, July 15, 1964, p. 1.

In attempting to improve the F-1 engine Rocketdyne continued an intensive research, development, and testing program at Canoga Park, the manufacturing site, and at Rocket Engine Test Site (RETS), Edwards, California, and Santa Susana, California. The developers performed about 120 firing tests of engine systems as well as numerous tests of various engine components.

Combustion instability and performance remained a principal R&D problem and required the continuing efforts of engineers. In the current six-month period the developers designed and tested many types of thrust chamber injectors in their search for a stable injector of high performance for use in the flight rating test (FRT) engine. Late in the period Rocketdyne selected two nearly identical injectors on a parallel basis and approved their production for the FRT engine; both injectors had demonstrated good stability and improved performance in thrust chamber testing. Following this dual selection engineers began to narrow the choice to one precise configuration. They concentrated on refinement of design, subjected the prototype to intensive testing, stopped work on new injector designs, and curtailed efforts in several other aspects of the combustion stability program.[50]

Other areas of engine component testing during this period included the turbopump, gas generator, heat exchanger, thrust chamber, and nozzle extension. Highlights of R&D work in these problem areas are summarized as follows:

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50. MSFC Engine Project Office, Quarterly Progress Report, F-1, H-1, J-2 and RL10 Engines, April, May, and June, 1964, pp. 10-13, hereafter cited as MSFC Engine Project Office, Engine QPR, April-June 1964.

Turbopump: Two LOX pumps of similar configuration exploded during this period -- one in February and the other in April. After each explosion all testing stopped while special investigative groups reconstructed the pumps and sought to find reasons for the failure. Damage to test facilities contributed to the delay in engine system tests at RETS. Since the pump that exploded in April was identical to the LOX pumps on Engines F-1001 and F-1002 at MSFC, firing of these production engines also was interrupted while recommended changes were made. Measures taken by Rocketdyne included efforts to improve the LOX impeller and decrease the required speed of the turbopump. To accomplish the latter objective engineers lowered the differential pressure in the system by modifying the LOX dome and substituting rigid high-pressure ducts for bellows type ducts. Preparations for evaluating these innovations were in progress at RETS at the end of the report period.[51]

Gas generator: The chief problem was to reduce oscillations or vibration. Testing continued on two types of combustor bodies -- a solid-wall and a double-wall configuration. The solid-wall was selected. In the search for a stable gas generator for the Block II (FRT) engine Rocketdyne also tested several injector designs. By June 30 engineers believed they had developed a satisfactory injector of a "doublet" design.[52]

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51. MSFC Engine Project Office, Monthly Progress Report, F-1, H-1, J-2, and RL10 Engines, February 1964, p. 3, hereafter cited as MSFC Engine Project Office, Engine MPR, February 1964; and MSFC Engine Project Office, Engine QPR, April-June 1964, pp. 6-10.

52. MSFC Engine Project Office, Engine QPR, April-June 1964, p. 2.

Heat exchanger: Redesign of this component was aimed at improving performance and structural integrity while simultaneously reducing weight. The first heat exchanger designed for Block II engines, delivered late in May 1964, weighed 180 pounds less than previous models. Testing of this unit was inconclusive at the end of the report period, but Rocketdyne decided to proceed with the current design as testing continued.[53]

Thrust chamber: Problems included cracking of tubes, jackets, and the exhaust manifold inlet during the stress of firing. Engineers solved much of the trouble by using new brazing methods, by affixing jacket straps to the chamber, and by designing a new type of exhaust manifold inlet. The new inlet was expected to undergo testing in July 1964.[54]

Nozzle extension: Most of the effort during this period was on evaluation of the gas-cooled 24-shingle extension. Several units underwent test. A "floating liner" extension proposed by Rocketdyne was approved for test by MSFC during the period, and the first R&D model of this type was scheduled for delivery in September 1964 for testing on a non-interference basis.[55]

Rocketdyne and MSFC had scheduled the F-1 engine FRT for mid-1964. However, with much component test work still uncompleted late in the current report period the developers decided in May to delay FRT until

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53. MSFC Engine Project Office, Engine MPR, Dec. 16, 1963 - Jan. 31, 1964, p. 4; and MSFC Engine Project Office, Engine QPR, April-June 1964, p. 3.

54. MSFC Engine Project Office, Engine MPR, February 1964, p. 3, and March 1964, p. 2; and Engine QPR, April-June 1964, p. 9.

55. MSFC Engine Project Office, Engine MPR, February 1964, p. 5; and Engine QPR, April-June 1964, p. 9.

the end of 1964. Tests leading to flight qualification of the engine were scheduled to start in September 1964.[56]

Prior to this period Rocketdyne had delivered one production F-1 engine, a ground test model, for static firing at MSFC. Test Laboratory personnel fired this engine (F-1001) three times late in December 1963. From January through April 1964 Test Laboratory conducted 16 additional firings of F-1001, for single-test durations ranging up to 121 seconds, utilizing the modified west position of the Saturn I static test stand. Test objectives included evaluation of total engine performance, the performance of various components and subsystems, and calibration and checkout of instrumentation. Tests of F-1001 ended after the LOX pump explosion at Rocketdyne in April made necessary inspection and reevaluation of all F-1 engines.[57]

The second production engine, F-1002, arrived at MSFC on April 1, 1964, following acceptance tests and checkout by Rocketdyne. F-1002 was also a ground test engine. Quality and Reliability Assurance (Quality) Laboratory received the engine and performed acceptance tests and inspection before transferring the engine on April 14 to Test Laboratory. On the basis of inspection and because of the April LOX pump explosion at Rocketdyne, MSFC technicians modified the high pressure ducts and LOX pump of F-1002. In June 1964, following this rework, Test Laboratory personnel placed the engine on the Saturn I test stand. The

56. NASA Historical Staff, Astronautics and Aeronautics, May 1964, (HRH-17), p. 244.

57. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 6-7.

F-1 ENGINE AND INSTALLER

Test Laboratory personnel operate an F-1 engine handler, the device used to install the five engines on a vertical S-IC stage.

first firing occurred on June 23. High LOX pressure in this test prompted further modifications to the engine. Three other brief firings of F-1002 took place before the end of June. Additional rework of the engine was in progress when this period ended.[58]

Rocketdyne expected to deliver Engine F-1004, the third production engine, to MSFC in September 1964. This engine will have an improved turbopump and other modified components.[59]

J-2 Engine

The J-2 engine is being developed and manufactured by Rocketdyne under three NASA contracts managed by MSFC. The R&D contract, NAS8-19, was awarded in 1960 and has been amended a number of times to meet the needs of the development program. A letter contract for production and delivery of 55 engines, NAS8-5603, was in the process of evaluation for definitization by MSFC at the beginning of this report period. The facilities contract for the J-2 program is NAS8-5609F. MSFC issued several modifications to the three contracts during the period, which increased their value.[60]

On March 10, 1964, Rocketdyne submitted its revised production contract proposal. Negotiation of the proposal began at MSFC on April 13

58. MSFC Engine Project Office, Engine MPR, March 1964, p. 5; MSFC Engine Project Office, Engine QPR, April - June 1964, p. 14; and MSFC Test Lab., Test Laboratory Monthly Progress Report, June 12, 1964 - July 12, 1964, p. 6; cited hereafter as Test MPR, June 12 - July 12, 1964.

59. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 15.

60. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 135 and 141; and MSFC Engine Project Office, Engine QPR, April - June 1964, pp. 32-34.

and ended on May 15, 1964. NASA Headquarters received the negotiated contract package on June 17 and approved the contract on June 24.[61]

Although there were not enough engines available to keep the five test stands at Santa Susana Test Area busy during this period, Rocketdyne performed about 196 firing tests of complete engine systems. Principal objectives of these tests included investigation of engine side loads, evaluation of engine start under varying conditions, testing of various engine components, gimballing demonstrations, engine operation under simulated altitude conditions, and acceptance testing of production engines.

In the period prior to January 1964 Rocketdyne had partially resolved the side load problem by devising a water-cooled diffuser for use on the thrust chamber during test, and by using a restraining device attached to the test stand. Because the problem persisted during the current period engineers redesigned the diffuser and tested several of the modified configurations. Diffuser evaluation continued to the end of this period. The engine developers also discovered that the engine's thrust chamber apparently assumed an "out-of-round" shape during the stress of repeated firing at sea level. Reinforcement of the thrust chamber with a rigid T-ring device during test prevented distortion of the chamber and improved the performance of the engine.[62]

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61. MSFC Engine Project Office, Engine MPR, March 1964, pp. 18-21; and Engine QPR, April - June 1964, p. 32.

62. MSFC Hist. Office, History of MSFC, (MHM-8), pp. 135 and 137; and MSFC Engine Project Office, Engine QPR, April - June 1964, pp. 30-31.

Gimballing tests, both "cold" and during hot-firing, occupied Rocketdyne engineers during much of this period. These tests culminated in achievement of the required PFRT performance--a full 7-degree gimbal pattern.

During May engine systems tests concentrated on elimination of fuel pump stall at flight stage inlet conditions. Test personnel modified the start sequence to allow LOX pump speed to build up higher than normal before fully opening the main LOX valve. This procedure reduced the stall problem as well as the engine side load problem; engineers continued effort at further improvements.

The major component problem during the period concerned performance of the fuel turbopump. An abnormally high cavity pressure rise in the pump's balance piston during mainstage operation caused the concern. Engineers tested several corrective theories with partial success, but the problem was still occurring occasionally when the period ended.[63]

Other component development progress included efforts to reduce engine weight as well as the following:

Thrust chamber injector: Considerable testing of different configurations occurred as engineers sought a stable injector for the FRT engine. As a result, the developers selected a promising injector and released it for production in March. Installed on three R&D engines and tested during April, the chosen injector proved to be as stable as the PFRT configuration under all operating extremes. By the end of

63. MSFC Engine Project Office, Engine QPR, April - June 1964, pp. 29-30.

this period injector performance therefore was no longer considered a problem.[64]

Gas generator: Engineers experienced some problems with this component but had solved most of them and selected a design suitable for the FRT engine by the end of the period.[65]

Other engine components tested and improved at Santa Susana included the LOX pump inducer, fuel pump diaphragm, augmented spark igniter, and heat exchanger.

Rocketdyne planned initiation of PFRT in June and completion in September 1964. Late in this period, however, the PFRT engine (J-2004) and the PFRT backup engine (J-2005) were damaged during acceptance testing and had to be returned to the manufacturing plant for rebuild. The PFRT engine was expected back in service during July 1964.[66]

On January 27, 1964, the engine contractor delivered the last of five operational simulator J-2 engines to S&ID, for use on the S-II stage electro-mechanical mockup.[67]

The first hot-firing production engine, J-2003, underwent a series of 15 acceptance firings at Santa Susana during March and April 1964. The engine was delivered to DAC on April 30 for S-IVB stage battleship testing at SACTO. On June 12, 1964, Rocketdyne delivered the second

64. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 31.
65. MSFC Engine Project Office, Engine MPR, March 1964, p. 18.
66. MSFC Engine Project Office, Engine QPR, April - June 1964, pp. 29 and 32.
67. MSFC Engine Project Office, Engine MPR, Dec. 15, 1963 - Jan. 31, 1964, p. 21.

production engine, J-2006, to S&ID. J-2006 was scheduled for S-II stage battleship testing at Santa Susana. The third production engine, J-2002, was undergoing acceptance testing at the end of the report period.[68]

Facilities

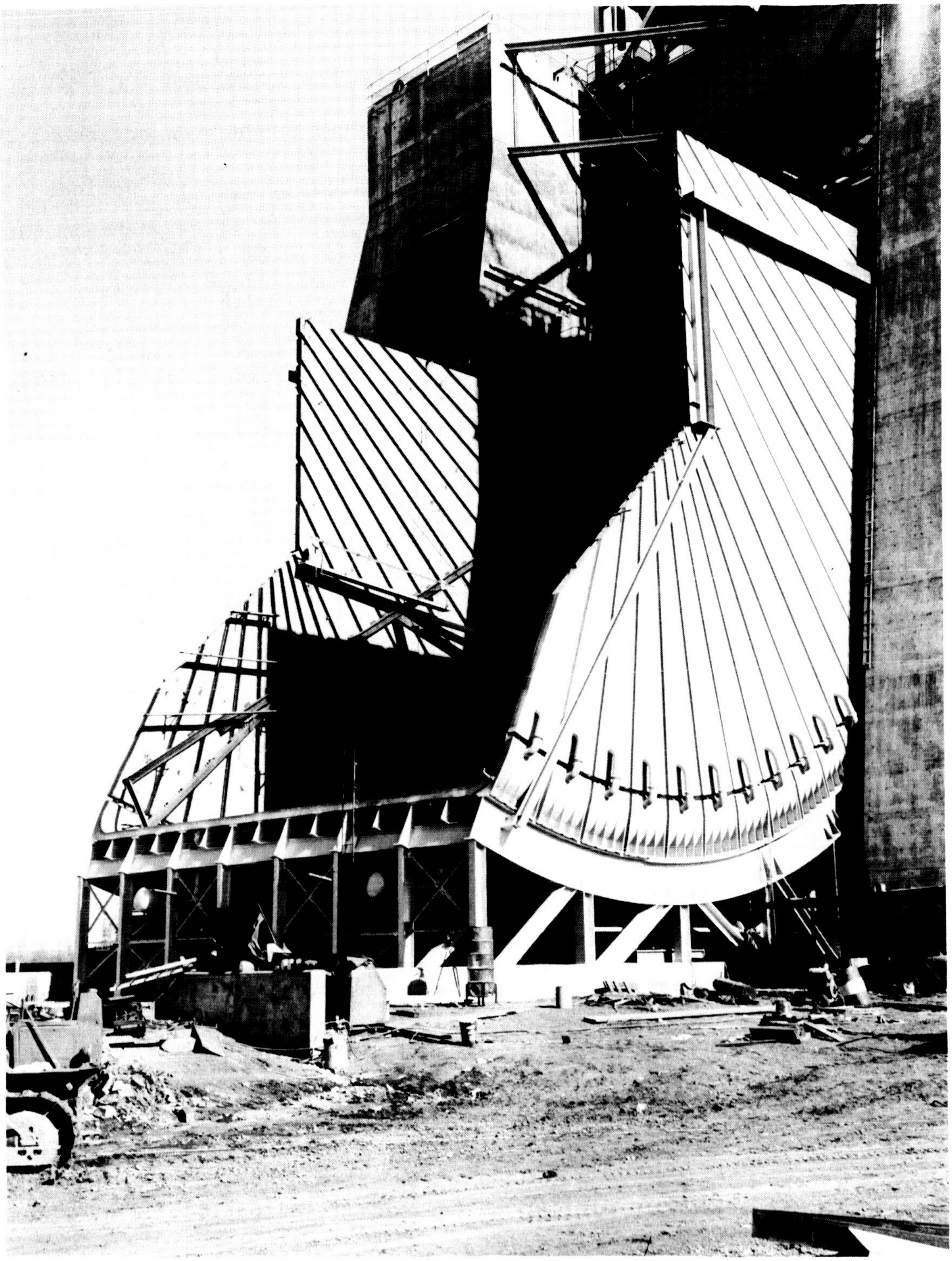
Specialized facilities needed for the development, manufacture, and testing of the Saturn V launch vehicle are situated at government and contractor sites across the country. Construction and modification of facilites proceeded throughout the current period. Principal facilities are at Huntsville, Michoud, MTO, Boeing, S&ID, DAC, and Rocketdyne production and test sites. Launch facilities are at Kennedy Space Center (KSC) in Florida.[69]

MSFC

One of the largest Saturn V facilities at MSFC is the S-IC Static Test Stand, under construction in the West Test Area since the summer of 1962. Erection of the massive 400-foot steel and concrete superstructure was complete when this report period opened. In February workmen began to install the flame deflector and weld the stand's load platform while proceeding with installation of technical systems. Procurement of instrumentation and controls ended on May 1. The stand and support items were near structural completion at the end of the period. Instrumentation

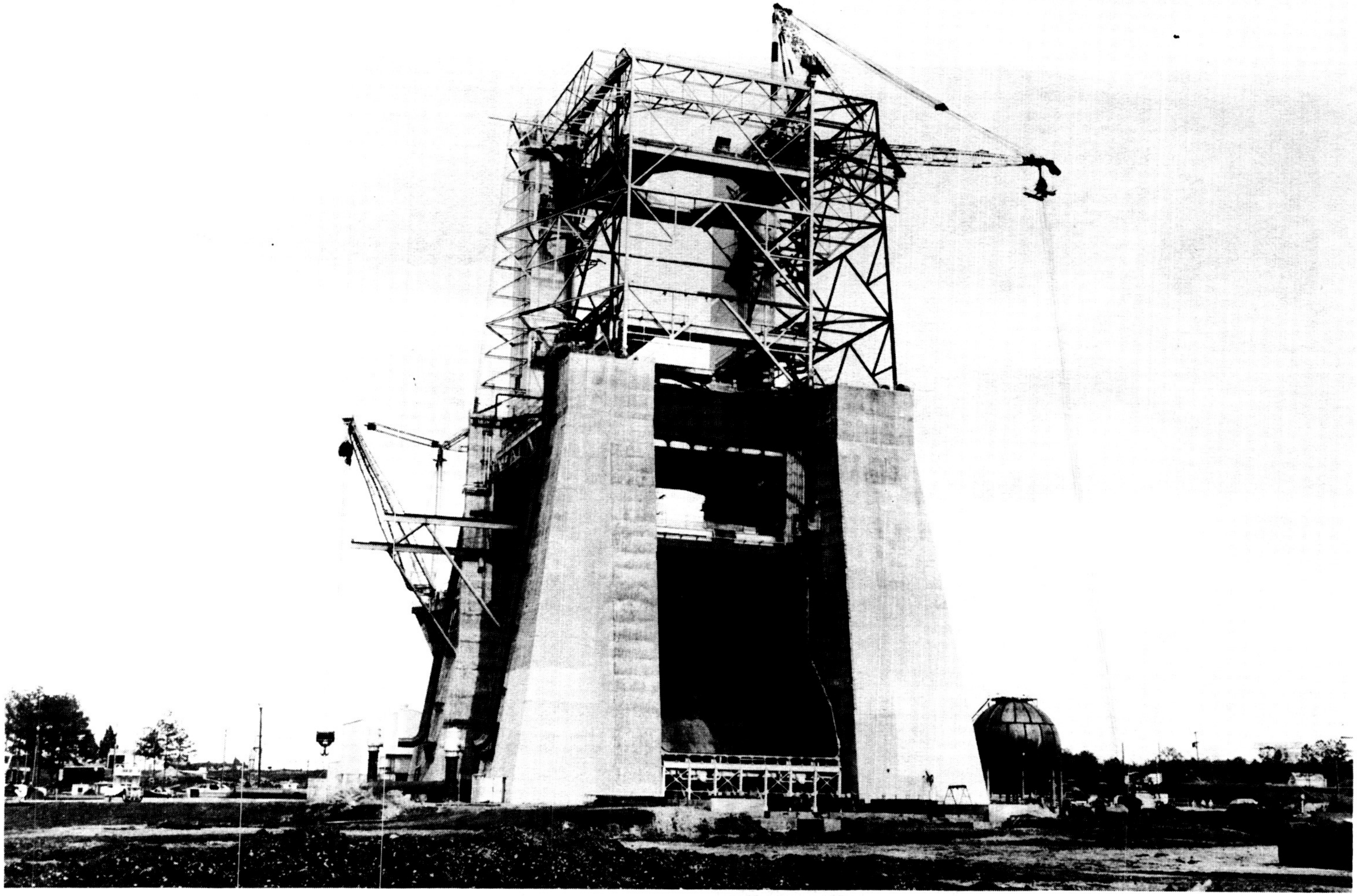
68. MSFC Engine Project Office, Engine MPR, March 1964, p. 17; and Engine QPR, April - June 1964, p. 32.

69. MSFC Hist. Office, History of MSFC, (MHM-8), p. 145.



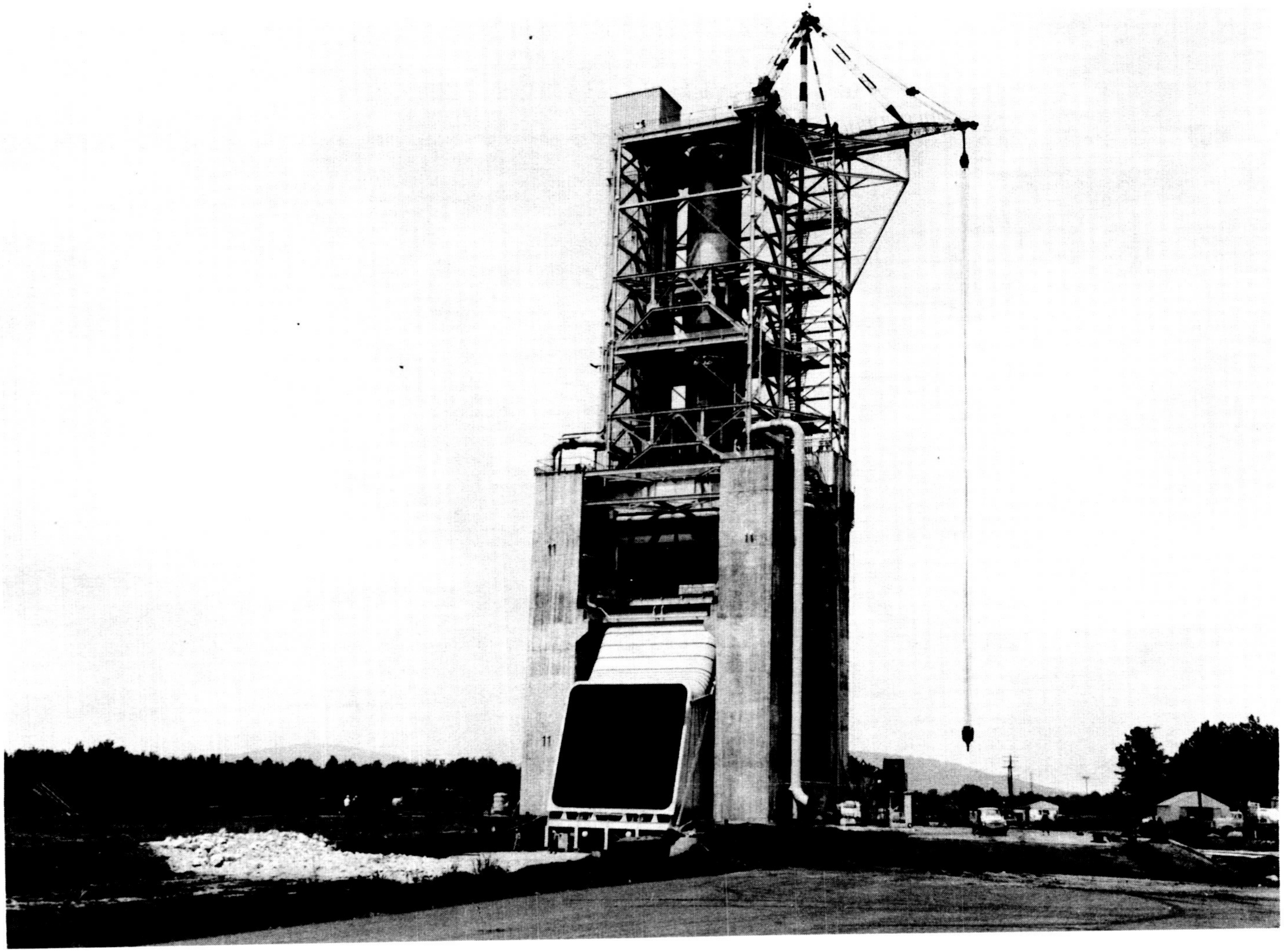
FLAME CATCHER INSTALLED

Installation of the S-IC Test Stand's flame deflector began at MSFC in February 1964. Workmen built the mammoth steel appurtenance near the stand and moved it into place between the concrete legs of the stand. The deflector will withstand the force of five F-1 engines, generating thrust of 7.5 million pounds.



WHERE S-IC WILL BE STATIC-FIRED

The MSFC S-IC Static Test Stand was near structural completion when this picture was made in April 1964. Its first use is scheduled in 1965.



F-1 ENGINE STAND AT HUNTSVILLE

This view of the MSFC F-1 Engine Test Stand shows the flame deflector pointed toward the camera. The photo was made shortly after the end of this January - June 1964 report period.

installation also was complete and being prepared for checkout. Beneficial occupancy of the facility was scheduled for August 1, 1964.[70]

MSFC completed in February 1964 the F-1 Engine Test Stand steel superstructure erection and deflector installation. Installation of major components and technical systems continued through most of the period. The stand was almost ready for use by the end of the period. Meanwhile, F-1 engine firings at MSFC proceeded in the modified west position of the Saturn I Test Tower.

Steel erection at the Saturn V Dynamic Test Stand proceeded on schedule from the beginning of the period until completion of the superstructure in March. Meanwhile, work progressed on the two tunnels provided for instrumentation and control cables. At the end of this period overall construction was 90 per cent complete, and officials had conducted pre-final inspection of the tunnels.[71]

Construction of the F-1 Engine Turbopump Facility ended in January. Outfitting of the stand was virtually complete by June 30. The turbopump test facility permits development tests on the S-IC/F-1 turbopump and propellant flow systems, simulating performance of the S-IC stage. An F-1 engine was in place at the facility for testing when the period ended.[72]

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70. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 11; MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 10; and MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 22.

71. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 12; and Feb. 16 - Mar. 16, 1964, p. 11; and MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 22.

72. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 11.

WEST AREA BLOCKHOUSE

MSFC engineers and officials will monitor F-1 engine and S-IC stage captive firings from this blockhouse.

The MSFC Liquid Hydrogen Facility includes a vertical J-2/S-IVB Test Stand, two high pressure LH_2 storage vessels, pumping equipment, and a Blockhouse extension. Blockhouse construction ended in January 1964. Major steel work on the J-2 Test Stand was completed by May. At the end of June the project was 60 per cent complete, with a scheduled completion date of October 27, 1964.[73]

Construction of the second addition to Building 4666, the Test Laboratory Engineering Building, ended late in this period. Personnel moved into the building on June 22.

Personnel completed several Saturn V support facilities during the current period. Welding on propellant storage tanks ended in February, and workmen insulated the LOX tanks during March. The high pressure industrial water system also was completed in March, and final inspection occurred in May. By the end of this period tests were in progress or scheduled for LOX and fuel lines and pumps, the helium system, and water pumps.[74]

In the GSE Test Facility area during March, workmen poured concrete for equipment foundations and the blockhouse walls. Completion of blockhouse structural concrete occurred in May. Meanwhile, technical systems design began. Erection of steel on all except one tower simulator was complete by June 30; construction of the support building and pumphouse was complete; and utilities were being installed in the nearly complete

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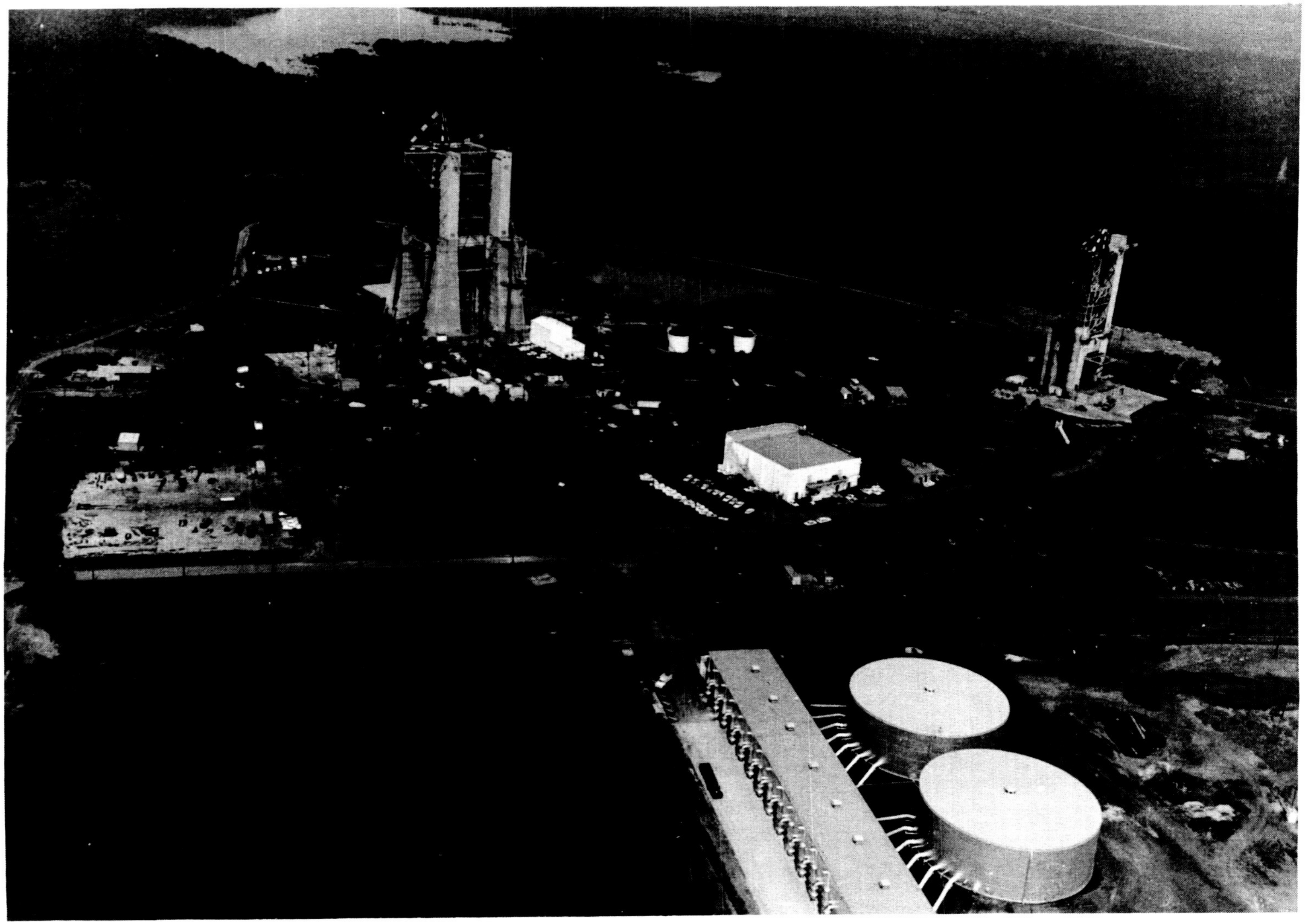
73. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 23.
74. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 23-24.

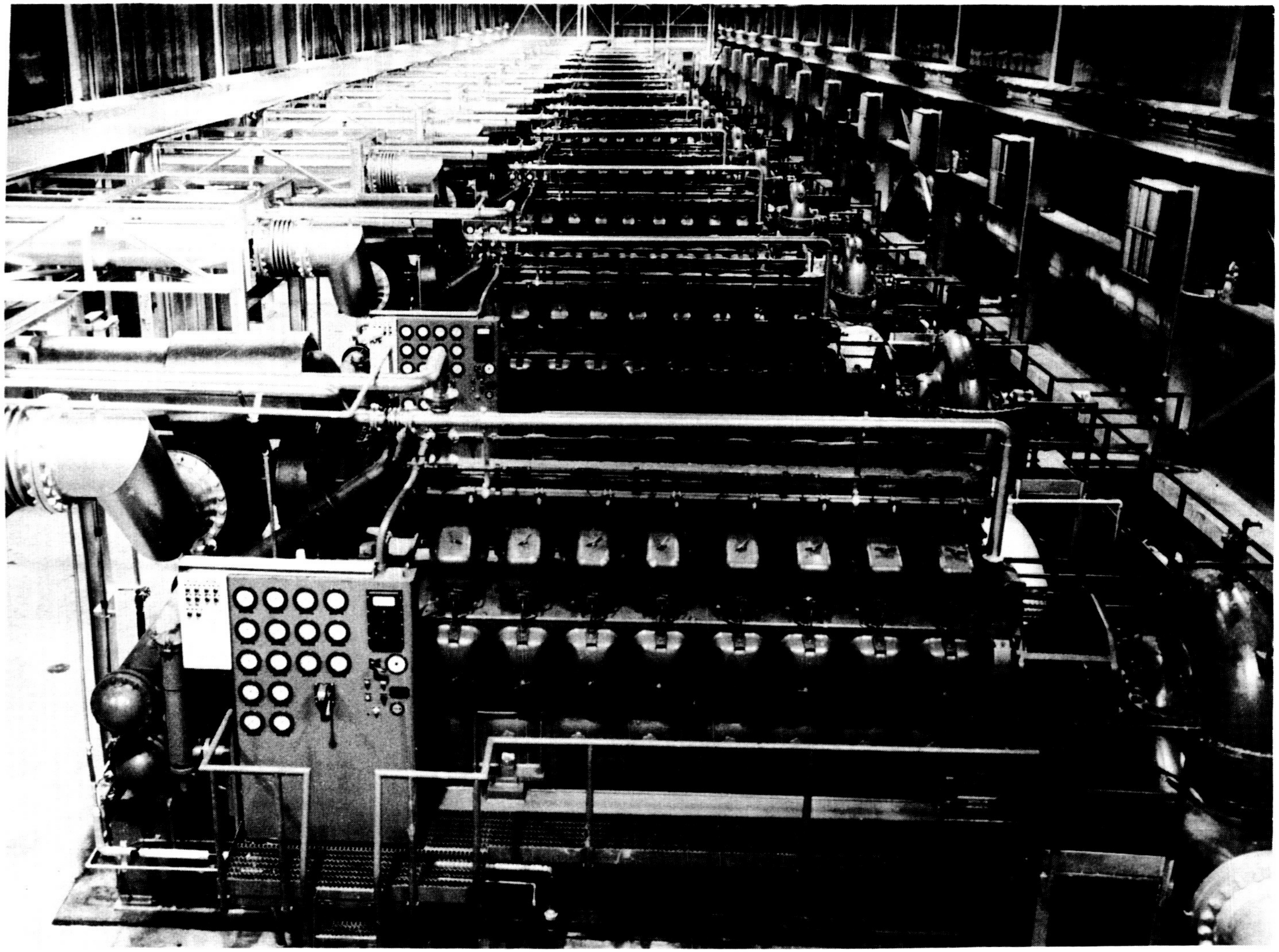


MSFC SATURN V TEST AREA

Major portions of the Saturn V ground test complex are shown in this June 1964 aerial view of the West Test Area. Left center is the S-IC Static Test Stand. The F-1 Engine Stand is at right. The high-pressure water system for the stands is in foreground, and the Blockhouse is at center of picture.

VALVE FOR BIG WATER LINE

Workmen install a 72-inch valve in the water line that will help control heat in the static test stands of MSFC's Saturn V Test Area.

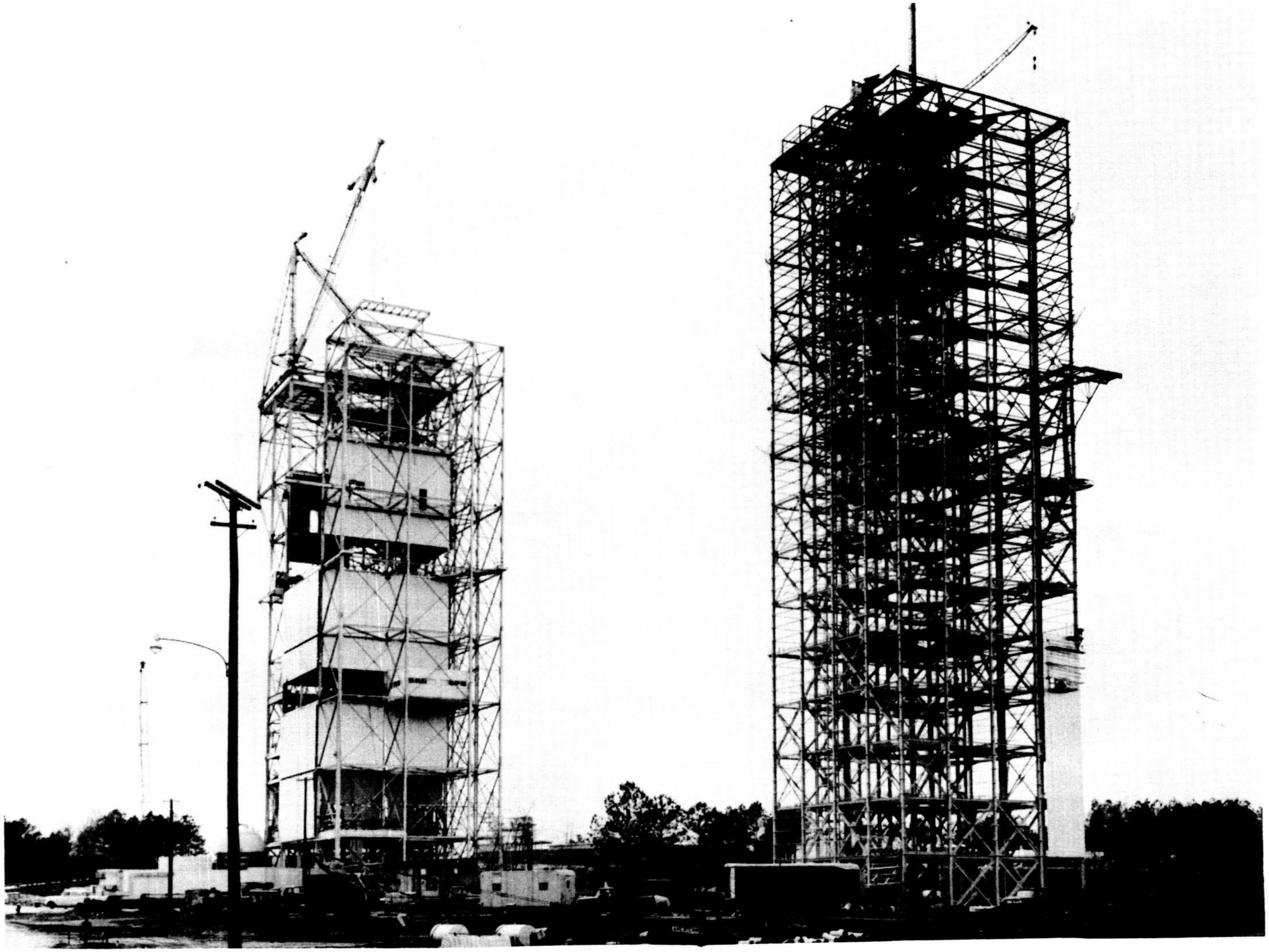


HIGH-PRESSURE WATER PUMPS

This inside view at the high-pressure water pumphouse in the MSFC Saturn V test area indicates the amount and force of water required to cool static test stands during firings.

WATER FACILITY

The exhaust system for the water pumps that support S-IC and F-1 engine tests at MSFC is pictured in the West Test Area.



DYNAMIC TEST STANDS

Construction progress on the Saturn V Dynamic Test Stand at MSFC is shown at right in this April 1964 photo. At left is the Saturn I Dynamic Test Stand, which will be modified later for Saturn IB testing. The Saturn V facility, more than 400 feet tall, was 90 per cent complete as of June 30, 1964.

assembly building. Engineers completed the design of the vehicle random motion simulator, and delivery of technical systems was on schedule.[75]

Construction of the Components Test Facility began in January 1964 and proceeded throughout the report period. At the end of the period construction was approximately 30 per cent complete. Technical systems installation under a $3.5 million contract was scheduled to start in October 1964. The $2.6 million contract for construction of an addition to the Components Test Facility went to Jones and Hardy Construction Company on June 8. Work started on June 24, with completion expected in July 1965. Meanwhile, plans were underway for an extension to the facility instrumentation. Proposals for the technical systems contract were received on June 19 and were being evaluated at the end of this period.[76]

On May 28 Kaminer Construction Company received the contract for construction of the Acoustic Model Test Facility. Final design of technical systems also began in May. Facility completion was scheduled for May 1965.[77]

Construction of the Instrument Laboratory continued throughout this period and was about 90 per cent complete by June 30. An environmental

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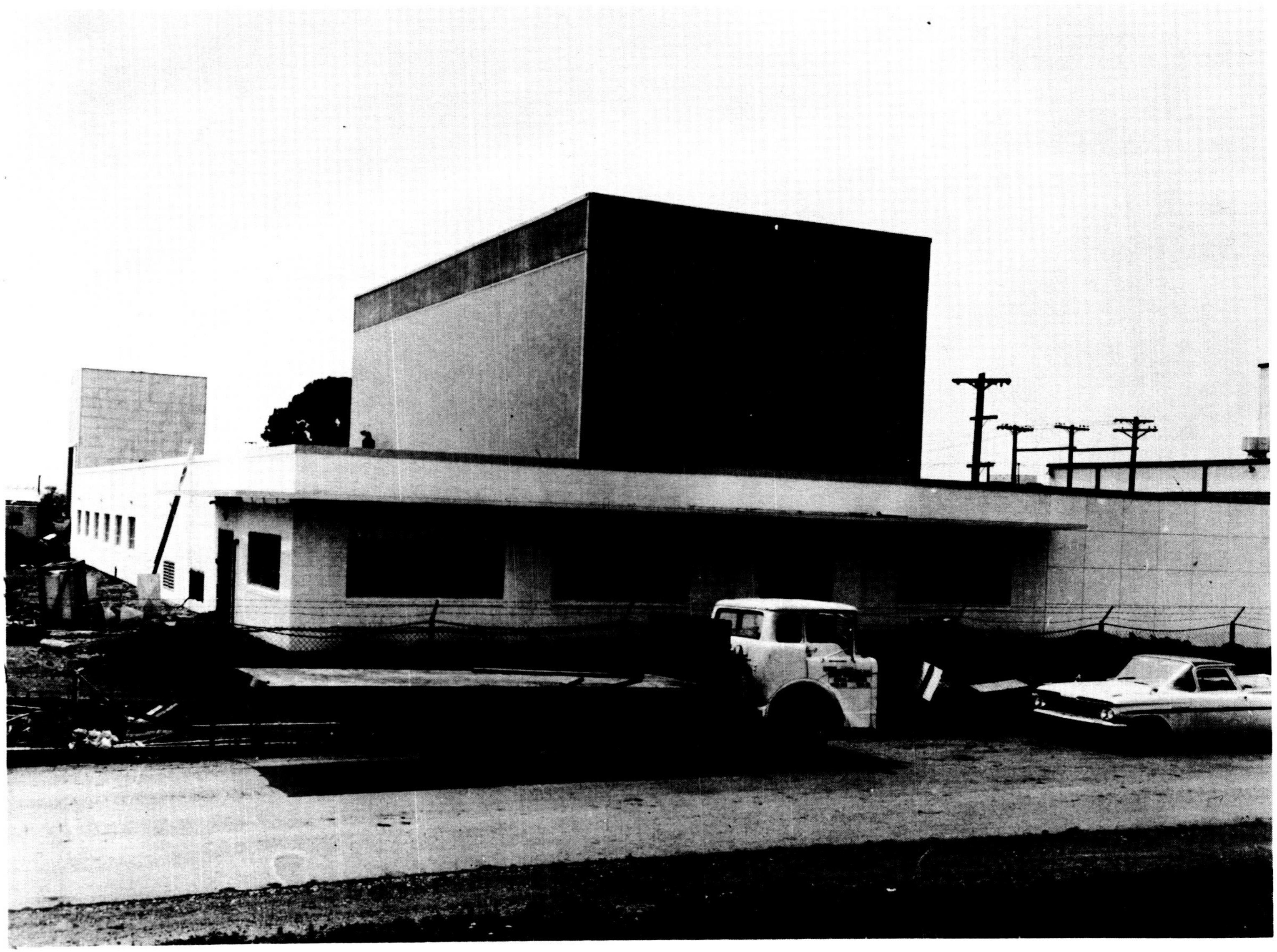
75. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, pp. 23-24.

76. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 25; MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 12; and MSFC Test Lab., Test MPR, May 12 - June 12, 1964, p. 29; and June 12 - July 12, 1964, p. 28.

77. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 26.



INSTRUMENT LABORATORY

Construction of the Test Laboratory's Instrument Laboratory was nearly complete at the end of this report period. The photograph was made June 8, 1964.

test chamber was in place, and installation of technical systems was in progress at the end of the period.[78]

The Saturn V Barge Dock and Loading Facility construction contract went to Ashburn and Gray, Inc., on April 17 at a cost of $256,000. Construction started on May 11. Excavation and piledriving were in progress adjacent to the Saturn I dock facility on the Tennessee River when the report period ended. Meanwhile, work continued on construction of the special Saturn V road from the Test Area to the dock facility. This project, also by Ashburn and Gray, was behind schedule because of bridge construction but was due for completion late in 1964.[79]

Major facilities projects under construction outside the Test Area during this period included a Load Test Annex for P&VE Laboratory, a Hangar for Vehicle Components and a Components and Subassembly Acceptance Building for ME Laboratory, the S-IC Checkout Complex and Saturn V Systems Development Breadboard Facility in the Quality Laboratory, and an Acceleration Test and Calibration Facility for Astrionics Laboratory.

The Load Test Annex to Building 4619, which is used to test Saturn V fuel tanks and other hardware under simulated flight loads, was in final stages of construction when this period ended. Delays in delivery and installation of massive components slowed completion of the facility until after the end of the period. MSFC meanwhile planned for an extension to the Load Test Annex, to be erected at an estimated cost of $2 million. The Center received the completed design for this extension

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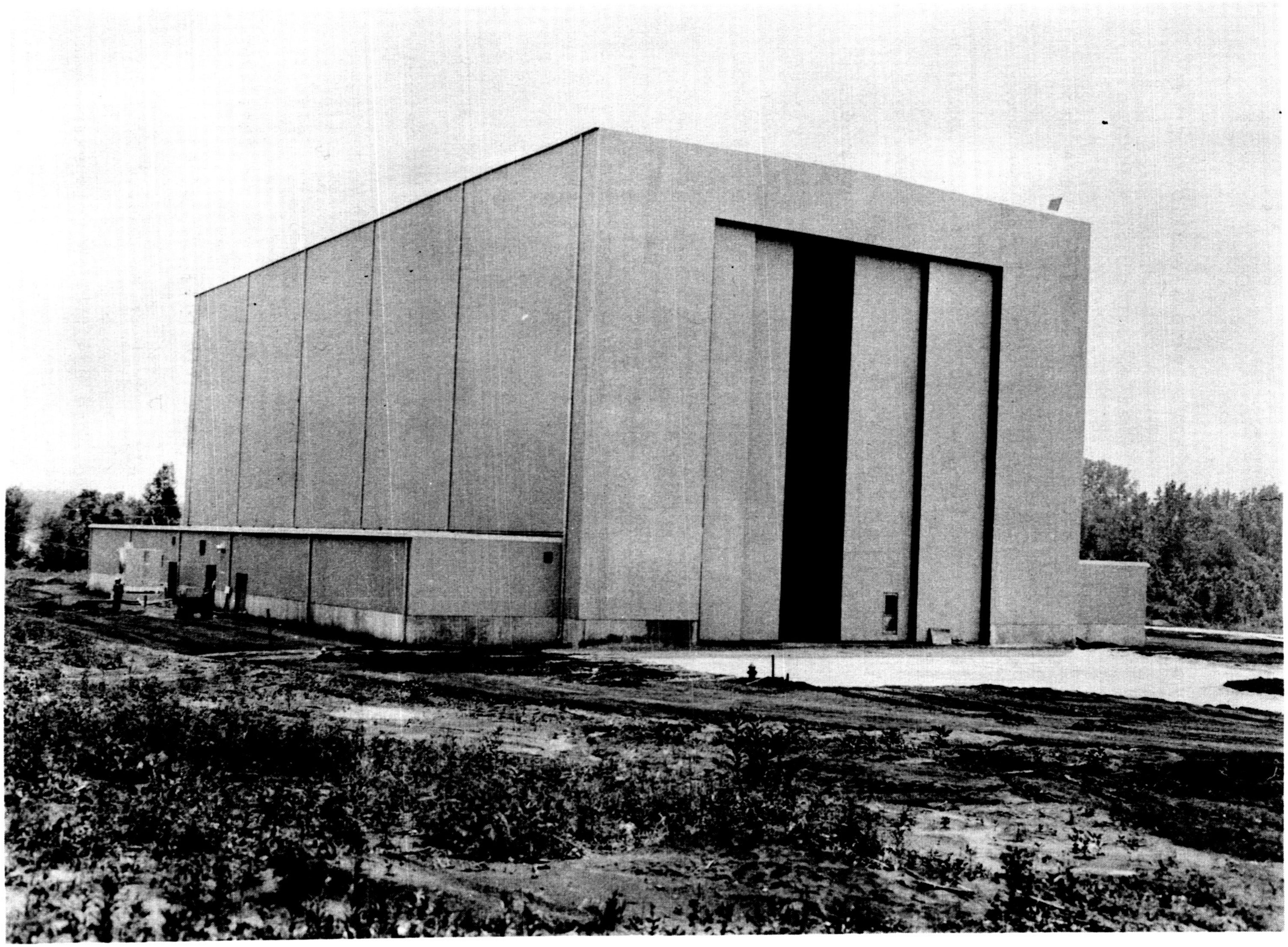
78. MSFC Test Lab., <u>Hist. Report, Jan. 1 - June 30, 1964</u>, p. 26.
79. MSFC Test Lab., <u>Test MPR, Apr. 12 - May 12, 1964</u>, p. 32.



COMPONENTS ACCEPTANCE BUILDING

In this June 1964 progress photo construction nears completion on the MSFC Components and Subassembly Acceptance Building, a facility of the Manufacturing Engineering Laboratory.

on May 12 and advertised for construction bids in June 1964. Testing machinery for the facility was placed on order also in May 1964.[80]

Bids for construction of the Hangar for Vehicle Components were opened on April 14. Winner of the $2.7 million contract later the same month was Sullivan, Long and Hagerty Construction Company. Construction started in June. The facility is designated Building S-4755.[81]

Construction of the Components and Subassembly Acceptance Building (Building 4752) proceeded throughout this period. This work started in August 1963; completion is scheduled for September 1964.[82]

Work also continued on two facilities in Building 4708: the S-IC Checkout Complex and the Saturn V Breadboard Facility. The former, being constructed by Bryson Construction Company, began in April 1964 and is scheduled for completion in October 1964. The two-story Breadboard Facility was placed under contract to M. F. Snyder Construction Company. Work started in May 1964 and should be completed in November 1964. Boeing will operate this facility.[83]

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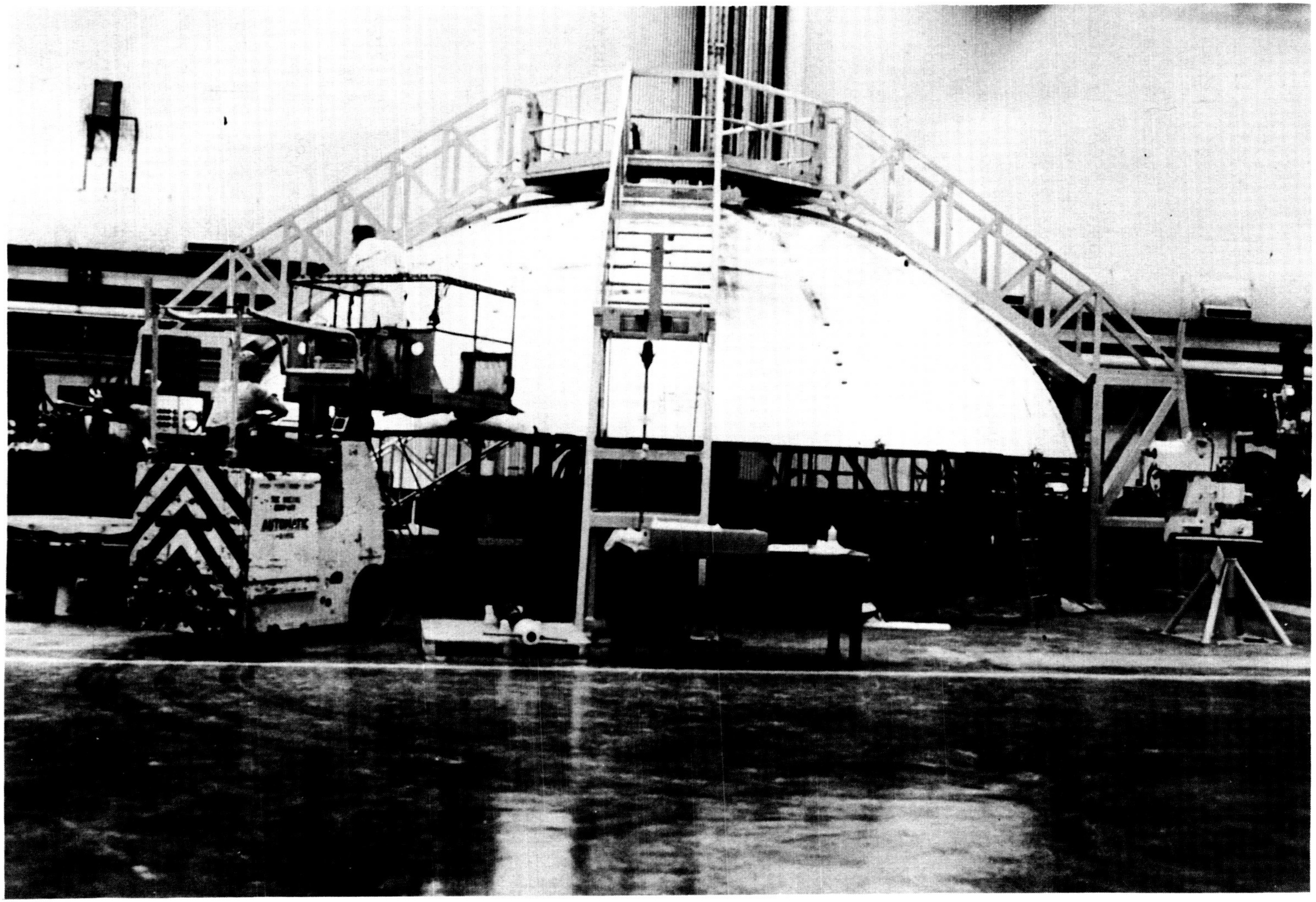
80. Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memos, subject, "Weekly Activity Report," Mar. 27, and June 5, 1964; MSFC Executive Staff, Management Information, Volume VII, August 1964, p. 6; and Chief, Facilities and Design Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," June 1, 1964.

81. Chief, Facilities and Design Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Apr. 17, 1964; and Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," June 1, 1964.

82. MSFC Quality and Reliability Lab., Historical Data, January 1 - June 30, 1964, July 29, 1964, p. 11, cited hereafter as MSFC Quality Lab., Hist. Data, Jan. 1 - June 30, 1964.

83. MSFC Quality Lab., Hist. Data, Jan. 1 - June 30, 1964; and MSFC Astrionics Lab., Saturn Monthly Progress Report, January 1964, p. 7.



SATURN V HARDWARE AT MICHOUD

In manufacture at Michoud Operations is an S-IC stage bulkhead. This giant tank end is held in a weld and trim fixture in the Boeing portion of the government-owned plant.

About March 1, 1964, Pearce and Gresham Company received the $789,970 contract to construct the Acceleration Test and Calibration Facility. This facility for Astrionics Laboratory will subject Saturn V guidance and control instruments to the influences of zero gravity, sound pressure, vibration, and extremes of temperature and vacuum conditions. It is being erected near Building 4487. A major feature of the facility is a 120-foot test tower.[84]

Michoud Operations

The government-owned Michoud Operations, a division of MSFC, is the principal manufacturing site for Saturn V boosters (S-IC stage). Boeing shares space at Michoud with Chrysler Corporation Space Division, the prime contractor for Saturn I and IB boosters. Michoud facilities of general application and those not used in the S-IC manufacturing program are covered in the Saturn I and Saturn IB chapters of this history.

Construction and S-IC plant modification at Michoud progressed satisfactorily during this six-month period. Major S-IC stage production and testing facilities that were uncompleted at the beginning of this period included the Stage Checkout Building, Vertical Assembly Building (VAB), high-pressure test facilities, and engine buildup facilities. Construction funds provided Boeing in the current period included $318,540 for the high-pressure facilities; $465,300 for the VAB; and $1.2 million

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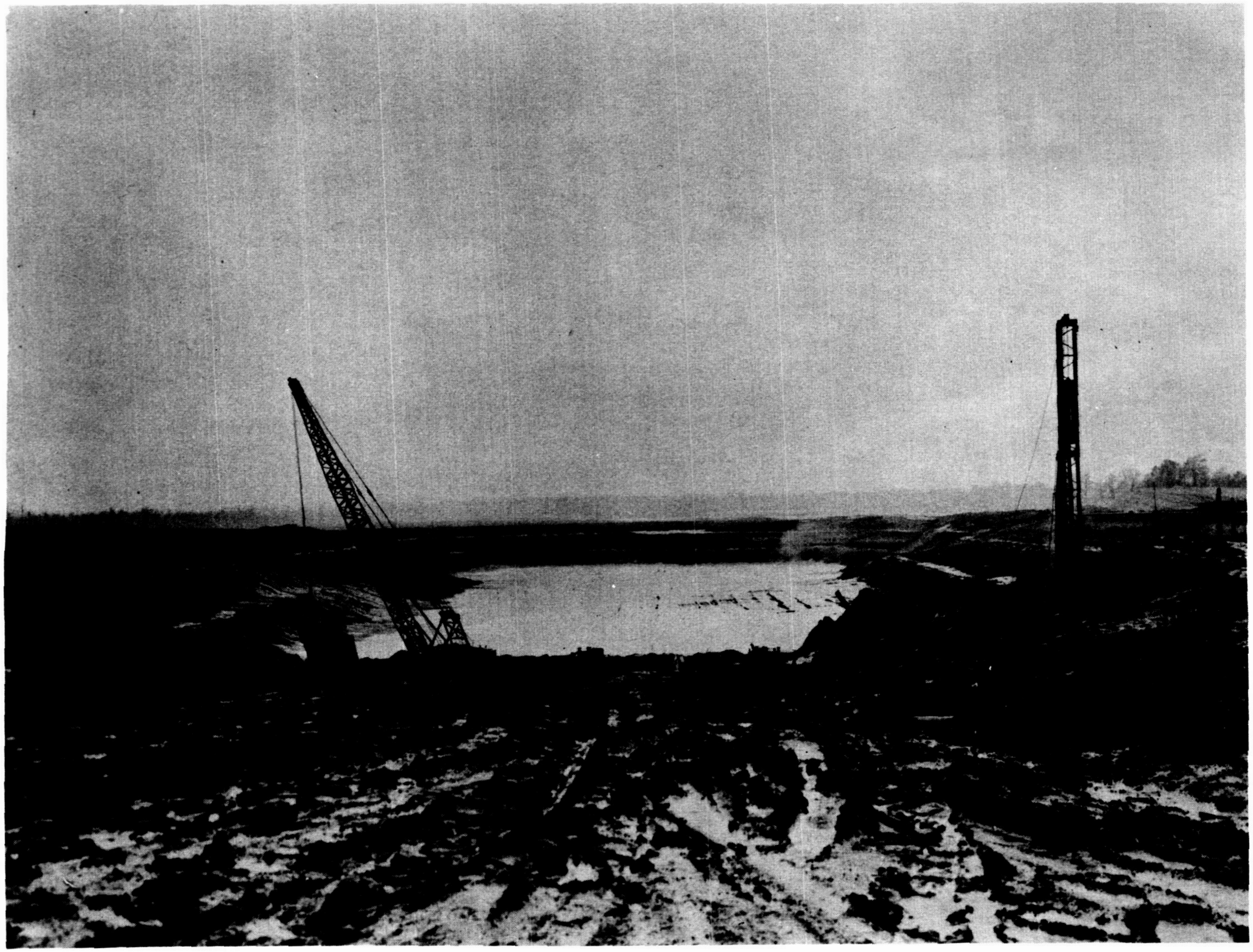
84. MSFC Executive Staff, Management Information, Volume III, 2nd Edition, October 1964, p. 40; and MSFC PAO, Press Release, Mar. 2, 1964.



MTO LOCK AND BRIDGE SITE

This January 1964 photograph shows the excavation at MTO for the Navigation Lock and Bascule Bridge. Heavy rain totalling 30 inches in the first three months of 1964 delayed MTO construction projects.

for additions and alterations to production facilities. NASA increased the Boeing funds for facilities equipment by more than $3 million--to a revised facilities contract total of $16.9 million. Facilities completed under the Boeing contract this period included the 180-ton crane for the VAB, non-destructible test and component test laboratories, chemical and major component cleaning facilities, special tooling, and various test facilities. Construction accomplishments by the Michoud support contractor (Mason-Rust) included Phase II completion of the VAB and Phase III completion of the Chemical Waste System.[85]

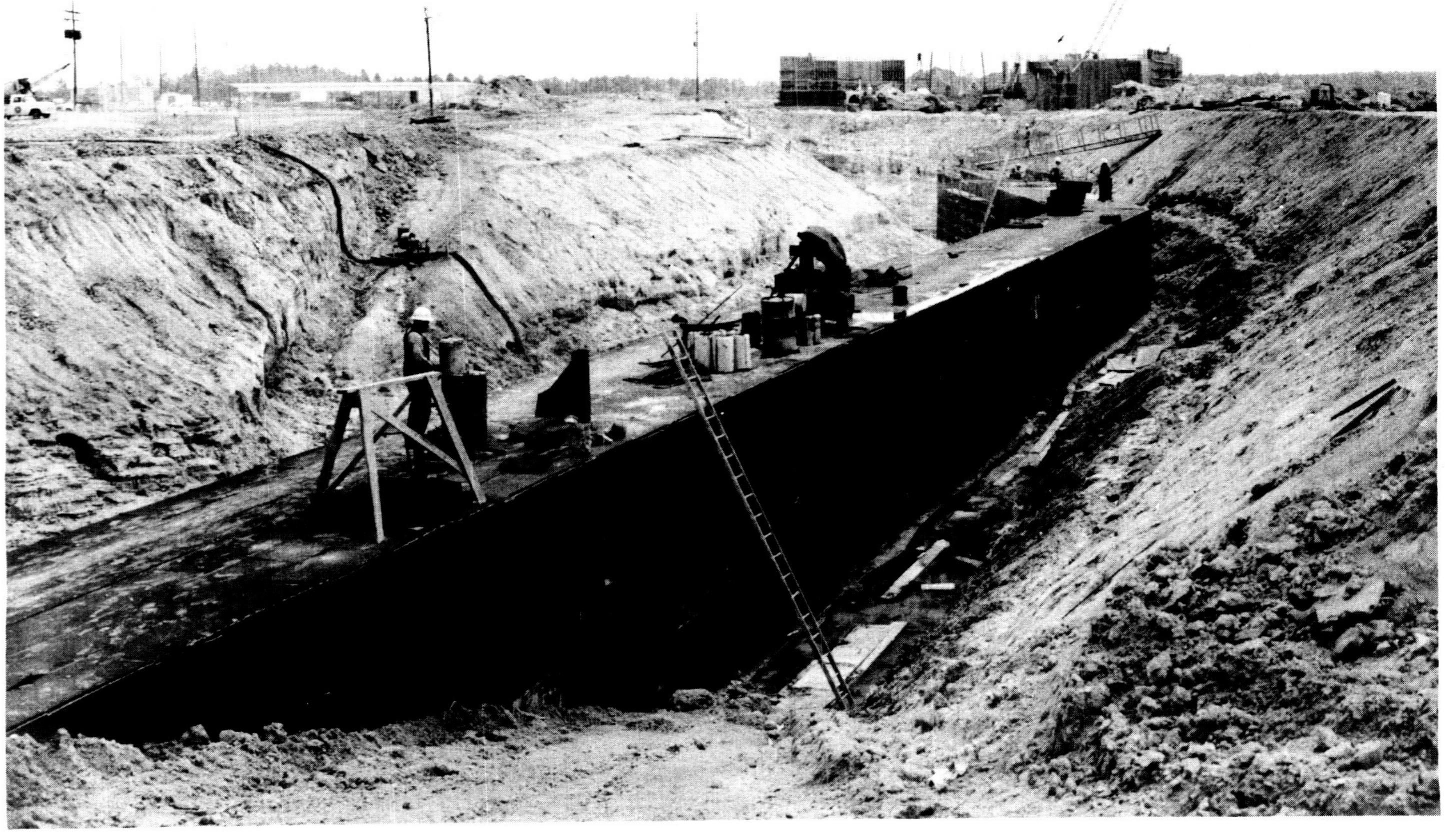
At the end of this report period major S-IC facilities remaining to be completed included the following: Hydrostatic Test and Cleaning Facility, scheduled for completion December 1, 1964; VAB, also scheduled to be completed December 1, 1964; modification of the manufacturing area, expected to be completed by June 1, 1965; and the Stage Checkout Building, on which completion was expected by May 15, 1965.[86]

Mississippi Test Operations

MSFC's Mississippi Test Operations (MTO), in southwest Mississippi a few miles from Michoud, is the acceptance testing site for Saturn V's S-IC and S-II stages. Site clearance and construction of massive facilities at MTO began about mid-year of 1963. The Army Corps of Engineers, Mobile District (MDE), as construction and procurement agent

85. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 13; and MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, pp. 24, 27, and 34.

86. MSFC Executive Staff, Management Information, Volume II. 2nd Edition, October 1964, p. 43.



MISSISSIPPI CONSTRUCTION SCENE

This June 1964 photograph shows construction of an instrumentation tunnel that will connect one S-II stage test stand at MTO to the Data Acquisition Facility.

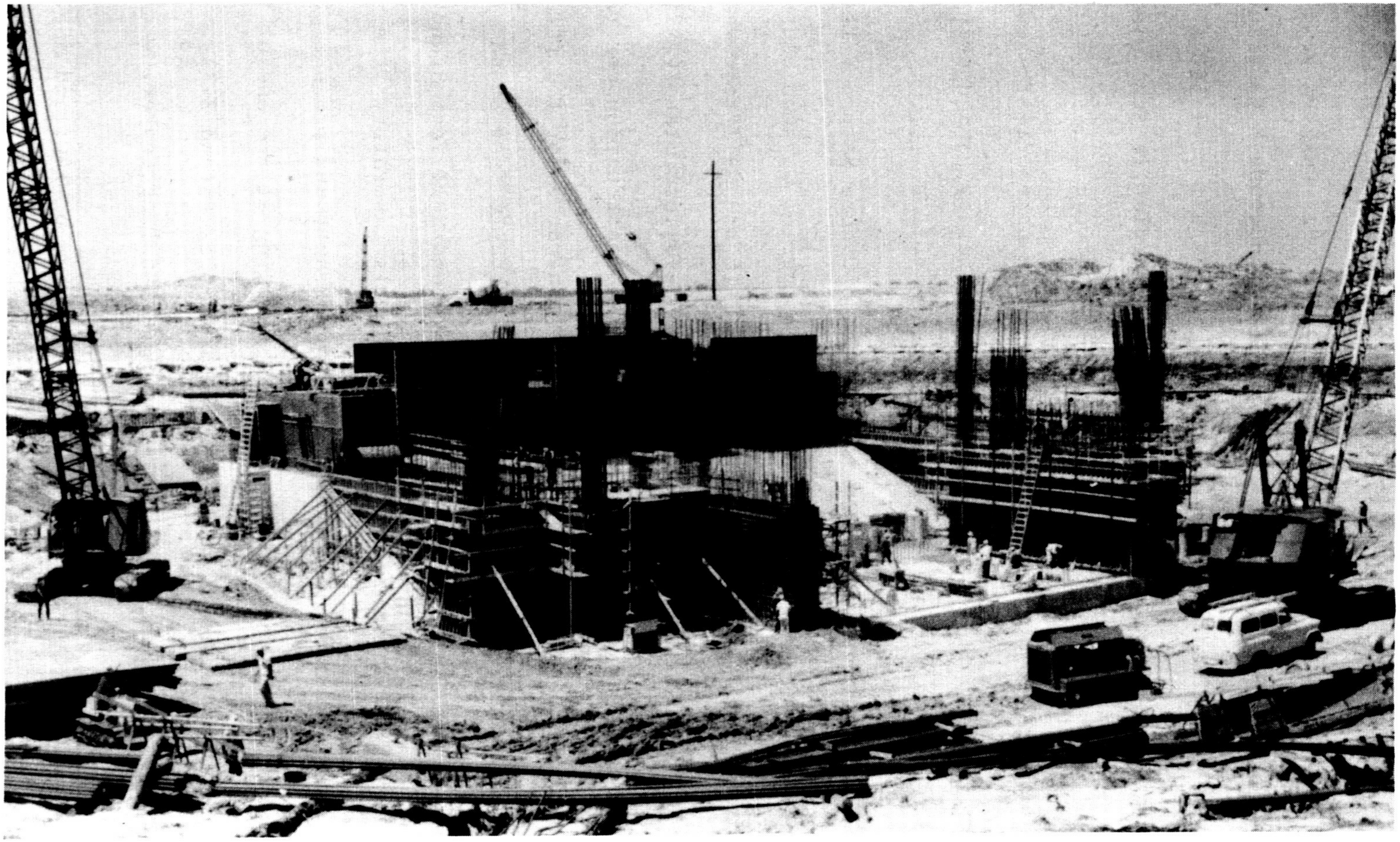
for MSFC supervises the MTO test site buildup. In this period MTO entered its major construction phase. By June 30, 1964, one year after groundbreaking, there were 28 construction projects underway. Contracts for these projects totalled more than $61 million, and almost 1,500 persons were employed. Completion of the MTO test complex is scheduled for 1966.[87]

MTO construction projects are divided into three categories: test facilities, general support facilities, and road, waterway, and docking facilities.

Test Facilities: Clearing of trees from the 850-acre Saturn V test complex ended in January 1964. By the end of this period workmen had completed the excavation and foundations for the S-IC and S-II test stands. Projects under construction included the S-II Test Stand (A-2) and the High-Pressure Gas Facility. MDE awarded 14 construction contracts during this period. Among the new projects were contracts for the Data Acquisition Facility; S-IC Booster Storage Building; S-IC Test Stand substructure; test piles and foundation for the second S-II Test Stand (A-1); the Electronics, Instrumentation and Materials Laboratory; the High-Pressure Water, Heating, and Emergency Power Plant; and procurement orders for valves, pumps, and other equipment. Pending at the end of the period was the contract award for the S-IC Test Complex (Stand B-2) and the contract for the Central Control and Data Handling Center.[88]

87. MSFC Hist. Office, History of MSFC, (MHM-8), p. 160; and MSFC PAO, Marshall Star, May 20, 1964, p. 11.

88. MSFC Mississippi Test Operations (MTO), Historical Report, Mississippi Test Operations, January 1, 1964 - June 30, 1964, pp. 13-15 and 18; cited hereafter as MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964.



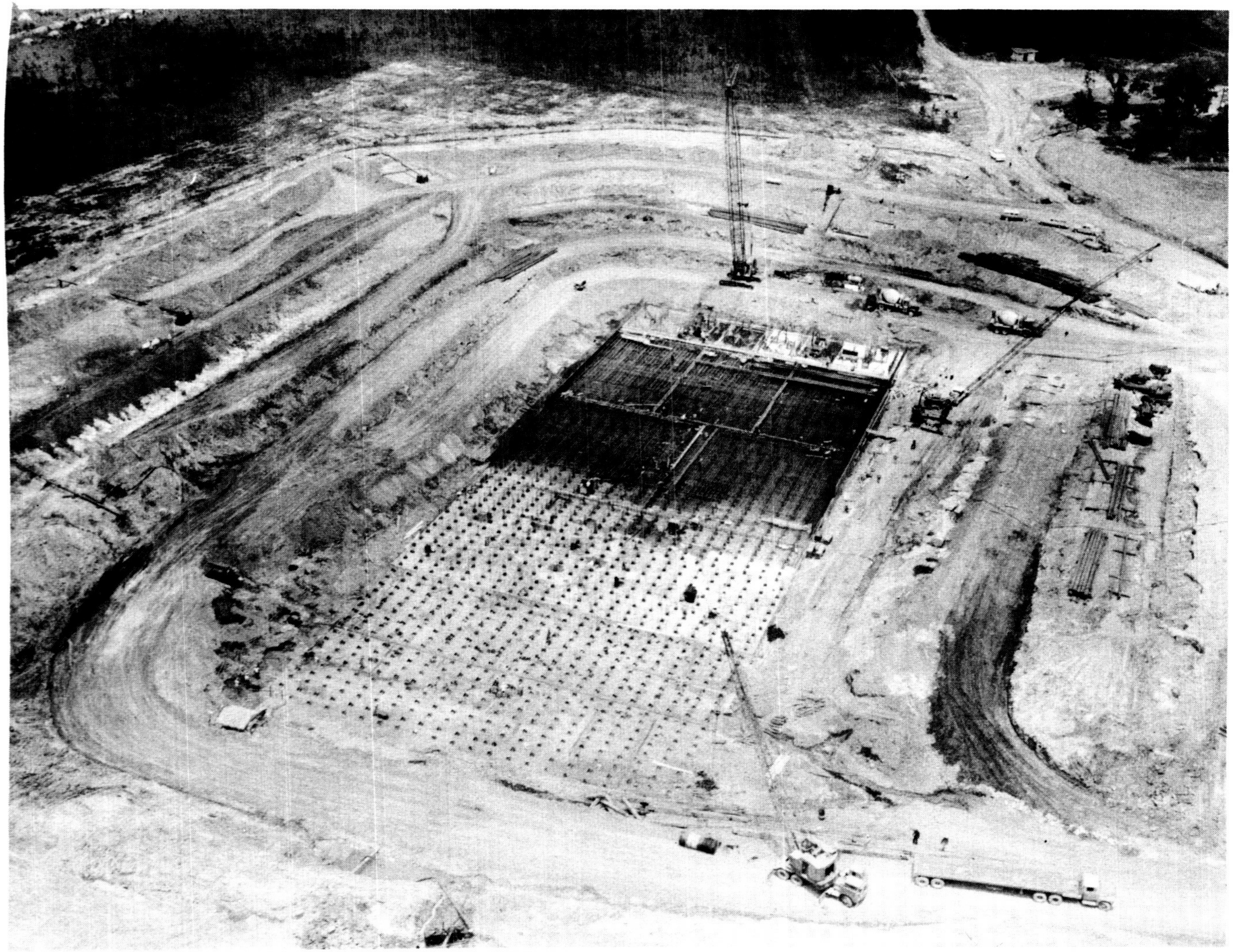
S-II STAND UNDER CONSTRUCTION

This picture shows June 1964 construction progress on the first of two S-II static test stands at MTO.

Support Facilities: Projects completed during this period included Industrial Water Well No. 1, two potable water wells, and an electric power substation and distribution system. Progress was made on construction of the Emergency Services Building (92 per cent complete), Warehouse Site and Maintenance Building (63 pct.), Office and Administration Building (57 pct.), Telephone Building (66 pct.), and Central Heating Plant (76 pct.). During the period MDE awarded contracts for support facilities and equipment including a Test Maintenance Building, Industrial Water Well No. 2, propellant facilities, remodelling of propellant barges, and miscellaneous utilities and equipment. Bids were scheduled for opening early in July on site work for the Emergency Services Building, Warehouse, and Administration Building.[89]

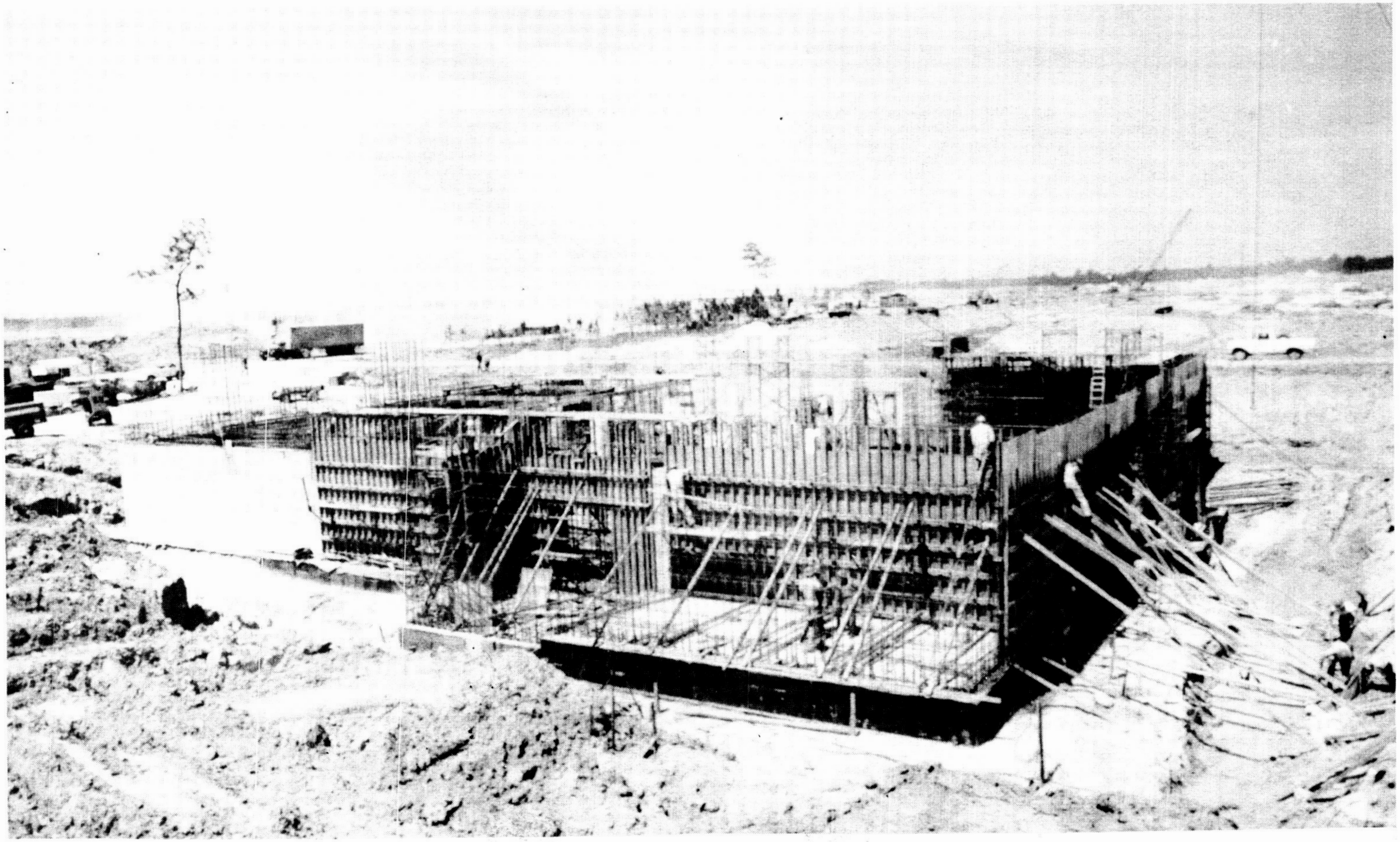
Roads, Waterways, and Dock Facilities: Work on the Construction Dock and the main access road ended in January. Also completed early in the period was the dredging of the MTO Harbor. Facilities under construction during the period included the Cryogenics Docks, canal extension, and deluge intake structure (86 per cent complete); roads, railroads and utilities (34 pct.); Bascule Bridge (45 pct.); and Railroad Classification Yard (92 pct.). New contracts during the period included awards for dredging the East Pearl River and lock approach channel; construction of the Main Canal; construction of the Navigation Lock and lock water supply; construction of four roads; construction of mooring devices and piers for the Cryogenics Docks; construction of the

89. MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964, pp. 14 and 18-20.



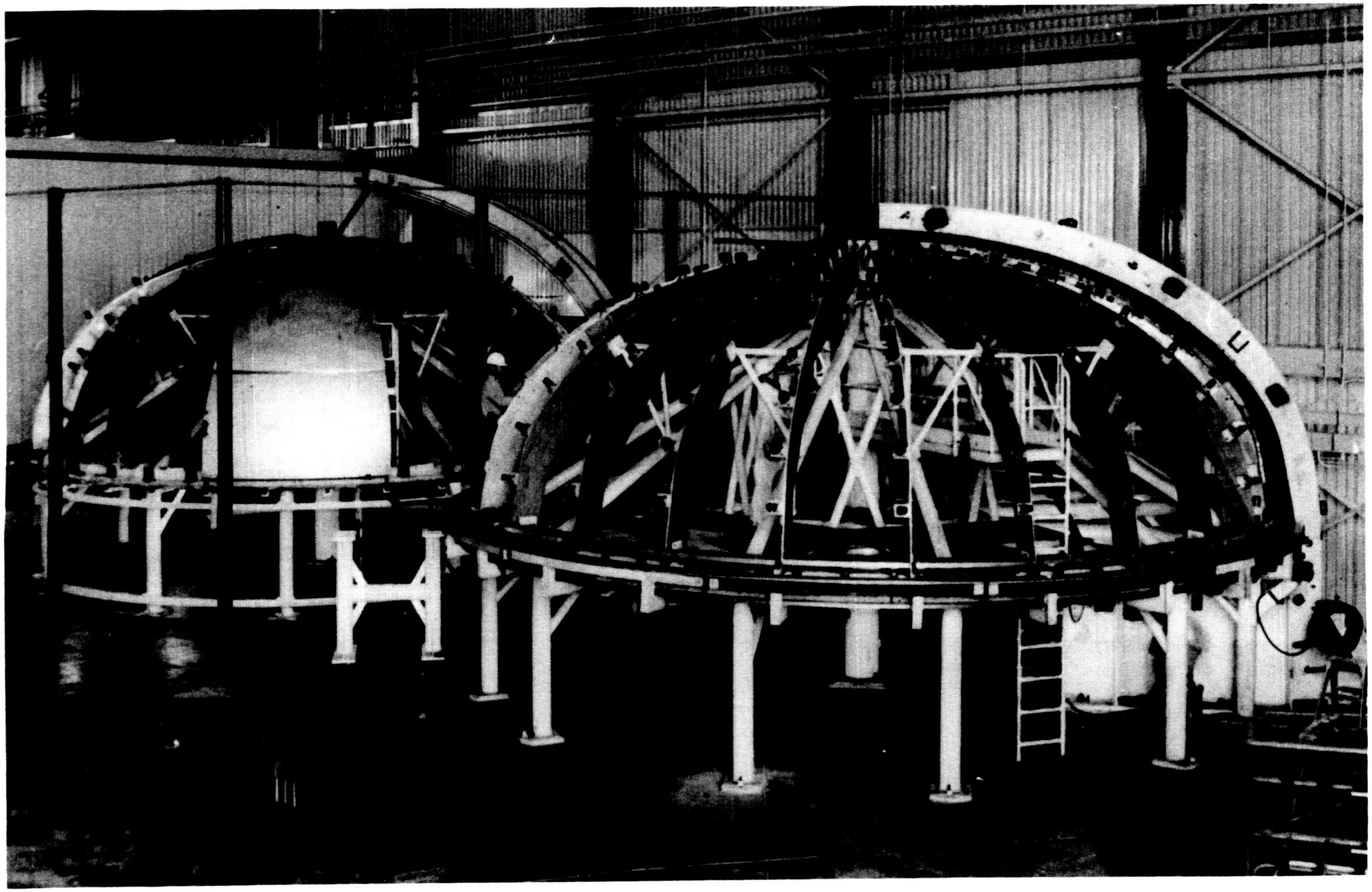
S-IC TEST STAND FOUNDATION AT MTO

This mass of concrete supported by steel pilings forms the base for the dual-position S-IC Static Test Stand at MTO. This is a June 17, 1964, photograph. Workmen excavated nearly 250,000 cubic yards of earth and drove 1640 pilings to depths of 97 feet below sea level to provide the foundation.



MTO FACILITY RISES

This June 1964 photo shows work proceeding on framework of the Data Acquisition Facility at MTO.



S-II BULKHEADS IN PRODUCTION

S-II stage bulkheads (tank ends) are welded on special fixtures at the Seal Beach facility of the S-II prime contractor, NAA's Space and Information Systems Division (S&ID).

RP-1 Transfer Dock and access road, Booster Transfer Dock and access canal; and construction of various other roads, railroads, and utilities.[90]

Contractor

Principal facilities for S-IC stage development, manufacture, and test are owned by the government and are described in the sections on MSFC, Michoud, and MTO facilities. The Boeing plant at Wichita, Kansas, owned by the S-IC prime contractor, also fabricates S-IC hardware.

Major S-II stage development and production facilities are at Downey, Seal Beach, and El Toro, California, and at Tulsa, Oklahoma. S-II stage R&D tests are performed at Santa Susana, California. Acceptance testing will be at MTO.

NASA owns the Downey plant, a former Air Force plant where engineering development and project management for the S-II stage are accomplished. S&ID operates this facility and is responsible for new construction. The S-II electro-mechanical mockup is located at Downey. Seal Beach facilities are leased from the Navy and operated for NASA by S&ID. At this location are the primary S-II engineering, fabrication, and assembly operations as well as vertical test and checkout facilities. Seal Beach facilities are constructed by NASA through the Navy Bureau of Yards and Docks. At Tulsa, in a facility owned by the Air Force, S&ID manufactures S-II components. In the NAA facility at El Toro S&ID makes fuel tank

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90. MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964, pp. 23-24.

bulkhead gores by means of explosive forming techniques. Test facilities at Santa Susana are provided by NASA through MSFC management.[91]

Facilities construction progress at Seal Beach during this period included completion of the Structural Static Test Facility and virtual completion of the Vertical Assembly and Hydrostatic Test Facility. Also near completion at the end of the period was the Pneumatic Test, Paint, and Packaging Building at Seal Beach. The site preparation design for the Vertical Checkout Facility was completed on May 15. At Downey workmen completed construction of the S-II Data Station. During this period also S&ID was building a Cryogenic Test Facility and a Pressurization Test Facility at Downey. Progress also occurred at Santa Susana, where by May 1 S&ID had completed superstructure mechanical and electrical systems, as well as procurement and installation of equipment and instrumentation, of the Coca I and Coca IV test stands. Coca I, the S-II battleship test stand, was structurally complete by the end of this period.[92]

S-IVB stage development and manufacturing plants are at Santa Monica and Huntingdon Beach, California, in plants owned and operated by DAC. R&D and acceptance testing of the S-IVB stage occur at SACTO.

The DAC facilities at Santa Monica consist of engineering, office, laboratory, and manufacturing space. DAC provides most of the facilities,

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91. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, pp. 7, 18-20, 23, 28, and 31.

92. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16,1964, p. 11; MSFC Saturn V Program Office, Saturn V QPR, April - June 1964, pp. 10-11; and MSFC PAO, Marshall Star, July 1, 1964, p. 9.

For further coverage of Santa Susana facilities see the F-1 and J-2 engine portions of this section.

although NASA has funded about $1.25 million for equipment there. At the Space Systems Center at Huntington Beach are located facilities for manufacture, assembly, and final checkout of the S-IVB stage for Saturn V and Saturn IB vehicles. NASA and DAC have conducted an extensive construction program, with NASA expenditures for equipment and instrumentation nearing $3 million. The Space Systems Center was dedicated late in 1963 and placed in partial operation. New facilities include a Space Simulator Building, Systems Integration Laboratory, Structural Test Laboratory, Production Test Facility, Assembly Building, Assembly and Checkout Tower complex, and Engineering and Administration Building.[93]

DAC owns SACTO, but NASA is spending about $30 million for construction of facilities there. The S-IVB test area at SACTO consists of an administrative and checkout area; the Beta Complex, which has two static test stands and a Control Center; and the Gamma Complex, utilized for testing of the S-IVB auxiliary propulsion system (APS).[94]

S-IVB facilities construction continued during this period at the major contractor locations. At Huntington Beach the Assembly and Checkout towers were operational and checkout facilities were nearly complete at the end of this period. Final phases of equipment installation were in progress at the Integration Laboratory, which is the proving ground for stage automatic checkout and the acceptance testing of stage GSE. At SACTO Beta 1 Test Stand, basic construction ended on May 1, 1964,

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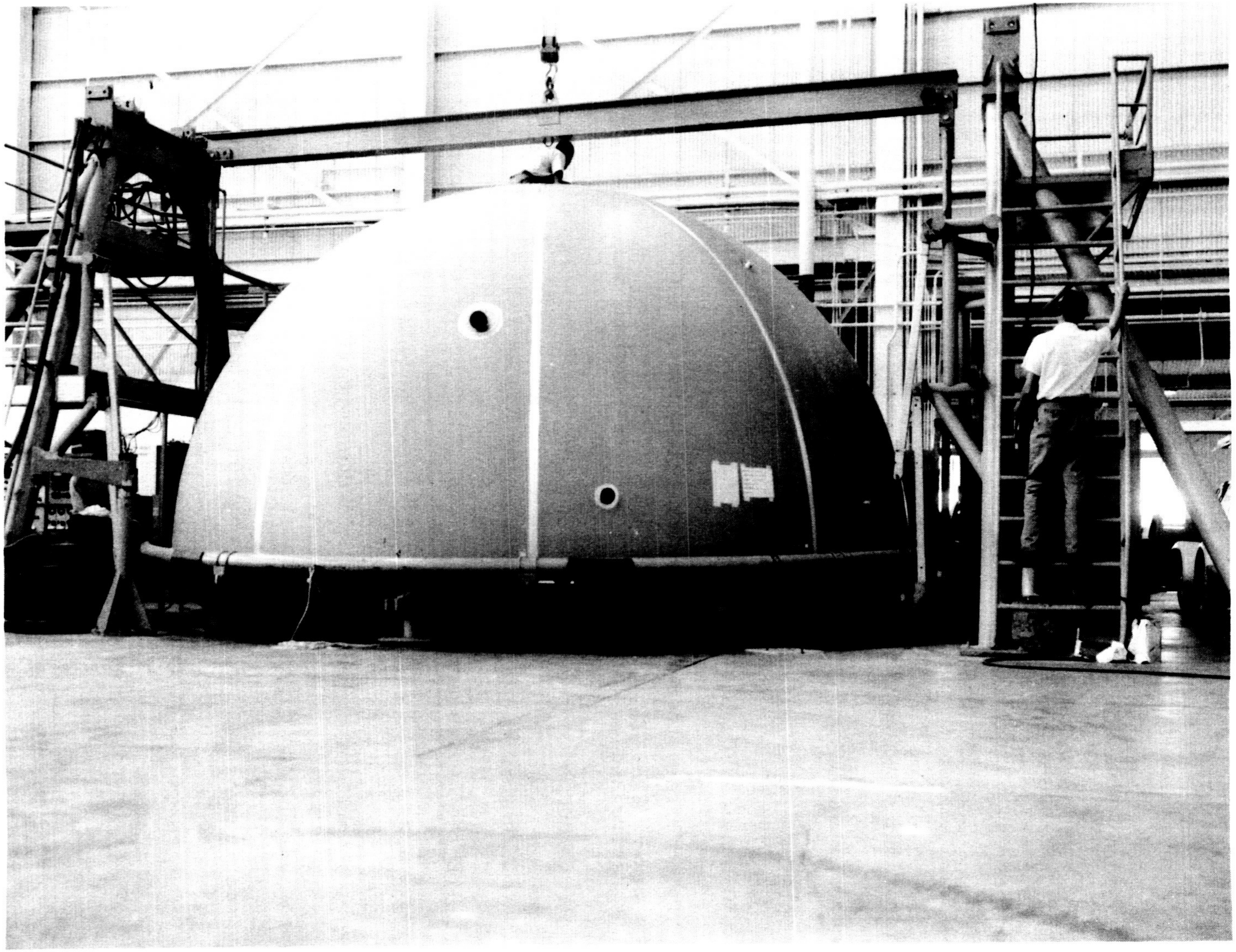
93. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, pp. 55 and 64.

94. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, pp. 72-74.



S-IVB BULKHEAD WELDED

The aft dome of an S-IVB stage is pictured in a weld fixture at Huntington Beach, California, plant of Douglas Aircraft Company.

and instrumentation placement in the facility was completed by June 1. Beta 3 Test Stand for acceptance testing was also near completion at the end of the period. Design of the S-IVB/V Checkout Facility started in June. Completion of the Gamma Complex for APS testing was expected by September 1964.[95]

F-1 and J-2 rocket engines are developed and produced principally at the contractor-owned plant of Rocketdyne at Canoga Park, California. Some engine component testing also is done at this plant. Rocketdyne performs facilities construction at Canoga Park under contract to MSFC. NASA, through MSFC management, is spending \$26.5 million for construction and equipment at this complex, using funds budgeted through Fiscal Year 1965.[96]

Rocketdyne accomplishes developmental and acceptance testing of F-1 engines at the Rocket Engine Test Site (RETS), Edwards Air Force Base, California. RETS is owned by the Air Force. Construction of facilities is directed by the Army Corps of Engineers for NASA. Approximately \$42 million for construction of facilities is budgeted for RETS through FY 1965. Test facilities at RETS consist of six F-1 engine test positions, with related support systems. Some F-1

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95. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964, p. 69; MSFC Saturn V Program Office, Saturn V QPR, April - June 1964, p. 10; and MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 35.

Both Beta Complex stands will later be converted into acceptance test stands.

96. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, p. 87.

components testing also is done at the Santa Susana Test Area, where two components test laboratories are located.[97]

The principal construction project at RETS during the current period was the new F-1 engine acceptance test complex, consisting of three firing stands, the Control Center, and Support Activities Building. Basic construction of the entire complex was completed during this period as follows: the Control Center was completed and checked out early in the period; Stand 1-D went into service when an engine was installed for a first firing scheduled July 1, 1964; Stand 1-C was activated June 10; the Support Activities Building was completed June 10 and occupied by Rocketdyne on June 15; and Stand 1-E was undergoing equipment installation at the end of the period, with activation scheduled by September 1, 1964.[98]

Also during this period engineers modified an existing test stand, 1-A, at RETS. The stand's flame deflector and eroded ground adjacent were reworked and reinforced. This work ended in June.[99]

Santa Susana is the major site for development and testing of the J-2 engine. Part of this facility is owned by the Air Force and part by NAA. Rocketdyne under the direction of MSFC supervises construction of the NASA facilities. Expenditure of about $36.6 million for

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97. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, pp. 31 and 103.

98. MSFC Hist. Office, History of MSFC, (MHM-8), p. 157; and MSFC Engine Project Office, Engine QPR, April-June, 1964, pp. 1 and 15.

99. MSFC Engine Project Office, Engine QPR, April-June, 1964, p. 15.

construction of facilities is budgeted at Santa Susana through FY 1965.[100] J-2 facilities at Santa Susana include six test stands and related facilities, and three components test laboratories. These J-2 test complexes are located in two areas, the Bowl Area and the Delta Area. Facilities construction during this period centered on modification and repair of existing facilities. The newest test positions, Delta 2-A and 2-B, went into service in December 1963. The Delta stands, capable of 500-second engine firings, were in use most of the period. During March Rocketdyne began preparing an estimate for conversion of Delta 1 Test Stand to a 500-second facility. An LH_2 explosion at Delta 2-A in April caused slight damage to support systems but forced only a brief interruption in testing. Vertical Test Stand 2 (VTS-2) was used for R&D as well as acceptance testing during much of this period. VTS-3A and VTS-3B were out of service much of the period because of modification work and also because of explosions and fires that caused damage during engine tests.[101]

Kennedy Space Center

Saturn V launches will occur at Launch Complex 39 (LC-39) at the Merritt Island Launch Area (MILA), which is a part of the NASA John F. Kennedy Space Center (KSC) in Florida. KSC has total responsibility for

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100. The H-1 engine and the S-II stage also are tested at this site.

101. MSFC Executive Staff, Management Information, Volume VII, 2nd Edition, January 1965, p. 31; MSFC Engine Project Office, Engine MPR, Dec. 16, 1963 - Jan. 31, 1964, p. 28, and March 1964, pp. 18-19; and Engine QPR, April-June 1964, pp. 32-33.

development of MILA, including LC-39. MSFC delegates to KSC the responsibility for preparation and checkout of Saturn V stages, launch vehicle, and active GSE at MILA. Since KSC has responsibility for development of LC-39 facilities, only general coverage of these facilities is provided in this report.[102]

LC-39 represents a new mobile concept in preparation and launch of space vehicles. The complex, now under construction, consists principally of a Launch Control Center, Vertical Assembly Building (VAB), three fixed launch pads, an Arming Tower, and crawlerways. Launch support equipment includes three Launcher/Umbilical Towers (LUT's) and two Crawler-Transporters. Saturn V vehicles will be assembled and checked out in a vertical position on LUT's inside the VAB; the vehicles will then move via the crawlerways to the launch pad area some distance away.[103]

The VAB is the largest of the LC-39 facilities (524 feet high, 513 feet deep, and 700 feet wide). Construction of the foundation for the structure ended June 1, 1964. About 13,000 tons of structural steel framing was in place by the end of this period, and construction was proceeding. The $66.3 million furnishing and outfitting contract for the VAB went on January 16, 1964, to a group of three firms: Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman Construction

102. MSFC Saturn V Program Office, Saturn V Program Development Plan, October 1964, p. 125.

103. MSFC Automation Board, MSFC Automation Plan, May 8, 1964, Revised June 1, 1964, pp. 81 and 84.

Company. Estimated overall construction progress on the VAB as of June 30, 1964, was 15 per cent, and completion was scheduled by February 1966.[104]

When the current period closed, work was proceeding satisfactorily on various appurtenances and adjunct facilities to the VAB, including crawlerways, water and sewer lines, utilities, roads and parking areas, fuel and gas storage facilities, and bridge cranes. Construction crews were pouring concrete and erecting columns and walls for the Launch Control Center.

Construction of the first launch pad, Pad A--with crawlerway, utilities, and foundation for the Arming Tower--was barely started when this period began. Work on the $19.2 million project was 30 per cent finished at the end of the report period and scheduled for completion in October 1965.[105]

Site preparation for Pad A and Pad B industrial water supply was nearly completed when this period opened. The completed project underwent final inspection on February 12. On March 17 Natkin and Company received the $1.7 million contract to construct the water

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104. Kennedy Space Center, Kennedy Space Center Technical Progress Report (KSC TPR), Jan. 24, 1964, p. 7; and Chief, Facilities Planning and Programming Office, KSC, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.

105. Chief, Facilities Planning and Programming Office, KSC, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.

system. Progress of construction at the end of this period was 15 per cent, with completion expected in March 1965.[106]

Rust Engineering Company was preparing the design for the Arming Tower when the period ended. Design completion was scheduled for July 7 and invitation for bids on July 21, 1964.

The contract for the Pad B and crawlerway surcharge and fill project was awarded in March 1964 to Gahagan Dredging Company. This $1.3 million project was approximately 30 per cent complete at the end of June 1964. Completion was scheduled by October 1964. The design for construction of Pad B and crawlerway began on April 13, 1964, and was 60 per cent complete when this report period ended.

On March 10 KSC started developing the criteria for the Operations Support Buildings for Pad A and Pad B. The criteria preparation was 90 per cent complete on June 30, 1964.[107]

Fabrication and erection of two major items of launch support equipment--the LUT's and the Crawler-Transporters--progressed during this period. Buildup of LUT No. 1 and two Crawler-Transporters was underway when the period began. Erection of LUT's at LC-39 and shop fabrication of the Crawler-Transporters proceeded satisfactorily throughout this period.[108]

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106. Kennedy Space Center, KSC TPR, Feb. 19, 1964, pp. 9 and 12; and Chief, Facilities Planning and Programming Office, KSC, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.

107. Kennedy Space Center, KSC TPR, March 19, 1964, p. 11; and Chief, Facilities Planning and Programming Office, KSC, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.

108. Kennedy Space Center, KSC TPR, Jan. 24, 1964, p. 7; and March 19, 1964, p. 15.

Saturn V and Related Studies

Major study effort during the current period encompassed a large number of in-house and contracted investigations. The Future Projects Office, the Systems Concepts Planning Office of the Aero-Astrodynamics Laboratory, and the Advanced Studies Office of the Propulsion and Vehicle Engineering (P&VE) Laboratory coordinated most of these studies, which involved work by many laboratories and offices of the Center. Studies were mainly concerned with the following categories: advanced launch vehicles, lunar systems, planetary systems, and advanced propulsion.

Advanced Launch Vehicles

Studies in this category included improvement of the present Saturn vehicles as well as design and development of post-Saturn and reusable space vehicles.

Receiving major attention was a broad Saturn V Improvement Study of possible increases in payload capability of the vehicle for future missions. Most MSFC laboratories contributed to this investigation. The early results indicated that the Saturn V's payload capability could be increased 40 to 50 per cent by redesigning stages, uprating engines, and/or adding solid motors for boost assist. In May P&VE Laboratory completed an interim study which would incorporate several improvements into some presently scheduled Saturn V vehicles. These minor changes would increase the launch vehicle's lunar injection capability to 95,000 pounds. MSFC top management approved these changes for incorporation in the seventh Saturn V flight vehicle. A more extensive in-house study considered a large number of possible vehicle modifications and selected probable growth configurations. In June 1964 six selected configurations were placed in the hands of contractors for more detailed study. The stage contractors (Boeing, S&ID, and DAC) received the study contracts for the respective stages; Rocketdyne, the F-1 and J-2 engine contractor, undertook the engine uprating studies. The series of contracted studies, costing about $2 million, will be completed during FY 1965.[109]

Another group of advanced launch vehicle studies concerned large reusable vehicles. The Center and contractors had completed several studies in this area prior to the current period. Among contracted studies completed in the January-June 1964 period were parallel investigations of A Reusable 10-Passenger Orbital Carrier Vehicle, by Lockheed Aircraft Corporation and NAA. Recommended in these studies was a two-stage (parallel) horizontal takeoff vehicle; also suggested was development of a high-pressure 300K LOX/LH_2 engine for use on the vehicle. Another completed study was one by Boeing of Reusable Ground Launch Vehicles in the 50-100 Ton Orbital Payload Class. In June 1964 MSFC awarded a contract to Boeing for a study of Recoverability and Reusability of the S-IC Stage, and contracts to Lockheed (first stage) and General

109. MSFC Propulsion and Vehicle Engineering Lab., Monthly Progress Report for Period May 12, 1964, Through June 11, 1964, pp. 5-6, cited hereafter as MSFC P&VE Lab., MPR for May 12 - June 11, 1964; MSFC Future Projects Office (FPO), Planning Information and Activity Report, July 1964, pp. 31-32 and 57-59; and MSFC PAO, Marshall Star, June 17, 1964, p. 1.

Dynamics (second stage) for studies entitled Reusable Orbital Transport--a follow-on to the study on the reusable 10-passenger vehicle. The Center prepared a work statement for a study to investigate the utilization of spent launch vehicle stages placed in orbit during a normal mission. The contract award was pending at the end of the period.[110]

A number of post-Saturn studies progressed during this period, and some were completed. Among completed studies was that on Advanced Nova Launch Vehicle, by General Dynamics and DAC. In process was a study on the Post-Saturn Launch Vehicle, by the Martin Company.[111]

In a related research program initiated during this period MSFC awarded to Lockheed a contract for Advanced Vehicle Technology studies.[112] The definitive research contract awarded on April 22, 1964, was valued at $1.7 million. Purpose of the research program is to develop advanced technology for large nuclear and chemical rockets. Also underway during the period were a number of in-house and contracted studies involving development and use of nuclear stages in conjunction with conventional and uprated Saturn V vehicles.[113]

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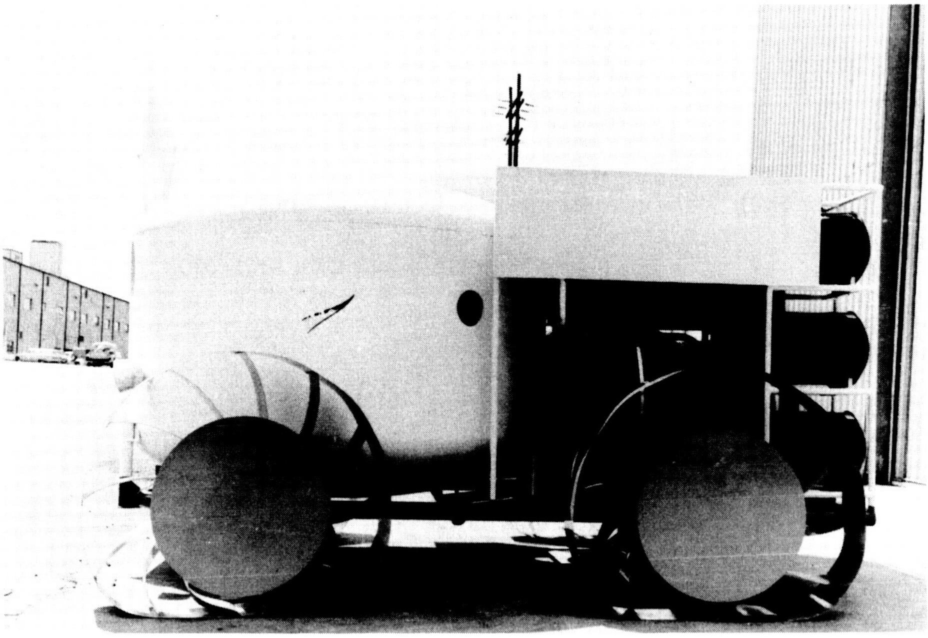
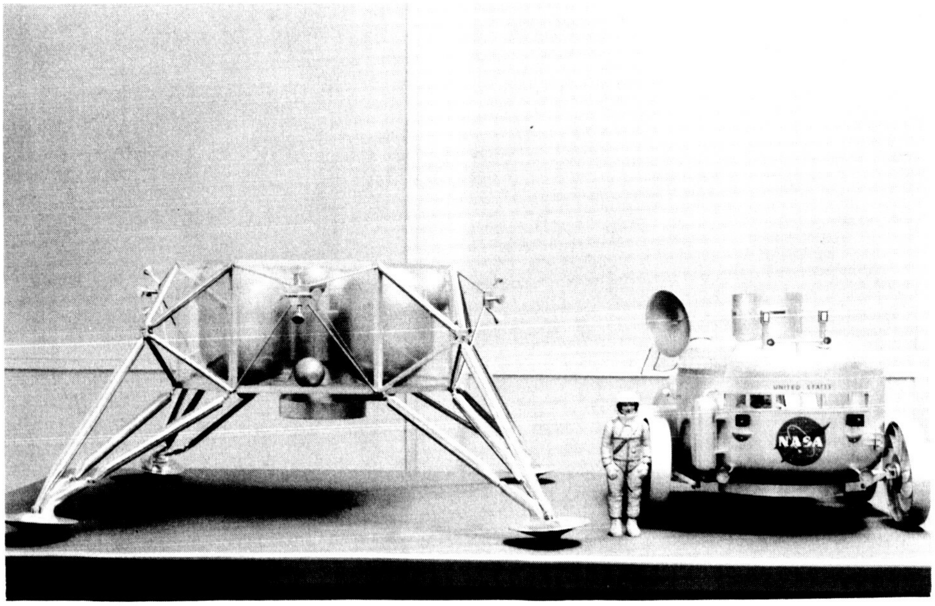
110. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 52, 54, 57, and 59; and MSFC P&VE Lab., MPR for Feb. 12 - Mar. 11, 1964, p. 12.

111. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 52-53 and 56.

112. This program was formerly covered under the RIFT (reactor-in-flight-test) contract with Lockheed, which NASA cancelled late in 1963.

113. Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Apr. 24, 1964; and MSFC P&VE Lab., MPR for June 12 - July 11, 1964, pp. 6-11.





MOLAB MODELS IN TWO SIZES

Bottom picture shows small models of major items in the proposed Apollo Lunar Logistic System (ALSS). At left is the LEM Truck, an Apollo Lunar Excursion Module modified to carry the roving mobile laboratory (Molab) shown at right. Upper picture is a full-size mockup of the Molab, which was built at MSFC. The ALSS concept grew out of MSFC studies for support of lunar explorers.

Lunar Systems

The objective of the lunar systems study program at MSFC is to define and analyze lunar exploration and logistics equipment and techniques for the Apollo and post-Apollo Lunar Excursion Module (LEM) period. A series of in-house studies prior to the current period led to contracted studies to investigate two lunar exploratory techniques, the Apollo Logistic Support System (ALSS) and the Lunar Exploratory Systems for Apollo (LESA). The ALSS is designed to support a scientific mission following the initial Apollo LEM landings; it would support two men on the lunar surface for a period up to 14 days. The system consists of a modified LEM with 7,000 pounds payload capability and a mobile lunar laboratory (Molab) to provide the LEM crew with shelter and surface mobility. The Systems Concepts Planning Office of the Aero-Astrodynamics Laboratory, with contractor support by Northrop Space Laboratories and Hayes International Corporation, developed the Molab concept. This development was in preparation for award of parallel contracted studies on ALSS to Boeing and the Bendix Corporation in June 1964. The Center awarded three LESA contracts: a study contract on Operations and Logistics for LESA went in June to General Dynamics; Westinghouse received a contract to study Communication and Control for LESA; the study Human Factors and Environmental Control for LESA went to Garrett Corporation in July following the close of this report period. The LESA study program is concerned with lunar exploration in the 1970's. The LESA technique centers around a basic shelter for lunar explorers on an extended stay--to support three men for up to three months. When augmented with resupply payloads it would support six men for a period of six months. A 17,000-pound shelter and an 8,000-pound Molab would be transported on each Saturn V logistic flight, which would be unmanned and direct from earth to moon.[114]

MSFC initiated several studies of cryogenic propulsion systems in modules of the Apollo spacecraft. Early in this period personnel investigated the feasibility of substituting LOX and propane and the RL10 engine instead of the storable propellant system in the conventional Service Module. Study results indicated that the engine modifications that would be required for such a substitution would be time consuming and costly. At the request of NASA Headquarters MSFC investigated use of a cryogenic space propulsion module as a backup for the present Service Module. A dual-engine configuration was selected over a single-engine configuration. The Center also performed a preliminary design study of a cryogenic landing stage for LEM; three basic configurations were investigated. It was determined that an RL10 engine replacing the storable-propellant propulsion system of the conventional LEM could be packaged in the present Saturn V with a considerable gain in performance. MSFC also started a conceptual design study to determine the cost of adapting a Centaur vehicle to perform the mission of the Apollo Service Module.[115]

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114. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 26, 28-29, and 57-59; and MSFC P&VE Lab., MPR for May 12 - June 11, 1964, pp. 7-9.

115. MSFC P&VE Lab., MPR for Dec. 12, 1963 - Jan. 11, 1964, pp. 8-9; Jan. 12 - Feb. 11, 1964, pp. 6-7; Feb. 12 - Mar. 11, 1964, p. 8; Mar. 12 - Apr. 11, 1964, p. 13; Apr. 12 - May 11, 1964, p. 4; and May 12 - June 11, 1964, p. 7.

In February 1964 Lockheed finished a study on the Preliminary Design of a Reusable Nuclear Lunar Ferry Vehicle. A related study, completed in February by Chance Vought/Astronautics, concerned an operations analysis of an advanced lunar transportation system employing nuclear propulsion.[116]

Orbital Systems

Orbital launch operations is defined as the procedures and techniques by which a vehicle is assembled, fueled, checked out, and launched from earth orbit. Chance Vought/Astronautics completed an advanced orbital launch operations study in February 1964. Results of this study indicated that an orbital launch facility was highly desirable for Mars, Venus, and lunar missions. They also indicated that a cryogenic tanker would be required to conduct these missions. Accordingly, in June 1964 the Center awarded two further contracts: an orbital tanker design study, to Lockheed, and an orbital launch facility study, to Boeing.[117]

Planetary Systems

Planetary mission studies concentrated on definition of and conceptual design for manned Mars and Venus missions. Past studies reveal that orbiting and landing missions during the 1970's are not practical without an advanced Saturn V and/or nuclear propulsion. Saturn V may be adequate,

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116. MSFC P&VE Lab., MPR for Feb. 12 - Mar. 11, 1964, p. 14; and MSFC FPO, Planning Information and Activity Report, July 1964, pp. 52-53.

117. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 23 and 56-57.

however, for manned flyby missions of these planets. A wide variety of planetary system studies occupied MSFC and contractors during this period.

A large number of contracted and in-house studies of planetary transportation systems involved nuclear and chemical/nuclear launch vehicles. Completed in February were parallel studies by General Dynamics and DAC of Manned Mars Exploration in the Unfavorable (1975-1985) Time Period. Data from these studies went into the larger MSFC study of planetary missions. Information from several EMPIRE (early manned planetary-interplanetary roundtrip expedition) studies also was channeled to the MSFC study. In March General Dynamics finished work on a preliminary study of a Nuclear Pulse Space Vehicle. MSFC completed in June 1964 a nuclear pulse vehicle performance study; the study determined the orbital and escape payload capabilities of a two-stage Saturn V vehicle utilizing a nuclear pulse second stage. Work continued at the Center on a study to determine desirability of using a nuclear modular stage concept for lunar and planetary missions. Midway in the report period MSFC began a study with the purpose of determining the maximum payload capability of Saturn V vehicles for unmanned flyby missions of the planet Saturn. Two configurations were under study, a standard Saturn V and an uprated version.[118]

Among Venus and Mars mission in-house studies of this period was A Mars Landing Mission in the 1982 Time Period. MSFC also performed a

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118. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 25-26 and 53; and MSFC FPO, Manned Mars Missions in the Unfavorable (1975-1985) Time Period, Executive Summary Report, (NASA TM X-53140), Sept. 24, 1964.

brief study of A Mars Reconnaisance Mission via a Venus Swingby Mode. Considered in this latter study was a Mars landing after swinging by Venus, utilizing a nuclear stage with two 250K engines; a two-module stage and a single-tank stage were studied. A Mars and Venus Flyby study at the Center ended in June 1964; the study analyzed vehicle design and performance requirements for manned flyby missions of Mars and Venus employing a 250K Phoebus-class nuclear engine for propulsion. Also near the end of this period the Center completed preliminary weight studies of life-support systems for Mars and Venus flyby missions. Contracted studies in this area included Mission Requirements for Manned Mars and Venus Exploration, and Manned Mars and Venus Exploration, both awarded in June to General Dynamics.[119]

Advanced Propulsion

MSFC efforts in advanced propulsion studies cover the complete spectrum of propulsion systems and their integration into launch vehicles. Included are chemical, nuclear, and electrical propulsion studies. Among solid motor studies completed during this period was an Applications Study for Large Solid Motors, performed by Boeing. MSFC conducted various studies of solid motor applications, principally in connection with uprating Saturn vehicles. The Center also considered the feasibility of developing a high-pressure LOX/hydrogen rocket engine for use as a

119. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 54-55 and 57; and MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964, p. 5; May 12 - June 11, 1964, pp. 10-11; and June 12 - July 11, 1964, pp. 7, 10-12, and 16.

post-Saturn second stage engine. Nuclear propulsion technology included a NERVA[120] definition study. Center personnel continued throughout the period this effort to define the weight of an operational NERVA engine for future missions. Also investigated were gaseous core and metallic core reactors for nuclear engines. Electrical propulsion studies were mainly in the area of the nuclear electric systems, including SNAP (space nuclear auxiliary propulsion).[121]

Funding

Commitments for the Saturn V program during the period January 1 - June 30, 1964, totalled $249,696,000. The total of commitments was divided into the following allotments: S-IC Stage, $118,971,000; S-II Stage, $15,748,000; S-IVB Stage, $32,048,000; Instrument Unit, $29,379,000; Ground Support Equipment, $2,562,000; F-1 Engine procurement, $18,750,000; J-2 Engine procurement, $11,475,000; Vehicle Support, Integration, Checkout, and Reliability, $20,763,000.

Construction of facilities for the Saturn V program during the six-month period amounted to $87,117,000.[122]

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120. NERVA stands for nuclear engine for rocket vehicle application. The engine's source of power is a solid-core (graphite) reactor.

121. MSFC FPO, Planning Information and Activity Report, July 1964, pp. 29-30 and 54; and MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964, p. 9, and June 12 - July 11, 1964, p. 9.

122. Information supplied by Louis Snyder, Financial Management Office, MSFC, January 1965.

Summary

Fabrication and assembly of ground test hardware occupied MSFC and Saturn V industrial contractors in the January--June 1964 period.

In the S-IC stage development program the Boeing prime contract increased in value by $55 million during the period. MSFC completed the first S-IC structural test component, the test fuel tank, and prepared it for test. With components provided by Boeing, MSFC also made progress in structural assembly of the first two complete stages: the S-IC-T (static test) and the S-IC-S (structural test) stages.

S-II stage research and development occurred primarily at North American Aviation's S&ID plants in California. The prime contractor began activation of the S-II battleship and reported progress in assembly and subassembly of structural, all-systems, and facilities checkout stages. Test operations on the S-II electro-mechanical mockup began following installation of all five J-2 simulator engines.

A major change in the Saturn V/S-IVB program resulted in redesign of the LH_2 venting system and redesign of the APS engine configuration. DAC also improved stage internal insulation. The changes improved performance and reduced weight, increasing the stage's payload capability about 3,500 pounds. The prime contractor also completed and certified all major tooling, began design verification and qualification testing, and started preparation for hot-firing of the S-IVB battleship and APS. DAC reported significant progress in assembly of ground test stages. The structural and hydrostatic test stage was in the hydrostatic test

tower at the end of the period; preparation was underway for placement of insulation in the dynamic test stage; the all-systems stage was structurally complete and ready for insulation installation; and assembly was underway on the facilities checkout stage.

During this period MSFC completed several contract actions concerning the vehicle instrument unit. In May Bendix received a contract to provide the first three of 29 ST-124M stabilized platform systems; the Bendix proposal for the 26 other platform systems was under evaluation at the end of the period. Following negotiations in February, MSFC also was evaluating IBM proposals covering Saturn V prototype and breadboard guidance computers and data adapters. In March the Center awarded to IBM the $5.5 million contract for procurement, integration, and checkout of the instrument unit. In April NASA announced selection of IBM as "lead contractor" for development of the Saturn IB/V instrument unit. MSFC was evaluating the IBM contract proposal when this period ended. MSFC completed assembly of the first instrument unit for ground test and started work on additional units.

Accomplishments in the area of ground support equipment included completion of negotiations with RCA for 19 ground computer systems, completion and test of the first S-IC land transporter, receipt of five Navy barges for transport of Saturn V stages, and completion of plans to convert another ship for shipment of S-II and S-IVB stages. MSFC established the Saturn V automation plan and automation techniques.

On March 30 MSFC awarded to Rocketdyne a $158.4 million definitive contract for production of 76 F-1 engines; four contract modifications later in the period for additional hardware and services added $22.3 million to the value of this contract. Rocketdyne performed 120 firing tests and continued to solve engine and component problems. The combustion instability problem appeared near solution at the end of the period following selection of the configuration for the FRT engine. MSFC decided to delay FRT until late 1964. Rocketdyne delivered the second production F-1 engine on April 1.

The J-2 engine contract covering production of 55 engines by Rocketdyne received NASA approval on June 24. Meanwhile, Rocketdyne continued engine development and test at facilities in California. Approximately 196 engine firings occurred. Several component problems were solved and the FRT engine configuration was selected. Rocketdyne delivered to S&ID the last of five operational simulator J-2 engines for use on the S-II stage electro-mechanical mockup. NASA accepted delivery of the first two production J-2 engines.

Facilities construction proceeded at government and contractor locations. Construction progress at Huntsville included major structural work on the S-IC Test Stand, F-1 Engine Test Stand, Saturn V Dynamic Test Stand, and J-2/S-IVB Test Stand, among others. Work began on the Saturn V Dock Facility and on the S-IC Checkout Complex and Saturn V Breadboard Facility. The pace of construction quickened at Michoud Operations and Mississippi Test Operations. Several facilities for development, production, and test of stages and engines went into service at contractor and government plants, principally in California. Kennedy Space Center's Launch Complex 39 began to take form.

Saturn V studies during this period concentrated on improvement of the launch vehicle by design changes and increased thrust for possible future missions. Other major studies investigated lunar logistics systems, advanced vehicle systems, and means of exploring the planets Venus and Mars.

APPENDICES

APPENDIX A: SATURN I CHRONOLOGY

SATURN I CHRONOLOGY

January--June 1964

January 14 - The service module of the BP-16 Apollo boilerplate spacecraft, scheduled for test during the SA-9 flight, arrived at MSFC. MSFC began modification of the module, adapter, and BP-16 insert to support the first Pegasus capsule. (1)

January 22 - The Douglas Aircraft Company (DAC), manufacturer of the S-IV stages, postponed the first attempt to static fire the All Systems Vehicle (ASV) because of a LOX umbilical leak. (2)

January 23 - An LH_2 fill and drain valve stuck in a partially open position and resulted in postponement of the second firing attempt of the S-IV ASV. (3)

January 24 - During the terminal stages of the countdown for a third attempt to static fire the S-IV ASV, the vehicle exploded and burned. Investigation showed the immediate cause of explosion to be overpressurization of the stage oxidizer tank. (4)

January 27 - Technicians at the Kennedy Space Center (KSC) scrubbed a first attempt to launch SA-5 because of a test flange inadvertently left in the S-I stage LOX replenish line. (5)

January 28 - Countdown for the second attempt to launch SA-5 began at 11:00 p. m. EST. (6)

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1. MSFC Industrial Operations, Saturn Monthly Progress Report, January 16, 1964 - February 16, 1964, p. 4, hereafter cited MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964.
2. J. B. Gayle, Propulsion and Vehicle Engineering Lab., MSFC, Investigation of S-IV All Systems Vehicle Explosion, Apr. 27, 1964, pp. 1-3; and MSFC Industrial Operations, Saturn MPR, Dec. 16, 1963 - Jan. 16, 1964, pp. 1 and 5.
3. J. B. Gayle, P&VE Lab., MSFC, Investigation of S-IV All Systems Vehicle Explosion, Apr. 27, 1964, pp. 1-3.
4. J. B. Gayle, P&VE Lab., MSFC, Investigation of S-IV All Systems Vehicle Explosion, Apr. 27, 1964; and Dr. Kurt Debus, Chairman, Investigating Committee, report, "S-IV All Systems Stage Incident - January 24, 1964," May 11, 1964.
5. MSFC P&VE Lab., Saturn SA-5 Vehicle Data Book, Flight Report Supplement, p. VI-1.
6. MSFC P&VE Lab., Saturn SA-5 Vehicle Data Book, Flight Report Supplement, p. VI-1.

January 29 - NASA successfully launched the first Saturn (SA-5) to have both first and second stages live. This flight tested the performance of the complete vehicle system and its capability to place an inert payload of 37,700 pounds in an earth orbit. (7)

February 10 - MSFC completed structural fabrication of the SA-8 instrument unit. (8)

February 11 - MSFC completed prestatic checkout of the S-I-9 stage. (9)

February 13 - DAC shipped the S-IV-7 stage via the Pregnant Guppy aircraft to the Sacramento Field Test Station (SACTO) for static testing. (10)

February 14 - After a delay since January to allow replacement of critical tubing assemblies, poststatic checkout resumed on S-I-7. (11)

February 17 - MSFC installed S-I-9 in the East Area Static Test Tower and began preparations for static firing the stage. (12)

February 18 - Chrysler Corporation Space Division (CCSD), manufacturer of the final two S-I stages (S-I-8 and S-I-10), completed prestatic checkout of S-I-8. (13)

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7. MSFC Saturn Flight Evaluation Working Group, Results of the Fifth Saturn I Launch Vehicle Test Flight, (MPR-SAT-FE-64-15), Apr. 1, 1964, p. 5.

8. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 4.

9. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 4.

10. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16 - September 30, 1964, p. 6, hereafter cited MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964.

11. MSFC Quality and Reliability Assurance Lab., Historical Data, January 1 - June 30, 1964, July 29, 1964, p. 3, hereafter cited as MSFC Quality Lab., Hist. Data, Jan. 1 - June 30, 1964.

12. MSFC Test Lab., Test Laboratory Historical Report, January 1, 1964 - June 30, 1964, p. 1, hereafter cited MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964.

13. MSFC Michoud Operations, Historical Report, Michoud Operations, January 1, 1964 - June 30, 1964, pp. 1 and 31, hereafter cited as MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964.

February 18 - The barge Promise, which had left Huntsville February 7 carrying the SA-6 S-I stage and instrument unit, arrived at the Kennedy Space Center. (14)

February 19 - NASA Manned Spacecraft Center (MSC) transferred its boilerplate Apollo spacecraft (BP-13) and associated equipment; transfer was from the Space and Information Systems Division (S&ID) at Downey, California, to KSC. (15)

February 20 - KSC erected the S-I-6 stage on Pad B at Launch Complex 37 (LC-37B). (16)

February 22 - The S-IV-6 stage arrived at KSC aboard the Pregnant Guppy aircraft. (17)

- DAC personnel installed the S-IV-7 stage in Test Stand 2B at SACTO and began preparations for static firing the stage. (18)

March 2 - MSFC began assembly of the S-IU-9. (19)

March 13 - MSFC successfully static fired the S-I-9. The short-duration firing lasted 35 seconds. (20)

March 19 - KSC technicians mated the S-IV-6 stage to the S-I-6 stage at LC-37B. (21)

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14. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 4.

15. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 4.

16. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 4.

17. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 4.

18. MSFC Test Lab., Test Laboratory Monthly Progress Report, February 12 - March 12, 1964, p. 38, hereafter cited MSFC Test Lab., Test MPR, Feb. 12 - Mar. 12, 1964, p. 38.

19. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 3.

20. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 1.

21. MSFC Public Affairs Office (PAO), Press Release, "NASA to Launch Sixth Saturn," May 20, 1964.

March 23 - NASA released the official mission assignment for the SA-10. According to this assignment, SA-10's primary flight mission includes confirmation of vehicle structure and performance capability and the orbiting of an unmanned Apollo spacecraft. As the bonus mission SA-10 will carry into orbit a third Pegasus capsule experiment. (22)

- Activity at LC-37B included mating of the S-IU-6 to the S-IV stage of the SA-6 flight vehicle. (23)

March 24 - MSFC test personnel successfully conducted a long-duration (145-second) static firing of the S-I-9 stage. (24)

In March - MSFC performed mechanical and environmental tests of the upper stages of a dynamic test vehicle; included were Pegasus meteoroid system load and separation tests. This tested vehicle represents the final configuration of the Saturn I research and development vehicle. (25)

April 2 - KSC technicians mated BP-13 to SA-6. Addition of the spacecraft increased the height of the vehicle about 26 feet over that of its predecessor, the SA-5. (26)

April 3 - Personnel completed the electrical mating of the S-I-6, S-IV-6, and S-IU-6 and began prelaunch checkout of the SA-6 vehicle. (27)

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22. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 18.
23. MSFC PAO, Press Release, "NASA to Launch Sixth Saturn," May 20, 1964.
24. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 1.
25. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 4.
26. Kennedy Space Center (KSC), Press Release, Apr. 2, 1964.
27. MSFC PAO, Press Release, "NASA to Launch Sixth Saturn," May 20, 1964.

April 8	-	MSFC removed the S-I-9 from the static test stand and transferred it to the Manufacturing Engineering area for modification and repair operations. (28)
April 15	-	DAC completed S-IV-10 leak checks and moved the stage to the assembly area. (29)
April 17	-	CCSD shipped the S-I-8 stage via the barge <u>Promise</u> from Michoud to Huntsville. (30)
April 25	-	The S-I-8 stage arrived in Huntsville from Michoud, and test personnel began preparations for static firing the stage. (31)
April 27	-	On completion of S-IV-8 assembly DAC began the stage checkout. (32)
April 28	-	DAC completed checkout of the S-IV-9 stage and began preparations for shipping the stage to SACTO for static firing. (33)
April 29	-	DAC successfully static fired the S-IV-7 stage for a duration of 485 seconds. The successful firing followed two abortive attempts on April 21 and 27. (34)
May 4	-	CCSD began prestatic checkout of the S-I-10, the final S-I stage. (35)

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28. MSFC Test Lab., <u>Hist. Report, Jan. 1 - June 30, 1964</u>, p. 1.
29. MSFC Saturn I/IB Program Office, <u>Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964</u>, p. 16.
30. MSFC Michoud Operations, <u>Hist. Report, Jan. 1 - June 30, 1964</u>, p. 1.
31. MSFC Michoud Operations, <u>Hist. Report, Jan. 1 - June 30, 1964</u>, p. 1.
32. MSFC Saturn I/IB Program Office, <u>Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964</u>, p. 14.
33. MSFC Saturn I/IB Program Office, <u>Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964</u>, p. 13.
34. MSFC Saturn I/IB Program Office, <u>Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964</u>, p. 6.
35. MSFC Michoud Operations, <u>Hist. Report, Jan. 1 - June 30, 1964</u>, p. 2.

May 5 - MSFC began poststatic checkout of the S-I-9 stage. (36)

May 8 - DAC installed the S-IV-9 stage in Test Stand 2B at SACTO and began static test preparations. (37)

May 12 - MSFC completed the poststatic checkout of S-I-7. (38)

May 20 - MSFC began the final series of dynamic tests of the Saturn I configuration. The vehicle undergoing tests simulated the configuration of the SA-9, SA-8, and SA-10 vehicles and included the Pegasus capsule and the Apollo spacecraft. (39)

May 26 - Launch of the SA-6 was scrubbed because of an environmental control system compressor malfunction in the ground facilities equipment. (40)

- The first static firing of the S-I-8 stage lasted 48.94 seconds. (41)

May 27 - Countdown for the SA-6 launch began at 11:55 p. m. EST. (42)

May 28 - NASA successfully launched the second Block II Saturn (SA-6) from LC-37B at Cape Kennedy, thus reaffirming the performance capability of the complete Saturn I vehicle. Also tested was the first closed-loop operation of the SA-6 guidance system. As part of the flight test, the SA-6 placed the first unmanned boilerplate model of the Apollo spacecraft into earth orbit. (43)

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36. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 13.
37. MSFC Test Lab., Test MPR, June 12 - July 12, 1964, pp. 38-39.
38. MSFC Quality Lab., Hist. Data, Jan. 1 - June 30, 1964, p. 3.
39. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 4.
40. MSFC P&VE Lab., Evaluation of Flight Test Propulsion Systems and Associated Systems, Saturn Vehicle SA-6, Aug. 28, 1964, p. 163.
41. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 1.
42. MSFC P&VE Lab., Saturn SA-6 Vehicle Data Book, Flight Report Supplement, p. VI-1.
43. MSFC P&VE Lab., Saturn SA-6 Vehicle Data Book, Flight Report Supplement, p. VI-1.

May 28 - MSFC shipped the S-I-7 stage and the S-IU-7 aboard the barge Promise to Cape Kennedy. (44)

June 7 - The S-I-7 and the S-IU-7 arrived at Cape Kennedy. Arriving simultaneously was the Pregnant Guppy aircraft and its cargo of the BP-15 Apollo spacecraft service module and adapter. (45)

June 9 - KSC technicians completed erection of S-I-7 on LC-37B. (46)

June 11 - The S-I-8 stage successfully performed a full-duration (145.61-second) firing at MSFC. (47)

June 12 - The S-IV-7 stage arrived at KSC aboard the Pregnant Guppy aircraft. (48)

June 15 - MSFC began assembling the SA-8 instrument unit. (49)

June 17 - The command module of the BP-15 Apollo spacecraft, shipped via aircraft from Downey, California, arrived at Cape Kennedy. (50)

June 19 - KSC personnel erected S-IV-7 atop the S-I-7 stage on LC-37B. (51)

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44. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.
45. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.
46. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.
47. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, p. 1.
48. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.
49. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 16.
50. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.
51. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.

June 22 - KSC technicians completed erection of the S-IU-7 atop the S-IV-7. (52)

June 29 - The S-I-8 stage arrived at Michoud Operations; it had been removed from the static test stand on June 23 and shipped from Huntsville June 24. (53)

52. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 6.

53. MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964, pp. 1 and 31.

APPENDIX B: SATURN IB CHRONOLOGY

SATURN IB CHRONOLOGY

January--June 1964

January 24 - In the week ending this date NASA approved extension of letter contracts to International Business Machines Corporation (IBM) through April 22, 1964, for design and development of data adapters and digital computers. (1)

January 28 - MSFC administratively changed the S-IB stage contract to include design, fabrication, and test of a new fin configuration. (2)

February 3 - NASA modified by letter action a contract with Bendix Corporation to cover procurement of ST-124M platform systems for the first two Saturn IB instrument units (S-IU-201 and 202) and for a test unit. (3)

In February - Douglas Aircraft Company (DAC) began fabricating S-IVB/IB-2 at Santa Monica, California. (4)

- MSFC distributed the operational plan for the Saturn IB instrument unit (IU) Systems Development Breadboard Facility. The facility will be used in IU design and development operational tests. (5)

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1. Garland G. Buckner, Chief, Purchasing Office, MSFC, to H. H. Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Report of Activities for Week Ending January 24, 1964," Jan. 24, 1964.

2. MSFC Michoud Operations, Historical Report, January 1 - June 30, 1964, pp. 18-20, hereafter cited MSFC Michoud Operations, Hist. Report, Jan. 1 - June 30, 1964.

3. MSFC Industrial Operations, Saturn Monthly Progress Report, January 16, 1964 - February 16, 1964, p. 7, hereafter cited MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964.

4. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 6.

5. MSFC Astrionics Laboratory (Lab.), Saturn Monthly Progress Report, February 1964, pp. 6-7.

March 10 - NASA awarded IBM a contract for digital computers and data adapters for the Saturn IB IU's. (6)

March 24 - NASA issued the first Flight Missions Assignment Document for the Saturn IB program. (7)

March 26 - MSFC issued Bendix Corporation a request for quotation (RFQ) for 26 ST-124M stabilized platform systems for use in Saturn IB and Saturn V IU's. Already covered by an existing contract were platform systems for two Saturn IB flight IU's and one test unit. (8)

In March - MSFC completed a plan for standardization of computer programming for space vehicle applications and established Automation Sub-Board No. 4 to implement the plan. This will include coordination of automated checkout, static firing, and launch control. (9)

- Rocketdyne, a division of North American Aviation, delivered the first three 200,000-pound-thrust (200K) H-1 production engines to Chrysler Corporation Space Division (CCSD) at Michoud. (10)

- NASA approved the award of a $5.5 million contract to IBM covering the first phase of IBM's IU integration effort. IBM will develop the test plan, program plan, and procurement specifications to be used in the hardware phase of the IU program. (11)

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6. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, pp. 2 and 6.
7. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16, 1964 - September 30, 1964, p. 19; hereafter cited as MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964.
8. MSFC Astrionics Lab., Saturn Monthly Progress Report, March 1964, p. 4.
9. MSFC Quality and Reliability Assurance Lab., Historical Data, Quality and Reliability Assurance Laboratory, January 1 - June 30, 1964, July 29, 1964, p. 11.
10. MSFC Engine Project Office, Monthly Progress Report, F-1, H-1, J-2, and RL-10 Engines, March 1964, p. 11.
11. Garland G. Buckner, Chief, Purchasing Office, MSFC, to H. H.

April 17 - MSFC completed contract negotiation with Avco Corporation for 62 cold plates for use in IU environmental control systems. (12)

April 29 - MSFC modification of Bendix Corporation's contract NAS8-5399 made final the purchase of three ST-124M platform systems procured by letter action February 3. (13)

April 30 - MSFC approved and released the criteria for the Saturn IB S-IB stage fin design. (14)

In April - CCSD began assembling the major structural components for the first flight S-IB stage (S-IB-1). (15)

- DAC began assembling the first S-IVB/IB flight vehicle (S-IVB/IB-1) in the assembly facility at Huntington Beach, California. (16)

- MSFC instructed General Dynamics/Fort Worth, an IU subcontractor, to redesign the IU structure to permit heavier vehicle loads. (17)

- NASA selected IBM as the "lead contractor" to develop the IU's for Saturn IB and Saturn V vehicles. In this role IBM will have responsibility for integration of all IU systems; MSFC will initially supply components and equipment. (18)

Gorman, Deputy Director, Administrative, MSFC, memo, subject, "Report of Activities for Week Ending January 24, 1964," Jan. 24, 1964, and "Report of Activities for Week Ending February 7, 1964," Feb. 7, 1964; and MSFC Public Affairs Office (PAO), Press Release, Mar. 31, 1964.

12. MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1 - June 30, 1964, p. 7.

13. John Harlow, Instrument Unit Office, Saturn I/IB Program Office, MSFC, interviewed Apr. 7, 1964.

14. MSFC Propulsion and Vehicle Engineering (P&VE) Lab., Monthly Progress Report for Period April 12, 1964, Through May 11, 1964, pp. 61 and 63, hereafter cited MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964.

15. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 19.

16. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 23 and 31.

17. John Harlow, Instrument Unit Office, Saturn I/IB Program Office, MSFC, interviewed Apr. 7, 1964; and MSFC P&VE Lab., MPR for Apr. 12 - May 11, 1964, p. 69.

18. MSFC PAO, Press Release, Apr. 20, 1964.

May 1	- MSFC released an RFQ to IBM to cover effort as lead contractor in developing the IU for Saturn IB and Saturn V vehicles. (19)
May 19	- MSFC negotiated cost proposals with DAC for work on one set of ground support equipment and for additional S-IVB/IB stages. (20)
In May	- DAC completed joining the liquid oxygen (LOX) tank, the liquid hydrogen (LH_2) cylinder, and the LH_2 forward dome to form the propellant tank assembly of S-IVB/IB-1. (21)
June 1	- IBM submitted to MSFC a contract proposal for effort as the lead contractor in development of Saturn IB and Saturn V IU's. (22)
June 10	- MSFC requested a quotation from DAC covering manufacture of eight S-IVB/IB stages and a set of ground support equipment. (23)
June 11	- MSFC contracted with Radio Corporation of America for 19 additional ground computers for use in the Saturn IB and Saturn V programs. (24)
June 19	- CCSD began clustering of the S-IB-1 stage in the assembly fixture at Michoud. (25)

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19. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25; and MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1 - June 30, 1964, p. 7.
20. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 21.
21. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, pp. 23 and 31.
22. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25.
23. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 21.
24. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 25.
25. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, Mar. 16 - Sept. 30, 1964, p. 19.

APPENDIX C: SATURN V CHRONOLOGY

SATURN V CHRONOLOGY

January--June 1964

January 16 - The $66.3 million contract for furnishing and outfitting the Vertical Assembly Building (VAB) at Launch Complex 39 (LC-39), Kennedy Space Center, went to Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman Construction Company. (1)

January 18 - North American Aviation's Space and Information Systems Division (S&ID) successfully completed LOX tank chill tests of the S-II battleship stage. (2)

January 27 - Rocketdyne Division of North American Aviation delivered the last of five operational simulator J-2 engines to the S-II stage contractor for use on the S-II electro-mechanical mockup. (3)

In January - Workmen finished clearing trees from the 850-acre Saturn V test complex at MSFC's Mississippi Test Operations (MTO). (4)

February 11 - MSFC and the International Business Machines Corporation (IBM) began negotiations on a contract covering Saturn V prototype and breadboard guidance computers and data adapters. (5)

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1. Chief, Facilities Planning and Programming Office, Kennedy Space Center, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.

2. MSFC Industrial Operations, Saturn Monthly Progress Report, January 16, 1964 - February 16, 1964, p. 9, cited hereafter as MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964.

3. MSFC Engine Project Office, Monthly Progress Report, F-1, H-1, J-2, and RL10 Engines, December 15, 1963 - January 31, 1964, p. 21; cited hereafter as MSFC Engine Project Office, Engine MPR, Dec. 15, 1963 - Jan. 31, 1964.

4. MSFC Mississippi Test Operations, Historical Report, Mississippi Test Operations, January 1, 1964 - June 30, 1964, p. 13; cited hereafter as MSFC MTO, Hist. Report, Jan. 1 - June 30, 1964.

5. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 10.

In February - Construction crews at MSFC completed erection of F-1 Engine Test Stand steel superstructure and flame deflector. (6)

- Workmen began to install the flame deflector of the S-IC Static Test Stand at MSFC. Work also proceeded on installation of the stand's load platform and technical systems. (7)

- MSFC completed assembly of the first S-IC transporter and modification of the M-26 power unit for the transporter. (8)

- MSFC directed Douglas Aircraft Company (DAC) to increase the battleship LH_2 tank pressure in order to meet J-2 engine start requirements. (9)

March 6 - Technicians moved the S-IC test fuel tank, first major Saturn V component assembled at MSFC, to the Load Test Annex and began preparations for load proof testing. (10)

March 30 - NASA awarded to Rocketdyne the production contract for 76 F-1 engines. Value of the contract was $158.4 million. (11)

In March - Naval architects approved the modification design proposal for the USNS Point Barrow and instructed the Military Sea Transport Service (MSTS) to

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6. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 12.
7. MSFC Industrial Operations, Saturn MPR, Jan. 16 - Feb. 16, 1964, p. 11.
8. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 10.
9. Douglas Aircraft Company, Missiles and Space Systems Division, Saturn S-IVB Annual Technical Progress Report, July 1963 - June 1964, cited hereafter as DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964.
10. MSFC Industrial Operations, Saturn MPR, Feb. 16 - March 16, 1964, p. 7.
11. NASA, News Release No. 64-48.

In March - proceed with plans for the modification. The ship operated by MSTS, will transport S-II and S-IVB stages from the West Coast to Michoud Operations, MTO, and Cape Kennedy. (12)

- Steel erection of the Saturn V Dynamic Test Stand superstructure ended at MSFC. (13)

- Rocketdyne selected a promising thrust chamber injector for the J-2 flight rating test (FRT) engine and released the design for production. (14)

- MSFC began assembly of the S-IC-T (static test stage) LOX tank and neared completion of the stage's fuel tank. Boeing workmen at Michoud continued to build the S-IC-T forward skirt and intertank assemblies. (15)

Late March - MSFC awarded to IBM a $5.5 million contract calling for procurement, integration, and checkout of the Saturn V instrument unit. (16)

April 1 - The second production F-1 engine, F-1002, arrived at MSFC for use in static firing tests. (17)

April 13 - MSFC and Rocketdyne began negotiation of the Rocketdyne contract proposal covering production of 55 J-2 engines. (18)

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12. MSFC Test Lab., Test Laboratory's Historical Report, January 1, 1964 - June 30, 1964, pp. 27-28; cited hereafter as MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964.
13. MSFC Industrial Operations, Saturn MPR, Feb. 16 - Mar. 16, 1964, p. 11.
14. MSFC Engine Project Office, Quarterly Progress Report, F-1, H-1, J-2, and RL10 Engines, April, May, and June, 1964, p. 31; cited hereafter as MSFC Engine Project Office, Engine QPR, April - June 1964.
15. MSFC Saturn V Program Office, Saturn V Quarterly Progress Report, April 1, 1964 - June 30, 1964, p. 2; cited hereafter as MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964.
16. MSFC Public Affairs Office (PAO), Press Release, Mar. 31, 1964.
17. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 14.
18. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 32.

April 17 - A construction firm won the $256,000 contract to build the Saturn V Dock and Loading Facility at MSFC. (19)

April 22 - A $1.7 million definitive contract calling for Advanced Vehicle Technology studies was awarded to Lockheed Missiles and Space Company following cancellation of the RIFT contract with that firm. (20)

April 29 - MSFC finalized a contract with Bendix covering three ST-124M platform systems. (21)

April 30 - The first hot-firing production J-2 engine, J-2003, was delivered to DAC for S-IVB battleship testing at Sacramento (SACTO) test site. (22)

In April - An F-1 engine LOX pump explosion, the second within three months, halted engine research and development (R&D) firings at contractor sites and at MSFC while engineers modified the pump. (23)

- NASA announced that it would negotiate with Radio Corporation of American (RCA) for purchase of 19 additional RCA 110A ground computer test and checkout systems. (24)

- NASA announced selection of IBM as "lead contractor" for development of Saturn V and Saturn IB instrument units. (25)

- S-IVB battleship test operations started at SACTO. (26)

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19. MSFC Test Lab., Test Laboratory Monthly Progress Report, April 12, 1964 - May 12, 1964, p. 32; cited hereafter as MSFC Test Lab., Test MPR, Apr. 12 - May 12, 1964.

20. Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," Apr. 24, 1964.

21. John Harlow, Saturn I/IB Program Office, MSFC, interviewed Apr. 9, 1965.

22. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 32.

23. MSFC Engine Project Office, Engine QPR, April - June 1964, pp. 10-13.

24. MSFC PAO, Press Release, Apr. 14, 1964.

25. MSFC PAO, Press Release, Apr. 20, 1964.

26. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964.

In April	-	NASA changed the S-II stage prime contract and increased its value by $12.3 million. Following this change the S-II contract held by S&ID was valued at $337.3 million. (27)
May 25	-	NASA announced that it would negotiate with DAC for an S-IVB stage mockup for use at MSFC. (28)
May 26	-	MSFC received from Bendix a contract proposal for 26 additional Saturn IB/V stabilized platform systems. (29)
May 28	-	The contract for construction of the MSFC Acoustic Model Test Facility went to Kaminer Construction Company. (30)
In May	-	J-2 engine developers decided to delay FRT from mid-1964 to the end of the year. (31)
	-	S&ID technicians at Seal Beach completed fabrication and subassembly of the S-II battleship stage pressurization, thermal control, and LOX bleed systems. (32)
June 1	-	Workmen completed construction of the foundation for the VAB at Kennedy Space Center's LC-39. (33)
June 8	-	A construction firm received the $2.6 million contract to build an addition to the MSFC Components Test Facility. (34)

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27. MSFC PAO, Press Release, Apr. 16, 1964.
28. NASA, News Release No. 64-123.
29. John Harlow, Saturn I/IB Program Office, MSFC, interviewed Apr. 9, 1965.
30. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 26.
31. NASA Historical Staff, Astronautics and Aeronautics, (HHR-17), May 1964, p. 244.
32. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 4.
33. Chief, Facilities Planning and Programming Office, Kennedy Space Center, to Distribution, memo, subject, "Narrative Project Status Report," July 7, 1964.
34. MSFC Test Lab., Test MPR, May 12 - June 12, 1964, p. 29.

June 10 - S&ID began activation of the S-II battleship. (35)

- Test Stand 1-C, one of three new F-1 engine acceptance test stands at Edwards, California, was activated; construction ended on the Support Activities Building. (36)

June 11 - IBM completed assembly of the S-IU-200/500D, the instrument unit for the dynamic test vehicle. (37)

- NASA ended contract negotiations with RCA for 19 automated test and checkout computer systems. (38)

June 12 - Rocketdyne delivered the second production J-2 engine, J-2006, to S&ID for S-II battleship testing. (39)

June 18 - The S-IC-T thrust structure moved into the MSFC assembly stand. (40)

June 22 - Test Laboratory personnel moved into the new second addition to Building 4666. (41)

June 23 - The first firing at MSFC of F-1 engine F-1002 occurred on the interim test stand. (42)

June 24 - NASA approved the J-2 engine production contract with Rocketdyne for 55 engines. (43)

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35. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 4.
36. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 15.
37. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16 - September 30, 1964, p. 33.
38. MSFC Saturn I/IB Program Office, Saturn I/IB Progress Report, March 16 - September 30, 1964, p. 25.
39. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 32.
40. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 2.
41. MSFC Test Lab., Hist. Report, Jan. 1 - June 30, 1964, p. 23.
42. MSFC Test Lab., Test MPR, June 12 - July 12, 1964, p. 6.
43. MSFC Engine Project Office, Engine QPR, April - June 1964, p. 32.

In June - Construction began at MSFC on the Hangar for Vehicle Components, a $2.7 million project. (44)

- DAC installed a J-2 engine on the S-IVB battleship stage in preparation for static firings. (45)

- MSFC awarded a number of study contracts involving Saturn V improvement, planetary probes, and lunar transportation and logistic techniques. (46)

Late June - S&ID started major subassembly work on the S-II facilities checkout stage. (47)

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44. Chief, Purchasing Office, MSFC, to Deputy Director, Administrative, MSFC, memo, subject, "Weekly Activity Report," June 1, 1964.

45. DAC, Saturn S-IVB Annual TPR, July 1963 - June 1964.

46. MSFC Future Projects Office, Planning Information and Activity Report, July 1964, pp. 26, 28-29, and 57-59.

47. MSFC Saturn V Program Office, Saturn V QPR, April 1 - June 30, 1964, p. 5.

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I N D E X

INDEX