MHM-10

VOLUME ONE

HISTORY of the GEORGE C. MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

JULY 1 - DECEMBER 31, 1964

NASA GEORGE C. MARSHALL SPACE FLIGHT CENTER

MSFC HISTORICAL MONOGRAPH NO. 10
(MHM-10)

HISTORY OF THE GEORGE C. MARSHALL SPACE FLIGHT CENTER FROM JULY 1 THROUGH DECEMBER 31 1964

VOLUME ONE

By

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MSFC Historical Office

MANAGEMENT SERVICES OFFICE

FOREWORD

This is the ninth semiannual history of the George C. Marshall Space Flight Center. It covers the period July 1 - December 21, 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

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PREFACE

Entitled Marshall Historical Monograph Number 10, this is the ninth 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 July 1 through December 31, 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 George C. Marshall Space Flight Center: January 1 - June 30, 1963. The history of the Center's fourth year of operation is in MHM-8, History of the George C. Marshall Space Flight Center: July 1 - December 31, 1963, and MHM-9, History of the George C. Marshall Space Flight Center: January 1 - June 30, 1964.

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 major 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.

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, Facilities and Design, 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.

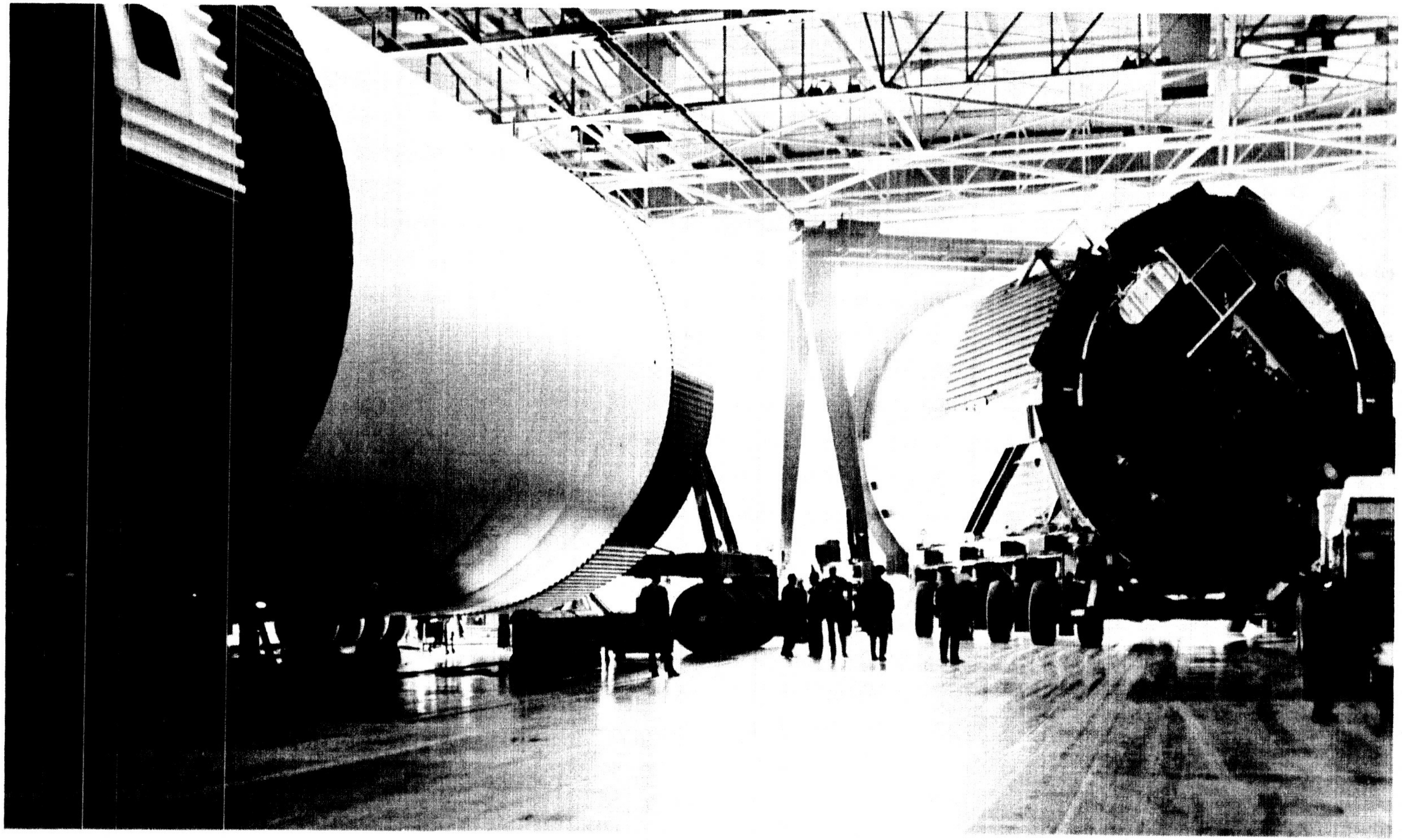
D. S. A., Chief
MSFC Historian

March 15, 1966

ACKNOWLEDGMENTS

In the preparation of this historical report, appreciation should be extended to the following MSFC personnel for their help and advice: H. H. Gorman, Deputy Director, Administrative; Leon D. Wofford, Jr., Associate Chief Counsel for Patent Matters; O. M. Hirsch, Chief, and S. H. Jones, Contracts Office; G. G. Buckner, Chief, Purchasing Office; Ray Kline and G. D. Willhite, Executive Staff; Leroy Aderholt, Katy Lyle, and Paul Perry, Manpower Utilization and Administration Office; Foster Haley, Public Affairs Office; V. C. Sorensen, Chief, and S. L. Fragge, Management Services Office; John Wood, Cost Reduction and Value Engineering Office; G. W. Dykes, Chief, Facilities and Design Office; Louis Snyder and Mack Hinton, Financial Management Office; W. R. Payne, Advanced Systems Office; E. D. Geissler, Director, Aero-Astrodynamics Laboratory; F. W. Brandner and H. E. Kroh, Astrionics Laboratory; W. R. Kuers, Director, and N. C. Milwee, Manufacturing Engineering Laboratory; Fred B. Cline, Director, and L. K. Zoller, Propulsion and Vehicle Engineering Laboratory; Dieter Grau, Director, Quality and Reliability Assurance Laboratory; Robert Sampson, Operations Management Office; Karl L. Heimburg, Director, and W. C. Sweetland, Test Laboratory; W. A. Mrazek, Assistant Director for Engineering, Industrial Operations; F. A. Speer, Manager, Mission Operations Office; L. F. Belew, Director, Engine Program Office; F. J. Henrie and Frances Prendergast, Michoud Operations; Mack Herring, Mississippi Test Operations; L. B. James, Director, Porter Dunlap, R. H. Ellis, J. E. Fikes, John Harlow, Melvin Johnson, W. G. Johnson, Gerald Ladner, W. K. Simmons, Arthur W. Thompson, and F. E. Vruels, Saturn I/IB Program Office; S. R. Reinartz, Director, Saturn IB/Centaur Program Office; and A. Rudolph, Director, Friedrich Duerr, S. E. Smith, and M. W. Shettles, Saturn V Program Office.

Eugene M. Emme, Chief, and William Putnam of the NASA Headquarters Historical Office were helpful in reviewing many phases of this history. Mrs. Evelyn Falkowski of our own Historical Staff assisted with the research and writing of the Administrative Highlights Chapter; Paul Satterfield helped with general research for the histories; and Mrs. Jean Watkins edited and typed much of the manuscript.



S-IC ASSEMBLIES AT MSFC

The fuel tank assembly for S-IC-T arrives at Manufacturing Engineering Building 4705 in December 1964 for mating to the LOX tank assembly shown at left. The completed stage is 138 feet long.

MARSHALL MILESTONES
July - December 1964

July 13	-	The U. S. Army Corps of Engineers, as agent for NASA, awarded a $17.2 million contract for construction of Position 2, S-IC Test Stand, at Mississippi Test Operations (MTO), to Koppers Company, Inc.
July 21	-	NASA Headquarters officially named the micrometeoroid measurement project the "Pegasus" project. It called the capsules Pegasus A, Pegasus B, and Pegasus C.
In July	-	The Personnel Office began the position review and evaluation project (PREP) with a survey of "benchmark" positions.
August 6	-	The first and only static firing of S-IV-9 lasted 398.94 seconds; all test objectives were achieved.
August 24	-	NASA announced that it would purchase 102 additional J-2 engines for Saturn IB and Saturn V vehicles, at an approximate cost of $165 million.
In August	-	A long-range road improvement project started at MSFC and Redstone Arsenal with award of a $512,000 contract.
	-	MSFC notified stage contractors that SA-201 and 202 would be "lob" missions to test reentry of the Apollo spacecraft heat shield.
	-	Douglas Aircraft Company (DAC) began structural tests of the S-IVB stage. The liquid hydrogen (LH_2) tank of the structural test stage ruptured during hydrostatic test as a result of insufficient weld at seams.
September 1	-	The F-1 Engine Test Stand contractor completed construction of the facility at Huntsville.

September 18	-	The SA-7/Apollo made a highly successful flight, with lift-off occurring at 11:22.43 a.m. EST, and orbital insertion of the payload 631.38 seconds later. Missions accomplished in flight included first demonstration of the S-IV nonpropulsive venting system; first demonstration of a fully active ST-124 guidance system, control rate gyros, and the ASC-15 guidance computer; and jettison of the Launch Escape System (LES) by the alternate mode involving both the launch escape motor and the pitch control motor.
September 22	-	NASA rescheduled Saturn launches SA-9, SA-8, and SA-10 about two months later than planned. This provided additional development time for the Pegasus payloads.
September 30	-	Major construction ended on the Saturn V Dynamic Test Facility at MSFC.
In September	-	Chrysler Corporation Space Division (CCSD) began assembly operations for S-IB-2.
October 6	-	In its third and final acceptance test S-I-10 fired for 149.93 seconds before inboard engine cutoff and then to 154.48 seconds until liquid oxygen (LOX) depletion caused cutoff of outboard engines. All test objectives were accomplished.
October 9	-	Activation of NASA's $34 million F-1 engine acceptance test complex occurred at Edwards Air Force Base, California. MSFC officials witnessed a readiness firing demonstration on the three new stands.
October 15	-	Negotiations ended with International Business Machines Corporation (IBM) concerning the scope of work to be included in the instrument unit (IU) lead contract. This contract covered integration of all IU systems and assembly and checkout of the flight units for the Saturn IB and Saturn V programs.
October 28	-	The S-II-S stage's aft LOX bulkhead ruptured during hydrostatic pressure test at Seal Beach, California, and was damaged beyond repair
October 29	-	NASA Administrator James E. Webb visited Huntsville and MSFC to discuss the role of the Center in future NASA programs.

In October	-	MSFC released all the documentation for redesign of the IU from the Saturn I configuration to the Saturn IB/V configuration.
	-	MSFC authorized DAC to proceed with design of S-IVB-203 for a prolonged near zero "g" LH_2 orbital experiment.
November 15	-	Construction ended on the Saturn V Barge Dock and Loading Facility at MSFC.
November 19	-	Kennedy Space Center (KSC) technicians completed erection of the S-IV-9 and the S-IU-9 atop the S-I-9 on LC-37B.
November 20	-	The S-IV-8 acceptance firing lasted for a duration of 475.8 seconds; all test objectives were achieved.
November 26	-	The first mainstage firing of the single-engine S-II battleship ended after 2.8 seconds.
In November	-	MSFC announced the appointment of Edmund F. O'Connor, an Air Force colonel, as Director of Industrial Operations.
	-	MSFC began modification of the Saturn I Dynamic Test Stand and the S-I Static Test Stand to support Saturn IB dynamic testing and static firings.
	-	Rocketdyne Division of North American Aviation, Inc. (NAA), performed J-2 engine preliminary flight rating tests (PFRT) at Santa Susana Field Laboratory.
December 11	-	NAA's Space and Information Systems Division (S&ID) achieved a 10-second full-thrust firing of the S-II battleship. This major milestone completed the single-engine test program for the stage.
	-	The J-2 engine demonstrated its restart capability, a significant milestone in the engine development program.
December 14	-	MSFC awarded a contract for a major addition to the Propulsion and Vehicle Engineering (P&VE) Laboratory, Building 4610.
December 15	-	Construction of the Vertical Assembly Facility at MSFC's Michoud Operations ended.

December 18 - MSFC selected 14 companies for final contract negotiations to provide support services for seven laboratories and three offices at the Center.

- Fairchild Hiller Company completed fabrication and checkout of the Pegasus A capsule and transferred it for final checkout to the General Electric plant at Valley Forge, Pennsylvania.

December 21 - The Aloha State with its cargo--the S-IVB-D--arrived at New Orleans. The S-IVB-D was transferred to the Promise, a river barge, for the remainder of its trip to MSFC.

December 22 - Following completion of modification and checkout of the S-IB-D/F, CCSD shipped the stage to MSFC for use in dynamic tests of the Saturn IB vehicle.

December 23 - The S-IVB battleship stage successfully completed the initial full-duration (414.7-second) static firing.

December 29 - Pegasus A, the first flight capsule, arrived at the launch site aboard the Pregnant Guppy.

In December - The Center announced that about 100 of 140 employees of a KSC launch support group temporarily assigned to MSFC would be transferred to Cape Kennedy in 1965.

- Two new telephone services--Federal Telecommunications System (FTS) and Centrex--went into operation at MSFC. Also operational was LIEF (Launch Information Exchange Facility), linking MSFC and KSC.

- Rocketdyne completed the F-1 engine flight rating tests (FRT).

CHAPTER I: ADMINISTRATIVE HIGHLIGHTS

The Saturn I launch vehicle became operational during the July--December 1964 report period. Highlights at MSFC included the seventh successful Saturn I flight (SA-7) and significant events in development of Saturn IB and Saturn V vehicles. During this period industrial contractors assumed a wider role in development of rockets for the Apollo manned lunar landing program. As the production pace quickened, MSFC enlarged its technical management responsibilities while maintaining a vigorous research and development program.

Vehicle Development Progress

NASA launched SA-7 on September 18. This first operational Saturn I vehicle employed as its booster the seventh S-I stage built at MSFC by government personnel. The 39,000-pound payload orbited by SA-7 included a boilerplate Apollo spacecraft, a live launch escape system, an instrument unit with fully active ST-124 guidance system, and an S-IV stage. The successful flight maintained the perfect record dating from Saturn I's first test flight in October 1961.

The Center and contractors worked toward completion of the Saturn I program, which will occur in 1965 with flights of three vehicles carrying Pegasus satellites as the primary payloads. The final Saturn I first stage built by MSFC and two boosters produced by Chrysler at Michoud Operations were scheduled for the last three flight vehicles--SA-9, SA-8, and SA-10. The first Pegasus was at Cape Kennedy with its launch vehicle (SA-9) when the period ended.

Saturn IB, which will fly Apollo spacecraft in earth-orbital test missions, drew nearer its first flight. Chrysler during the period completed the first flight booster (S-IB-1) and Douglas Aircraft Company made steady progress in development of the second stage (S-IVB-201) of this vehicle. Douglas completed the dynamic test version of S-IVB and performed static firing tests of the S-IVB battleship.

Saturn V, the moon rocket, entered the ground test phase. At Huntsville, and at government and industrial sites across the nation, there were major milestones in development of the Saturn V's three stages and two engine systems. MSFC neared completion of S-IC-T, the static test stage, and was assembling structural test hardware and the first flight booster, while Boeing manufactured components and other test stages at Michoud. North American Aviation's Space and Information Systems Division (S&ID) static-fired the S-II stage battleship and surmounted second stage insulation and production problems. Douglas, in dual development of the S-IVB for two Saturn programs, conducted full-duration firing of the battleship stage. Rocketdyne Division of North American Aviation, contractor for the F-1 and J-2 rocket engines, delivered several production engines and completed flight rating tests for the F-1 and preliminary flight rating tests for the J-2.

The improvement of current vehicles and investigations of new missions and vehicles gave rise to a variety of study programs during the period. More than 30 study contracts went to industry, while MSFC laboratories pursued a wide range of investigations. Many of the studies emphasized post-Apollo missions.

Management Activities

The third and final phase of the major MSFC reorganization that began in 1963 was the consolidation of support services contracts. Prior to this change 39 different private firms were providing engineering, fabrication, and institutional support to seven laboratories and three offices at the Center. MSFC announced in March 1964 that when the old contracts expired new contracts would be negotiated, with a single firm providing all support services for each laboratory and office. From July through September MSFC issued requests for proposals covering these services for the ten Center organizations. Review and evaluation of proposals and selection of appropriate bidders proceeded through October and November.

On December 18, 1964, MSFC announced selection of 14 companies with which negotiations would be made for the ten support contracts. The cost-plus-incentive-fee contracts, to be effective March 1, 1965, would run for one year at an estimated cost of $68 million. The consolidation of support contracts was expected to reduce costs and improve management operations at MSFC.[1]

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1. Ray Kline, Executive Staff, MSFC, interviewed Jan. 10, 1966; and Public Affairs Off., Press Release, Dec. 18, 1964.

CHANGES MADE

The Center filled a key management post in November 1964 with the appointment of Edmund F. O'Connor as Director of Industrial Operations (IO). O'Connor, an Air Force colonel, succeeded Robert B. Young, who resigned the IO directorship after one year to return to private industry. The IO Director is responsible for management of all Saturn program contracts and for operation of the government-owned facilities at Michoud Operations and Mississippi Test Operations (MTO).

The Meteoroid Measurement Payload Office of Industrial Operations was redesignated the Pegasus Project Office in October 1964.[2]

On December 11 the Center established the Instrument Unit Stage Configuration Control Board - Interim. Friedrich Duerr was chairman and W. K. Simmons, Jr., co-chairman.[3]

Created on October 6, 1964, were two new organizational elements--the Experiments Review Board and the Experiments Coordination Office. These units were established to work with the Manned Space Flight Experiments Board at NASA Headquarters. Dr. Oswald H. Lange became head of the Experiments Review Board, and Dr. J. P. Kuettner was named head of the Coordination Office. Purpose of the new units was to insure maximum participation by MSFC in proposing and evaluating inflight experiments for future rocket flights.[4]

In December NASA announced impending transfer of a group of Kennedy Space Center (KSC) launch support personnel temporarily assigned to MSFC by agreement when KSC became a separate center in 1962. During 1965 about 100 of 140 employees in the KSC Launch Support Equipment Engineering Division would move from Huntsville to Cape Kennedy.

COST REDUCTION

Cost reduction was a major management goal during this period, in line with President Johnson's government-wide economy drive joined by the NASA

2. Memo, Dr. Wernher von Braun, MSFC Director, to Distribution, "Pegasus Project Office," Oct. 6, 1964.

3. Memo, Manager, Saturn V Instrument Unit, to Distribution, "Instrument Unit Stage Configuration Control Board - Interim," Dec. 11, 1964.

4. Memo, Dr. von Braun to Distribution, "MSFC Management of 'In-Flight Experiments,' " Oct. 6, 1964.

Administrator. Cost-cutting effort directed by the MSFC Cost Reduction and Value Engineering (CRAVE) Office resulted in $36 million savings. This reduction, resulting from 78 cost-saving actions, was more than one-third of NASA's $100 million savings for the period.[5]

The Center cut costs in many ways. Methods included motivating employees to search for innovations, converting costly equipment to new uses, and finding new manufacturing techniques. A specific example which resulted in estimated savings of $2.1 million, was invention of a "magnetic hammer" that would remove welding distortions from Saturn stage bulkhead segments. This device, invented by Robert J. Schwinghamer and L. E. Foster of the Manufacturing Engineering Laboratory,[6] made possible the salvage of expensive components and gave promise of further applications in Saturn programs. As another example, the Center saved more than $1 million by eliminating certain informational reports on the S-IVB stage program. Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA, complimented MSFC on its contributions.[7] Eleven major contractors also reported substantial savings in cost reduction programs monitored by the CRAVE office.

TECHNOLOGY UTILIZATION

Technology utilization, another NASA-wide program, is an effort to make available to industry innovations in aerospace technology. MSFC's Technology Utilization Office worked with laboratories and contractors to identify, evaluate, and disseminate data on new techniques. Valuable space technology thus received the widest possible application.

COMMUNICATIONS

Several improvements in communications facilities occurred at the Center in the six-month period.

MSFC instituted a Launch Information Exchange Facility (LIEF) linking the Center and Kennedy Space Center. LIEF began operating in December 1964 to provide instantaneous launch data concerning Saturn vehicles. A 100-foot

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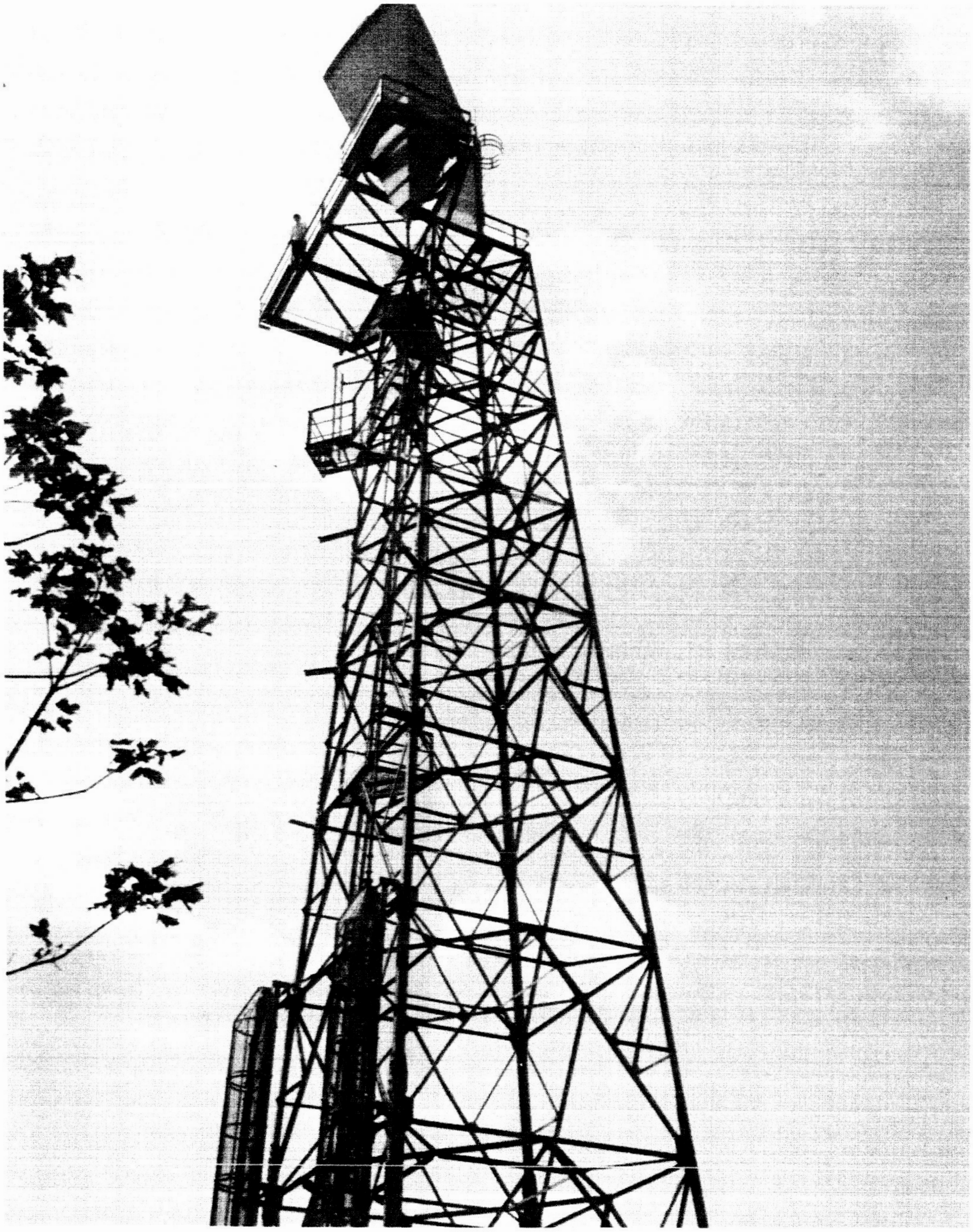
5. Memo, W. S. Fellows, Chief, Cost Reduction and Value Engineering Office, to Distribution, "NASA Cost Reduction Report to the President," Feb. 12, 1965.
6. Schwinghamer and Foster received a Presidential Citation for their invention.
7. Memo, Dr. von Braun to Distribution, "Dr. Mueller's Talk Before the MSFC Staff and Board on Oct. 23, 1964," Nov. 13, 1964.



COMMUNICATIONS TOWER

This 100-foot microwave relay tower at the MSFC Central Communications Facility became operational in this period.

microwave relay tower at the MSFC Central Communication Facility (Building 4207) and a similar relay tower on Brindlee Mountain were erected by Southern Bell Telephone Company as parts of this new system.

Other major communications changes involved two new telephone services, installation of underground cables at MSFC, and expansion of Building 4207. Following completion of a telephone traffic study by the General Services Administration the Federal Telecommunications System (FTS) became operational in December. MSFC installed FTS because it is a nation-wide government telephone service for executive agencies, its purpose being to link major federal organizations in order to reduce costs of long-distance commercial toll calls. Centrex, a Huntsville exchange providing service for downtown MSFC activities and contractors, also began operation in December. Construction started in October on an underground cable system connecting all MSFC buildings. This cable system, scheduled for completion in July 1966, will replace existing above-ground lines and poles. Plans were complete in December for a 20,500-square-foot addition to Building 4207, on the north and east sides of the building. A satellite exchange, part of the Redstone Arsenal telephone exchange, will be in the new addition. This satellite exchange, with a capacity for 8,000 lines, will consolidate all MSFC telephones and connect with Army exchanges on the Arsenal and Centrex in downtown Huntsville. The LIEF switchboard, now manually operated, will convert to automatic operation when space is available in the new building addition.[8]

MANNED FLIGHT AWARENESS

A Manned Flight Awareness Program conference at MSFC in September 1964 inaugurated a vigorous NASA campaign to assure the safety of Apollo astronauts. The MSFC Director keynoted the two-day meeting with a plea to government, contractor, and vendor personnel to do their very best in building the Saturn vehicle for the lunar landing program. The Center established a Manned Flight Awareness Office to maintain a continuing reliability program. This office designed a manned flight awareness van to be built in 1965 for tours to contractor plants and NASA installations.

SUPPORT TO UNIVERSITY

MSFC maintained a close relationship with the University of Alabama Huntsville Campus, where many employees attended classes as part of the Center's training program. Twenty-two employees also served as teachers in off-duty

8. Memos, V. C. Sorensen, Chief, Management Services Office, MSFC, to Harry Gorman, Deputy Director, Administrative, MSFC, "Weekly Report," Sept. 11, 1964; and Dec. 18, 1964; and Public Affairs Off., Marshall Star, "Two Apollo Spacecraft Now at Cape," Dec. 9, 1964, pp. 1 and 11.

hours. The Center gave official support to the University in expanding its graduate study program and introducing new curricula. Graduate study in the fields of public administration, science, and engineering resulted from a $462,000 contract awarded to the University by MSFC. The Center also supported the University's $750,000 fund drive for expansion of the Huntsville Campus facilities and inauguration of a full four-year degree program.

General Facilities[9]

MSFC property at Huntsville (including real estate, facilities, and capital equipment) is valued at approximately $280 million. Within the 1786-acre Center complex at Redstone Arsenal specialized facilities and buildings occupy about 3.6 million square feet. MSFC uses an additional 600,000 square feet of warehouse space belonging to the Army and leases more than 200,000 square feet of office and engineering space in downtown Huntsville.[10]

Construction of Building 4202, the Project Engineer Office Building, was about 25 per cent complete at the end of this period. Work on this $2.2 million project, the last of three buildings in the MSFC headquarters complex, began in May 1964. When completed late in 1965 Building 4202 will accommodate approximately 650 government personnel.

The addition of three-story extensions to the three wings of the Computation Laboratory (Building 4663) progressed almost to completion. MSFC accepted portions of this project from the contractor late in the period.

On December 14, 1964, MSFC awarded the construction contract for a major extension to Building 4610, the Propulsion and Vehicle Engineering Laboratory. The firm of Pearce, DeMoss and King received this $1.8 million contract. The five-story extension, 68 by 180 feet, will provide 77,000 square feet of office space for about 450 P&VE employees. Completion of the project will occur in one year.

9. Facilities directly supporting the launch vehicle programs are covered in the applicable chapters of this history.
10. Executive Staff, Management Information, Vol. III, 3rd Ed., June 1965, pp. 3 and 8-9.

ROADS

A long-range road improvement project began at the Center in August when MSFC awarded a $512, 000 contract for building one new road and modifying three old ones. MSFC and Army agencies planned the road work to distribute traffic more evenly and speed the flow of the thousands of motor vehicles traversing the Arsenal each work day. When completed in 1966 the renovated road system will include several new stretches of road, intersection innovations, a six-laned Rideout Road, and an improved network of roads diverting traffic away from the MSFC office complex.

MICHOUD AND MISSISSIPPI TEST OPERATIONS

At MSFC's Michoud Operations on October 15 builders completed the three-story Engineering and Office Building. This $6.7 million structure provided space for approximately 5, 000 government and contractor personnel who on November 10 completed the move from temporary offices in downtown New Orleans.[11]

Mississippi Test Operations (MTO) reported construction progress on a number of major facilities. Work was completed on the Emergency Services Building, Warehouse and Site Maintenance Building, Telephone Building, Central Heating Plant, and miscellaneous utilities. The $3.6 million Office and Administration Building was 82 per cent complete. Also near completion were several other general support facilities, including roads and railroads, Central Control Building, and the Data Handling Center. Several dock and waterways projects were also complete at the end of the period.[12]

Personnel

MSFC had 7738 civil service employees at the beginning of this report period on July 1, 1964. Contractor personnel at that time totalled approximately 6294. On December 31, 1964, when the period ended, MSFC had 7652 civil service personnel plus 50 military details. Of these government personnel 590 were at locations outside the Huntsville area: 282 were at Michoud, 37 at MTO, and the remaining 271 were at contractor plants and other government installations. The total number of MSFC contractor personnel at Huntsville and other locations when the period ended was 8202.[13]

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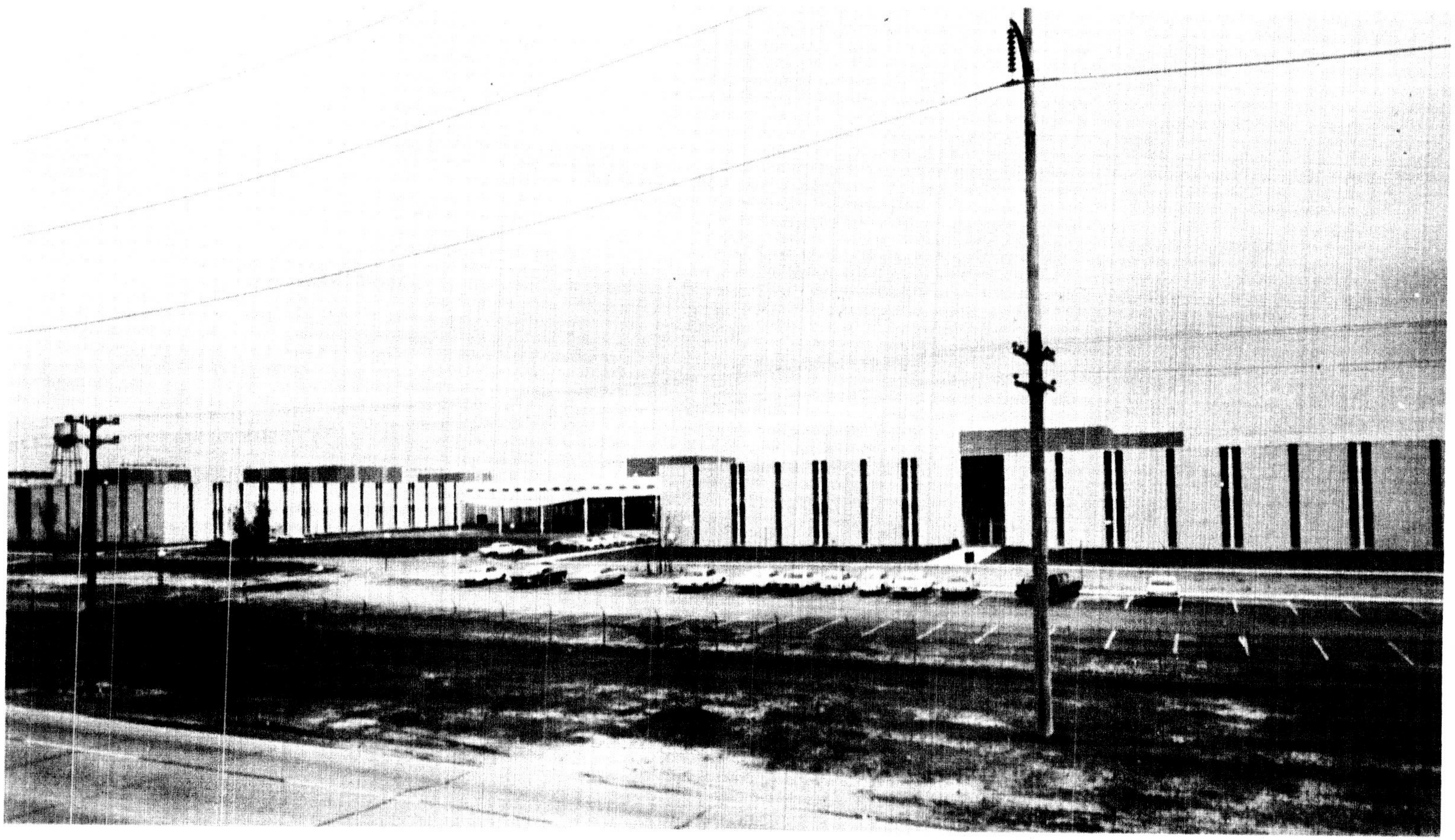
11. Michoud Op., Historical Report, July 1 - Dec. 31, 1964, p. 37.
12. MTO, Historical Report, July 1 - Dec. 31, 1964, pp. 13-19.
13. Executive Staff, "MSFC Manpower Status Summary as of July 3, 1964;" and "Dec. 31, 1964;" and "MSFC Contractor Status as of July 31, 1964;" and "Dec. 31, 1964."



CENTER OF MICHOUD ACTIVITY

This photo made late in 1964 shows the Michoud Operations' Engineering and Office Building. Completed in October, it was fully occupied early in November.

MTO HEADQUARTERS

The Laboratory and Engineering Building at Mississippi Test Operations, shown in this December 1964 photo, was 82 per cent complete when this report period ended.

MS-T

TECHNOLOGY UTILIZATION OFFICE

CHIEF	J W WIGGINS	876-1514

CHI
DE
HIS
SA
AD
CO
GR

SE
SP

FUTURE

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DEPUTY DIRECTOR
SPECIAL ASSISTANT
ADVANCED LAUNCH VEH G
ADVANCED PROPULSION GR
LUNAR SYSTEMS GROUP
ORBITAL SYSTEMS GROUP
PLANETARY SYSTEMS GROU
PROGRAM ANALYSIS & CON

R-AERO

AERO-ASTRODYNAMICS LABORATORY

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DEPUTY DIRECTOR	O C JEAN	876-1422
ASSISTANT DIRECTOR	**P J deFRIES	876-4711
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ASTRODYNAMICS & GUIDANCE THEORY DIVISION	R F HOELKER	876-1524
DYNAMICS & FLIGHT MECH DIV	H J HORN	876-4446
FLIGHT-EVALUATION & OPERATIONS STUDIES DIVISION	F A SPEER	876-2701

R-ASTR

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GUIDANCE & CONTROL DIVISION	F B MOORE	876-3420
INERTIAL SENSORS & STAB DIV	C H MANDEL	876-5330
INSTRUMENTATION & COMM DIV	O A HOBERG	876-2941
APPLIED RESEARCH BRANCH	J C TAYLOR	877-2168
ELECTRO-MECH ENGR BRANCH	J BOEHM	876-2742
FLIGHT DYNAMICS BRANCH	H HOSENTHIEN	877-2151
PILOT MFG DEVELOPMENT BRANCH	W ANGELE	876-4525

R-QUAL

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PROGRAM & RESOURCES OFFICE	F M SITTASON	876-4349
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RELIABILITY ASSURANCE DIVISION	R L CHANDLER (ACT)	876-2166
VEHICLE SYSTEMS CHECKOUT DIV	C O BROOKS	876-2040

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Personnel on board at Michoud at the period's end totalled 11,463. The Boeing Company accounted for 6842, Chrysler 3236, Mason-Rust (the support contractor) 932, and Telecomputing Services, Inc. (computer services) 157.[14]

MTO counted 2689 personnel on December 31, 1964. Of this number 1877 were construction workers, the Army Corps of Engineers had 165, General Electric Company (support contractor) 443, and other contractors 153.[15]

AWARDS

In October NASA gave its second highest award, the Medal for Outstanding Leadership, to Dr. Wernher von Braun, MSFC Director. Dr. Ernst Stuhlinger, Director of the Research Projects Laboratory, and Dr. William R. Lucas, Chief of the Materials Division of the Propulsion and Vehicle Engineering Laboratory, received the NASA Medal for Exceptional Scientific Achievement. Dr. Stuhlinger also received the Hermann Oberth Medal. In a Washington ceremony Mr. Webb presented to Dr. von Braun a group achievement award for "exceptional achievement" by MSFC employees in the Saturn I program. At the same time a Presidential Citation went to the Test Laboratory's Mississippi Test Facility Working Group. NASA approved invention awards for two Center employees: William J. D. Escher of Future Projects Office, $50, and Max Sharpe of Manufacturing Engineering Laboratory, $1,000. NASA honorary service awards went to 894 MSFC employees; five of these awards were for 30 years of service, 80 for 20 years, 163 for 15 years, 220 for 10 years, and 426 for one year of service.

MSFC awarded 61 sustained superior performance awards. Cash awards totalling $22,275 went to the 61 employees for tangible savings of $290,000. From a total of 739 suggestions received, the Center adopted 140 with estimated first-year net savings of $300,884; suggesters received $6,820 in awards. The largest suggestion award, $1,400, went to Emmett L. Martz, John L. Burch, and William L. Kimmons of Astrionics Laboratory for their suggestion concerning the Saturn guidance system. Eleven employees of the Purchasing Office received a $495 group achievement award for exceptional work. The Center presented 530 letters of appreciation and 115 letters of commendation to employees during the period.[16]

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14. Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, p. 32.
15. MTO, Hist. Rpt., July 1 - Dec. 31, 1964, p. 2.
16. Memo, Leroy Aderholt, Incentive Awards Committee, to D. S. Akens, Historical Office, "Incentive Awards Program Data - Historical Report," Feb. 10, 1965.

EQUAL OPPORTUNITY

The Equal Employment Coordination Office of MSFC's Personnel Office pursued its "affirmative action program" to promote job and community opportunities for Negroes. Of 603 permanent employees hired in the last half of 1964, 14 were Negroes. There was a shortage of qualified Negro applicants in several position categories. Equal opportunity objectives received circulation through talks with supervisors, letters to employees, articles in The Marshall Star, and personal contact with Negro colleges and civic groups. Since some Negroes interviewed for jobs objected to living conditions in Alabama, the affirmative action program also included efforts to solve housing and education problems. Program personnel worked with a Huntsville bi-racial committee on these and other problems. MSFC released $337,000 in excess federal property to predominantly Negro schools in 1964. Included were electronic parts and equipment, office furniture, and shop equipment.[17]

HOUSING

MSFC issued "809" housing eligibility certificates to 868 employees during this period. Under Section 809 of the National Housing Act NASA helps secure housing for essential government and contractor employees by guaranteeing home loans through FHA in communities where federal programs have had unusual impact.[18]

EMPLOYEE ACTIVITIES

Employee activities this period included the election in October of an MSFC employee, Everette Brouillette, as 1965 president of Redstone Arsenal Lodge 1858, American Federation of Government Employees (AFGE).

AFGE Lodge 1858 petitioned MSFC for exclusive recognition as bargaining agent for employees. An election held on August 26 failed when fewer than the required 60 per cent of eligible employees cast ballots.

17. MSFC initiated the affirmative action program in July 1963 in response to Executive Orders 10925 and 11114. See Equal Employment Coordination Office, Personnel Office, MSFC, Equal Employment Opportunity Program, Quarterly Report, July - September 1964, and October - December 1964.

18. Interview with Paul Perry, Manpower Utilization and Administration Office, MSFC, Dec. 8, 1965; and Management Services Off., MSFC, George C. Marshall Space Flight Center Administrative Regulations and Procedures, Chapter 17-1, Annex A, Change 90, pp. 201-204.

In the annual community charity fund drive Center employees contributed more than $121,000 to the United Givers Fund. This amount was 12½ per cent above the MSFC goal. Employees also gave $8,400 to the Federal Health and Charity Drive.

The Marshall Athletic, Recreation and Social Exchange (MARS) elected a 15-man executive council and named James Hiers as president. MARS is the employee association responsible for planning a social and recreational program at the Center.

POSITION EVALUATION

The position review and evaluation project (PREP) began at the Center in July 1964 with the distribution of questionnaires to representative employees. This survey of "benchmark" positions was the start of a Center-wide program aimed at evaluation of all jobs. The purpose of PREP is to attain equity in position classification and salary administration.[19]

NEW BADGES

Issuance of new standardized NASA identification and security badges began at the Center on December 4. This standard badge would apply to all NASA installations after February 1965. Rebadging at MSFC was about half completed at the end of the report period.[20]

Special Events

Key officials from NASA Headquarters visited MSFC on several occasions during the six-month period. Among the visitors were Administrator James E. Webb, Associate Administrator Robert C. Seamans, and Dr. George E. Mueller, Associate Administrator for Manned Space Flight.

Mr. Webb visited Huntsville and MSFC in October to discuss news reports that top level management elements of MSFC might be transferred to Michoud. He met with business and community leaders at a conference arranged by Huntsville Industrial Expansion Committee. Mr. Webb told the group that MSFC, which is NASA's largest center, was important as both "the research and development and

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19. Interview with Katy Lyle, Personnel Office, MSFC, Dec. 7, 1965.
20. Memo, Sorensen to Gorman, "Weekly Activities," Nov. 27, 1964.

the management center for the Apollo boosters....We in NASA want to keep it that way," he said. But, Mr. Webb added, NASA has found it difficult to get top level executives to come and work in Alabama. "If we cannot get the seasoned executives here that we need for the management function, then we will do more of this work at other locations."[21]

The sixth birthday anniversary of NASA, celebrated at MSFC on October 28, was the occasion for reassuring words from Dr. von Braun. The MSFC Director told 500 Center employees in Morris Auditorium that current programs at MSFC "will keep all of us here in Huntsville tremendously busy for years to come, no matter what you read in the papers." Also appearing on this program was Astronaut Scott Carpenter, who helped the Director present several employee awards.

Other birthday celebrations during the period concerned Michoud and MTO. Michoud Operations, where contractors assemble Saturn boosters, marked its third anniversary on September 7. Mississippi Test Operations had its third birthday on October 25, the date in 1962 when NASA announced that rocket test facility would be created in Hancock County, Mississippi.

John F. Griner, national president of AFGE, visited MSFC in August, toured the Center, and addressed employees.

Most visitors to the Center came in an unofficial capacity. More than 75,000 persons visited the Space Orientation Center during the six-month period--nearly 3000 a week. Over half of these visitors were from out-of-state.

An event significant to MSFC was the Army's formal retirement ceremony for the Redstone missile. MSFC officials participated in the October 30 program at the Army Missile Command. The Redstone, developed in the early 1950's by engineers and scientists now working at MSFC, was the booster that launched the first U. S. earth satellite (in 1958) and our first man in space (1961).

During this report period also came the final static firing test of Saturn I boosters. S-I-10, the first stage for the SA-10 vehicle, fired at MSFC for 154 seconds on October 6. Thus ended a series of 55 Saturn firing tests that began in the Center's Test Area in April 1961.

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21. Text of speech by NASA Administrator James E. Webb to the Huntsville Industrial Expansion Committee, Oct. 29, 1964.

VISITORS WITH DIRECTOR

Franklin D. Roosevelt, Jr., Under Secretary of Commerce (left), and William R. Anderson, Congressional nominee from Tennessee, hear Dr. Wernher von Braun, MSFC Director, explain a Saturn guidance system during a visit to the Center in September 1964.

Funding

In the last six months of 1964 (which was the first half of Fiscal Year 1965) MSFC obligated $1,072,133,000. Research and development required $911,097,000, or approximately 85 per cent of the total. Facilities construction took $91,765,000, or about 8.5 per cent. The administrative operations allocation was $69,271,000, or 6.5 per cent.[22]

22. Information furnished Aug. 24, 1965, by Louis E. Snyder, MSFC Financial Management Office.

CHAPTER II: SATURN I

Prior to the beginning of this report period Saturn I had already attained a perfect flight test record with six successful flights and no failures. Therefore, NASA had declared Saturn I, first in a series of Apollo launch vehicles, ready for operational use.

NASA's Marshall Space Flight Center manages this Saturn I program. MSFC's major contractors for this program have been Chrysler Corporation Space Division (CCSD) and Douglas Aircraft Company (DAC) as stage contractors,[1] and Rocketdyne Division of North American Aviation and Pratt and Whitney as engine contractors.[2]

NASA had scheduled ten Saturn flights in the Saturn research program, but because of the perfect record of the first six flights NASA redesignated the four remaining vehicles as operational. With this redesignation, flight mission assignments for the seventh through tenth vehicles changed from demonstration of R&D technology to placement of experimental spacecraft and micrometeoroid measurement (Pegasus) capsules into near-earth orbit.

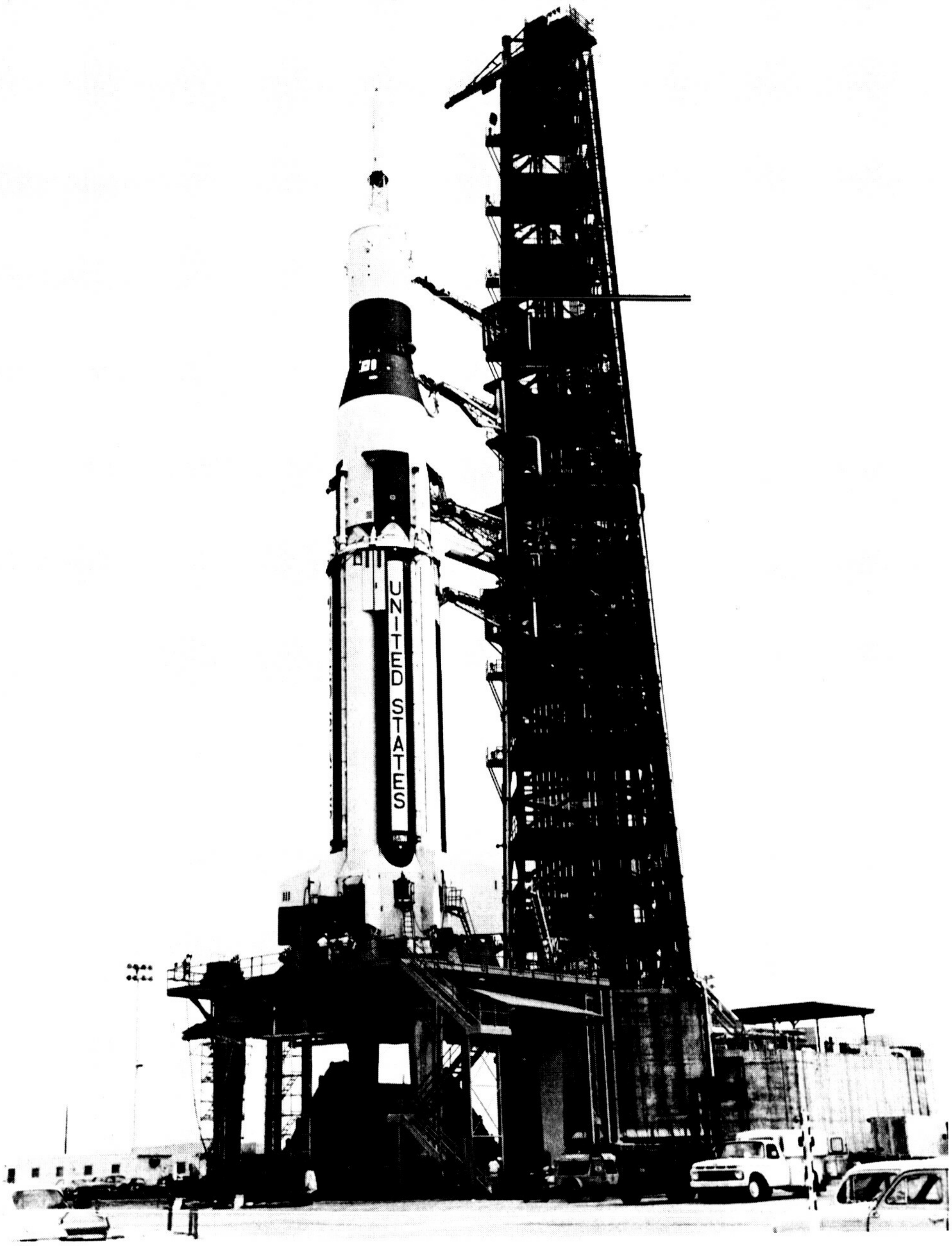
Flight of the first operational vehicle, SA-7, occurred on September 18, 1964. The vehicle flight-tested a boilerplate Apollo spacecraft and the launch escape tower.

The last three Saturn I vehicles will insert Apollo spacecraft into earth orbit and will also orbit Pegasus capsules. These three vehicles are scheduled for launch in 1965 from NASA's Kennedy Space Center (KSC).

The First Saturn Operational Flight

Only one Saturn I flight occurred in the period July - December 1964. This flight of the SA-7 was the third flight test of a Block II Saturn I,[3] the second

1. CCSD assisted MSFC in designing the S-I stage. The contractor built the S-I stages for two operational vehicles, SA-8 and SA-10. DAC designed and produced S-IV stages for the Saturn I program.
2. Rocketdyne is the S-I stage H-1 engine contractor, and Pratt and Whitney is is the S-IV stage RL-10 engine contractor.
3. For a description of the Block II vehicle and the two previous Block II flight tests see MSFC, Marshall Historical Monograph No. 9 (MHM-9), History of the George C. Marshall Space Flight Center, Jan. 1 - June 30, 1964, pp. 17-36.



SA-7 PREPARED FOR LAUNCH

The seventh Saturn I flight vehicle waits on Launch Complex 37B at Cape Kennedy in preparation for September 18 launch.

consecutive test with a boilerplate Apollo spacecraft, and the first operational flight of a Saturn rocket. SA-7 placed a 39,000-pound payload into a 105-nautical-mile orbit.

The SA-7/Apollo flight further demonstrated compatibility and competency of the Saturn I/Apollo components and systems. The flight also confirmed techniques for use in building the more powerful Saturns in support of manned lunar landings and other space exploration.[4]

The SA-7/Apollo flight vehicle consisted of four units; the S-I stage, the S-IV stage, the instrument unit (IU), and the boilerplate No. 15 (BP-15) Apollo command and service modules with the launch escape system (LES). Changes which distinguished SA-7 from SA-6 were confined to the S-IV stage and the IU. These changes were elimination of the S-IV liquid oxygen (LOX) tank backup pressurization system and addition of a nonpropulsive venting system on the S-IV stage. The IU changes included elimination of the ST-90S stabilized platform system and supporting equipment and activation of the ST-124 system for vehicle control at liftoff instead of the S-IV stage flight only. The S-IV and IU changes here described resulted in weight reductions of 300 and 600 pounds, respectively. The only other change in the SA-7/Apollo vehicle was use of live launch escape and pitch control motors to eject the LES.[5]

PRELAUNCH CHECKOUT

As this report period began, SA-7 was undergoing prelaunch checkout on Pad B of Launch Complex 37 (LC-37B) at KSC. Automation of checkout by RCA-110 computers as initiated for SA-6, was used and extended somewhat for SA-7.

Shortly after start of checkout operations technicians discovered cracks in the LOX dome of H-1 engine 2011. The discovery led to removal and shipment of the engine to MSFC for inspection. MSFC technicians assisted by Rocketdyne personnel, determined that stress corrosion caused the cracks. MSFC directed removal of LOX domes from all H-1 engines and replacement with domes of a

4. Ltr., George E. Mueller, Assoc, Adm. for Manned Space Flight, NASA, to NASA Adm., "Saturn I Development Flight Test, SA-7," Sept. 14, 1964, with enc., "Mission Operation Report," Rpt. M-931-64-07, p. 1; and F. A. Speer, Chairman, MSFC Saturn Flight Evaluation Working Group, "Saturn SA-7 Flight Resume."
5. P&VE Lab., Vibration and Acoustic Analysis, Saturn SA-7, NASA TM X-53213, pp. 1-2; and MSFC Saturn Flight Evaluation Working Group, Results of the Seventh Saturn I Launch Vehicle Test Flight, MPR-SAT-FE-64-17, pp. 277-283.

different aluminum alloy more resistant to stress corrosion. In the period July 4 through July 20 all the H-1 engines of S-I-7 were returned to Rocketdyne at Neosho, Missouri, and retrofitted with new domes.[6]

Meanwhile, KSC technicians installed on S-IV-7 the newly designed and fabricated nonpropulsive venting system received from DAC in August. KSC technicians also modified S-IV-7's flight relay components. This modification became necessary when DAC inspection of Crystal Can relays used in the S-IV sequencer and propellant utilization electronics assembly revealed an abnormally high failure rate.[7] On August 6 KSC technicians completed electrical mating of the S-I, S-IV, and IU, and on August 7 technicians completed spacecraft electrical mating to the vehicle. Ten days later they accomplished the all systems vehicle overall test.[8]

On August 26 prelaunch activities stopped and KSC personnel evacuated the Center as Hurricane Cleo neared. Cleo passed Cape Kennedy August 27; its damage to SA-7 and LC-37B was light. Postponement of the checkout activities for Cleo accounted for a two-day slip in the launch date. Another hurricane, Dora, halted activities on September 8. Dora passed 85 miles north of the Cape and, as before, damage was light and restricted to water damage. Dora accounted for still another day of delay, and the SA-7 launch date slipped to September 18.

KSC accomplished the remaining checkout activities without additional significant problems. These activities included radio frequency tests, a full-scale simulated flight test, and tanking tests. The simulated flight test or countdown demonstration test (CDT), a new feature, included many of the tests ordinarily associated with launch preparations and permitted their omission during the actual countdown.

Technicians resolved several discrepancies noted during the CDT. This action assured flight readiness of the vehicle and precluded a number of holds during the actual countdown. One discrepancy was failure of the S-I stage LOX fill and drain valve to close at termination of main fill, thus allowing LOX to drain back into the storage area. Tests indicated that the valve would function under no-flow conditions, and technicians closed the valve and proceeded with LOX tanking

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6. C. E. Cataldo, P&VE Lab., H-1 Engine LOX Dome Failure, NASA TM X-53220, pp. 1-4; and Teletypes, Apollo Program Management Off., KSC, to Apollo Program Director, NASA, "SA-7 Launch Schedule," July 17, 1964, and Manager, Apollo Spacecraft Program Off., NASA, to KSC, "SA-7 Launch Schedule," July 22, 1964.
7. Saturn I/IB Off., I/IB Progress Report, Mar. 16 - Sept. 30, 1964, MPR-SAT-I/IB-64-2&3, p. 7.
8. MSFC, MPR-SAT-FE-64-17, p. 9.

in the replenish mode.[9] Another discrepancy was a corroded pin in the cable connector between the S-IV LOX tank propellant utilization (PU) probe and the PU electronics assembly. This caused the PU system to act erratically and prematurely terminate the fast fill operation. Technicians cleaned the pin, and the system operated properly. A third discrepancy resulted from overheating of the ground supply furnishing power to the S-IV stage. KSC replaced the power supply with a heavy duty unit for the launch countdown. The last major problem was an intermittent failure of the S-IV low level multicoder, and technicians replaced the faulty multicoder with the extra multicoder in the launch kit.

Following the CDT, technicians noted a crack in the weld that held two LOX tank vent lines to the skin of the S-I stage. Riveting of doublers to furnish additional support prevented complete rupture of the weld during launch; rupture could have caused LOX vapor to be dumped into the S-IV aft interstage.[10]

LAUNCH COUNTDOWN

The actual launch countdown occurred in two time periods. The first began at T minus 1035 minutes. At T minus 795 minutes excessive moisture in the initial S-IV liquid hydrogen (LH_2) gas sample necessitated several tank purges and delayed the start of the S-IV ordnance installation about 80 minutes. At T minus 740 minutes the vacuum jacket failed to hold vacuum. Although technicians discovered no leak, all the welds and fittings in the jacket were coated with a sealant. No delay resulted. The final count for the launch started at 11:25 p.m. EST September 17, at T minus 545 minutes, and continued without interruption for five hours.[11] Then trouble started and continued intermittently until liftoff.

At least half of the major difficulties during the final countdown concerned Eastern Test Range (ETR) instrumentation. Some of these problems resulted from effects of a new hurricane, Hurricane Gladys, while others resulted from site radar problems. At least one interruption was blamed on range interference by a ship.

A total of four holds, lasting two hours and 43 minutes, interrupted the final countdown. The first hold, at T minus 245 minutes and lasting 69 minutes, was caused by inadvertent firex system activation on the service structure during air conditioning duct removal. At T minus 30 minutes a scheduled 20-minute

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9. Prior to initiation of actual launch countdown, KSC personnel cycled the count for an additional 30 minutes to allow for S-I stage LOX fill by the replenishing mode.

10. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 7-9.

11. Ibid., p. 9.

hold was extended four minutes when the S-IV LOX pressurizing regulator indicated a malfunction. The third hold, at T minus 12 minutes and lasting 20 minutes, resulted from a malfunction of the S-I hydraulic pump temperature OK interlock that prevented the pumps from being turned on. Range safety called the final hold of 45 minutes at T minus 5 minutes because the Grand Turk Island radar operation was intermittent. KSC recycled the count to T minus 13 minutes and the count continued uninterrupted through launch.[12]

SA-7 FLIGHT

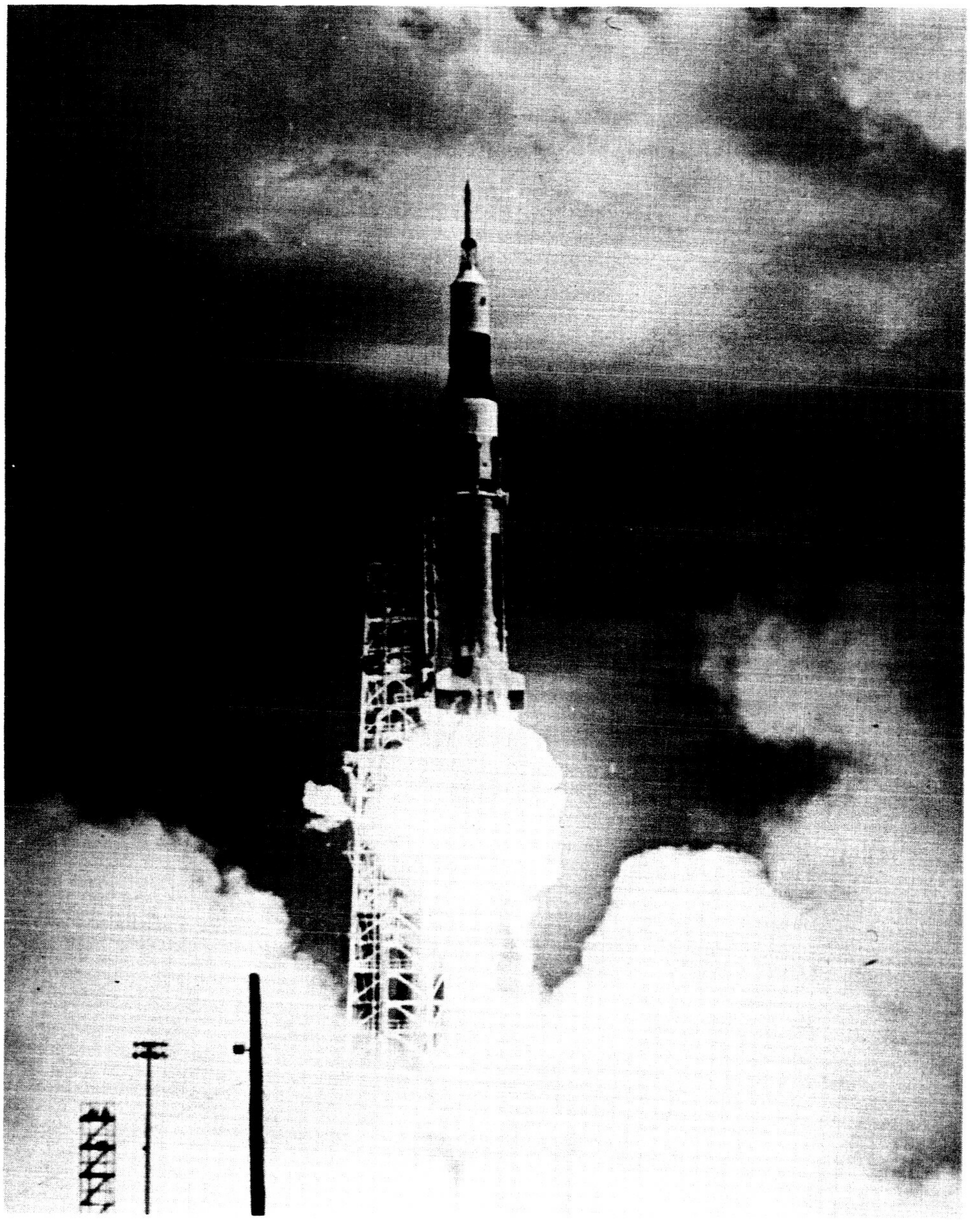
Liftoff of SA-7 occurred September 18 at 11:22.43 a.m. EST.

The active GSE (including the launcher, engine service platform, hold-down arms, firing accessories, umbilical swing arms and pneumatic distribution system) sustained less damage than during any previous launch. The only difficulty at liftoff involved umbilical swing arm No. 3. This swing arm failed to disconnect when the umbilical pneumatic system operated; rotation of the swing arm actuated its mechanical release.

Flight performance of the S-I stage was better than usual; total velocity at outboard engine cutoff exceeded nominal. The S-I stage H-1 engines burned approximately 141 seconds before the inboard engines shut down. The outboard engines continued to burn for another six seconds until cutoff by a backup timer; nearly all the LOX was consumed. Pressure sensitive switches called "thrust-OK" switches failed to initiate shutdown of the outboard engines at detection of oxidizer starvation. This new shutdown method, attempted for the first time on SA-7, is to be used on the Saturn IB vehicle; it is designed for more efficient propellant consumption.[13]

Overall flight performance of the S-IV stage was satisfactory. Separation command, ullage rocket ignition command, engine start command, ullage rocket jettison command, and the engine cutoff command occurred as planned. The S-IV stage propulsion system performed satisfactorily throughout powered flight. The RL-10 engines burned approximately eight minutes.[14] The nonpropulsive vent system on trial for the first time on SA-7 performed satisfactorily. This

12. MSFC, MPR-SAT-FE-64-17, pp. 7-9.
13. P&VE Lab., Evaluation of Flight Test Propulsion Systems, and Associated Systems, Saturn S-I-7 Stage, IN-P&VE-P-64-28, pp. 14-25 and 55-60; and Aviation Week & Space Technology, "SA-7 Flies Near-Perfect Mission," Sept. 28, 1964, p. 27.
14. Teletype, DAC to NASA/MSFC, "S-IV-7 Post Flight Quicklook Report," Sept. 22, 1964; and MSFC, MPR-SAT-FE-64-17, p. 76.



SA-7 ON ITS WAY

The seventh Saturn I flight begins at Cape Kennedy as SA-7 rises from the launch pad carrying a boilerplate Apollo spacecraft. This first operational Saturn flight, on September 18, 1964, featured the first use of a fully active guidance system.

venting method will be used on the remaining Saturn flights to end excessive tumbling resulting from propellant venting.[15]

The ST-124 guidance system and associated hardware controlled the vehicle from liftoff through orbital insertion. The ST-124 provided attitude reference for the control mode while the control rate gyros provided rate signals. In addition, the ASC-15 guidance computer, used for the first time, generated the roll and pitch program during the S-I stage flight.[16] This was the first flight of a fully-active ST-124 guidance system.

The S-IV stage, instrument unit, and the Apollo BP-15 entered orbit at 631.38 seconds range time. By then all the mission test objectives were satisfactorily achieved including successful jettison of the LES. This jettisoning was by the alternate method that consisted of firing the launch escape motor and the pitch control motor rather than the smaller tower jettison motor used on the SA-6/Apollo flight. The new jettison maneuver carried the tower safely out of the spacecraft's path.[17]

The SA-7 transmitted more measurements to ground stations than had any previous U. S. space vehicle. Overall reliability of the measuring system was 99.35 per cent. The SA-7 radar altimeter, a self-contained automatic range tracking device, provided the first fully reliable altitude and elapsed time data during a Saturn flight. This data proved valuable in establishing the actual SA-7 flight trajectory.[18] Ninety-one cameras provided optical coverage of SA-7. Immediate recovery of the eight onboard cameras ejected from the vehicle became impossible because of Hurricane Gladys. However, two of the cameras were discovered on San Salvador and Eleuthera Islands about 50 days following the launch. These two cameras provided good coverage of the vehicle in flight.[19]

15. MSFC, MPR-SAT-FE-64-17, pp. 162-166.
16. Teletype, F. A. Speer, Chairman, Flight Evaluation Working Group, to Dr. George E. Mueller, Assoc. Adm., NASA, et. al., "SA-7 Flight Results," Sept. 28, 1964.
17. MSFC, MPR-SAT-FE-64-17, pp. 162 and 273-274; and Olen Ely and Parley Howell, Astrionics Lab., Radio Frequency Evaluation of SA-7 Vehicle, NASA TMX-53250, p. 2.
18. Moses M. Coleman, Astrionics Lab., Performance of Saturn Radar Altimeter, NASA TM X-53277, pp. 1 and 4-5.
19. MSFC, MPR-SAT-FE-64-17, p. 256.

SA-7 CAMERA CAPSULES

Two of the eight onboard cameras carried by SA-7 launch vehicle and dropped into the ocean are shown following their eventual recovery downrange. Rough seas delayed their discovery nearly two months.

Status of Operational Vehicles

Prior to the July-December 1964 period MSFC and the stage contractors had completed development of stages for all scheduled Saturn I vehicles. Also completed were all R&D tests except stage acceptance tests. Thus, emphasis in this report period shifted from development of vehicle hardware to checkout and flight preparation of the SA-9, SA-8, and SA-10 vehicles for the eighth, ninth, and tenth flights respectively.[20] Most of the vehicle activity occurred at contractor sites. Exceptions included the static firing of the S-I stages at MSFC in Huntsville and development and checkout of the instrument units at MSFC.

Only one problem area marred the steady progress of the vehicles from checkout to the launch site. This concerned fabrication and checkout of the Pegasus capsule payload and is described later in this chapter.

Program managers realized, near the beginning of this report period, that Pegasus development problems would prohibit launch of SA-9 as soon as scheduled. NASA in August considered three alternatives for alleviating the impact on the schedule. They were cancellation of the SA-9 launch, postponement of the launch to allow more development time for the Pegasus A capsule, or reduction of requirements for a fully qualified Pegasus A. In the end NASA chose to establish a new set of guidelines for Pegasus development with less stringent requirements for Pegasus A. Pegasus A would be launched by SA-9 as planned, but only with those components in final configuration which time would allow to be fully qualified. Components not qualified would be functionally identical to the final design. Less than the one year required life expectancy would be acceptable for Pegasus A. The guidelines called for no changes in development requirements for the Pegasus B or C capsules. With these guidelines NASA hoped to minimize the possible delay in the Saturn launch schedule and also to enhance success of the Pegasus experiments with information gained from a Pegasus A launch.

An MSFC/NASA Headquarters reassessment of the Pegasus development program on September 22 resulted in the expected change in the launch schedule. The SA-9 launch was rescheduled about two months later than planned (from December to February), and the SA-8 and SA-10 slipped two months and one month. At this time MSFC notified the stage contractors of the adjusted need dates for the hardware and the change in shipping dates.[21]

20. The Saturn flight schedule called for SA-9 to follow SA-7 because development of the first industry-built booster (S-I-8) required more time than S-I-9, the last booster developed by MSFC.

21. Memo, Lee B. James, Mgr. Saturn I/IB Program, MSFC, to Maj. Gen. Samuel C. Phillips, NASA, "Saturn I Schedules," Sept. 23, 1964; and ltr., George E. Mueller, Assoc. Adm. for Manned Space Flight, NASA, to Dr. Wernher von Braun, Dir., MSFC, Nov. 25, 1964.

SA-9--FROM CHECKOUT TO LAUNCH SITE

Prior to this report period MSFC completed static firing and initiated poststatic checkout of the last Saturn I booster (S-I-9) built at MSFC. The Center interrupted the S-I-9 poststatic checkout in July 1964 to allow for replacement of the H-1 engine LOX domes.[22] Workmen removed the engines from the stage and shipped them to Rocketdyne at Neosho, Missouri, for this work. Rocketdyne returned the engines to MSFC in late August. Following reinstallation of the engines, technicians resumed and completed S-I-9 checkout.

Scheduled mid-September shipment of the stage to KSC was postponed until late October because of the delay in the Pegasus delivery and the change in the launch schedule. During this interval MSFC installed the S-I-9 hardware originally planned for installation at KSC.[23]

The S-IV stage contractor began in July to subject the S-IV-9 stage to prestatic checkouts and modifications in anticipation of a static firing July 31. During these checkouts and modifications DAC covered the stage with a large plastic bag, circulated warm air around the stage to prevent frost buildup, and completed a cryogenic propellant weighing program. This advanced weighing program provided accurate data for use at MSFC in calculating a precise orbital trajectory.

The workload on recorders in the blockhouse at the Sacramento test site proved greater than anticipated and delayed completion of hardware instrumentation checkout until August. DAC rescheduled the S-IV-9 static firing from July 31 to August 3.

On August 3, 1964, following the loading of liquid hydrogen (LH_2) in S-IV-9, excessive noise in low level multicoder system No. 1 caused DAC to abort the static test and reschedule it for August 6. During the 398.94-second static firing on August 6 all major test objectives were successfully achieved. DAC decided that the few minor discrepancies noted during the firing were not serious enough to warrant a second test. The contractor completed the S-IV-9 poststatic repair and modification in August.

DAC postponed shipment of S-IV-9 to KSC until October because of the change in the launch schedule. During this delay DAC removed the S-IV-9 engines and cleaned them of all traces of oxylube contamination discovered in the

22. Following the discovery of the H-1 engine LOX dome problem on SA-7, MSFC directed replacement of the LOX domes on all Saturn I vehicles.

23. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 13.

helium system after the static firing. DAC also replaced all 18 solenoid valves in the engines.[24] In addition, during this delay DAC completed design of an auxiliary fuel tank vent tube and associated hardware that supplement the nonpropulsive vent system. The improved equipment will prevent LH_2 venting through the relief valves during and after separation of the payload.[25]

In late July MSFC completed the S-IU-9 component installation and started checkout of the unit. The Center completed the S-IU-9 checkout in mid-September and prepared the unit for shipment to launch site.[26]

On October 19 MSFC shipped the S-I-9, the S-I stage fins, and the S-IU-9 to KSC aboard the barge Promise. The craft and its cargo arrived at KSC October 30. DAC transported S-IV-9 to KSC October 22 aboard the Pregnant Guppy aircraft. The command module of the BP-16 Apollo spacecraft, already at the launch site, awaited arrival of the service module, its adapter, and associated hardware from MSFC where it was undergoing modification to accept Pegasus A. These arrived aboard the Pregnant Guppy on November 13.

KSC technicians completed "receiving inspection" of all units of the SA-9/ Apollo except Pegasus A. By the end of November KSC completed erection of SA-9 on LC-37B. Erection of the S-I-9 occurred November 3 and the S-IV-9 and S-IU-9 on November 19. Electrical mating of the S-I, S-IV, and IU took place December 19. KSC continued to perform subsystems checkout and integrated launch vehicle tests throughout the remainder of this report period.

Meanwhile, until December 18 Pegasus A remained in fabrication and checkout at the contractor's plant in Hagerstown, Maryland. On this date it went to General Electric at Valley Forge, Pennsylvania, for further checkout prior to shipment to KSC on December 29. Whether the slippage in its schedule could be recovered at KSC in time for the proposed SA-9 launch in February 1965 remained to be seen at the close of the period.[27]

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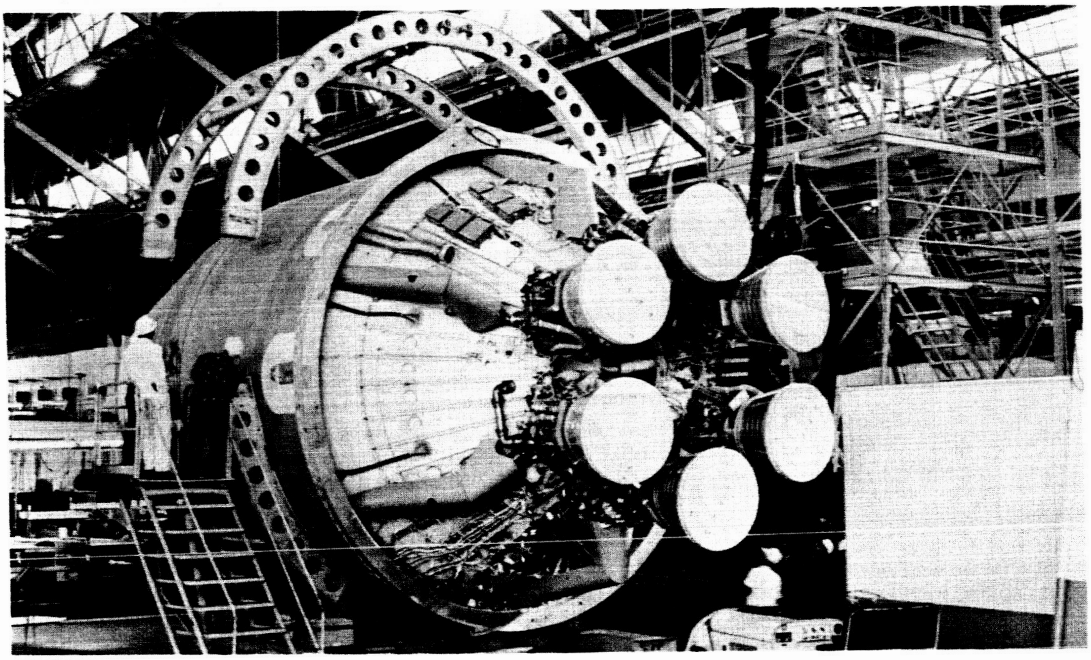
24. Test Lab., Test Laboratory Monthly Progress Report, July 12 - Aug. 12, 1964, pp. 42-43; Aug. 12 - Sept. 12, 1964, p. 47; and Sept. 12 - Oct. 12, 1964, p. 40.
25. W. H. Faulkner, S-IV Stage Project Engineer, P&VE Lab., Fourth Flight Vehicle, S-IV-9.
26. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 13-14.
27. KSC, Technical Progress Reports, Third and Fourth Quarter, CY-1964, (TR-159), p. 4; and First Quarter, CY-1965, (TR-168), pp. 2-3; and Memo, Lee B. James, Saturn I/IB Project Off., to Dr. von Braun, et. al., "Pegasus Schedule," Dec. 15, 1964.

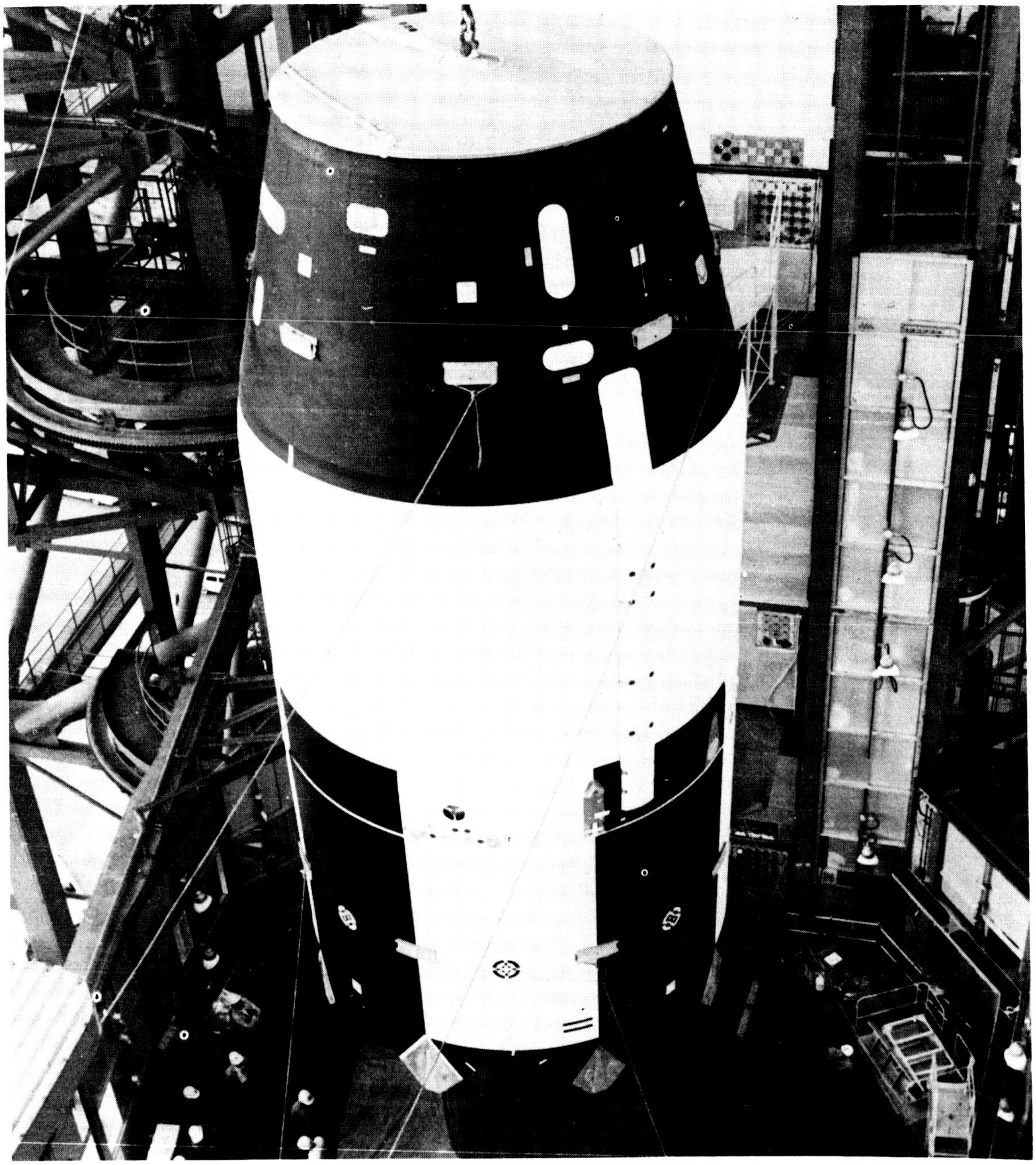
SA-9 INSTRUMENT UNIT TESTED

Pictured during vibration testing at Wyle Laboratories, Huntsville, is S-IU-9, the instrument unit for the SA-9 flight vehicle.



S-IV STAGE IN CHECKOUT

A flight S-IV stage for a Saturn I launch vehicle undergoes checkout at Douglas Aircraft Company's Santa Monica, California, plant.



S-IV STAGE MATED

Shown during erection of a Saturn I vehicle at Kennedy Space Center is an S-IV stage being positioned on an S-I stage at the launch pad.

SA-8--READY FOR SHIPMENT

In July CCSD at its Michoud Operations S-I plant began poststatic modification and repair of the first industry-built Saturn S-I stage. During this modification and repair CCSD personnel noted that contraction of the LOX tanks had sheared a large number of bolts in the four antenna panels attached to the LOX tanks. MSFC issued CCSD an engineering order to correct this condition. There were no other major problems and the contractor completed the routine modification and repair operations in late September. The LOX dome retrofit of all H-1 engines was accomplished concurrently. Upon return from Rocketdyne the engines were reinstalled in the stage, and CCSD began the final checkout.[28]

On October 13 CCSD began electrical checkout of the S-I-8. While disassembling an ignition monitor valve from engine No. 8 for replacement, technicians found that the valve contained water. CCSD then inspected all the other valves for water contamination. During inspection of the valve on engine No. 4 a pair of pliers fell and pierced two thrust chamber tubes. This incident necessitated removal of the engine for return to Rocketdyne for repair. The S-I-8 shipping date to KSC had already been changed from December 19, 1964, to late February 1965, a time more compatible with the revised launch schedule; therefore, no delay resulted.[29]

By the end of July DAC at Santa Monica completed checkout of the S-IV-8 stage. On August 7 DAC shipped the stage to the Sacramento test site for static tests. At the test site technicians positioned the stage horizontally in an area adjacent to Test Stand 2B facilities. Here, DAC personnel by the middle of August completed the receiving inspection and an ultrasonic inspection of the fuel tank. The contractor then initiated installation of the nonpropulsive venting systems, electrical modifications, and hardware instrumentation installation. The latter included instrumentation for cryogenic calibration.

After removal of the S-IV-9 stage from Test Stand 2B on August 27, test engineers installed the S-IV-8. Vehicle and ground support equipment (GSE) checkout and vehicle modifications continued throughout August and September.

From October 13 to October 26 DAC performed the S-IV-8 cryogenic calibration weight system tests. These tests involved two fuel and one LOX tank cryogenic calibrations, for the purpose of comparing the stage mass sensor output with the actual mass determined by the weight system. Prefiring checkouts

28. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 14.
29. Michoud Op., Historical Report, July 1 - Dec. 31, 1964, pp. 8-9.

continued during the intervening period from cryogenic calibration October 26 to November 18. DAC replaced the LOX and fuel tank vent and relief valves which malfunctioned during the weight testing. Because of a possible stage/engine control helium oxylube contamination problem the contractor also replaced the 18 engine solenoid valves.

Countdown for the S-IV-8 acceptance firing on November 20 began smoothly; the acceptance firing lasting 475.8 seconds was highly successful.

On December 4 technicians moved the stage from the test stand to the Evaluation and Development building. Poststatic checkout and repair were almost complete when this period ended, and plans were underway for shipping the stage to KSC in mid-January.[30]

Meanwhile, at MSFC technicians continued assembly of the S-IU-8 components, work that had begun in June 1964. MSFC completed the assembly operations in October and initiated final checkout of the unit. After finishing the checkout, MSFC prepared the unit for shipment to KSC and then stored it to await shipment in 1965.

SA-10--CHECKOUTS UNDERWAY

During prestatic checkout of S-I-10 CCSD encountered some difficulty in modifying prevalves for the stage. The contractor decided to ship the stage and the valves to MSFC separately and to complete modification of the valves for installation at MSFC prior to static tests. The barge Promise left Michoud with the S-I-10 aboard on July 24 and arrived in Huntsville on July 31.

Immediately upon its arrival MSFC technicians installed the stage in the static test stand. They removed the H-1 engines and returned them to Rocketdyne for LOX dome retrofit and completed prefiring modifications.

On August 19 test personnel performed a special LOX loading test of the S-I-10 without the engines. This test established LOX boiloff rates and the effectiveness of helium bubbling at various rates and duration. Rocketdyne returned the engines and they were reinstalled on the stage during the period August 24 - 29. On September 9 CCSD performed a second S-I-10 propellant loading and flight sequence test.

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30. Test Lab., MPR, Nov. 12 - Dec. 12, 1964, pp. 37-38; and W. L. Fowler, S-IV Stage Project Engineer, P&VE Lab., Fifth Flight Vehicle, S-IV-8.

The S-I-10 stage underwent three static firings. The first firing occurred September 22 following a postponement from September 16 because of a LOX leak at the center LOX tank rear cover flange. This firing lasted 3.01 seconds before being automatically cut off due to the failure of a thrust pressure switch. Test SA-23 on September 24 lasted 35.08 seconds and ended with inboard engine cutoff initiated by the firing panel operator. All systems in operation performed satisfactorily. After this second firing workmen discovered cracks in the test stand holddown bracket lower clevis ears at positions 1 and 3. Evaluation of the cracks indicated there was no need to replace the brackets prior to the next test. However, CCSD eliminated a portion of the gimbal program during the next test to avoid unnecessary strain on the brackets. During the third and final acceptance test (SA-24), performed October 6, S-I-10 fired for 149.93 seconds before inboard engine cutoff and then to 154.48 seconds until LOX depletion cutoff of the outboard engines. Data evaluation indicated satisfactory performance of all systems during the test.

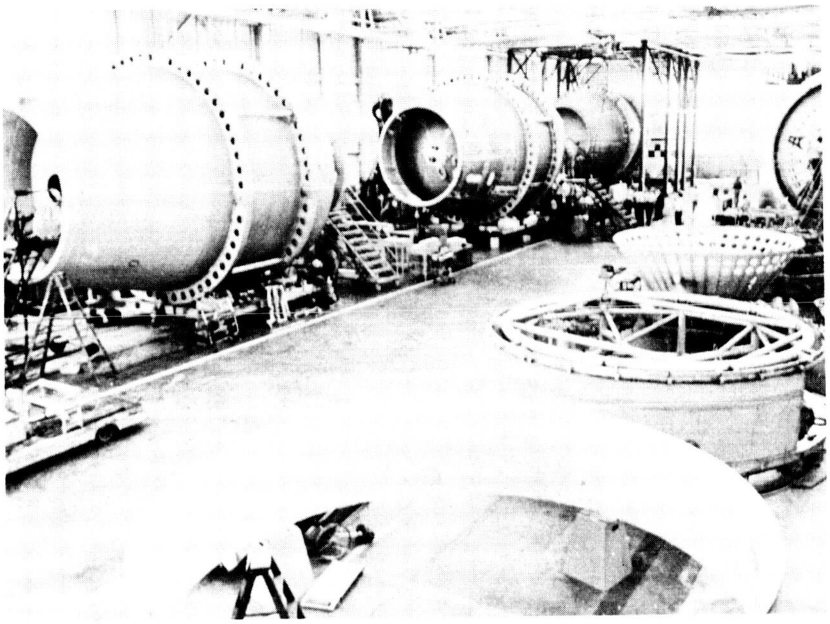
Following completion of the acceptance tests CCSD conducted a series of propellant loading tests on S-I-10 to investigate problems associated with loading LOX to a 2.2 per cent ullage. These tests ended in October.

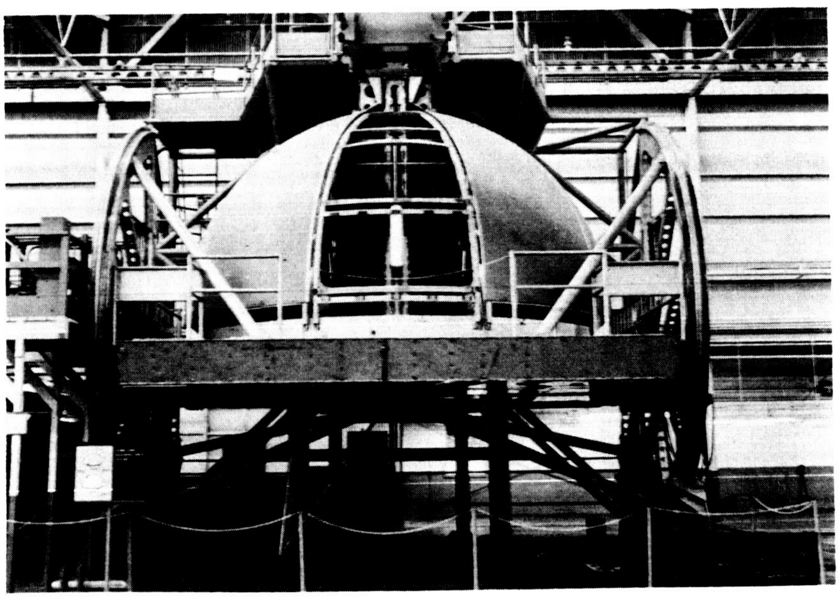
Technicians removed S-I-10 from the test stand on October 29 and loaded it aboard the barge Palaemon for its return trip to Michoud. The stage arrived at Michoud November 7 for final checkout and preparation for shipment to Cape Kennedy.[31]

During July and August DAC completed final assembly of the last Saturn I S-IV flight stage (S-IV-10). On August 6 the contractor began checkout of the stage; checkout operations lasted through mid-October. Immediately after a full simulated flight checkout on October 14 preparations began for shipping the stage to the Sacramento test site.

The stage arrived at the test site November 5. The next day personnel moved the stage to the Evaluation and Development Building for prefiring modifications. The major modifications included rework of support installations, instrumentation panel, and forward interstage bracket; installation of the nonpropulsive continuous venting system; rework of the LH_2 and LOX point level sensors and

31. Don Adams, CCSD, Saturn Stage S-I-10 Final Static Test Report, pp. 1-2; and Test Lab., Historical Report, July 1 - Dec. 31, 1964, pp. 1-2.





S-IV STAGE PRODUCTION

These pictures show views of S-IV stage production at the Santa Monica facility of Douglas Aircraft Company. At top is a general view of the manufacturing area. Bottom picture shows an S-IV tank dome in a meridian weld fixture.

replacement of the control unit as well as rework of LH_2 and LOX overfill control units; installation of Crystal Can relays in the sequencers; and rework of the signal commutators.

In line with a NASA/DAC agreement to amend the checkout procedures DAC eliminated certain items from the S-IV-10 checkout program. This action expedited completion of the S-IV program. The amended checkout procedures also avoided budget and manpower problems arising from conflicting S-IV and S-IVB test program schedules. Items omitted included cryogenic weighing operations, GSE checkout, vehicle/GSE interface checkout, electromagnetic compatibility checkout, instrumentation stimulation, instrumentation telemetry compatibility, and instrumentation radio frequency compatibility during post firing. The instrumentation subsystem checkout during postfiring checkout will replace the instrumentation stimulation. Because of the incompatibility of the GSE in Test Stand 2B, checkout of the exploding bridgewire destruct controller will occur at KSC.

On December 5 test engineers installed S-IV-10 in Test Stand 2B and continued the prefiring modifications started in the Evaluation and Development Building. During the remainder of the month technicians continued to prepare S-IV-10 for a January 1965 acceptance firing.[32]

At MSFC in mid-September technicians removed the S-IU-10 structural shell from storage and began component assembly operations. The assembly operations continued on schedule during the remainder of the report period.

Status of Payloads for Saturn Flight Vehicles

Vehicles SA-9, SA-8, and SA-10 have two payloads, the boilerplate Apollo spacecraft and a micrometeoroid measurement capsule. During the flight of these three Saturn vehicles the structural soundness and aerodynamics of the spacecraft will be tested. The role of the micrometeoroid measurement capsule--on July 21, 1964, officially renamed "Pegasus A, B, and C"--will be to provide engineering data about the near-earth meteoroid environment in which space vehicles operate. The primary data to be collected will be the meteoroid penetration frequency versus material thickness.

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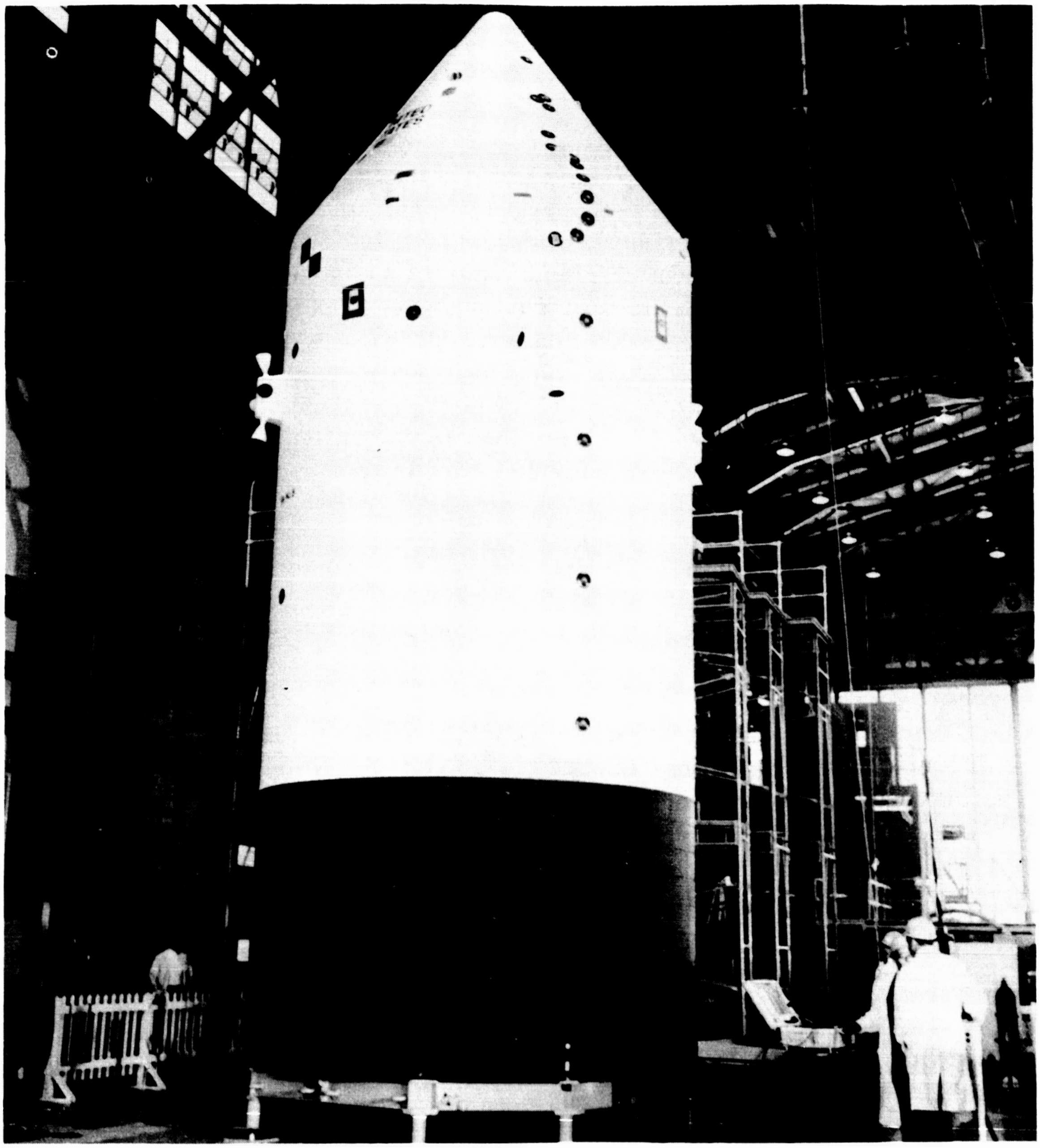
32. Test Lab., MPR, Nov. 12 - Dec. 12, 1964, p. 38; Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 16; and W. L. Fowler, S-IV Project Engineer, Sixth Flight Vehicle, S-IV-10, pp. 2-4.



APOLLO BOILERPLATE AT CAPE

Shown in a hangar at Kennedy Space Center is a boilerplate Apollo spacecraft scheduled for flight aboard a Saturn I vehicle.

North American Aviation (NAA) develops the boilerplate Apollo spacecraft under contract to NASA's Manned Spacecraft Center (MSC). MSFC, however, has responsibility for adapting the service modules for launch storage of the Pegasus capsules. MSFC is responsible also for adapting BP-9, a spacecraft previously used by MSFC and MSC in development tests, as a flight spacecraft. Design and development responsibility for the Pegasus capsules also belongs to MSFC. Fairchild Hiller Corporation (FHC) which until October 1964 was Fairchild Stratos Corporation, is contractor to MSFC for design and development of these capsules.

BOILERPLATE APOLLO SPACECRAFT--BP-16, BP-26, AND BP-9

The Apollo spacecraft for Saturn SA-9, SA-8, and SA-10 flights consists of a boilerplate command module, boilerplate service module, spacecraft adapter, and the launch escape system with its live jettison motor. The spacecraft weighs about 18,600 pounds, measures 63.4 feet in length from the adapter field splice to the LES nosecone, and has a maximum diameter of 12.1 feet.

Earlier in 1964 NAA's Space and Information Systems Division (S&ID) had shipped the boilerplate service modules, spacecraft adapters, and associated hardware to MSFC for modification. The modification made these adaptable for the Pegasus payloads. In July and August 1964 S&ID accelerated manufacturing operations on BP-16 and BP-26 command modules and launch escape systems in order to have both ready for shipment to KSC at the same time. Toward the end of August S&ID shipped the command modules to KSC aboard the Pregnant Guppy aircraft. The contractor transported the two LES units to KSC by truck.[33]

Meanwhile, at MSFC personnel completed modification of the BP-16 service module, adapter, and insert to make them adaptable for Pegasus A. On November 14 the Center shipped the module and its associated hardware to KSC via the Pregnant Guppy. MSFC's modification of the BP-26 service module progressed satisfactorily throughout the rest of this report period.

In the first half of the report period MSFC received from MSC the BP-9, a government-purchased spacecraft used as a test article. MSFC immediately began to prepare the spacecraft for flight. Preparation included performing the necessary documentation, rework, and testing of each major assembly, including a separation system not a part of the original hardware. The Center also began to modify the service module to make it adaptable for Pegasus C. The modification

33. Public Affairs Off., Marshall Star, "Two Apollo Test Craft Now at Cape," Aug. 26, 1964, p. 9.

operations proceeded steadily during the last quarter of the report period. Following modification of the spacecraft MSFC will perform flight qualification and verification on BP-9. The Center will schedule delivery of BP-26 hardware and the BP-9 spacecraft to correspond with the delivery of Pegasus B and C at KSC.[34]

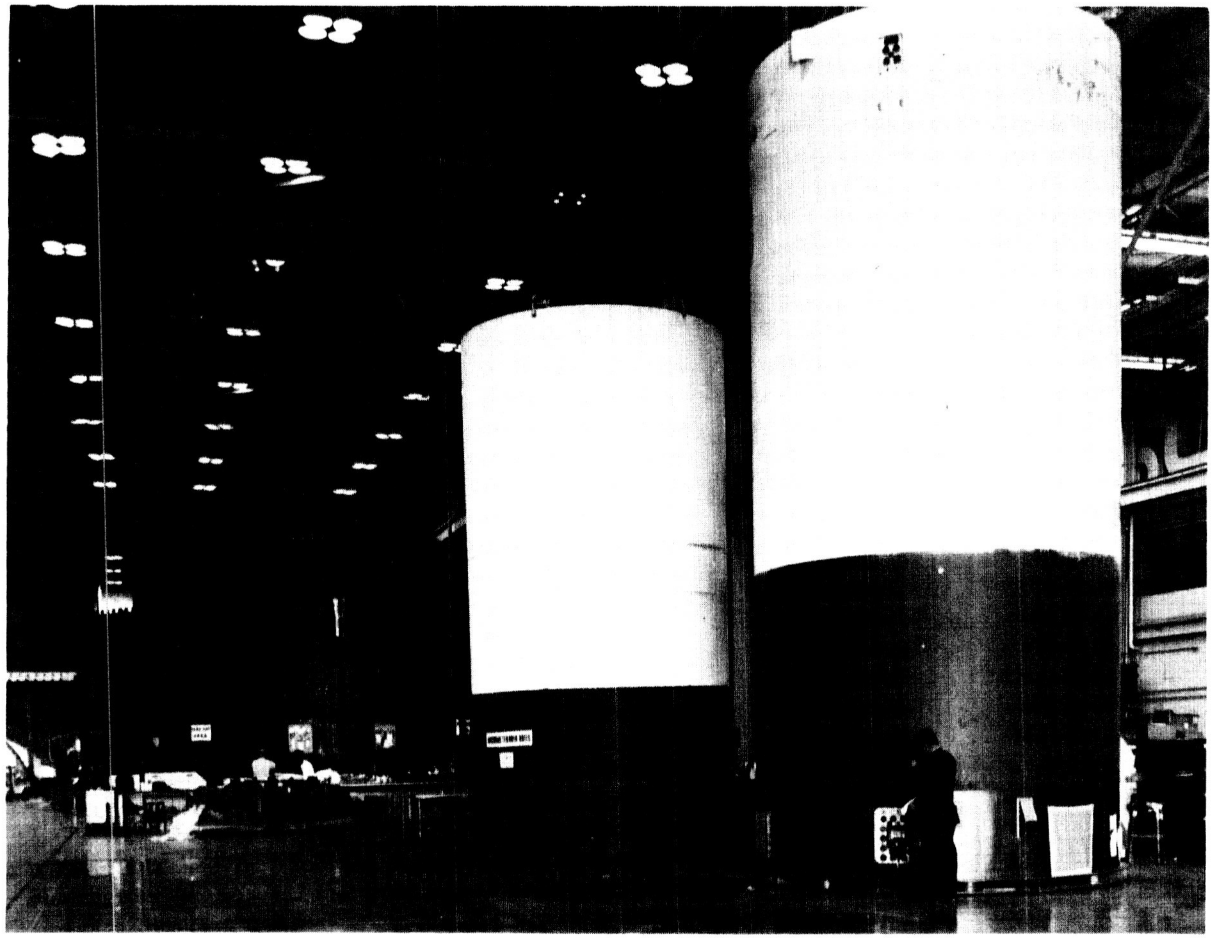
PEGASUS CAPSULES A, B, AND C

The Pegasus is part of NASA's expanding meteoroid detection program. This program directed by NASA's Office of Advanced Research and Technology is defining the hazards that meteoroids present to space vehicles. The specific objective of the Pegasus Project, as stated earlier in this chapter, is to provide engineering data about the near-earth meteoroid environment in which space vehicles operate.

Before and during launch the Pegasus is housed in the 10-foot-diameter Apollo service module attached to the S-IV stage. After injection into orbit and separation of the conical Apollo command module and part of the service module, the Pegasus remains attached to the S-IV stage. On deployment the folded wings of the Pegasus, now a satellite, are 14 feet wide and 96 feet long.

The satellite's wings are covered by thin sheets of aluminum coated with thin layers of mylar. The back of the mylar surface is coated with an extremely thin layer of vapor-deposited copper on gold foil. An electric potential established between the outer aluminum skin and the inner metal coating charges the entire "sandwich" and makes it a huge capacitor. Each time a panel is penetrated by a meteoroid, the material removed by the impact is vaporized to form a conducting gas plasma that discharges the capacitor. Levels of impact energy are differentiated through use of double-sided capacitors, target sheets of three different thicknesses. Directional information is gained by use of a combined solar sensor/earth sensor system. The Pegasus electronic system registers all penetrations and stores a record of panel thickness, panel number, and time of penetration as well as temperature data. Upon ground command the information is read out of the memory system and telemetered to the ground. A digital command system provides on/off control of the various system components, circuit replacement, certain in-flight tests, and other control functions. A solar cell (nickel-cadmium) battery power supply provides all power for the satellite during its one-year life.[35]

34. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 3, 14, 16, and 18; Memo, Lee B. James to Distribution C, "Project Name for MMC," Aug. 3, 1964; and KSC, TR-159, p. 4 and TR-168, pp. 2-3.
35. Public Affairs Off., Pegasus Fact Sheet, Sept. 1964.



PEGASUS CANISTERS

Two canisters for Pegasus meteoroid measurement satellites are shown at MSFC in October 1964. The one in the foreground is attached to a Saturn I instrument unit.

In this report period the Pegasus contractor, FHC, continued fabrication, assembly, and testing of the prototype components and Pegasus A, B, and C capsules. Difficulties experienced in developing the prototype electronic canister (the last component to be developed for the prototype) persisted through July and August. FHC completed testing of the canister on August 21. Testing of Pegasus A began with prototype hardware until flight hardware became available. Two major problems in flight component development involved Alodine coating of the detector panel skins and development of hard foam cores for the detector panels. FHC and a subcontractor, G. T. Schejeldahl (G.T.S.) Company, increased efforts in both these areas in August.

To avoid delay and also to gain full advantage from launching Pegasus A, NASA and MSFC realized late in August the necessity to reprogram Pegasus development. The program managers considered deletion of the Pegasus A experiment but finally decided to retain the experiment and to use the resulting data in the Pegasus B and C experiments. The program guidelines established at this time called for launch of Pegasus A with as many components as possible in final configuration and completely qualified. The components not formally qualified would be functionally identical to the final design. NASA stated that flight life of less than one year would be acceptable for Pegasus A. The guidelines called for no changes in the requirements for Pegasus B or C capsules.

Review of the Pegasus development in September and October revealed that many critical items, both vendor- and FHC-supplied, had not completed formal qualification tests. Development and qualification of the capacitor detector panels, a necessary item, continued to be the major difficulty. The problems still were Alodine coating of the panels and degradation of the foam core due to space radiation. Completion of the capacitor detector panels became the pacing item in development of the flight capsules. MSFC and FHC intensified their efforts toward solution of both problems. The launch schedules for SA-9 and SA-8 were rescheduled two months later and SA-10 one month later to allow more development time.

In October NASA Headquarters reassessed the Pegasus Project and again decided that little saving could be gained by eliminating Pegasus A and Saturn flight SA-9. Instead, NASA on October 26 directed MSFC to appoint a Pegasus Project Officer to give technical direction to the project. As directed by NASA, the Project Officer appointed by MSFC continued to follow the guidelines established in August. The Project Officer and his staff took direct action in monitoring and assisting FHC in its development and qualification program. MSFC also supplemented FHC's efforts with in-house help by the Astrionics Laboratory.

trailer for all remaining S-I shipments beginning with S-I-9. The contractor assumed full responsibility for transporting the Saturn S-I stages to and from Michoud.[38]

On August 1 MSFC awarded Saucer Marine Ways of New Orleans, Louisiana, a contract for modifications to the barge Palaemon. The contractor in October completed the modifications, which included installation of a pilot house as well as a wing bridge. The barge returned to operation November 2. In November MSFC removed a defective radar from the barge Promise and replaced it with a new RCA unit. This change standardized all radar sets on existing and proposed water transportation vessels.[39]

Support in the area of air transportation involved modification of a pallet for shipment of boilerplate service modules. Hayes Aircraft Corporation manufactured and modified the pallets for MSFC to meet Federal Aviation Agency stress standards. In November MSFC prepared a layout for air shipment of Pegasus A aboard the Pregnant Guppy. Tiedown arrangements were checked out also in November. First air shipment of a Pegasus flight capsule occurred in December.[40]

MSFC tested GSE for KSC and returned the equipment to Cape Kennedy. The Center on July 21 completed testing of umbilical swing arm No. 3 and associated equipment under conditions as similar as possible to vehicle launch situations. The swing arm operated satisfactorily and required only minor modification. This swing arm will provide electrical, pneumatic, air conditioning, and propellant services to the various stages of Saturn vehicles SA-9, SA-8, and SA-10. In August MSFC checked out six KSC-modified Hadley valves and a Flodyne valve for umbilical swing arm No. 2. These valves, used to shut off LOX and LH_2 lines after disconnection of the umbilical housing from the S-IV stage, failed to close properly because of a faulty control system. MSFC completed functional tests on these valves and returned them to KSC for use during the SA-7 launch. MSFC also tested Block II holddown arm components used at LC-37B and LC-34 to define and eliminate all unsatisfactory conditions.[41]

38. MSFC, MHM-9, pp. 59-60; and Test Lab., MPR, July 12 - Aug. 12, 1964, p. 41.

39. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 38; and Test Lab., Hist. Rpt., July 1 - Dec. 31, 1964, p. 23.

40. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 39; and Nov. 12 - Dec. 12, 1964, p. 36.

41. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 39; and Test Lab., Hist. Rpt., July 1 - Dec. 31, 1964, p. 5.

An MSFC Astrionics' review of the project in mid-November indicated that the electronic design was satisfactory and that the mechanical design at the blackbox level and the power supply were marginal. In a Pegasus A quality review on December 14 Astrionics personnel tagged a number of component areas for further checking. Delivery of Pegasus A to General Electric's plant at Valley Forge, for scheduled checkout prior to shipment, slipped to December 19. FHC shipped Pegasus A to KSC December 29, 1964. The Cape hangar checkout began on a two-shift operation, in an attempt to recover the slippage in schedule and support the proposed February launch date for SA-9.

In spite of the Pegasus A delays, at the end of this period no delay was anticipated in delivery of Pegasus B and C to KSC. NASA expected delivery to be in time for the proposed launches of SA-8 and SA-10.[36]

Vehicle Support Activity

Major facilities to support Saturn I development were complete prior to this report period except for an Engineering and Office building under construction at Michoud Operations. This building, for use by Saturn I, IB, and V contractor personnel, was completed on October 15. The government gained beneficial occupancy on September 1. By November 10 all personnel had moved into the building.[37]

The Center's activity in the support area diminished considerably during this six-month period, as was expected with the Saturn I program nearing completion. Some of the remaining support activities involved Saturn I transport vehicles; the rest were concerned with testing Saturn I launch GSE for KSC.

In July MSFC completed a spare parts inventory of S-I dolly equipment preparatory to transfer of S-I dolly maintenance to CCSD. The Center submitted the inventory to CCSD July 29 and requested CCSD to use an R&D instrumentation

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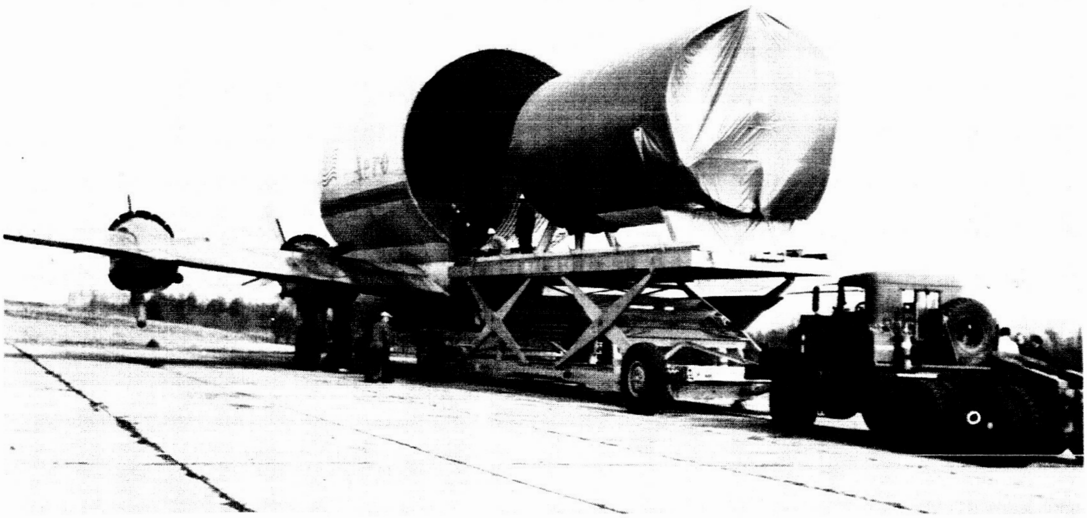
36. NASA, Minutes of the Project Pegasus Review Meeting, Aug. 19, 1964, and Oct. 26, 1964; Memo, Raymond L. Bisplinghoff, Assoc. Adm. for Advanced Research and Technology, NASA, to Assoc. Adm. for Manned Space Flight, "Qualification of Capacitor Detectors for Pegasus Spacecraft," Oct. 23, 1964; Ltr., George E. Mueller, Assoc. Adm. for Manned Space Flight to Dr. Wernher von Braun, Dir., MSFC, Nov. 25, 1964; Memo, Lee B. James, Saturn I/IB Project Off., to Dr. von Braun, et. al., "Pegasus Schedule," Dec. 15, 1965; and KSC, TR-159, p. 4.
37. Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, p. 37.

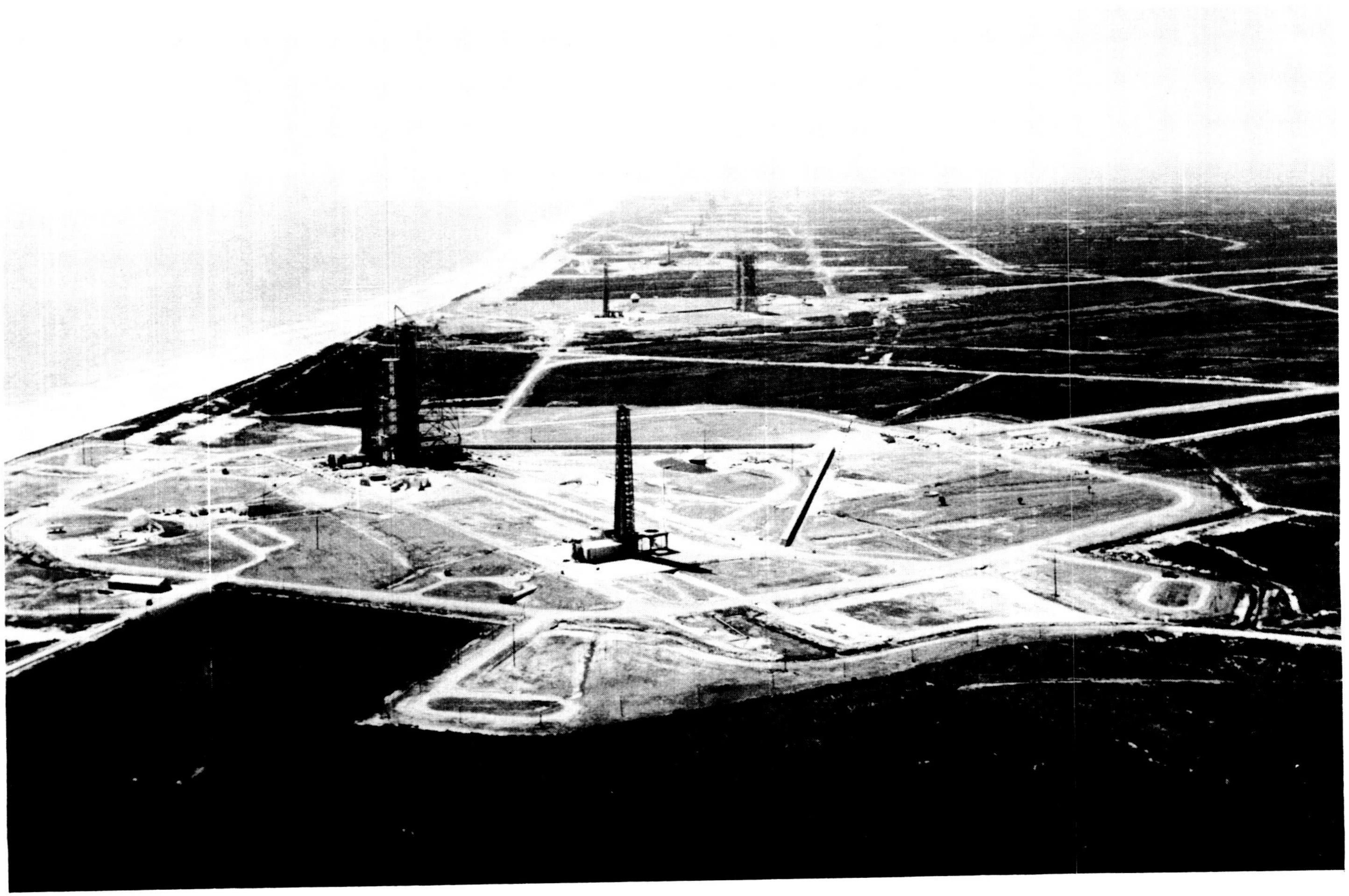
UNIT OF SATURN FLEET

The riverbarge, Palaemon, is used in the transportation of Saturn I components. The vessel underwent modification during the period of the report.



APOLLO IS LOADED

A boilerplate Apollo spacecraft is loaded on the aircraft Pregnant Guppy for transport from Redstone Arsenal Airfield.



SATURN I AND IB LAUNCH COMPLEXES

This aerial view of a part of Cape Kennedy shows Launch Complex 37 (foreground) and Launch Complex 34 (center picture).

Near the end of the July-December 1964 period MSFC completed and shipped to LC-37B the second mobile capsule checkout unit to support the Pegasus launches. A third mobile unit and a set of blockhouse GSE to support the capsule at the launch site will be shipped to KSC in January 1965.[42]

Funding

MSFC obligations for the Saturn I program during the first half of Fiscal Year 1965 totalled $22,252,000. Breakdown of the obligations by program phases was as follows: Saturn S-I stage, $5,481,000; S-IV stage, $9,676,000; Instrument Unit, $1,047,000; Ground Support Equipment, $690,000; and Vehicle Support, $5,358,000.[43]

Summary

The Saturn I became operational during this report period when NASA orbited a 39,000-pound payload that included the S-IV stage, the IU, BP-15, and an LES. This highly successful flight occurred on September 18 from LC-37B.

Emphasis in the Saturn I program changed from hardware development to checkout and launch preparation of SA-9, SA-8, and SA-10. MSFC and the stage contractors completed acceptance tests of all Saturn I hardware except the S-IV-10 in January 1965.

Shipment of the SA-9/Apollo vehicle to KSC began in October and ended in November. In November KSC completed erection of the vehicle on LC-37B and immediately began prelaunch checkout.

In August MSC's Apollo spacecraft contractor, S&ID, completed delivery of all the spacecraft hardware that would fly on Saturn I vehicles. S&ID delivered BP-16 and BP-26 command modules and launch escape systems to KSC. The service modules, spacecraft adapters, and associated hardware for these spacecraft underwent modification at MSFC to accommodate Pegasus capsules. MSFC delivered the BP-16 hardware to KSC on November 13 and planned to deliver BP-26 at a time compatible with delivery of Pegasus B. At the close of this period modification of BP-9 for launch by SA-10 was underway at MSFC.

42. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 18.
43. All funding information supplied by Louis E. Snyder, Chief, Budget and Operations Branch, Financial Management Office, MSFC, Aug. 24, 1965.

One phase of activity interrupted the progress in the Saturn I program during this six months. This problem area involved fabrication, assembly, and checkout of the Pegasus A, B, and C capsules for SA-9, SA-8, and SA-10. Solution of problems connected with development of the capsules' capacitor detector panels slowed the development program and required the concerted efforts of the contractor, FHC, and MSFC. In August NASA established new guidelines for the Pegasus Project; in September the proposed dates for the Saturn launches were slipped several months to allow more time for capsule development. On December 29 FHC delivered the first flight capsule, Pegasus A, to KSC.

CHAPTER III: SATURN IB

The two-stage Saturn IB launch vehicle will launch manned Apollo spacecraft into earth orbit for astronaut training and spacecraft development preparatory to manned spacecraft flights to the moon using the larger Saturn V.

Standing 225 feet tall and with a liftoff weight of about 1,297,000 pounds, the Saturn IB is a "hybrid" vehicle incorporating the first stage (S-I) of Saturn I and the third stage (S-IVB) of Saturn V. The IB's instrument unit (IU) is almost identical to that of Saturn V's.

For Saturn IB application, the S-I stage is designated S-IB. The stage's weight is reduced by some 20,000 pounds from that of the Saturn I configuration, the thrust of its eight H-1 engines is increased from 188,000 pounds (188K) each to 200K, and it has improved and lighter fin construction. Saturn IB application of the S-IVB stage calls for lighter aft and forward skirt construction; a cylindrical interstage to coincide with the 257-inch diameter of the S-IB stage; and a smaller attitude control module because there is no restart requirement for its J-2 engine. Minor changes in the Saturn IB and Saturn V IU are in equipment and instrumentation and vary according to the different mission requirements.

In the two years[1] of Saturn IB program management MSFC completed preliminary definition of the vehicle, provided industrial contractors with stage specifications and much of the design data, and directed the contractors in the research and development (R&D) of the stages and instrument unit.

When the Saturn IB program entered its third year of R&D in September 1964, production and testing of ground test stages was well underway. Before the current report period ended in December, the manufacture of the first flight vehicle (SA-201) was nearly complete and manufacture of stages for the next three flight vehicles was in progress.

NASA, MSFC, and the Manned Space Center (MSC) continued in the July - December 1964 period to coordinate Saturn IB mission requirements for the 12-vehicle program (three R&D and nine operational vehicles). Missions other than

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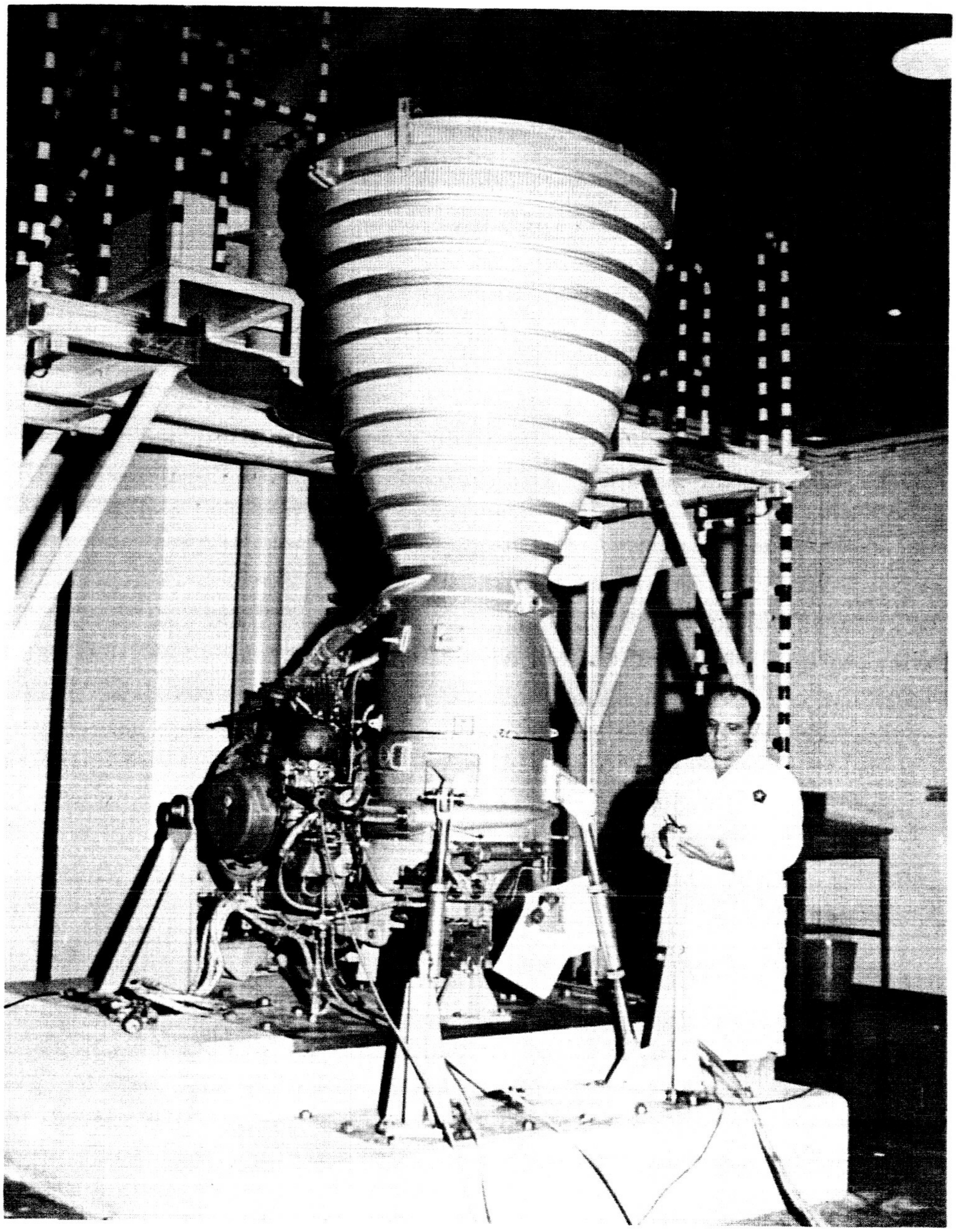
1. The past history of the Saturn IB program is contained in MSFC, Marshall Historical Monograph No. 7 (MHM-7), History of the George C. Marshall Space Flight Center, Jan. 1 - June 30, 1963, pp. 65-86; and subsequent histories, MHM-8, pp. 57-91; and MHM-9, pp. 65-105.

FIRST S-IB IS ASSEMBLED

Propellant tanks of S-IB-1, the first Saturn IB flight booster, are clustered in the Michoud Operations manufacturing building during July 1964.



FIRST UPRATED H-1 ENGINE

A Chrysler engineer completes acceptance inspection on the first 200,000-pound-thrust H-1 engine delivered by Rocketdyne for the Saturn IB vehicle.

the primary mission--placement of the Apollo spacecraft in earth orbit for development testing and astronaut training--received consideration. Suborbital "lob" missions were assigned to SA-201 and SA-202, and a liquid hydrogen (LH_2) experiment was a primary mission for the third flight vehicle (SA-203). A number of missions under consideration called for more payload capability, and MSFC continued study efforts leading to a third stage and/or to vehicle improvements that would increase the payload capability.

S-IB Stage Research and Development

The S-IB (booster or first) stage of the Saturn IB vehicle is 80.2 feet long and 21.4 feet in diameter without fins (40.7 feet with fins). Eight H-1 engines provide total sea level thrust of 1.6 million pounds.[2] Four model MB-1 solid propellant rocket motors provide first stage retrothrust at S-IB/S-IVB separation.[3] Dry weight of the S-IB stage is about 94,500 pounds.

Chrysler Corporation Space Division (CCSD) is the prime contractor for research, development, fabrication, assembly, checkout, static test, and launch support for the S-IB stage. CCSD uses drawings and specifications furnished by MSFC, except for certain areas for which CCSD has design responsibility. Except for static testing and launch operations, the contractor performs all S-IB stage effort at the government's Michoud Operations, New Orleans, Louisiana. Contractor personnel conduct S-IB static testing in modified S-I stage test facilities at the MSFC complex in Huntsville, Alabama, and launch operations at Kennedy Space Center (KSC).

Modifications to CCSD's S-I/IB stage contract (NAS 8-4016) in the July - December 1964 period increased its value by $11,970,481 for a total value of $317,262,198. The period increase extended through June 1965 CCSD's support in aeroballistics, engineering documentation services, and direct engineering. The increase also provided for modification of plant facilities, restoration of former office facilities in New Orleans to their original condition, modification to NASA's barge Promise, study effort to define a preliminary Saturn IB/Minuteman

2. P&VE Lab., Saturn IB Mission Plan and Technical Information Checklist, Vol. II, Rev. 3, Sept. 1, 1964, p. 4.
3. KSC, Technical Progress Report, Third Quarter, CY-1965, (TR-250), p. 21.

configuration, concept design of Saturn IB ground support equipment (GSE) data, procurement of new S-IB stage hardware, and redesign, fabrication, and qualification of certain S-IB components.[4]

DESIGN AND ENGINEERING ACTIVITY

In the July - December 1964 period all S-IB stage program participants continued efforts to reduce the weight of the stage and also to improve its capability. Separate investigations in areas of structural and component engineering, strength analysis, dynamics and loads, and vibrations and acoustic characteristics were performed at Michoud by CCSD personnel and by MSFC personnel in Huntsville.

Engineering activity resulted in systems improvement in several areas. One major design improvement was rerouting of the inboard turbine exhaust to end hot-gas ducting above the firewall. Rocketdyne shortened the ducts and CCSD eliminated the turbine exhaust fairings; the new ducting system resembled the aspirator system used on outboard engines. Advantages were improved aeroballistic characteristics for the stage and reduction in overall weight of the stage.[5] The design change will be incorporated in S-IB-3 and subsequent stages.

Changes in the S-IB liquid oxygen (LOX) venting system, another major redesign, solved a LOX loading problem which was a carryover from the S-I stage program.[6] The redesigned system has a 7-inch butterfly valve on each outboard LOX container and a 4-inch mechanical relief valve[7] on the center container closing the vents and preventing spillage during the replenishing process. The system retained inflight vent capability.[8]

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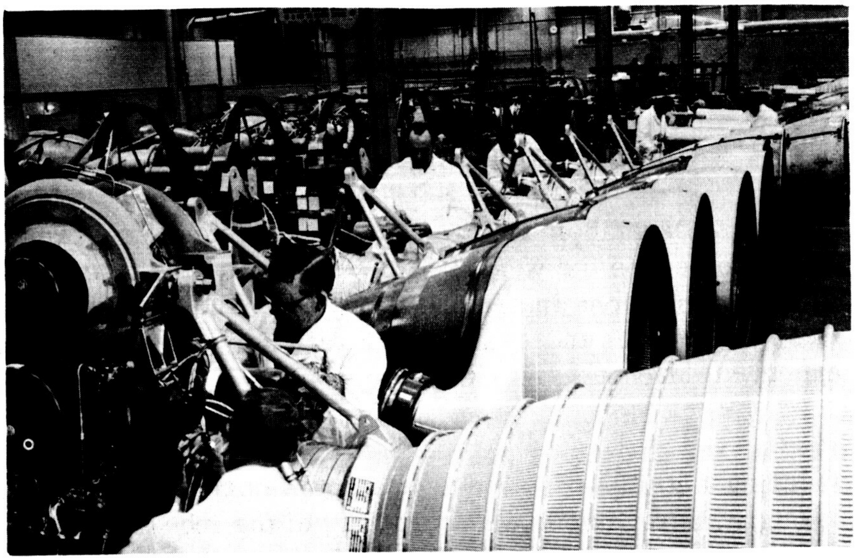
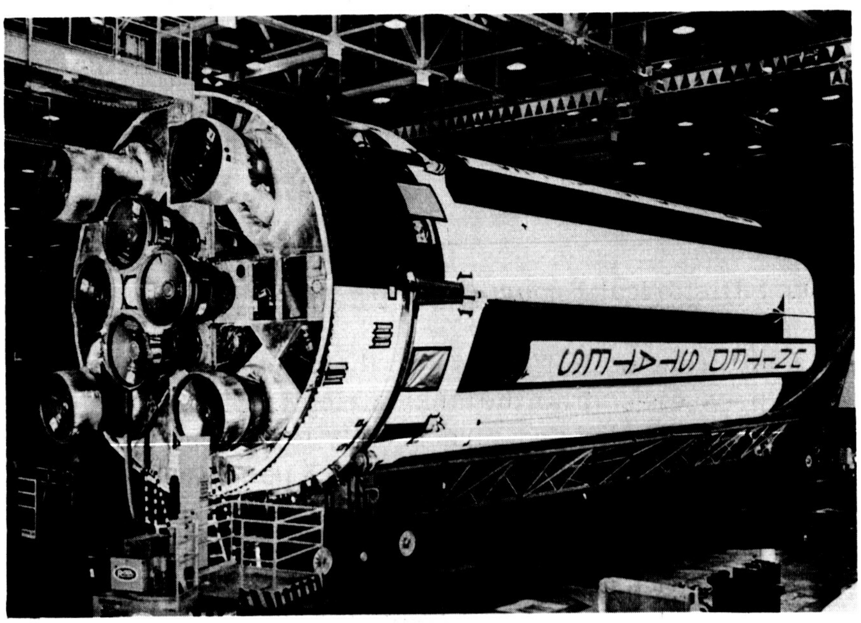
4. Michoud Op., Historical Report, July 1 - Dec. 31, 1964, pp. 13-15.
5. Ibid., pp. 7-8.
6. In Saturn I different boiloff rates for the windward and leeward LOX tanks created different pressures within the tanks during loading. This caused different heights of liquid to be loaded and consequently less than the required amount of fuel. Replenishing the tanks to the required 1.5 per cent fuel ullage resulted in LOX spillage into the GOX riser.
7. This mechanical relief valve will be replaced by a pneumatic relief valve for S-IB-3 and subsequent stages.
8. P&VE Lab., Monthly Progress Report for Period Aug. 12, 1964, Through Sept. 11, 1964, MPR-P&VE-64-9, p. 33; MPR-P&VE-64-10, p. 34; MPR-P&VE-64-11, pp. 36-37; and Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, p. 8.



H-1 FINAL ASSEMBLY

An H-1 rocket engine for Saturn IB is shown being assembled at Rocketdyne's Neosho, Missouri, plant.



S-IB STAGE AT MICHOUD

In the Saturn I/IB manufacturing area at Michoud Operations is a flight S-IB stage.

Rocketdyne Division of North American Aviation (NAA), prime contractor for the H-1 engine, completed development of the basic 200K qualification and flight configuration engine during this report period. Uprating the 188K engine to 200K required modification of the main LOX valve, main fuel valve, oxidizer discharge duct, turbine exhaust hood, and heat exchanger. Also required were improvements to the number 7 turbopump bearing. Production of the modified components will be effective in S-IB-3 engines; S-IB-1 and S-IB-2 engines will be retrofitted with the components.

The engine contractor also initiated at the Rocketdyne plant in Canoga Park, California, a development program for an improved injector. Rocketdyne began this program to increase the payload capability of the S-IB stage.[9]

S-IB DYNAMIC TEST STAGE

The S-IB stage ground test program includes only the dynamic and facility tests. This is true because its functional design received flight certification during the Saturn I S-I stage program.

The Saturn I dynamic test stage (SA-D5) modified to the Saturn IB configuration (S-IB-D/F) will be used to support both the dynamic and facility tests.

On July 22 CCSD received the SA-D5 at Michoud for modification. The S-IB stage contractor weighed the stage to determine the longitudinal center of gravity and then removed the components and tanks. One fuel tank and the 105-inch LOX tank were shipped to Ling-Temco-Vought in Dallas, Texas, for modification. The other components were labeled S-IB-D/F and stored. In late September CCSD began buildup of the S-IB-D/F with a modified flight tail section, a new spiderbeam, the modified tanks, and the usable SA-D5 components. Ballast was added in the stage to relocate the center of gravity to the S-IB-1 configuration. CCSD completed modification and checkout of the stage in early December and on December 22 shipped it to MSFC's test complex in Huntsville.[10]

S-IB FLIGHT STAGES

Production of the first four S-IB flight stages progressed at Michoud during the report period.

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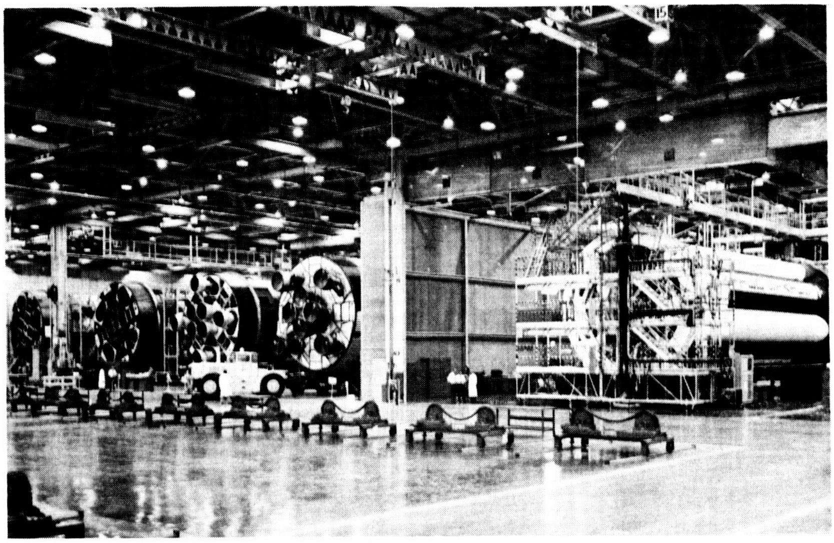
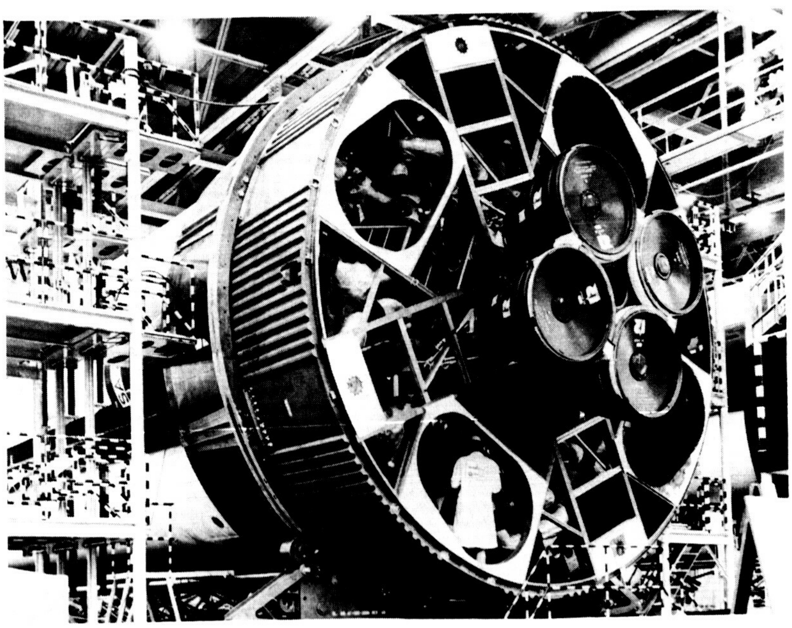
9. Engine Project Off., Quarterly Progress Report, F-1, H-1, J-2, and RL10 Engines, July, Aug., & Sept., 1964, QPR-Eng-64-2, pp. 21-23; and QPR-Eng-65-1, pp. 15-17.

10. Saturn I/IB Off., I/IB Progress Report, Mar. 16 - Sept. 30, 1964, MPR-SAT-I/IB-64-2&3, p. 21.



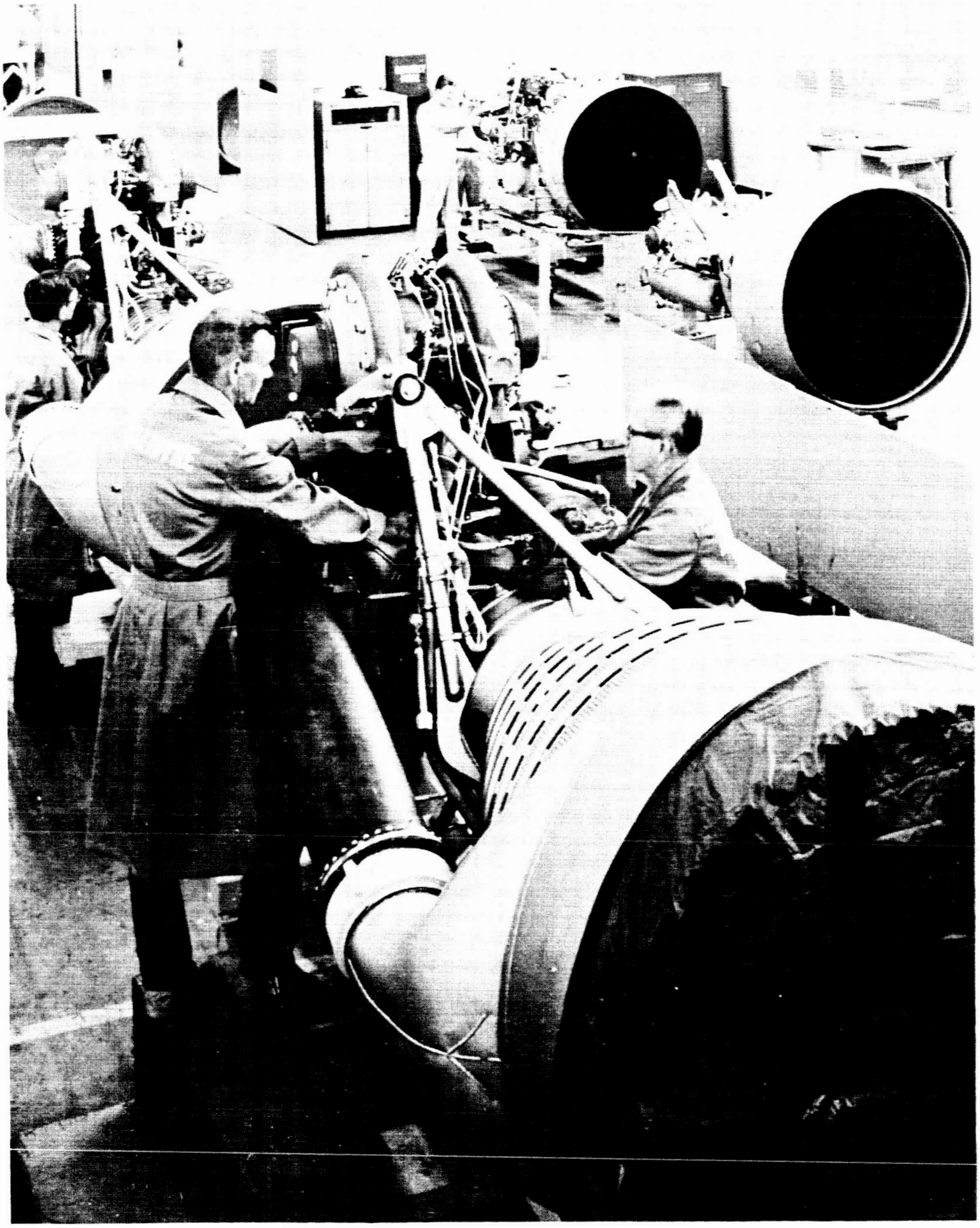
FIVE SATURN BOOSTERS

Pictured at Michoud Operations are S-I and S-IB stages in various degrees of completion. Chrysler Corporation builds these boosters for NASA.



S-IB-2 IN ASSEMBLY

In November 1964 Chrysler workmen at Michoud Operations fit inboard engines in S-IB-2, the second Saturn IB flight booster.



SATURN I BOOSTER ENGINE ASSEMBLY

Workmen at North American Aviation's Rocketdyne Division, Canoga Park, California, assemble an H-1 engine.

In the week of July 20 CCSD completed clustering of tanks for the first flight stage (S-IB-1). The stage contractor received all the uprated (200K) engines for S-IB-1 from Rocketdyne in late July and installed them in the stage. In early November CCSD interrupted S-IB-1 assembly operations to allow removal and return of the engines to Rocketdyne for LOX dome and injector retrofit. On November 20 CCSD completed assembly operations without the engines and on November 24 placed the stage in Checkout Station No. 2. The contractor completed 55 per cent of the prestatic checkout; reinstallation of the engines and completion of prestatic checkout will occur in January and February 1965.[11]

CCSD accomplished buildup of the spiderbeam for S-IB-2 in July and August. In late September the contractor began the S-IB-2 assembly operations with tank clustering. By the end of December CCSD had completed 60 per cent of the assembly operations.

Fabrication of S-IB-3 components began at Michoud in July. At the end of this report period CCSD had completed the S-IB-3 barrel assembly, and assembly of the outriggers to the barrel assembly was underway.

CCSD commenced fabrication of S-IB-4 components on October 18, 1964.[12]

S-IVB Stage Research and Development

The S-IVB (second) stage of the Saturn IB vehicle is 59.1 feet long, 21.7 feet in diameter, and weighs about 14 tons dry. Fully loaded with propellant the S-IVB/IB stage weighs over 130 tons. Its one J-2 engine provides 200,000 pounds thrust (in a vacuum). The basic structure of the S-IVB consists of the forward skirt assembly, liquid hydrogen (LH_2) tank, LOX tank, aft skirt assembly, thrust structure engine assembly, and aft interstage assembly. Both propellant tanks are in one container with the LH_2 tank forward of the LOX tank. A common bulkhead within the container separates the two tanks.[13]

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11. Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, pp. 2 and 10; and Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 19-21; and MPR-SAT-I/IB-65-1, p. 10.

12. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 21 and 30; Michoud Op., Historical Report, July 1 - Dec. 31, 1964, p. 12; and Teletype, M. Johnson, Chief, Program Control Off., MSFC, to Director, Apollo Program Control Off., NASA, "Weekly Notes, Saturn I/IB," Jan. 4, 1965.

13. P&VE Lab., Saturn IB Mission Plan & Technical Information Checklist, Vol. II, Rev. 3, Sept. 1, 1964, p. 4; and Saturn V Off., Saturn V Glossary, MSR-SAT-V-65-52.

DOUGLAS SPACE SYSTEMS CENTER

This facility at Huntington Beach, California, is used for development, test, and production of S-IV and S-IVB stages for Saturn vehicles.

The Missile and Space Systems Division of Douglas Aircraft Company (DAC) is the prime contractor for design, development, fabrication, and test of the S-IVB stage. DAC performs the S-IVB stage operations at company sites in Huntington Beach, Santa Monica, and Sacramento, California.

The first S-IVB/IB contract action (a modification to the Saturn V S-IVB contract in December 1963) provided for four S-IVB/IB stages. On June 10, 1964, MSFC forwarded to DAC a request for quotation for the remaining eight S-IVB/IB stages scheduled in the program and for a set of ground support equipment (GSE). MSFC received DAC's proposal in September, and in December final contract negotiations were progressing.[14]

A thorough investigation in August and September of the Saturn IB program status--by Saturn IB contractors, NASA Headquarters, and MSFC--revealed the S-IVB stage to be the pacing item in the development program. Several critical areas in the S-IVB program caused delays. To overcome delay in the program and to regain contract delivery schedules for test stages and flight stages, DAC rearranged test objectives among S-IVB test stages and concentrated on management improvement.

The contractor deleted requirements for all-systems testing and diverted most of the engineering effort from development of the "live" ground test stage[15] to the first flight stage (S-IVB-201). The contractor also deleted design assurance and qualification testing prior to SA-201 acceptance firings. These revisions placed the S-IVB-201 acceptance tests back on schedule. DAC made other provisions in the qualification test program to assure total component qualification prior to the flight of SA-201. The auxiliary propulsion system (APS) test program was revised so that a production flight module could be hot-fired in conjunction with a J-2 engine acceptance firing.[16]

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14. MSFC, MHM-9, p. 83; and Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 21.
15. In May 1964 program planners terminated production of the facilities checkout stage. They planned, on completion of all-systems testing, to use the all-systems test stage in checkout of facilities. The program assessment in August resulted in deletion of all-systems testing and left only facilities checkout missions. Engineering effort to develop the stage for "live" testing ended and DAC redesignated the stage as the facilities checkout stage.

See Saturn I/IB Off., MPR-SAT-I/IB-2&3, pp. 23 and 31.

16. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 19 and 21; Ltr., C. R. Able, Vice Pres. and General Mgr., DAC Missile & Space Systems Div., to Dr. Wernher von Braun, Dir., MSFC, Sept. 17, 1964; and DAC, <u>S-IVB Saturn Monthly Technical Progress Report,</u> Issue 26, SM-46794, pp. 3-4 and 129.

DESIGN AND ENGINEERING ACTIVITY

The design of each component and system in the stage undergoes a period of qualification before being released to production. Design qualification involves studies, analysis, and tests of prototype components and systems. The design qualification phase often ends in component and system improvement. Much of the improvement results from engineering activity to correct defects. New or additional mission requirements call for other changes and improvement to the basic component and system design.

Design analyses in the current period led to selection of the TX-280 motor for Saturn IB and Saturn V S-IVB ullage rocket systems. Results of the analyses also led to strengthening of the ullage rocket fairing in the region of the forward motor support. This move would preclude possible delays in vibration qualification of the motor in bracketry simulating the flight configuration. In October DAC finalized contract action with Thiokol Chemical Corporation for 48 TX-280 motors and spares. Thiokol will deliver the motors in four separate groups in 1965, 1966, 1967, and 1968 to avoid over-aging of motors.

A number of design and development analyses underway during this period concerned the retrorocket system, the effects of retrorocket flame impingement on the S-IVB stage during separation, and controllability of the S-IVB stage during separation from the S-IB stage.[17]

DAC's analyses of the primary propulsion system involved the oxidizer system, cold helium purge, propellant tank pressurization, J-2 engine LOX chilldown system, and LOX system performance during steady state operation. Rocketdyne, the J-2 engine contractor, continued investigations leading to solution of several component problems existing in J-2 engine development. Among major problems solved were operation of the fuel turbopump, gas generator, and propellant utilization valve. Late in this period Rocketdyne completed the J-2 engine preliminary flight rating tests (details are in the Saturn V chapter).

Design analyses led to definition of the S-IVB operational telemetry system in September. The telemetry system on operational vehicles will consist of a single PCM/FM link from the S-IVB stage. This single link will carry mission

17. DAC, SM-46770, Issue 25, pp. 14 and 41; SM-46824, Issue 27, pp. 19 and 52; SM-46897, Issue 28, pp. 18 and 20; and SM-46935, Issue 29, pp. 20, 22, 23, and 27.

control data and engineering performance data. The system is so designed that S-IVB mission control data will appear on both the S-IVB and IU telemetry links. In event of failure of one link, vehicle mission control data will be available from the other link. Drawings for the component design neared completion. DAC awaited MSFC authority to proceed with procurement of telemetry components for S-IVB-205 and subsequent Saturn IB stages and S-IVB-502 and subsequent Saturn V stages.[18]

The new missions assigned to flight vehicles SA-201, SA-202, and SA-203 necessitated vehicle design analysis and changes, particularly in the S-IVB stages. Consequently, DAC initiated the additional design analyses during this report period.

MSFC notified DAC in August that SA-201 and 202 would test reentry of the Apollo spacecraft heat shield. The vehicles will "lob" the spacecraft in trajectories that will allow reentry and recovery in the South Atlantic and Pacific oceans. The propulsion system of the spacecraft's service module will fire to cause a reentry speed of about 28,000 feet per second in a realistic test of the heat shield. The trajectory required could affect loads, heating, sloshing, and other environmental conditions imposed on the S-IVB stage. Throughout the remainder of this period DAC investigated the impact of this mission change on the S-IVB structure.[19]

In October MSFC authorized DAC to proceed with design of S-IVB-203 for a prolonged near zero "g" LH_2 orbital experiment. The experiment will determine the adequacy of the Saturn V continuous vent and ullage control rocket systems, the behavior and heat transfer characteristics of LH_2 under near zero "g" conditions, and J-2 engine restart capability. For this mission considerable redesign is required for the 203 flight vehicle, particularly the S-IVB-203 stage. LOX will be loaded to 65 per cent of normal capacity in S-IVB-203 to achieve a greater quantity of LH_2 in orbit for observation. DAC redesigned the slosh baffle to maintain stability during the S-IVB burn. In the new baffle configuration, a slosh ring was added near the new loading limit. DAC also completed the layout and details for mounting LH_2 instrumentation probe supports to the tank wall, and for mounting the required additional ambient helium bottle on the thrust structure. Design was also underway for the TV system to view the interior of the LH_2 tank as were modifications to the LOX vent port, batteries, and propulsive vents on the stage structure when this period ended.[20]

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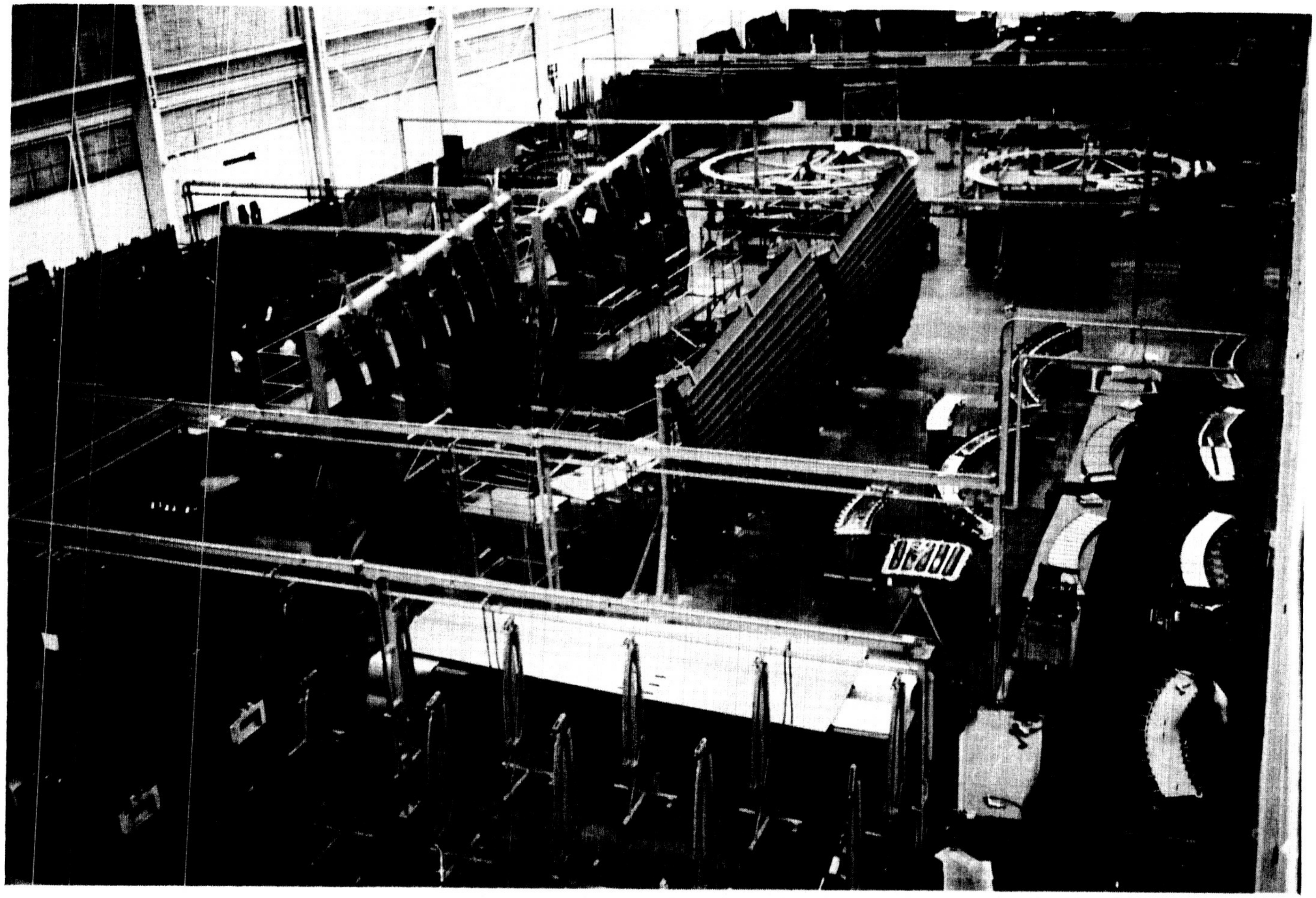
18. DAC, SM-46794, Issue 26, pp. 4-5; SM-46897, Issue 28, pp. 11-12; SM-46935, Issue 29, pp. 8-9; and Engine Project Off., QPR-Eng-64-2, p. 26; and QPR-Eng-65-1, p. 23.
19. DAC, SM-46770, Issue 25, p. x; SM-46794, Issue 26, p. 8; and Joseph W. Cremin and William M. Gillis, MSFC, SA-201 Launch Vehicle Reference Trajectory, TM X-53242, abstract.
20. DAC, SM-46824, Issue 27, p. 4; SM-46897, Issue 28, p. 4; and SM-46935, Issue 29, pp. 3, 22, 30, and 38.



S-IVB MANUFACTURE

Components of the S-IVB stage are pictured in the S-IVB manufacturing area of facilities at Tulsa, Oklahoma.

Another redesign necessitated by new mission requirements involved the retro system. MSFC authorized definition of a retro system for deorbiting the Saturn IB/S-IVB from earth orbit with oceans (Indian, Pacific, and Atlantic) as available impact areas. On December 3 DAC presented to MSFC results of a study in which four different retrorocket configurations were investigated. The system considered most feasible consisted of two 20-inch spherical retros attached to the thrust structure of the S-IVB. MSFC requested a cost and schedule quotation of the motors most likely to be selected from potential motor suppliers. Meanwhile, NASA directed DAC to proceed with a follow-on study of de-orbiting the Saturn V/S-IVB with a view toward combining the design concepts of the Saturn IB and Saturn V retro systems.[21]

Considering the number of design revisions resulting from design analyses and mission changes, DAC made significant progress in the fabrication and qualification of S-IVB components. When this period ended, the majority of layout and production drawings for S-IVB structural components and subsystems were complete; the rate of development and qualification tests had increased significantly.

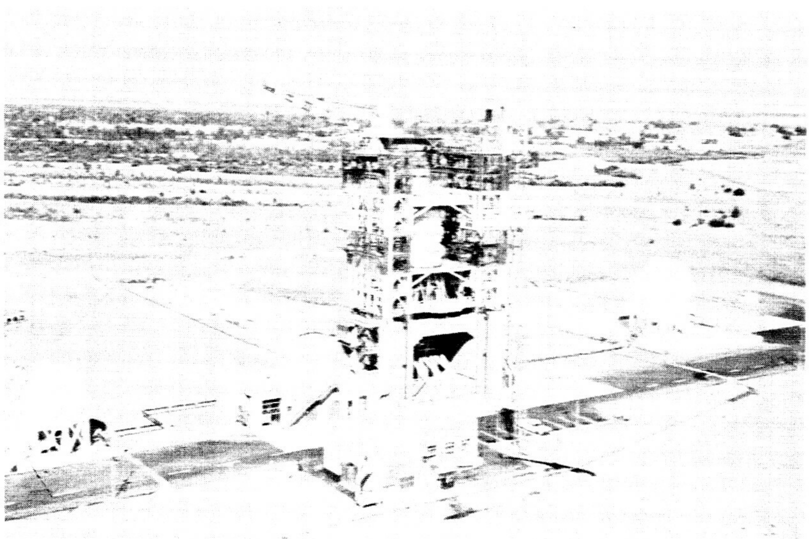
During July - December 1964 the contractor completed certain qualification tests of structural components. Qualification of the tank cylinder was completed on September 2. The tank cylinder withstood combined 100 per cent design ultimate loads of moment and axial compression with no structural damage. DAC completed axial load, bending moment, pressure influence tests, and the flight simulation maximum load test on the forward skirt section. Also completed were stability analysis of the forward skirt and aft interstage frames and a load analysis of the aft skirt frame.[22]

DAC completed evaluation of the APS module design at Santa Monica in July. In October the contractor completed Phase I qualification of the APS. Phase I qualification consisted of engine cluster design evaluation tests. The tested cluster contained three 150-pound-thrust attitude control engines; they were fired separately in the cluster and then together as a unit. Following successful static firing of the S-IVB battleship stage in December (see Test Vehicle section of R&D coverage) DAC began preparations for the APS Phase II tests. Phase II tests, scheduled for completion in June 1965, will evaluate the module design at sea level

21. DAC, SM-46897, Issue 28, pp. 2 and 20; and SM-46935, Issue 29, pp. 21 and 81.
22. DAC, SM-46749, Issue 24, p. 65; SM-46770, Issue 25, p. 40; SM-46794, Issue 26, p. 53; and SM-46897, Issue 28, p. 53.

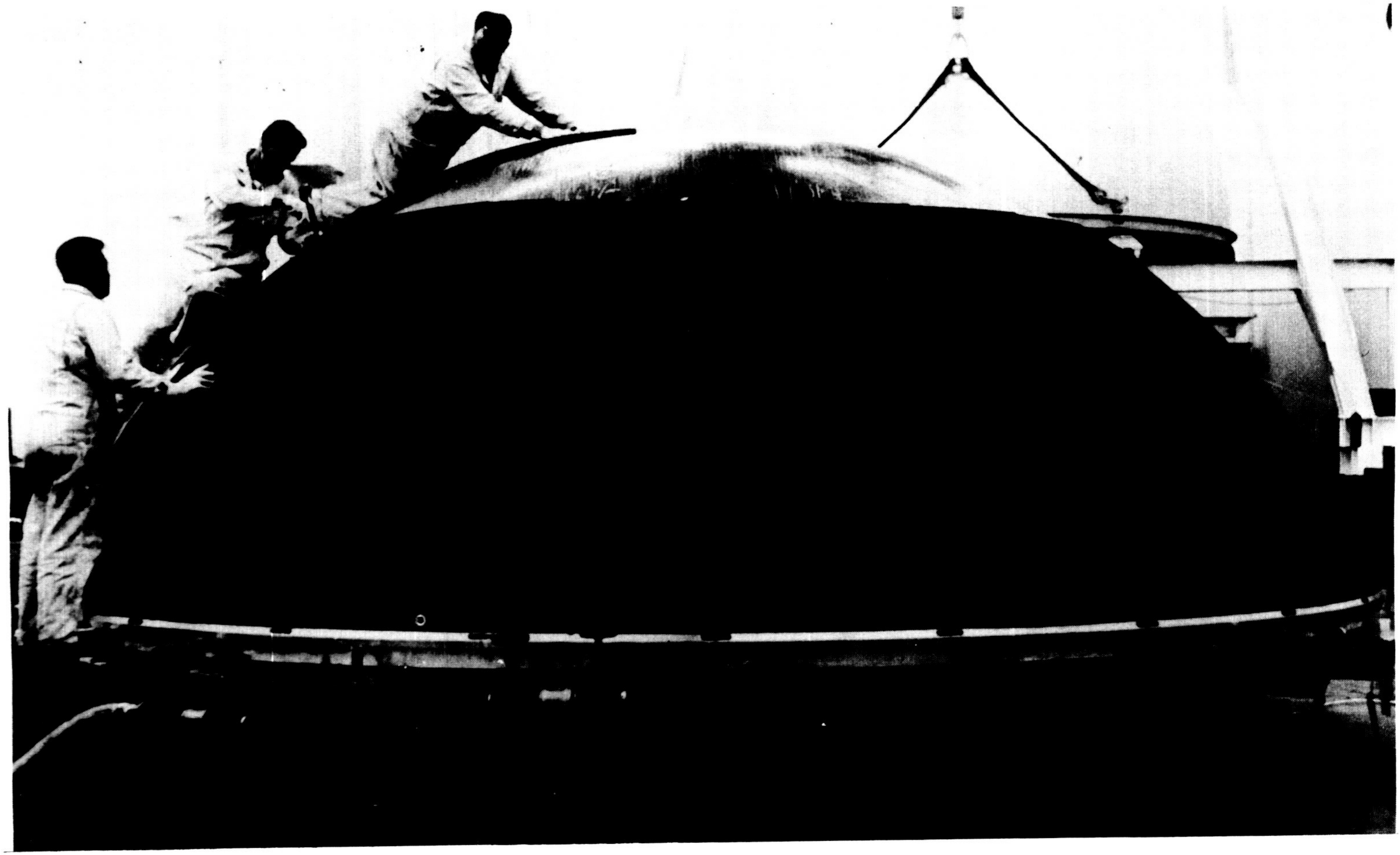
GAMMA TEST COMPLEX AT SACTO

S-IVB stage auxiliary propulsion system (APS) modules are tested in these test cells at Sacramento Test Center's Gamma Complex. Douglas Aircraft Company operates this facility.



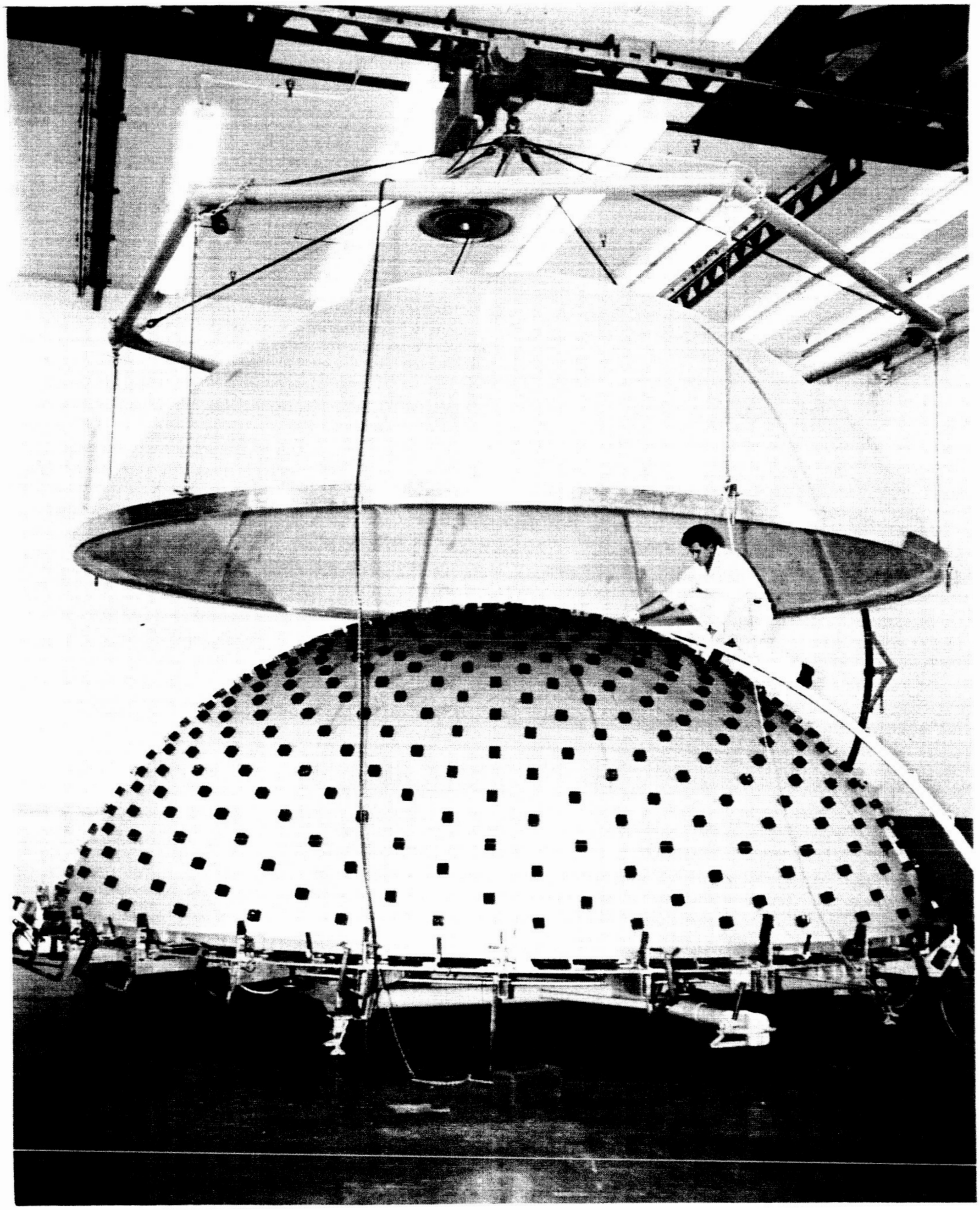
S-IVB BATTLESHIP IN STAND

The S-IVB battleship, in Saturn IB configuration, is shown in the Beta 1 test stand at Sacramento Test Center (SACTO), California, where firings occured late in the current period.



S-IVB TANK COMPONENT

Workmen at Douglas Aircraft Company's Santa Monica plant apply adhesive to a common bulkhead dome.



COMMON BULKHEAD BUILDUP

An S-IVB common bulkhead shell is lowered onto the lower dome for fit check before installation of honeycomb insulation.

conditions. It will be the first test of a complete module, and two sets of engines will be employed in succession for testing. The APS flight rating tests are scheduled to begin in August 1965.[23]

S-IVB GROUND TEST STAGES

The S-IVB ground test program--consisting of extensive development and qualification tests leading to flight verification--requires the following test stages: structural test stage, battleship test stage, dynamic test stage, and facilities checkout test stage.

Structural Test Stage: DAC completed fabrication and assembly operations in April 1964 for this stage, and in June completed checkout operations. Early in July DAC installed additional instrumentation in the stage to provide more complete data in event of a rupture during tests. The contractor then began testing components to optimize and prove the design load-carrying capability and to establish a margin of safety beyond maximum expected operational environment.[24] The LOX tank passed the proof requirement pressure (hydrostatic) test but, during proofing of the LH_2 tank on July 14, the cylinder and forward dome ruptured at approximately limit pressure. X-ray examination showed that failure began with lack of fusion in one area of the weld seam on the longitudinal portion of the LH_2 tank assembly. MSFC sent a representative to participate in investigation of DAC's welding practices and controls. The investigating committee recommended improvements in welding techniques and changes in DAC's radiographic inspection procedures.[25] MSFC approved DAC's plan for continuing the structural tests in August. The contractor returned the LOX tank to Santa Monica for rework in preparation for the thrust structure test. In October DAC completed dynamic spring-rate tests, initiated the retrorocket bracket test program of the aft interstage and the forward skirt, and ran a preliminary systems checkout. Testing of the forward skirt section continued to the end of December.[26]

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23. Saturn I/IB Off., MPR-SAT-I/IB-65-1, p. 6; and DAC, SM-46935, Issue 29, p. 1.
24. Edmund F. O'Connor, MSFC Industrial Op., "Saturn Launch Vehicles," AAIA Paper No. 65-302, p. 31.
25. The weld cracking problem also existed in S-IV stage development. P&VE Lab., MPR-P&VE-64-8, pp. 104-105.
26. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 29; P&VE, MPR-P&VE-64-8, pp. 57 and 101; MPR-P&VE-64-9, pp. 42, and 103-105; and MPR-P&VE-64-10, p. 88; DAC, SM-46749, Issue 24, pp. 1, 28-29, and 33; SM-46897, Issue 28, p. 59; and SM-46935, Issue 29, p. 63.

Battleship Test Stage: The S-IVB program review at the beginning of the current report period showed this stage to be pacing development of the S-IVB propulsion program. MSFC extended the test period for the stage two additional months (to March 31, 1965) to provide additional testing if necessary. From the beginning of the report period to mid-September DAC reworked the S-IVB battleship stage[27] in preparation for the test program. The contractor successfully conducted the first battleship cryogenic loading with liquid nitrogen and LH_2 on September 18 at the Sacramento test site. The stage, facility, ground support equipment (GSE), and instrumentation systems performed well. Successful cryogenic loading with LOX and LH_2 and the overboard bleed chilldown occurred September 25. Successful propellant loading and forward flow recirculation chilldown on October 2, and special thrust chamber chilldown tests on October 9, completed the battleship chilldown program. DAC attempted the battleship ignition firing on October 24 but encountered problems with the LOX and LH_2 prevalves. The valves were returned to Clary Dynamics Corporation for rework and then reinstalled in the stage. The first mainstage shakedown firing occurred on December 1. The start conditions were obtained and maintained throughout the simulated booster flight time of ten seconds. The stage, facility, and GSE performed well during the highly successful firing. The second mainstage firing took place on December 9 with engine sequence time as 53.6 seconds and mainstage duration as 50.5 seconds. A successful 150-second mainstage shakedown firing, conducted on December 15, completed the shakedown static firing series. On December 23 the battleship stage successfully endured the initial full-duration (414.7-second) static firing. The engine performed satisfactorily through engine start, steady state operation, and shutdown operation. Saturn IB configuration battleship firings will continue to February 20, 1965. Test operations will then be shut down and the stand and stage modified to permit engine gimballing and conversion to the Saturn V configuration. The Saturn V development firings and cold and hot gimbal testing will follow. This firing plan will require extension of the program from the scheduled date of March 31 to April 16, 1965.[28]

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27. The battleship configuration duplicates the flight stage in all aspects with the exception that propellant containers are of heavier thickness. During the battleship tests, repeated engine firings are conducted to evaluate thoroughly the engine/stage performance, propellant feed system operation, and compatibility of all stage systems with engine systems.

28. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 29; Saturn V Off., MPR-SAT-V-64-4, p. 16; DAC, SM-46770, Issue 25, pp. xi-xii, and 13; SM-46794, Issue 26, pp. 129 and 136; SM-46824, Issue 27, pp. 21, 55-56; SM-46897, Issue 28, pp. 3, 43-44, and 74-75; and SM-46935, Issue 29, pp. 1-2, and 45-46; and Public Affairs Off., Press Release, Dec. 1, 1964.

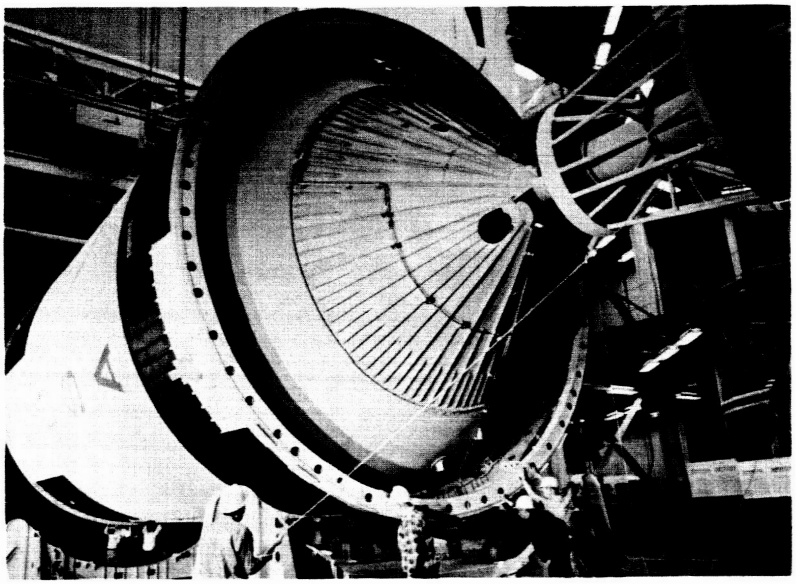
Meanwhile, DAC encountered difficulty in procuring hardware for a battleship for use in a follow-on battleship program at MSFC. Configuration changes resulting from the Sacramento battleship program caused the procurement delays. DAC initiated an expediting system to provide MSFC with satisfactory components at the earliest possible date. The most critical items are the propulsion system and electronic components.[29]

Dynamic Test Stage: At the beginning of the current report period this stage (S-IVB-D) was in the environmental chamber at DAC's Huntington Beach facility. During August DAC completed insulation of the S-IVB-D LH_2 tank, cleaned the tank, and positioned it in Assembly Tower 2 where bonding of mounting clips in the tunnel area progressed. In August Rocketdyne delivered J-2 engine J-2006 to DAC for S-IVB-D. DAC placed the stage in the Huntington Beach Vertical Checkout Tower 5 at the end of September. This was for installation of the simulated engine and hookup of the hydraulic system. On October 13 DAC initiated checkout of the S-IVB-D, less a few vendor-supplied items still missing. The contractor completed leak testing of the LOX tank fittings on October 14; completed leak testing of the LH_2 tank fittings on October 22; and ended the stage checkout October 28 with the exception of one retest. "Oil canning" or buckling of the LH_2 bulkhead necessitated an additional proof pressure test on November 8 to insure structural integrity. DAC then painted the stage, weighed it, and attached roll rings before loading it on the States Marine Ship Aloha State at Seal Beach, California, on December 8. The Aloha State sailed on December 9 for New Orleans via the Panama Canal route. On December 21 the stage was transferred to the river barge Promise and shipped up the Mississippi, Ohio, and Tennessee Rivers to MSFC. DAC shipped vendor-supplied items missing during stage checkout to MSFC direct by truck on December 14.[30]

Facilities Checkout Stage (Former All-Systems Stage): Certain components of this stage (S-IVB-500F) remained in storage in Tower 1 at Huntington Beach until October 12 while floor assembly of the aft interstage continued in Building 45. DAC completed the thrust structure assembly and machined the attach ring in October. Installation of the thrust structure floor and out-of-position electrical and mechanical installations of the forward and aft skirts continued throughout October, November, and December. In late December DAC moved the

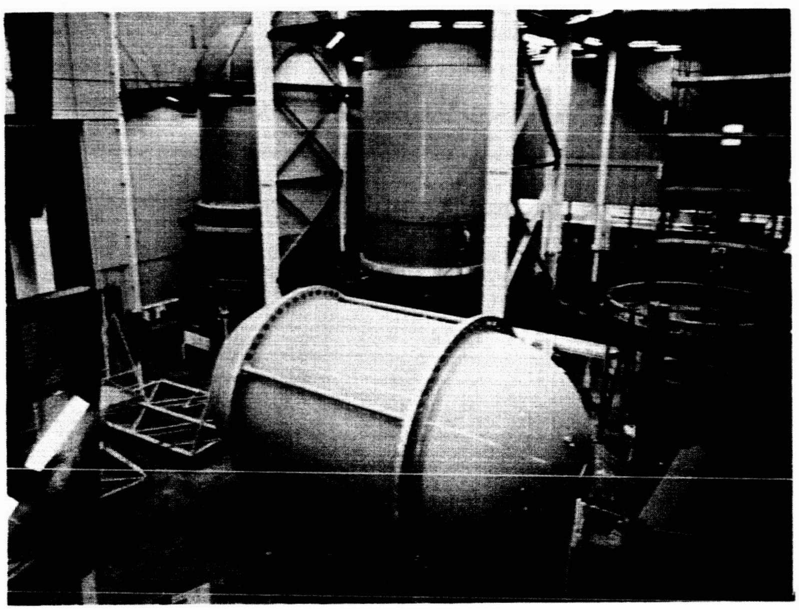
29. DAC, SM-46897, Issue 28, p. 9; and SM-46935, Issue 29, p. 8.

30. DAC, SM-46749, Issue 24, p. 63; SM-46770, Issue 25, pp. 1, 13, 40, and 70; SM-46794, Issue 26, pp. 108 and 111; SM-46824, Issue 27, pp. 73 and 92; SM-46897, Issue 28, pp. 59 and 75; SM-46935, Issue 29, p. 63; and Saturn V Off., MPR-SAT-V-64-4, p. 16.



S-IVB DYNAMIC STAGE

S-IVB-D, a dynamic test stage, is shown following completion of assembly tests at Huntington Beach.



S-IVB STAGES

In various stages of manufacture at Huntington Beach, California, are S-IVB stages for the Saturn IB/V programs.

stage to Assembly Tower No. 2 and joined the forward skirt, aft skirt, and thrust structure to the tank section. During the period DAC recovered about seven of ten weeks' delay in assembling the S-IVB-500F. The contractor expedited redesign and delivery of several vendor-supplied items, particularly the liquid level control unit and the propellant utilization electronic assembly. DAC also used premium time during the manufacturing process and employed a special work task group to locate and solve problems associated with completion and delivery of the stage. The contractor expects to complete S-IVB-500F by January 2, 1965, for delivery to the Sacramento test site. At Sacramento the S-IVB-500F will be used to qualify the Beta 3 test facilities prior to the SA-201 acceptance test program. Involved in Beta 3 checkout are propellant tanking tests originally slated for the all-systems test stage prior to the S-IVB program realignment. Completion of GSE at the test site has been the major problem precluding immediate initiation of the Beta 3 test program. DAC expected, however, to overcome this delay so that delivery could be made to KSC by the scheduled date of July 1.[31]

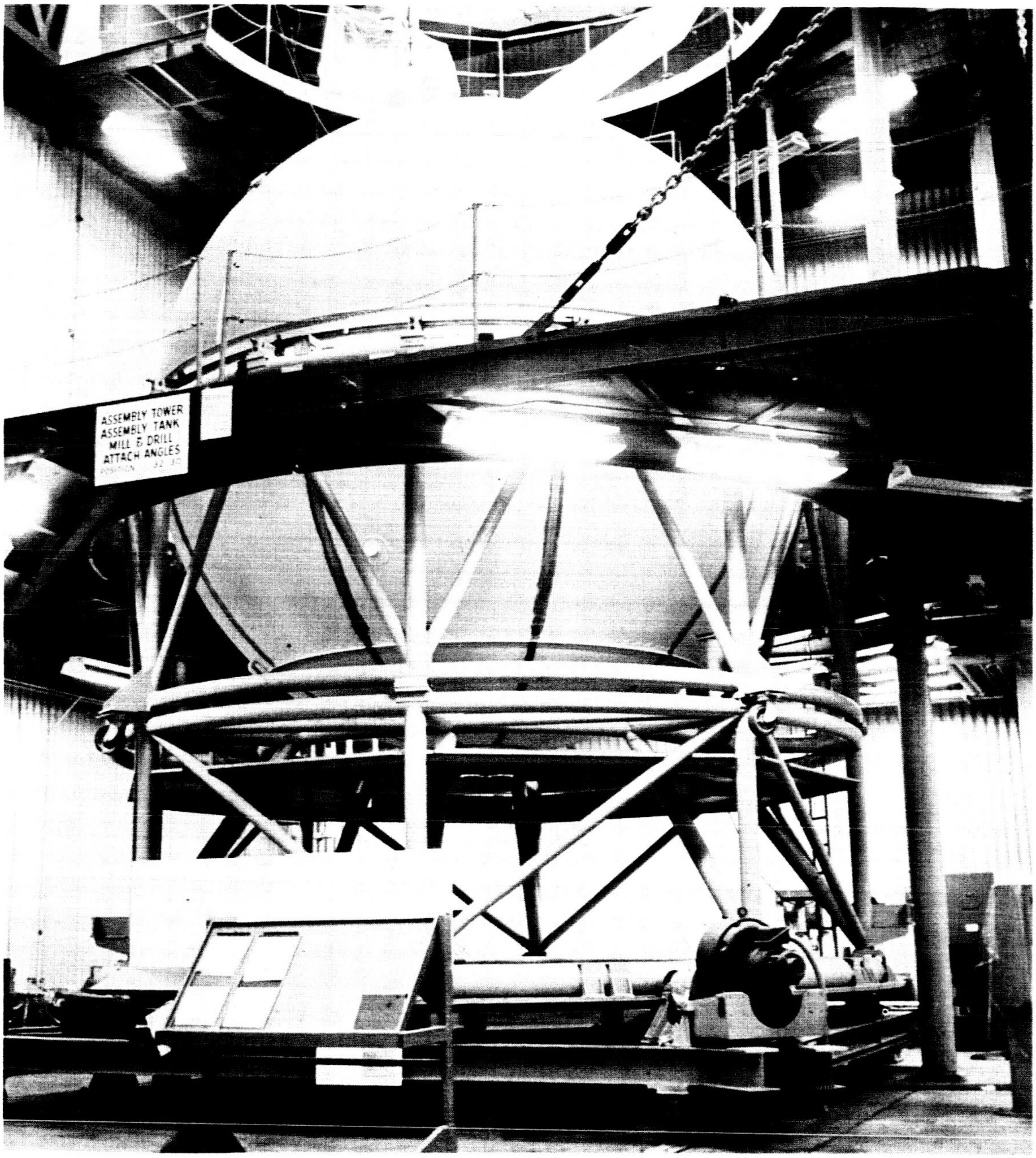
S-IVB FLIGHT STAGES

Production of the first four S-IVB flight stages progressed at DAC's Santa Monica and Huntington Beach facilities in this report period.

DAC had the S-IVB-201 stage in Assembly Tower No. 1 at Huntington Beach on July 1, 1964. A four-month delay in development existed because of late vendor deliveries, design changes, and welding problems. Following the S-IVB program review by DAC, MSFC, and NASA, the contractor initiated a vigorous recovery plan to meet contract delivery schedule. After cancellation of the all-systems testing, DAC shifted the engineering effort required to perfect a test stage for "live" testing to development of the S-IVB-201 stage. The contractor rearranged the sequence for many critical installations to relieve some of the procurement and manufacturing problems. DAC also began in the most critical areas to use additional resources such as multiple shifts, premium time, and additional manpower.

In August DAC began prefitting the insulation tile in the S-IVB-201 tanks and also began welding assembly of the basic structure. By the end of October DAC completed tank assembly insulation. In November DAC installed the tank in

31. DAC, SM-46749, Issue 24, p. 101; SM-46770, Issue 25, p. 112; SM-46824, Issue 27, pp. 73, 75, and 93; SM-46897, Issue 28, pp. 59 and 76; and SM-46935, Issue 29, pp. 63 and 83.



S-IVB LOX TANK

Undergoing manufacture in an assembly tower at Huntington Beach, California, is the liquid oxygen tank of an S-IVB stage for Saturn IB and Saturn V vehicles.

Assembly Tower No. 2 for LOX tank beam and baffle rework. Horizontal placement of the tank assembly occurred in December for LH_2 tank installations and clip bonding. By the end of December DAC had completed assembly of the forward skirt, aft skirt, and thrust structure. The contractor planned to begin subassembly of the aft interstage in January 1965.

Program review at the end of the report period showed that DAC had recovered about two months in the S-IVB-201 schedule; the contractor planned to begin systems checkout at Huntington Beach in February and turnover of the stage to NASA at KSC in mid-October.[32]

In the current report period DAC managed to recover approximately four months' delay in the S-IVB-202 contract schedule. DAC did this by instituting many of the same actions taken in recovery of the S-IVB-201 schedule. In the first quarter of this period DAC completed fabrication and assembly of the propellant tanks. Personnel placed the tank assembly in Assembly Tower No. 4 in September and in October completed hydrostatic proof test, cleaning, and leak checks. The leak checks revealed that the attach angle welds needed repair. Following the repair the contractor began insulation of the tank assembly; the insulation was completed in December. Fabrication and assembly of the forward skirt structure and the thrust structure progressed to final stages, and subassembly of the aft skirt was in progress at the end of December. DAC expected to have S-IVB-202 ready for checkout at Huntington Beach in May 1965, approximately two months later than scheduled.[33]

In July production of major S-IVB structural subassemblies for S-IVB-203 was in process at Santa Monica. At the same time assembly of the cylindrical tank section for the stage was underway in Huntington Beach. Work at both places progressed satisfactorily except for welding problems. Weld repairs to the LOX tank assembly at Santa Monica delayed shipment of the assembly to Huntington Beach until October. DAC completed seam welding of the cylindrical section of the LH_2 tanks in late September and began welding the forward and aft rings to the

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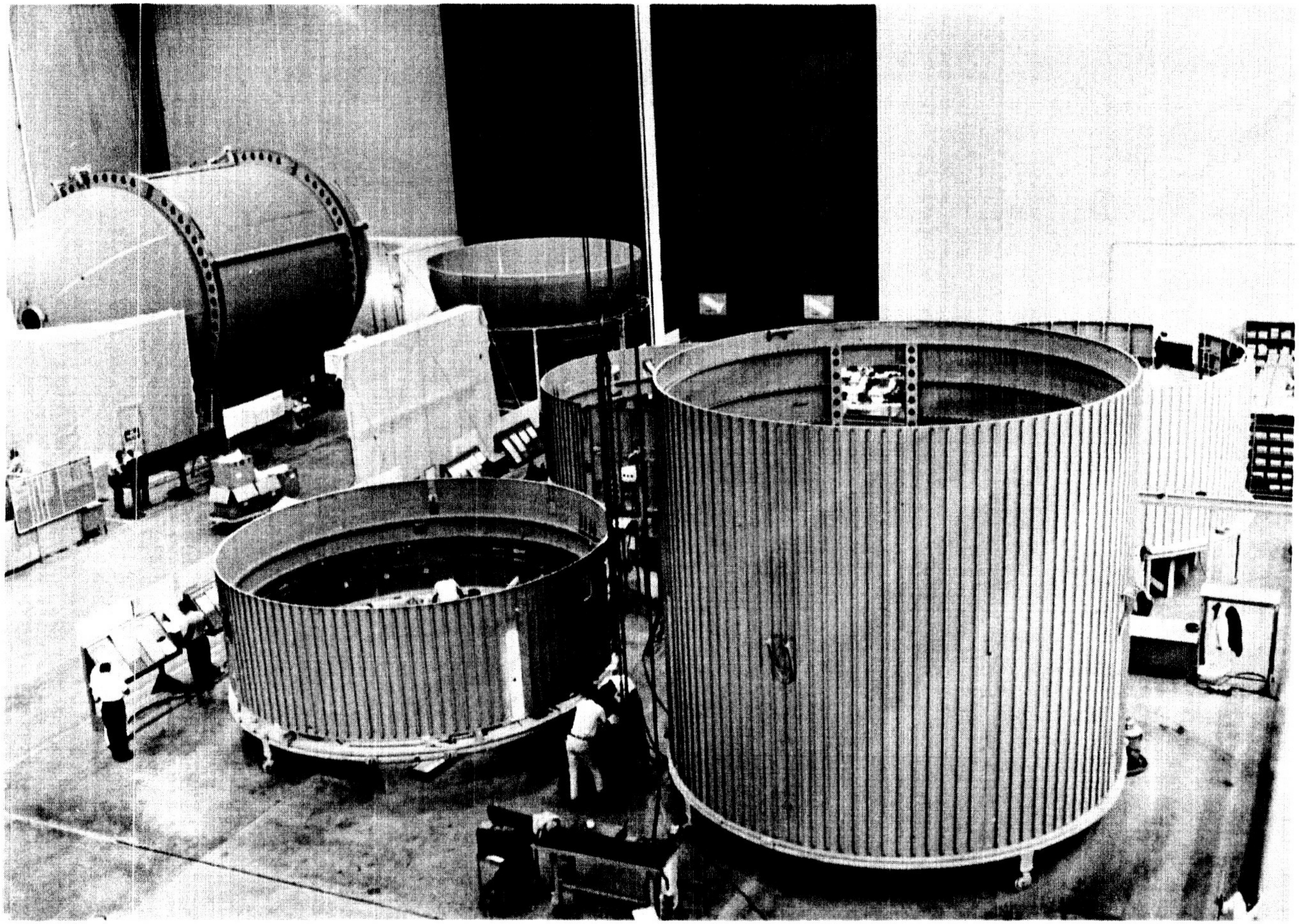
32. DAC, SM-46749, Issue 24, pp. 63 and 101; SM-46770, Issue 25, pp. 70, 75, and 112; SM-46794, Issue 26, pp. 111, 136, and 138; SM-46824, Issue 27, pp. 75, 91, and 93; SM-46897, Issue 28, pp. 60 and 76; and SM-46935, Issue 29, p. 84.
33. DAC, SM-46749, Issue 24, pp. 63-64 and 101; SM-46770, Issue 25, p. 75; SM-46794, Issue 26, pp. 111 and 138; SM-46824, Issue 27, pp. 75 and 94; SM-46897, Issue 28, pp. 60 and 76; SM-46935, Issue 29, pp. 63 and 84; and Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 23.



S-IVB SUBASSEMBLIES

Major subassemblies of the S-IVB stage are shown in the manufacturing area at Douglas Aircraft Company's Huntington Beach plant.

section. After transfer of the LOX tank assembly and the LH_2 dome assembly from its Santa Monica plant to Huntington Beach, DAC began welding the sections together. The contractor completed the propellant tank assembly in November and installed the tank for leak and dye checks in Assembly Tower No. 1. With the stage in the No. 1 Tower DAC personnel accomplished LOX tank beam and baffle rework necessary for the LH_2 orbital experiment. Other modifications to the LH_2 tank, including addition of brackets for mounting the LH_2 orbital experiment instrumentation probe, will be accomplished prior to installation of tank insulation. When modified the stage will contain hydrogen vent, hydrogen repressurization, and APS systems simulating the S-IVB/V design.[34]

During the report period DAC began subassembly of major structural hardware for the S-IVB-204 stage at Santa Monica. DAC fabricated the forward dome segments and assembly, and the cylinder segments and assembly, for reduced NPSH (net positive suction head) at 39 pounds per square inch, absolute ullage, effective on stage SA-204. The S-IVB stage contractor experienced considerable difficulty in fabricating the common bulkhead. Replacement of a large section of undersized core at one location was necessary and at another location misfit of the forward skin to the core necessitated multiple layers of adhesives. This resulted in a wavy forward skin and a payload penalty of 50-60 pounds (the weight of additional adhesives used). Weld deficiencies in the LH_2 tank seam welds also required rework at Huntington Beach. At the end of this report period assembly of the LOX tank was in process at Santa Monica, welding of the LH_2 cylindrical section attach rings was completed, and preparations were underway for welding the LH_2 forward dome to the section.[35]

Instrument Unit Research and Development

The instrument unit houses the major portion of the equipment of the astrionics system, which provides the vehicle with guidance, control, and instrumentation. For Saturn IB and Saturn V the IU is almost identical. It is a

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34. DAC, SM-46749, Issue 24, p. 64; SM-46770, Issue 25, p. 75; SM-46794, Issue 26, p. 111; SM-46824, Issue 27, p. 75; SM-46897, Issue 28, p. 60; SM-46935, Issue 29, p. 65; Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 21; P&VE Lab., MPR-P&VE-64-11, p. 85; and P&VE Lab., SA-203 Design Data Manual, IN-P&VE-V-64-8, Nov. 9, 1964, p. 3.1.1.
35. DAC, SM-46749, Issue 24, p. 25; SM-46824, Issue 27, p. 75; SM-46897, Issue 28, p. 60; SM-46935, Issue 29, p. 65; P&VE Lab., MPR-P&VE-64-11, p. 85; and MPR-P&VE-65-1, p. 79.

260-inch-diameter honeycomb wafer in three 120-degree segments three feet high, located between the S-IVB stage and the payload. All components within the IU are located on the inner periphery, mounted on cold plates cooled by a convective fluid. This fluid, flowing through tubes, conducts generated heat away from the components.[36]

Responsibility for developing the IU rests with MSFC. The Center has selected several industrial firms to provide the major components. These include General Dynamics Corporation, the structure for S-IVB-201, 202, and 203, and NAA for all other Saturn IB and V IU structures; Electronics Communications Inc., control computer; Bendix Corporation, ST-124M inertial platform; and International Business Machines Corporation (IBM) Federal Systems Division, launch vehicle digital computer and launch vehicle data adapter.[37] A number of electronics companies, including Brown Engineering Company, furnishes equipment for MSFC developed subsystems for data acquisition (telemetry) and communication.

Prior to the current report period MSFC selected IBM as lead contractor to integrate all IU systems and to assemble and check out all flight units. Negotiation of the IBM contract continued throughout the July - December 1964 period. Negotiations concerning the scope of work ended October 15 and negotiations concerning cost began November 9. Finalization of the contract is expected in early 1965. Meanwhile, MSFC authorized IBM to proceed with its efforts in personnel and facility buildup at Huntsville. IBM opened a resident management office at its Huntsville site in November. The contractor will assume full mission responsibility for the instrument unit beginning with Saturn IB 204 vehicle.[38]

The only other major IU contract action occurred in August. MSFC completed negotiations with Bendix Corporation for 26 additional ST-124M stabilized platform systems at a total cost of $36.4 million. Incentive provisions based upon cost, delivery, and performance were incorporated into the contract.[39] MSFC expects delivery of the first prototype ST-124M stabilized platform system in early 1965.

IU DESIGN AND ENGINEERING ACTIVITY

The Saturn IB/V IU is patterned after the instrument unit flown on the latter Block II Saturn I vehicles. MSFC completed most of the redesign for the advanced

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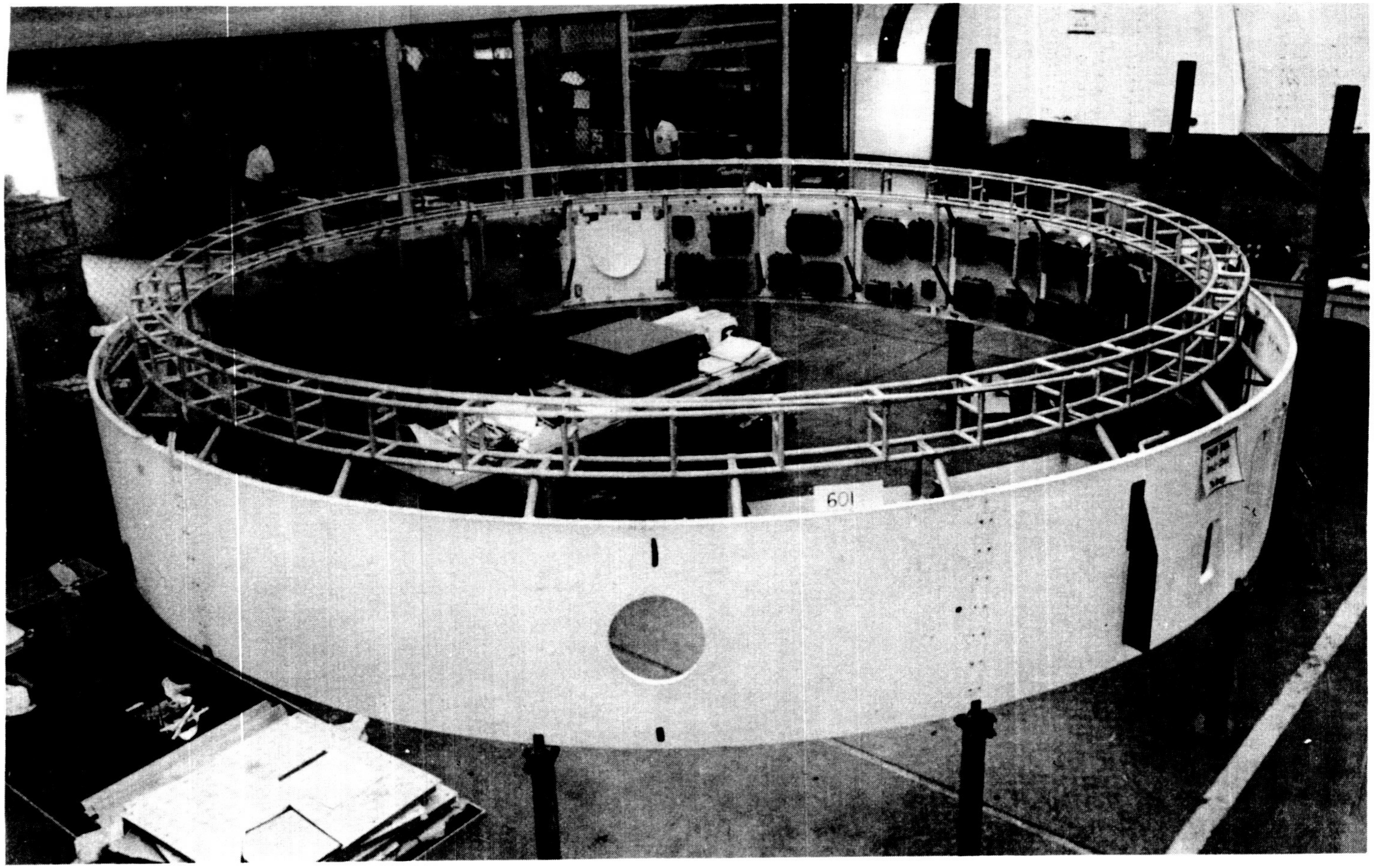
36. Astrionics Lab., Saturn IB/V Astrionics System, MTP-ASTR-S-63-15, p. 1; and MSFC Public Affairs Off., Saturn Project Fact Sheet, Aug. 16, 1965, pp. 9-10.
37. Public Affairs Off., Saturn Project Fact Sheet, Aug. 16, 1964, p. 10.
38. MSFC, MHM-9, pp. 89-91; Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, pp. 23 and 25; and Saturn V Off., MPR-SAT-V-64-4, p. 2.
39. Memo, F. W. Brandner, Astrionics Lab., to Distribution, "Saturn Monthly Progress Report, August 1964" Sept. 21, 1964, p. 4.



SATURN IB/V IU MOCKUP

MSFC built this mockup of the Saturn IB/V instrument unit for use in determining placement of equipment.

IB/V configuration prior to July 1964. In the current report period MSFC directed major effort toward completion of the redesign and documentation to support the redesign. Near the end of October MSFC released all the documentation for redesign of the IU. On November 17 the Center released the IU assembly documentation, along with detail and subassemblies, for SA-201.[40]

MSFC in July completed fabrication of the first prototype of the instrumentation measuring racks in the Saturn IB configuration. Vibration test of the prototype, also completed in July, showed the basic design to be good. Some changes, however, will be required in the internal mounting fixture.[41]

In August MSFC received six Mod 1 switch selector units[42] from Electronic Communications, Inc. (ECI). These and additional units delivered in September passed qualification tests, and MSFC forwarded them to stage contractors for use in breadboard mockups and system checkouts. Meanwhile, IBM completed electrical design of the Mod II units and began packaging design. Phase-in of the Mod II units will occur in SA-202 and SA-501 (first Saturn V) flight vehicles.[43]

During the report period the Center completed vibration tests with several cold plate designs at various simulated battery loads. Final test of the AVCO design ended on October 26; two cold plates, one tested with 165-pound batteries and the other with 200-pound batteries, operated successfully. Tests of an Aeronca design ended on November 20 when the plate failed during the first axis run with a loading of two 200-pound batteries. An Atomics International cold plate panel passed vibration and qualification tests in December. On completion of the tests MSFC awarded Atomics International a contract for manufacture of plates for the S-IU-500V (vibrational test unit) and for vehicle hardware. Award of the Phase I optimization contract went to AVCO.[44]

Prototype components passing acceptance tests in November included the preflight heat exchanger and the Imperial thermal probe, the latter for use on the S-IB stage and the IU. Testing of a 12-module prototype sublimator in November ended because of structural failures. The tests will resume when the second prototype, a 7-module sublimator, is received from the contractor.[45]

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40. P&VE Lab., MPR-P&VE-64-8, pp. 58-59; MPR-P&VE-64-9, pp. 42-43; MPR-P&VE-64-10, p. 55; and MPR-P&VE-64-12, p. 17.
41. Memo., F. W. Brandner, Astrionics Lab., to Distribution, "Saturn MPR, July 1964," Aug. 22, 1964, p. 3.
42. The stage switch selector units act as communication links between the digital computer/data adapter and the stage equipment controlled by the digital computer.
43. Memos, Astrionics Lab to Distribution, "Saturn MPR, August 1964," p. 4; and "Saturn MPR, September 1964," p. 4.
44. P&VE Lab., MPR-P&VE-64-10, p. 37; MPR-P&VE-64-11, pp. 37 and 53; MPR-P&VE-64-12, p. 46; and MPR-P&VE-65-1, pp. 41 and 48.
45. P&VE Lab., MPR-P&VE-64-11, p. 37.

Development problems in the current period hampered delivery of several prototype components and threatened delivery schedules for production models. MSFC took action to expedite component deliveries even though the delays had no immediate effect on the IU development schedule.[46]

The Budd Electronics firm, Long Island City, New York, experienced scheduling problems concerning delivery of the IU/S-IVB ground support cooling unit. An agreement with the firm transferred contractural responsibility to Pall Corporation. This "novation and supplemental agreement" incorporated revised procurement specifications, addition of three more units, and a revised delivery schedule. The new contractor failed to complete manufacture and delivery of the first unit to MSFC for tests on November 30 as scheduled. When this period ended, an MSFC contracting officer was determining cause for the slippage.[47]

Also of concern to MSFC was possible delay in receipt of the prototype digital computer and data adapter from IBM. The solution of production problems at the contractor's plant continued to be difficult.[48]

Near the end of this period MSFC completed manufacture of an IU mockup for use as a development fixture. Technicians in two of the Center's Laboratories--Manufacturing Engineering Laboratory and Astrionics Laboratory--used the mockup to determine placement of navigational and telemetry equipment and cable routing. Routing of cables of the SA-201 configuration will be completed in the mockup by January 7, 1965.[49]

IU GROUND TEST UNITS

Prior to the current report period MSFC received structural segments for the IU and began assembling ground test and flight units. When revised vehicle loads required redesign of the structure, MSFC stopped assembly operations pending completion of the redesign.

In August 1964 General Dynamics/Fort Worth delivered the prototype of the redesigned structural segments to MSFC. The Center successfully tested the redesigned segments above maximum loads and then discussed methods of expediting production and delivery of the segments with the contractor. To avoid

46. IU development was not considered the pacing item in the Saturn IB development program.
47. P&VE Lab., MPR-P&VE-64-11, p. 37.
48. Memo, Astrionics Lab to Distribution, "Saturn MPR, November 1964," p. 4.
49. Saturn V Off., MPR-SAT-V-64-4, p. 22; and P&VE Lab., MPR-P&VE-65-1, p. 23.

further delay in assembly of ground test stages MSFC decided to strengthen the assembled structures on hand for the vibrational test and the facilities checkout unit. The first redesigned segments delivered in November and December were allocated to the dynamic test unit and to the structural test unit.[50]

Vibrational Test Unit: Components for this unit (S-IU-200V) remained in storage at MSFC until completion of the structure redesign in August. MSFC then strengthened the original structure to simulate the redesigned structure before continuing assembly of components in the unit. The Center designed, fabricated, and tested a cold plate pressurizing and water replenishing system for use in the vibration test unit. Delivery of this system and the S-IU-200V unit to Wyle Laboratories[51] occurred on November 30. MSFC personnel completed work on the unit at the contractor site and also began alignment of the unit in the test facility. Early in December MSFC released the environmental test plan for S-IU-200V and S-IU-500V (Saturn V configuration). On December 22 Wyle Laboratories completed the first test run on S-IU-200V. Preliminary test results indicated that modifications to the top support ring were necessary because of excessive structure resonances.[52] Vibration tests will continue during 1965.

Facilities Checkout Unit: MSFC allocated the structure originally intended for the dynamic test unit to the facilities checkout unit (S-IU-500F). Structural modification to strengthen the unit was still in progress when this report period ended. Manufacture of S-IU-500F is scheduled for completion in April 1965. It will then be prepared for shipment and stored at MSFC until required at KSC for facility checkout of Launch Complex 34.[53]

Dynamic Test Unit: In November MSFC received the redesigned structural segments for the dynamic test unit (S-IU-200/500D) from General Dynamics/Fort Worth and began a concerted effort to complete the structural assembly. Assembly operations were still in progress when the report period ended.[54]

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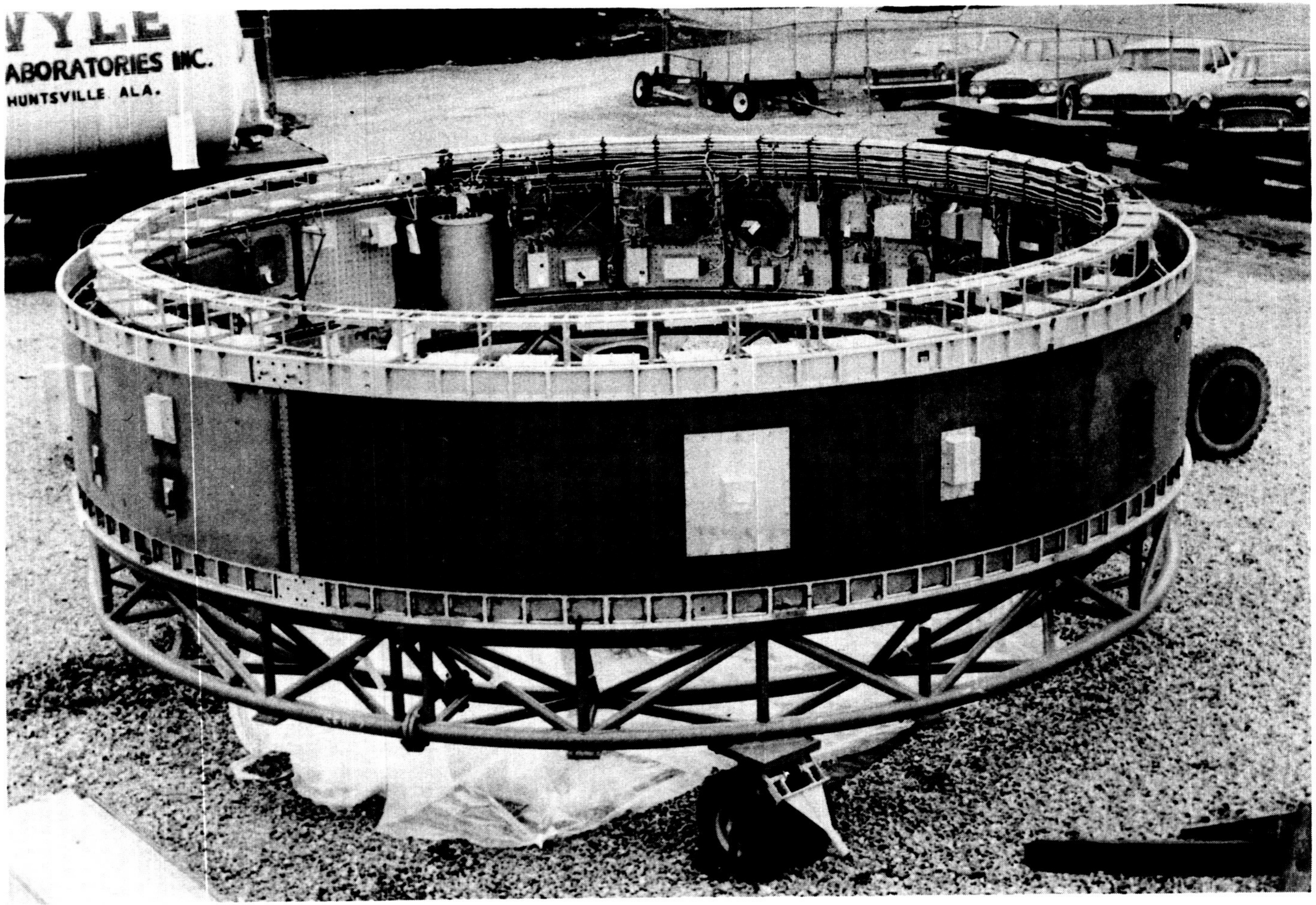
50. MSFC, MHM-9, p. 93; P&VE Lab., MPR-P&VE-64-9, p. 42; and Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 25.
51. MSFC completed final negotiations with Wyle Laboratories for the environmental testing of the Saturn IB and V instrument units and awarded the contract on June 30, 1964. At the same time MSFC awarded Brown Engineering Company, Inc., a contract for the purpose of vibration testing of the IU mounting components.
52. P&VE Lab., MPR-P&VE-64-8, pp. 23, 53, and 67; MPR-P&VE-64-10, p. 29; MPR-P&VE-64-11, p. 27; MPR-P&VE-64-12, p. 17; and MPR-P&VE-65-1, p. 48.
53. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 33; and MPR-SAT-I/IB-65-1, p.10.
54. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 33; and Saturn V Off., MPR-SAT-V-64-4, p. 22.



INSTRUMENT UNIT TESTED

The Saturn IB instrument unit for vibration testing, S-IU-200V, is shown at Wyle Laboratories, Huntsville, near the end of this period.

Structural Test Unit: MSFC concentrated upon completion of documentation for the structural test unit (S-IU-200/500S) while awaiting delivery of the redesigned structural segments. Design of the lower loading ring and upper loading ring was completed; fabrication started in December. Instrumentation and cable rack loads for the unit were completed on December 11. A simulated (dummy) Apollo payload adapter for use in IU structural tests arrived at MSFC on December 15. Near the end of December the structural segments for the unit arrived from General Dynamics/Fort Worth. Use of the jigs and tool fixtures in assembly of the S-IU-200/500D precluded start of the S-IU-200/500S structural assembly until early 1965.[55]

Facilities, Support Equipment, and Transportation

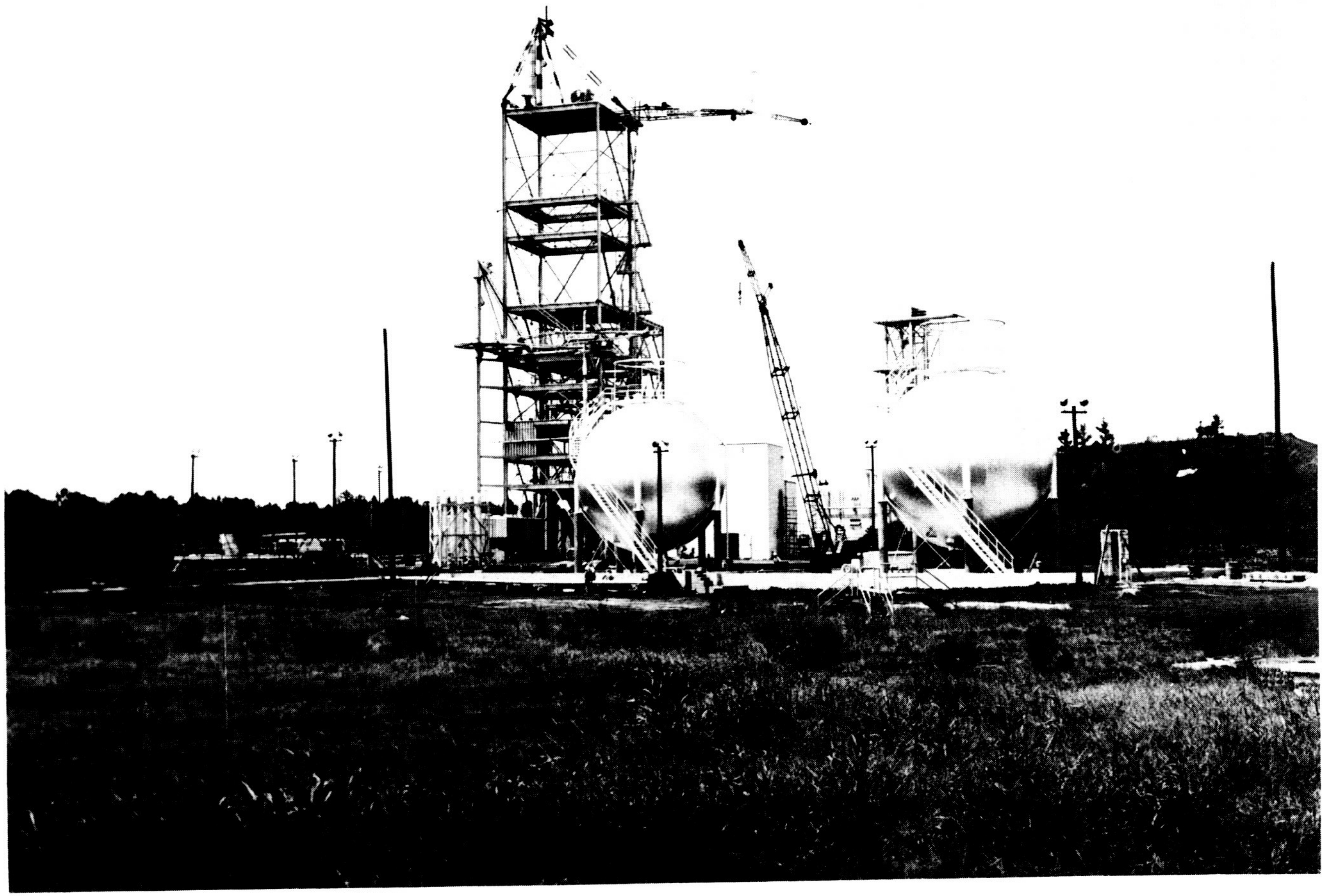
Facilities and support equipment are required at each of the prime contractor sites, at engine contractor sites, at MSFC, and at KSC. Because of the size of the Saturn IB, special transportation equipment is required to move the stages and vehicles from assembly to ground test sites and from ground test sites to KSC.

FACILITIES

Most of the facilities supporting the Saturn IB program are used in common with the Saturn I and Saturn V programs.[56] The facilities used exclusively for the Saturn IB program at MSFC include the Systems Development Facility (SDF) and the Electrical Support Equipment (ESE) Facilities. Buildup and modification of both facilities continue.

Conversion of Saturn I MSFC test facilities for exclusive Saturn IB use also continued in this report period. This involved modification of the west side of the East Static Test Tower to support Saturn IB static firings, and modification of the Dynamic Test Stand. In September MSFC completed design for modification of the Dynamic Test Stand. The Center began the modification in mid-November and will ready the stand for operation in February 1965. Modification of the west side of the Static Test Tower and blockhouse began also in November after removal of the last Saturn I booster. The Center scheduled the tower for operational use with S-IB-1 in February.

55. P&VE Lab., MRP-P&VE-64-10, p. 55; MPR-P&VE-64-11, pp. 27, and 52-53; MPR-P&VE-65-1, p. 47; Saturn I/IB Off., MPR-SAT-I/IB-2&3, pp. 25 and 31; and Saturn V Off., MPR-SAT-V-64-4, p. 22.
56. For information on these facilities see the Saturn I and Saturn V chapters of this historical monograph and see MSFC, MHM-9, pp. 58-61, 95-98, 149, 169, and 178-183; and MHM-8, pp. 45-54, 86-89, 147-151, and 156-157.



J-2/S-IVB TEST FACILITY

This photo made in September 1964 shows progress on the J-2/S-IVB Test Facility in MSFC's East Test Area. Construction was 95 per cent complete at the end of this period.

In October MSFC technicians completed facilities design of and ordered necessary material for the 200K H-1 engine turbopump facility located in the south position of the Cold Calibration Stand. They will use vehicle suction lines and a 200K H-1 turbopump mounted on a bobtail H-1 engine. MSFC has scheduled operational use of the facility in February 1965.

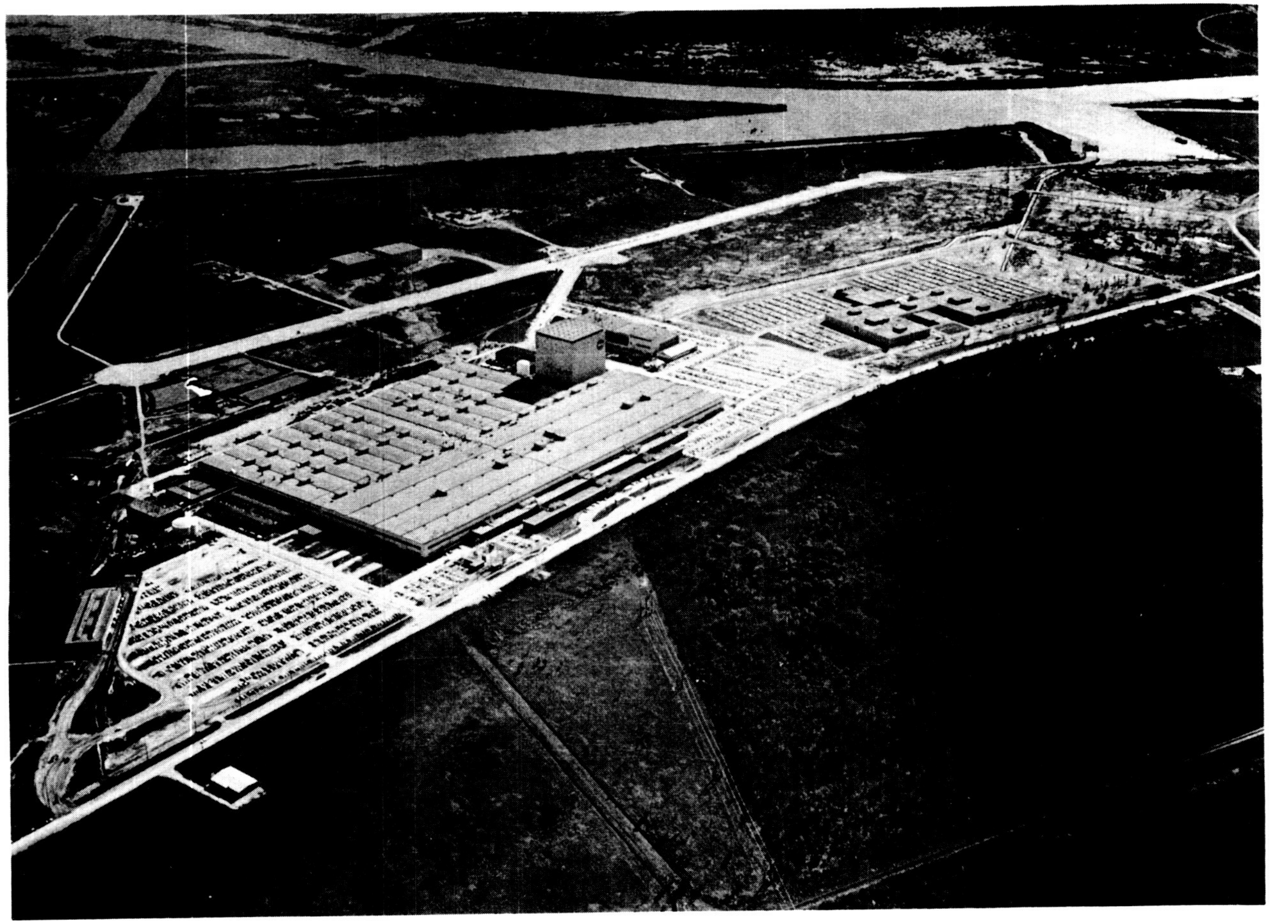
Expansion of the blockhouse and J-2/S-IVB Test Facility proceeded on schedule. MSFC technicians inspected the LOX area on December 21, 1964; pre-final inspection of the test stand is scheduled for January 8, 1965. The Center accepted the 50- and 75-ton derricks tested during the period December 21 to December 30. Kennamer Construction Company will complete construction of the facility in January 1965.[57]

Construction and modification of manufacturing facilities exclusively for Saturn I/IB at Michoud Operations occurred prior to the current report period. However, construction and modification of facilities supporting both the Saturn IB and V programs continued in this period. J. A. Jones Construction Corporation of New Orleans completed construction of the new Engineering and Office building on October 15, 1964; MSFC gained beneficial occupancy in various sections of the building by September 1. Movement of personnel into the building ended on November 10. Construction began on a Component Warehouse and a Hazardous Storage Building. Other construction underway at Michoud included modifications to the Boiler Plant, additions to roads and parking lots, incorporation of a mezzanine cafeteria in the south end of the Manufacturing Plant, and modification of the air conditioning system in the Slidell Computer Facility.[58]

Modification of facilities continued at DAC's S-IVB development and checkout sites supporting Saturn IB and Saturn V programs at Santa Monica and Huntington Beach. Most of the effort involved design, fabrication, and installation of major manufacturing and assembly tooling and checkout equipment. At DAC's test site in Sacramento, effort continued toward readying the Beta and Gamma Complexes for operational use, and toward construction of the Vehicle Checkout Laboratory.

The Wismer-Becker firm, contractor for the Gamma Complex, turned the facility over to DAC on July 22, 1964, with accomplishment of some cleanup work and the site checkout remaining. DAC began installation of the engine cluster for the APS in Cell III and continued installation of checkout equipment through August. Activation of the complex occurred in September on initiation of the Phase I APS

57. Test Lab., Test Lab Historical Report, July 1, 1964 - Dec. 31, 1964, pp. 2, 4, 8, and 17.
58. Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, pp. 37-38.



MSFC'S MICHOUD OPERATIONS

This aerial photo of Michoud Operations in December 1964 shows the entire facility including the barge dock and waterway (top right). In the sprawling building at left center Chrysler manufactures Saturn I/IB boosters and Boeing produces Saturn V boosters.

tests. Construction of the Maintenance and Assembly Building at the site continued until October 20 when the contractor completed the external construction, installation of electrical and plumbing fixtures, and grading, surfacing, and blacktopping the surrounding area. Phase I testing of the APS ended in October and when this period ended, configuration changes for implementing the Phase II test program were in progress. [59]

At the Beta Complex, activity involved both the Beta 1 and Beta 3 test stands.

DAC erected the S-IVB battleship test stage in the Beta 1 test stand in December 1963. However, the stand did not become operational until this report period. Installation of ground instrumentation systems occurred in July. Wismer and Becker and Paul Hardeman Company, construction contractors, continued activity at the stand through August. Work consisted primarily of modification and cleaning of valves and actuators in the LOX and LH_2 transfer lines, rework of the helium and auxiliary pressurization systems, and correction of leakage in the LH_2 storage tank. Checkout of the GSE for the stand was completed ahead of schedule and allowed connection of the umbilicals several days ahead of the work plan. Activation of the stand occurred in September with cryogenic loading of the S-IVB battleship stage. Saturn IB S-IVB battleship tests continued at the facility throughout the remainder of this period.

Modifications similar to those at the Beta 1 stand continued at the Beta 3 test stand. The Chicago Bridge and Iron Company repaired the LH_2 storage tank in July. In August and September the Paul Hardeman Company corrected five major deficiencies including hydrogen burn pond modification, test stand elevator modifications, cleaning of high-pressure gas lines, and calibration of gages. Additional modifications at the stand continued throughout the remainder of the period. Completion of GSE for Beta 3 in time for scheduled loading tests with the facility checkout vehicle posed the major problem at the end of December. [60]

Architectural and engineering design for DAC's Sacramento Vehicle Checkout Laboratory continued through October. Site preparation, including leveling, grading, and surfacing, began in October. Actual construction of the facility began in December. [61]

Launch facility construction is the responsibility of KSC; therefore, this report includes only a summary of activity in support of the Saturn IB launch program. The Saturn IB program requires modification of two launch complexes.

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59. DAC, SM-46749, Issue 24, pp. xxi, 86, and 92; SM-46770, Issue 25, pp. 95 and 97; SM-46794, Issue 26, pp. 117 and 120; and SM-46935, Issue 29, p. 2.
60. DAC, SM-46749, Issue 24, pp. 84-85; SM-46770, Issue 25, pp. 94-95; SM-46794, Issue 26, p. 119; and SM-46897, Issue 28, p. 75.
61. DAC, SM-46794, Issue 26, p. 120; and SM-46897, Issue 29, p. 69.

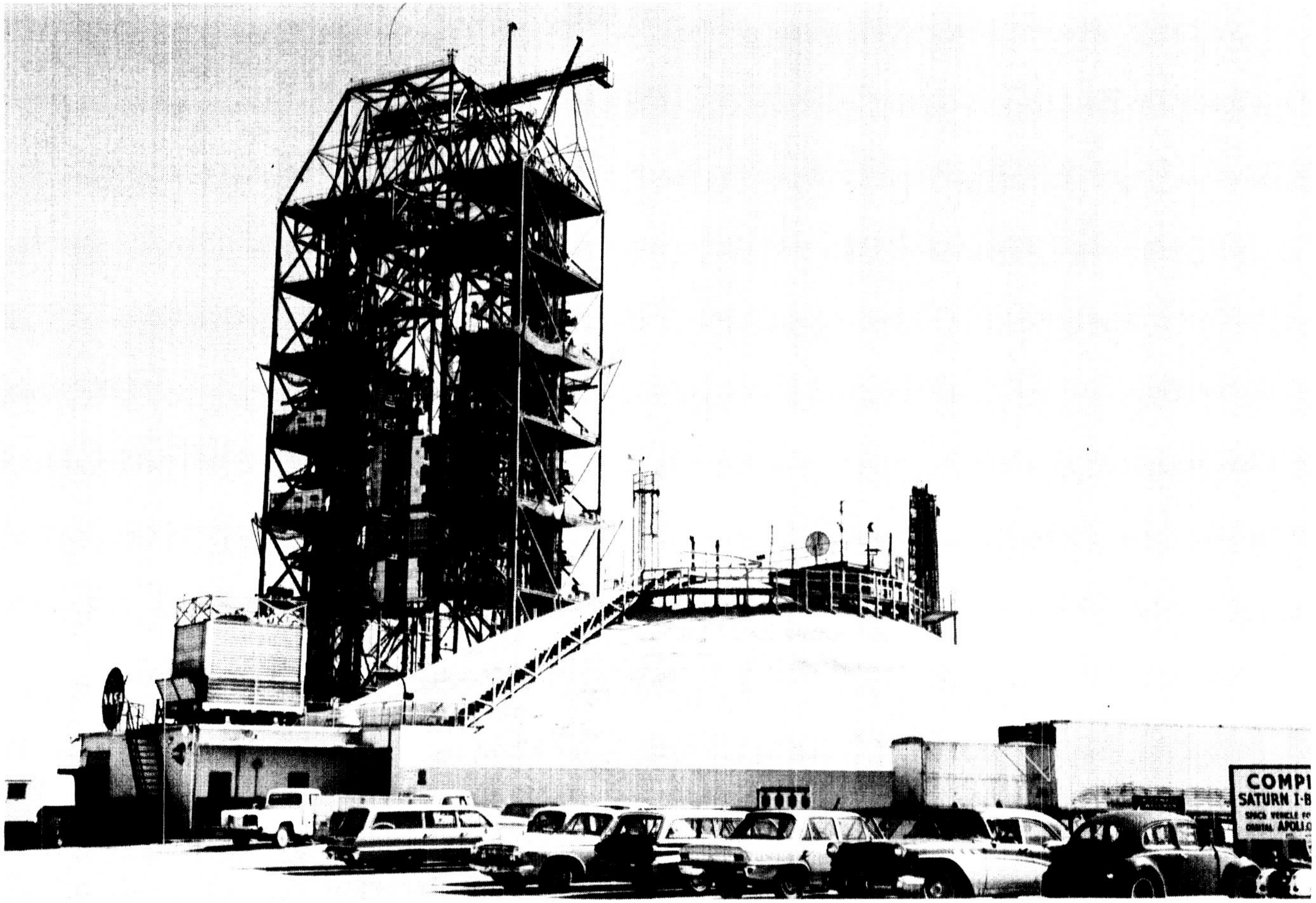
Modification of Launch Complex 34 (LC-34), initiated early in 1964, continued throughout this report period. Contracts awarded and construction completed were as follows: award of contract on July 16 to Akwa Construction and Downey Heating for modification to the High-Pressure Hydrogen facility and completion of the work on December 2; award of the Phase I construction contract for modification of the Emergency Egress-Ingress system on July 30 to Julian Evans and Associates with construction well underway at the end of December; completion of final design for Phase I modification of the service structure on August 24 and Phase II modification on December 14 by M. Connell and Associates; award of the construction contract for Phase I effort to McDowell-Wellman Engineering Company on August 24 and initiation of construction; award of contract to the American Machine and Foundry Company for fabrication of modifications to the Pneumatic and Electrical Distribution Systems on November 27, with construction commencing in December.

Only that effort not affecting the Saturn I launch program could be performed at the second complex, Launch Complex 37 (LC-37), during this report period. Contracts awarded and construction completed included the following: award of contract to J. C. Abbott on July 8 for a Storage Compound Hydrogen Spares Building and additional parking with completion of the effort on September 1; award to the same contractor on July 8 a contract for an additional catwalk and steps at Valve Pit No. 1 with work completed September 1; completion of Phase I hoist modification by Voigt Construction Company including installation of Lebus Grooving and Ball Bearing Swivel on July 17, and award of Phase II hoist modification contract to F. A. Kennedy Inc. on August 11; award of contract to Construction Services Company on July 1 for the Water Pump Station bypass water line and completion of work on December 2; completion of construction of lightning protection of cross-country cable trays on August 24 by Akwa Construction and Downey Heating; award of the Man Lift Belt contract to Heyl and Patterson on October 28; completion of criteria by KSC for the Service Structure modifications and start of design by M. Connell and Associates on December 1.[62]

SUPPORT EQUIPMENT

Support equipment includes all electrical and mechanical equipment and services needed to accommodate the Saturn IB stages and vehicle from assembly through liftoff at launch time. The vehicle checkout equipment, environmental simulation equipment, and handling fixtures are termed ground support equipment (GSE).

62. KSC, Technical Progress Report, Third and Fourth Quarter, CY-1964, TR-159, Mar. 5, 1965, pp. 7-17.



LAUNCH COMPLEX 34

The LC-34 blockhouse and service structure at Kennedy Space Center are shown in this picture. LC-34 underwent modification throughout this report period as workmen converted it from Saturn I to Saturn IB launch capability.

The automatic checkout equipment comprises the bulk of the GSE. The checkout GSE is used at each of the prime contractor sites in stage checkout, at MSFC for vehicle static checkout and launch programming, and at KSC for launch checkout.

CCSD converted S-I equipment for S-IB and completed installation of the automatic checkout equipment for S-IB stage checkout at Checkout Station No. 2, Michoud Operations; activation of the facility occurred on November 2. Checkout of the first stage in the facility (S-IB-1) will continue into January 1965.[63]

Installation of electrical support equipment (ESE) in DAC's Engineering Developmental Systems Integration Laboratories (EDSIL) at Huntington Beach continued throughout the report period. During the period DAC used the facility to evaluate and check out the prototype S-IVB automatic checkout equipment. The contractor also conducted a series of system self-tests in the A-3 system integration laboratory to provide a complete test of the analog portion of the GSE/vehicle interface. This constituted the first fully integrated exercise of the digital test equipment. One rerun of GSE self-test to the S-IVB-201 configuration ended in December; another run is required because of configuration changes requiring modification.[64]

Progress occurred in design, fabrication, checkout, delivery, and installation of checkout GSE to stage checkout areas--particularly to the factory checkout facilities at Huntington Beach--and to the Control Station and test stands at Beta and Gamma Complexes, Sacramento. Late delivery, installation, and modification of GSE at the Sacramento test site early in this period caused some delay in start of the APS and battleship tests. The GSE installed for both tests performed satisfactorily during the test programs. Modification of the GSE for use in advanced phases of APS and battleship testing at the tests sites was underway when this report period ended.[65]

IBM's IU checkout station is located at Huntsville. IBM received delivery of some mechanical support equipment and ESE for installation in the facility in this report period; however, delivery of ESE lagged. Activation of the station is scheduled for June 1965 for checkout of S-IU-201.[66]

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63. Executive Staff, Management Information, October 1964, Vol. 1, 2nd Ed., pp. 85-86; and Michoud Op., Hist. Rpt. July 1 - December 31, 1964, p. 10.
64. DAC, SM-46897, Issue 28, pp. 67-69; and SM-46935, Issue 29, p. 67; and Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 27.
65. Ibid.
66. Executive Staff, Management Information, October, 1965, Vol. 1, 4th Ed., p. 20.

MSFC is responsible for design of the launch vehicle checkout GSE. The Center has awarded contracts to CCSD and to General Electric (GE) for final design of the GSE and to Radio Corporation of America (RCA) for computers for all the vehicle testing and checkout areas.[67]

At MSFC installation, checkout, and operation of equipment in the ESE checkout facilities continued throughout this period. The ESE checkout facilities occupy a total of 35,000 square feet, and contain a full complement of computers and checkout equipment. The facilities include a digital events evaluator, an automatic panel checkout machine, automatic circuit testers, and simulation equipment. The facilities are used for checkout and acceptance of the Saturn IB.[68]

Also at MSFC, there was progress in enlargement of the Saturn Systems Development Facility (SDF) to accommodate the Saturn IB prototype automatic checkout equipment GSE and stage simulators. The facility, 6500 square feet in dimension with computers and simulation equipment, will permit simulation of the complete vehicle and GSE for the IB vehicles. The facility will also facilitate development of launch programs and will provide automatic checkout for design or design change in the systems.[69]

In this period there was continuation of installation and checkout of the Saturn IB Phase I equipment in the SDF. This included the S-IB simulator, ESE, RCA-110A computer, Digital Data Acquisition System, and the count clock. The major racks and cables constituting the booster simulator arrived at MSFC in July. Rocketdyne also delivered the H-1 engine for the simulator in July. Fabrication of known ESE panels and modification of S-I panels to the S-IB configuration also began in July. Preliminary design for all the S-IB ESE was completed in October. MSFC completed the Phase I equipment layout in November and satisfactorily performed a series of SA-201 tests to demonstrate the equipment.[70] The remaining GSE and flight simulation equipment will be delivered and installed early in 1965.[71]

MSFC is responsible for development of GSE used in handling and servicing the Saturn IB at the launch sites. Although CCSD is under contract to MSFC for integration of all launch GSE, actual design and development of some of the equipment is accomplished by stage contractors.

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67. Ibid.
68. Facilities and Design Off., Technical Facilities & Equipment Digest, Dec. 1965, p. 35.
69. Ibid.
70. Memos, Brandner, Astrionics Lab. to Dist., "Saturn MPR, July 1964," pp. 4-5; "October 1964," p. 6; and "November 1964," p. 6.
71. Saturn I/IB Off., MPR-SAT-I/IB-64-2&3, p. 27.

During this report period MSFC and CCSD began modification of launch support equipment for the S-IB stage. Analysis by MSFC showed that swing arm No. 3 ducting at both launch sites required modification to a $1\frac{1}{4}$-inch-diameter system. The modification would satisfy preflight cooling requirements during umbilical drop test and during bypass of the onboard pumping system.

DAC completed a study in September to determine the launch support and equipment required for S-IVB at KSC. In October the contractor proceeded to build up its personnel at KSC to support stage testing and checkout in the KSC low bay area. In December DAC completed drawings for all S-IVB GSE required at KSC.

Meanwhile, IBM completed design for IU support equipment for the launch sites. In December MSFC approved IBM's conceptual design of the component handling cart and the IU entrance hoist. IBM planned to build a working model of the handling cart to check out handling operations of the cart and to check out clearances on the S-IVB forward skirt platform. The IU entrance hoist will extend about 79 inches outside the IU access door; the swing arm structure will prohibit extension to a greater length. IBM and DAC agreed on the guiding method to be used in interfacing the IU handling cart and the S-IVB work platform.[72]

Servicing equipment designed for use at KSC included S-IVB and IU pneumatic GSE. Phase I review of DAC's S-IVB pneumatic GSE designed for use at the launch site occurred at MSFC on August 18. MSFC granted tentative approval of the design pending certain changes. In December MSFC issued a change order to DAC's contract to provide the APS pneumatic equipment to the Saturn IB and Saturn V launch sites.

Hayes International Corporation, contractor for the IU pneumatic GSE, delivered a prototype console and test set to MSFC on October 23. MSFC scheduled the functional acceptance test to begin on November 4; however, test and checkout were suspended pending receipt of approved test procedures. On December 29 the contractor delivered design drawings for the IU penumatic GSE required for Saturn IB and Saturn V launch sites.[73]

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72. P&VE Lab., MPR-P&VE-64-10, p. 27; MPR-P&VE-64-12, pp. 17, 24, and 36; MPR-P&VE-65-1, pp. 17 and 23; and DAC, SM-46770, Issue 25, p. ix; SM-46897, Issue 28, p. 8; and SM-46935, Issue 29, p. 67.

73. P&VE Lab., MPR-P&VE-64-10, pp. 26-27, and 29; MPR-P&VE-64-11, p. 25; MPR-P&VE-64-12, pp. 16-17; MPR-P&VE-65-1, p. 17; and DAC, SM-46770, Issue 25, p. 77; and SM-46794; Issue 26, p. 113.

TRANSPORTATION

NASA's transportation equipment for Saturn IB stages, IU, support equipment, and spacecraft consists primarily of river and ocean vessels and a Boeing 377 aircraft converted for large cargo and termed "Pregnant Guppy." The river vessels are used to ferry the S-IB stages from Michoud to MSFC for static testing and to return them to Michoud for poststatic checkout and modification. These vessels also transport the S-IB stage, IU, and GSE from MSFC and Michoud to KSC. The river vessels are used in conjunction with ocean vessels to transport the S-IVB and the Saturn V S-II stage from the contractors' West Coast facilities to Michoud or the Mississippi Test Operations (MTO) and on to MSFC/Huntsville. The ocean vessels transport the stages from the West Coast to Michoud and MTO and to the launch sites at KSC. Saturn IB use of the Pregnant Guppy is to transport the Apollo spacecraft from MSC to MSFC and KSC for dynamic and facilities tests and to KSC for flight tests.

CCSD personnel completed training for transportation of the S-IB stages early in this report period. The same vessels used for Saturn I transportation--barges Promise and Palaemon--will ferry the S-IB stages to and from destination points. On August 1 MSFC awarded Saucer Marine Ways, New Orleans, a contract for modifications to the Palaemon. The modifications included installation of a pilot house and wing bridge. The firm completed modifications and placed the barge back into service on November 2.

Most of the same transportation equipment used in Saturn I transportation (pallets, coverings, dolly parts, and tie-down equipment) is employed in transportation of the Saturn IB S-IB stage and the IU. Hayes International Corporation completed design of the Saturn IB/V IU shipping container in October. Fabrication of the first of the containers began in November; delivery to MSFC was due in January. Design modifications to the R&D IU trailer began in October. The modifications include moving the hoisting tiedown ring for better attachment.[74]

DAC and MSFC completed transportation plans for the S-IVB stages early in this period. An open-deck river vessel, Courtland Barge, would transport S-IVB stages on the Sacramento River. Other vessels, converted Navy LSD and YFNB ocean vessels, would be used in the West Coast ocean transport of the stage

74. Test Lab., Test Laboratory Monthly Progress Report, July 12 - Aug. 12, 1964, p. 38; Aug. 12 - Sept. 12, 1964, p. 42; Sept. 12 - Oct. 12, 1964, p. 30; Oct. 12 - Nov. 12, 1964, p. 36; and Test Lab. Hist. Rpt., July 1 - Dec. 31, 1964, p. 23.

VESSEL FOR SATURN STAGES

This special barge, Promise, transports Saturn I and Saturn IB stages from manufacturing and test sites to Cape Kennedy.

and for shipping the stage via the Panama Canal to Michoud and to KSC. Modification of the West Coast Barge (YFNB-20) for shipping stages along the California Coast was almost completed by the Harbor Boat Building Company at the end of this period. The Military Sea Transport Service (MSTS), operator of the ocean vessels, completed modification design for Point Barrow, a Navy LSD, on July 31. Award of the construction contract occurred October 29; completion of the contract was due in May 1965.[75]

Design and fabrication of S-IVB stage protective covers, dolly transporters, cradle kits, and stage handling kits were complete and fabrication of the first units completed during August 1964. In November DAC completed the stage transportation instrumentation kit and installed it on the dynamic test stage. The MSFC-furnished R&D instrumentation trailer arrived at DAC in November and the contractor prepared it for operation with the stage transportation instrumentation kit. DAC scheduled use of the instrumentation kit to monitor vibration measurements on the stage during shipment.[76]

Loading of the first S-IVB stage, the dynamic test stage, on the States Marine Ship, Aloha State, occurred on December 8. The Aloha State transported the stage to New Orleans via the Panama Canal route. There the stage was transferred to the river barge Promise on December 21 for the rest of its journey to Huntsville.[77]

Saturn IB use of the Pregnant Guppy aircraft will be for transportation of the Apollo spacecraft. On August 31 MSFC representatives visited Food Machinery Corporation, San Jose, California, to accept two cargo lift trailers (CLT) for use in loading aircraft at MSC, Houston, Texas. All former CLT's had been procured from Dorsey Trailer Company, Elba, Alabama. During this report period MSFC began modifying four of the six Dorsey CLT's to make them more reliable. The modifications included addition of redundant circuits and changing the jacks from electrical to manual operation.[78]

At the end of this report period MSFC continued investigation of proposals by aircraft firms to transport S-IVB and Saturn V S-II stages. Aero Spacelines, owner of the Pregnant Guppy, presented a proposal for shipment of the stages by a "Super" or "Very Pregnant Guppy" near the end of this report period. MSFC decision on air transport of the stages was still pending.[79]

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75. Test Lab., Test MPR, July 12 - Aug. 12, 1964, p. 38; Sept. 12 - Oct. 12, 1964, p. 38; and Test Lab. Hist. Rpt., July 1 - Dec. 31, 1964, p. 22.
76. DAC, SM-46770, Issue 25, pp. 77 and 82; and SM-46897, Issue 28, p. 61.
77. Saturn V Off., MPR-SAT-V-64-4, p. 16.
78. Test Lab., Test MPR, Aug. 12 - Sept. 12, 1964, p. 43.
79. Test Lab., Test MPR, Dec. 12, 1964 - Jan. 12, 1965, p. 37.

Saturn IB and Related Studies

Saturn IB studies dealt with methods for improving the payload capability of the vehicle, definition of possible third stage configurations, and advanced payloads for the vehicle.

IMPROVEMENT STUDIES

Review of launch vehicle development programs shows that about ten years are required to fully develop new technologies for developing advanced vehicles. The current trend in advanced launch vehicle development is to increase payload capabilities of currently approved vehicles. This decreases the development time required for advanced vehicles and provides early accomplishment of primary space flight objectives in addition to being more economical.[80]

Methods considered in the July - December 1964 report period for improving the Saturn IB payload capability were varied. One involved strap-on of four Minuteman solid rockets to the S-IB stage. MSFC completed the feasibility study in August. The results formed a basis for continuing definition phase effort. Precontract negotiations with CCSD for definition of the Saturn IB/Minuteman continued through November. On December 4 MSFC modified CCSD's Saturn I/IB contract by cost letter to include immediate Phase I definition study of a preliminary Saturn IB/Minuteman configuration. During the report period MSFC personnel met with representatives of KSC, CCSD, and the Martin Company (Denver) to determine the solid motor effects on launch facilities. On December 30 MSFC personnel also met with Thiokol Corporation to discuss the Minuteman case design, belly-band attachment, forward and aft skirt design, ignition and destruct systems, and handling and logistics. MSFC passed this data on to CCSD for consideration in the design analysis.[81]

Other methods receiving consideration included uprated liquid rocket engine, increased propellant capacity, and/or substitute propellants in the S-IB stage; substitution of a large solid propellant rocket for the liquid propellant S-IB stage; liquid strap-ons to the S-IB stages; application of an S-IVB stage with advanced propulsion in combination with a basic or uprated S-IB stage; and applica-

80. Future Projects Off., FPO Planning Information and Activity Report, June 1965, pp. 8-9.
81. P&VE Lab., MPR-P&VE-64-9, pp. 1 and 44; MPR-P&VE-64-10, p. 2; MPR-P&VE-64-11, p. 2; MPR-P&VE-64-12, p. 2; and MPR-P&VE-64-1, p. 1; and Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, p. 15.

tion of a cryogenic third stage to the basic or uprated Saturn IB vehicles.[82] Studies involving these varied methods were performed in-house at MSFC and by DAC and CCSD under contracts awarded in June 1964.

CCSD investigated methods of improving the payload capability and mission versatility by uprating the S-IB stage, by use of solid motor strap-ons, and uprating the S-IVB stage. DAC provided support for the S-IVB stage uprating effort. In addition, CCSD investigated the use of a third stage on a selected improved vehicle. DAC evaluated the use of a 260-inch-diameter solid propellant motor to replace the S-IB stage and supported CCSD in the evaluation and modifications of the S-IVB stage. DAC also investigated the use of a third stage on a selected improved vehicle. Effort by both contractors continued into 1965.[83]

In September MSFC completed a preliminary study effort concerning the feasibility of increasing Saturn IB and Saturn V performance capability by using liquid strap-on units. The results of the study, published October 23, 1964, indicated that a Saturn IB equipped with two strap-on units had a payload capability increase of 8,050 pounds to a circular earth orbit of approximately 115 miles. The Saturn V with four strap-on units showed an increase of 12,580 pounds in an approximate two-stage-to-140-mile circular earth orbit. In December MSFC initiated a study to define Saturn IB and Saturn V first stage configurations with strap-on liquid propellant pods. When this period ended, configuration drawings, weight summaries, and propulsion system analysis had been completed for various candidate configurations. After preliminary definition of the more promising concepts, a Marshall-wide in-house improvement study was expected.[84]

In October MSFC personnel completed an in-house analysis to determine if performance gains for the Saturn IB could be obtained by increasing the amount of propellant loaded in the S-IB stage. A performance increase of approximately 4 per cent was realized with limitation of the liftoff thrust-to-weight ratio to 1.14. Study of possible performance gains for Saturn IB and Saturn V vehicles with use of a J-2 aero-spike engine ended September 28 with results published in October. Aero-spike engines of 200,000 pounds thrust in the present S-II and S-IVB stages would increase payload to escape by 7,000 pounds. MSFC published results of an in-house Saturn IB/FLOX[85] study in December. This study led to determination

82. Advanced Systems Off., Saturn IB Improvement Studies (Phase I), TM X-53323, Executive Summary Report, Aug. 26, 1965, p. 1.
83. Ibid., pp. 1-2.
84. P&VE Lab., MPR-P&VE-64-9, p. 3; MPR-P&VE-64-12, pp. 2-3; and MPR-P&VE-65-1, p. 2.
85. FLOX indicates addition of fluorine to the oxidizer to increase engine performance.

of payload gains derived from Saturn IB two- and three-stage basic launch vehicles using FLOX in combination with other chemical fuels and with kerosene as first stage propellants.[86]

SATURN IB THIRD STAGE CONFIGURATIONS

In this period MSFC reviewed the previous work on Saturn IB third stage configurations. Third stages investigated were Centaur, Agena D, Titan III Transtage, Apollo Service Module, and the S-VI.[87] Curves of gross payload versus altitude, weight summaries, stage descriptions, and launch vehicle configurations, were plotted. In the review, all third stages were considered to be ignited in a 100-nautical mile circular orbit and were based on a two-stage capability of 34,750 pounds. A 260-inch-diameter shroud was used on all configurations.

Third stage configurations still under consideration during this report period included the Saturn IB/Agena D, Saturn IB/Service Module, and the Saturn IB/Centaur.

The Saturn IB/Agena study had three purposes: establishment of the configuration; definition of the necessary modifications to adapt the Agena D to the Saturn IB; and determination of the payload capabilities of the three-stage vehicle. Lockheed Missiles and Space Company provided the data for generation of configurations, structural definition, weights, and performance. Weights were also determined for the nosecone, payload shroud, and payload support structure, and an analysis of a separation system similar to the Saturn IB/Centaur was made. MSFC published results of the study on November 10. The Agena D can be adapted as a third stage with a minimum of modification; however, because of the load-carrying capabilities of the Agena D, a conical adapter is required to carry the payload during the burning of the first and second stages. The study revealed that the Agena D is capable of transferring payloads up to 260 inches in diameter from a 100-nautical mile parking orbit to higher orbits or to earth escape velocity. Missions considered for the vehicle included orbital transfer maneuvers and the 24-hour synchronous orbit satellite mission.[88]

86. P&VE Lab., MPR-P&VE-64-10, p. 2; and MPR-P&VE-64-12, p. 3.
87. MSFC, MHM-8, pp. 79-84, and MHM-9, pp. 101-102, contain descriptions of third stage effort prior to the current report period.
88. P&VE Lab., Agena D Within a 260-inch Shroud as a Third Stage of the Saturn IB, IN-P&VE-A-64-18, p. 1; and MPR-P&VE-64-10, pp. 1-2; and MPR-P&VE-64-12, p. 1.

In August MSFC completed definition of the 260-inch shrouded Centaur as the Saturn IB third stage. Results of the study were published in October. The defined configuration employed the Centaur AC-12 with only a few modifications necessary to make it compatible with the Saturn IB. These modifications included fabrication of a 260-inch-diameter shroud of aluminum honeycomb material, shroud insulation and purging, arrangement of access to the astrionics equipment, and the addition of a shroud jettison system. No major modifications were required for the Centaur stage itself. For unmanned flight the Saturn IB stages require no modification; however, for on-the-pad protection in maximum wind conditions, pressurization of the S-IB stage would be necessary. The standard Saturn IB IU would be used as an adapter forward of the S-IVB stage in lieu of the regular adapter and would provide guidance through boost; the standard Centaur guidance system would be used for third stage flight. Fabrication of the shroud and most of the modifications would occur at MSFC and the Centaur stage would be shipped as a unit to KSC. The Centaur stage manufacturer, General Dynamics/Astronautics, would assist MSFC in the modification by modifying the tank adapter rings for payload adapter and S-IVB interstage; by adapting the stage helium insulation annular purge system for the shroud; by deleting fill and vent lines; and by installing temporary valves and blanks required to maintain tank pressure during transportation to MSFC. NASA Headquarters requested determination of the modifications required of the contractor.[89]

ADVANCED PAYLOADS FOR SATURN IB

Most of the Saturn IB advanced payload effort in this report period involved definition of payload criteria, development of methods to define potential payloads, definition of the potential markets for advanced Saturn IB payloads, and actual definition of advanced payloads.

CCSD, under a task order, initiated effort toward compiling a "Payload Design Criteria Data Book." The book will provide factual information to be used by payload designers in integrating a payload with the Saturn IB vehicle.[90]

In September MSFC issued to Brown Engineering Company a task order entitled "Advanced Payload Studies Applicable to Saturn IB." Brown's task involved development of scale factors for a manned orbiting laboratory, one of the more promising missions considered for the two-stage Saturn IB. Brown completed structural layouts and analysis to compute optimum weight/volume relationships, and defined the critical problem areas in design, fabrication, and

89. P&VE Lab., Centaur As a Third Stage of the Saturn IB, TM X-53043, Oct. 23, 1964, pp. 1, 7-8, and 42-43.
90. P&VE Lab., MPR-P&VE-64-9, p. 2.

manufacture of the laboratory. MSFC personnel assisted Brown in making a preliminary cost estimate for manufacturing assembly and testing of the laboratory. The contractor completed the study in November and submitted its report to MSFC in December.

In October MSFC awarded a new task order to Brown entitled "Saturn IB Advanced Payload Study." The contract directed development of plans and methods for defining potential missions for advanced payloads in the Saturn IB capability range (two- and three-stage). In December MSFC extended Brown's contract for three months for completion of the study. Payload definition will help MSFC to define the potential markets for Saturn IB vehicles beyond 1965.[91]

In-house MSFC reviewed NASA's Office of Space Science and Applications (OSSA) "Prospectus for 1964." Determination of MSFC's role in possible OSSA activities received particular emphasis. OSSA's launch vehicle schedule for the years 1967 to 1980 called for only 17 Saturn IB vehicles. MSFC suggested and described additional missions for two- and three-stage Saturn IB vehicles. The suggested missions made use of the excess payload and volume capability of the Saturn IB to reduce development costs for new payloads. One mission suggested involved use of the Saturn IB as a manned orbital launch platform to place various payloads in their required orbits; this mission would use the man-in-the-loop as a control element.[92]

MSFC established the feasibility of a Saturn IB orbital laboratory payload. The laboratory would occupy the space now assigned the Lunar Excursion Module of the Apollo spacecraft. The laboratory would be inserted in a long-duration orbit where it would provide up to 3490 cubic feet of usable laboratory space.[93]

Astran Division of Space Craft, Inc., completed for MSFC the "Study of the Utilization of the Saturn IB Instrument Unit to Support Space Experiments." The contractor reviewed the IU to determine its capabilities, orbit parameters, packaging constraints, environments, and requirements; investigated techniques to extend the lifetime of the IU including consideration of radiation damage, equipment degradation, remote checkout, and instrumentation; coordinated with MSFC the possible experiment requirements to determine suitability for the IU; estimated the modification lead times and possible schedule influences due to the

91. P&VE Lab., MPR-P&VE-64-9, p. 12; MPR-P&VE-64-10, p. 3; MPR-P&VE-64-11, p. 3; MPR-P&VE-64-12, p. 3; and MPR-P&VE-65-1, p. 2.
92. P&VE Lab., MPR-P&VE-64-11, p. 3.
93. P&VE Lab., Study of a Saturn IB Orbital Laboratory Payload, IN-P&VE-A-65-2, pp. 1-2.

postulated integration of experiments with the IU; and investigated the feasibility of packaging rendezvous equipment so that the spent S-IVB and Saturn IU combination could be used as a target vehicle. Results of the study indicated that use of the IU in support of space experiments was feasible. The contractor recommended methods to extend the lifetime of the IU and made suggestions for use of the on-board IU components and systems in support of space experiments.[94]

Another study concerned the feasibility of integration of standard payload modules on the Saturn IB. Two concepts, a module attached to the S-IVB cold plates, and a module that would be ejected in earth orbit, were used for preliminary design purposes. The preliminary design of the standard module to be incorporated on the cold plates of the IU or the S-IVB stage forward skirt was completed in December. Problems involved in the concept included structural modification to provide for a new antenna system, cable routing and installation to experiments, and schedule impact. Work continued on development of a conceptual design of a jettisonable module and accompanying installation concept.[95]

The advanced payload investigations included definition of the payload requirements of the Saturn IB/Centaur. Definition of the payload requirements concerned the feasibility of packaging spacecraft in the prescribed payload envelope, payload separation, structural integration of the payload, and limitations of the Deep Space Instrumentation Facility (DSIF), or the Space Flight Operations Facility (SFOF), to monitor and control multiple payloads simultaneously. Results of the study indicated that the 260-inch-diameter payload envelope would accommodate the Voyager spacecraft, or two Surveyor spacecraft mounted abreast, or two Surveyors mounted in tandem. Other payloads considered for the Saturn IB/Centaur included the Communications Satellite (Comsat), and the Optical Technology Satellite. The latter would monitor satellites and other payloads in orbit; it is currently under investigation by the Perkin-Elmer Corporation for MSFC.[96]

Program Funding

Obligations for the Saturn IB program in the July 1 - December 31, 1964, period totalled $127,481,000. This total was allotted as follows: S-IB stage,

94. Astran Division, Space Craft, Inc., The Study of the Utilization of the Saturn IB Instrument Unit to Support Space Experiments, ASTRAN-8-11301-FR-3, Nov. 1964, pp. vi, 1-2, and 96-97.
95. P&VE Lab., MPR-P&VE-64-10, p. 12; MPR-P&VE-64-11, p. 9; MPR-P&VE-64-12, pp. 10-11; and MPR-P&VE-65-1, p. 11.
96. P&VE Lab., MPR-P&VE-64-9, pp. 2-3; MPR-P&VE-64-11, p. 2; and MPR-P&VE-65-1, pp. 2-3.

$49,687,000; S-IVB stage, $20,909,000; Instrument Unit, $15,055,000; Ground Support Equipment, $16,859,000; H-1 Engine procurement, $9,200,000; J-2 Engine procurement, $9,800,000; Vehicle Support, $5,971,000.[97]

Summary

During the July - December 1964 period in the Saturn IB R&D program there was component qualification, ground testing of stages, and manufacture and assembly of flight vehicles.

CCSD at Michoud completed modification of the first and only S-IB ground test stage, the dynamic/facilities test stage. The contractor also completed assembly of the first flight S-IB stage, activated the vehicle checkout station, and began manufacture of the second and third S-IB flight stages.

DAC accomplished qualification of major components and systems, including the auxiliary propulsion system module for the S-IVB stage. The S-IVB contractor completed manufacture of two ground test stages, the battleship stage and the dynamic test stage. The major achievement in the Saturn IB S-IVB program was full-duration firing of the S-IVB battleship stage in the Saturn IB configuration. Other activity by the contractor included manufacture of the other ground test stages almost to completion, and manufacture of the first four flight S-IVB stages.

IU progress included completion of documentation for redesign of the basic Saturn I IU to the Saturn IB/V configuration, qualification of various prototype components, manufacture of an IU mockup for use as a development fixture, and initial fabrication of the IU ground test stages.

Activation of several Saturn IB facilities occurred. CCSD activated the checkout station at Michoud Operations for checkout of the S-IB stages. DAC activated the Beta 1 stand at Sacramento for hot-firing of the ground test stages and flight stages. Progress continued in fabrication and installation of ground support equipment for automatic checkout of the Saturn IB. MSFC also made progress in planning transportation for Saturn IB stages and in modification of the transport vessels.

Saturn IB study activity emphasized payload improvement, definition of third stage configurations, and investigation of advanced payloads.

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97. Information furnished August 24, 1965, by Louid E. Snyder, MSFC Financial Management Off.

CHAPTER IV: SATURN V

The Saturn V launch vehicle under development at MSFC was authorized by NASA in January 1962. MSFC has technical program management responsibility and directs the development and production of Saturn V at Huntsville and numerous other locations across the United States. Saturn V's primary mission is to launch the manned Apollo spacecraft to the vicinity of the moon. The vehicle will perform the boost portion of the lunar orbital rendezvous (LOR) mission; it will launch a 95,000-pound Apollo spacecraft consisting of three sections through an earth parking orbit into a translunar trajectory.

Secondary objectives of the Saturn V program include such proposed future missions as Apollo logistic support, extended lunar exploration orbiting research laboratories, satellite inspection and repair, and probes to the planets.

The Saturn V vehicle is capable of carrying a payload of 280,000 pounds into low earth-orbit. The launch vehicle with Apollo spacecraft attached is approximately 360 feet high. It weighs over six million pounds at liftoff. The space vehicle in mission configuration consists of the S-IC first stage, S-II second stage, S-IVB third stage, instrument unit containing navigation and guidance equipment, and the Apollo spacecraft. The Apollo spacecraft, for which NASA Manned Spacecraft Center has responsibility, consists of the lunar excursion module (LEM), service module (SM), command module (CM), and launch escape system (LES).

NASA's Office of Manned Space Flight (OMSF), as manager of the Saturn V vehicle program, adopted the "all-up" flight concept in order to reduce the number of costly flight tests. By this philosophy the complete vehicle flies as soon as it is available. OMSF has scheduled unmanned flights of Apollo/Saturn V in 1967, manned flights in 1968, and manned lunar landing and return before 1970.

Vehicle Research and Development

The preliminary design of Saturn V stages and hardware was almost complete when the current report period began. Manufacture of ground test stages at various sites, which was well underway prior to this period, proceeded at a steady pace throughout the period. Hardware testing increased in tempo; stage static firing tests began; and MSFC prepared to convert major Saturn V contracts to incentive contracts.

S-IC STAGE

The first (S-IC) stage is 138 feet long, 33 feet in diameter, and weighs approximately 300,000 pounds. The propulsion system consists of five F-1 engines, which burn kerosene (RP-1) and liquid oxygen (LOX). Each engine develops 1.5 million pounds thrust, for a total first stage thrust of 7.5 million pounds at sea level. Propellant capacity of the stage is about 4.4 million pounds.

The mission of the S-IC stage is to power the Apollo/Saturn V vehicle for the first 150 seconds of flight--from launch until the vehicle attains altitude of about 39 miles. The S-IC stage then separates and falls back to earth.

MSFC and the Boeing Company have joint responsibility for the design, development, procurement, and test of the S-IC stage. MSFC is responsible for assembly of two ground test stages and the first two flight stages. Boeing is manufacturing two ground test stages and eight flight stages at the government's Michoud Operations, New Orleans, Louisiana; Boeing also provides certain tooling and assembly support to MSFC.

Boeing received the prime S-IC stage contract January 1, 1963. NASA amended the Boeing contract several times in the current period. In October two major contract modifications occurred. One was a $2.9 million modification covering design, development, and manufacture of components for S-IC stage umbilical connections and related hardware. The other October change was an $11.8 million modification for the structural static load testing program. These two modifications increased total value of the S-IC prime contract to $516.2 million. On December 24, 1964, NASA awarded Boeing an $89.9 million contract modification for Saturn V vehicle systems engineering and integration support. This work is to be performed at MSFC and Michoud in two major areas: systems engineering and integration, and vehicle ground support equipment.[1]

On August 4, 1964, technicians at MSFC hydrostatically tested the S-IC test fuel tank, the first structural test component in the Saturn V booster development program. Partial collapse of the tank's upper bulkhead occurred during test. After rework further hydrostatic testing occurred on September 28 and was

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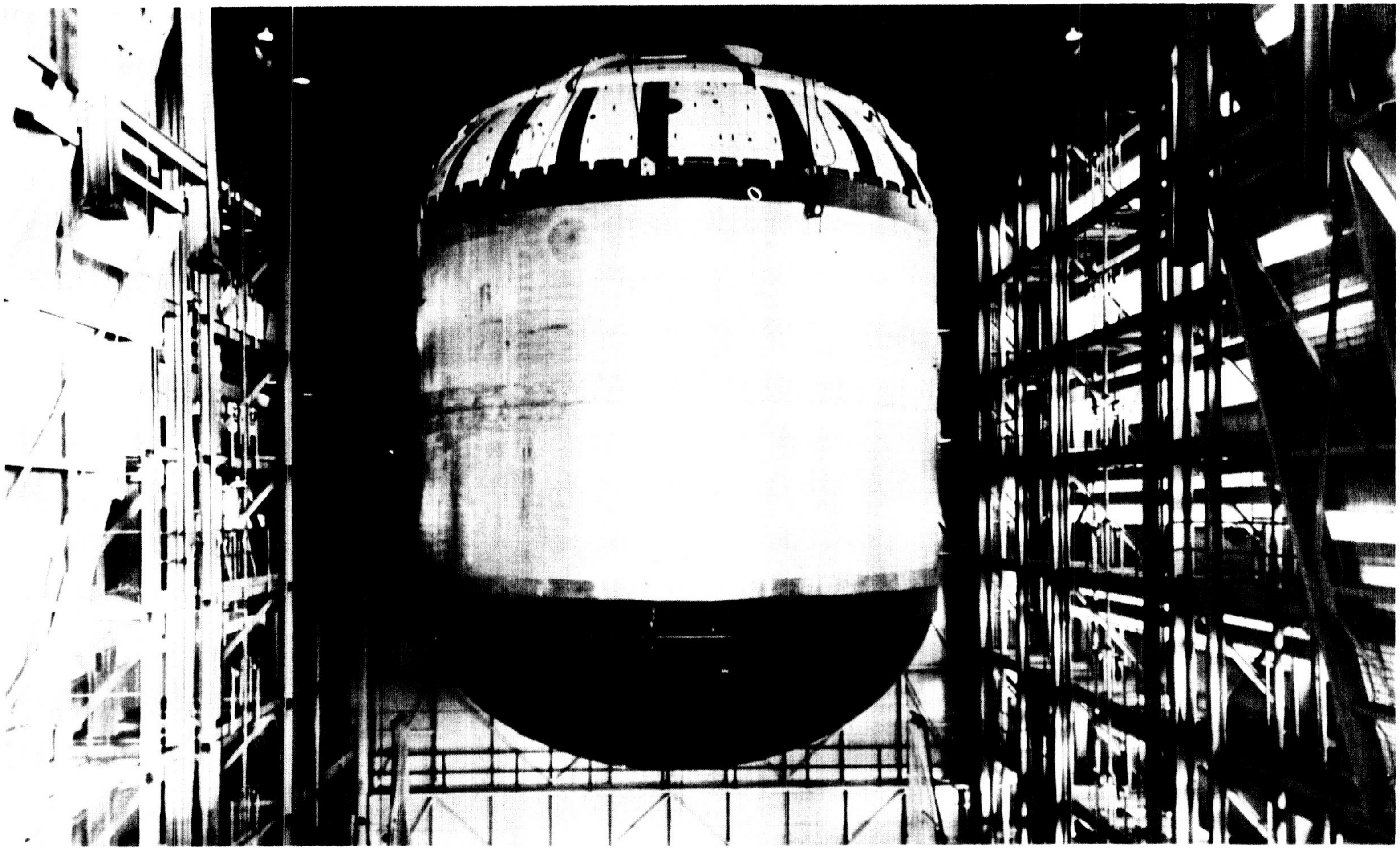
1. NASA, Astronautics and Aeronautics, 1964, Chronology on Science, Technology, and Policy, SP-4005, p. 352; and 89th Cong., 1st sess., H. Rpt., Hearings on H. R. 3730 (Superseded by H. R. 7717), 1966 NASA Authorization, Mar. 3, 4, 11, 16, and 17, 1965, (No. 2), Part 2, p. 721.



SATURN V TEST TANK

This S-IC test fuel tank, a structural test component, is pictured in the Vertical Assembly Facility at MSFC.

appraised as a "qualified success." Inertial loads testing began in October and was scheduled for completion in February 1965. Various other structural tests on the tank will continue through 1965.[2]

Work continued on the several assemblies of S-IC-S, the structural test stage.[3] Boeing at Michoud delivered the S-IC-S intertank to MSFC by mid-period. On November 20 Manufacturing Engineering (ME) Laboratory completed fuel tank welding in the Vertical Assembly Facility. MSFC technicians hydrostatically tested the tank on December 1. LOX tunnel installation preparations were underway when the period ended. The LOX tank lower assembly, completed at MSFC late in this period, moved into the Vertical Assembly Facility for installation of baffles and helium bottles. Significant design changes in the stage's fins and engine fairings caused delays but no expected impact in the structural test program. Meanwhile, work progressed on the thrust structure and other parts of the aft section; MSFC scheduled assembly completion for February 1965. Boeing's schedule called for delivery of the forward skirt to Huntsville also in February 1965, and the Center expected to complete assembly of the S-IC-S forward section in April 1965.[4]

S-IC-D, the dynamic test stage, experienced some delay in tank bulkhead assembly at Michoud during this period. Boeing and ME Laboratory resolved technical problems and proceeded with assembly of the S-IC-D LOX and fuel tanks as the report period ended. Assembly of the thrust structure was 90 per cent completed at the end of the period. Redesign of fins and fairings delayed assembly of these components.[5]

S-IC-D bulkhead welding problems at Boeing/Michoud also delayed manufacture of the S-IC-F, facilities checkout stage, throughout this period. Major assembly operations for S-IC-F were expected to begin early in 1965. Improved manufacturing methods developed in previous stages promised to benefit the S-IC-F program. Also awaited were the release of tooling from previous assemblies and release of the assembly position in the Michoud Vertical Assembly Building.[6]

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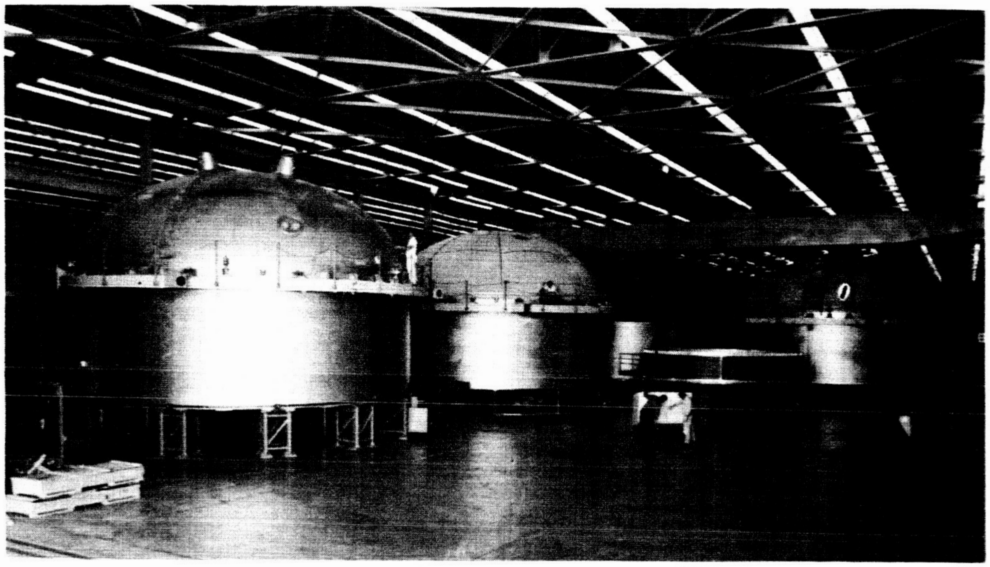
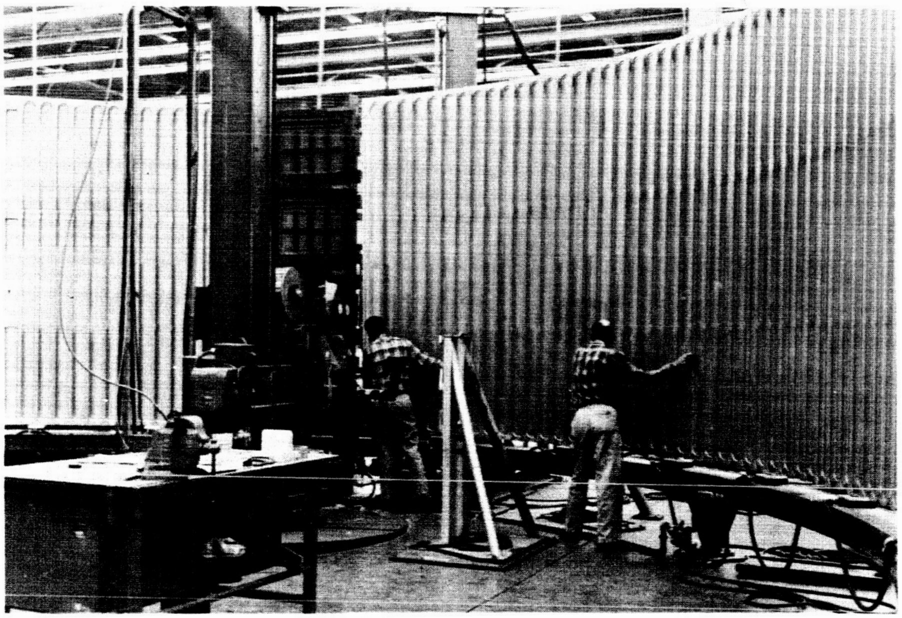
2. Saturn V Off., Saturn V Quarterly Progress Report, July 1 - Sept. 30, 1964, MPR-SAT-V-64-3, p. 2; P&VE Lab., Monthly Progress Report for Period Sept. 12, 1964, through Oct. 11, 1964, MPR-P&VE-64-9, pp. 56-57; and Boeing, Saturn S-IC Quarterly Technical Progress Report, Oct. 2, 1964 - Dec. 31, 1964, D5-11994-7, p. 115.
3. S-IC-S will be tested in sections, not as a complete stage.
4. Saturn V Off., MPR-SAT-V-64-4, pp. 5-6.
5. Saturn V Off., MPR-SAT-V-64-3, p. 3; MPR-SAT-V-64-4, p. 4; and Boeing, D5-11994-7, p. 33.
6. S-IC-D and S-IC-F are the two ground test stages being manufactured by Boeing at Michoud. See Saturn V Off., MPR-SAT-V-64-3, p. 3; MPR-SAT-V-64-4, p. 5; and Boeing, D5-11994-7, p. 40.



S-IC TANK SUBASSEMBLIES

Bulkheads for LOX and fuel tanks for the S-IC stage are shown in Building 4707 at MSFC.



INSIDE S-IC TANK SKIN

Workmen using an air bearing fixture perform a skin weld and trim operation on an S-IC tank skin assembly in an MSFC laboratory.

S-IC-T, the static firing stage, experienced welding and other manufacturing problems that delayed its completion by several months. The current period began with work on the stage several weeks behind schedule. Technicians discovered and repaired numerous minute weld cracks in both LOX and fuel tank bulkheads of this stage. LOX tank hydrostatic testing ended in August, and fuel tank hydrostatic testing ended in November. The S-IC-T forward skirt and intertank, made at Michoud, arrived at Huntsville early in the period for rework and assembly. Major progress toward completion of these tasks occurred in the final months of the period. In the Vertical Assembly Facility ME Laboratory joined the forward skirt to the LOX tank on October 18; joined the fuel tank to the thrust structure on November 24; completed LOX delivery lines on December 3; and joined the fuel and LOX tanks to the intertank on December 18. As this period ended workmen were moving the forward and aft assemblies of S-IC-T to Building 4705 for completion of horizontal assembly operations. Rapid mating of assemblies demonstrated outstanding coordination and tooling.[7]

MSFC at Huntsville, with fabrication support from Boeing, worked to build S-IC-1, the first flight stage. By December 31, 1964, the upper bulkhead of the fuel tank was complete and baffle installation was in progress; the lower part of the tank was ready for baffle installation. The LOX tank's lower bulkhead had been welded to the Y-ring. Holding up progress was the thrust structure, still incomplete.[8]

Assembly of S-IC-3, the first flight stage to be produced at Michoud by Boeing, started late in the current period and progressed on schedule. Suction fittings for the fuel tank were 35 per cent completed when the period ended. MSFC will weld these fittings to the gores of the LOX tank bulkhead in order to maintain the S-IC-3 delivery schedule.[9]

The S-IC stage development program experienced several serious problems during this period. A new engineering release documentation system, utilizing automatic data processing equipment, was introduced by Boeing to minimize one problem. Other problems included welding, parts shortages, delayed tooling releases, and late deliveries by vendors. Late in the period MSFC established ad hoc committees to investigate delays in qualification testing of valves and other vendor items.[10]

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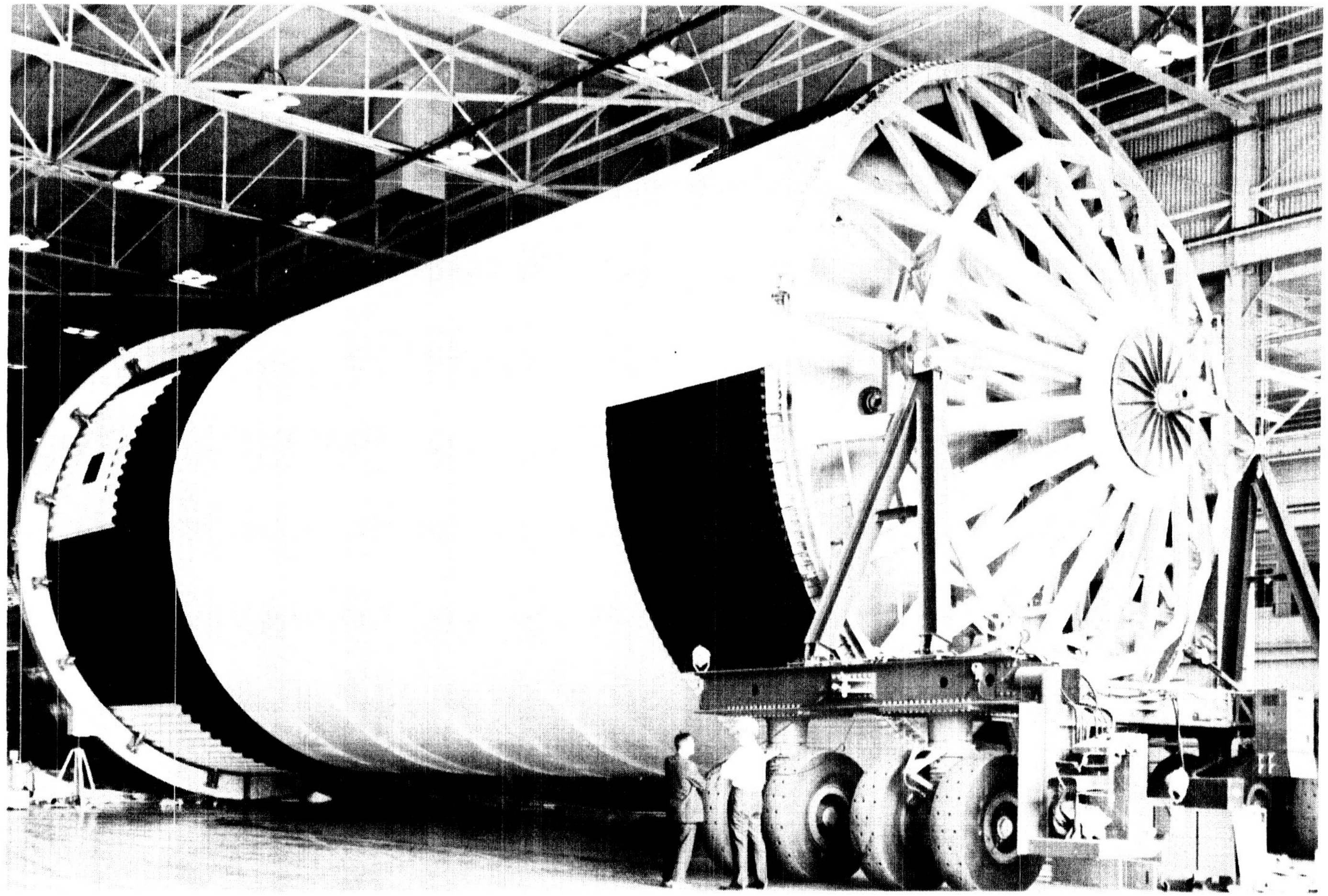
7. P&VE Lab., MPR-P&VE-64-12, p. 48; and Saturn V Off., MPR-SAT V-64-3, pp. 4-5; and MPR-SAT V-64-4, p. 7.
8. Saturn V Off., MPR-SAT V 64-4, p. 8.
9. Boeing, D5-11994-7, p. 42.
10. Saturn V Off., MPR-SAT V-64-3, p. 6; and MPR-SAT V-64-4, p. 8.



TOP HALF OF S-IC STAGE

The LOX tank assembly of S-IC-T, the static test stage, is shown as it neared completion in a shop at MSFC during November 1964.

S-II STAGE

The second (S-II) stage of the Saturn V vehicle is 81.5 feet long and 33 feet in diameter. It weighs approximately 80,000 pounds empty and about 1,025,000 pounds loaded with propellants. The stage is powered by a cluster of five Rocketdyne J-2 rocket engines. The J-2 burns liquid hydrogen (LH_2) and LOX, develops 200,000 pounds thrust, and is designed for optimum performance at high altitude.

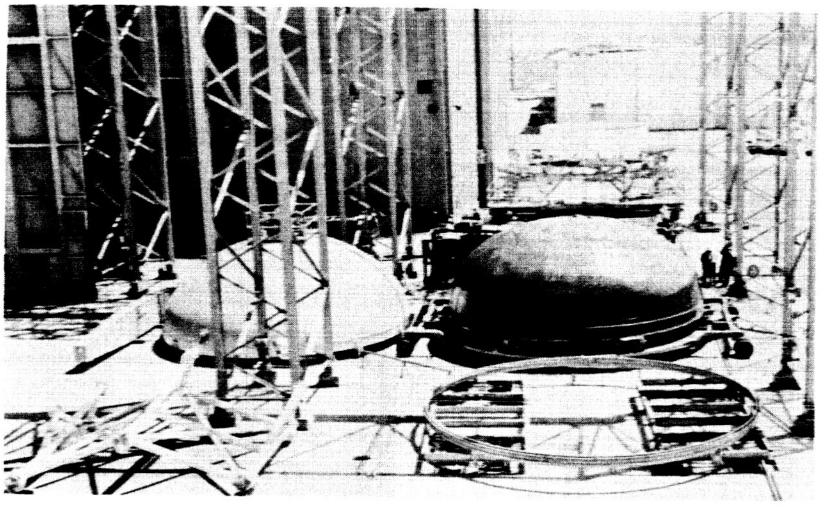
The mission of the S-II stage is to provide second-stage boost of one million pounds for 395 seconds, increasing the vehicular velocity from 5600 miles per hour to 16,500 mph and the vehicular altitude from 50 to 113 miles. Upon depletion of propellants the S-II stage separates and reenters the atmosphere.

Prime contractor for the S-II stage is the Space and Information Systems Division (S&ID) of North American Aviation, Inc. (NAA). S&ID received the definitive contract in October 1962 and is responsible to MSFC for design, development, and manufacture of the S-II stage. The contract schedule requires fabrication and assembly of ground test stages and delivery of 10 flight stages to Launch Complex 39 (LC-39) at NASA Kennedy Space Center (KSC). No major contract modifications occurred during the current report period. At the end of the period the S-II stage contract value was approximately $475 million.

The S-II program advanced in the July-December 1964 period from the design phase to the start of the development and qualification test phase. Major milestones included a successful single-engine firing of the S-II battleship and technological advances in cryogenic tank insulation, base heat shielding, and propellant utilization.[11]

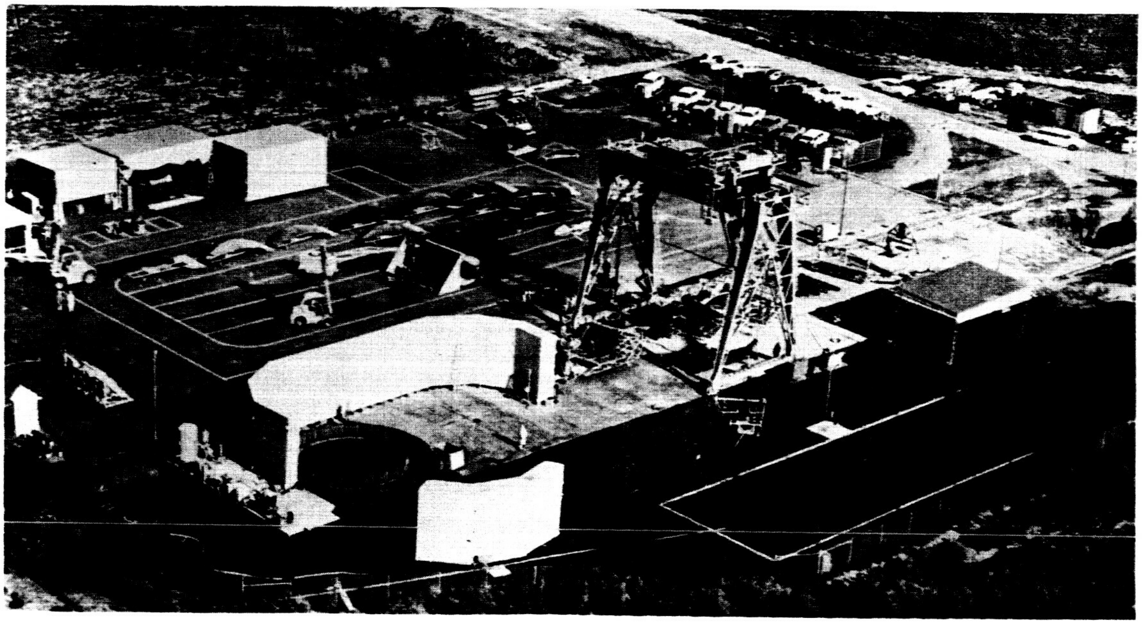
Late deliveries of ground support equipment, special development devices, and stage systems delayed completion of the S-II battleship at Santa Susana Field Laboratory (SSFL) during the first two months of this report period. By the end of September 1964, however, the battleship activation program was nearing completion. Activation for single-engine tests ended in October. Following erection and checkout, S&ID in November began static firings of the single J-2 engine on the battleship. These firings included an ignition test on November 9, a transition test on November 21, and an attempted mainstage firing on November 26. The November 26 firing ended after 2.8 seconds. A successful 10-second full-thrust firing on December 11 was a major milestone in the S-II development program

11. MSFC, Marshall Historical Monograph No. 9 (MHM-9), History of George C. Marshall Space Flight Center, Jan. 1 - June 30, 1964, pp. 117-119; and NAA S&ID, Saturn S-II Annual Progress Report, July 1, 1964, Through June 30, 1965, SID 63-1028-3, pp. 1-3.



S-II COMPONENTS

An S-II stage common bulkhead, tooling, and equipment are shown at the Seal Beach facility of North American Aviation's Space and Information Systems Division (S&ID).



S-II STAGE FACILITY

S&ID operates this facility at El Toro, California, which forms S-II bulkhead gores by a process involving use of explosives.

and completed the single-engine test program. During the remainder of December technicians prepared the battleship for 5-engine cluster firings, scheduled for spring of 1965.[12]

Assembly of S-II-S, the structural static test stage, ended at Seal Beach in October 1964. During hydrostatic pressure test of the stage's aft LOX bulkhead on October 28 the bulkhead ruptured and was damaged beyond repair. While a committee investigated the cause of this failure S&ID workmen immediately began fabrication of a replacement bulkhead. Meridian welding of this replacement bulkhead ended on November 21. During December the bulkhead progressed through "dollar" or dome weldment, hydrostatic inspection, and dye penetrant inspection. All major structural subassemblies for the stage were complete and preparation for circumferential welding was underway when the period ended. Meanwhile, an engineering evaluation of the failure in the original bulkhead showed the cause to be a weakness in a critical weld area--the region where the recirculation system plate was welded into the bulkhead gore.[13]

Manufacturing activity on the all-systems stage (S-II-T) proceeded well from the start of the period. In August full-pressure testing of the common bulkhead aft facing sheet resulted in discovery of a minute hole, which was repaired in September. Assembly of the thrust structure started in July and ended in October with installation of the aft skirt panels. Twelve completed bulkhead gores for S-II-T were diverted for use in assembling the replacement for the S-II-S aft LOX bulkhead (see previous paragraph). This delayed completion of the S-II-T bulkhead. In December S&ID workmen at Seal Beach began welding gore assemblies for S-II-T; they completed this work on December 23. S&ID personnel finished and successfully pressure tested the forward bulkhead also in December. They had almost completed tank cylinders for the stage by the end of the period.[14]

S-II-F, the facilities checkout stage, was in manufacture throughout this period following the "freeze" of the stage configuration in August. S&ID workmen completed meridian welding of the common bulkhead aft facing sheet in September, except for several welds that needed repair. Mockup of 70 electrical and instrumental harnesses on the electro-mechanical mockup (EMM), preparatory to fabrication of the actual harnesses, ended in October, Welding problems delayed

12. Saturn V Off., MPR-SAT V-64-3, p. 8, and MPR-SAT V-64-4, pp. 10-11; and NAA S&ID, Saturn S-II stage Monthly Progress Report, November 1964, SID 63-266-22, pp. 1 and 33-37, and SID 63-266-23, pp. 1 and 37.

13. NAA S&ID, SID 63-266-21, pp. 27 and 30; SID 63-266-22, pp. 27 and 45-46; and SID 63-266-23, pp. 1 and 46.

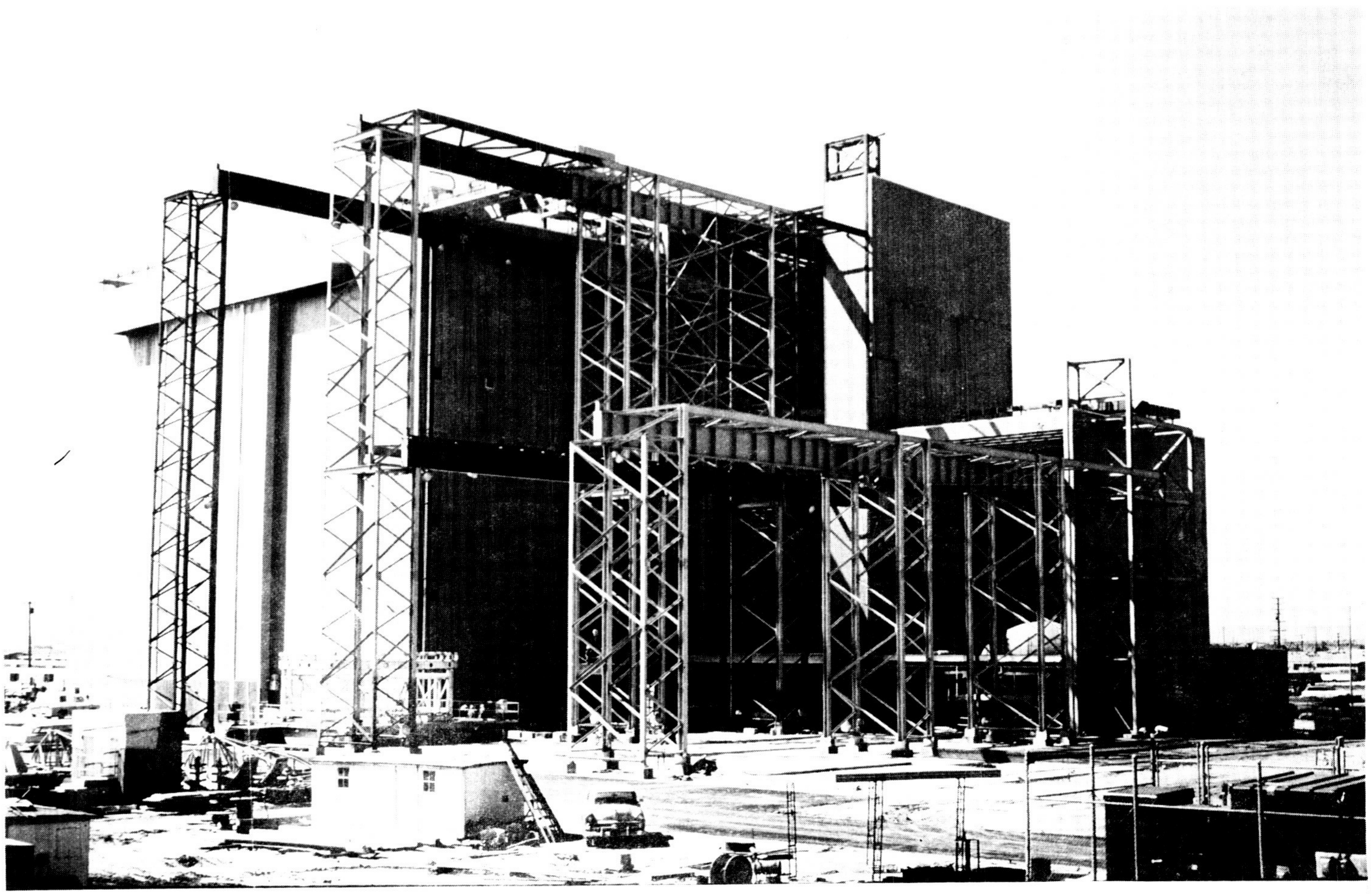
14. NAA S&ID, SID 63-266-18, p. 4; SID 63-266-19, p. 38; SID 63-266-21, p. 31; and SID 63-266-23, p. 33.

repair of the welds of the aft facing sheet until late December. The thrust structure assembly was completed and aft skirt panels were being aligned at the end of the period. Tank cylinder assembly at Seal Beach proceeded on schedule. Fabrication of gores for the forward LH_2 bulkhead was ahead of schedule. Panels for three LH_2 cylinders were complete at the end of the period. Meanwhile, S&ID had changed shop completion date for the stage from October to December 1965. A major program schedule change in December was the decision by NASA to deliver S-II-F directly to KSC, bypassing Mississippi Test Operations (MTO). NASA will use the stage for checkout of LC-39 only.[15]

In August MSFC and S&ID froze the configuration design for S-II-D, the dynamic test stage. S&ID's Tulsa facility fabricated and stored ahead of schedule the non-pressurized structure for the stage. Components fabricated, delivered, and stored prior to the end of this period included the aft skirt, thrust structure, interstage, center engine support, forward skirt, and cruciform baffles. On schedule in fabrication were LH_2 tank panels, LOX slosh baffles, and systems tunnels. Bulkhead gores were slightly behind schedule. Initial assembly operations at Seal Beach were scheduled to start in January 1965.[16]

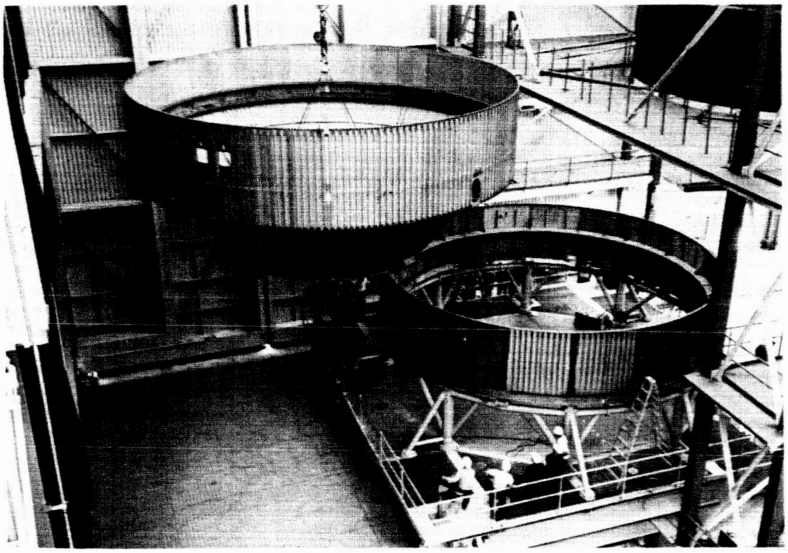
The common bulkhead test tank (CBTT) is a special test article in the S-II program. The CBTT consists of a production common bulkhead, a production forward bulkhead, two production LH_2 cylinders, a special forward skirt, and a simulated aft bulkhead. These components are joined to form a large tank divided by the common bulkhead into two smaller tanks. Fabrication and assembly of components were well advanced when this period began. In July S&ID completed assembly of the forward bulkhead. Assembly of both cylinders required for the tank ended in August. During September workmen completed the forward facing sheet and insulated the LH_2 cylinders. Insulation, bonding, and testing occupied technicians in October and November. In December S&ID welded together the two cylinders, finally inspected the forward bulkhead, bonded together the aft and forward facing sheets to form the common bulkhead, conducted inspections, and prepared to transfer the various subassemblies to the Vertical Assembly Facility at Seal Beach for circumferential welding.[17]

15. Saturn V Off., MPR-SAT V-64-3, p. 10, and MPR-SAT V-64-4, pp. 11-12; and NAA S&ID, SID 63-266-23, pp. 2 and 34.
16. Saturn V Off., MPR-SAT V-64-3, p. 10; and NAA S&ID, SID 63-266-19, p. 3; SID 63-266-21, pp. 31-32; and SID 63-266-22, p. 29.
17. NAA S&ID, SID 63-266-18, pp. 34-35; SID 63-266-19, p. 37; SID 63-266-21, p. 33; SID 63-266-22, p. 30; and SID 63-266-23, p. 35.



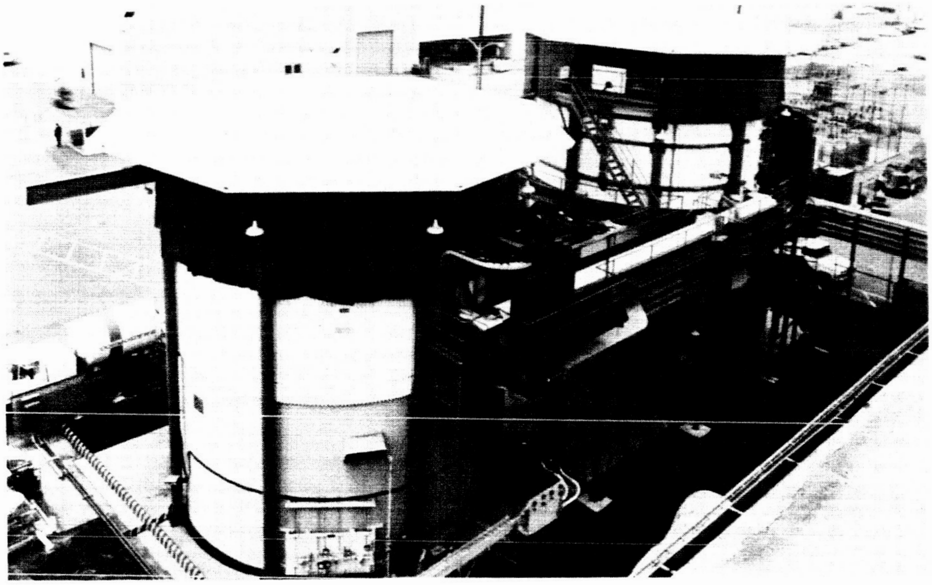
SEAL BEACH FACILITY

This S-II Vertical Assembly and Hydrotest Building is at S&ID's Seal Beach plant.



THRUST STRUCTURE FOR S-II

The S-II-S thrust structure is mated to the stage's aft skirt at Seal Beach. S-II-S is the structure static test stage.



S-II ELECTRO-MECHANICAL MOCKUP

The electro-mechanical mockup (EMM) at Downey, California, consists of two structures as shown here. The EMM represents a total S-II system.

Buildup of the S-II electro-mechanical mockup (EMM) at Downey was slow during July and August 1964 because of late deliveries of GSE and other equipment. By September a three-shift work schedule was in operation to install and check out equipment as it arrived. By the end of September the fluid distribution system was complete and progress toward activation of the EMM was accelerating. Automatic equipment rack checkout began. Mockup activity for the S-II-F ended in October. On November 25 the fluid distribution system and the engine actuation system saw their first use when a J-2 engine was gimballed on the EMM. During December fabrication of all EMM systems was complete, and installation was near completion. On December 2 personnel performed an environmental engine gimbal operation. Another gimbal test occurred on December 5. Automatic equipment integration began on December 17. By the end of this period all GSE end item models required for EMM activation had been delivered.[18]

By the end of August 1964 S&ID was fabricating non-pressurized structural subassemblies for S-II-1, the first S-II flight stage. This manufacturing took place at Tulsa and Los Angeles divisions of S&ID. From September through the remainder of the current period MSFC and S&ID made several major decisions involving design changes. The first flight stage would differ from ground test stages chiefly in LOX tank details: a new baffle design and a thicker aft bulkhead; increase from about 48 to 111 inches in the diameter of the aft bulkhead dollar section, with correspondingly shortened gore assemblies; and incorporation of integral systems plates in the LOX bulkhead. Another approved change was reduction of LH_2 tank pressure from 39 to 36 pounds per square inch (psi). The design changes caused a 9-week delay in the manufacturing schedule, but delivery of S-II-1 to MILA was still scheduled for July 1966. Program participants also decided that the double seal insulation developed by MSFC would be used as the primary LH_2 tank insulation, effective with S-II-4. In December S&ID released the engineering drawings for the new 111-inch sump ring and shortened gore assemblies. Redesigned components were being manufactured at the end of this period. Twenty-four of the 36 gore assemblies for S-II-1 were complete; four of the necessary 24 LH_2 cylinder panels were complete; and Tulsa Division was working satisfactorily on manufacture of the aft skirt, thrust cone, center engine beam, forward beam, forward skirt, and systems tunnel.[19]

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18. The EMM consists of two structures. One is a full-size replica of the forward skirt and LH_2 tank bulkhead. The other is a full-size replica of the LOX tank, aft skirt, thrust structure, and interstage. The EMM represents a total S-II system that includes fully integrated and checked out sets of ground support equipment and automatic checkout equipment. It will be modified to the configuration of each test and flight stage. See Saturn V Off., MPR-SAT V-64-3, pp. 7-8; and NAA S&ID, SID 63-266-20, pp. 1-2 and 37; SID 63-266-21, p. 36; SID 63-266-22, pp. 19, 21, and 31; and SID 63-266-23, pp. 25-26 and 39.

19. NAA S&ID, SID 63-266-19, p. 5; SID 63-266-21, p.32; SID 63-266-22, p. 30; and SID 63-266-23, p. 34.

S-IVB STAGE

The third (S-IVB) stage of the Saturn V vehicle also serves as the second stage of the Saturn IB vehicle. The S-IVB stage as used in the Saturn V is 58.5 feet long and 21.6 feet in diameter; the aft interstage flares to a diameter of 33 feet at the base where it joins the S-II stage. Dry weight of the stage is approximately 27,000 pounds. Propellant capacity is about 230,000 pounds of LH_2 and LOX. S-IVB has a single J-2 engine for propulsive power, generating 200,000 pounds of thrust in the vacuum of space.

The function of Saturn V/S-IVB in the LOR mission is to boost the Apollo payload into earth orbit and then into a translunar trajectory. Following separation of the S-II stage at 113 miles altitude the S-IVB stage ignites for the first of its two burn periods. The first burn of 170 seconds accelerates the vehicle to orbital velocity and injects it into a parking orbit about the earth. The vehicle then coasts until it reaches the proper point for translunar injection. At the precise instant the S-IVB restarts and burns for another 310 seconds to achieve transfer orbit. The S-IVB and instrument unit remain attached to the Apollo Lunar Excursion Module to provide additional inertia during the separation, turnaround, and docking of the Apollo Command and Service Modules. Upon completion of this maneuver the Saturn V portion of the mission is complete, and the S-IVB/IU combination separates from the spacecraft.

Douglas Aircraft Company's (DAC's) Missile and Space Systems Division is the S-IVB stage prime contractor. Under terms of the contract awarded in August 1962 DAC is responsible to MSFC for design, development, manufacture, and test of S-IVB stages for the Saturn IB and Saturn V programs. The original contract called for DAC to provide five ground test stages and six flight stages, all for Saturn V. Subsequently, NASA approved the Saturn IB vehicle program and amended the S-IVB contract to include Saturn IB requirements. Currently under contract are 12 flight stages for Saturn IB and six for Saturn V. Approximate value of the prime contract at the end of the report period was $319 million.

Except for a few minor differences the S-IVB stage is alike for both launch vehicles. The Saturn IB version is approximately 4,000 pounds lighter, by current estimates. The areas of weight difference include the forward skirt, auxiliary propulsion system, aft skirt, propulsion system, interstage, and electrical system. The auxiliary propulsion system (APS), which is used for ullage and attitude control, is different because of mission differences. The Saturn V/S-IVB has a flared aft interstage to fit the larger-diameter S-II stage, whereas the Saturn IB/S-IVB aft interstage is the same diameter as the rest of the S-IVB stage. The primary propulsion system of the Saturn V/S-IVB has orbital restart capability to meet the needs of the LOR mission, while the Saturn IB/S-IVB is designed to burn only once.

There are five S-IVB ground test stages: battleship, structural test, dynamic, facility checkout, and stage simulator (the simulator for use at MSFC). DAC will initially deliver all ground test stages except the MSFC simulator in the Saturn IB configuration and will later modify the stages to the Saturn V configuration. DAC will deliver the simulator in the Saturn V configuration for use with the Saturn V Systems Development Breadboard Facility.

Since the Saturn IB is being developed first and is scheduled to fly before the Saturn V, the research and development (R&D) coverage of the S-IVB stage is contained in the Saturn IB chapter of this report.[20]

MSFC and DAC completed contract negotiations for the MSFC simulator (S-IVB-500-ST) program on November 22, 1964. Hardware from the cancelled S-IVB all systems stage will be reallocated for use in the simulator.

In October DAC began fabrication of S-IVB-501, the first Saturn V flight stage. LH_2 tank cylindrical sections arrived at Huntington Beach, and LOX tank assembly started at Santa Monica. Design problems in the forward and aft skirt electrical installations delayed the program. Work was several weeks behind schedule at the end of the period, but DAC was making progress in spite of engineering problems. Fabrication of the common bulkhead was underway: five of the nine gore segments for the aft LOX bulkhead had been welded in the meridian weld fixture at Huntington Beach.[21]

INSTRUMENT UNIT

The Saturn V instrument unit (IU) is 21.6 feet in diameter and 3 feet high. It weighs about 3,500 pounds, based on current estimates. The IU is almost identical in both Saturn IB and Saturn V vehicles. It is a cylindrical assembly composed of three honeycomb segments and located between the S-IVB stage and the payload. The IU structure contains equipment mountings and supports and a unique thermal conditioning system that circulates a coolant to the electronic components and through mounting and thermal conditioning panels in both the IU and the S-IVB stage. The IU equipment includes instruments and systems for navigation, guidance, control, range safety, telemetry, and tracking.

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20. Saturn V Off., Saturn V Project Development Plan, February 1965, Document MA 001-AZD-2H, pp. 9-10; MSFC, MHM-9, pp. 123-125; and 89th Cong., 1st sess., H. Rpt., 1966 NASA Authorization, Mar. 3-17, 1965, pp. 431, 926, and 927.

21. DAC, S-IVB Saturn Monthly Technical Progress Report, SM 46824, Issue No. 27, October 1964, pp. 2, 4, 75, and 94; DAC Rpt. SM 46935, Issue No. 29, p. 84; and Saturn V Off., MPR-SAT V-64-4, p. 17.

MSFC is responsible for developing the IU. Major guidance components are provided by International Business Machines Corporation (IBM) and Bendix Corporation. Early in 1964 NASA selected IBM to be the "lead" or prime contractor for the Saturn IB/V IU. As lead contractor IBM will integrate all IU systems, assemble flight units, and assume full mission responsibility beginning with the fifth Saturn IB vehicle.[22]

Since most IU development during the current report period concerned the Saturn IB program, general R&D progress and contract actions are reported in the Saturn IB chapter of this report.

Several ground test IU's belonging exclusively to the Saturn V program underwent development and preparation for test at MSFC during this period. Among these units were the S-IU-500-FS (flight systems test), the S-IU-500-ST (systems test), and the S-IU-500-V (vibration test) units. MSFC also built an IU mockup for use in determining placement of equipment and systems. Vibration and structural tests of IU components and subassemblies occurred. The buildup of Saturn V ground test units proceeded, and preparations were underway for tests beginning early in 1965 of complete units with electronic systems aboard. On December 7 Astrionics Laboratory began the S-IU-500-FS training course for engineers and technicians.[23]

Vehicle Ground Support Equipment

Saturn V ground support equipment (GSE) includes nonfacility hardware used to check out assembled vehicles; to handle, transport, and service all stages and the instrument unit; and to launch the vehicle. GSE associated primarily with launch support is the responsibility of NASA Kennedy Space Center and is not covered in this report.

During July 1964 MSFC modified the Boeing S-IC stage contract to provide some $16 million in automated ground test and checkout equipment for the S-IC stage. NASA authorized Boeing to purchase this equipment to support S-IC static firings at MSFC and at MTO. Boeing integrates the vehicle mechanical support equipment supplied by Boeing and other contractors and also operates the Saturn V equipment management system. Contract supplements to the S-IC prime contract cover these GSE services and the hardware involved. Negotiations with

22. MSFC, MHM-9, pp. 131-133.

23. Saturn V Off., MPR-SAT V-64-3, p. 16; MPR-SAT V-64-4, pp. 22-23; and memo, F. W. Brandner, Astrionics Lab., to Distribution, "Saturn Monthly Progress Report, December 1964, "Jan. 19, 1965.

Boeing on the vehicle GSE mission contract were nearly complete at the end of this period. MSFC received the revised Boeing cost proposal for the vehicle equipment management contract in mid-December and immediately began negotiations. Completion of negotiations on both contract supplements was expected early in 1965.[24]

General Electric Company (GE) under a contract awarded in February 1962, provides Saturn V electrical support equipment (ESE). MSFC and GE were negotiating the ESE design portion of the overall contract at the end of the current period. Contract approval and award were anticipated early in 1965.

Radio Corporation of America (RCA) is responsible for the necessary computer systems and also provides related maintenance and support operations. The RCA 110A computer system is used to check out, test, and launch the Saturn V vehicle. MSFC and RCA completed negotiations in June 1964 for purchase of 19 RCA 110A systems. On August 12, 1964, MSFC awarded the fixed-price-incentive-fee contract in the amount of $27 million. This contract was in addition to an order placed with RCA in August 1963 for seven 110A computer systems. The 26 computers will be used for both Saturn IB and Saturn V vehicles. In December 1964 MSFC investigators found that soldering in 110A computers was of poor quality and directed RCA to improve this work. RCA then submitted a revised delivery schedule by which the S-IC checkout computer for MSFC would be delivered 10 weeks late, in February 1965.[25]

In August 1964 MSFC sought quotations for purchase of seven operational display systems, to be used with computers for checkout and launch of Saturn V vehicles. In October the Center chose Sanders Associates, Inc., for negotiations to provide these systems. On December 11 NASA approved the resulting fixed-price-incentive-fee contract, valued at $7.4 million.[26]

Early in September 1964 MSFC awarded to Hamilton Standard, a division of United Aircraft Corporation, a $2.5 million contract for manufacture of eight propellant servicing trailers. These trailers will be used at KSC to fuel auxiliary propulsion systems on the S-IVB stage of Saturn IB and Saturn V vehicles.

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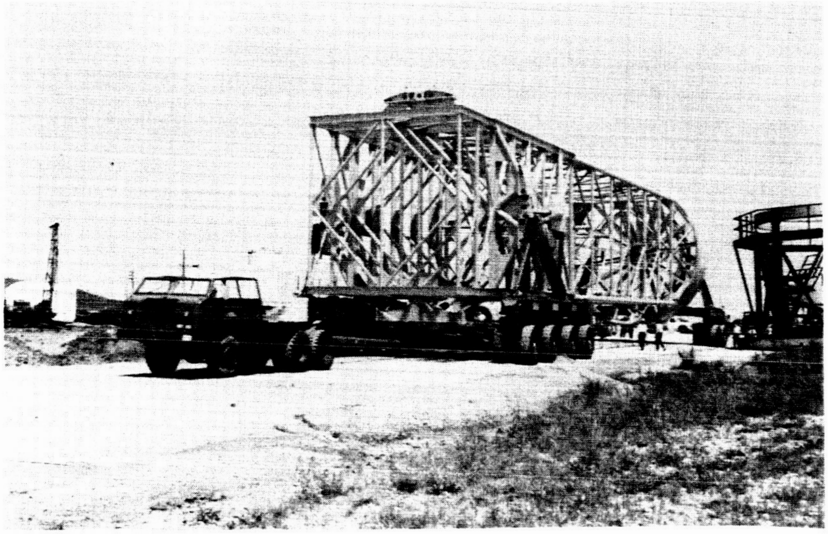
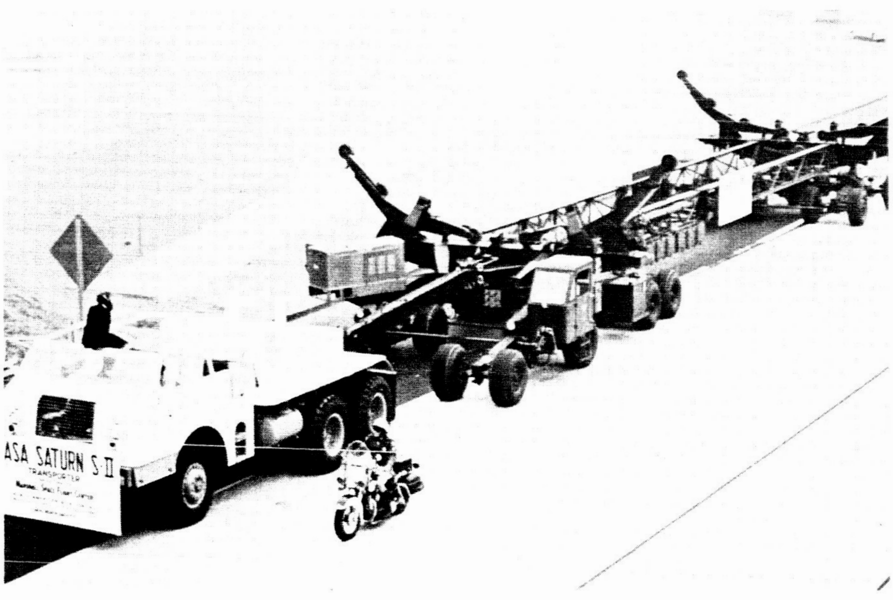
24. 89th Cong., 1st sess., Authorizing Appropriations to the National Aeronautics and Space Administration, H. Rpt. No. 273, May 3, 1965, p. 17; and Saturn V Off., MPR-SAT V-64-4, p. 25.
25. NASA, SP-4005, p. 297; and Saturn V Off., MPR-SAT V-64-4, p. 25.
26. Saturn V Off., MPR-SAT V-64-3, p. 18; MPR-SAT V-64-4, p. 25; and 89th Cong., 1st sess., H. Rpt. No. 273, p. 432.



SIMULATOR AND TRANSPORTER

The S-IC simulator is shown at MSFC on a stage transporter used to move the Saturn V booster from manufacturing site to test and launch sites. The simulator is the same size and weight as the S-IC stage.



S-II STAGE TRANSPORTER

This Type I S-II stage transporter, built to move S-II stages over California highways, was delivered to Seal Beach and put to use during this report period.

Astrionics and Quality and Reliability Assurance Laboratories continued throughout this period the buildup of the Saturn V Systems Development Breadboard Facility (SDBF). The SDBF is a prototype set of checkout equipment for the first facility checkout of LC-39. Workmen laid telephone cables between Astrionics Building 4436 and Quality Building 4708 for the breadboard data link, and connected the equipment. During September MSFC and Boeing completed negotiations calling for Boeing operation of the breadboard facility. In November the support contractor completed the SDBF development plan and submitted it to MSFC for approval. By the end of December 1964 Boeing had placed 33 breadboard operations personnel in Building 4708.[27]

The first S-IC transporter, assembled at MSFC prior to the current period, went into service following tests and checkout. The transporter, No. 101, supported S-IC-T during assembly of that static test stage in ME Laboratory's Building 4705. On October 9, 1964, MSFC accepted delivery of S-IC transporter No. 102, the first of two to be provided under contract by the Fruehauf Corporation. Work began on assembly and checkout of No. 102. Near the end of this period Fruehauf completed structural assembly of transporter No. 103 and scheduled delivery in early January 1965. During December MSFC received bids from 12 firms for fabrication of three additional S-IC transporters, No. 104 through No. 106. Award of the contract was expected in January 1965. Five Boeing personnel, plus two from Michoud and three from KSC, visited MSFC in December to receive training on the transporter and the M-26 prime mover used to operate the transporter.[28]

The S-IC stage simulator, a structural mockup that simulates the bulk and weight of the S-IC stage, was used at MSFC prior to this period in road-testing the S-IC transporter. In July 1964 the Center started design work to modify the simulator by cutting it into two sections. During August workmen divided the simulator into sections simulating the LOX tank and the fuel tank as fabricated at MSFC. ME Laboratory used these two sections to simulate movements of the stage from Building 4705 to the Vertical Assembly Facility. Following this exercise workmen during September and October reassembled the simulator and

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27. Memos, Astrionics Lab to Distribution, "Saturn MPR, July 1964," "September 1964," "November 1964," and "December 1964."

28. The S-IC transporter is a massive wheeled vehicle on which the S-IC stage moves from manufacturing to test and launch areas. See Test Lab., Test Laboratory Monthly Progress Report, Sept. 12 - Oct. 12, 1964, p. 39; Oct. 12 - Nov. 12, 1964, p. 36; Nov. 12 - Dec. 12, 1964, p. 36; and Dec. 12, 1964 - Jan. 12, 1965, pp. 36-37.

fitted it with a steel forward handling ring. MSFC received the steel handling ring from a contractor on October 30 and installed it on the simulator to replace the aluminum handling ring; this cost reduction measure released the much more costly aluminum handling device for use on the S-IC stage during manufacture.[29]

The contractor responsible for providing the S-II transporter,[30] American Machine and Foundry Company (AMF), completed the Type I transporter in July 1964 and tested it. AMF shipped the Type I transporter to Seal Beach, where S&ID accepted it on August 31 and began training personnel in its use. Meanwhile, the first M-26 prime mover (an Army surplus tank retriever modified for use with the transporter) had arrived at Seal Beach on August 12. A second modified M-26 supplied by NASA was delivered on August 26. Also in August S&ID awarded a contract for tree-trimming along roads from Port Hueneme to SSFL, California. Tree-trimming and other route clearance began in September and continued throughout this period. A transporter trial run along this route was scheduled for January 1965. S&ID acceptance tested the first Type II transporter at the AMF facility at York, Pennsylvania, during November. Delivery of this transporter was due at the end of this period.[31]

Hayes International Corporation completed design of the Saturn IB/V instrument unit shipping container in October 1964 and was manufacturing the first of the containers when this period ended. Delivery to MSFC was due in January 1965.[32]

NASA has accumulated a fleet of about 20 river- and sea-going vessels of varying size for transportation of Saturn stages. In the current period several of these surplus Navy and Army ships were in the process of being adapted to their

29. The aluminum handling ring, built to exacting requirements, cost $710,000. The steel ring designed to replace it in handling the S-IC simulator cost only $16,000. See Test Lab., MPR, July 12 - Aug. 12, 1964, p. 40; Aug. 12 - Sept. 12, 1964, p. 44; Sept. 12 - Oct. 12, 1964, p. 39; and Oct. 12 - Nov. 12, 1964, p. 36.

30. The Type I S-II transporter, specially designed to comply with California road laws, will move the stage from Seal Beach to the loading dock and over highways to Santa Susana. The Type II transporter will be used to transport the stage on roads controlled by the U. S. government. One Type I and four Type II transporters are ordered.

31. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 39, and Aug. 12 - Sept. 12, 1964, pp. 45-46; and NAA S&ID, SID 63-266-19, pp. 18, 39, and 40; SID 63-266-20, p. 43; SID 63-266-22, p. 41; and SID 63-266-23, p. 43.

32. Test Lab., MPR, Nov. 12 - Dec. 12, 1964, p. 37.

newuse. NASA chose YFNB-40 for conversion to use as the S-IC barge; modification drawings were complete and scheduled for contract bidding by the end of this period. The West Coast Barge (YFNB-20) will be modified for shipping S-II and S-IVB stages along the California coast. On August 31, 1964, Harbor Boat Building Company won the $265, 000 modification contract for this barge; the firm had almost completed the work at the end of this period. NASA allocated three YFNB vessels as open-deck shuttle barges--two for use at Michoud/MTO and one for the Cape Kennedy area. One of these, YFNB-45, underwent temporary modifications during this period at a cost of $85, 448; this vessel was scheduled to move the S-IC simulator from MSFC to Michoud in February 1965. Design and drafting modifications to all three shuttle barges were complete by December 31, 1964.[33]

Other vessels used for Saturn V transport include the barge Promise, a converted YFNB used throughout the Saturn I program; the USNS Point Barrow, a self-propelled Navy LSD being converted as a carrier for S-II and S-IVB stages from the West Coast to the New Orleans and Cape Kennedy areas; and 12 heavy Army barges, undergoing modification as propellant tankers and general purpose barges at Michoud and MTO. The Promise, scheduled to transport the S-IVB dynamic stage from Michoud to MSFC, had its defective radar system replaced with a standardized radar set late in this period. On July 31, 1964, Military Sea Transport Service (MSTS) completed the modification design for the Point Barrow; the modification contract was due for completion in May 1965.[34] Shipyards were converting nine of the Army barges to LOX and LH_2 tankers, and three barges went into service at MTO carrying heavy equipment and construction material.

During this report period MSFC began to investigate proposals by aircraft firms to design a plane big enough to transport the S-II and S-IVB stages. Aero Spacelines, owner of the Pregnant Guppy aircraft, made a presentation to MSFC officials near the end of this period. No decision was announced.[35]

MSFC completed the Saturn Stage Transportation Plan In August 1964 and distributed it on August 25.[36]

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33. Test Lab., MPR, Aug. 12 - Sept. 12, 1964, p. 42; Nov. 12 - Dec. 12, 1964, pp. 35-36; and Dec. 12, 1964 - Jan. 12, 1965, p. 37.
34. Test Lab., MPR, Nov. 12 - Dec. 12, 1964, p. 36; and Test Lab., Historical Report, July 1 - Dec. 31, 1964, p. 22.
35. Test Lab., MPR, Dec. 12, 1964 - Jan. 12, 1965, p. 37.
36. Test Lab., MPR, Aug. 12 - Sept. 12, 1964, p. 46.

Engine Research and Development

The F-1 and the J-2 rocket engines comprise the primary propulsion systems of the Saturn V launch vehicle. Both engines are designed, developed, and produced by the Rocketdyne Division of NAA. MSFC manages both engine programs for NASA.

The F-1 engine burns RP-1 and LOX. It generates 1.5 million pounds of thrust at sea level and is the Free World's most powerful liquid rocket engine. Five F-1 engines in the first stage of the launch vehicle provide a total of 7.5 million pounds thrust. Rocketdyne began development of the F-1 in 1958. Prior to this period the F-1 had achieved rated thrust and duration in numerous tests and had completed preliminary flight rating tests (PFRT).

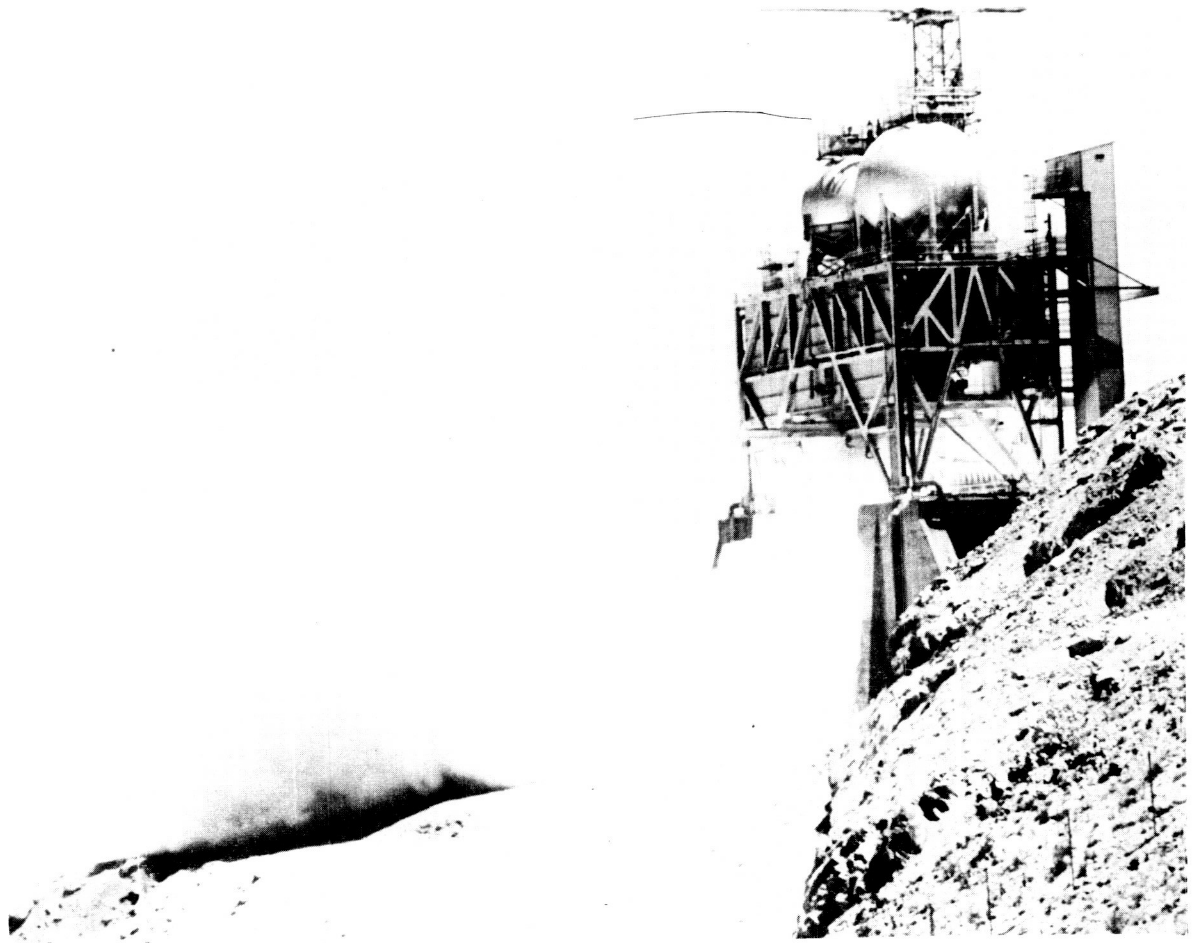
The J-2 engine, under development since 1960, burns LH_2 and LOX. It develops thrust of 200,000 pounds in the vacuum of space. Five J-2 engines in the second stage of Saturn V produce 1,000,000 pounds thrust. A single J-2 powers the Saturn V third stage. Rocketdyne achieved full thrust and full duration firings many times in tests prior to the current period, both at sea level and in simulated vacuum conditions.

F-1 ENGINE

Rocketdyne continued F-1 development, test, and production throughout this period under R&D contract NASw-16 and production contract NAS8-5604. The definitive production contract calling for 76 engines was awarded on March 30, 1964. Engine development and manufacturing occurred at Canoga Park, California. F-1 engine and component testing was at the Edwards Air Force Base Rocket Engine Test Site (RETS) and SSFL, both in California. Engine tests also occurred at MSFC.

Engineers concentrated on solving several major development problems before the time for flight rating tests (FRT). They conducted a total of 282 engine system tests during the six-month period, including 225 R&D, FRT, and 57 acceptance firings at RETS. Development problems included combustion instability, nozzle extension, turbopump, thrust chamber, heat exchanger, and gas generator.

Combustion stability seemed assured after selection of a new type of thrust chamber injector that passed numerous tests in the previous reporting period.



F-1 ENGINE FIRING

The F-1 engine developer, Rocketdyne Division of North American Aviation, Inc., fires an engine on Test Stand 1-D of the Rocket Engine Test Site at Edwards Air Force Base, California.

Continued testing of the chosen injector during the current period proved that the injector's performance was satisfactory for FRT. Eighty-seven per cent of all tests during the period lasted for the scheduled duration, signifying solution of the combustion stability problem. Injector testing continued to the end of the period, however, to satisfy the stability requirements of the engine qualification program.[37]

Turbopump design changes following two LOX pump explosions early in 1964 proved satisfactory in testing during the first half of this report period.[38]

Gas generator developers testing the single-wall uncooled combustor for the FRT configuration had some success in reducing gas generator oscillations during the start phase. The engineers also designed a new type of pyrotechnic igniter for the generator and modified the combustor to accept the igniter. Tests continued with gas generator injectors and acoustic liners.[39]

Testing of a heat exchanger designed earlier in 1964 demonstrated that the unit met FRT requirements. Heat exchangers from two vendor sources performed well in tests. Engineers encountered a structural cracking problem and developed an insulated flange that appeared to reduce the temperature variation and solve the problem.[40]

Thrust chamber difficulties during this period included tube cracking, fuel manifold leaks, and cracking in injectors. The tube cracking problem, believed basically due to thermal stresses, was corrected by reducing operating temperatures, increasing fuel orifice size, and improving tooling to eliminate tube dents and surface brazing. After these corrective actions, there was a significant increase in the tube durability. Fuel manifold leaking was corrected by hand-brazing of joints. Injectors in Block I engines tested at MSFC cracked during firing tests; analysis indicated that the cause was environmental factors, but Rocketdyne also investigated the problem from a metallurgical standpoint. Overheating and erosion of the 24-shingle skirt extension caused concern, but new welding techniques helped reduce erosion damage.[41]

A new type of contoured manifold inlet designed prior to this period underwent testing with apparently satisfactory results. A new low-pressure LOX dome also went into use.

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37. Engine Project Off., Quarterly Progress Report, F-1, H-1, J-2, and RL10 Engines, July, Aug., & Sept. 1964, QPR-Eng-64-2, pp. 11-12; QPR-Eng-65-1, pp. 10-11; and 89th Cong., 1st sess., H. Rpt., 1966 NASA Authorization, Mar. 3-17, 1965, p. 216.
38. Engine Program Off., QPR-Eng-64-2, p. 1.
39. Ibid., pp. 3-4; and Engine Projects Off., QPR-Eng-65-1, pp. 3-4.
40. Ibid.
41. Engine Program Off., QPR-Eng-64-2, pp. 4-8; and QPR-Eng-65-1, pp. 7-8.

Testing of the selected 24-shingle gas-cooled nozzle extension continued from the preceding report period. Shingle erosion caused by overheating and buckling prompted engineers to modify the shingle edges and change welding techniques to reduce damage. Tests on production engines toward the close of this period showed erosion greatly reduced in long-duration firing.[42]

During the July-December 1964 period Rocketdyne delivered to NASA five production F-1 engines. The Block II type engines were for ground firing tests. Rocketdyne used two of the engines, F-2004 and F-2006, at RETS to perform FRT in November and December. Rocketdyne completed FRT at RETS during December. The engine contractor delivered three engines--F-2005, F-2007, and F-2008--to MSFC for use on the S-IC-T stage.[43]

J-2 ENGINE

NASA gave Rocketdyne the J-2 engine R&D contract in 1960 when development of the liquid hydrogen engine started. This contract, NAS8-19, remained in effect during the current report period. The definitized production contract, NAS8-5603, covering 55 engines and related services, went into effect June 24, 1964. Initial value of this contract was $89.5 million. On August 24, 1964, NASA announced that it would purchase 102 additional J-2 engines for Saturn IB and Saturn V vehicles, at an approximate cost of $165 million. The new engine order, to be negotiated by MSFC and Rocketdyne beginning in March 1965, will be a supplement to contract NAS8-5603.[44]

Rocketdyne develops and manufactures J-2 engines at Canoga Park, California, and performs testing at SSFL. Development and acceptance testing during the report period resulted in 173 engine system firings, for a total firing time of 14,345 seconds.[45]

Engineers solved several component problems during the period. Major problems included operations of the fuel turbopump, gas generator, and propellant utilization valve.

Rocketdyne resolved the fuel turbopump difficulties dating from the preceding report period. The engineers also eliminated an abnormal rise in the balance piston cavity pressure by incorporating leaded bronze rub-rings, and they halted pump stall by modifying the pump's rotor blade. Another persistent problem involved cracks in the curvic couplings of fuel pump turbine wheels. After extensive analysis engineers corrected this failure by replacing the curvic coupling wheels with shear bolt wheels.

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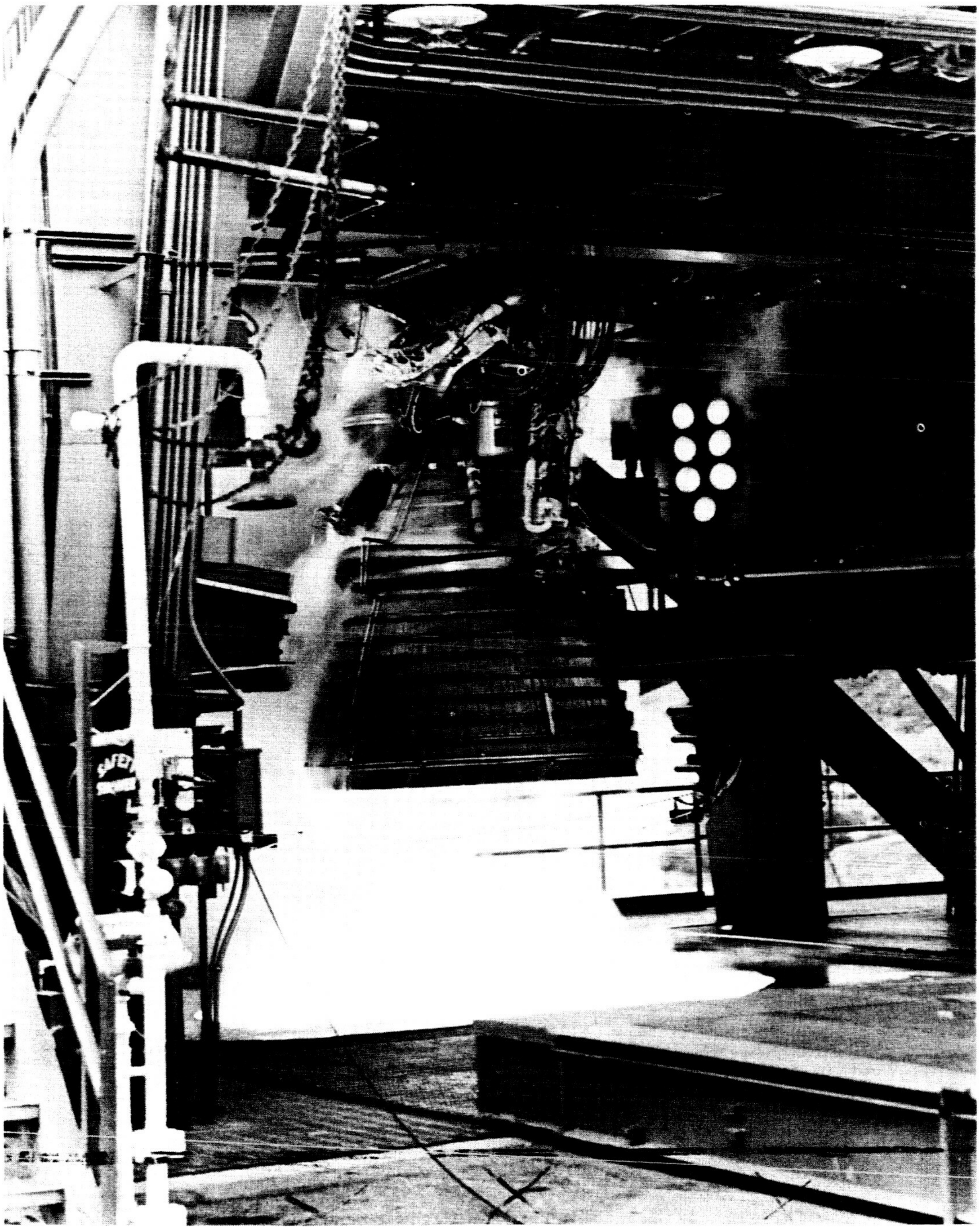
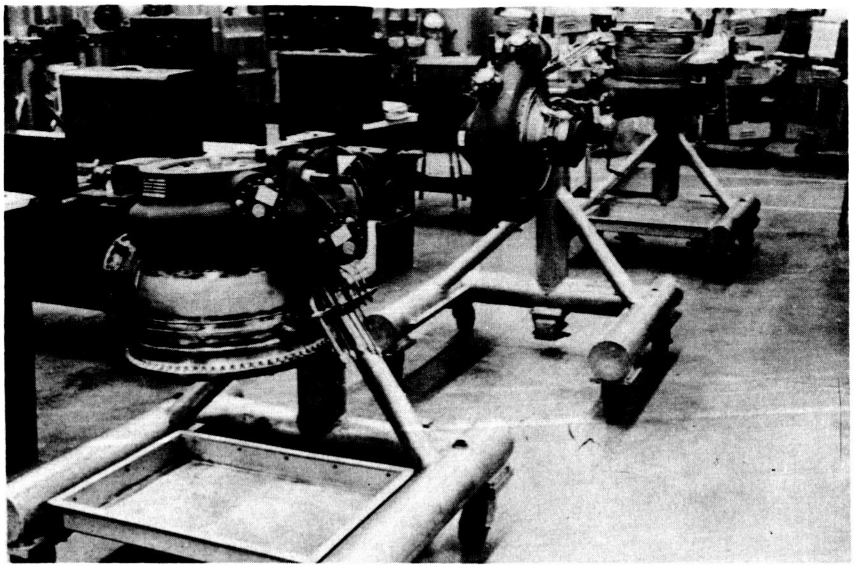
42. Engine Program Off., QPR-Eng-64-2, pp. 6-8; and QPR-Eng-65-1, p. 8.
43. Engine Program Off., QPR-Eng-65-1, pp. 1 and 11.
44. MSFC, MHM-9, p. 145; and NASA, SP-4005, p. 294.
45. Engine Program Off., QPR-Eng-64-2, p. 25; and QPR-Eng-65-1, p. 19.



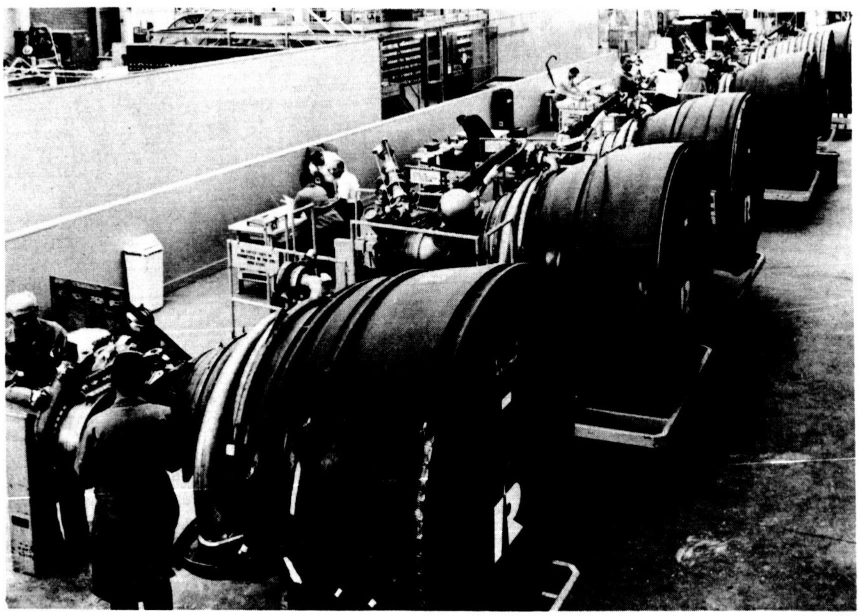
J-2 IS FIRED

A J-2 engine is test fired at Santa Susana Field Laboratory.



TURBOPUMP FACTORY

J-2 engine turbopumps are produced in this Rocketdyne facility at Canoga Park.



J-2 ASSEMBLY LINE

Liquid hydrogen J-2 engines for Saturn IB and Saturn V upper stages are shown on a Rocketdyne assembly line at Canoga Park, California.

Failures in the gas generator combustor body brought on an intensified investigation. Rocketdyne engineers solved the problem by increasing the thickness of injector rings and by brazing the rings to the body of the gas generator. Rocketdyne also investigated leakage in the control valve and face poppet. A new method of LOX poppet valve installation reduced the leakage.

In an effort to reduce the drop in bypass pressure in the propellant utiliaztion valve Rocketdyne developers reworked three volutes and successfully tested them.[46]

Rocketdyne delivered several J-2 production engines during this period. By the end of December Rocketdyne had delivered seven: two to DAC for the S-IVB battleship; one to DAC for spring-rate tests; three to S&ID for the S-II battleship; and one to Rocketdyne for the informal PFRT program. In addition to initiating procurement action for 102 additional engines, NASA made plans to convert the cost-plus-fixed-fee contract to a cost-plus-incentive-fee contract.[47]

The engine contractor performed the J-2 engine PFRT late in this period. PFRT firings occurred in November on Test Stands Delta 2-A and 2-B at SSFL. In this same period of testing a J-2 engine demonstrated its restart capability for the first time. This major milestone in the J-2 program occurred on December 11. In the ground test the engine operated for 165 seconds and was shut down. After a 75-minute "orbital coast" period simulating the Saturn V/S-IVB mission the engine restarted. Seven seconds later it was shut down for six minutes. Then the engine was restarted and operated for 310 seconds. J-2 engine FRT is scheduled for completion in May 1965. Engine qualification tests should be completed in December 1965.[48]

Facilities

Facilities supporting the Saturn V vehicle program underwent construction and modification during this report period. The principal facilities for development, manufacture, and test of the Saturn V are at MSFC/Huntsville and at Michoud Operations, Mississippi Test Operations, Boeing, NAA S&ID, DAC, NAA Rocketdyne, and various government sites. Launch facilities are at NASA Kennedy Space Center in Florida.

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46. Engine Program Off., QPR-Eng-64-2, p. 26; and QPR-Eng-65-1, p. 23.
47. Engine Program Off., QPR-Eng-64-2, p. 31; and QPR-Eng-65-1, p. 30; and Saturn V Off., MPR-SAT V-64-4, p. 20.
48. Engine Program Off., QPR-Eng-65-1, p. 19; and NASA, SP-4005, p. 416.

Major Saturn V facilities at Huntsville are in the MSFC Test Laboratory area. The principal facilities include the S-IC Static Test Stand, F-1 Engine Test Stand, Saturn V Dynamic Test Facility, J-2/S-IVB (Liquid Hydrogen) Test Facility, Ground Support Equipment (GSE) Test Facility, Components Test Facility, Instrument Laboratory, Barge Dock and Loading Facility, and supporting systems.

The S-IC Static Test Stand, which was almost completed structurally when this period began, had completion troubles during most of the period. Inspectors found major deficiencies in both 200-ton and 150-ton derricks, the rollout platform, LOX system design, water deflector, and the stand's steel superstructure. Corrective actions and installation of technical systems led to final acceptance of the stand late in the period. Minor modifications were still in progress when the period ended, although activation of the stand was also in progress. MSFC awarded a contract in November for installation of activation hardware on the stand. This $355,000 contract, due for completion in February 1965, went to McAlister and Quinn Construction Company. Workmen inserted the S-IC simulator in the stand on December 23 to check out stage handling procedures, equipment, and clearances.[49]

The F-1 Engine Test Stand contractor completed construction by September 1, 1964. Modifications, general cleanup, painting, and utilities installation continued. During a load test of the 100-ton derrick on November 10 the test load of 100 tons was accidentally dropped. The load fell 50 feet before striking the concrete apron. Damage consisted of broken crane cables and cracked concrete. By the end of the period all brick-and-mortar work was complete except for repair of damage caused by the accident and installation of safety devices on the 100-ton derrick. Major technical system items were in place, with completion expected in January 1965.[50]

At the mammoth Saturn V Dynamic Test Facility major construction ended by September 30. Facility inspection and tests occupied the remainder of the period. The 200-ton derrick motor had to be returned to the factory for rework. Derrick load tests were scheduled for January 1965.[51]

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49. Test Lab., MPR, Aug. 12 - Sept. 12, 1964, pp. 26-28; and Dec. 12, 1964 - Jan. 12, 1965, pp. 21-22.
50. Saturn V Off., MPR-SAT V-64-3, p. 19; MPR-SAT V-64-4, p. 28; and Test Lab., MPR, Nov. 12 - Dec. 12, 1964, pp. 22-23; and Dec. 12, 1964 - Jan. 12, 1965, p. 23.
51. Saturn V Off., MPR-SAT V-64-3, p. 19; and Test Lab., MPR, Oct. 12 - Nov. 12, 1964, p. 24.

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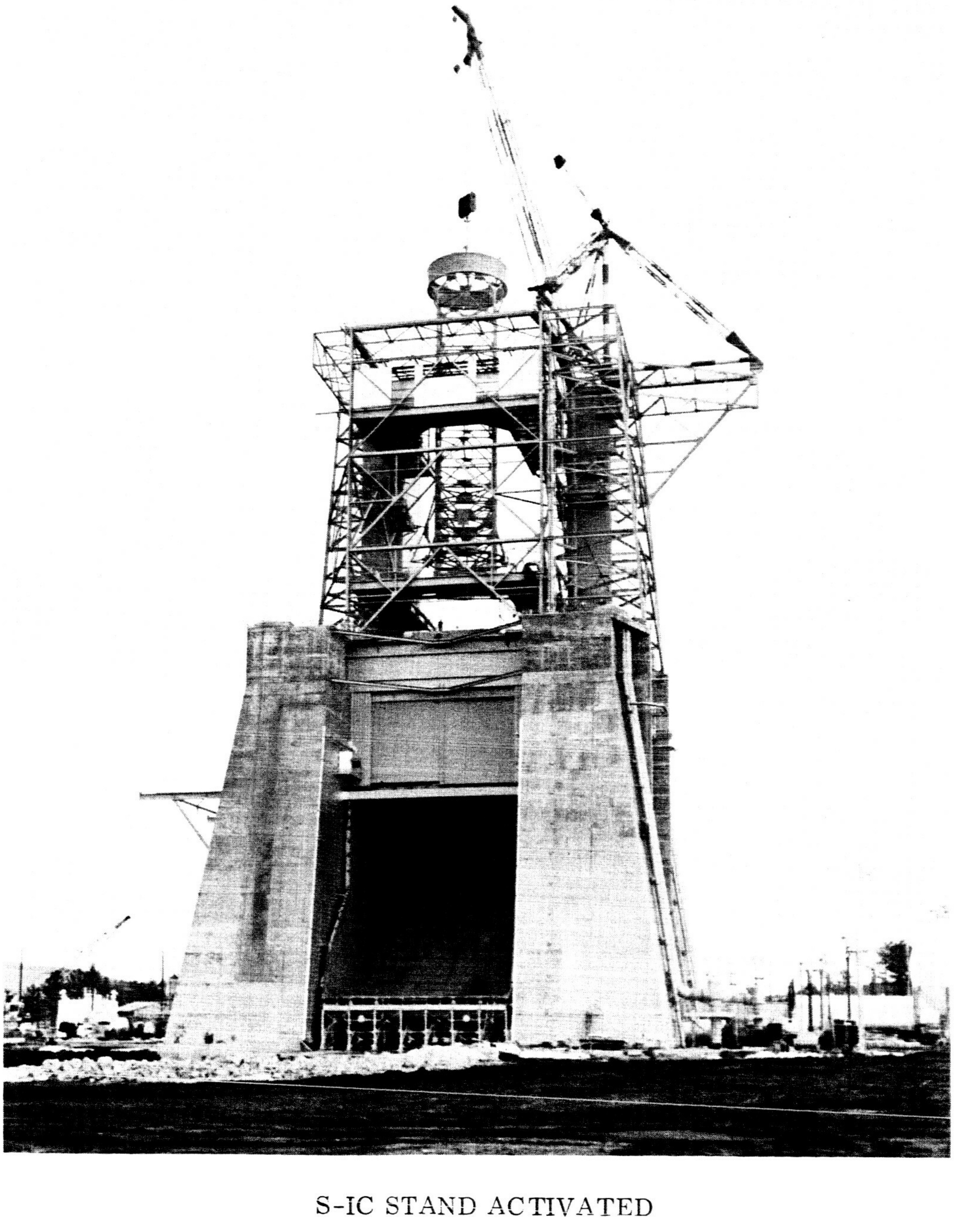
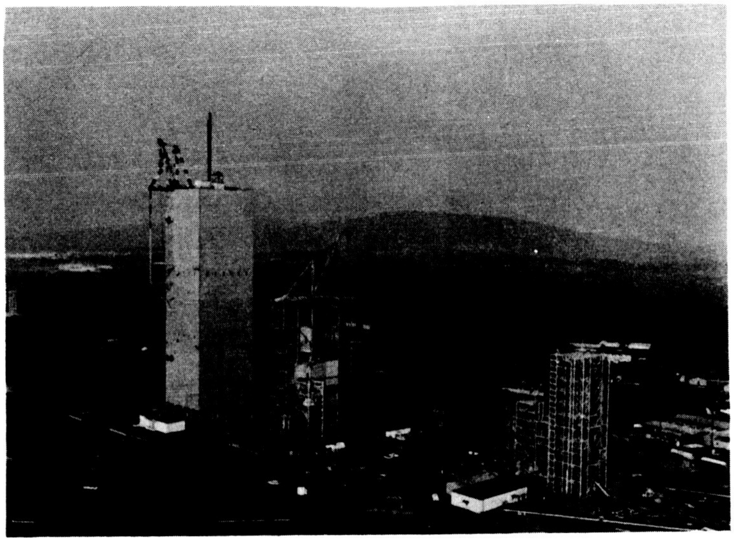


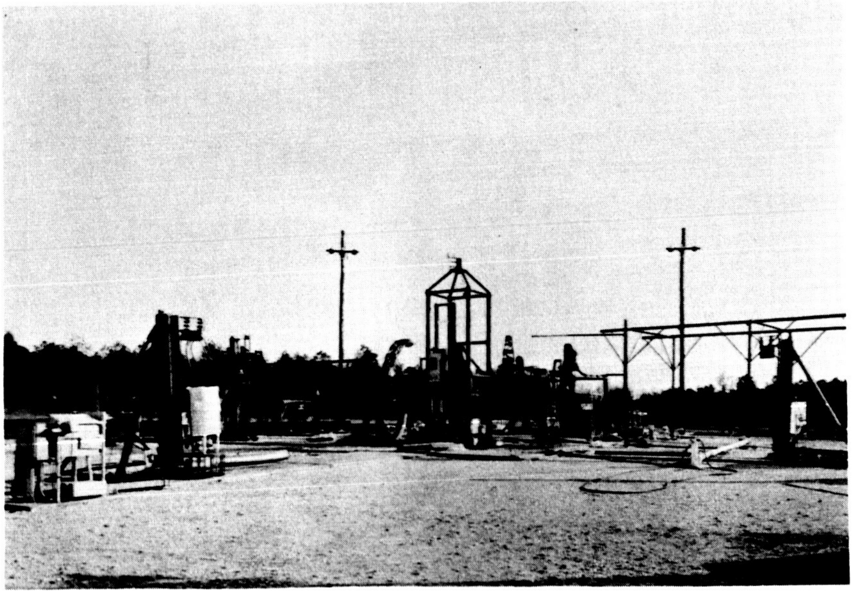
S-IC STAND ACTIVATED

A derrick lowers the S-IC stage simulator into the S-IC Static Test Stand at MSFC on December 23, 1964. The simulator duplicates the weight and dimensions of the S-IC stage to be fired in this stand during 1965.



MSFC TEST FACILITIES

Shown in this November 1964 picture are, left to right: Saturn V Dynamic Test Facility, Saturn I/IB Dynamic Test Facility, and F-1 Turbopump Test Stand.



SWING ARM TEST AREA

This facility at MSFC is used to test Saturn swing arms.

The J-2/S-IVB Test Facility construction project was 65 per cent complete when this period began. Lear Siegler, the technical systems contractor, started installation of equipment and instrumentation on September 8. Brick-and-mortar work moved slowly late in the period. Load tests of the 75-ton and 50-ton derricks started on December 11 and continued to the end of the period. Construction was more than 95 per cent complete when the period ended. Technical systems installation was 67 per cent completed.[52]

The Saturn V GSE Test Facility was more than 75 per cent complete at the start of this period. Construction of the blockhouse ended in August. On September 1 MSFC notified Lear Siegler to proceed with installation of technical systems. By early December 1964 the first high-pressure nitrogen system was complete. Construction of the facility was 97 per cent complete. Installation of equipment and technical systems continued. Meanwhile, design was in progress for an extension to the GSE Test Facility.[53]

Construction of the Components Test Facility lagged during the July-December 1964 period, and this project was about 75 per cent complete when the period ended. Installation of equipment began on December 14. An addition to this facility was 35 per cent complete and proceeding on schedule at the end of the period. On December 10 MSFC awarded a $357, 873 contract for an extension to the Components Test Facility instrumentation.[54]

Construction of the Instrument Laboratory ended on September 1, 1964. MSFC assumed beneficial occupancy of the entire facility in November and started operating it. Installation and checkout of technical systems was completed in December.[55]

Work which started in May 1964 on the Acoustic Model Test Facility continued throughout this report period. The $1.1 million project was more than 30 per cent complete at the end of the period. Technical systems procurement and fabrication began on October 22. Construction completion was due in May 1965.[56]

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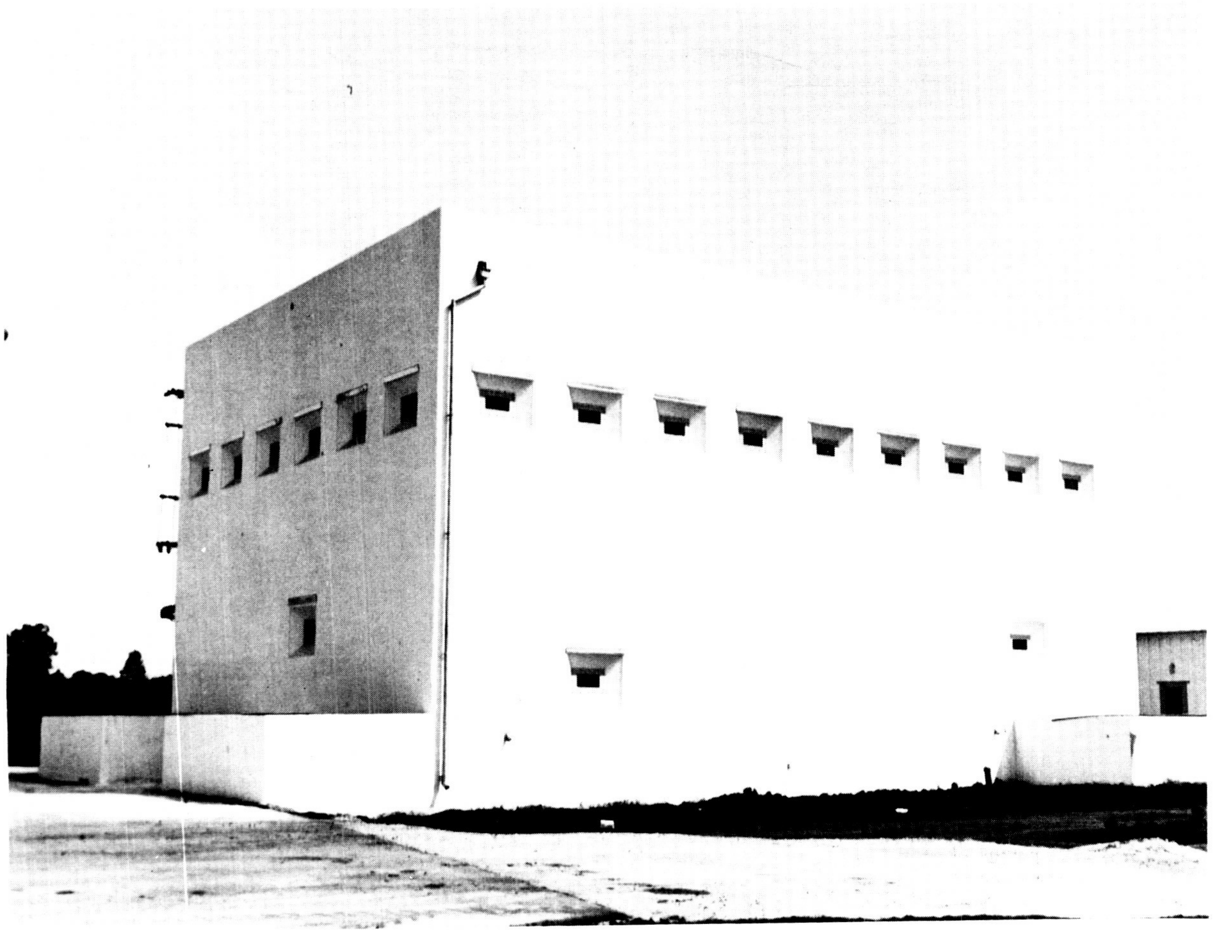
52. This project also includes a blockhouse expansion, power plant test stand, and LOX storage facilities. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 30; Aug. 12 - Sept. 12, 1964, p. 31; Nov. 12 - Dec. 12, 1964, p. 25; and Dec. 12, 1964 - Jan. 12, 1965, pp. 24-25.

53. Test Lab., MPR, July 12 - Aug. 12, 1964, p. 28; Aug. 12 - Sept. 12, 1964, p. 30; Sept. 12 - Oct. 12, 1964, p. 31; and Nov. 12 - Dec. 12, 1964, p. 23.

54. Test Lab., Hist. Rpt., July 1 - Dec. 31, 1964, pp. 19-20.

55. Ibid. and Saturn V Off., MPR-SAT V-64-3, p. 19.

56. Test Lab., MPR, Nov. 12 - Dec. 12, 1964, p. 27; and Dec. 12, 1964 - Jan. 12, 1965, p. 26.



GSE BLOCKHOUSE

Construction progress is shown in September 1964 on the blockhouse at the Saturn V GSE Test Facility.

On August 1, 1964, MSFC awarded the contract for construction of an addition to the Test Support Shop. Site grading and relocation of utilities required most of this report period. Structural steel was arriving at the end of the period, and erection of steel was scheduled to begin early in January 1965.[57]

On September 24, 1964, MSFC opened construction bids for expansion and modernization of the High-Pressure Gas System. Daniel Construction Company won the $995,000 contract and started work on October 19.[58]

Among other Test Laboratory projects in design or ready for construction when the period ended were the following: Modernization of instrumentation and control systems in the East Area; Transportation Hangar and addition to Building S-4653; the Acoustic Control Communication Center, an addition to Building 4566; replacement of the deflector pit at the Power Plant Test Stand; a new addition to the Test Laboratory Engineering Building; extension to the High-Pressure Gas System; and additional LOX storage facilities for the F-1 Engine Test Stand.

Construction of the Saturn V Barge Dock and Loading Facility, adjacent to the Saturn I Dock on the Tennessee River at MSFC, ended on November 15, 1964, except for grassing.[59] The four-mile Saturn V Road leading to the dock area was almost complete at the end of this period.

At MSFC's Propulsion and Vehicle Engineering (P&VE) Laboratory construction of the Load Test Annex ended on August 1, 1964, except for minor completion tasks and utilities installation. On August 15 the Center awarded a $2 million construction contract for an extension to the Load Test Annex.[60]

Under construction in the Manufacturing Engineering Laboratory area was the $3.7 million Hangar for Vehicle Components, Building 4755.

Construction of the Components and Subassembly Acceptance Building ended on July 15, 1964. MSFC held final inspection of the building on July 27 and Quality personnel moved into the building in August.[61]

The Astrionics Laboratory's Acceleration Test and Calibration Facility, although not completed, was pressed into partial service about July 1. It was scheduled for completion in the summer of 1965.[62] Construction of the Hazardous

57. Saturn V Off., MPR-SAT V-64-3, p. 19; and Test Lab., Hist. Rpt., July 1 - Dec. 31, 1964, p. 21.

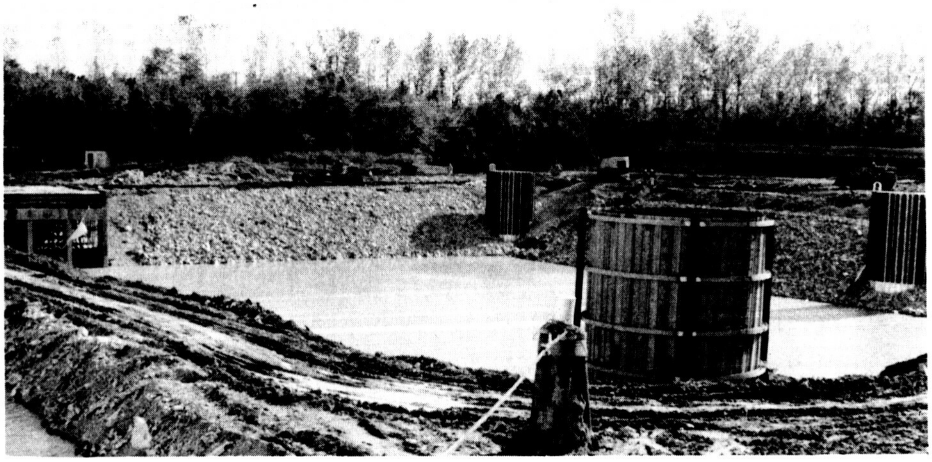
58. Test Lab., MPR, Oct. 12 - Nov. 12, 1964, p. 28.

59. Test Lab., Hist. Rpt., July 1 - Dec. 31, 1964, p. 21.

60. Saturn V Off., MPR-SAT V-64-3, p. 19.

61. Ibid.

62. Executive Staff, Management Information, Vol. III, 2nd Ed., October 1964, p. 7.

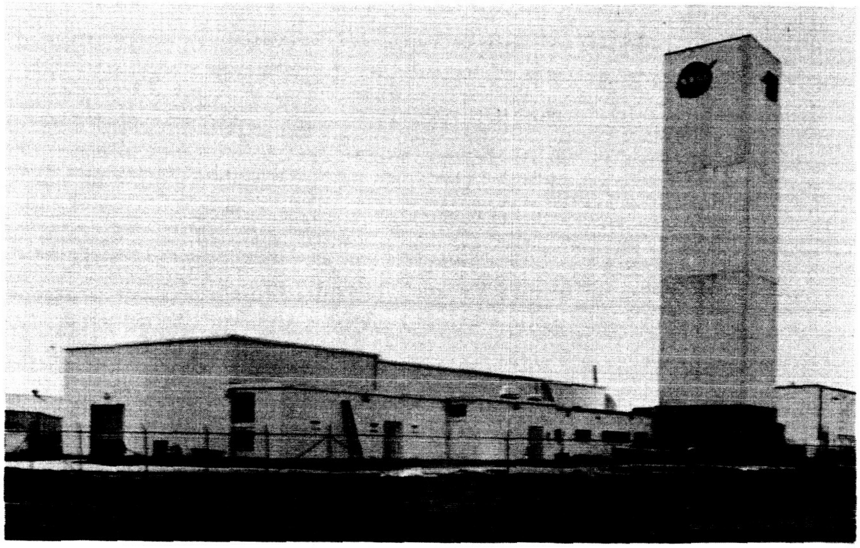


SATURN V DOCK PROGRESS

Work proceeds in October 1964 on the Tennessee River dock to be used by the S-IC barge in transporting Saturn V boosters.

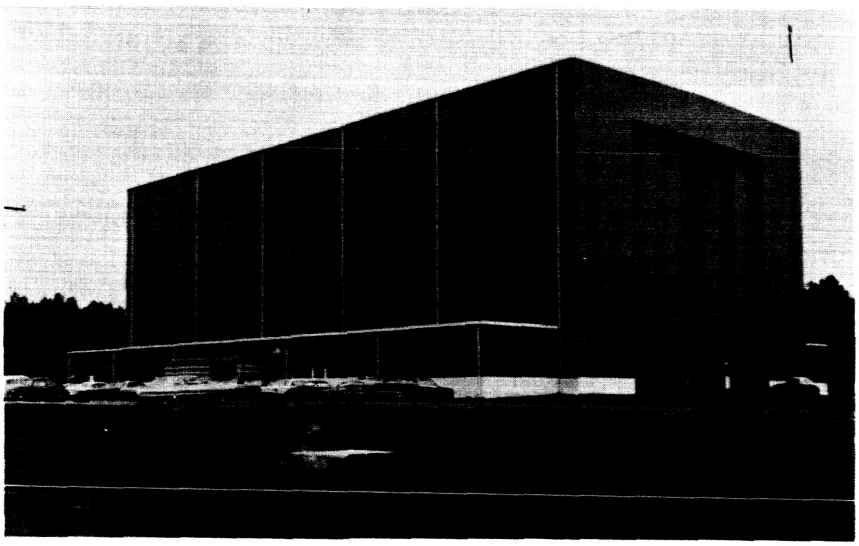
ROAD PROGRESS

A bridge is under construction on the Saturn V Road leading to the MSFC Barge Dock. This picture was made in October 1964.



ASTRIONICS FACILITY

The Acceleration Test and Calibration Facility is shown nearly completed at the Astrionics Laboratory.



NEW BUILDING IN SERVICE

MSFC Quality and Reliability Assurance Laboratory began using the huge Components and Subassembly Acceptance Building following its completion in July 1964.

Operations Laboratory began on August 5, 1964, with completion scheduled for June 1965. Workmen completed the Saturn V Systems Development Breadboard Facility (SDBF) in Building 4708 on November 14. At the end of the period work continued on electrical support equipment (ESE) checkout facilities which started October 29 in Building 4373.

MICHOUD

Construction workers at MSFC's Michoud Operations completed several major Saturn V facilities during this report period. Work continued there on a number of other large projects supporting the Saturn V launch vehicle program. The Boeing facilities contract, NAS8-5606(F), increased in value by more than $2 million, to a revised total of approximately $19 million.[63]

The Michoud Engineering and Office Building, beneficially occupied on September 1, 1964, was completed on October 15 at a cost of $6.7 million. Boeing and other contractor and government personnel moved from downtown New Orleans and other temporary locations into the new structure during October and November. The move ended on November 10.[64]

The construction contract for the Vehicle Component Supply Building and the Hazardous Materials Storage Building was awarded on November 19. Granite Construction Company won this $2 million contract on which completion was scheduled in September 1965.[65]

Completed on December 15 was the Vertical Assembly Facility. Boeing completed the equipping and instrumenting of this facility and occupied it during the period. The tank repair station for the facility was still under design, however, when the period ended.[66]

At the end of the period Boeing still lacked about three months of completing the S-IC Stage Test and Checkout Facility, a $2.5 million project. The structure will consist of four cells for testing Saturn V boosters.

Very near completion at the end of this period was the Hydrostatic Test and Cleaning Facility, which was scheduled for full use in the first quarter of 1965.

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63. Michoud Op., Hist. Rpt., July 1 - Dec. 31, 1964, p. 21.
64. Ibid., p. 37.
65. Ibid., p. 38.
66. Ibid., and Saturn V Off., MPR-SAT V-64-4, p. 32.

FACILITY AT MICHOUD

The Michoud Operations Vertical Assembly Facility was completed in December 1964 and placed in service as an S-IC stage assembly site.

Other construction progress at Michoud included plant modifications and improvements, additions to production facilities, and road and utilities improvements.[67] MSFC awarded a contract on December 17 for construction of additions to the nearby Central Computer Facility at Slidell, Louisiana.

MISSISSIPPI TEST OPERATIONS

Under construction at Mississippi Test Operations (MTO) in Southwest Mississippi is the acceptance test site for S-IC and S-II stages. Selected in 1961, this government-owned facility which is a division of MSFC occupies about 13,500 acres and is surrounded by a leased acoustical buffer zone of about 125,000 acres. Major construction started at MTO in 1963. When completed in 1966 at a cost of approximately $250 million, MTO will provide two test positions for the S-IC stage and two for the S-II stage, plus all necessary support facilities and equipment.

During the July-December 1964 period the Army Corps of Engineers, as construction and procurement agent for MSFC, completed acquisition of all needed land at the site. The Engineers supervised a growing program of construction and procurement. By the end of the period 135 construction and procurement contracts totalling $126.6 million were in force or completed. Construction weather was generally good throughout the period. A total of 2,689 persons, mostly construction workers, were employed at MTO when the period ended.

MTO facilities can be divided into three categories: Test Facilities, Support Facilities and Utilities, and Waterway and Docking Facilities.

Test Facilities: Major projects completed in this category during the current period included Industrial Water Well No. 2, on October 21, and the foundation for S-II Test Stand A-1, completed on December 22. Progress on test facilities was as follows: High-Pressure Gas Facility, 73 per cent complete; Data Acquisition Facility, 90 per cent; S-IC Test Stand substructure (two positions), 70 per cent; S-II Test Stand A-2 57 per cent; and High-Pressure Water Pump Station, Heating Plant, and Emergency Power Plant, 33 per cent. New contracts awarded: S-IC Test Stand, position B-2, awarded on July 13 to Koppers Company, Inc., for $17.2 million (6 per cent complete at end of period); S-II Test Stand A-1, to Koppers on December 4 for $8 million; and Industrial Water Supply, to the firm of Chaney and Hope on November 30, for $309,000.

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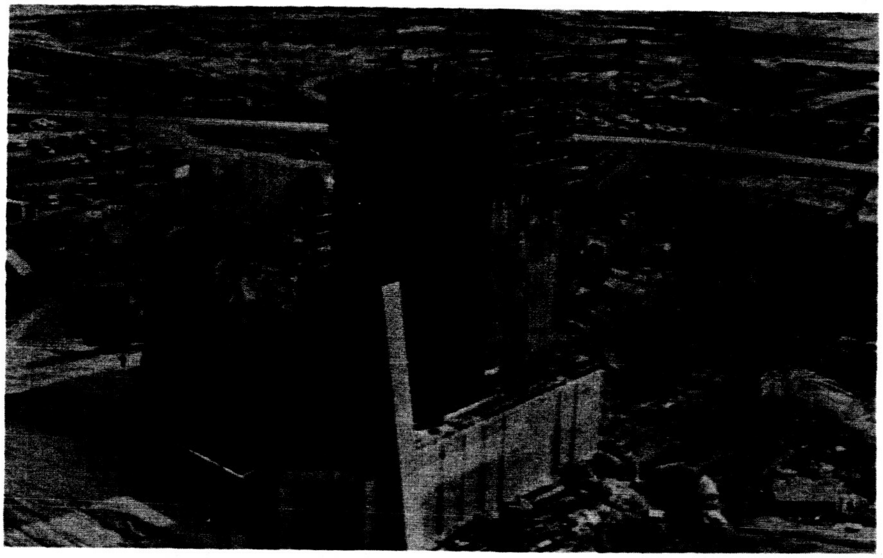
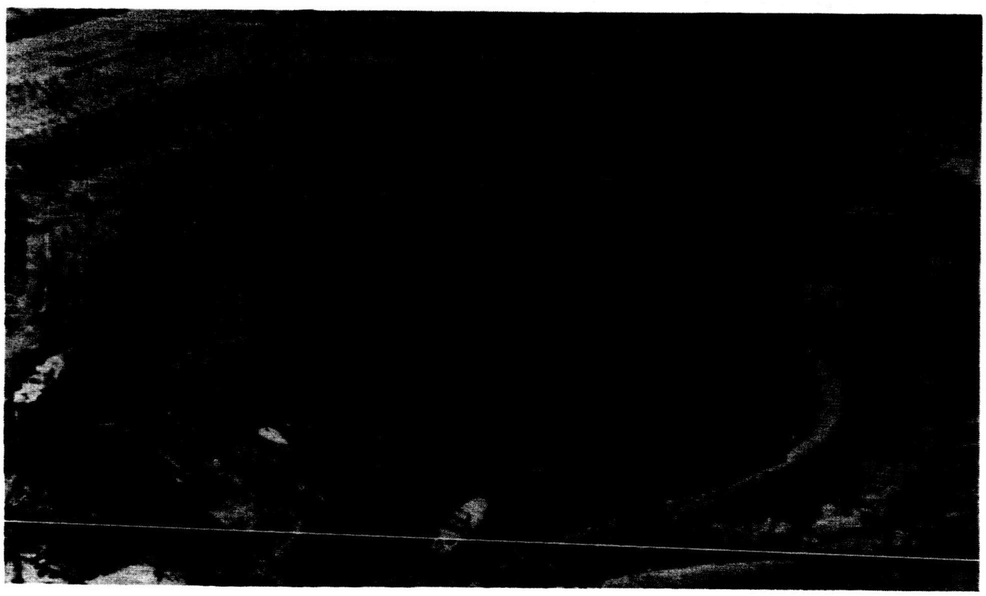
67. Michoud Op., Hist. Rpt. July 1 - Dec. 31, 1964, pp. 21, 32, and 38; and Executive Staff, Management Information, Vol. II, 3rd Ed., May 1965, pp. 38 and 48.



OVER HALF COMPLETED

S-II Test Stand A-2, the first stand started at Mississippi Test Operations, is pictured in December 1964, when it was 57 per cent completed.



SECOND S-II STAND AT MTO

S-II Test Stand A-1 is shown in a November 1964 picture at Mississippi Test Operations during foundation construction. A-1 is the second of two S-II stands being built there.

S-IC TEST STAND FOUNDATION

This December 1964 picture shows foundation work on the two-position S-IC static test stand at Mississippi Test Operations. The substructure construction project was 70 per cent complete when this report ended.

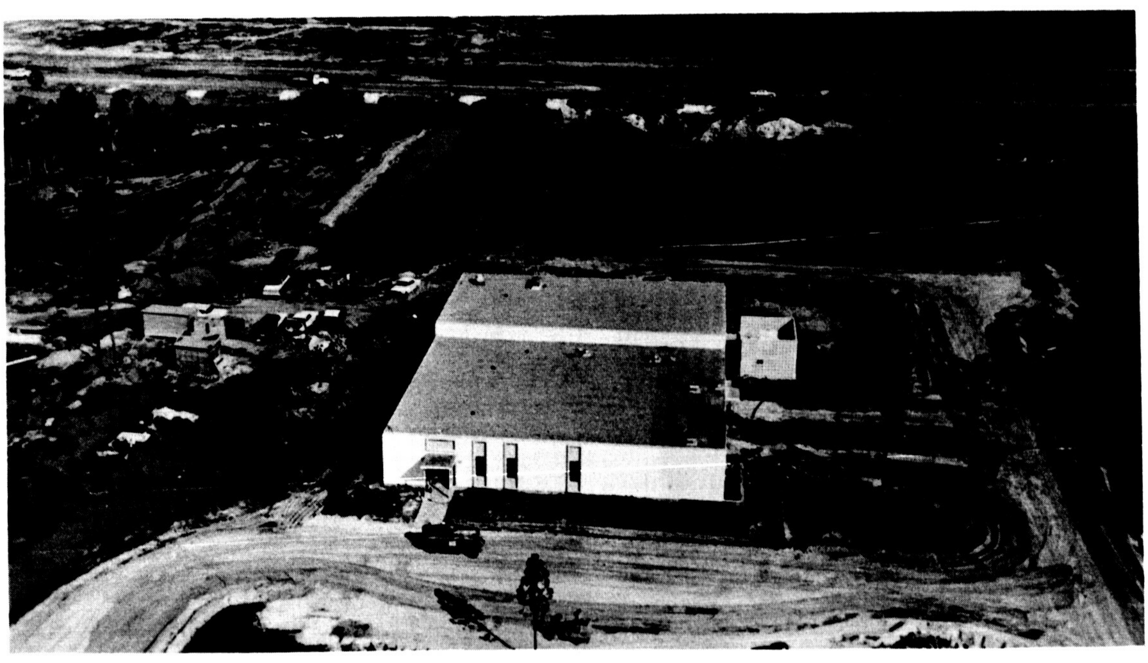
Support Facilities: Projects completed were: Railroad and Classification Yard, completed July 18; Emergency Services Building, August 18; Warehouse and Site Maintenance Building, November 25; Telephone Building, November 11; Central Heating Plant, November 16; and Miscellaneous Utilities (Central Control Building and Data Handling Center), September 20; and Miscellaneous Utilities (Central Heating Plant and Administration Building), July 1964. Support facilities progress during this period: Roads, Railroads, and Utilities, 86 per cent complete; Office and Administration Building, 82 per cent; Roads A, H, K, and L, 35 per cent; S-IC Booster Storage Building, Booster Dock, and Canal Extension, etc., 74 per cent; Central Control Building and Data Handling Center, 71 per cent; Propellant Facilities, 46 per cent; Electronics, Instrumentation, and Materials Lab, 47 per cent; site work for Emergency Services, Office and Administration, Central Control and Data Handling Center Buildings, and Warehouse area, 65 per cent; and Test Maintenance Building, 30 per cent. New contracts: Site work for several buildings and areas, awarded on July 2 to Thornton Construction Company and Hyde Construction Company, for $683,000 (65 per cent complete at the end of the period); Inflammable Materials and Welding Tank Storage Buildings, awarded October 28 to Carpenter Brothers for $258,000 (70 per cent complete); Sonic Measuring Facilities, awarded November 2 to Carpenter Brothers for $636,000 (9 per cent complete); warehouse additions and site work, to Fullerton Construction Company for $1.6 million on December 18; Roads, Parking Areas, and Scale, Components Services Facility, and site work, awarded on December 23 to Hyde and Thornton combined firms for $1.7 million; and Mobile Equipment Maintenance Building, awarded December 28 to Carpenter Brothers for $1.1 million.

Waterways and Docking Facilities: Projects completed this period included the Cryogenics Dock, Canal Extension, and Deluge Intake Structure, on July 31; and dredging of the East Pearl River and lock approach channel, completed November 3. Progress on other projects: mooring devices and piers for Cryogenics Dock, 99 per cent complete; Bascule Bridge, 96 per cent; Navigation Lock and Lock Water Supply, 74 per cent; and Main Canal construction, 73 per cent. There were no new contract awards in this category during the period.

Major MTO procurement contracts monitored by the Mobile District of the Corps of Engineers and status of contracts as of December 31, 1964: ten high-pressure industrial water pumps, Nordberg Manufacturing Company, total cost $2.9 million, 80 per cent completed; modification of nine LOX and LH_2 barges, Chicago Bridge and Iron Company, $5.4 million, 44 per cent completed; relocation of State Highway 43 from MTO buffer zone, $2.2 million, 25 per cent completed; and cryogenic and high-pressure gas valves, filters, etc., $3.4 million, 12 per cent completed.

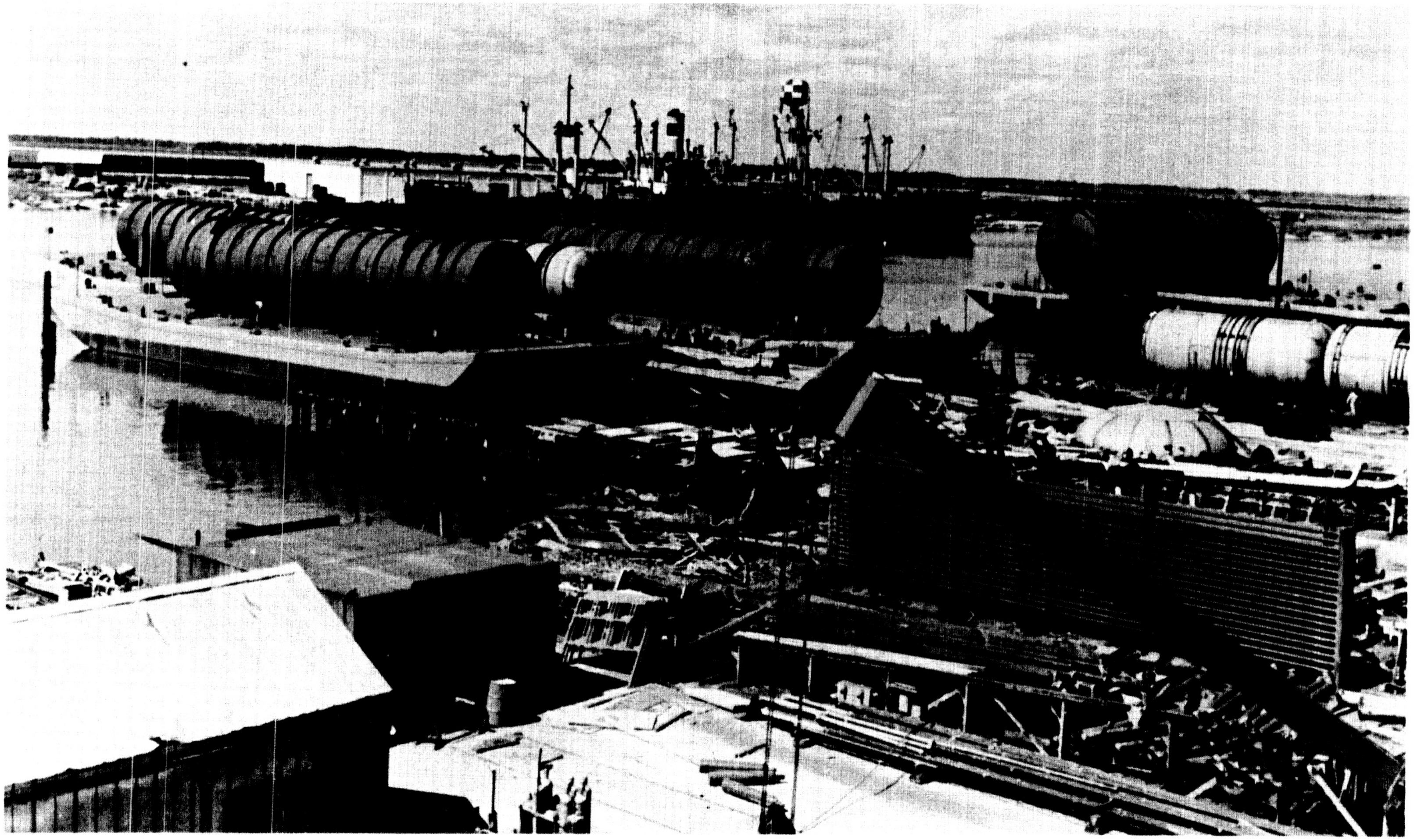
BUILDING AT MTO

This December 1964 photo shows the newly completed Emergency Services Building at Mississippi Test Operations.



MTO TELEPHONE CENTER

Workmen completed the Mississippi Test Operations' Telephone Building in November 1964, a month after this picture was made.



CRYOGENIC PROPELLANT BARGES

These barges for cryogenic propellants are shown at Mississippi Test Operations. They are scheduled for use in S-IC and S-II stage acceptance tests.

During this period MSFC supervised a number of large contracts at MTO. These contracts, totalling more than $64 million, included procurement of technical systems as well as facility activation and support operations.[68]

CONTRACTOR

Major facilities for the development, production, and test of the S-IC stage are owned by the government and located at Huntsville, Michoud, and MTO. These facilities are described elsewhere in this report. Boeing owns manufacturing facilities principally at Seattle, Washington, and Wichita, Kansas.

S-II stage development and production facilities are at Downey, Seal Beach, and El Toro, California, as well as at Tulsa, Oklahoma. Development tests of the stage are conducted at Santa Susana Field Laboratory (SSFL), California. At Seal Beach major construction during this period involved the Structural Static Test Tower, the Vertical Checkout Building, and a warehouse. Basic construction of the test tower ended prior to this period, but modifications were needed before starting test of the S-II-S stage. On October 21 NASA awarded a contract for rework of the tower. This project ended in December. NASA awarded the contract for construction of the Vertical Checkout Facility early in November 1964. Completion was scheduled in mid-1965. The contract for construction of a 32,000-square-foot warehouse was awarded in November, with a scheduled completion date of July 1965. Other facility projects that progressed at Seal Beach included expansion of the Pneumatic Test, Paint, and Packaging Building; and extension of the Bulkhead Fabrication Building. SSFL S-II stage test site facilities underwent some modifications and additions. Activation of Coca 1, the battleship test site, occurred in November. Work continued toward completion of Coca 4, the All-Systems Test Stand. Construction of the Common Bulkhead Test Facility began in September 1964 and progressed on schedule through November, when nearby battleship test operations and inclement weather delayed construction progress.[69]

S-IVB stage contractor facilities are described in the Saturn IB chapter of this report.

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68. MTO, Mississippi Test Facility Construction/Activation Bi-Weekly Activity Report, covering Dec. 14, 1964 - Jan. 11, 1965, Rpt. No. 38, pp. 1-9; and MTO, Historical Report, July 1 - Dec. 31, 1964, pp. 2 and 11-21.
69. NAA S&ID, SID 63-266-21, p. 20; SID 63-266-22, p. 22; and Saturn S-II Annual Progress Report, July 1, 1964 - June 30, 1965, Report SID 63-1028-3, pp. 179 and 182; and Saturn V Off., MPR-SAT V-64-4, p. 34.

F-1 engine facilities are at the following locations: Canoga Park, California, where Rocketdyne develops and manufactures both F-1 and J-2 engines; and Edwards Air Force Base, California, where Rocketdyne performs development and acceptance tests of F-1 engines and components. MSFC provides augmented facilities at both Canoga Park and Edwards. Facility construction at Canoga Park in this period involved expansion of manufacturing and production facilities and construction of an engine checkout cell. At Edwards the major facilities activity was at the F-1 engine acceptance test complex of RETS, consisting of three static test stands and associated equipment. Activation of this $34 million complex took place on October 9, 1964, when NASA formally accepted the complex from the Corps of Engineers. On this occasion MSFC officials also witnessed a readiness firing demonstration on the stands. On November 21 an environmental capability on one of the three new stands was accepted. On December 2 a contract was awarded for construction of a 2500-ton LOX tank at RETS. Completion of the tank is scheduled for August 1965.[70]

J-2 engine facilities work at Canoga Park included expansion of manufacturing and production test facilities as well as development support equipment. In July MSFC awarded a $3.6 million contract modification to Rocketdyne which included provisions for additional engine production equipment at Canoga Park. Also in this modification project were provisions for test support facilities at SSFL, which included construction of propellant storage facilities and modification of Vertical Test Stand 3 and Delta 1 Test Stand, as well as repairs to various facilities.[71]

KENNEDY SPACE CENTER

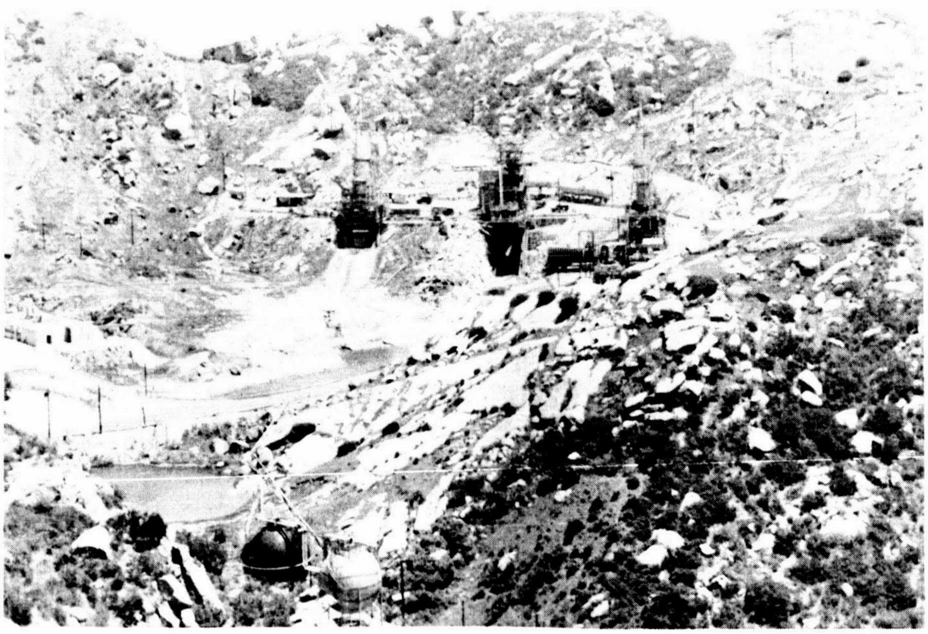
NASA Kennedy Space Center (KSC) in Florida provides launch operations support for the Saturn V vehicle program. Launch Complex 39 (LC-39) at Merritt Island Launch Area (MILA) is under construction for the Apollo/Saturn V program. Since KSC has primary responsibility for launch facilities construction, this report includes only brief general coverage of these facilities.

LC-39 facilities consist of the Vehicle Assembly Building (VAB) and associated systems, the Launch Control Center, Pad A and Crawlerway, Pad B and

70. Executive Staff, Management Information, Vol. VII, 2nd Ed., January 1965, pp. 5 and 90; and Engine Program Off., QPR-Eng-64-2, p. 17; and QPR-Eng-65-1, p. 11.
71. Executive Staff, Management Information, Vol. VII, 2nd Ed., January 1965, pp. 37 and 89.

F-1 ENGINE TEST AREA

This is a view of the F-1 engine acceptance test complex at Edwards Air Force Base, California. The three test stands in this area became operational in October 1964.



J-2 TEST COMPLEX

The Bowl Area at Santa Susana Field Laboratory, California, includes three test stands for developmental firing of J-2 engines.

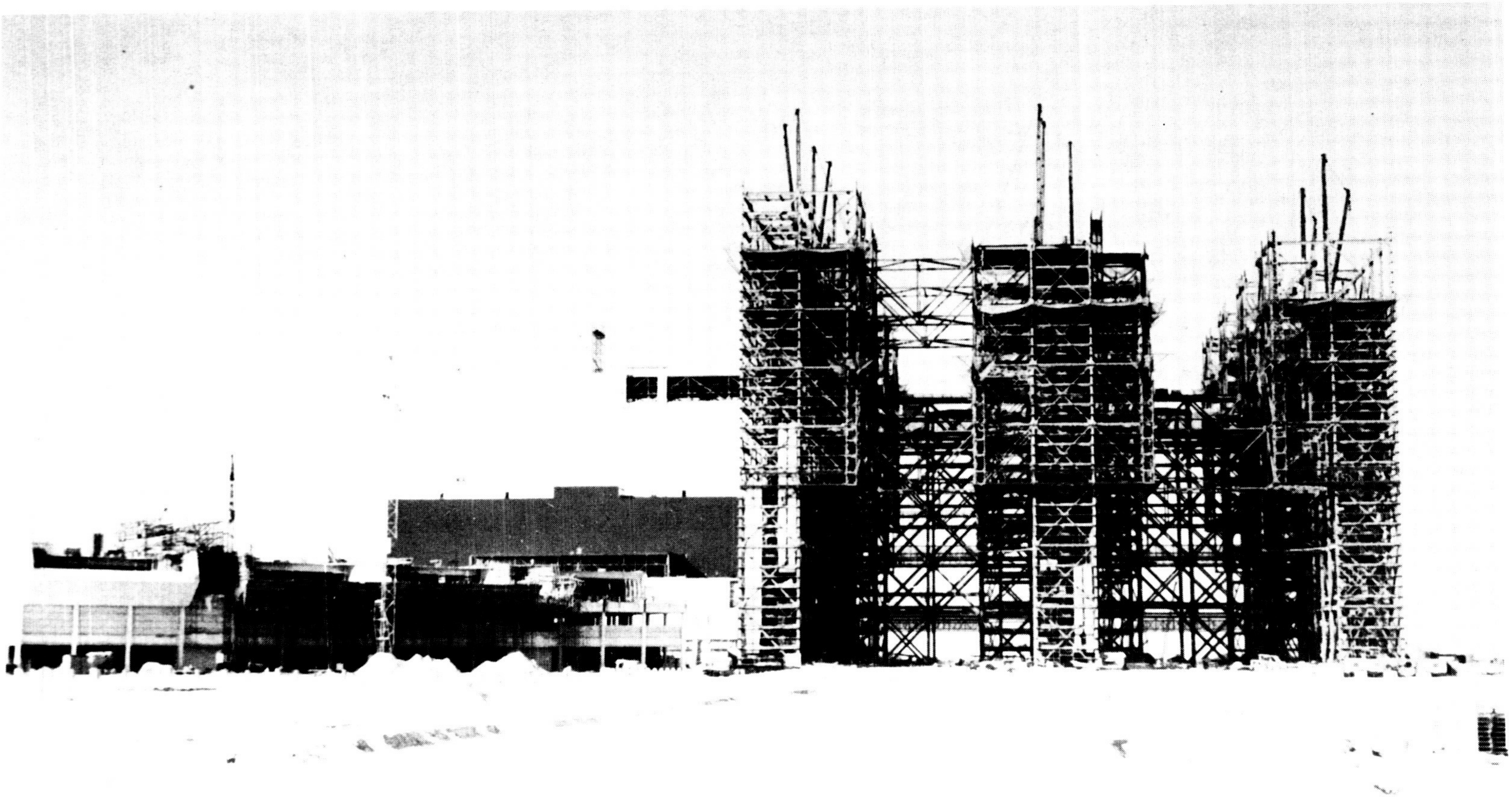
Crawlerway, and a Mobile Service Structure (formerly called the Arming Tower). Launch support equipment at LC-39 includes three mobile launchers (formerly called launcher/umbilical towers) and two crawler-transporters. Launch vehicles will be assembled vertically and checked out in the VAB. Aboard the mobile launchers on which they were assembled inside the VAB, the vehicles will then move to the launch pad for prelaunch checkout and launch.

The VAB, called the world's largest building, was about 15 per cent completed when this period began. American Bridge Division of U. S. Steel Corporation is erection contractor for the building, which will contain more than 50,000 tons of steel and 25,000 tons of concrete when completed. By the end of this period overall VAB construction progress was approximately 84 per cent. All structural steel work was complete in the low-bay area. Steel erection in the high-bay area was at the 419-foot level in all four towers. A 175-ton crane shipment arrived in December.

Launch Control Center: Construction progress was on schedule for the Launch Control Center and various support facilities including the utility annex, crawler road tunnel, water and sewage systems, electrical substation, fuel storage tanks, and high-pressure gas facilities. The Instrumentation Building was 33 per cent complete. Construction began November 10 on the Launch Equipment Shop, a $1.4 million project. On December 28 work began on the Ordnance Storage Facilities. Contract awards were pending for the vehicle unloading area and the VAB Repeater Communications Building.

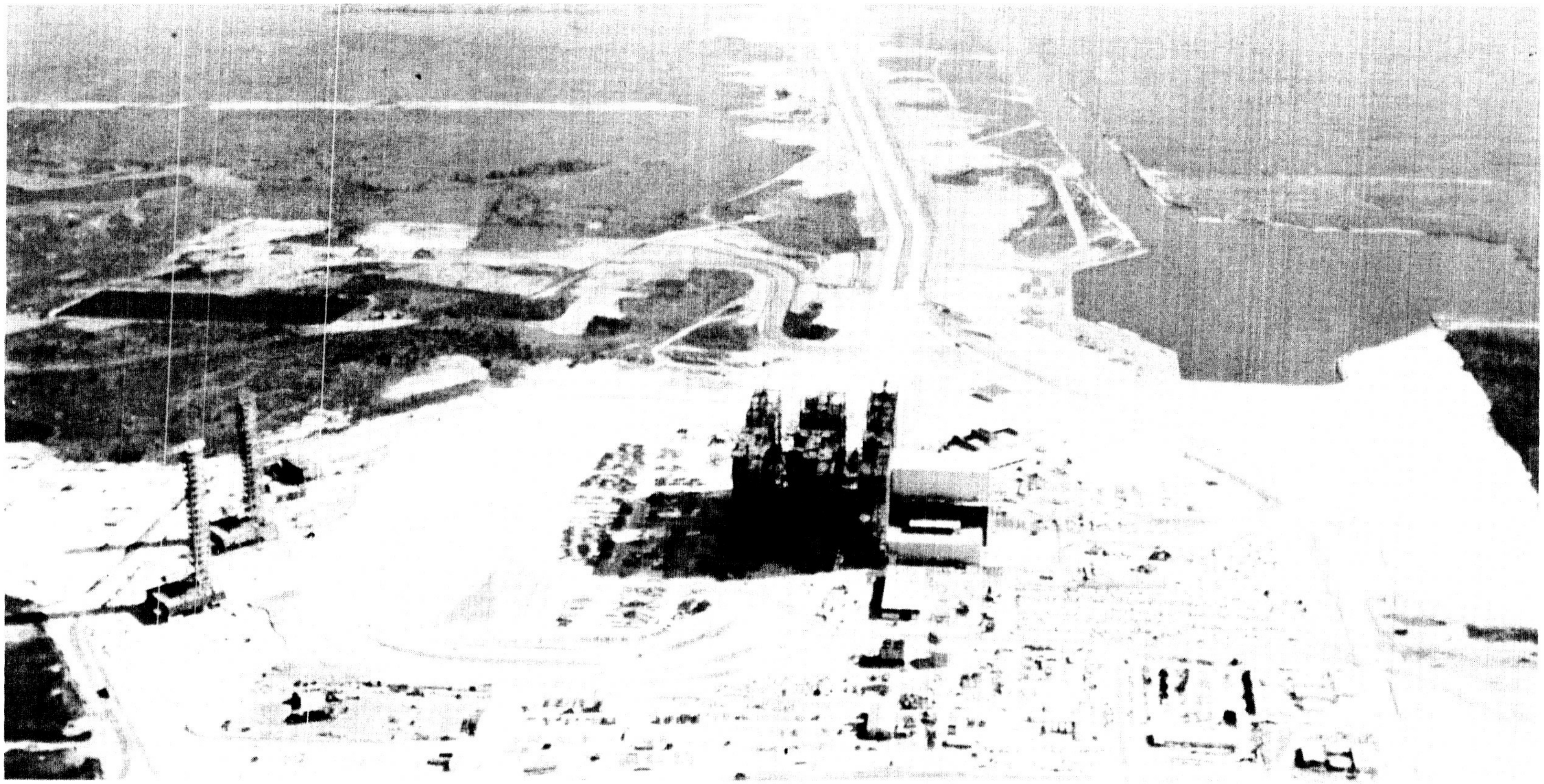
Pad A and Crawlerway: This $19.2 million project will provide the first vehicle launch site. At the end of the period crawlerway construction (from VAB to the pad) was 83 per cent complete. Pad construction and adjunct facilities continued generally on schedule. Foundation work for the Mobile Service Structure ended on December 28. Propellant service facilities construction and installation proceeded under several subcontracts managed by Catalytic Construction Company. On December 6 the Corps of Engineers completed the design for the Operations Support Buildings for Pad A and Pad B.

Pad B and Crawlerway: The site preparation contractor completed the surcharge and fill contract on October 23. On November 30 the Corps of Engineers awarded to the firm of G. A. Fuller the pad and crawlerway construction contract. Notice to proceed on the $19 million contract was issued on December 12, and the contractor began work.



WORLD'S LARGEST BUILDING RISES

The steel framework of the Vehicle Assembly Building (VAB) at the Merritt Island Launch Area (MILA) of Kennedy Space Center dominates this December 1964 photograph. The structure will accommodate four Saturn V vehicles simultaneously in its high-bay assembly areas. The unfinished Launch Control Center (LCC) is at left.



LAUNCH COMPLEX 39

This aerial view of Kennedy Space Center's LC-39 on Merritt Island shows December 1964 construction progress in the Vehicle Assembly Building (VAB) area. Framework of the VAB is at center of picture. Mobile launchers and crawler-transporters are under construction at left. Dual-tracked crawlerway leading from VAB extends toward launch pad area.

SATURN V CRAWLER UNIT

This crawler track unit is one of four comprising the tractor portion of the Saturn V crawler-transporter at Launch Complex 39. The track is shown at the manufacturing plant, Marion, Ohio, prior to shipment to Merritt Island, Florida.

Mobile Service Structure: Rust Engineering Company completed the design on July 8, 1964. Award of the $11.4 million contract to the combined firms of Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman Construction Company occurred on September 21. Notice to proceed came on October 2.

Mobile Launchers: In 1963 Ingalls Iron Works Company won the $11.4 million contract covering erection of three mobile launchers. During the current report period NASA extended the late-1964 completion date because of bad weather, strikes, and other delays. By the end of this period Mobile Launcher No. 1 was virtually complete. Units No. 2 and No. 3 continued under erection: No. 2 was "topped out" and the hammerhead crane installed; No. 3 erection was at the 160-foot level when the period ended. Electrical-mechanical work on the launchers began in August under a separate contract. A contract covering modifications to the three mobile launchers, to both launch pads, and to other launch support equipment was issued on December 21 to Pacific Crane and Rigging Company, with a completion date of September 1966. On September 14 NASA ordered 20 pneumatic separators for launcher arms; eight units were delivered during the period. The first of 16 holddown arms for the mobile launchers arrived at KSC on October 31 from the fabrication contractor. On September 10 Hayes International Corporation received the $11.4 million contract to fabricate Saturn V service arms and related equipment.

Crawler-Transporters: The manufacture and fabrication of all components for Crawler-Transporter No. 1 had been completed by the contractor and shipped to LC-39 by the period's end. Assembly of the massive vehicle continued at MILA. Components for Crawler-Transporter No. 2 started arriving at the site and erection was underway when the period ended.[72]

Saturn V and Related Studies

Saturn V studies during this period emphasized improvement of the launch vehicle and selection of payloads and missions to supplement or come after Apollo. Other major studies concerned lunar exploration and logistics, earth-orbital operations, planetary systems, reusable rockets, and advanced propulsion systems. MSFC awarded approximately 30 study contracts on these subjects in June and July 1964. The Center managed the studies and provided contractors with in-house support.

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72. KSC, Technical Progress Report, Third and Fourth Quarter CY-1964, TR-159, Mar. 5, 1965, pp. 33-73.

LAUNCH VEHICLE STUDIES

Near the start of the current period MSFC awarded vehicle improvement study contracts to the Saturn V prime contractors. These studies, carefully defined beforehand by in-house investigations, sought ways to increase the payload capability and operational efficiency of the Saturn V. Boeing, the S-IC stage contractor, received four of these contracts--one applying to the S-IC stage and three to the entire vehicle. S&ID was awarded the S-II stage study. DAC undertook the S-IVB stage study. All the Saturn V improvement studies were scheduled for completion in the spring of 1965.

P&VE Laboratory's Advanced Studies Office performed a study of liquid strap-on units for Saturn IB and Saturn V vehicles. Results of this study, published in January 1965, concluded that such a strap-on propulsion system was technically feasible and would increase the Saturn V payload by 12,500 pounds.[73]

The Advanced Studies Office also conducted a conceptual study of a two-stage launch vehicle consisting of modified S-II and S-IVB stages, minus the S-IC stage. This Saturn V-X launch vehicle would employ high-pressure LOX/LH_2 engines instead of J-2 engines and would have a payload capability between that of Saturn IB and Saturn V. The preliminary investigation showed that such a concept appeared feasible.[74]

Other contracted launch vehicle study programs were as follows: Launch Vehicle Systems Criteria, to Boeing and NAA; Launch Vehicle Cost Parameters, to General Dynamics/Fort Worth and Martin/Denver; Launch Vehicle Component Cost, to Lockheed; and Launch Vehicle Cost Model, to General Dynamics/Fort Worth. None of these was completed during the current period. MSFC also summarized the results of the Fiscal Year 1964 launch vehicle cost model study in a report published September 21, 1964.[75]

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73. P&VE Lab., Compatible Liquid Strap-on Units for Saturn Launch Vehicles, IN-P&VE-A-65-3, Jan. 25, 1965, pp. 1 and 20.
74. P&VE Lab., Saturn V-X Launch Vehicle, IN-P&VE-A-65-1, Jan. 18, 1965, pp. 1 and 3.
75. Future Projects Off., Planning Information and Activity Report, June 1965, pp. 36-49; and Launch Vehicle Systems Cost Model, NASA TM X-53136, Sept. 21, 1964.

A Boeing study of S-IC stage recovery and reusability concluded in December 1964 that a non-winged recovery method appeared most attractive. The report recommended recovery by water impact, for immediate implementation. Two other reusability studies were in progress during this period. Boeing investigated a first-stage Reusable Orbital Transport, while General Dynamics/Astronautics studied a second-stage concept for this transport. Awarded to NAA in September 1964 was a contract for a study entitled "Utilization of Spent Stages." MSFC conducted an in-house study for utilizing the spent S-II stage to enclose and shield a manned earth-orbiting research laboratory.[76]

A Post-Saturn Launch Vehicle Study by Martin/Baltimore ended in November 1964. MSFC summarized this study program in a February 1965 report. The report concluded that gaseous core reactor and nuclear pulse engines appeared preferable to solid core reactor engines for large post-Saturn chemo-nuclear vehicles.[77]

LUNAR STUDIES

Major studies in this category concerned adaptation of Apollo hardware to support and extend lunar exploration. The Apollo Logistic Support System (ALSS) program included award of parallel contracts to Bendix and Boeing covering preliminary design study of a mobile lunar laboratory (Molab) to support the initial landings. Meanwhile, MSFC designed and built a Molab mockup. MSFC and contractors began work on Apollo Extension Systems (AES) studies, involving use of Apollo and Saturn capabilities for manned missions beyond currently approved programs. AES studies investigated missions including lunar surface exploration, lunar-orbital surveys, and advanced earth-orbital operations. Effort in this report period concerned evaluation, analysis, and conceptual design of lunar surface mobility systems. MSFC awarded three contracts for Lunar Exploration Systems for Apollo (LESA) studies related to lunar activities of the middle and late 1970's: General Dynamics/Fort Worth is investigating LESA operations and logistics; Westinghouse, communications and control; and Garrett Corporation, human factors and environmental control. A related study, underway by Bell Aerosystems, concerned a rocket-powered translunar vehicle or "lunar hopper" for short flights on the lunar surface. All these lunar studies were due for completion by June 1965. Completed by Martin in December 1964 was the "Orbital and Lunar Flight Handbook," a study begun in 1962.[78]

76. Boeing Co., Study of Saturn S-IC Recovery and Reusability, Summary Technical Report, D2-23722-1, December 1964, pp. 1-2; and FPO, Planning Information and Activity Report, June 1965, p. 36.
77. Future Projects Off., Planning Information and Activity Report, June 1965, pp. 36-37; and Advanced Post-Saturn Earth Launch Vehicle Study, Executive Summary Report, NASA TM X-53200, Feb. 3, 1965, pp. 18-19.
78. Future Projects Off., Planning Information and Activity Report, June 1965, pp. 21, 37, and 46-48.

EARTH-ORBITAL OPERATIONS

Several studies of orbital launch operations (OLO) were in progress during this period. OLO is defined as the procedures and techniques by which a vehicle is assembled, fueled, checked out, and launched from earth orbit. Chance Vought/Astronautics continued a systems study begun in June 1963 entitled "Advanced Orbital Launch Operations," which was due for completion in October 1965. Support studies included two contracts awarded just before the start of the current period: "Orbital Tanker Design," involving a cryogenic tanker, awarded to Lockheed; and "Orbital Launch Facility," undertaken by Boeing.[79]

PLANETARY SYSTEMS

Most planetary mission studies of this period concentrated on definition of manned Mars and Venus exploration and conceptual design of systems for these missions. Included were extensive in-house contracted investigations. Among contracted studies were the following: "Manned Mars and Venus Exploration," by GD/A; "Low Acceleration Space Transportation," by United Aircraft Corporation and General Electric; "Mars Surface Operations," by Avco Corporation; "Mission Requirements for Manned Mars and Venus Exploration," by General Dynamics/Fort Worth; "Advanced Nuclear System Parameters," a continuation of a study started in June 1963 by Space Technology Laboratories; and "Planetary Transportation System Model," by GD/A and Martin/Denver. MSFC also continued in-house studies on manned and unmanned interplanetary flyby missions.

Several in-house studies contributed to the overall investigation of planetary systems. In February 1965 the Future Projects Office published an Executive Summary Report which summarized results of the first phase of MSFC study on manned Venus or Mars flyby missions based largely on Apollo/Saturn V hardware. Such missions might be desirable in the last half of the 1970 decade, the report said. MSFC also summarized contracted studies on manned planetary flyby missions and orbiting missions. The flyby study report showed that both Mars and Venus missions were feasible using available hardware but should be deferred until 1975-1980 because of funding limitations. The planetary orbiting study concluded that fast roundtrip missions to Venus and Mars in 1975-1977 appear feasible, using nuclear solid-core propulsion.[80]

79. Ibid., pp. 18-20 and 36-37.
80. P&VE Lab., MPR-P&VE-64-8, p. 15; Future Projects Off., Planning Information and Activity Report, June 1965, pp. 23 and 36-37; Manned Planetary Reconnaissance Mission Study: Venus/Mars Flyby, NASA TM X-53204, Feb. 5, 1965, p. 1; Early Manned Planetary Flyby Mission Study, Executive Summary Report, NASA TM X-53201, Feb. 4, 1965, p. 1; and Early Manned Planetary Orbiting Mission Study, Executive Summary Report, NASA TM X-53202, Feb. 4, 1965, p. 1.

ADVANCED PROPULSION

The P&VE Laboratory and Future Projects Office continued to investigate the complete spectrum of propulsion systems and their integration in launch vehicles. Chemical, nuclear, and electric propulsion were considered. Chemical systems included liquid and solid rockets, air-breathing propulsion, and combinations or hybrids. Nuclear systems studies included solid and gaseous core reactors as well as nuclear pulse schemes; and electric propulsion methods included electro-thermal, electro-static, and electro-magnetic systems. The Future Projects Office concluded, shortly after the end of this report period, that there was no urgent reason to develop an operational electric propulsion capability at this time, since no high-energy missions were currently planned. Continued studies were recommended.[81]

Funding

Obligations for the Saturn V program at MSFC during the period July 1 - December 31, 1964, totalled $628,560,000. This total was divided into the following allotments: S-IC stage, $182,106,000; S-II Stage, $139,564,000; S-IVB stage, $80,592,000; Instrument Unit, $31,619,000; Ground Support Equipment, $26,866,000; F-1 Engine procurement, $60,900,000; J-2 Engine procurement, $47,118,000; Vehicle Support, $59,795,000.[82]

Summary

The Saturn V launch vehicle program under MSFC's direction emerged from the preliminary design phase and entered the ground test phase during the July-December 1964 period. The government-industry team approached full strength of approximately 300,000 persons across the United States.

MSFC and Boeing made strides in development of the S-IC stage. The static firing stage, S-IC-T, neared completion at Huntsville while structural testing of booster hardware got underway. Ground test stages were taking shape in shops at MSFC and Michoud Operations. Work also began on the first three flight stages--two at Huntsville and one at Michoud.

81. Future Projects Off., Planning Information and Activity Report, June 1965, pp. 24-25; and Study of Electrical Propulsion in Space, Executive Summary Report, NASA TM X-53196, Jan. 28, 1965, pp. 14-15.
82. Information furnished Aug. 24, 1965, by Louis E. Snyder, MSFC Financial Management Off.

S-II stage development by NAA S&ID included significant progress in manufacture of ground test hardware and the first flight stage. Milestones of the period included assembly of the first common bulkhead and successful static firing of the S-II battleship.

S-IVB stage progress, reported in detail in the Saturn IB Chapter of this history, included a full-duration firing of the S-IVB battleship. Among other notable achievements by DAC, the prime contractor, were completion of the dynamic test stage, near completion of several other ground test stages, and start of fabrication on the first flight stage.

The F-1 and J-2 engines, under development by NAA Rocketdyne, made scheduled progress toward operational readiness. The F-1 demonstrated its stability and also passed flight rating tests (FRT), a major milestone. The J-2 engine performed preliminary flight rating tests (PFRT) and also, for the first time, demonstrated its restart capability.

Several milestones occurred in Saturn V facilities construction. Many major facilities at MSFC were virtually complete, including the S-IC Static Test Stand, F-1 Engine Test Stand, and Saturn V Dynamic Test Facility. At Michoud workmen completed the Engineering and Office Building and the Vertical Assembly Facility. MTO construction reached a new peak of activity; several support facilities were complete and rapid progress was made on S-IC and S-II test stands. Contractor facilities placed in operation included three new F-1 engine test stands at Edwards Air Force Base, S-II vertical assembly and structural test towers at Seal Beach, and major development and test facilities at Santa Susana Field Laboratory and Sacramento Test Center.

A wide study program, in-house and by contractors, placed emphasis on improving the Saturn V vehicle and selecting payloads, missions, and space exploration methods for the post-Apollo period.

APPENDICES

APPENDIX A: SATURN I CHRONOLOGY

July - December 1964

July 21 - NASA Headquarters officially named the micrometeoroid measurement project the "Pegasus" project. It called the capsules Pegasus A, Pegasus B, and Pegasus C.

July 31 - The barge Promise with the S-I-10 aboard docked at MSFC following a seven-day journey from Michoud. Technicians immediately installed the S-I-10 in the static test tower at the MSFC test site.

In July - Chrysler Corporation Space Division (CCSD) began post-static modification and repair of S-I-8.

- MSFC completed S-IU-9 component installation and initiated final checkout procedures.

August 6 - The first and only static firing of S-IV-9 lasted 398.94 seconds; all test objectives were achieved.

- Kennedy Space Center (KSC) technicians completed electrical mating of S-I-7, S-IV-7, and S-IU-7 at Launch Complex 37, Pad B (LC-37B).

August 7 - KSC technicians at LC-37B mated the boilerplate Apollo spacecraft (BP-15) to the SA-7 vehicle.

- The Douglas Aircraft Company (DAC) shipped the S-IV-8 stage to the Sacramento test site for static tests.

August 27 - Test engineers at the Sacramento test site removed S-IV-9 from Test Stand 2B and installed S-IV-8.

- Because of Hurricane Cleo near Cape Kennedy, technicians suspended for two days SA-7 prelaunch activities.

In August	-	DAC completed final assembly of the last S-IV flight stage, S-IV-10.
	-	MSC's spacecraft contractor, Space and Information Systems Division (S&ID) of North American Aviation, delivered BP-16 and BP-26 command modules and launch escape systems to KSC.
	-	To avoid delay in the Saturn launch schedule and also to enhance success of the Pegasus experiments, NASA and MSFC reprogrammed Pegasus development. The new directive reduced the requirements for a fully-qualified Pegasus A but called for no changes in development requirements for Pegasus B or C capsules.
September 8	-	SA-7 prelaunch activities were suspended as KSC personnel evacuated the Center for Hurricane Dora. The hurricane passed 85 miles north of Cape Kennedy and caused little damage to SA-7 or the launch site.
September 17	-	Final countdown for the SA-7/Apollo launch began at 11:25 p. m. EST. The count continued uninterrupted for five hours before the first hold occurred.
September 18	-	Four holds, lasting two hours and 43 minutes, interrupted the final countdown for the SA-7/Apollo launch.
	-	The SA-7/Apollo made a highly successful flight, with liftoff occurring at 11:22.43 a.m. EST, and orbital insertion of the payload 631.38 seconds later. Missions accomplished in flight included first demonstration of the S-IV nonpropulsive venting system; first demonstration of a fully active ST-124 guidance system, control rate gyros, and the ASC-15 guidance computer; and jettison of the Launch Escape System (LES) by the alternate mode involving both the launch escape motor and the pitch control motor.
September 22	-	The first S-I-10 static firing lasted 3.01 seconds before automatic cutoff occurred. Automatic cutoff came at "time for commit" when a thrust pressure switch failed to operate.

September 22	-	NASA rescheduled Saturn launches SA-9, SA-8, and SA-10 approximately two months later than planned. This provided additional development time for the Pegasus payloads.
September 24	-	The second S-I-10 static firing lasted 35.08 seconds.
In September	-	MSFC completed final checkout of S-IU-9 and prepared the unit for shipment to KSC.
October 6	-	In its third and final acceptance test S-I-10 fired for 149.93 seconds before inboard engine cutoff and then to 154.48 seconds until LOX depletion caused cutoff of outboard engines. All test objectives were accomplished.
October 13	-	CCSD began final checkout of S-I-8.
October 15	-	Workmen completed construction of the Engineering and Office Building at Michoud Operations. The building will house personnel of the Saturn I, Saturn IB, and Saturn V programs.
October 19	-	The barge Promise with the S-I-9, the S-I stage fins, and the S-IU-9 aboard began a ten-day trip to KSC from the MSFC dock.
October 22	-	DAC shipped the S-IV-9 stage to KSC aboard the Pregnant Guppy aircraft.
October 26	-	NASA directed MSFC to appoint a Pegasus Project Officer to provide technical direction for the project.
October 29	-	Technicians removed S-I-10 from the MSFC static test stand and loaded it aboard the barge Palaemon for a return trip to Michoud Operations.
In October	-	MSFC completed assembly operations for S-IU-9 and began final checkout of the unit.
November 3	-	KSC technicians erected S-I-9 on LC-37B at KSC.

November 5	-	DAC transferred the S-IV-10 stage to the Sacramento test site for prestatic checkout and acceptance tests.
November 7	-	The S-I-10 arrived at Michoud Operations for poststatic checkout and repair.
November 13	-	The BP-16 Apollo service module, adapter, and insert arrived at KSC from MSFC aboard the Pregnant Guppy aircraft.
November 19	-	KSC technicians completed erection of the S-IV-9 and the S-IU-9 atop the S-I-9 on LC-37B.
November 20	-	The S-IV-8 acceptance firing lasted for a duration of 475.8 seconds; all test objectives were achieved.
December 4	-	DAC moved S-IV-8 from the static test stand to the Evaluation and Development Building for poststatic checkout and repair.
December 5	-	Test engineers installed S-IV-10 in Test Stand 2B at DAC's Sacramento Test Center. Preparations for firing the stage began.
December 18	-	Fairchild Hiller Company completed fabrication and checkout of the Pegasus A capsule and transferred it for final checkout to the General Electric plant at Valley Forge, Pennsylvania.
December 19	-	KSC completed electrical mating of the S-I-9, S-IV-9, and S-IU-9 at LC-37B.
December 29	-	Pegasus A, the first flight capsule, arrived at the launch site aboard the Pregnant Guppy.

APPENDIX B: SATURN IB CHRONOLOGY

July - December 1964

July 2	-	Chrysler Corporation Space Division (CCSD) completed its clustering of tanks for the first S-IB flight stage (S-IB-1).
July 14	-	DAC began structural tests of the S-IVB stage. The liquid hydrogen (LH_2) tank of the structural test stage ruptured during hydrostatic test as a result of insufficient weld at seams.
July 22	-	CCSD received the S-I dynamic stage at Michoud for modification to the S-IB stage configuration (S-IB-D/F).
	-	The Wismer-Becker firm, contractor for the Gamma Complex at Sacramento, California, turned the facility over to Douglas Aircraft Company (DAC).
July 31	-	The Military Sea Transport Service (MSTS), completed modification design for Point Barrow, a Navy LSD procured for S-IVB transportation.
In July	-	CCSD began fabrication of S-IB-3 components.
	-	DAC began production of major S-IVB structural subassemblies.
	-	DAC completed evaluation of the auxiliary propulsion system (APS) module design.
August 1	-	MSFC awarded Saucer Marine Ways, New Orleans, Louisiana, a contract for modifications of the Palaemon barge. The modifications would include installation of a pilot house and wing bridge.
August 18	-	MSFC reviewed DAC's S-IVB pneumatic ground support equipment (GSE) design.

August 24	-	The firm of M. Connell and Associates completed Phase I design for modification of the service structure at Launch Complex 34 (LC-34), NASA Kennedy Space Center (KSC).
August 31	-	MSFC representatives visited Food Machinery Corporation, San Jose, California, to accept two cargo lift trailers for use in loading aircraft at NASA's Manned Spacecraft Center.
In August	-	MSFC notified stage contractors that SA-201 and 202 would be "lob" missions to test reentry of the Apollo spacecraft heat shield.
	-	Saturn IB stage contractors, MSFC, and NASA Headquarters reviewed the status of the Saturn IB program. The review revealed S-IVB stage development to be the pacing item in the Saturn IB program.
	-	DAC rearranged test objectives among S-IVB test stages and concentrated upon management improvement in an effort to overcome delays in the S-IVB stage program.
	-	Segments of the instrument unit (IU) structure, redesigned because of increased vehicle loads, underwent maximum loads testing.
	-	MSFC completed contract negotiations with Bendix Corporation for 26 additional ST-124M stabilized platform systems to be used in the Saturn IB/V IU's.
September 18	-	DAC conducted the first S-IVB battleship cryogenic loading with liquid nitrogen and liquid hydrogen (LH_2).
September 25	-	DAC successfully completed cryogenic loading of the S-IVB battleship with liquid oxygen (LOX) and LH_2.
In September	-	CCSD began assembly operations for S-IB-2.
	-	MSFC received DAC's contract proposal for production of eight S-IVB/IB stages and a set of ground support equipment.

In September	-	DAC completed definition of the S-IVB operational telemetry system.
	-	MSFC completed design for modification of the Dynamic Test Stand to support the Saturn IB dynamic test program.
	-	DAC activated the Gamma Complex with initiation of Phase I APS testing.
	-	Activation of the Beta 1 stand at Sacramento occurred with cryogenic loading of the S-IVB battleship test stage.
October 15	-	Negotiations ended with IBM concerning the scope of work to be included in the IU lead contract. This contract covered integration of all IU systems and assembly and checkout of the flight units for the Saturn IB and Saturn V programs.
	-	Construction of the new Engineering and Office building at Michoud Operations was completed.
October 23	-	Hayes International Corporation, contractor for IU pneumatic GSE, delivered the prototype console and test set.
October 24	-	Problems with LOX and LH_2 prevalves prevented first ignition firing of the S-IVB battleship.
October 28	-	DAC completed checkout of the S-IVB dynamic test stage (S-IVB-D).
In October	-	MSFC authorized DAC to proceed with design of S-IVB-203 for a prolonged near zero "g" LH_2 orbital experiment.
	-	DAC finalized contract action with Thiokol Corporation for 48 TX-280 motors and spares for S-IVB ullage rocket systems.

In October	-	MSFC authorized DAC to proceed with buildup of personnel at KSC to assist in the required testing and checkout of the S-IVB stage in the low bay area.
	-	MSFC released all the documentation for redesign of the IU from the Saturn I configuration to the Saturn IB/V configuration.
	-	Hayes International Corporation completed design of the Saturn IB/V IU shipping container.
November 2	-	CCSD activated Checkout Station No. 2 at Michoud Operations. The facility will be used to check out S-IB stages after assembly and prior to shipment to KSC for launch.
	-	Saucer Marine Ways, New Orleans, Louisiana, completed modifications of the Palaemon barge.
November 9	-	MSFC and IBM began cost negotiations for the IU lead contract.
November 17	-	MSFC released the IU assembly documentation including detail and subassemblies for the first flight unit (S-IU-201).
November 30	-	MSFC delivered the first IU test unit (S-IU-200V) to Wyle Laboratories in Huntsville for vibrational tests.
In November	-	IBM opened a resident management office at its Huntsville site to facilitate management of the Saturn IB IU contract.
	-	The first redesigned segments of the IU structure arrived at MSFC from General Dynamics/Fort Worth. They will be assembled to form the structure for the IU dynamic test unit.
	-	The prototype preflight IU heat exchanger completed its acceptance test.
	-	On completion of the S-I stage static test program MSFC began modification of the static test stand to support the Saturn IB static test program.

In November	-	MSFC began modification of the Saturn I Dynamic Test Stand to support Saturn IB dynamic testing.
December 1	-	The first mainstage shakedown firing of the S-IVB battleship stage had an engine sequence time of ten seconds.
	-	KSC completed criteria for modification of the service structure at LC-37, and M. Connell and Associates began designs for the modification.
December 3	-	DAC presented to MSFC the results of a study defining a retro system for de-orbiting the Saturn IB/S-IVB from earth orbit to ocean impact areas.
December 8	-	DAC loaded the S-IVB-D stage aboard the States Marine Ship Aloha State at Seal Beach, California, for shipment to New Orleans via the Panama Canal route.
December 9	-	The second mainstage firing of the S-IVB battleship test stage lasted 50.5 seconds.
December 14	-	M. Connell and Associates completed design for the second phase of modification for the LC-34 service structure.
December 15	-	A dummy Apollo payload adapter arrived at MSFC. It will be used in structural test of the IU.
	-	A successful 150-second mainstage shakedown firing of the S-IVB battleship stage ended the shakedown static firing series.
December 21	-	The Aloha State with its cargo--the S-IVB-D--arrived at New Orleans. The S-IVB-D was transferred to the Promise, a river barge, for the remainder of its trip to MSFC.
December 22	-	Following completion of modification and checkout of the S-IB-D/F, CCSD shipped the stage to MSFC for use in dynamic tests of the Saturn IB vehicle.
December 23	-	The S-IVB battleship stage successfully completed the initial full-duration (414.7-second) static firing.

In December

- NASA directed DAC to proceed with a follow-on study defining a retro system for de-orbiting the Saturn V/S-IVB stage with oceans as impact areas. Emphasis would be on a system common to the Saturn IB and Saturn V.

- DAC moved the S-IVB facilities checkout stage to Assembly Tower No. 2 and assembled the forward skirt, aft skirt, and thrust structure to the tank section.

- DAC completed assembly of the forward skirt, aft skirt, and thrust structure for the second S-IVB flight stage (S-IVB-202).

- MSFC modified DAC's S-IVB contract to provide APS pneumatic equipment to the Saturn IB and Saturn V launch complexes at KSC.

- MSFC completed manufacture of a mockup of the IU for use as a development fixture.

- MSFC awarded Atomics International a contract for manufacture of cold plates for the IU vibrational test unit and for the flight units.

- MSFC personnel completed design of the biconic nosecone required for the SA-203 LH_2 orbital experiment. The double-angle nosecone will be used in lieu of the Apollo spacecraft.

APPENDIX C: SATURN V CHRONOLOGY

July - December 1964

July 13 - The U. S. Army Corps of Engineers, as agent for NASA, awarded the $17.2 million contract for construction of Position 2, S-IC Test Stand, at Mississippi Test Operations (MTO), to Koppers Company, Inc.

July 18 - Completed by a contractor at MTO was the Railroad and Classification Yard.

July 27 - MSFC conducted final inspection of the Components and Subassembly Acceptance Building, on which construction ended July 15.

July 31 - Construction ended on the MTO Cryogenics Dock, Canal Extension, and Deluge Intake Structure.

- Military Sea Transport Service (MSTS) completed the modification design for the USNS Point Barrow.

In July - MSFC awarded Rocketdyne Division of North American Aviation, Inc. (NAA), a $3.6 million contract modification covering J-2 engine production equipment.

- MSFC modified the Boeing Company's S-IC stage contract to provide about $16 million in automated ground test and checkout equipment for static firings at MSFC and MTO.

August 1 - Construction, except for minor tasks, ended on the Load Test Annex at MSFC.

August 4 - The S-IC test fuel tank, first structural test component in the Saturn V booster program, underwent hydrostatic testing at MSFC.

August 12 - MSFC awarded to Radio Corporation of America (RCA) a $27 million contract for purchase of 19 RCA 110A ground computer systems.

August 15	-	MSFC awarded a $2 million contract for construction of an extension to the Load Test Annex at Huntsville.
August 24	-	NASA announced that it would purchase 102 additional J-2 engines for Saturn IB and Saturn V vehicles, at an approximate cost of $165 million.
August 25	-	MSFC distributed the Saturn Stage Transportation Plan.
August 31	-	NASA awarded the $265,000 contract for conversion of YFNB No. 20 to the West Coast Barge.
	-	NAA's Space and Information Systems Division (S&ID), prime contractor for the S-II stage, accepted from American Machine and Foundry Company (AMF) the Type I S-II stage transporter.
In August	-	Configuration design of S-II-F and S-II-D stages in the S-II stage development program was "frozen."
September 1	-	The F-1 Engine Test Stand contractor completed construction of the facility at Huntsville.
	-	MSFC notified a contractor to proceed with installation of technical systems of the Saturn V Ground Support Equipment (GSE) Test Facility at the Center.
	-	MSFC Instrument Laboratory construction ended.
September 8	-	A contractor started installation of equipment and instrumentation on the J-2/S-IVB Test Facility at MSFC.
September 10	-	Hayes International Corporation received the $11.4 million contract covering fabrication of Saturn V service arms and related equipment for Launch Complex 39 (LC-39) at NASA Kennedy Space Center (KSC).
September 21	-	At KSC the Corps of Engineers, NASA's construction agent, awarded to the combined firms of Morrison-Knudsen Company, Inc., Perini Corporation, and Paul Hardeman Construction Company the $11.4 million contract for construction of the LC-39 Mobile Service Structure.

September 30	-	Major construction ended on the Saturn V Dynamic Test Facility at MSFC.
October 9	-	MSFC accepted delivery of S-IC transporter No. 102, the first built under contract.
	-	Activation of NASA's $34 million F-1 engine acceptance test complex occurred at Edwards Air Force Base, California. MSFC officials witnessed a readiness firing demonstration on the three new stands.
October 19	-	A construction contractor started work on the project to expand and modernize the MSFC Test Area's High-Pressure Gas System.
October 28	-	The S-II-S stage's aft LOX bulkhead ruptured during hydrostatic pressure test at S&ID's Seal Beach, California, facility, and was damaged beyond repair.
In October	-	Assembly of S-II-S (the S-II structural static test stage) ended at Seal Beach.
	-	Inertial loads testing of the S-IC test fuel tank began at MSFC.
	-	NASA twice modified the Boeing S-IC stage prime contract. One modification covered components for the stage umbilical connections and related hardware. The other concerned the structural static load testing program.
November 2	-	MSFC and Douglas Aircraft Company (DAC), the S-IVB stage prime contractor, completed contract negotiations for the MSFC simulator (S-IVB-500-ST).
November 3	-	Workmen at MTO completed dredging of the East Pearl River and lock approach channel.
November 9	-	S&ID performed a single-engine ignition test on the S-II battleship at Santa Susana Field Laboratory (SSFL), California.

November 10 - Personnel conducting a load test of the 100-ton derrick at the MSFC F-1 Engine Test Stand accidentally dropped the 100-ton load, causing considerable damage to the stand.

- Construction began on the Launch Equipment Shop at KSC's LC-39.

November 14 - Work ended on the Saturn V Systems Development Breadboard Facility (SDBF).

November 15 - Construction ended on the Saturn V Barge Dock and Loading Facility at MSFC.

November 20 - MSFC's Manufacturing Engineering (ME) Laboratory completed welding of the S-IC-S fuel tank.

November 21 - S&ID conducted a transition firing test on the S-II battleship.

November 26 - The first mainstage firing of the single-engine S-II battleship at SSFL ended after 2.8 seconds.

In November - The support contractor completed the Saturn V Systems Development Breadboard Facility (SDBF) development plan and submitted it to MSFC for approval.

- Rocketdyne performed J-2 engine preliminary flight rating tests (PFRT) at SSFL.

- MSFC awarded a contract for installation of activation hardware on the Center's S-IC Static Test Stand.

December 1 - The S-IC-S fuel tank underwent hydrostatic testing at MSFC.

December 2 - S-II stage electro-mechanical mockup (EMM) personnel performed the first environmental engine gimbal operation at Downey, California.

December 4 - The $8 million construction contract for S-II Test Stand A-1 at MTO went to Koppers Company.

December 10	-	MSFC awarded a contract for an extension to the Components Test Facility instrumentation.
December 11	-	S&ID achieved a 10-second full-thrust firing of the S-II battleship. This major milestone completed the single-engine test program for the stage.
	-	NASA approved a $7.4 million contract for purchase of seven Saturn V operational display systems from Sanders Associates, Inc.
	-	The J-2 engine demonstrated its restart capability, a significant milestone in the engine development program.
	-	Derrick load tests started on the MSFC J-2/S-IVB Test Facility as construction neared an end.
December 12	-	The Corps of Engineers notified the firm of G. A. Fuller to proceed with construction of Pad B and Crawlerway at LC-39. The $19 million contract for the second Saturn V launch pad had been awarded to Fuller on November 30.
December 15	-	Construction of the Vertical Assembly Facility at MSFC's Michoud Operations ended.
December 18	-	MSFC personnel joined the LOX and fuel tanks of S-IC-T (static firing stage) to the intertank in the Vertical Assembly Facility.
December 23	-	MSFC placed the S-IC simulator in the Static Test Stand to check out stage handling procedures, equipment, and clearances.
December 24	-	NASA awarded Boeing an $89.9 million contract modification calling for Saturn V vehicle systems engineering and integration support.
In December	-	Rocketdyne completed the F-1 engine flight rating tests (FRT).

In December - S&ID completed fabrication of the first S-II stage common bulkhead, a major accomplishment.

- MTO construction contract awards included: warehouse additions and site work, to Fullerton Construction Company for $1.6 million; roads, parking areas, and scale, Components Service Facility, and site work, to Hyde Construction Company and Thornton Construction Company for $1.7 million; and Mobile Equipment Maintenance Building, to Carpenter Brothers for $1.1 million.

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