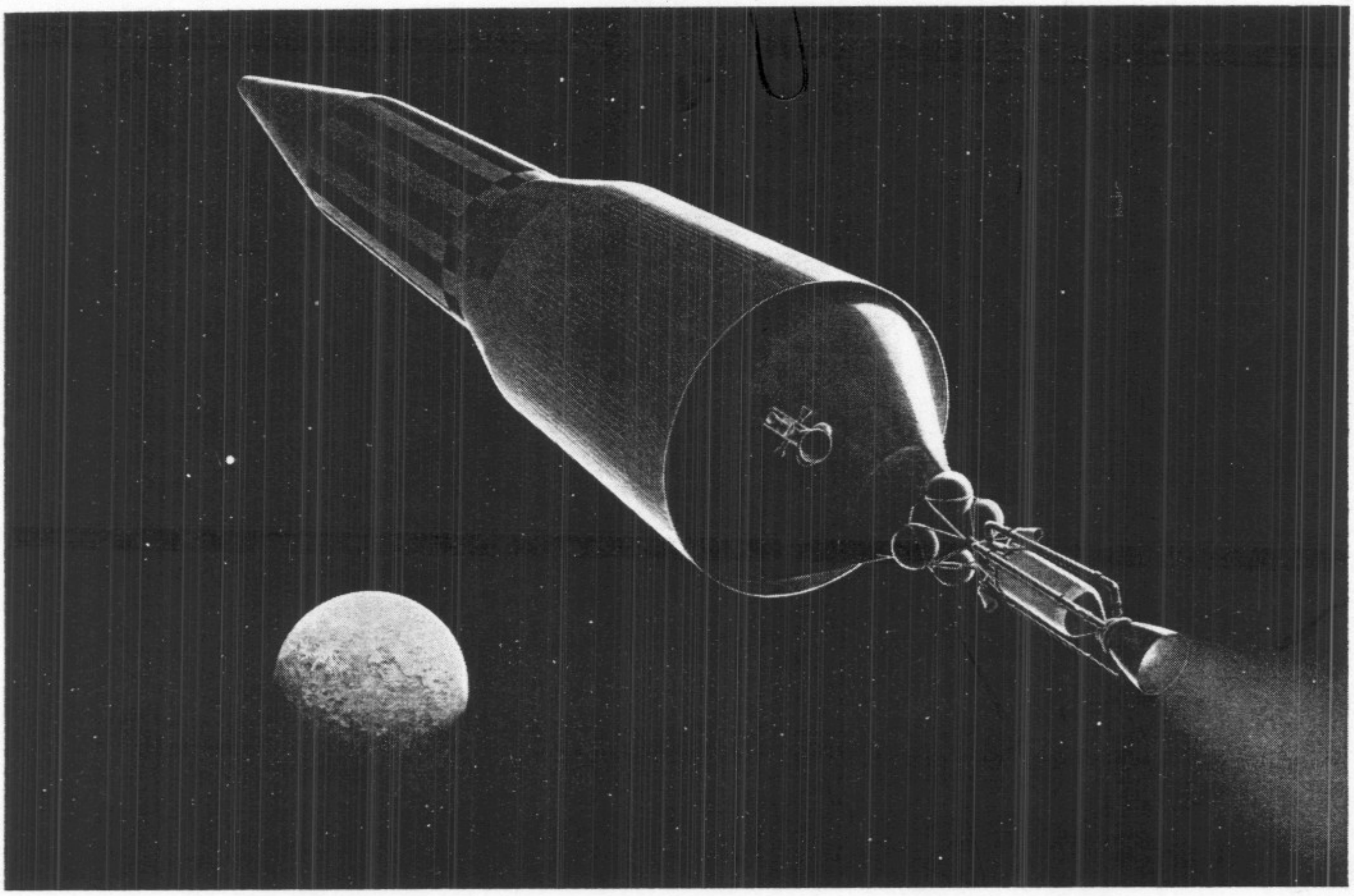


Illustration courtesy of Lockheed Missiles and Space Co.

RIFT

The first nuclear-rocket vehicle, Rift, moves toward flight tests on firm state-of-the-art ground, anticipating early application of nuclear propulsion to space exploration

BY COL. W. SCOTT FELLOWS
NASA MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

IT IS now recognized that ambitious manned missions in space will require vehicles utilizing engines having a greater specific impulse than chemical rockets give. The application of a nuclear-rocket stage to large launch vehicles will increase payload capability by a factor of two or three for near-earth missions and even more for deep-space missions. Conversely, a nuclear-rocket stage allows a lighter launch vehicle for a given payload. Project Rift (Reactor-in-Flight-Test) will furnish the vehicles for the first flight tests of nuclear-rocket engines and will demonstrate the practicality of nuclear-rocket propulsion for space-vehicle application.

Scope of Project. The Rift project consists of the design of the nuclear stage, the associated research and development necessary to qualify materials and components which will adequately withstand the added environment of nuclear radiation, the fabrication and assembly of the stages for static testing and launching, integration of the Nerva engine and other systems into a complete stage and the stage into a complete vehicle, and, nish solutions to problems representative of those expected of nuclear stages in such operational applications.

The illustration opposite shows a Saturn C-5/N vehicle for a typical lunar-escape mission. It consists of an S-IC stage, an S-II stage, the nuclear S-N stage, lunar-landing and escape stages, and a spacecraft.

The plot on page 40 shows an operational application of such a vehicle in a lunar mission. The Saturn C-5/N boosts from earth using the S-IC and S-II chemical stages and injects into earth orbit with the first operational cycle of the S-N stage. The vehicle coasts in orbit, and then injects into an earth-moon transfer trajectory with the second operational cycle of the S-N stage. After a 60-hr coast to the moon, the vehicle applies a retro maneuver using a third operational cycle of the S-N stage to achieve lunar orbit.

toward maximum utilization of static tests in the development of the nuclear-stage in order to keep the cost of the program to a minimum. Rift development philosophy requires that the hardware flown in the flight tests be identical to that used in the preflight testing, and that the necessary modifications required by these tests be reflected as final design changes. Therefore, reliability, quality assurance, and nuclear safety have, and will continue to have, the greatest influence on the design of the stage and the development test program.

Contract Status. Lockheed Missiles and Space Co. was selected this past spring as the prime contractor for the Rift project. The contract was signed and structures. Since Rift will respond to progress in the Kiwi and Nerva projects, actual fabrication of nuclear stages is not scheduled to commence until 1963, following successful Kiwi tests with liquid hydrogen.

Project Management. Responsibility for managing the Rift project was assigned to the Marshall Space Flight Center a year and a half ago. Up to that time, work had been limited to studies concerning missions for nuclear-propulsion systems and their application to space vehicles, definition and conceptual design of such systems, radiation-environment analyses and effects, shielding, range safety, and nuclear flight test methods. Now Marshall is bringing its experience and facilities to the task of developing and integrating Rift with its other programs, particularly the Saturn C-5 development.

The Rift project is managed in a similar fashion to the other major proj-

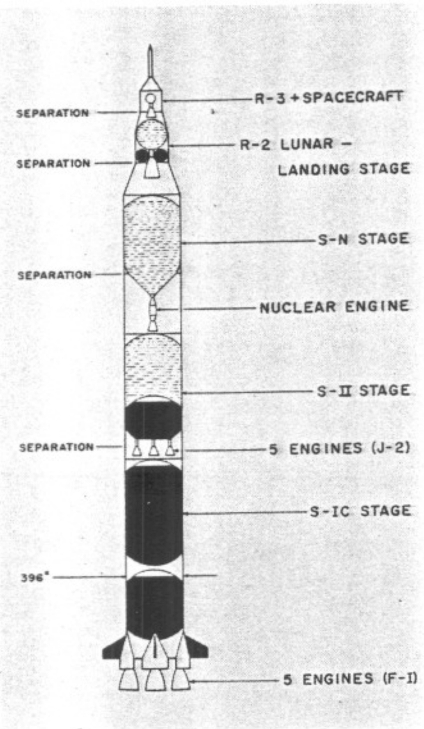
management, personnel, legal, and similar functions are handled by the appropriate administrative offices. Strong technical support, including monitoring the work of contractors, is provided to each of the project offices by the line divisions. This type of organization provides an excellent means for rapidly communicating technical information among the many scientific and engineering disciplines involved. It also allows the full technical and managerial talents within Marshall to be brought to bear on any problem as it arises in any of the projects.

The Nuclear Vehicle Projects Office, established at Marshall a year and a half ago, at the same time the nuclear-rocket responsibilities were assigned, ect manager acts for the Rift project manager in handling program matters on the spot and has a "business representative" assigned to perform contracting actions commensurate with his delegated authority. In a similar fashion a representative of NVPO will also be established at the Nuclear Rocket Development Station in Nevada as soon as necessary.

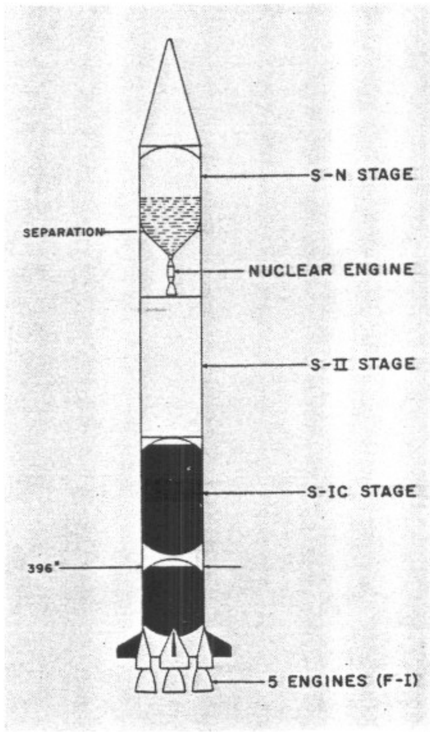
To provide working-level information on Rift to the Nerva project, the NVPO project engineer for propulsion integration is a member of the Nerva Technical Committee, which has members from all the agencies and contractors having responsibilities in the Nerva project, and therefore provides a forum for review of technical details and problems encountered in development of the reactor and engine. This project engineer, moreover, chairs the Nuclear Propulsion Review Committee, which includes representatives from all Marshall line divisions and relations provide the means for rapid exchange of information on the nuclear vehicle and its engine.

Rift is the only spaceflight system at Marshall not having the engine development for the designated stage also assigned there. The project therefore has an additional organizational interface between engine and stage. An Engine-Vehicle Interface Coordination Committee has therefore been formed to work with the contractors to define and resolve engine and stage interface problems. The Space Nuclear Propulsion Office (Cleveland Extension) and the Nuclear Vehicle Projects Office project engineers, working through normal project channels, assist and participate as required.

TYPICAL C-5/N CONFIGURATION



TYPICAL RIFT CONFIGURATION



Program Plan. The chart on page 43 describes the time phasing of the various engineering activities required to accomplish the Rift project. The program emphasizes flexibility; that is, development activities are keyed to milestones in the Kiwi and Nerva projects.

As now envisioned, Rift objectives are expected to be achieved with the completion of the fourth launch. In all, 10 Rift stages are planned for fabrication. The table on page 41 lists stages required. It also indicates destination and purpose of each stage. The first two stages scheduled for fabrication will be of the "battleship" type. These stages are required at the Nuclear Rocket Development Station in the initial phases of the static-test program to checkout facilities and to start the preliminary engine and vehicle test program; and they are also important to verify, for the first time, the tooling and manufacturing techniques and to check quality-assurance and reliability programs. These stages have been designated S-N-TA.

The next three stages fabricated will be of the Rift flight configuration, insofar as possible. These three stages are also scheduled for the Rift static-test program at the Nuclear Rocket Development Station, and can be used over and over again in static tests with Nerva engines. They have been designated S-N-T.

A Rift stage is also required for dynamic testing in Marshall's Dynamic Test Stand with the Saturn S-IC-D and S-II-D boosters. This stage has been designated S-N-D.

The last four stages scheduled for fabrication, designated S-N, are for the four launches, and will be delivered directly to the Atlantic Missile Range. They will not have been checked out at the Nuclear Rocket Development Station with the specific Nerva engine scheduled for the stage, as would be the case for a chemically powered stage. Even after a single run at full nuclear power the stage and its components would become radioactively "warm," preventing hand, or contact, assembly and checkout. The Nerva engine would also become radioactively "hot" and remote handling techniques would be required. This is not desirable for launch operations in the present state of technology, although with operational experience this safety concern may well prove to be overemphasized. So Rift stages launched from the Atlantic Missile Range will be essentially in a virgin state.

The Rift Vehicle. The Rift launch-vehicle system consists of the following building blocks, sketched at the left: the S-IC stage, the S-II stage, the S-N, stage, the instrument unit, the nose cone, and the automated-checkout launch system.

The S-IC first stage is 396 in. (nominal) in outside diameter and approximately 138 ft long. It is powered by five Rocketdyne F-1 engines with a total nominal sea-level thrust of 7.5-million lb.

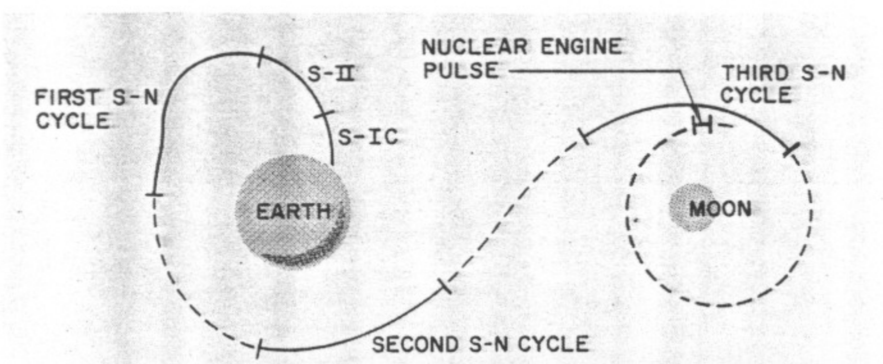
THE S-II stage, also 396 in. (nominal) in outside diameter, is approximately 81.5 ft long. It is powered by five Rocketdyne J-2 engines with a total nominal thrust of 1-million lb in vacuum. For Rift flights, the S-II stage to be used will be a dummy, however.

The Rift S-N stage will be 396 in. (nominal) in outside diameter and approximately 80 ft long including the interstage structure. It will be powered by the Nerva engine using liquid-hydrogen propellant.

The instrument unit, a torus 396 in. in outside diameter and 36 in. long, rides above the S-N stage. The nose cone joins the S-N stage at the forward end of the instrument unit; it has a half angle of 15 deg, is 396 in. in diameter at base, is about 57 ft long.

A recently implemented plan for automatic launch-vehicle checkout has been incorporated into the Rift proj-

LUNAR-MISSION PROFILE



ect. It will allow rapid testing and checkout (with malfunction indication and localization of failure source) of nuclear vehicles as part of the over-all Saturn program. Possible failures have been analyzed to provide design criteria for mechanical and electrical automation and emergency-detection systems.

S-N-Stage Design Features. In general, the design requirements for the operational S-N stage exceed the requirements for the Rift S-N stage. Consequently, the Rift S-N stage design provides a conservative structure and propulsion system for accomplishing flight-test objectives.

ENGINE gimbaling gives thrust-vector control in pitch and yaw. Turbine-exhaust nozzles can be used to provide roll control during engine operation. In addition, an auxiliary storable-bipropellant attitude-control system provides roll as otherwise needed during Nerva engine operation and for control of pitch, yaw, and roll during coast phases with the engine shut down. Thrust-vector control requires only low gimbal rates and accelerations. The engine's gimbal actuators have locks for protection from both transportation loads and loads during chemical-stage boost.

The over-all stage structure, shown on page 42, includes a forward elliptical dome welded into an integral forward tank skirt. External integral stiffeners and internal frames make the skirt rigid to provide an efficient unpressurized load-carrying structure. The aft tank bulkhead is welded to the cylindrical tank section at the transition between the tank and aft skin structure. The aft bulkhead has a major shape of a 45-deg half-angle cone following an elliptical transition starting at the weld line. Engine thrust and gimbal loads are transmitted through a monocoque thrust cone to load ring integral with conical wall. The engine attaches to aft end of the thrust cone by pneumatic-actuated marmon clamps. A zero-leak propellant-isolation valve, installed in series with the main propellant valve, is provided at the tank outlet for safety, prevention of inadvertent flooding, and heat-leak minimization. The propellant tank is insulated internally with 1-in.-thick semi-rigid polyurethane foam bonded to the wall with epoxy resin. A vapor barrier in contact with the liquid hydrogen consists of 1-mil aluminized Mylar film protected by a two-ply fiberglass cloth.

S-N electronic instrumentation, control equipment, and engine programmer together with associated umbilical plugs are located in an equipment bay subdivided into modular compartments in the forward skirt area. These compartments, accessible from the umbilical tower, are designed to prevent the possibility of inadvertently mixing replaceable packages. Flush antennas and destruct receivers are strategically located around the skirt. The propulsion-system gas accumulator and associated feed lines, and the externally supplied nose-fairing purge and air-conditioning distribution system, are located above the equipment bay.

The aft skirt houses umbilical connection for an 8-in.-diameter fill and drain system, purge systems for engine and interstage disconnect fittings for the gaseous-hydrogen-pressurant ground charge system, and auxiliary rocket systems for ullage and attitude control. The liquid-hydrogen fill system will deliver 10,000 gpm and has a drain rate of approximately 6600 gpm. It is equipped with a zero-leak quick-disconnect valve.

The interstage joins the Rift S-N and the S-II stages. A riveted assembly, it is designed to transmit all flight and "free-standing" loads to the lower stages.

Radiation Considerations. The use of nuclear energy as a source of power for rocket propulsion introduces a new environment—nuclear radiation—to the state of the art of rocket design, and introduces special engineering design requirements.

The vehicle profiles on page 43 indicate the difficulties encountered in ground testing and flight of a nuclear vehicle by the impingement of direct and scattered radiation on the test stand, adjacent facilities, the vehicle's structural and functional components, and propellant. There is a hazard to personnel by direct and scattered radiation, as well as a contamination of the test stand due to the expulsion of radioactive fission products in the rocket's exhaust. The activation and excessive heating of materials near the radiation source will require careful engineering design and materials selection for those structural and operational components which make up the test stand. Then, too, in order to closely simulate the actual flight environment during tests, it will be necessary to design radiation shielding which will reduce the amount of incident radiation reflected or scattered back to the vehicle.

The effect of the radiation and environment on cables, signal-conditioning equipment, valves, actuators, transducers, and insulation materials used on the vehicle will also require careful consideration, especially for successful operation of the vehicle during flight in the atmosphere. The radiation-sensitive guidance, control, tracking, and telemetry equipment will be located in the payload region where the radiation, consisting of gammas and neutrons, will be at a minimum.

Most of the neutrons passing directly through the propellant will be absorbed in the liquid hydrogen. The energy transferred to the subcooled liquid propellant by the nuclear radia-

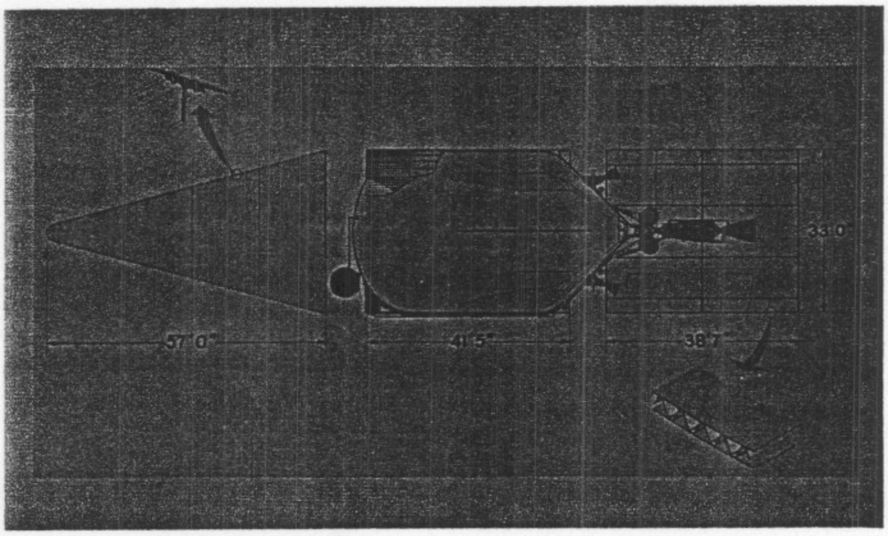
RIFT STAGE TYPE AND PURPOSE

DESIGNATION	TYPE	DESTINATION	PURPOSE
S-N-TA 1	Battleship	NRDS	Rift Testing
S-N-TA 2	Battleship	NRDS	Rift Testing
S-N-T 1	Preliminary Flight Configured	NRDS	Rift Testing
S-N-T 2	Flight Configured	NRDS	Rift Testing
S-N-T 3	Flight Configured	NRDS	Rift Testing
S-N-D	Flight Model	MSFC	Dynamic Test
S-N-1	Flight Configured	AMR	Flight Mission 1
S-N-2	Flight Configured	AMR	Flight Mission 2
S-N-3	Flight Configured	AMR	Flight Mission 3
S-N-4	Flight Configured	AMR	Flight Mission 4

tion will result in a rise in the saturation temperature and pressure. These effects are now being investigated to determine their influence on the fluid flow model and the thickness of the tank walls.

Radiation considerations for the vehicle in space differ from those in air, the major difference being that once out of the earth's atmosphere the vehicle no longer experiences a buildup of radiation in any direction due to air scattering. Therefore, direct radiation from the nuclear engine is the major consideration in determining shielding requirements. However, consideration must also be given to the additional source of high-energy electromagnetic and charged-particle radiation which exists in the space environment.

INBOARD PROFILE OF RIFT



Radiation-Testing Program. Before the first full-run testing of the Rift stage at the Nuclear Rocket Development Station, information will be required by design engineers to produce radiation-hardened systems. The performance of an electronic, mechanical, or pneumatic system in a nuclear environment to a large extent depends on the reliability of each of the separate components or parts which make up the system. The components in turn depend on the reliability of materials.

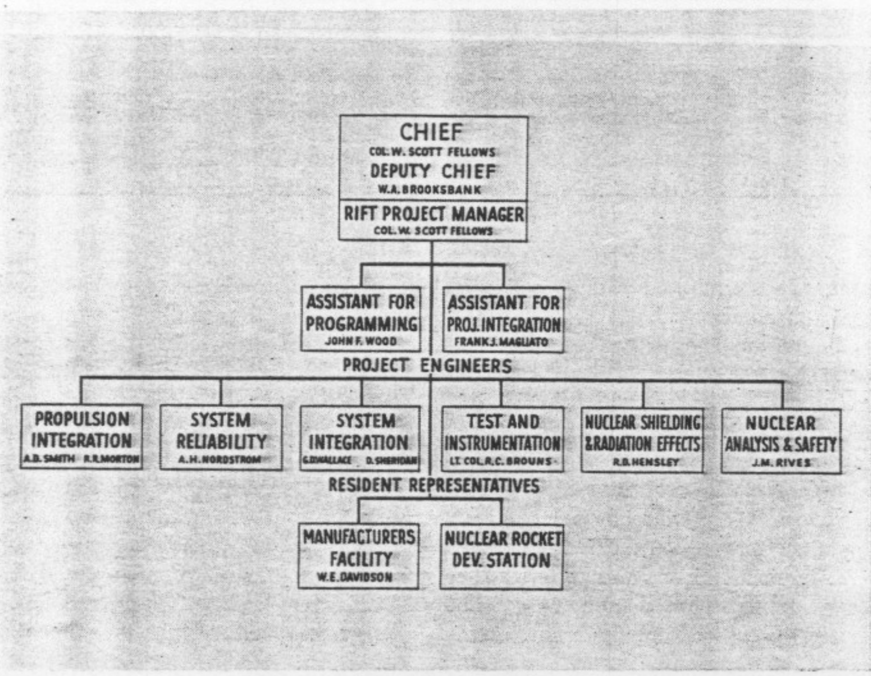
There is at present no theory that will analytically correlate the amount of nuclear radiation which a material receives with resultant property changes of the material. For this reason the study of radiation damage is directly associated with experimental data. One of the important purposes of a Rift radiation-testing program is to determine the amount of radiation-induced deterioration in vehicle components and subsystems. This will be accomplished through an extensive materials screening and selection program in which tank insulation, cables, connectors, auxiliary propellants, explosives, nuclear detectors, and sealant materials are irradiated. Later, off-the-shelf hardware items such as transducers, pressure regulators, valves, flow meters, gages, and data-link subsystems will be tested. Where necessary, all materials and components will be radiation-tested in vacuum, using vibration at cryogenic temperatures to determine the synergistic effects of the combined environments.

Experiments are planned to provide certain basic information relating to the attenuation of nuclear radiation in liquid hydrogen and to analyze the influence of this energy absorption on the hydrodynamic characteristics of the pressurized propellant system. The information gained from these experiments will be used to confirm the data being used in the propellant-heating calculations for an analytical computer program on hydrodynamics.

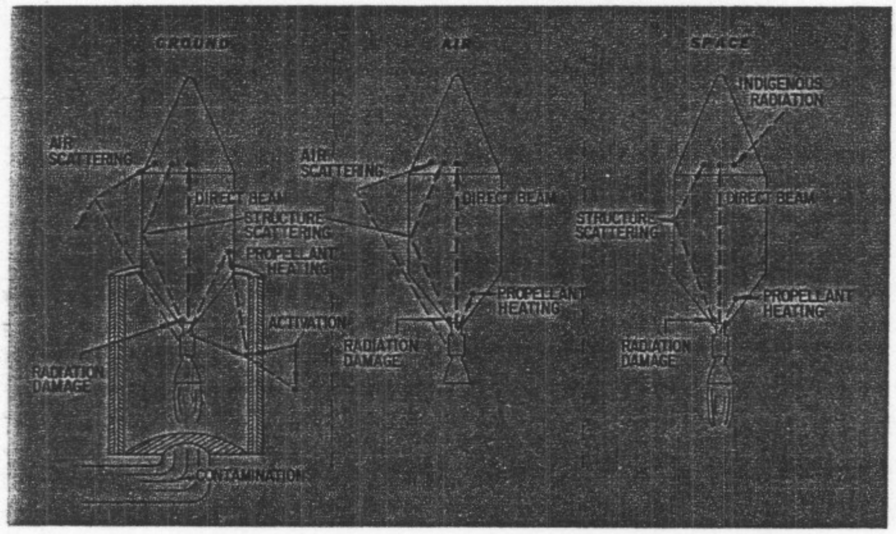
Radiation testing will also be performed on those Marshall Space Flight Center-furnished assemblies and systems that make up the instrument unit. The guidance and control, telemetry, and tracking equipment making up this unit will have to be radiation-hardened in the same manner as are other items of stage hardware. The development procedures to be used for these radiation-sensitive components will consist of multi-component irradiation, subsystem (black box) irradiation, and a complete system checkout during the preflight qualification testing. Because the instrument unit aboard the Rift stage will not be pressurized, it will be necessary to perform the development testing of the electronic subsystems in a large-scale vacuum simulator located near a nuclear reactor.

The Lockheed-operated Georgia

NUCLEAR VEHICLE PROJECTS OFFICE MARSHALL SPACE FLIGHT CENTER



RADIATION CONSIDERATIONS FOR NUCLEAR VEHICLES



Nuclear Laboratories (GNL), located on an 11,500-acre reservation near Dawsonville, Ga., is performing the Rift radiation testing. The main facilities of GNL are a Radiation Effects Laboratory containing four large hot-cells, a hot-materials transportation system, a radiation-effects reactor, and a nuclear-support laboratory.

THE radiation testing started in Aug. 1962. This testing program will provide design engineers with the experimental data necessary to select materials and components for manufacturing and assembling the first test vehicle that will be used at the Nuclear Rocket Development Station in Nevada.

The final checkout of all radiation-hardened systems will be accomplished in the test environment provided at the Nuclear Rocket Development Station during the preflight qualification testing of the Rift vehicle.

Stage Manufacture and Assembly. A Rift-stage manufacturing plan has been developed which outlines the major fabrication, assembly, test, and checkout operations with associated tooling and test equipment. In this plan, components and subassemblies will be procured, in conformity with a Rift "make or buy" policy, from subcontractors and sources that have demonstrated their ability to produce high-quality, reliable material. At the Rift assembly facility, all components and materials will undergo rigorous receiving inspection, proper identification, and incorporation into the fabrication and assembly operations.

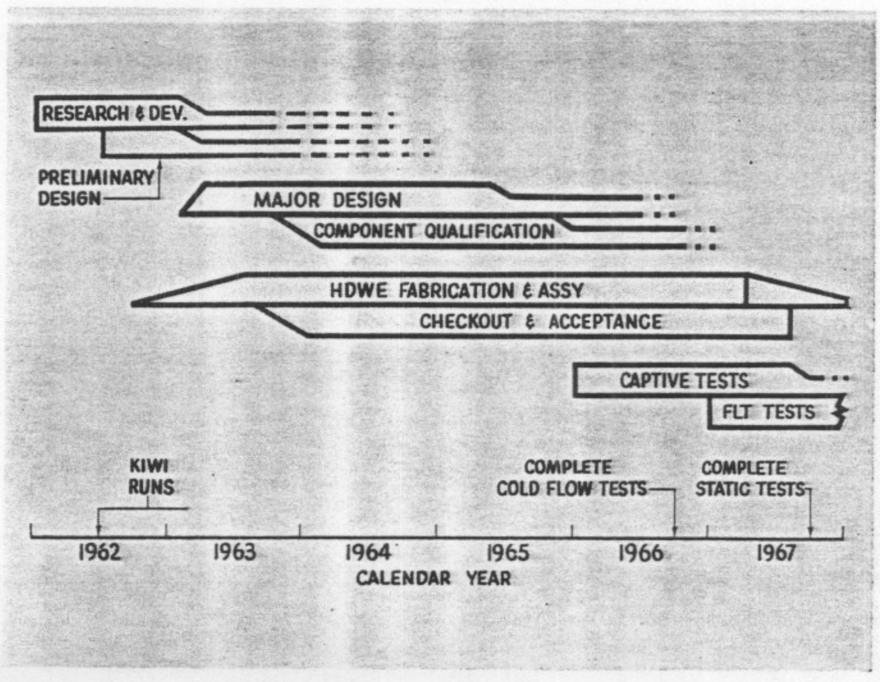
The following assembly sequence for a Rift stage is illustrated on page 44. The propellant-tank forward and aft ellipsoidal bulkheads will be assembled in a multiple-use weld fixture that provides for trimming, welding, radiographic inspection, milling, drilling, and other manufacturing and inspection operations. The propellant tank includes forward and aft barrel sections, in which the tank bulkheads will be subsequently welded, and three additional center barrel sections. Each of these barrel sections will be composed of four integrally stiffened skin panels that will be assembled in a weld fixture which provides for trimming, vertical "out-of-position" welding, radiographic inspection, and other operations.

Assembly of the forward and aft bulkheads to their respective barrel sections will be provided by a common weld fixture. The fixture will provide for circumferential locators for the tank barrel to establish the correct relationship to either the forward or aft bulkhead, welding, radiographic inspection, trimming, and other operations.

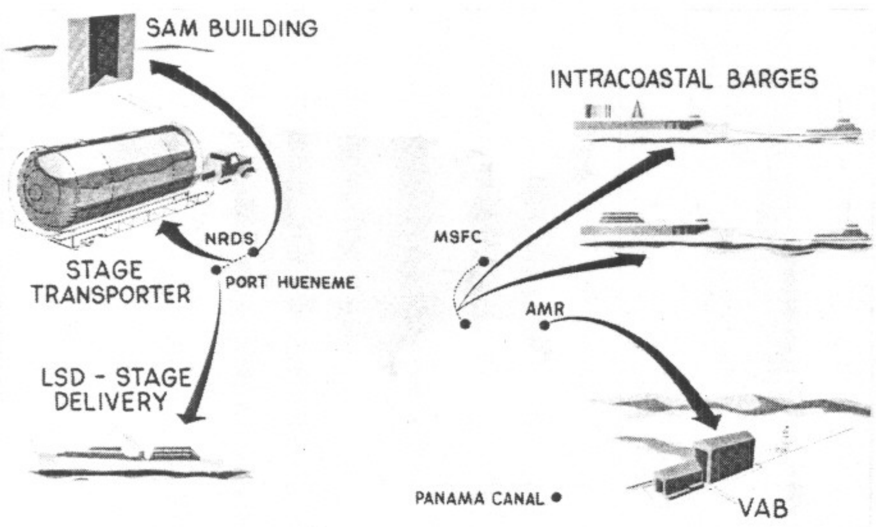
Assembly of the propellant tank, which consists of the forward and aft sections and the three center barrels, will be accomplished in a vertical six-level tower accommodating all girth welding, assembly, and radiographic-inspection operations. After installation of the forward and aft closures, a low-pressure leak test of the tank structure will be accomplished using halide leak detectors and gaseous nitrogen containing a halide-bearing tracer. The propellant tank will then be moved to the hydrostatic test stand.

The sequence of final assembly operations performed on the Rift stage will begin following hydrostatic test and cleaning of the propellant tank. The propellant tank will rest on a vertical support fixture which has a hydraulically elevated work platform for installation of insulation, instrumentation, and pneumatic-system equipment. Upon completion of the

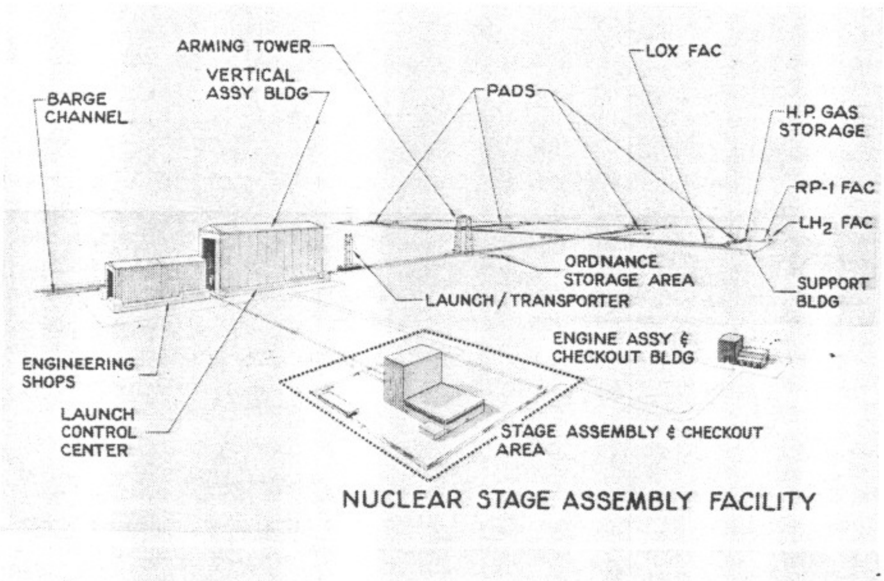
RIFT DEVELOPMENT PROGRAM PLAN



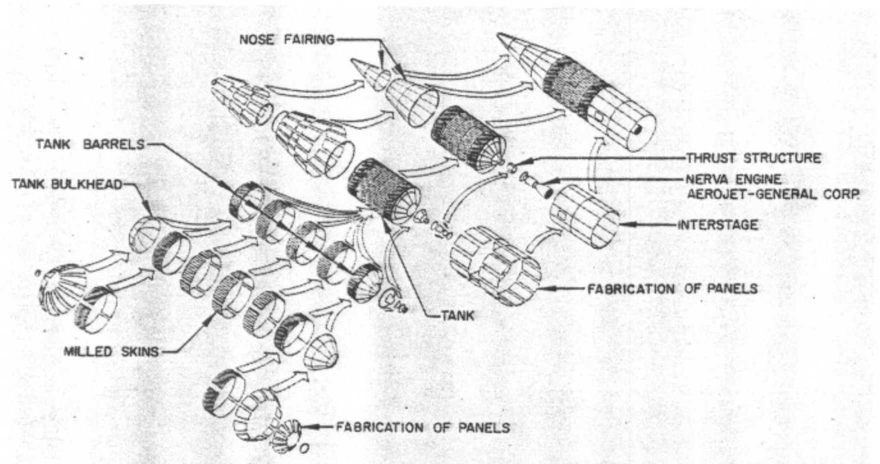
RIFT TRANSPORTATION MODES



TYPICAL RIFT LAUNCH COMPLEX



MANUFACTURING SEQUENCE FOR THE RIFT VEHICLE



first phase of final-assembly operations, the tank will undergo a cold-soak test at a Cold-Flow Test Facility adjacent to the manufacturing facility.

Final assembly and checkout will be done through a support fixture which positions the stage vertically above the floor level. This will provide access for mating of a dummy engine and checking out by automated digital-computer equipment, which will be similar to that used in static-test and launch operations.

The nose-cone assembly, nose-cone adapter, and the interstage will be assembled in fixtures which will provide for correct relationship of panel and ring segments, drilling, installation of mechanical fasteners, and other manufacturing and inspection operations. Following final assembly and system checkout, the stage will be mated and optically checked for alignment. The stage weight and balance will be determined after which the stage will be prepared for shipment. A multiple-use fixture will serve as a structural test fixture and as a stage-mating and alignment dock.

Extensive factory testing will be performed as an integral part of the manufacturing operations to maintain rigorous quality and reliability standards. The drawing on page 45 shows the factory test sequence for a Rift stage.

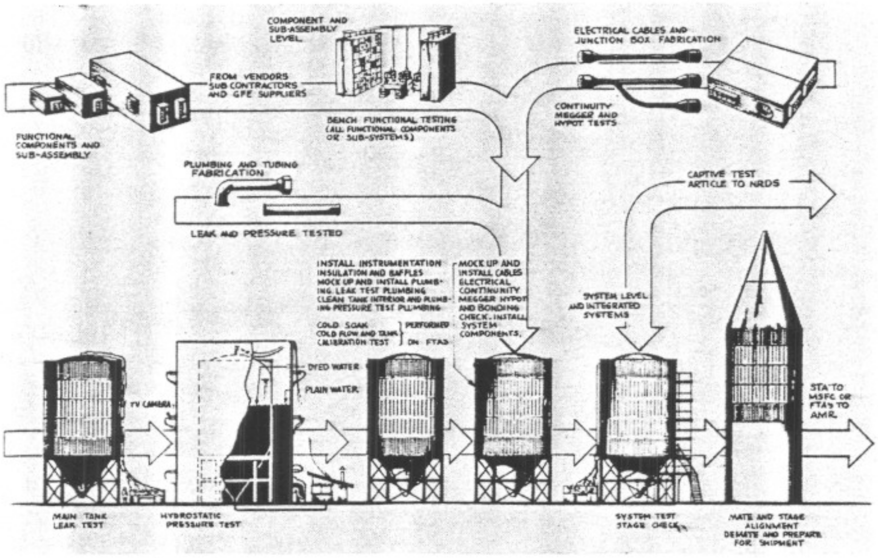
All procured components will be inspected for shipping damage and compliance with procurement specifications. Electrical components will be tested for continuity, shorts, opens, insulation resistance, and proper functioning. Mechanical components such as valves, regulators, and filters will be tested for compliance with critical characteristics and to insure proper operation.

Following radiographic weld inspection, a low-pressure leak test of the propellant tank will be performed using gaseous nitrogen and halide leak detectors to assure complete seal of all weld joints.

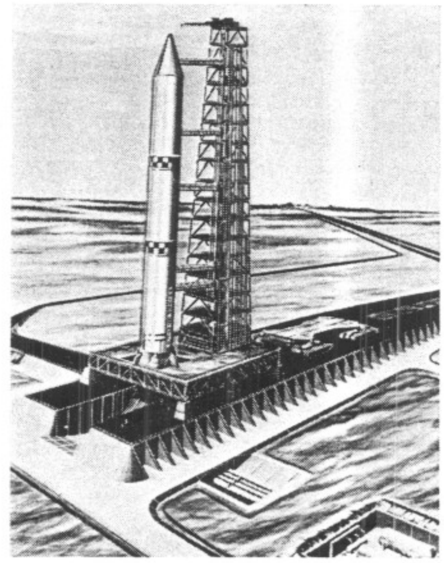
Hydrostatic pressure tests will then be conducted on the propellant tank to assure material, fabrication and weld integrity. The propellant tank and the hydrostatic test facility will simultaneously be filled with water to prevent undue stress on the propellant tank. Pressure and structural tests will be performed under water.

After installation, the pneumatic

FACTORY PLAN FOR RIFT STRUCTURE



LAUNCH SETUP FOR RIFT



system and plumbing will be purged with low-pressure nitrogen and then leak-tested using halide detectors and selected liquid solutions. Pressure tests will be conducted at or near system pressure, and all valves and controls will be cycled and checked for proper operation.

Before installation of additional system components, the propellant tank will undergo cold-soak, cold-flow, and calibration tests at the Cold-Flow Test Facility. These tests of the insulated and instrumented propellant tank will be performed by loading liquid hydrogen at the design rate.

During final assembly operations, integrated-system tests will be performed utilizing automated, computer-controlled checkout equipment. Tests will be performed on auxiliary controls, electrical networks and the power supply, instrumentation, and guidance, control, and propulsion systems. A simulated flight test will be performed to demonstrate system compatability and to prove stage qualification for static or flight tests.

Transportation. Transporting the 33-ft-diam Rift stages will be difficult, and requires considerable advance planning. As illustrated on page 44, these stages must be moved from the manufacturing site to the Nuclear Rocket Development Station in Nevada, to the Marshall Space Flight Center, Ala., and to the Atlantic Missile Range launch site. Transportation will require both land and sea modes. Air transportation, although considered, was not found to be practical with the planes available.

In all cases, the Rift stages listed on page 41 will be loaded aboard a specially designed rubber-tired land transporter at the manufacturing site and will remain on it until the final destination is reached. Transfer for water shipment will be by means of the transporter and a prime mover; long-haul ocean trips by deep-draft vessels such as an LSD or a rail-car ferry; and river movements by shallow-draft barges. In some cases, a single movement will require several changes in transportation mode. For example, a movement from the manufacturing site to the Marshall Space Flight Center may require, in sequence, land transport, barge to reach deep water, deep-draft vessel to a Mississippi River port, shallow-draft vessel up the Mississippi and Tennessee rivers, and land transport at Marshall.

The greatest problem will be transporting the Rift stage from a West Coast port over about 425 mi. of California and Nevada highways to the Nuclear Rocket Development Station. Each movement must be closely coordinated with the highway department of each state, with all public utility companies, and even with some private property owners. Detailed land-route surveys have been conducted to determine the extent of required route modifications, such as raising or relocating power and telephone lines, trimming trees, and widening, straightening, or leveling roads.

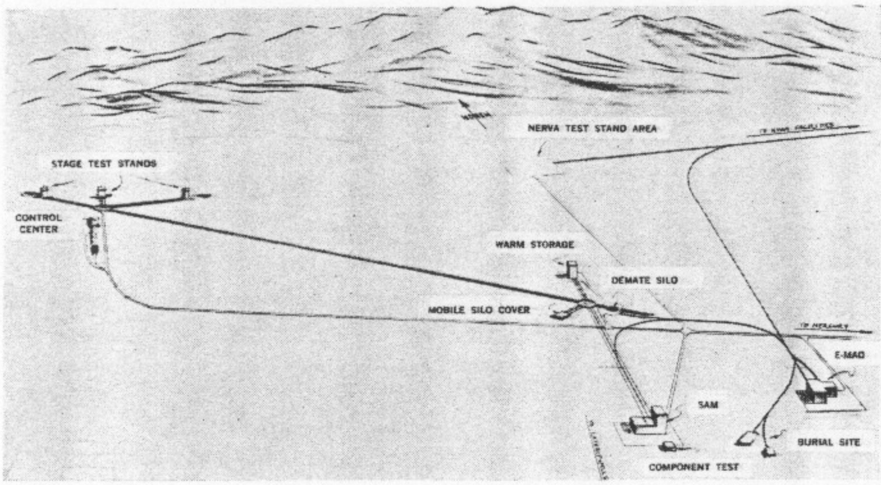
Static-Test Facility. The Rift stage will go through extensive static-firing tests at the Nuclear Rocket Development Station (NRDS), which lies approximately 90 mi. northwest of Las Vegas. On page 46 appears an artist's conception of the planned Rift test-facility complex. It will adjoin the test facility presently under construction for Nerva, which in turn adjoins the facility where Kiwi-reactor tests are being conducted and where Nerva-engine tests will be run. The Engine Maintenance and Disassembly Building (E-MAD) of the Nerva site is shown because it is needed in the Rift project to provide engine maintenance and inspection following nuclear operation.

The activities at NRDS can best be described by following a typical Rift stage through the site. The Rift stage, minus engine, will be delivered to the NRDS Stage Assembly and Maintenance (SAM) Building aboard a land transporter. This building will contain a bay for erection and assembly of stages upon arrival at the NRDS, and maintenance of stages (minus engine) that have previously been tested, work areas for assembly of guidance and control equipment, plus maintenance shops, stage-checkout equipment, a data-acquisition system, and office space.

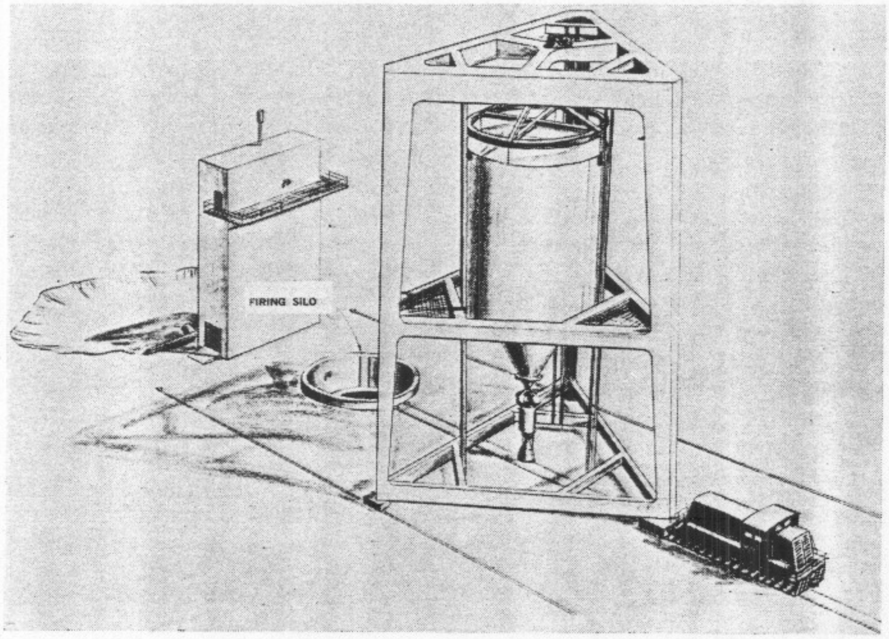
At the SAM Building, the stage will be mated to a nuclear "cold" Nerva engine and receive a thorough inspection and functional checkout of all components.

When qualified for static firing, the stage will be moved by a transporter on a railroad track to one of the test stands. The sketch on page 46 shows

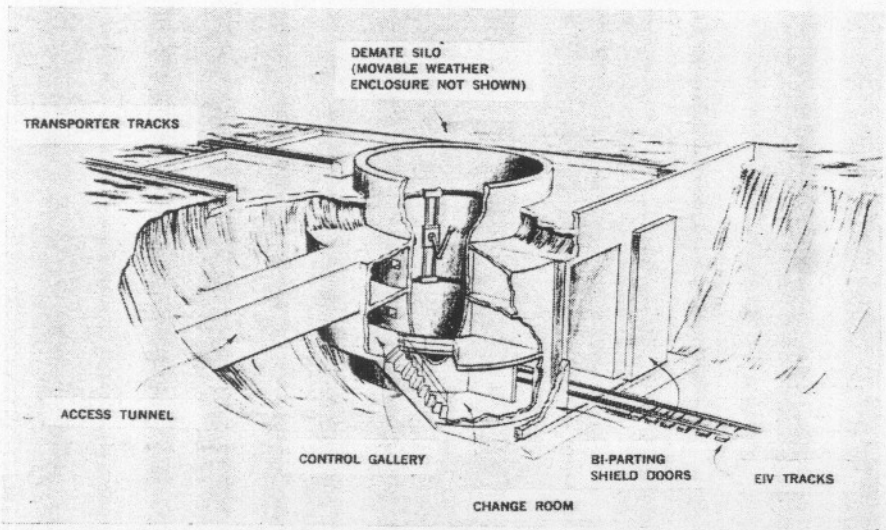
NRDS STATIC TEST SITE CONCEPTS FOR RIFT STAGES



NRDS TEST STAND FOR RIFT STAGE



NRDS DE-MATE FACILITY FOR RIFT



an artist's conception of a stage in its transporter approaching a test stand. When at the test stand, the stage will be lowered so that the engine portion will be below grade in a test cell. Each test position will be able to static test the complete Rift flight configuration vertically downward with full power and altitude simulation. Each test position will also have engine-exhaust ducting, altitude simulation on the engine during firing, and all necessary termination points for connection of cryogenic systems (liquid hydrogen), high-pressure gases, and data-acquisition and control systems.

After a thorough preparation and checkout at the test stand, the stage will be put through an engine startup, firing, and shutdown sequence. All firing tests will be remotely controlled from a shielded control center. This will be provided with consoles and equipment for area radiation monitoring and complete checkout, control, data acquisition and recording, and monitoring of all phases of the test-stand operations.

Following power operation, the Rift stage will be disconnected remotely from all service connections at the test stand and taken on the transporter to a de-mating facility. This facility will be used to uncouple the engine from the stage remotely after the engine has been operated for any substantial time and is radioactively "hot." The sketch at bottom shows an artist's concept of the de-mating facility and indicates some principal features.

After the engine has been uncoupled from the stage, it will be taken to the E-MAD Building by an Engine Installation Vehicle (EIV) for either maintenance or inspection, as required. The stage, after engine removal, will be transported to an open cooldown area, where it will be stored for several days to allow radioactivity to decay to a point sufficiently low for contact maintenance and servicing. It will then be returned to service in the SAM Building for mating to another engine for further testing.

In addition to laboratories in the SAM Building, a Components Test Area will also be provided for nonnuclear testing of various stage components in a cryogenic environment.

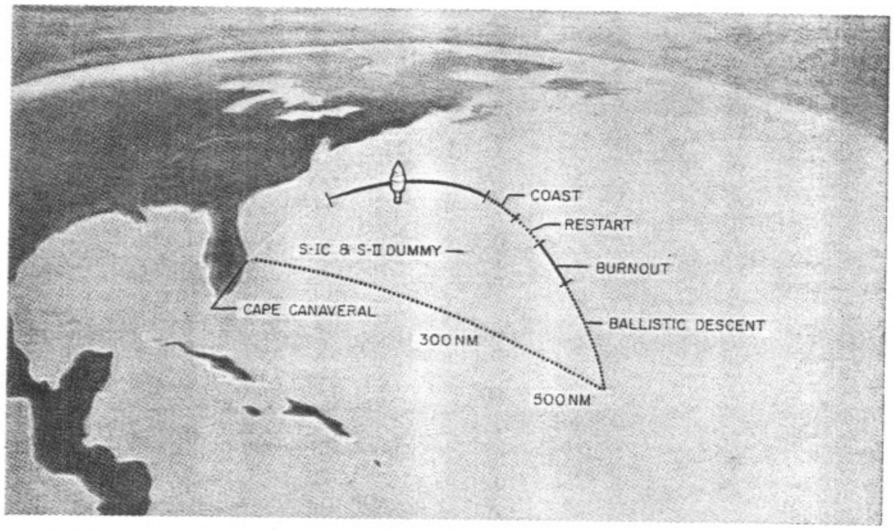
Typical Launch-Facility Complex. The sketch on page 44 shows an artist's concept of a typical facility that might be required at the Atlantic Missile Range for the Nerva and Rift projects for inspection, assembly, checkout, and launch. The Rift stage will be delivered to the AMR by barge or ship and received at a stage-assembly and checkout area. Simultaneously, the Nerva engine would be undergoing assembly and calibration in an engine-assembly and checkout building. Typical functions performed on the Rift stage will include inspection, records examination, mechanical and visual inspection, pressure tests, components examination and bench checks, engineering modifications, installation of components and flight instrumentation, electrical continuity and RF checks, stage subsystems tests, and the like.

Following a thorough non-nuclear check of the Rift stage (less Nerva engine), mating of the engine to the stage will take place. Except for possible zero-power checks of the Nerva engine to confirm its reactivity, the reactor will probably be maintained in a "poisoned" condition to minimize possibilities of a nuclear excursion. After all of the tests necessary on the subsystems, electrical guidance and controls, etc. for complete checkout, the Rift stage will be transported to a Vertical Assembly Building (VAB) and mated with the Saturn S-IC and S-II stages for integral system compatability checks. From here on, the launch sequence will be similar to that planned for the all-chemical Saturn C-5. Additional special precautions might be necessary, however, for increased nuclear safety.

The C-5/Rift vehicle will be transported from the VAB to an Arming Tower and thence to the launch platform by means of a crawler, as indicated in the illustration on page 45. The vehicle appears in position for service and checkout by the Launch Umbilical Tower (LUT), the crawler transporter to the right of the launch platform. Final checks will be made on all pertinent components and instrumentation in this position to insure satisfactory operation during flight. Fueling of the C-5/Rift vehicle will be made just before prelaunch checkout. Access to the vehicle by the operators during checkout will be through the service arms extending from the LUT.

Rift Trajectory. On all four Rift flights, a ballistic trajectory will be followed. Rift will impact in deep water,

RIFT TWO-STAGE LOB TRAJECTORY



beyond the Blake Escarpment, approximately 250 mi. down range. The flight azimuth will be selected so that safety will be maintained for the downrange tracking stations and yet provide adequate data transmission from Rift to these stations. The Rift-stage startup and test-sequencing operation will occur during the high-altitude portion of the flight trajectory. Recovery of recording instrumentation carried in the nose section will probably be required to verify data transmitted during flight. This will be particularly important to Rift because of the possible problem that may be experienced in data transmission through the radiation field of the engine during nuclear operation.

The illustration here depicts a typical trajectory—with nuclear operation, coast, and nuclear restart—for a Rift mission. Only the S-IC bottom booster and the Rift stage will be operated. The S-II second stage will be included in the launch vehicle to simulate vehicle bending moments, but will be a dummy to limit boost accelerations.

The first flight may be performed with an inert Nerva engine, that is, one which cannot go "critical." In all other respects, however, the Rift stage for this flight will be identical to those used in subsequent ones involving operational Nerva engines. The propellant loadings will be the same as those planned for subsequent flights, so that the launch system will be subjected to the same trajectory and environmental conditions as the operational engine tests. The first flight will thus provide considerable verification of design before introduction of the live nuclear engine.

The other three flights will be performed with the identical S-IC boost trajectory used on the first flight. On the second flight the Nerva engine will be operated through a single cycle with a carefully controlled startup and shutdown sequence. The third and fourth flights, however, may have an operating cycle in which the Nerva engine is shut down, the vehicle coasts, and restart is demonstrated. Operation of the nuclear stage will occur above the atmosphere, during which time the stage will be oriented vertically to extend flight time and restrict downrange impact. The nuclear-stage operation will be completed before atmospheric re-entry.

Conclusion. Design and development of the Rift vehicle, along with associated component development, follows a logical plan, in which conceptual engineering design, planning of the over-all development and test program, and thorough investigation of critical problem areas will be done before commitment of major hardware items to fabrication. Although there are many technical areas in which state-of-the-art work must be extended, there are no identifiable vehicle problems that require a breakthrough in the state of the art. The Rift project can therefore be pursued in an orderly fashion based on availability of Kiwi/-Nerva powerplants. It is reasonable to expect that early application of nuclear propulsion to space exploration can be achieved. ◆◆