CHECKOUT AND FINAL TEST

Before any Apollo spacecraft is launched it has "flown" its complete mission a number of times on the ground. These ground flights are part of an extensive series of tests the completed spacecraft must pass before it is committed to launch.

The final checkout and testing of the Apollo command and service modules takes place in two stages: that conducted at North American Rockwell's Space Division in Downey, Calif., to assure that the vehicles are in condition for delivery to NASA, and that conducted at the Kennedy Space Center to assure that the modules are ready for launch.

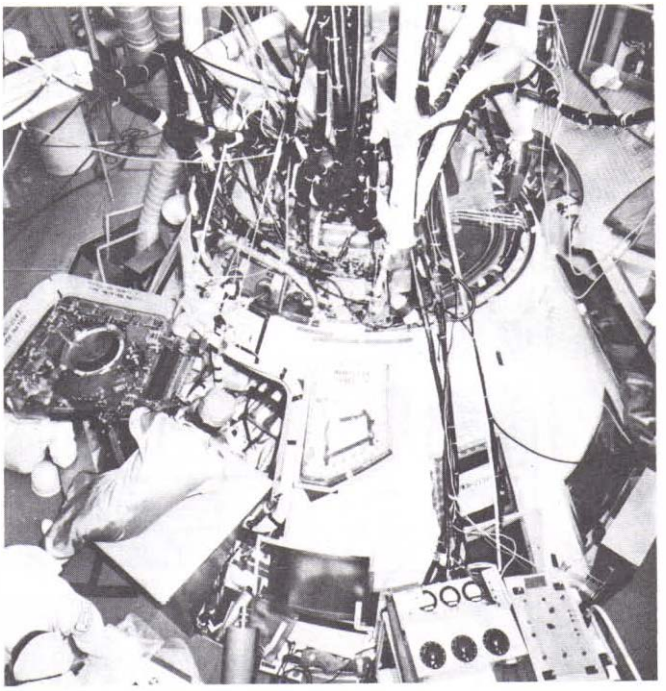
NORTH AMERICAN ROCKWELL SPACE DIVISION

Final assembly of the command and service modules takes place in a large "clean room," at Downey. When components reach this room, they have already gone through many hours of severe testing.

Checkout and testing at Downey can be separated into three broad categories: component and subassembly, individual subsystem tests during build-up, and integrated system testing. The first is at the component and subassembly level, before the equipment is installed in the spacecraft. The second follows installation on the spacecraft and is a long and complex series of tests involving such major operations as pressure cell testing, continuity checks of all wiring, and testing of each subsystem after installation in the vehicle.

The third category—integrated systems testing—is the final operation at Downey. It is conducted in two phases: "plugs-in" and "plugs-out" checkout in which the command and service module subsystems are operated together through a complete simulated mission. In addition, a manned suit loop test is performed with the flight crew to check the environmental control subsystem and all other crew equipment.

The individual and integrated system testing is conducted with acceptance checkout equipment (ACE) similar to that at KSC. This equipment interrogates the spacecraft systems to elicit automatic responses as to their status. The responses



CM undergoes electrical test in Downey clean room

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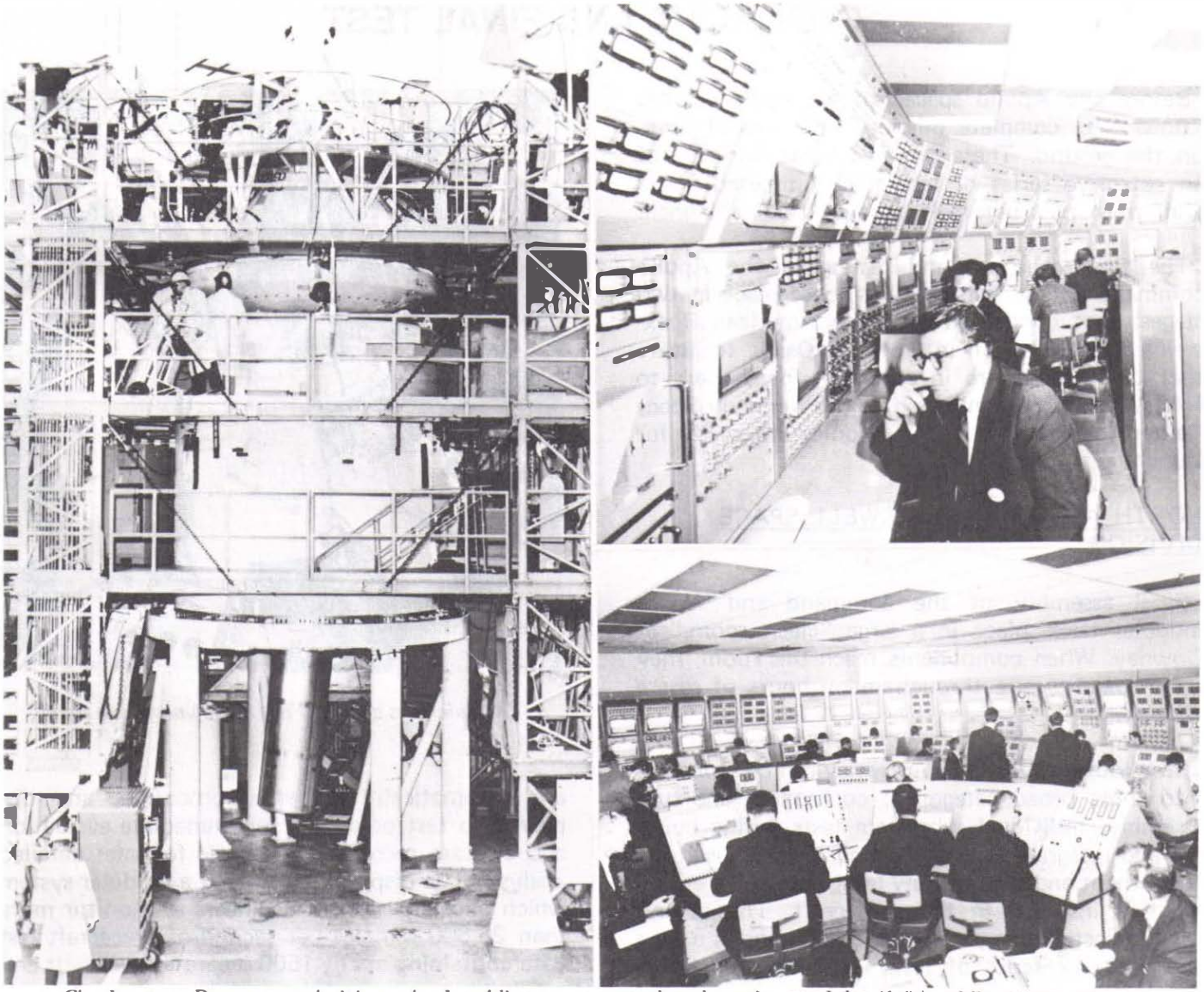
are automatically gathered, processed, and displayed to test personnel for immediate evaluation and also are recorded and stored for later detailed analysis. The displays are part of a modular system which allows a staff of engineers to monitor more than 25,600 samples per second of spacecraft test data containing about 1500 separate spacecraft and ground support conditions while the test is being performed.

The integrated system tests have a number of objectives: to check the operation of each subsystem under mission conditions and assure that all subsystems work together properly, to verify the electromagnetic compatibility of the subsystems, to assure that all crew equipment functions properly, and to check operation of specific alternate and backup equipment and procedures.

The plugs-in and plugs-out tests are similar. The differences are that the former uses ground power and ACE connected to the spacecraft while the latter uses simulated fuel cell power and the ACE is removed so that responses are sent over spacecraft communications equipment as it would operate during the actual mission.



Checkout at Downey; technicians check cabling to command and service modules (left), while others monitor responses to stimuli on battery of computerized display equipment

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The spacecraft is prepared for these tests exactly as it would be for actual flight except that special test devices are installed in place of some equipment such as ordnance and expendable items.

In each phase the proper operation and interaction of all spacecraft subsystems are checked. The checkout equipment enables both automatic and manual operations to be performed, so that manual backups and overrides to automatic operations can be evaluated. When the series of testing at Downey has been completed, the spacecraft and its subsystems are considered ready. Before it is delivered to NASA, however, additional tests are performed to be sure that all the crew equipment, and particularly the environmental control subsystem, works properly with an actual suited crew aboard.

All loose crew equipment is stowed aboard the spacecraft in its proper place. Three crewmen don and check out the space suits and check ease of entering and leaving the command module. The flight crew then enters the cabin and checks the operation and manipulation of all crew equipment while in a pressurized suit, in a ventilated suit, and in shirtsleeves. Operation of the environmental control subsystem's suit loop is checked as the final step in the test sequence.

After the manned suit loop test the modules are prepared for shipment. This preparation involves demating, final checkout of pressure vessels and the reaction control subsystem, installation of the aft heat shield, application of a thermal coating to the exterior of the command module, installation

of earth landing subsystem components and ordnance, a tumble-cleaning, and weight and balance checks.

KENNEDY SPACE CENTER

When the command and service modules arrive at Kennedy Space Center, they begin another long series of tests leading up to launch in which every vital part of the spacecraft is checked once again. Inspection, cleaning, fit checks, functional checks, and leak tests all are part of the pre-launch operations.

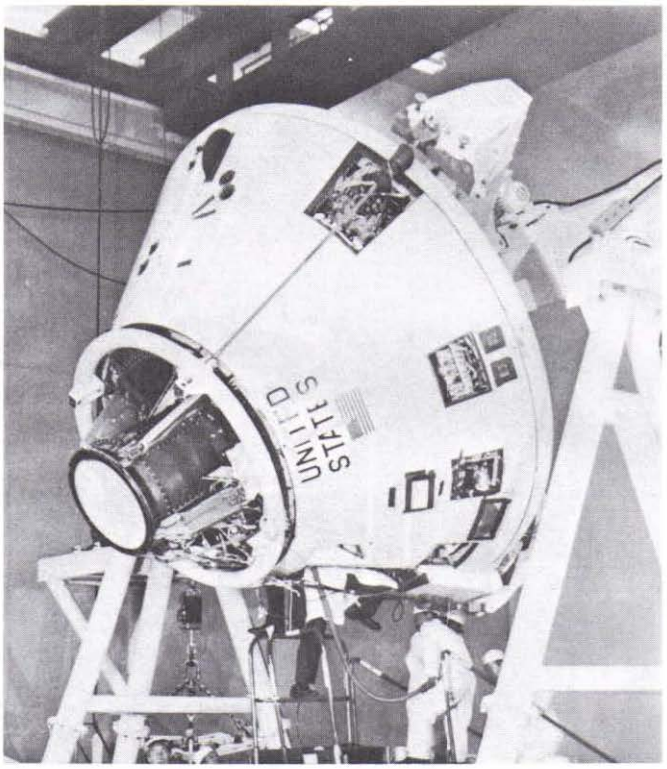
Interspersed with these tests are the spacecraft and launch vehicle handling operations. When the command and service modules arrive at Kennedy Space Center, they are taken to the Manned Spacecraft Operations Building where they undergo inspection, and leak and functional tests. The modules are then moved into the altitude chamber and are mated there.

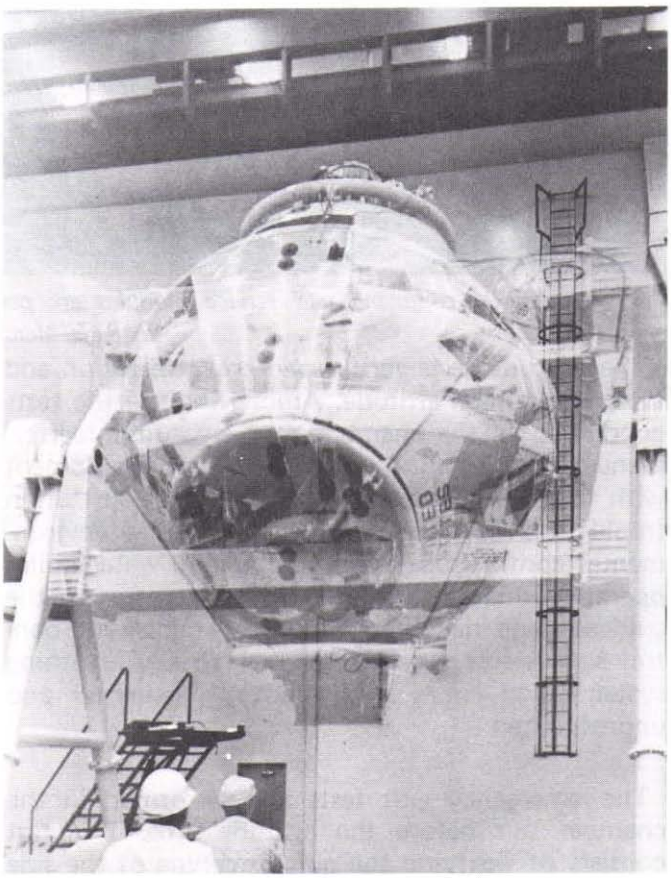
After the chamber and reaction control subsystem tests, the CSM will be moved to a test stand where the service propulsion engine nozzle will be installed and the modules mated with the spacecraft-LM adapter. The latter will already have a lunar module installed.

The spacecraft next is moved to the Vehicle Assembly Building for mating with the launch vehicle and additional tests, including the simulated flight tests. The launch escape subsystem also is mated to the spacecraft in the Vehicle Assembly Building. (On Apollo 7, the first Apollo manned flight, the spacecraft did not go to the Vehicle Assembly Building; instead, it was moved directly to the pad from the Manned Spacecraft Operations Building for testing.)

Two of the most important of the pre-launch operations are the altitude tests and the flight readiness test.

The altitude tests are conducted in a chamber in which conditions at an altitude of more than 200,000 feet can be simulated. The tests consist of four runs: a manned egress test at sea level, an unmanned run at 150,000 feet, and two manned runs at more than 200,000 feet, one with the primary crew and one with the backup crew. All operations in the altitude chamber are televised and recorded.





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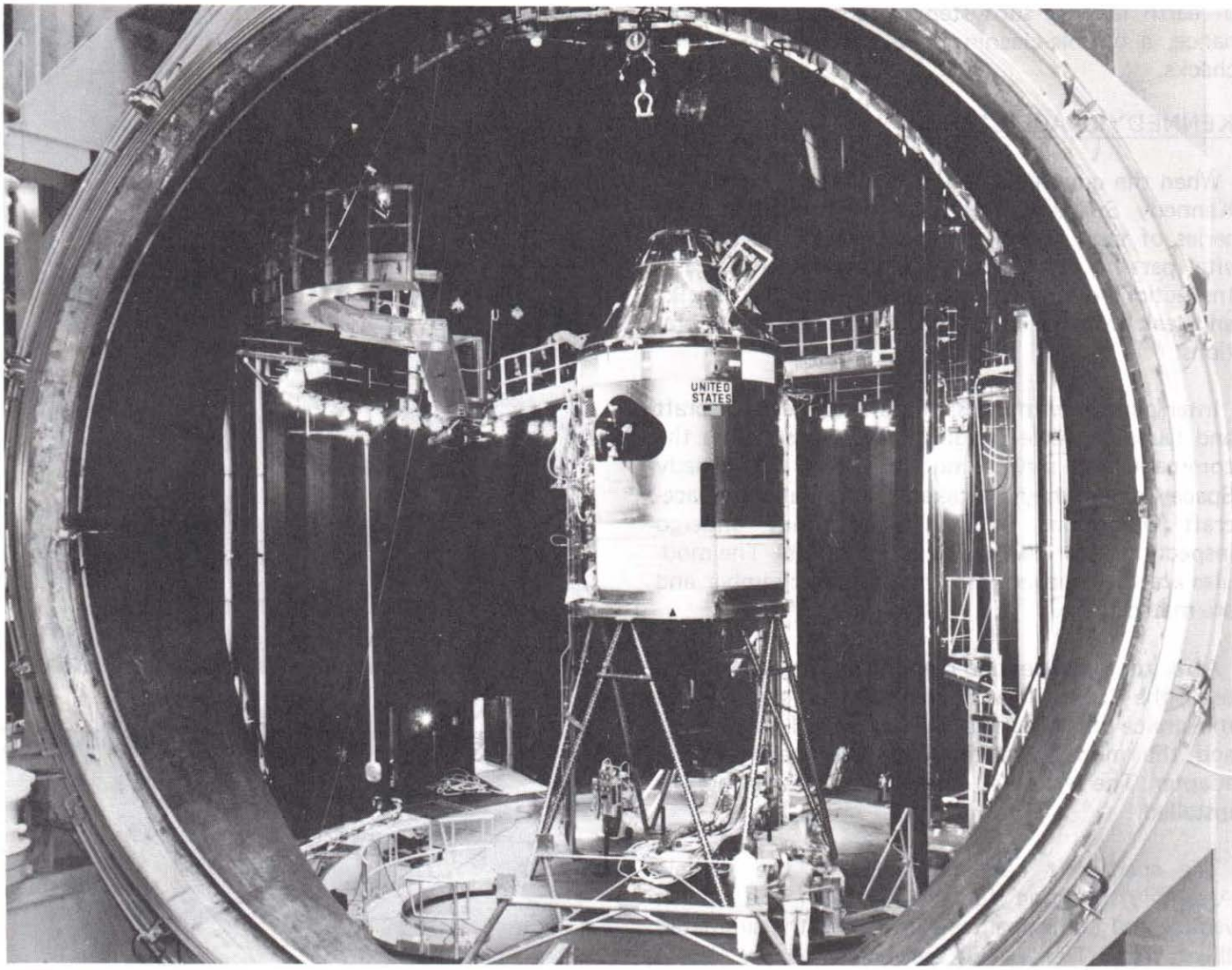
Tumbling shakes dust and debris from CM



P-278 *Apollo command and service modules are prepared for thermal-vacuum tests in huge test chamber at NASA's Manned Spacecraft Center*

The altitude tests verify spacecraft operation and integrity at high altitude. Among the specific tests conducted in the chamber runs are suit integrity, manual manipulation of controls and equipment with the cabin depressurized, cabin repressurization (rapid and normal), fuel cell operation, environmental control subsystem cooling and water boiler operation, manual and automatic operation of the guidance and navigation and stabilization and control subsystems, urine dump, emergency breathing system, and entry while both pressurized and unpressurized.

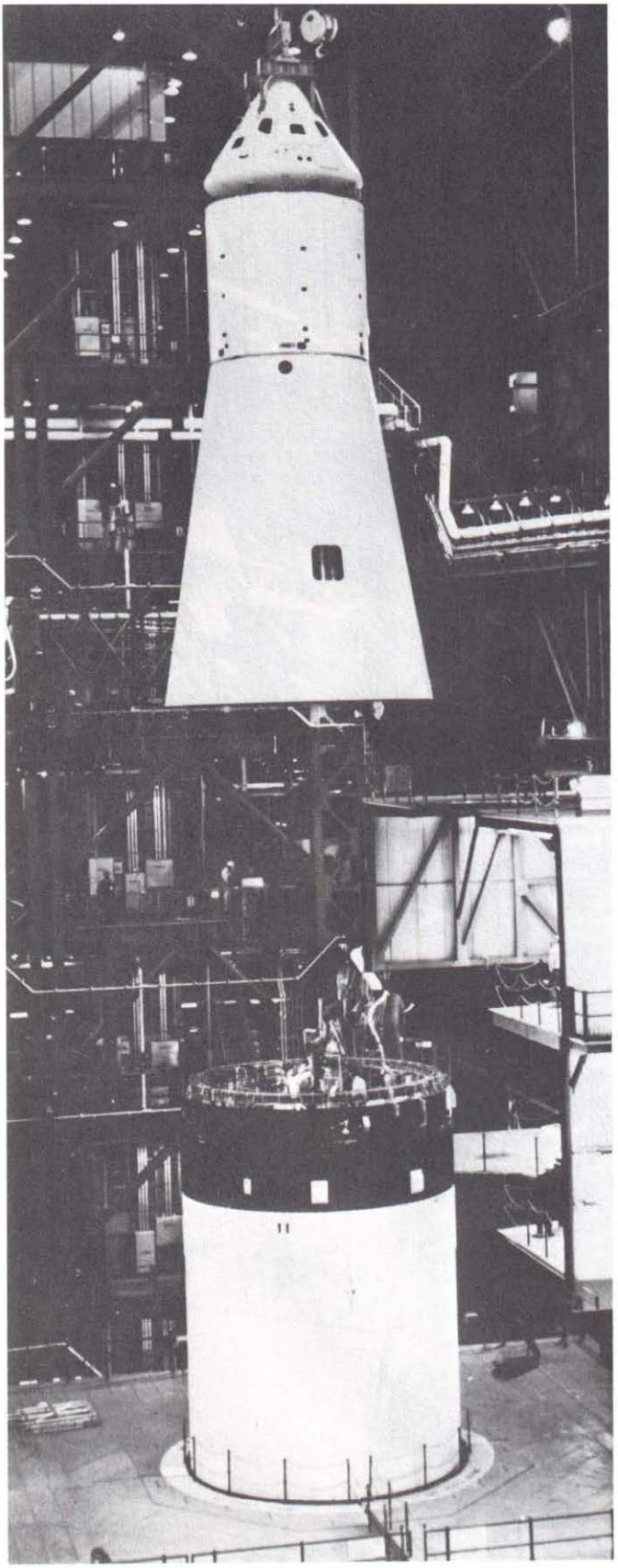
The emergency exit tests are performed in the chamber but before the altitude runs. This test consists of verifying the quick opening of the side hatch after the boost protective cover has been installed.

The countdown demonstration test is one of the final hurdles before launch. In it a complete countdown is performed to verify proper timing and sequence of operations and to check spacecraft-ground communications.

The flight readiness test is the last test of the whole spacecraft before launch. It is designed to check out all subsystems and assure that the craft is ready to proceed to countdown. The electrical power, environmental control, instrumentation, and communications subsystems are first checked to assure proper operation and so that they will support the test. Then the operation of a number of subsystems is checked individually: guidance and navigation, stabilization and control, service propulsion, reaction control, and entry monitor. Next, the

integrated operation of these subsystems is checked. Finally, the spacecraft is taken through several simulated aborts and then a complete mission from liftoff to splashdown. The same kind of acceptance checkout equipment used at Downey is used for these tests.

When the flight readiness test is completed satisfactorily, the spacecraft is essentially ready for launch. The only thing left is a final leak and functional test of the service propulsion and reaction control subsystems. After that propellants and cryogenics are loaded and the launch countdown is begun.



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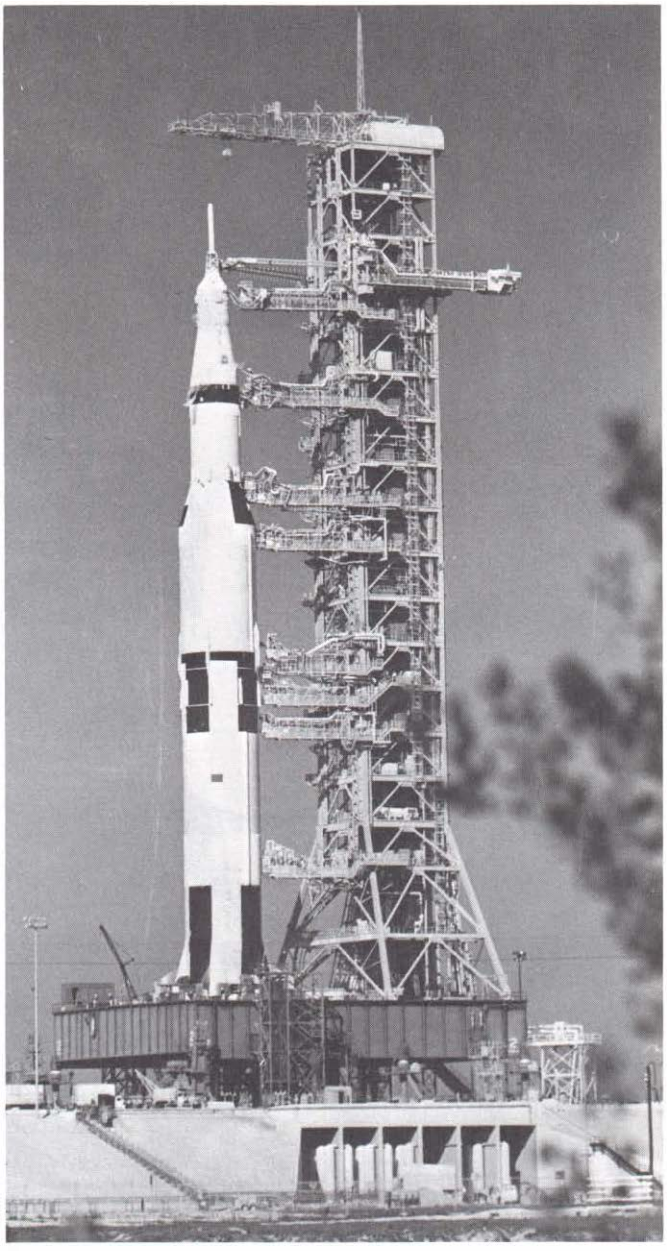
Spacecraft is mated with Saturn V



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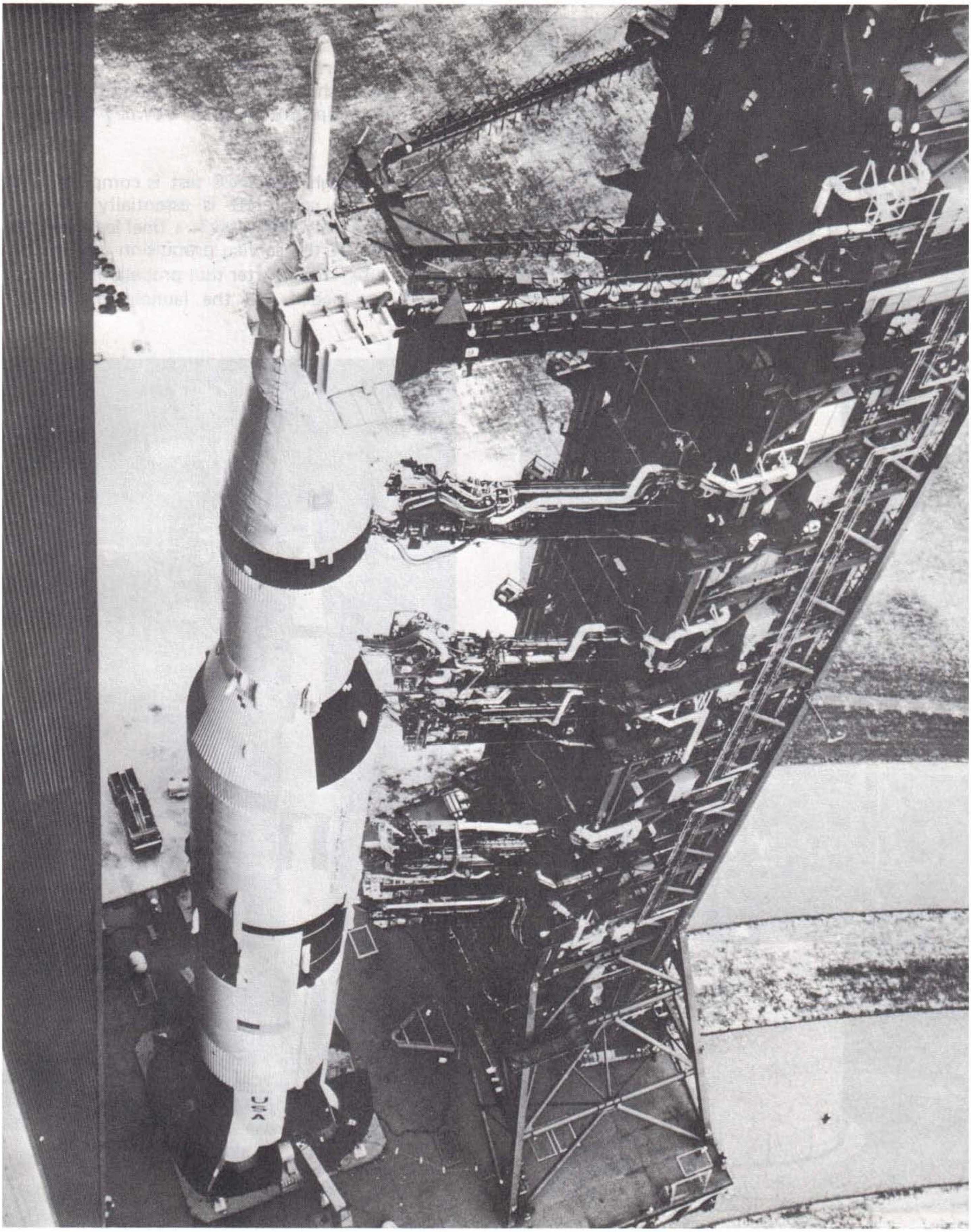
Apollo spacecraft at Kennedy Space Center



P-280 *Final tests of spacecraft and launch vehicle are performed on pad at Kennedy Space Center*