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Construction of the Saturn Launch Facilities

W. L. Starnes

NASA PHOTO

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Colonel W. L. Starnes

IN THE RACE for the moon, the Saturn rocket system is carrying the colors of our country. This rocket system is composed of parts that come from localities spread throughout the United States; however, the payoff window is at Cape Canaveral. It is there that all the various systems, scientists, astronauts, engineers, and dollars combine to work together to launch, first experimental probes, then orbital missions and unmanned surveys of the moon and other planets followed by the culmination for this decade—manned lunar landing and return to earth.

A vital part of the entire complicated, far reaching program is the construction work required to produce the exotic facilities that are used by the NASA scientists and engineers to launch these giant rockets. This construction work is made up of the simple and commonplace, such as clearing the palmettos with bulldozers to the difficult and complex, such as fabricating a 6000 pound test pipe line made of a new type of bimetalic pipe to carry nitrogen or helium gas.

To solve the design and construction problems required to produce the basic facility, to let the construction contracts, and finally to administer and inspect the construction contractor to the end so that the highest quality construction is obtained on time, NASA has turned to the Corps of Engineers. The Corps utilizes for the most part the three part team concept of Architect-Engineer design, construction contractor execution, and Corps of Engineer direction, inspection, and administration that has successfully completed such projects as the Ballistic Missile Early Warning System in Thule and Alaska, the Ballistic Missile Launch Sites all over the United States, and military bases in every area in the free world.

Complex 34 is the only Saturn launch site that is now operational. There have been four successful launchings to date from this complex. These launchings have been experimental in nature with dummy upper stages. The Saturn to be eventually fired from here is designed to put 33,000 pounds in orbit. When this feat is accomplished, the United States will have passed the Russians in heavy lift capability (Russian capability so far is around 20,000 pounds).

The most striking feature of any launch complex is the service tower. On the Saturn complex it is a 310 foot high mobile steel structure that provides the means of erecting the rocket on its launch pedestal and checking it out prior to launch. This service tower moves on rails 25 feet from the launch position to an off site area during actual firings. The 2900 ton tower contains its own 400 KW diesel-electric generator which powers four 100 HP motors, one for each twelve wheel carriage located at the bottom four corners of the tower. An elaborate system of hydraulically operated equalizer beams and automatic motor controls prevents skewing of the tower as it moves at speeds varying from 1.5 to 40 feet per minute on the two parallel sets of railroad tracks.

Because the Saturn engines produce the largest amount of rocket thrust yet controlled by man —2,000,000 pounds of thrust — considerable study was given to the foundation requirements for the launch site. Cape Canaveral is mainly sand and some silt and is not too well compacted in its natural state. In order to withstand the vibration of launch, it was decided to use a patented technique known as vibroflotation to compact the subsoil.

The basic equipment is a light crane equipped with leads from which the vibrator and its follow-up pipe are suspended. The device is first jetted with water into the ground to a predetermined depth, in this case 28 feet, and then withdrawn in one foot increments with the vibrator in action. Sand is continually added during the operation to fill up the voids.

Each penetration produces a cylinder of compacted material and successive penetrations are made at the vertices of equilateral triangles. The spacing depends on the density results required, and at Complex 34 averaged six feet between holes. A total of 1,881 penetrations were made and approximately 7, 000 cubic yards of additional material were required to bring the foundation up to the grade required. The vibroflotation technique resulted in a relative density of 80 percent in the foundation area which allowed the use of reinforced concrete spread foundations for the launch pedestal and service tower rail system rather than a much more expensive pile foundation.

Two Launcher Complex

As a continuation of the Saturn program, and for the purpose of providing a higher launch rate, a two launcher complex was conceived by NASA scientists. The Corps of Engineers was given the problem of designing and constructing the basic facilities. It is called Complex 37, and has just been finished.

The Blount Brothers Construction Company of Montgomery, Alabama, was the low bidder with a price approximating 25 million dollars. NASA's scientists, engineers, and installation experts are now installing the really expensive parts of the complex; the computers and the propellant systems. This GSE can amount to two or three times the cost of the "brick and mortar," as the basic facilities are sometimes called.

During the construction of this complex, foundation problems were again encountered, but not as seriously as at Complex 34. The soil beneath this complex has less clay and silt and the vibroflotation technique resulted in compaction to 85 percent relative density—enough to allow the use of spread footings rather than more expensive piles.

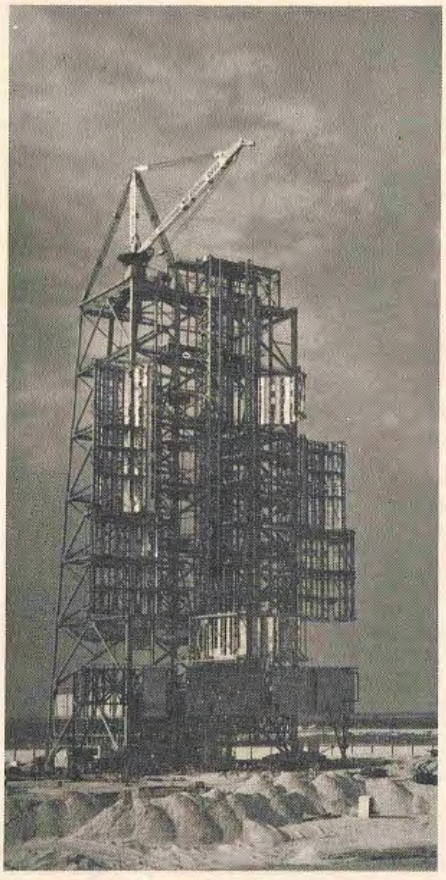
One of the key facilities of any launch complex is the block house from which the launching is controlled. The basic structure of the blockhouse at 37 is reinforced concrete. The blockhouse is two stories high but will have a mezzanine suspended from the second floor ceiling for VIP's to view the activity on the firing floor. It will be lined with controls and instruments and when completely fitted out by NASA it will be an electronic facility unequalled in the free world.

The contractor for this blockhouse devised a reusable steel form which reduced costs considerably. Over this five foot thick concrete shell was placed seven feet of earth and over that four inches of pneumatically placed concrete-gunite.

The blockhouse is constructed with such thick walls so that the personnel working in it during launch will be protected from an explosion of the rocket on the pad.

Service Tower

The service tower has been completed and has successfully met all the tests required to prove the basic construction. It is the largest moving structure in the free world. It is 328 feet high—a 33 story building—and weighs about 5000 tons. This tower has tremendous gates that enclose the missile for checkout. These gates contain adjustable moving platforms that allow the technicians access to the different parts of the bird during checkout. During movement



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Pad 37 Gantry

of the tower, these gates are open. On top of the tower, also, just as on Complex 34, is a mechanism to erect the launch vehicle. In this case, it is a stiff leg derrick with a 60 ton, 40 ton, and 10 ton hook to lift the various parts of the vehicle from the transporters and erect them on the launch pedestal. This tower also moves on rails.

Amazingly enough, it was possible to reduce the power that was required for the complex 37 tower. The total power needed to move this monster is only 200 HP, about as much as for a car. Of course, the tower moves at the blazing speed of ½ mile per hour between the two launch pads.

The launch pedestals for this tower have tremendous steel members. The pedestal for Complex 37 was fabricated at Bartow, Florida, under very rigid specifications which required radiographic inspection of both shop and field welds. We have found this technique is the best to pick up flaws, which can then be repaired so that a sound structure is the final result.

The umbilical tower for this complex is 268 feet tall and sits over a three story reinforced concrete build-

ing which houses much of the ground support equipment required for launching. This building, of course, doesn't move, but is completely evacuated during launching. This entire area, including the tower, is protected from the searing heat of the rocket motors by an automatic deluge system that saturates the structures with protective sheets of water. This system is fed by a 36 inch high pressure main and puts out 30,000 gallons in 60 seconds.

A final portion of Complex 37 is the gas transfer system. Tank trucks bring in nitrogen and helium to this point from which the gases are transferred either to this pressure vehicle or by special pipe line to other storage vessels on the complex itself.

Launch Complex 39

Everything about this newest project on the Merritt Island Launch Area is big, including the real estate required to contain it. Cape Canaveral is approximately 15,000 acres in size. The new land area, which has been almost all acquired, will amount to 103,000 acres, about twice the size of the District of Columbia. Only in the last few months have construction machines begun to change this largely wet soggy area into the beginning of Spaceport, USA. The rattlesnake and the alligator are being dispossessed, as huge pipeline dredges suck up sand and water from the bottom of the Banana River and Banana Creek, pumping the semiliquid as much as 10,000 feet through a 27 inch pipeline to the areas that are being built up so they can be used for facility foundations. Since so few people lived and worked in this part of Florida, the acquisition proceedings carried out by the Corps of Engineers have proceeded smoothly. The total land cost will approximate 55 million dollars.

There are really three areas of intense activity—the new industrial area near Orsino right in the heart of Merritt Island, Pad 39, and the Vertical Assembly Building Complex near the A1A crossing over Banana Creek.

Vertical Assembly Building

The final project will be completed in late '65 or early 1966. The Vertical Assembly Building, or VAB, with its barge unloading facility, is in essence the end of the assembly line for the advanced Saturn launch vehicle. The parts of the 360 feet tall Saturn vehicle (it is about the height of the Statue of Liberty), will arrive by barge, railroad, and truck, be unloaded and then assembled, erected, and checked out inside this 524 foot high building.

This building, with its 5 acres of roof areas, will be visible from as far north as Daytona Beach and from as far west as Orlando. It will be the tallest structure in the eastern states south of the Washington Monument and is only 35 feet shorter than that structure. Inside the VAB will be unobstructed headroom space 450 feet high, large enough to contain the UN building. A 250 ton bridge crane will operate from rails in the top trusses to erect the missile.

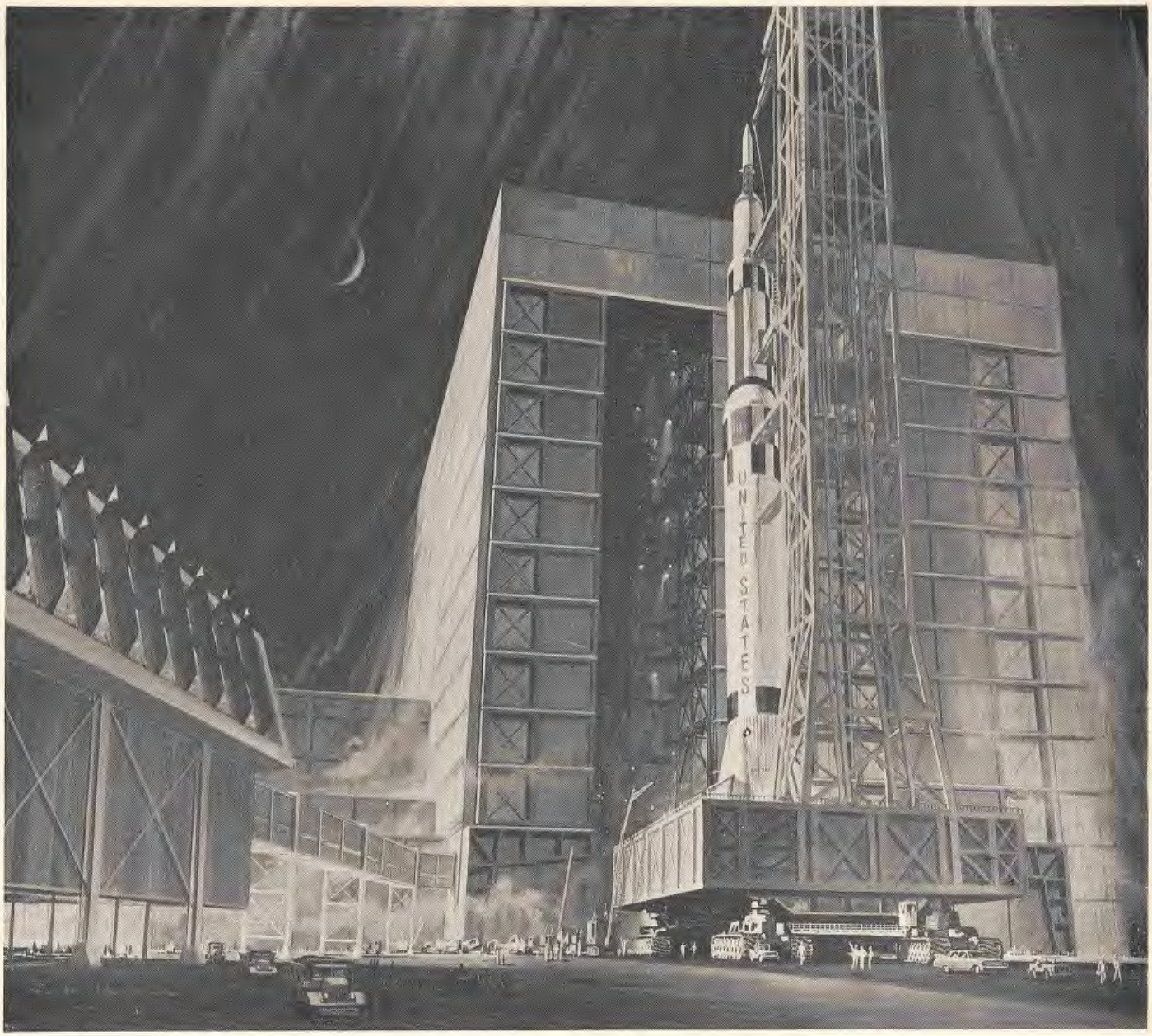
Hurricane-proof and water tight, the VAB must be able to ride out the worst storms that have ever been recorded in Florida. Naturally, these sheer walls rising over 500 feet in elevation and the tremendous loads of the structure and the missile inside have given rise to really severe foundation problems.

Foundations

Vibroflotation is no longer good enough. For this structure, cylindrical steel piles will be driven 150 to 160 feet to bedrock to support the loads expected. The area has been cleared and grubbed, stripped of unsuitable material, and is now being filled with sand dredged from Banana Creek to an average height of 6.7 feet. The contract to drive the piles and prepare the foundation will be let sometime this summer. It is expected that a new technique of pile driving using a sonic hammer will be seriously considered by the prospective contractors. The sonic hammer is a recent development which makes use of ultra high frequency sound waves to drive steel pile.

The Architect-Engineer firm that the Corps of Engineers engaged to design the VAB was authorized to run a series of tests both with conventional pile drivers and the sonic hammer at the VAB site last fall. The driving time for conventional means averaged 45 minutes to one hour for a 120 foot test pile; the sonic hammer required only 3 to 10 minutes driving time. This will be quite a saving when considering about 328,000 feet of piling. The sonic rig seems to just push the pile slowly and steadily into the ground while the conventional pile driver slams the pile in a few inches each blow.

The rapidity with which piles may be placed sonically is a basic result of the high degree of efficiency in energy transfer, because the pile is vibrated at its natural frequency. With



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Artist's concept of Vertical Assembly Building.

the conventional hammer, a great deal of available power is dissipated in forms of heat and deformation and in overcoming inertia. Consequently, the energy available for driving at the bottom of the pile is reduced. The disadvantage of the sonic type of pile driving, however, is the very considerable set-up time required for each pile. It may well be that the successful contractor will use a combination of the two methods.

Missile Transporter

The concept for Complex 34 and Complex 37 was to perform erection and checkout of the vehicle on the pad where it is launched. This procedure ordinarily takes months. Pad 39, on the other hand, will utilize the mobile concept, which means that the Advanced Saturn will be totally integrated and checked in a controlled environment protected from the corrosive salt laden atmosphere, and then moved in the vertical position along the crawler ways from the VAB to the launch pad. There, only minimum checkout will be required before firing. The missile transporter with its tower mounted on top (called LUT), will be larger and heavier than the tower on 37 and with the rocket on it also will present a fantastic sight as it moves at the speed of one mile per hour along the crawlerways.

The prime mover and LUT will stay on the pad until the rocket is fired. The multiple pads and the off site checkout will permit launchings as close together as one hour, which may be required for space station operations.

The construction costs of the VAB are estimated to reach 100 million dollars and each pad to cost 50 million. When added to those large sums are the cost of the LUTs, the arming towers, the propellant systems, the instrumentation systems, and the intricate electronic checkout and firing systems, one billion dollars is approached. That is the investment that is being made in the facilities at Cape Canaveral to extend man's knowledge and control to the next frontier — space.