LAUNCH VEHICLES

Development of launch vehicles for the lunar landing mission represents a tremendous stride forward in rocket propulsion: they are bigger, more powerful, and vastly more complex than previous U.S. launch vehicles.

Development of the Saturn family began in late 1958 under the Department of Defense's Advanced Research Projects Agency. The work was conducted by the Army Ballistic Missile Agency at Redstone Arsenal in Huntsville, Ala., which in 1960 was transferred in part to NASA to become the nucleus of the Marshall Space Flight Center.

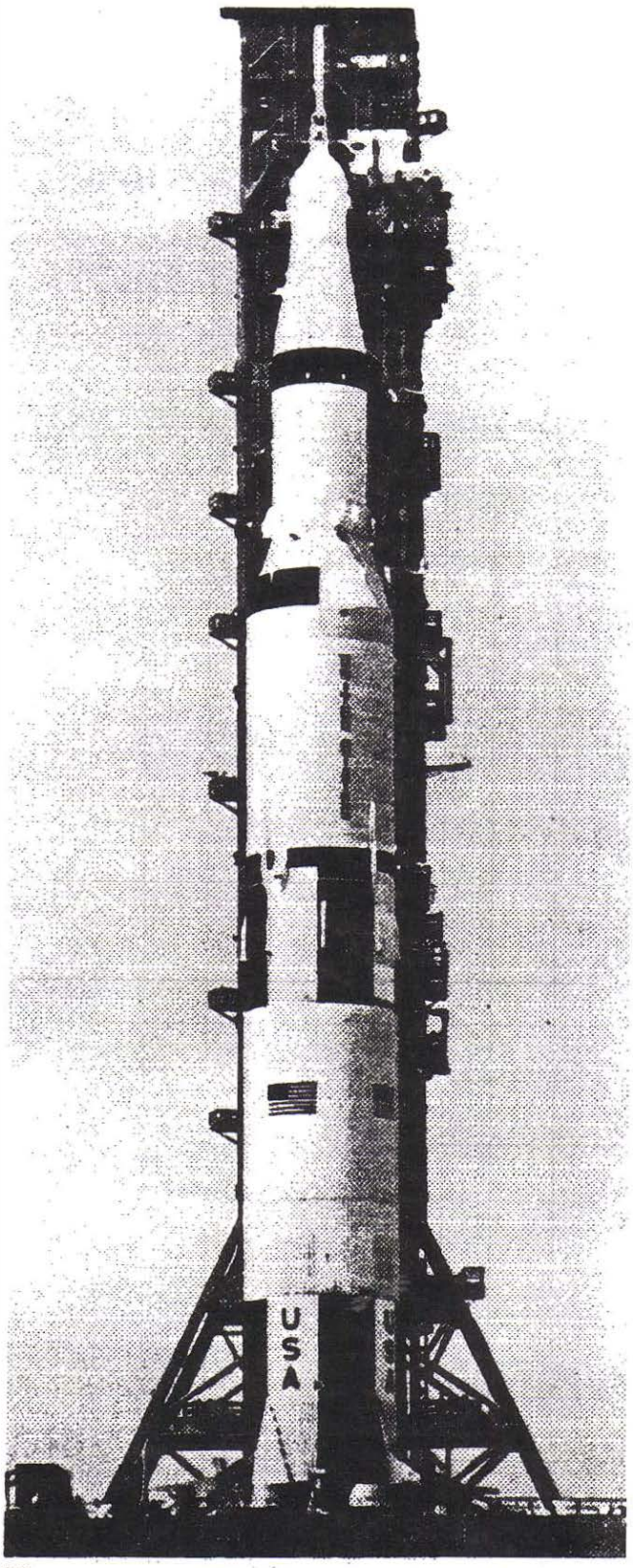
Studies under Dr. Wernher von Braun aimed at developing a booster with a total thrust of 1.5 million pounds had been conducted in 1957.

There are three launch vehicles in the Saturn family: the Saturn I, which had a perfect record of ten successful flights; the Saturn IB, and the Saturn V. The name Saturn was adopted in 1959 and at that time applied only to the 1.5 million-pound thrust vehicle which became the Saturn I.

This stepping stone approach led to the development of Saturn V in three phases: Saturn I, which used primarily modified existing equipment; Saturn IB, which uses a modified first stage of the Saturn I and a new second stage and instrument unit; and the Saturn V, which uses new first and second stages and the third stage and instrument unit of the Saturn IB.

Development of the engines needed for the Saturn vehicles was begun separately, but much of it was in parallel with the vehicle program. Work started on the F-1 engine, the nation's largest, in 1958 and on the hydrogen-powered J-2 engine in 1960. The J-2, which burns a cryogenic (ultra low temperature) propellant composed of liquid hydrogen and liquid oxygen, was the key to development of the powerful upper stages of the Saturn IB and Saturn V.

The Saturn I program is complete. From 1961 through 1965 it was launched 10 times successfully, putting Apollo boilerplate (test) vehicles and Pegasus meteoroid technology satellites into orbit.



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Saturn V launch vehicle (with Apollo)

The first launch of a Saturn IB came in early 1966 and also was the first space test of an Apollo spacecraft. Succeeding tests also have been successful.

The first flight test of the Saturn V was November 9, 1967, when it boosted an Apollo spacecraft into space. A NASA report described the performance of the North American Rockwell-produced Apollo spacecraft as satisfactory in all respects.

The Saturn IB and the Saturn V are the basic heavy launch vehicles of the United States civilian space program. Saturn V will be used for Apollo test flights and for lunar missions. The Saturn IB will be used with smaller payloads.

In the early studies on the Saturn, many configurations were considered. The Saturn I originally was designated C-1; the Saturn V was C-5. Although the other configurations were dropped, the designations "I" and "V" remained.

Specific figures are given on weight, height, and amount of propellant for each Saturn vehicle. However, all are approximate. Like Apollo, changes and improvements affect the figures, particularly those on weight. In addition, each launch vehicle produced and each mission is somewhat different.

SATURN IB

The Saturn IB has two stages and an instrument unit (IU).

The first stage (S-IB) built by the Chrysler Corp., is the same size and shape as the first stage of the Saturn I (S-1), but was redesigned to cut its weight and increase its power.

The second stage (an S-IVB), produced by McDonnell Douglas Co.'s Missile and Space Systems Division, is a large, all-cryogenic booster. The cryogenic propellant—liquid hydrogen at 423° below zero F and liquid oxygen at 297° below zero—provides more energy per pound of weight than the chemical fuels used previously, but posed many problems in insulation, handling, and engine systems.

The instrument unit (IU), a cylindrical-shaped segment mounted atop the second stage, contains equipment for sequencing, guidance and control, tracking, communications, and monitoring. It was designed by NASA and is being produced by IBM's Federal Systems Division.

The engines for the Saturn IB are designated the H-1, used in the first stage, and the J-2, used in the second stage. Both are produced by North American Rockwell's Rocketdyne Division. The H-1 engine was used for the first stage of the Saturn I, but was uprated, first 200,000 pounds, then to 205,000 for the Saturn IB. The stage has eight H-1 engines for a total thrust of 1,600,000 pounds. The J-2 engine used on the second stage is more than 11 feet long and weighs about 3400 pounds. It has a thrust of up to 225,000 pounds at high altitude.

Basic facts about the two-stage Saturn IB:

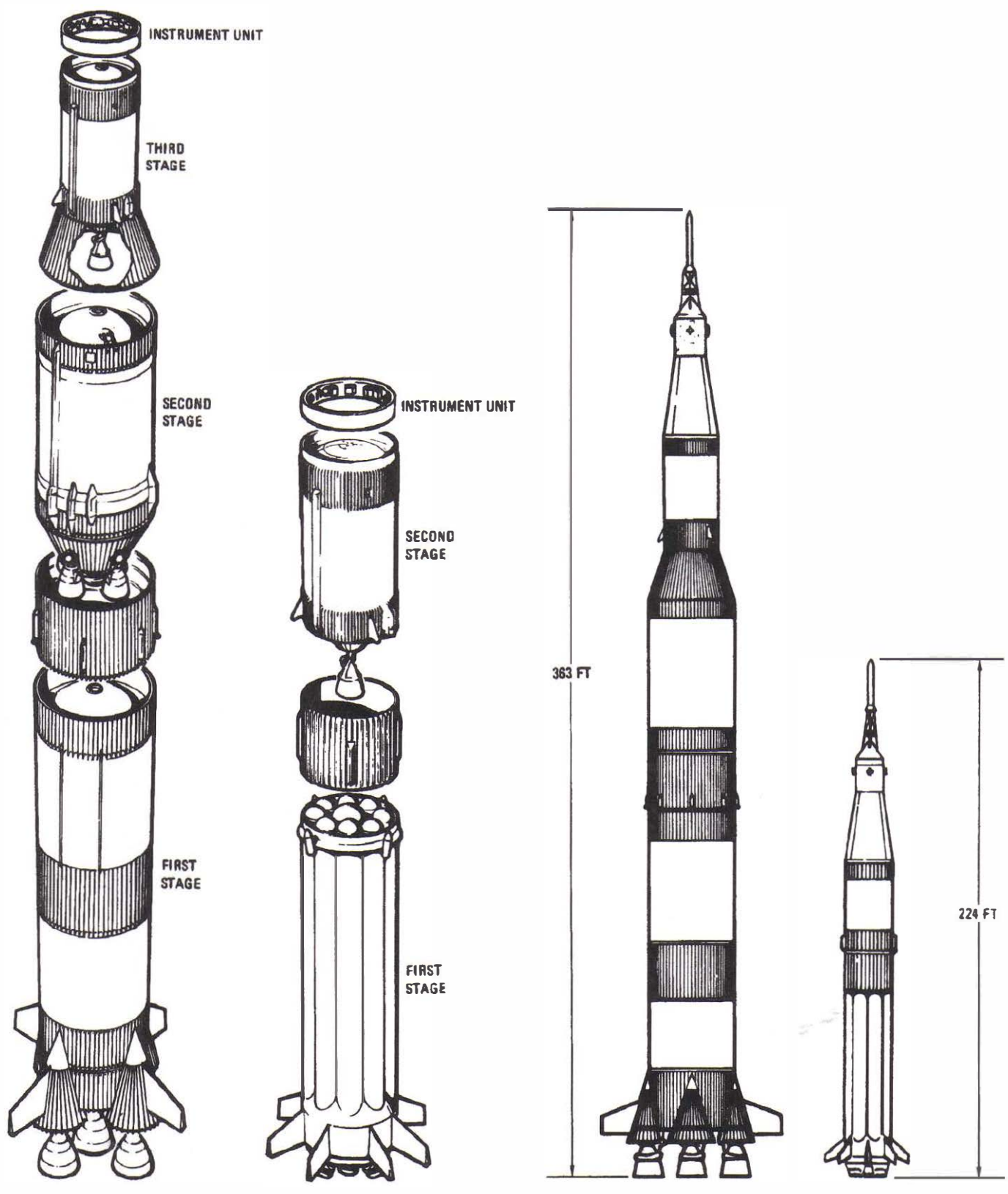
Height	138 ft (vehicle only) 224 ft (with spacecraft)
Weight	1,300,000 lb (with propellant) 153,000 lb. (dry)
Payload	40,000 lb in low earth orbit

FIRST STAGE

Height	80.3 ft
Diameter	21.4 ft
Gross weight	1,000,000 lb
Propellant weight	910,000 lb
Propellant	RP-1 and liquid oxygen
Engines	8 H-1's
Thrust	1,600,000 lb (sea level)

SECOND STAGE

Height	58.4 ft
Diameter	21.7 ft
Gross weight	253,000 lb
Propellant weight	230,000 lb
Propellant	Liquid hydrogen and liquid oxygen



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Saturn V (left) and Saturn IB

Engine	1 J-2
Thrust	225,000 lb (vacuum)

INSTRUMENT UNIT

Height	3 ft
Diameter	21.7 ft
Weight	4500 lb (approximate)

SATURN V

The Saturn V is the nation's largest and most powerful launch vehicle. It has three stages and an instrument unit.

The first stage produced by the Boeing Co.'s Launch Systems Branch, is 138 feet high (higher than any entire pre-Saturn launch vehicle) and weighs close to five million pounds when fueled. The function of this stage is to lift the enormous weight (more than 6.2 million pounds) of the Apollo/Saturn V space vehicle off the pad and carry it to an altitude of about 38 miles and a speed of about 6000 miles per hour.

The second stage, built by North American Rockwell's Space Division, is the largest and most powerful hydrogen-fueled stage ever produced. It is 81.5 ft. tall and weighs more than 1 million pounds fueled. It takes over from the first stage and boosts its payload of the third stage and Apollo spacecraft into space (an altitude of about 118 miles) and to a speed of more than 14,000 miles per hour.

The third stage is essentially the same as the second stage of the Saturn IB. On the Saturn V it serves in a double capacity. After the second stage burns out and is jettisoned, the third stage's engine burns briefly, just long enough to increase its velocity to about 17,400 miles per hour and put it and the Apollo into earth orbit. It stays connected to the spacecraft from one to three orbits, then its engine is reignited at the proper moment to power itself and the spacecraft toward the moon.

The instrument unit for Saturn V is essentially the same as on the Saturn IB. Like the third stage, however, it is modified and improved to help it carry out the different missions of the Saturn V.

There are two types of main engines used on the Saturn V, both built by North American Rockwell's Rocketdyne Division. The first stage uses the F-1, the most powerful engine ever produced. It is 19 feet long, weighs about 18,500 pounds and produces 1,500,000 pounds of thrust. The first stage has five F-1 engines for a total thrust of 7,500,000 pounds. Both the second and third stages use the J-2 engine, the largest hydrogen-fueled engine ever built. The J-2 engine produces up to 225,000 pounds of thrust; the second stage uses five J-2 engines producing a maximum of 1,125,000 pounds of thrust. The third stage uses one J-2 engine.

Basic facts about the Saturn V:

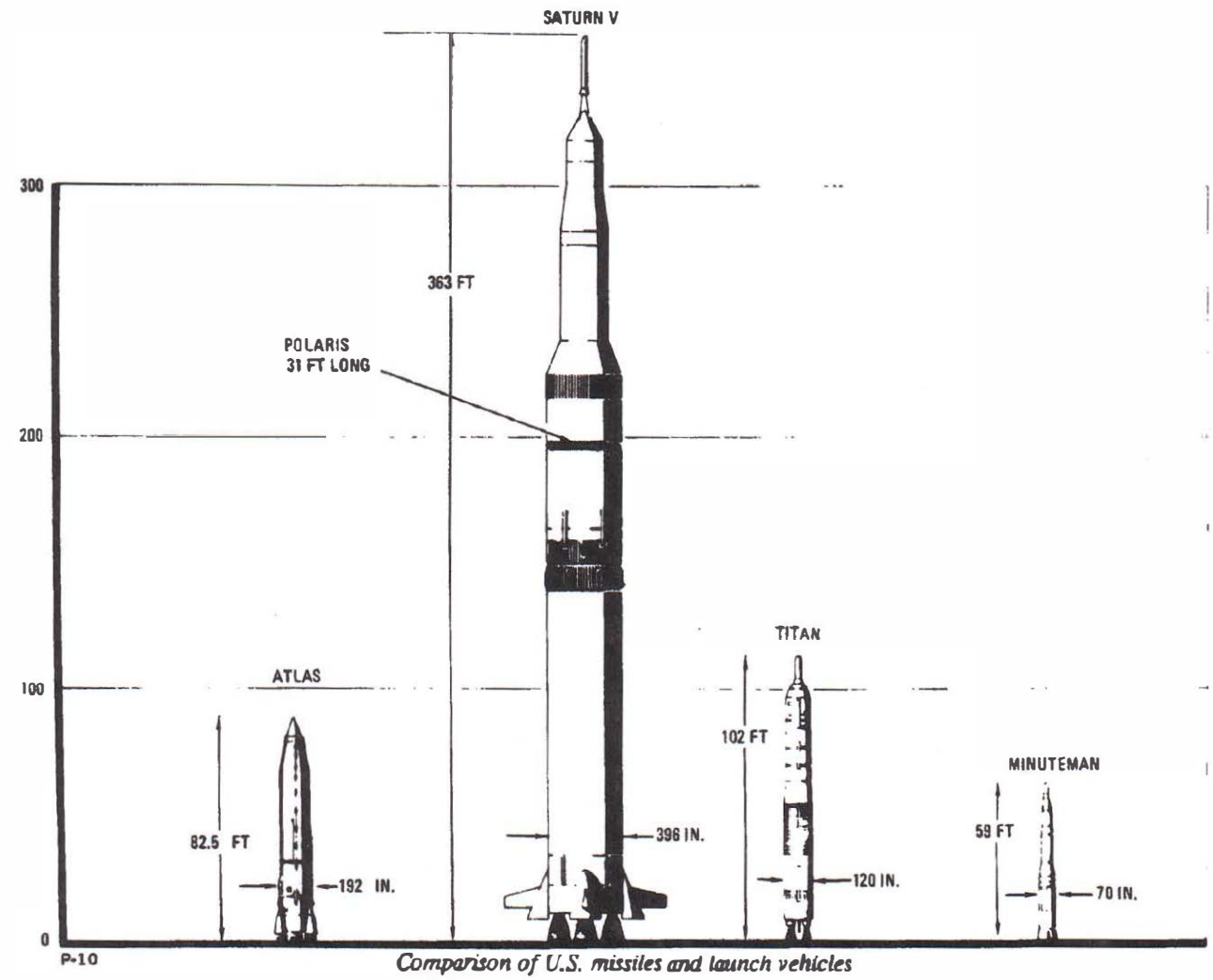
Height	282 ft (vehicle only) 363 ft (with spacecraft)
Weight	6,200,000 lb (with propellant) 430,000 lb (dry)
Payload	270,000 lb in low earth orbit 100,000 lb translunar injection

FIRST STAGE

Height	138 ft
Diameter	33 ft
Gross weight	4,792,000 lb
Propellant useable weight	4,492,000 lb
Propellant	RP-1 and liquid oxygen
Engines	5 F-1's
Thrust	7,500,000 lb (1,500,000 lb each engine)
Burning time	150 sec

SECOND STAGE

Height	81.5 ft
Diameter	33 ft



Comparison of U.S. missiles and launch vehicles

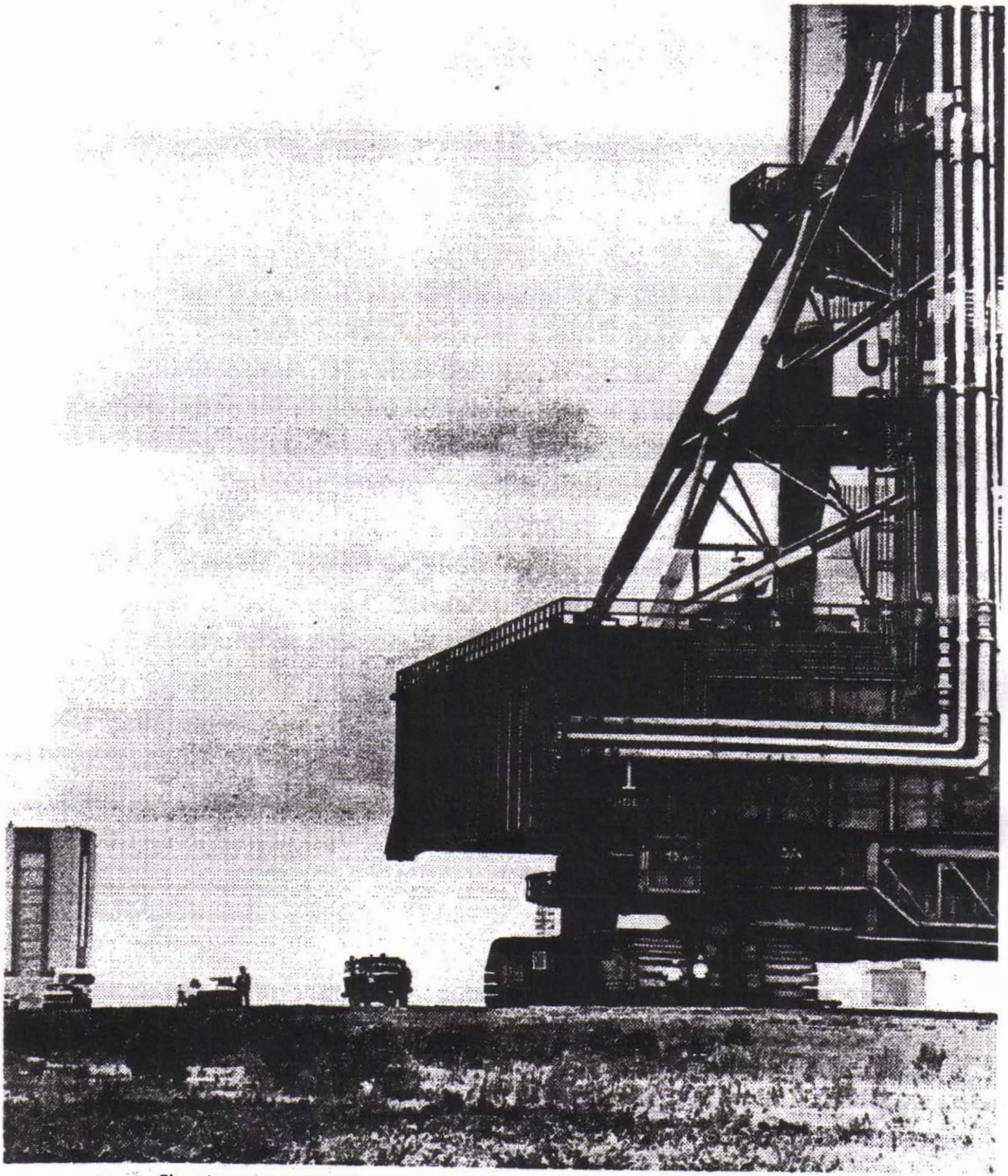
Gross weight	1,037,000 lb at liftoff
Propellant useable weight	942,000 lb
Propellant	Liquid hydrogen and liquid oxygen
Engines	5 J-2's
Thrust	1,125,000 lb (225,000 lb each engine)
Burning time	359 sec

THIRD STAGE

Height	58.5 ft
Diameter	21.7 ft (lower interstage expands to 33 ft)
Gross weight	262,000 lb
Propellant useable weight	228,000 lb (excluding reserves)
Propellant	Liquid hydrogen and liquid oxygen
Engine	1 J-2
Thrust	225,000 lb maximum (at altitude)
Burning time	480 sec (2 burns)

IU

Height	3 ft
Diameter	21.7 ft
Weight	4500 lb (approximate)



P-11 *Gigantic mobile launcher inches along on way to launch pad carrying Saturn V/Apollo*