Rockets
Of The Armed Forces

By Erik Bergaust

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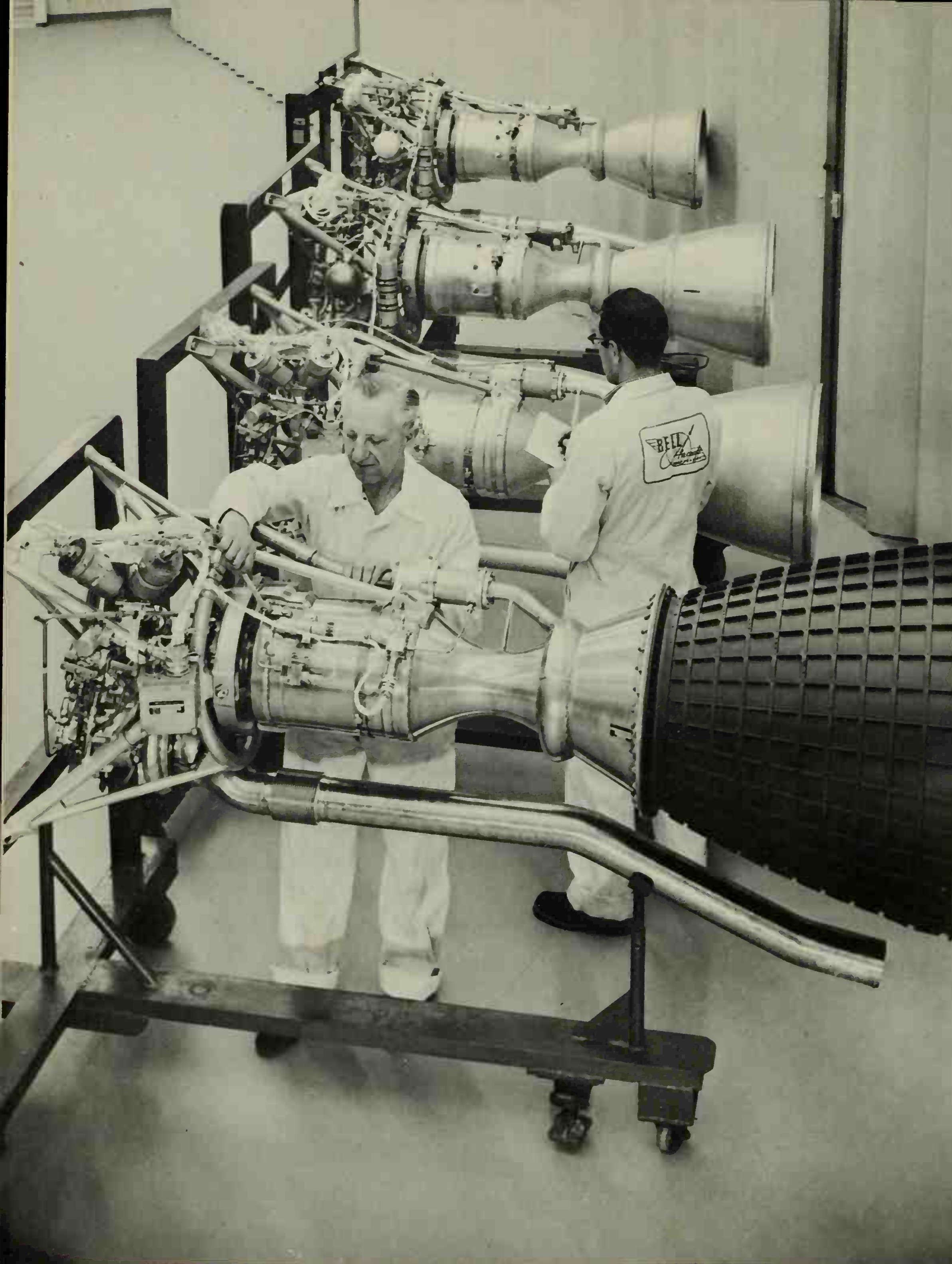
Between primitive man's rock-hurling days, and modern technology's refined rocket systems, man has come a long way in missile combat. Beginning with the principles of rocketry from early time to the present, Erik Bergaust classifies all forty-two current operational missiles into four basic categories: air-to-air; air-to-surface; surface-to-air; and surface-to-surface. From the Navy's highly sophisticated Polaris to the Sidewinder, widely used in Vietnam, the author pinpoints the type, propulsion, guidance, performance, and construction of each rocket. A picture and a short paragraph describing each rocket's military use, plus a glossary, are included.



Inspection of liquid hydrogen engines. Hydrogen is a powerful fuel and is often used in combination with liquid oxygen. Fuels are carried in the missile in separate tanks and are mixed in the rocket's combustion chamber where the burning takes place. / *Bell*

ROCKETS of the ARMED FORCES

By Erik Bergaust

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The cooperation of the Office of the Assistant Secretary of Defense, Magazine and Book Branch, Directorate of Information Services, made it possible to compile in this book the latest information and data on all operational United States military rockets.

This book covers all of the current missile programs and does not deal with older missiles or rockets which are not in use any longer. Most of the information was provided by official sources. The cartoons were provided by U.S. Army Missile Command's U.S. Army Missiles and Rockets. All other illustrations were provided by the Department of Defense unless otherwise stated.

Erik Bergaust
Washington, D. C.

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Rockets of the Armed Forces

How Does a Rocket Work?

Missiles have always been used by man. The first operational guided missile probably was a rock. Man hurled rocks at birds and game and at his enemies. His eyesight provided the guidance; the muscle in his arm gave the rock its forward thrust.

But nearly everything becomes outdated. In recent times we have witnessed that the horse-drawn plow, the steam locomotive and the propeller-driven fighter plane have all had their day. Likewise, early man one day discovered that a sharp rock fastened to a handle provided a much better weapon than just the rock. So the ax was born, and man used it for many purposes, sometimes as a guided missile. He could throw it farther than he could throw a rock, and he developed accuracy. We know that American Indians could throw tomahawks with great skill.

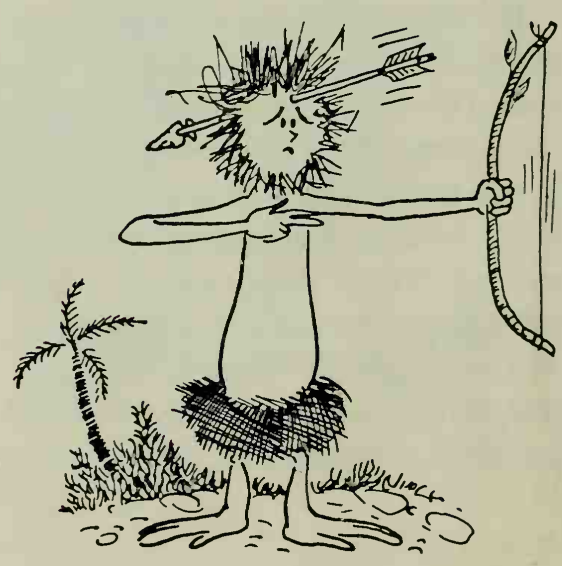
For a long time man probably was quite satisfied with his ax. In fact, the ax became so useful to man that he never has abandoned it as a tool. But in the very early days man must have dreamed about different methods of throwing his ax farther. He soon found out that it was extremely difficult to throw the ax at birds, for example. The ax was heavy, and the birds flew high. Man discovered that he had his limitations in this department, so he kept looking around and

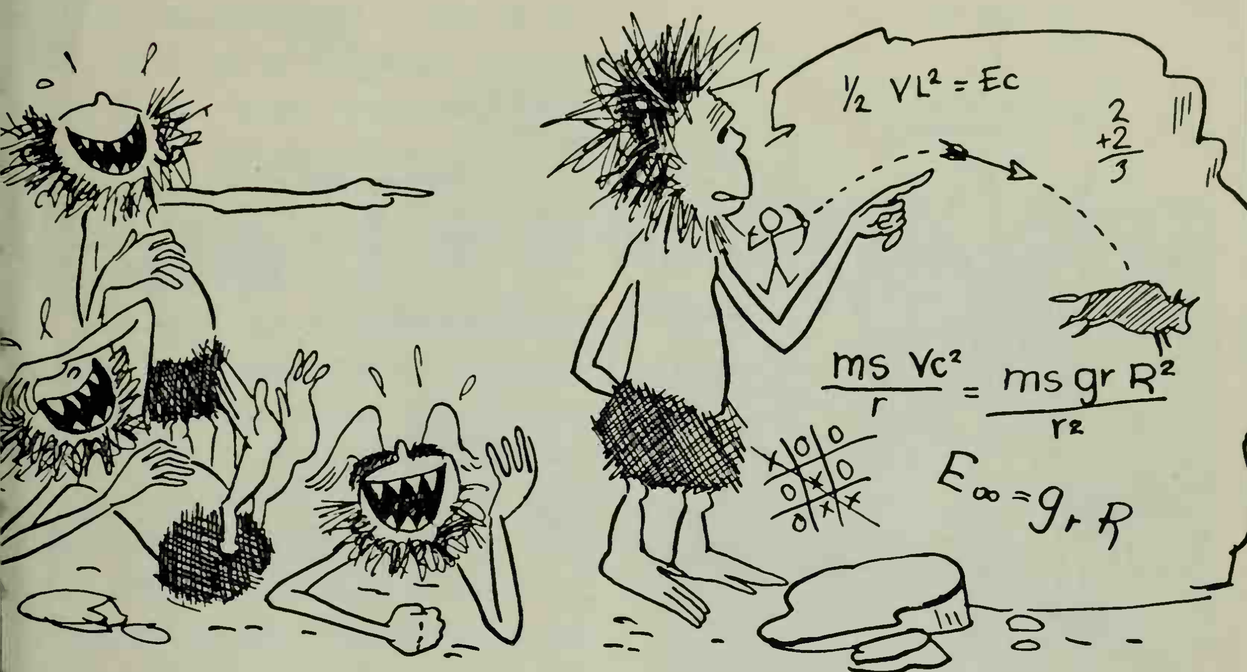
thinking about how to increase the range of his missile. Probably he had another thing in mind as well: the ax was difficult to make, for it took much work to grind the blade to proper sharpness. And sometimes when he hurled his ax at a target, he simply lost the ax. He might have gotten quite tired of looking in the bushes for his lost weapon — or tired of running from an enemy he had missed. So he finally came up with the idea of building himself a bow that could shoot arrows.

This was to early man what we might call a major technological breakthrough. It probably started with some sort of slingshot. And it probably took many years, perhaps even generations, before man had developed a truly workable archery set.

He must have tried all kinds of wood for his bow, and through much test firing he discovered that some kinds of wood tended to crack or break sooner than others. Likewise, it must have taken him a good many years before he found the right kind of string for his bow and the best material for his arrows, such as sharp stones for the arrowheads and feathers for the tail fins. Like modern engineers and scientists, early man must have had a good many failures and accidents while developing the science of archery. He must have found out at an early stage that the business of guided missiles can be very dangerous unless you really know how to operate the weapon — or how the weapon operates.

Man had come a long way though. And he continued to improve his archery equipment for many generations. Finally, the bow became a fine, balanced piece of launching gear, and with much patience man made his ar-

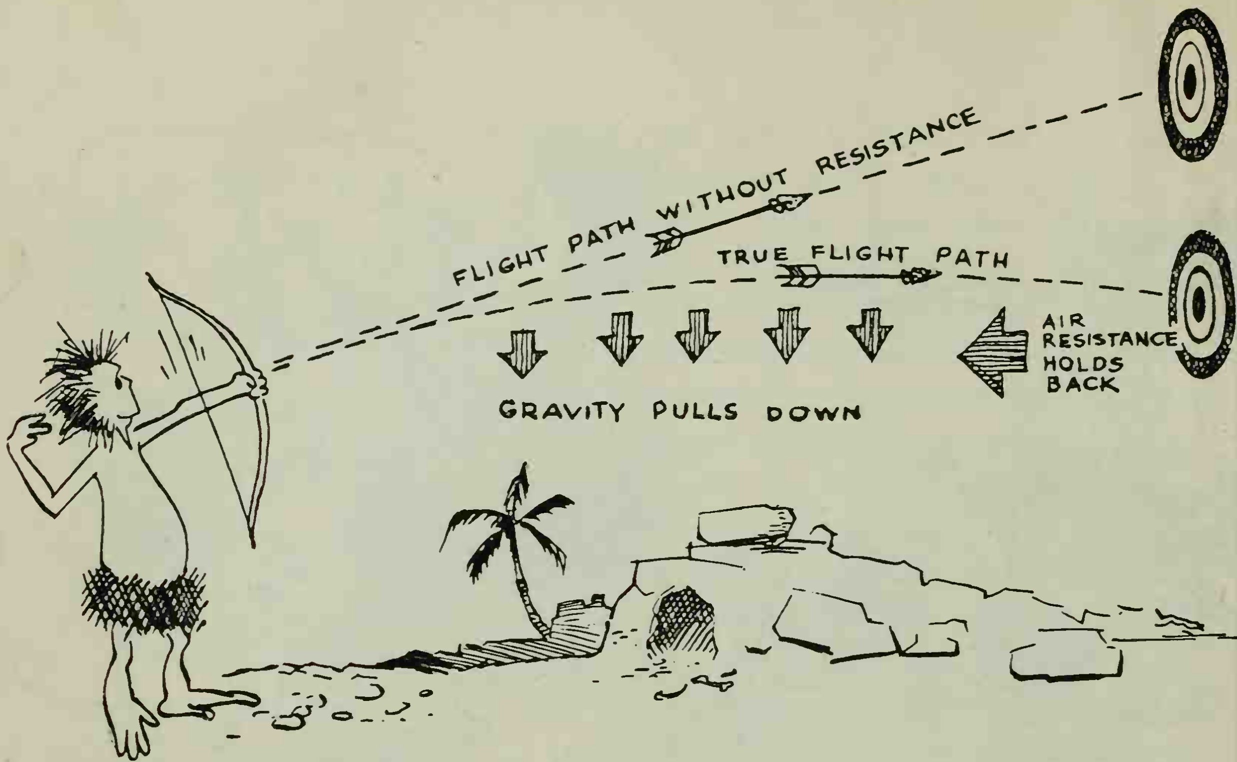




rows with improved warheads. For example, he had great trouble keeping his arrows on course; sometimes they wobbled through the air completely unstable. He made them longer and he made them shorter. He made them thicker and he made them thinner. He put on lighter and heavier warheads. But for many years he could not eliminate the unstable motion of the arrows.

Early man knew very little about ballistics, air resistance and the pull of gravity. But we can assume that he must have spent a lot of time trying to find out what the things were that prevented him from perfecting his weapons system. Perhaps he found the solution by watching his children throwing round, flat stones along the surface of the water. He might have noticed how straight the stones would travel when they were spun around as the children let go of them. So this was it! He must make the arrow spin, he thought. And he went back to his hut and started making arrows with slightly twisted feathers. Sure enough. The arrow would spin through the air in a straight, beautiful path. He had developed a truly guided missile, spin stabilized just like many of our modern rockets.

By and by man learned that the arrows must be as streamlined as possible, and soon he had developed such a perfect weapon that he could use it with great accuracy to defend himself and to hunt all kinds of game. He could even use the bow and arrow to catch fish, and with a powerful bow he could sometimes shoot birds in



flight. In fact, the bow and arrow were almost the "ultimate" weapon for man. It took literally thousands of years before he invented something better.

We don't know exactly when it happened, but it must have been about 5,000 years ago. Then somewhere in ancient China, somebody discovered gunpowder. History has recorded how the Chinese made all kinds of fancy fireworks throughout the first centuries since 3000 B.C. But the first recording of gunpowder being used for military rockets was not written down by historians until the year 1232. At that time, Ogdai, son of the fearsome Genghis Khan, used "arrows of flying fire" to repulse an attack by Mongols on the Chinese walled city of Kar-fung-fu.

Throughout the next few centuries rockets were used with some degree of success by pirates around 1600, by Indians against the British in 1799, by the British against the French in 1806 and against Napoleon's navy in Copenhagen's harbor. But in the early days of rocketry man had not enough knowledge of how to build accuracy or a guidance system into the rockets. So the guns took over. In the period between Napoleon and Hitler (1812 to 1942 — 130 years) big artillery was the most important weapon available to man. It was then replaced by long-range bombers — and then, about 1950, the rockets had their comeback.

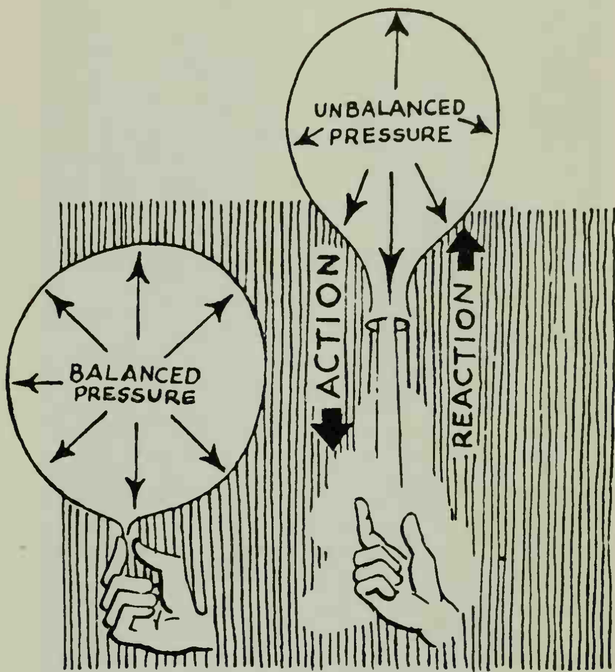
The first workable, long-range military rocket was developed by the Germans. This missile was the V-2, which was used quite effectively during the latter part of World War II.

But it was introduced too late to affect the outcome of the war. Nevertheless, all major powers clearly understood the importance of this new weapon, and today the rocket is perhaps the most important weapons system in use anywhere.

Rockets do not fly because the escaping gases from the nozzles push against air, but because the gases in the combustion chamber push against the forward wall of the chamber. This illustrates Newton's third law of motion, which states that a force in one direction always creates an equal force in the opposite direction.

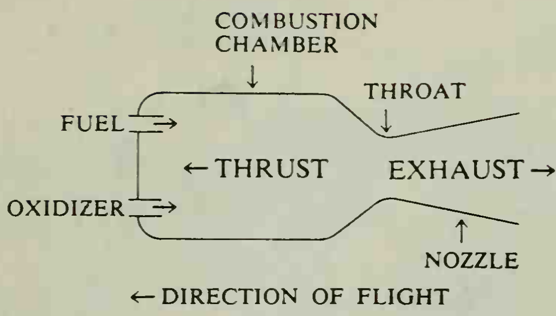
In fact, rockets work better in a vacuum (space) than in the atmosphere because of the lack of air resistance. Since a rocket carries its own oxygen aboard for combustion, it is the only combustion engine that will work outside the earth's atmosphere. It also works underwater.

A modern rocket is a complex piece of machinery despite the fact that



rocket propulsion in itself is the simplest combustion method used by man. A liquid-propellant rocket system consists of a fuel tank, an oxidizer tank and the engine with a maze of controls, valves, pumps and delicate mountings and fittings. The fuel (for example, alcohol) and the oxidizer (for example, liquid oxygen) are pumped into the rocket combustion chamber, mixed in a fine mist and ignited. There are no cylinders in a rocket, no carburetors, no crankshaft.

The rocket engine itself, or the combustion chamber and its nozzle, is simple in design: it usually consists of a double-walled, cylindrical tube open at one end. The hot gases developed by the burning of the fuel and



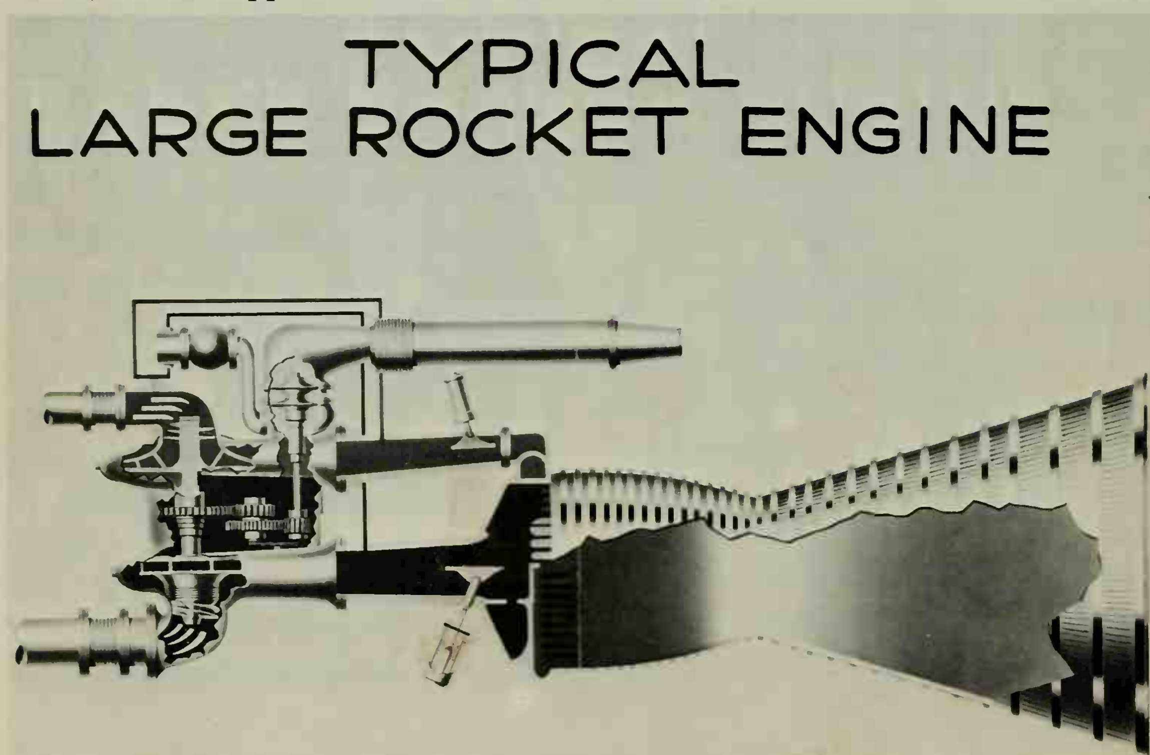
How a rocket works: fuel and oxidizer are pumped into a combustion chamber and ignited. The explosion or combustion and the expansion of the burned, hot gases create a pressure — thrust — and an equal force of exhaust through the nozzle.

the oxidizer in the rocket chamber escape through the open end of the nozzle at great speed. The combustion of the gases creates a push inside the rocket, in the opposite direction of the exhaust nozzle where the gases escape. The faster and more unrestricted the exhaust of the gases, the faster the rocket itself will travel in the opposite direction.

While the rocket combustion chamber is simple in design, the many different control systems required for pumping the right amount of fuel and oxidizer, the cooling system, ignition control and the like make the overall liquid-propellant rocket engine very complex.

Most high-power liquid-propellant rocket engines burn chemical fuel

Schematic drawing of common liquid-propellant rocket engine. To the left are the two intakes for oxidizer and fuel. The pump is driven by the combustion of propellants through the "gas generator" — the "pipe" on top pointing to the right. The rocket combustion chamber is to the right. / *Rocketdyne*

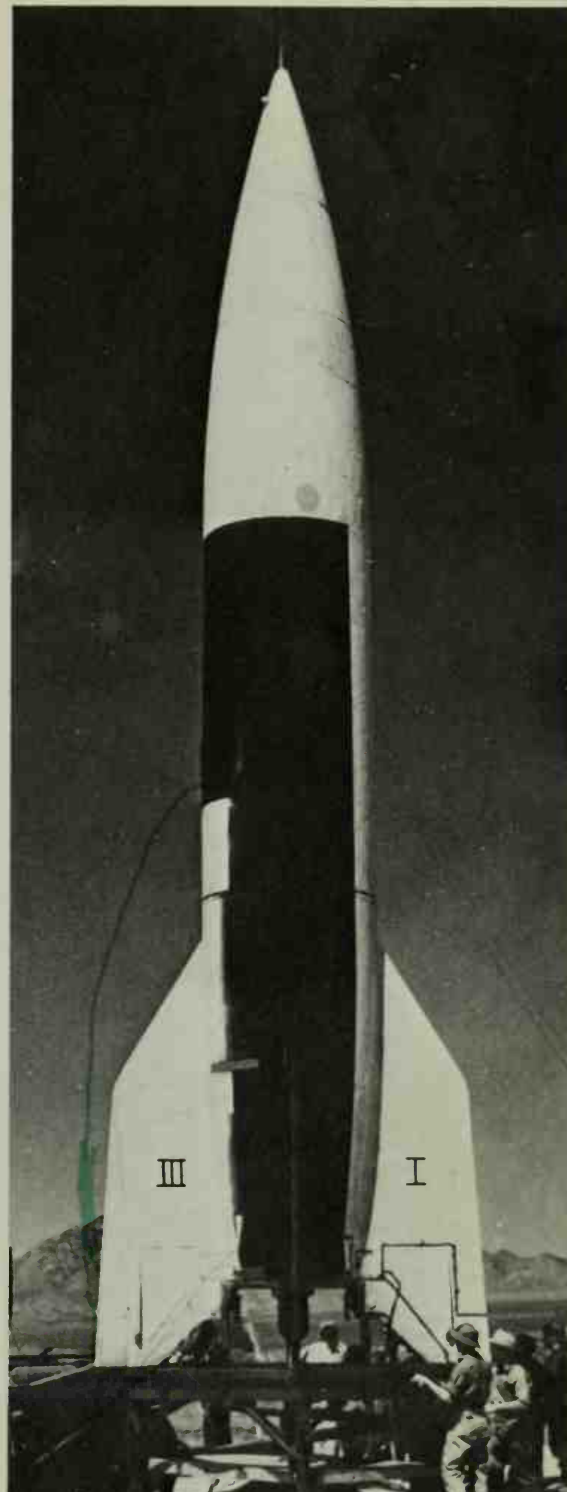


that will yield a great amount of energy. The most widely used fuel is kerosene, and the most widely used oxidizer is liquid oxygen. Other popular fuels include hydrazine, alcohol and liquid hydrogen. A widely used oxidizer is nitric acid.

Power from a rocket is measured in pounds of thrust instead of horsepower. The German V-2 rocket, which could hurl a one-ton warhead some 200 miles, had a thrust of 56,000 pounds. The U.S. Air Force intermediate-range ballistic missile *Thor*, which flies more than 1,500 miles, has a thrust rating of 165,000 pounds. The most advanced rocket propulsion systems of the United States now under development give between 1.5 and 9 million pounds of thrust.

Truly operational liquid-propellant rockets were not developed until the turn of the century. In 1895-97 an engineer, Pedro E. Paulet of Lima, Peru, made what is believed to be the first firing of a liquid rocket. In 1909 Professor Robert H. Goddard of Worcester, Massachusetts, began work on liquid rocket engines. But the first full-fledged long-range liquid rocket was the German V-2 which was first flown successfully in October, 1942.

In the beginning, all big rockets were developed for military purposes. But after the last World War many rockets were developed for scientific research only. Today our biggest



The world's first operational, mass-production rocket was the German V-2, developed in the late thirties and fired successfully for the first time on October 3, 1942. The rocket was 46 feet long. All modern liquid-propellant rockets are based on the V-2.

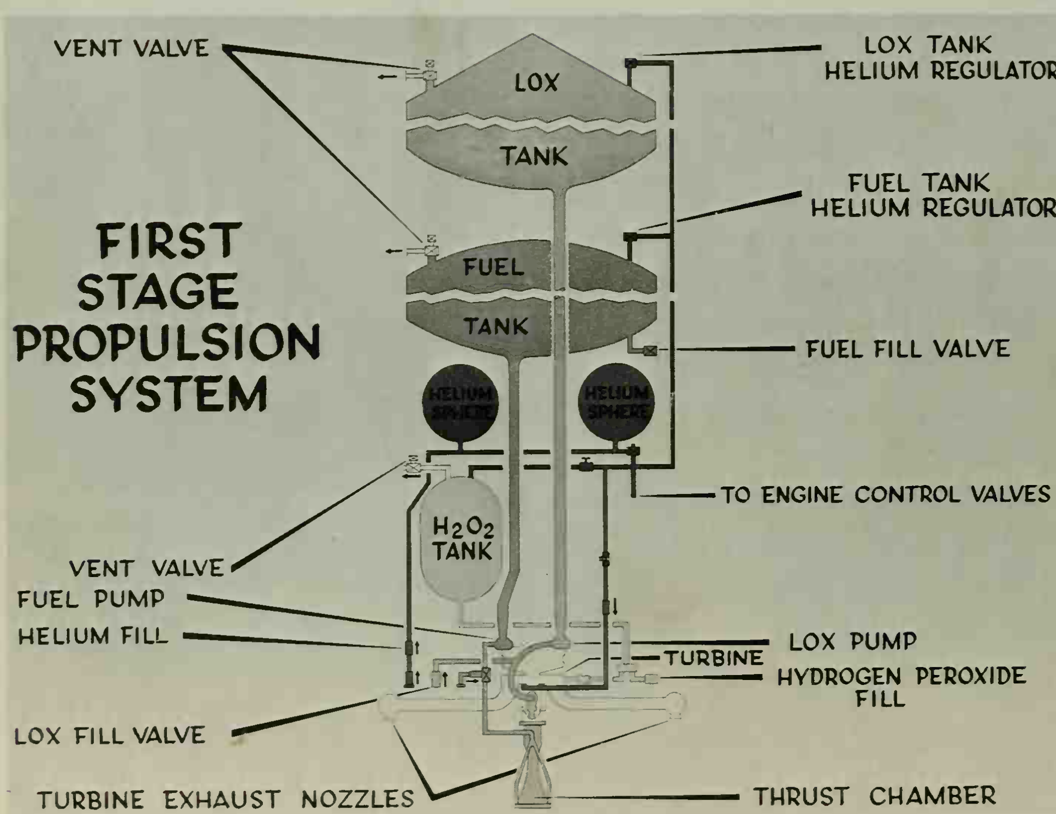
rockets are developed for the peaceful exploration of space for the advantage of all sciences and all mankind. The big rockets now being built help send aloft satellites and spaceships which assist man in his search for knowledge about our universe and many practical "down-to-earth" sciences, such as better navigation, television, weather forecasting and astronomy, to name a few.

In rocket technology the most frequently used terms to define performance are *thrust, specific impulse, and exhaust velocity*. Thrust is expressed in pounds and is arrived at by multiplying the speed of exhaust gases by their mass flow rate. Specific impulse indicates the amount of thrust developing from each pound of propellant in one second of engine operation. Exhaust velocity is the speed in feet per second at which exhaust gases are expelled from the nozzle.

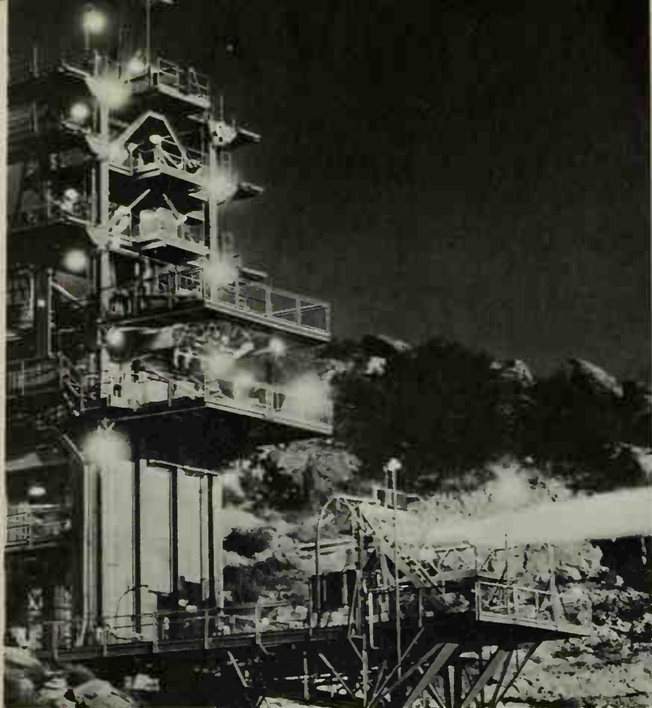
Since the last World War the Army, Navy and Air Force all have developed a number of different kinds of rockets for different purposes. Some rockets are small and can be shoulder-fired by a soldier much like a bazooka antitank weapon. U.S. infantrymen have shoulder-fired rockets for use against low-flying aircraft. Other missiles are so big that they require huge launching equipment and many men to conduct the firing. The biggest military rockets are launched from fixed launching positions; for the most part these are concrete and steel underground structures called silos.

The many different rocket systems

/ Martin

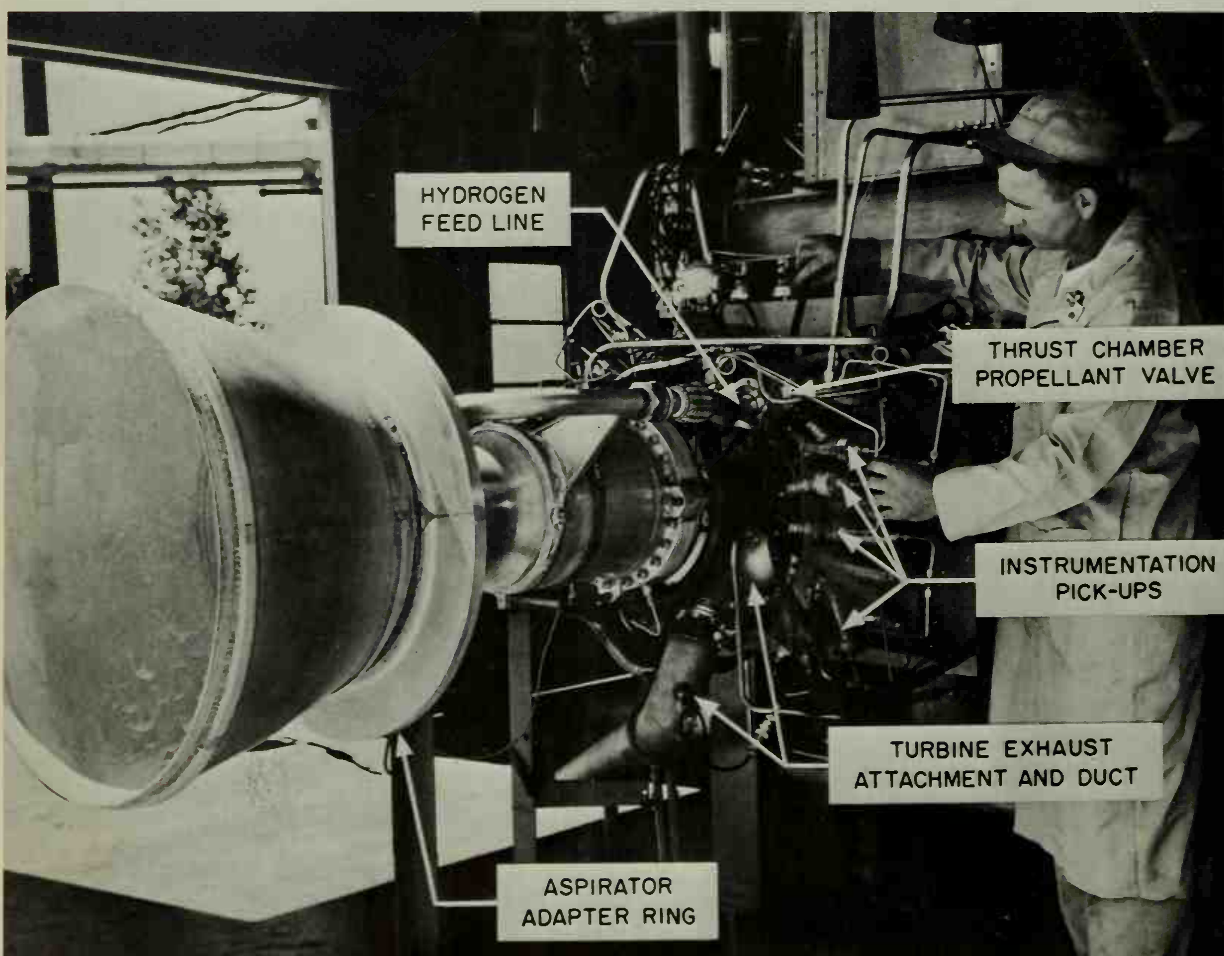


Production of solid-propellant rocket casings for small missiles. Solid-propellant rockets are practical for many smaller missiles because they can be readily stored and transported.



Typical static test stand for liquid-propellant rocket engines. Liquid-propellant rockets are called engines, while solid-propellant rockets are called motors.

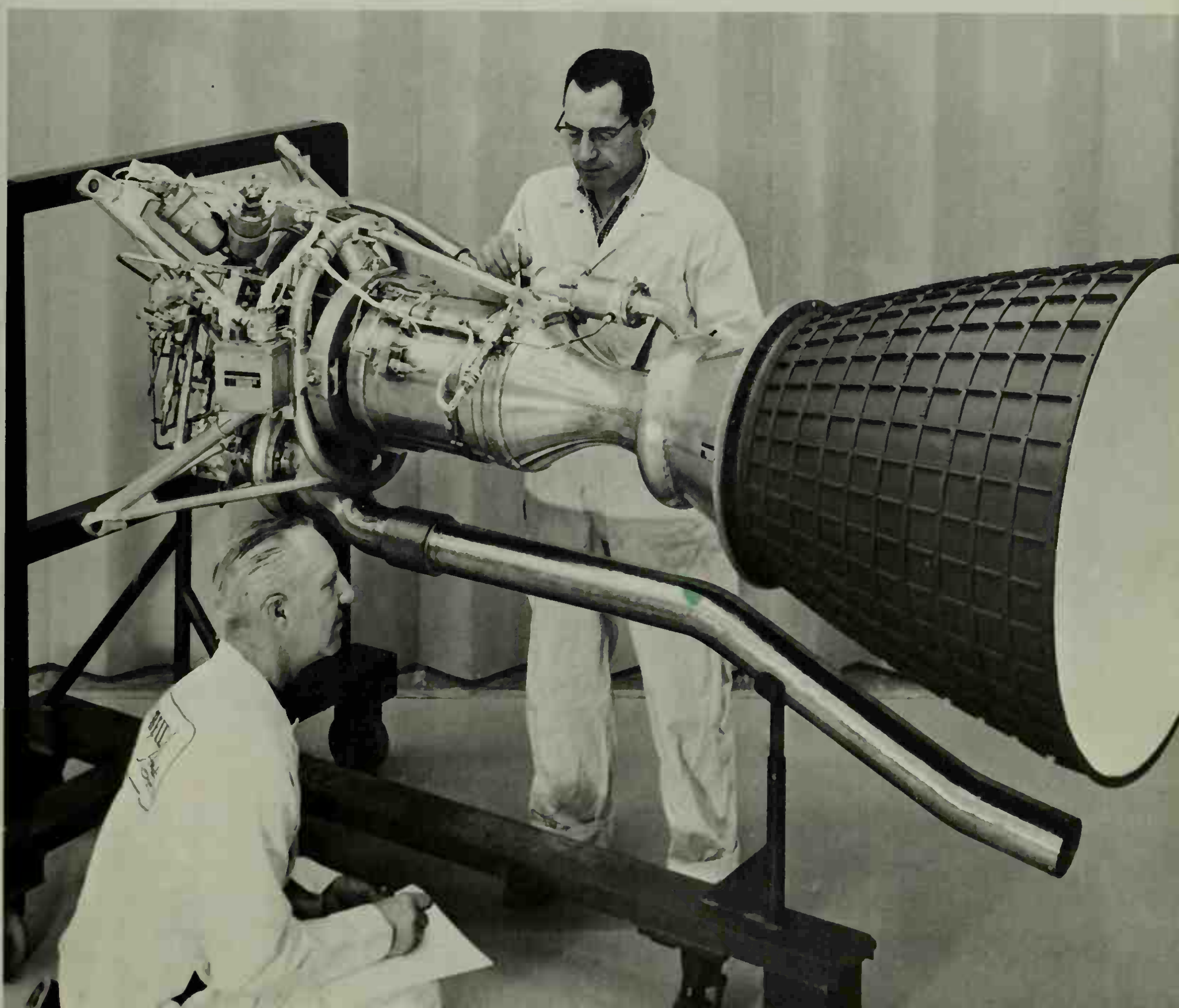
Technician making adjustments on a typical liquid-propellant rocket engine. Although the principle of rocket power is simple, the rocket engine is very complex. / *Bell*

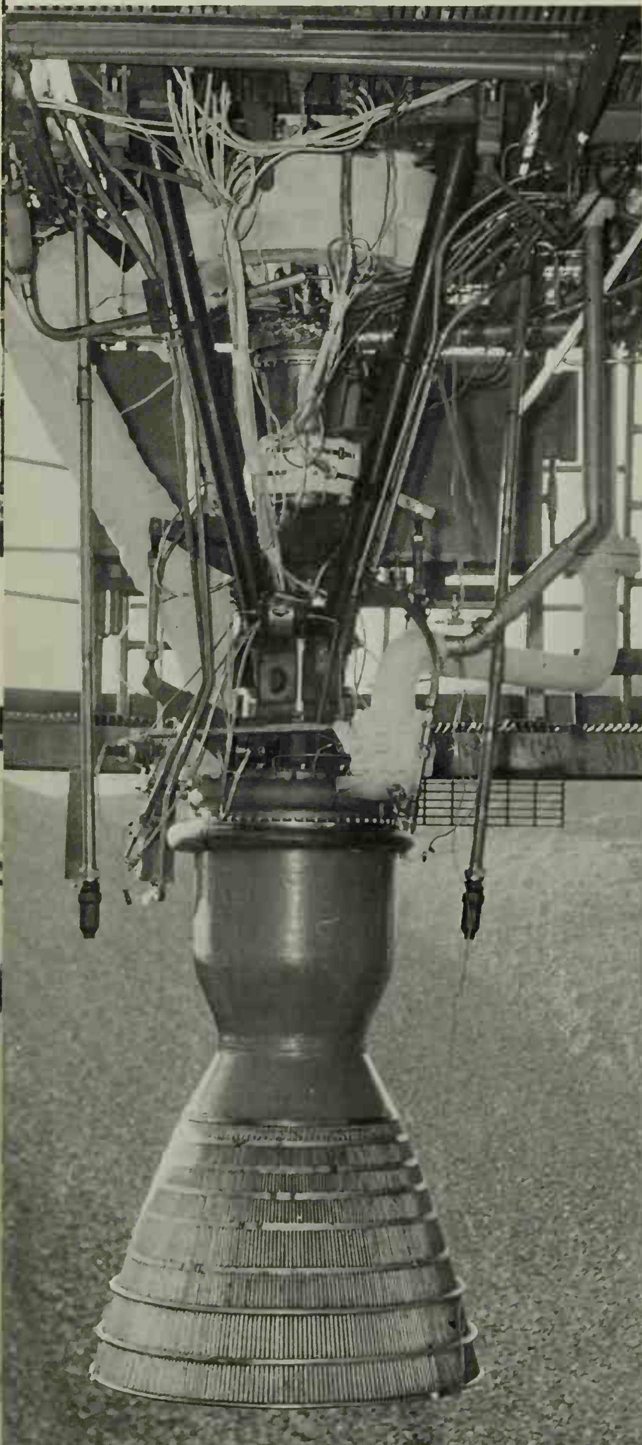


in use by our services have been designed to supplement older weapons systems, but in many cases rockets have replaced other weapons. For example, because of rocket power the Navy has been able to increase the range of its torpedoes, and because of long-range rockets the Air Force has almost stopped building heavy bombers. Likewise, the Army nowadays uses long-range rockets instead of cumbersome artillery.

Rockets and guided missiles fall into distinct categories or groups. Today, about 90 percent of all guided missiles are powered by rockets. But a few years ago many missiles were fitted with jet engines, such as turbojets and ramjets.

Liquid hydrogen engine with "exhaust pipe" for the gas generator. / *Bell*

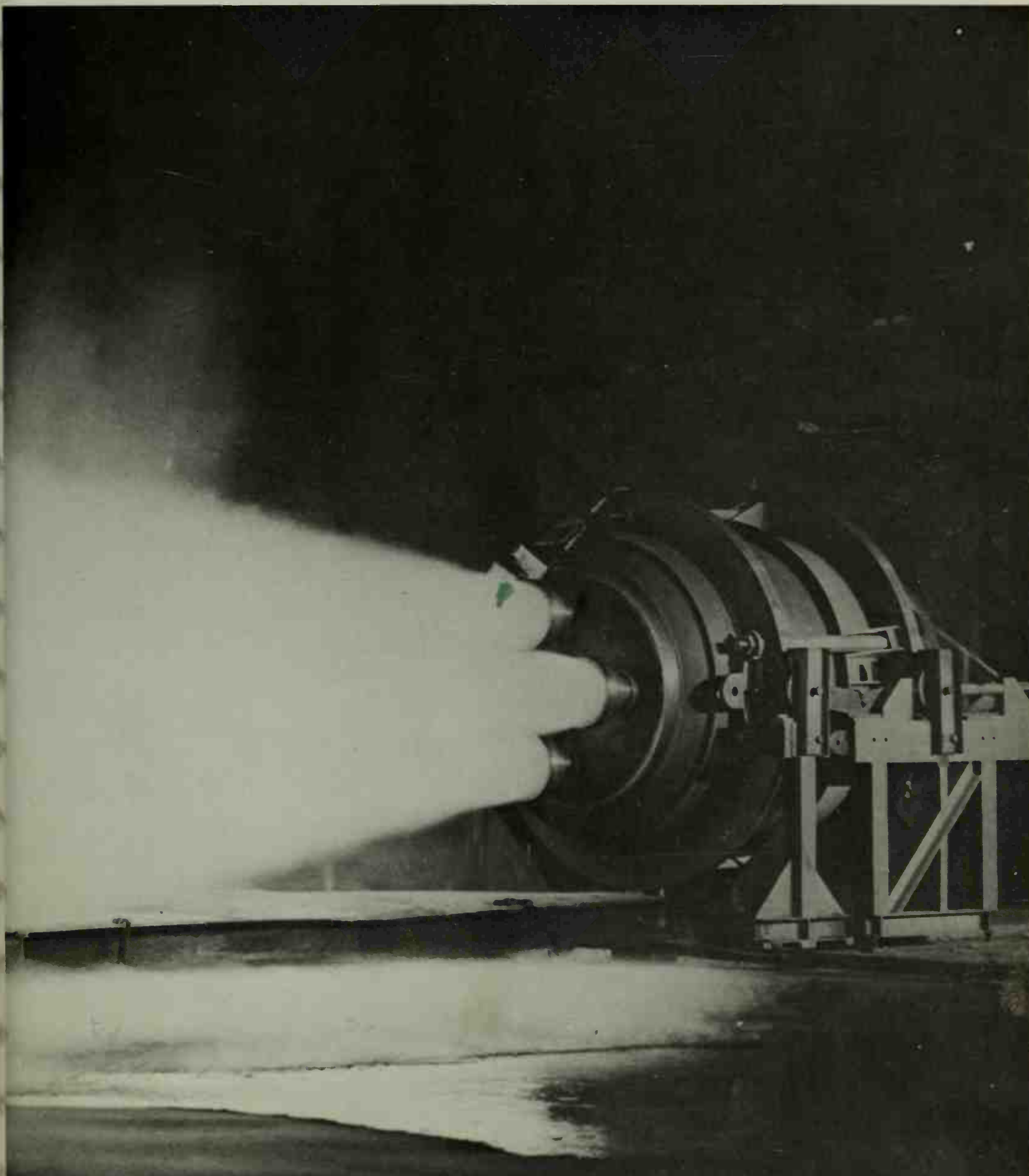




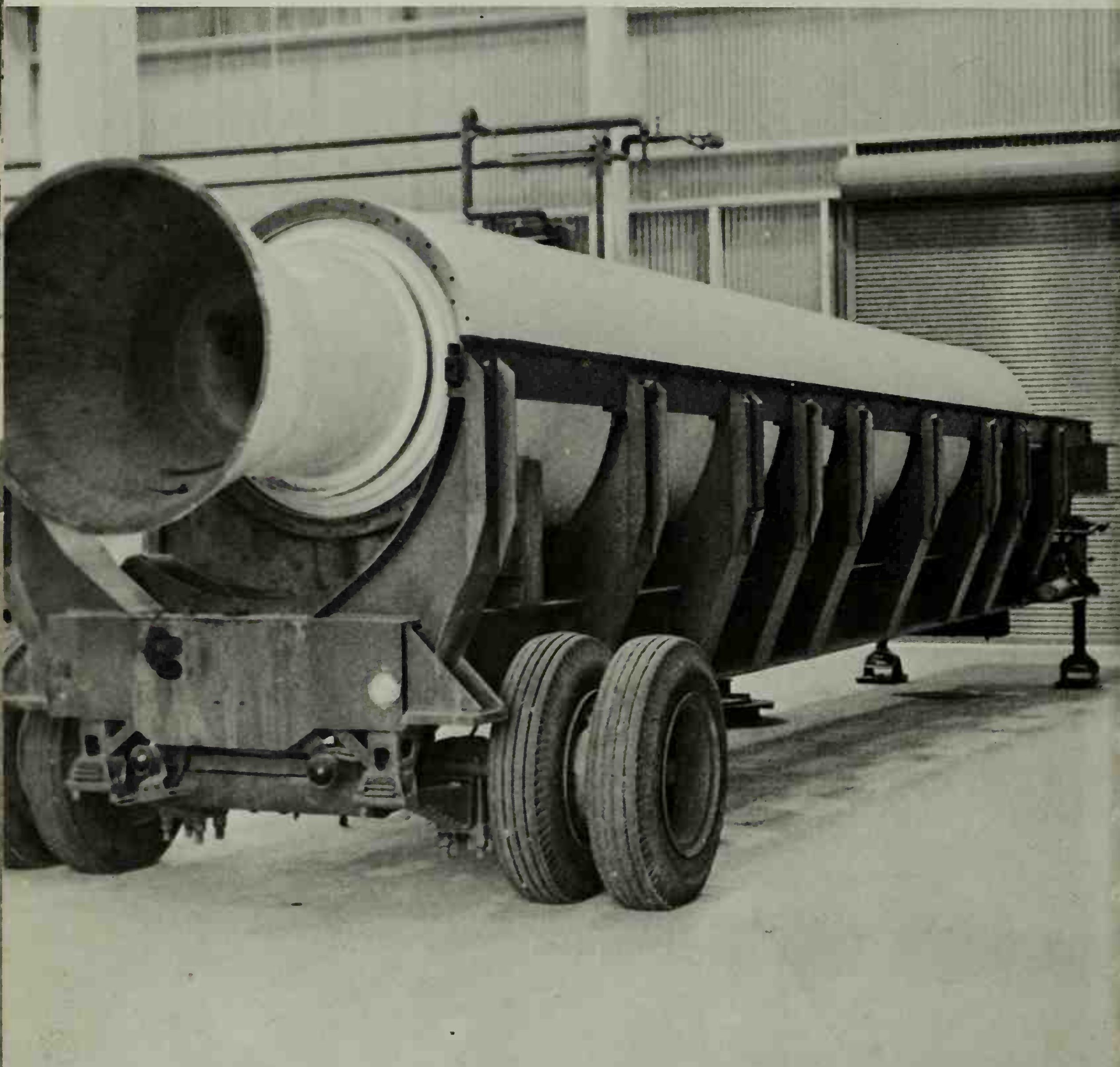
A complete breakdown of all missile categories is included in the glossary of this book. For example, you will find that ICBM stands for *intercontinental ballistic missile*, and IRBM for *intermediate-range ballistic missile*, and MMRBM for *mobile midrange ballistic missile.* Yet all these types of missiles fall in the basic category of surface-to-surface missiles. Consequently, the next four chapters group all operational missiles in the four basic categories: *air-to-air*, *air-to-surface*, *surface-to-air* and *surface-to-surface.* All missiles can be classified as belonging in one of these four groups.

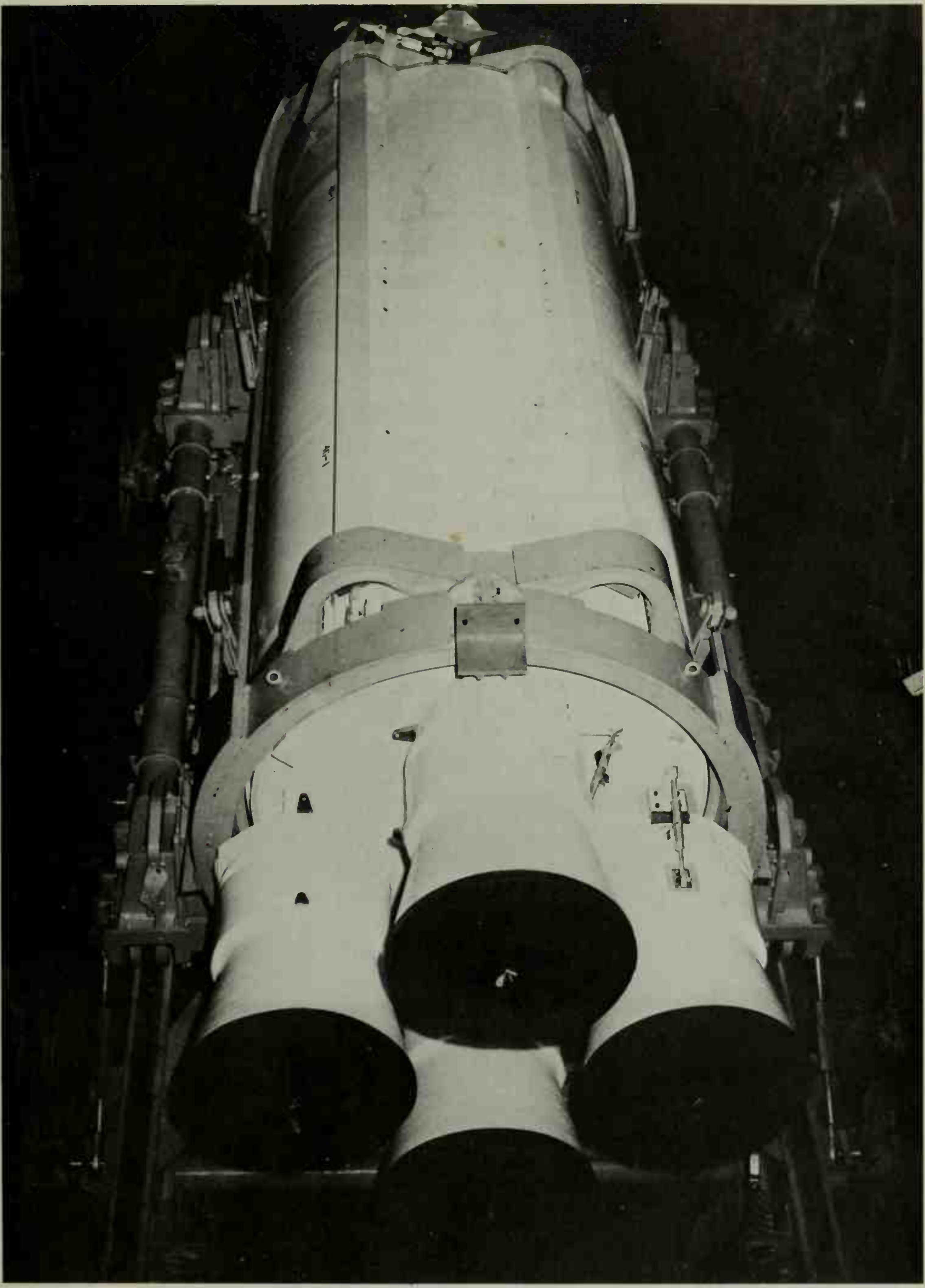
Large liquid-propellant engine mounted in its test stand. Many test firings are required before the engine can be shipped off for mounting in the missile. / *Aerojet*

Four-chamber solid booster during static test firing. Some solid-propellant boosters develop over one million pounds of thrust.



Large single-chambered solid rocket on its transporter. Most solid propellants consist of a chemical rubber-type mixture rich in oxygen.





Solid-propellant booster rocket with four combustion chambers. Large boosters like this one are often used to hurl aloft unmanned satellites and space probes.

Air to Air Rockets

FALCON *(Air Force)*

(AIM-4A, C, E, F; AIM-26A/AIM-47A)

Type: air-to-air missile for jet combat aircraft

Propulsion: solid-propellant rocket

Guidance: varies with missile; active radar homing/infrared homing

Performance: 6,000 pounds of thrust; range over 5 miles; supersonic speed; altitude over 50,000 feet

Construction: single-stage; length 6.5 feet; diameter 6 inches; weight, over 100 pounds; AIM-26A length 7 feet; diameter 11 inches; fin-span 20 inches; weight over 200 pounds

Remarks: nuclear warheads on larger AIM-26A model, high-explosive on other models

Falcon guided missiles are supersonic air-to-air weapons designed for defense against supersonic bombers and fighters. Previously, this missile was called a guided aircraft rocket and was designated GAR. The first GAR to become operational was attached to a unit of the Air Defense Command in 1957. The latest Falcon fills a vital need in the Air Defense Command for a nuclear defense weapon giving safe and effective protection against fast-closing, head-on attacks. The missile has been or is being used by aircraft of the following types: F-89, F-101, F-102 and F-106.

Air Force pilot ready to go aloft with his F-102 and its *Falcon* air-to-air rocket. *Falcons* carry small nuclear warheads.

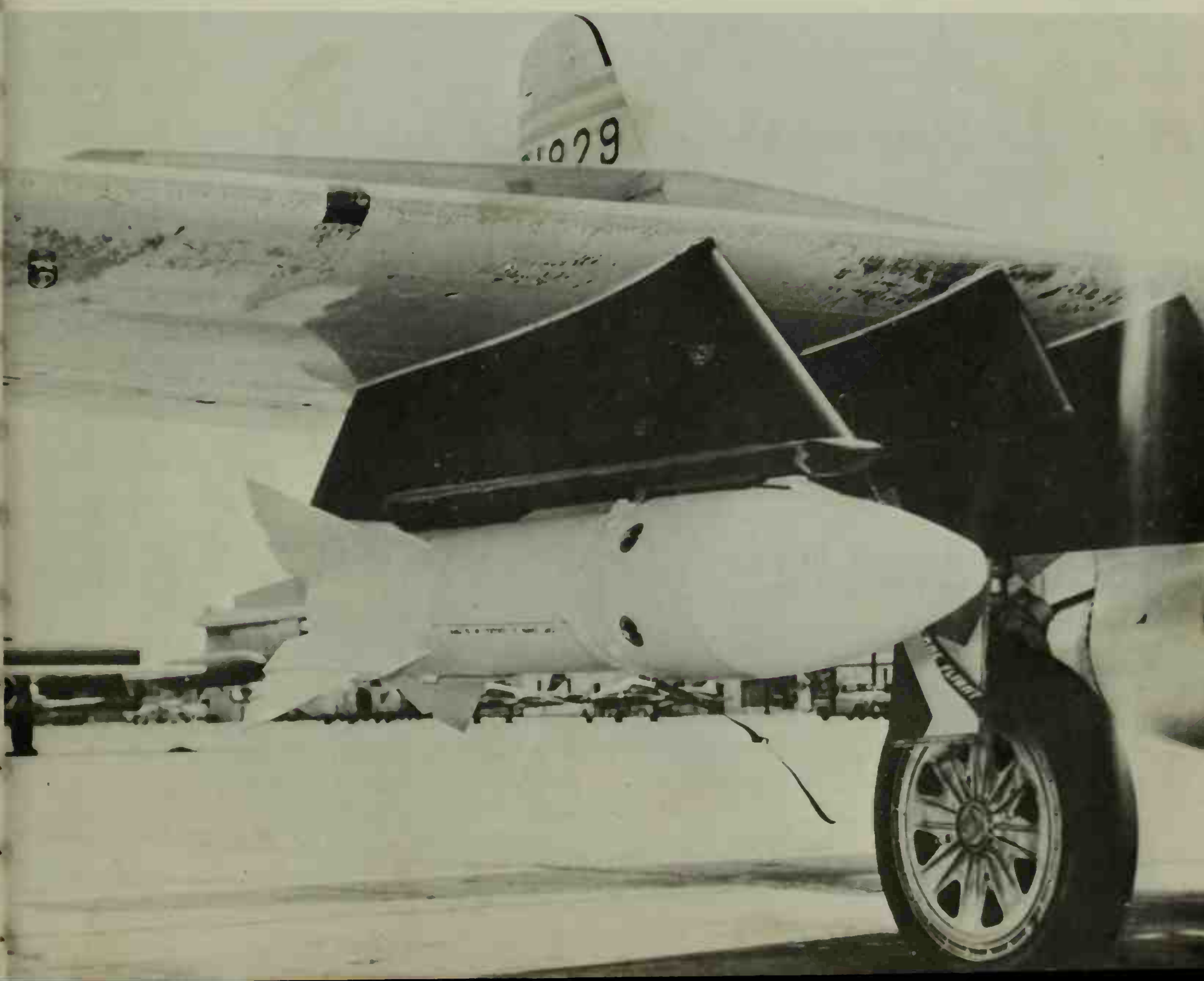
GENIE (Air Force)

(AIR-2A)

Type: air-to-air missile for interceptors against bombers
Propulsion: solid-propellant rocket
Guidance: free-flight
Performance: range over 6 miles; speed three times the speed of sound; altitude over 50,000 feet
Construction: length 9.5 feet; diameter 17.35 inches; weight 800 pounds
Remarks: nuclear warhead with proximity fusing; missile is designed for area defense against enemy bombers

Formerly referred to as the MB-1, the Genie is an air-to-air rocket with a nuclear warhead, designed for area defense. This free-flight, 6-mile-range missile is fired against enemy bombers at high altitudes (about 50,000 feet) and explodes in the vicinity of the enemy to create a nuclear blast barrage which the enemy cannot penetrate. Probably, the heat from the explosion will finish the enemy bombers off. First successful tests of the Genie were conducted from F-89D and YF-102 interceptors in 1956. The missile became operational with the Air Defense Command in January, 1957, and is now used on F-101B and F-106 aircraft.

First air-to-air rocket to be fitted with a nuclear warhead was this Air Force *Genie* missile.



PHOENIX (Navy)

(AIM-54A)
Type: air-to-air missile for F-111B (TFX) aircraft
Propulsion: single-stage solid-propellant rocket
Guidance: classified
Performance: classified
Construction: classified
Remarks: although details are classified, missile is reported to have extensive range and altitude capabilities

Phoenix designates the guided missile being developed as the major armament for the F-111B, the Navy version of the TFX tactical fighter plane. In 1961 the Air Force, Navy and several aircraft manufacturers initiated studies directed toward determination of the optimum tactical fighter program for the two military departments. Later the General Dynamics Corporation was picked to build the F-111A and F-111B. These advanced aircraft will be used to attack enemy missiles and planes as well as targets on the ground.

SIDEWINDER (Navy and Air Force)

(I-C AIM-9D)
Type: air-to-air missile for fighter aircraft
Propulsion: solid-propellant rocket
Guidance: infrared homing; some missiles equipped with semiactive radar homing device
Performance: range over 2 miles; supersonic speed; altitude over 50,000 feet
Construction: length 9 feet; diameter 5 inches; weight about 155 pounds
Remarks: high-explosive warhead

Sidewinder, a homing guided missile designed to destroy high-performance fighter aircraft and bombers, became operational in July, 1956. This reliable, relatively inexpensive missile has very few moving parts and no more electronic equipment or components than an ordinary radio. No specialized technical training is required for personnel who handle and assemble the missile. For these reasons, Sidewinder missiles are used by the Air Force, the Navy and the Marine Corps in great numbers. These missiles were used by Chinese Nationalist forces in the Quemoy Island crisis in 1958 and by Vietnamese and U.S. forces in Vietnam in 1965.

F-104 Starfighter jet with *Sidewinder* rocket mounted under the wing tips.

Pair of *Sidewinder* air-to-air rockets mounted under the fuselage of jet fighter. This rocket is guided toward its target by infrared homing device mounted in the missile's nose.

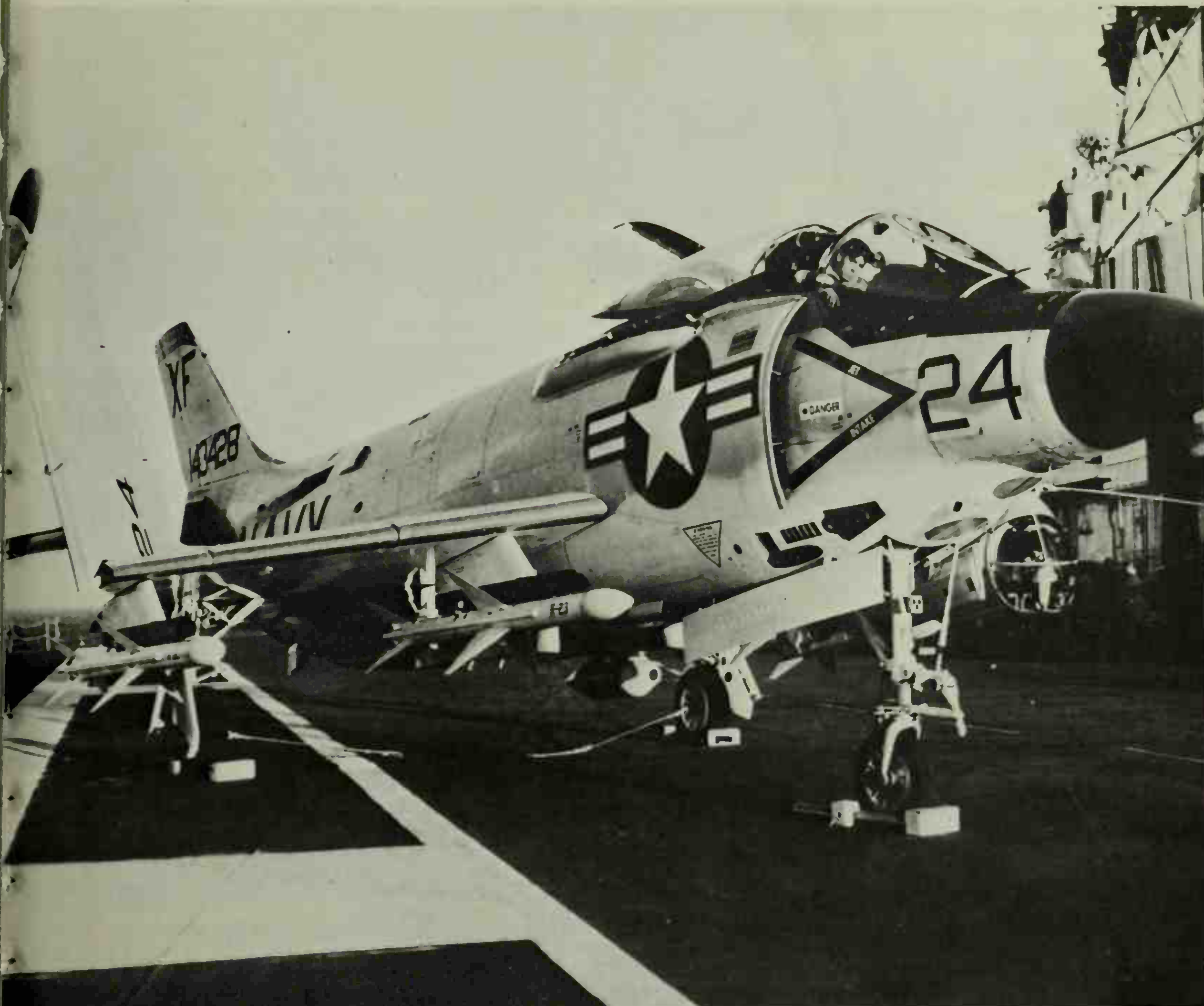
SPARROW III-6B (Navy)

(AIM-7E)

Type: air-to-air missile for fighter aircraft
Propulsion: solid-propellant rocket
Guidance: semiactive homing
Performance: range 8 miles; three times the speed of sound; altitude over 50,000 feet
Construction: length about 12 feet; diameter 8 inches; weight 350 pounds
Remarks: missile built for all-weather attack capability; used by carrier fighter aircraft

Sparrow III offers two performance features not before available for fleet defense: it can attack high-performance aircraft in all kinds of weather and from all directions, including head-on. It can also be fired by the pilot by radar-spotting of the target; in other words, the pilot need not actually see the enemy with his own eyes. Sparrow III has been operational since August, 1958, when replacement of Sparrow I was begun. The new missile first was deployed with F3H-2 Demon fighter squadrons in the West Pacific. Today, the missile is being used by several different Navy fighter planes.

Sparrow air-to-air rocket being fired from a Navy F4H Phantom II jet fighter. In tests this supersonic missile has shot down supersonic target missiles.



Navy F3H-2 fighter in the Pacific being readied for strike attack with four *Sparrow III* air-to-air missiles.

Air to Surface Rockets

BULLPUP (Navy and Air Force)

(AGM-12 B and C)

Type: air-to-surface missile

Propulsion: solid-propellant rocket for B version; prepackaged liquid storable propellant engine for C version

Guidance: pilot uses visual reference for aiming; then missile follows radio-link command guidance from the firing aircraft

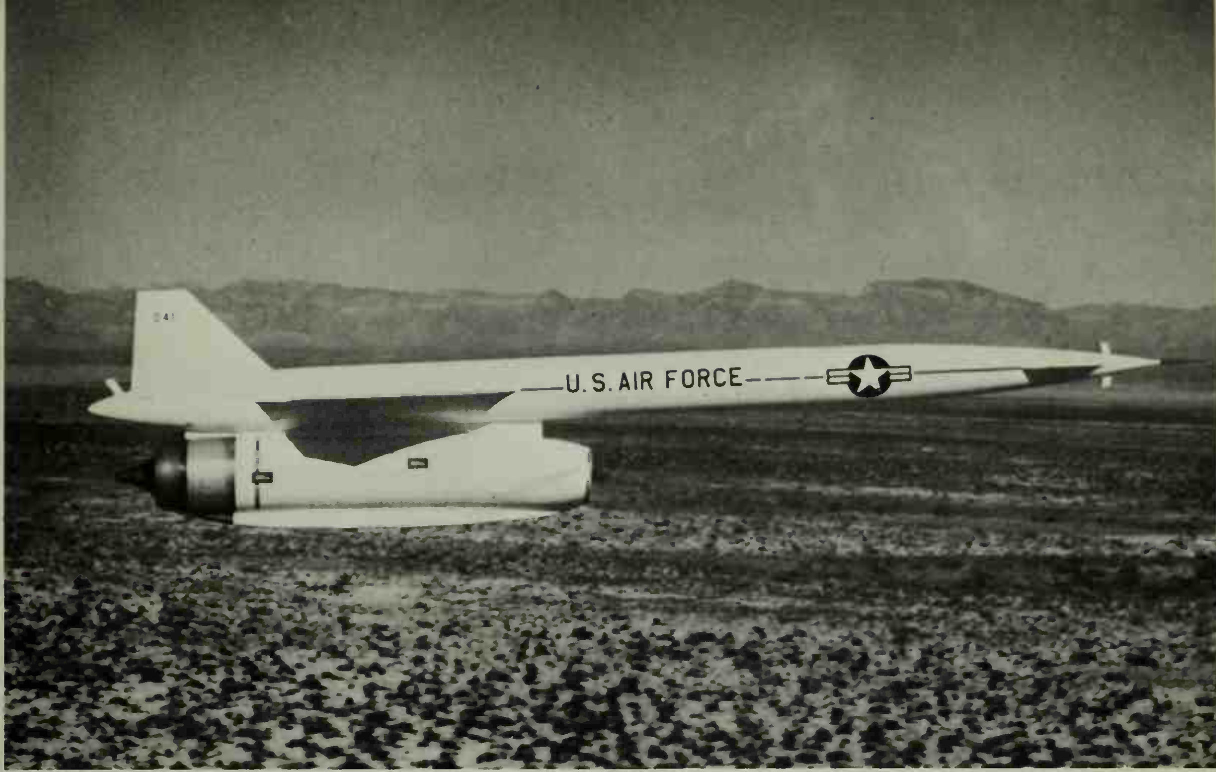
Performance: range 6 miles; speed 1,400 miles per hour

Construction: B model length 11 feet; diameter 12 inches; weight 573 pounds; C model length 13.5 feet; diameter 18 inches; weight 1,800 pounds

Remarks: extremely accurate against fixed targets, such as bridges; B model uses high-explosive, 250-pound warhead; C model warhead weighs 1,000 pounds; missile also being produced in Europe for NATO

Bullpup was developed to meet the requirements for a weapon that could be launched by an aircraft at a safe distance from enemy ground fire and accurately guided by the pilot to a comparatively small surface target. The missile has been successfully fired from helicopters as well as F-100 and F-105 fighters. It became operational aboard the USS *Lexington* in 1959. The desirable features of this missile have stimulated several new developments by the Navy and Air Force.

Navy A4D fighters with *Bullpup* air-to-surface missiles mounted between the external fuel tanks. The *Bullpup* is used against tanks, bridges and boats.



Air Force *Hound Dog* air-to-surface missile flying low over White Sands Proving Ground. It is launched from a B-52 bomber.

HOUND DOG (Air Force)

(AGM-28)

Type: air-to-surface strategic defense-suppression missile

Propulsion: J52 turbojet engine

Guidance: all-inertial (preprogrammed, preset, nonjammable)

Performance: 7,500 pounds of thrust; range over 600 miles; twice the speed of sound; altitude over 50,000 feet

Construction: length 42.5 feet; wingspan 12.2 feet; height 9.3 feet; weight 9,600 pounds

Remarks: 400 missiles are stocked by the Air Force; a standoff missile is designed to suppress enemy defenses so that B-52 bombers can penetrate to their targets; nuclear warhead

Hound Dog is designed to extend the effective lethal radius of the long-range B-52 bomber, improve its survivability, and compound the enemy defense problem. The first successful launch of this missile was from a B-52 over the Atlantic missile range in April, 1959. In April, 1960, a B-52 carried two Hound Dog missiles from Eglin Air Force Base, Florida, to the North Pole and back to the coastal waters off Cape Kennedy. Following the 22-hour, 10,800-mile nonstop flight, one of these missiles was launched over the Atlantic missile range. The missile flew several hundred miles on a preset path, which included evasive action, before impacting in the target area. The Hound Dog system was deployed in 1960 with the 4135th Wing of the Strategic Air Command. Each B-52H bomber can carry two of the missiles in addition to its bomb load.

QUAIL (Air Force)

(ADM-20C)
Type: decoy to simulate B-52 bomber
Propulsion: J85 turbojet
Guidance: gyroscopic automatic pilot system
Performance: 2,450 pounds of thrust; range 250 miles; new model 400 miles; speed comparable to B-52; altitude over 50,000 feet
Construction: length 12.9 feet; height 3.3 feet; wingspan 5.5 feet
Remarks: carried by B-52s for release as they approach enemy defenses; both bombers and decoys fly B-52 formation style patterns over wide area to maximize enemy confusion

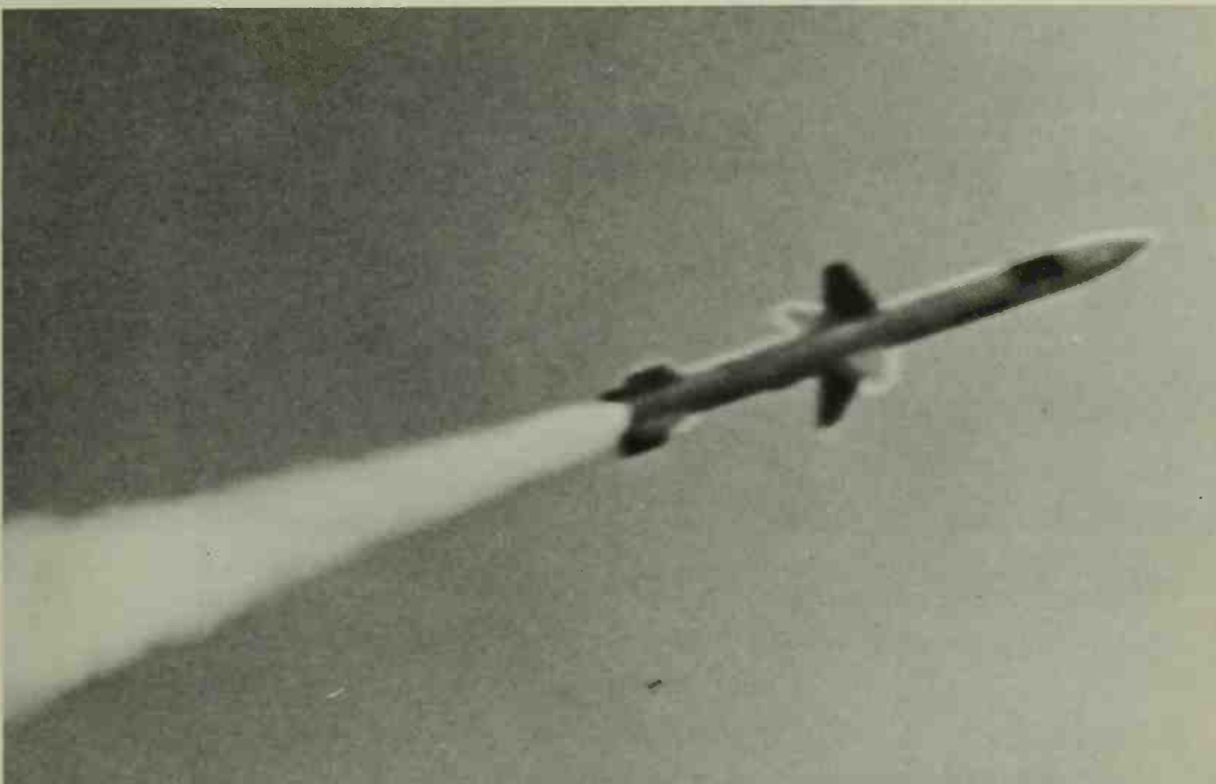
Quail is an air-launched decoy missile with speed, altitude and radar reflectivity comparable to the characteristics in the B-52. This airplane is capable of carrying several Quail missiles. When released in a group, the missiles confuse enemy radars by seeming to be additional bombers. In February, 1961, the last test flight of a Quail was conducted at the Air Force Proving Ground in Florida, concluding over three years of intensive research, development and squadron testing. Delivery of combat-ready Quail weapon systems to operational Strategic Air Command bases began in 1961.

SS-11 (Army)

Type: air-to-surface antitank missile
Propulsion: solid-propellant rocket
Guidance: wire-guided
Performance: range 3,800 yards; speed over 400 miles per hour
Construction: length 46 inches; diameter 6 inches; wingspan 20 inches; weight 63 pounds
Remarks: swept-back cruciform wings; high-explosive shaped charge; employed by helicopters capable of carrying 6 missiles

SS-10 and SS-11 are imports from Nord Aviation of France. The two models are both capable of defeating enemy tanks. They can be operated by field troops and launched from the ground, a vehicle or a helicopter. The SS-10 is intended mainly for ground troops. The SS-11, while based on the SS-10, is complementary to it. It has twice the range of the SS-10 and greater speed. The missile was procured by the United States Army in 1959 for evaluation. Production of the missiles in the United States was made possible through a license agreement signed in 1961. The United States Government has contributed to the development of the SS-11 under the Mutual Weapons Development Program. Several other antitank missiles have been developed since, but the SS-11 is still being used extensively.

Shrike air-to-surface antiradiation missile for fleet fighter and attack aircraft.



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SHRIKE (Navy)

(AGM-45A)

Type: air-to-surface antiradar missile

Propulsion: solid-propellant rocket

Guidance: passive all-weather radar homing

Performance: classified

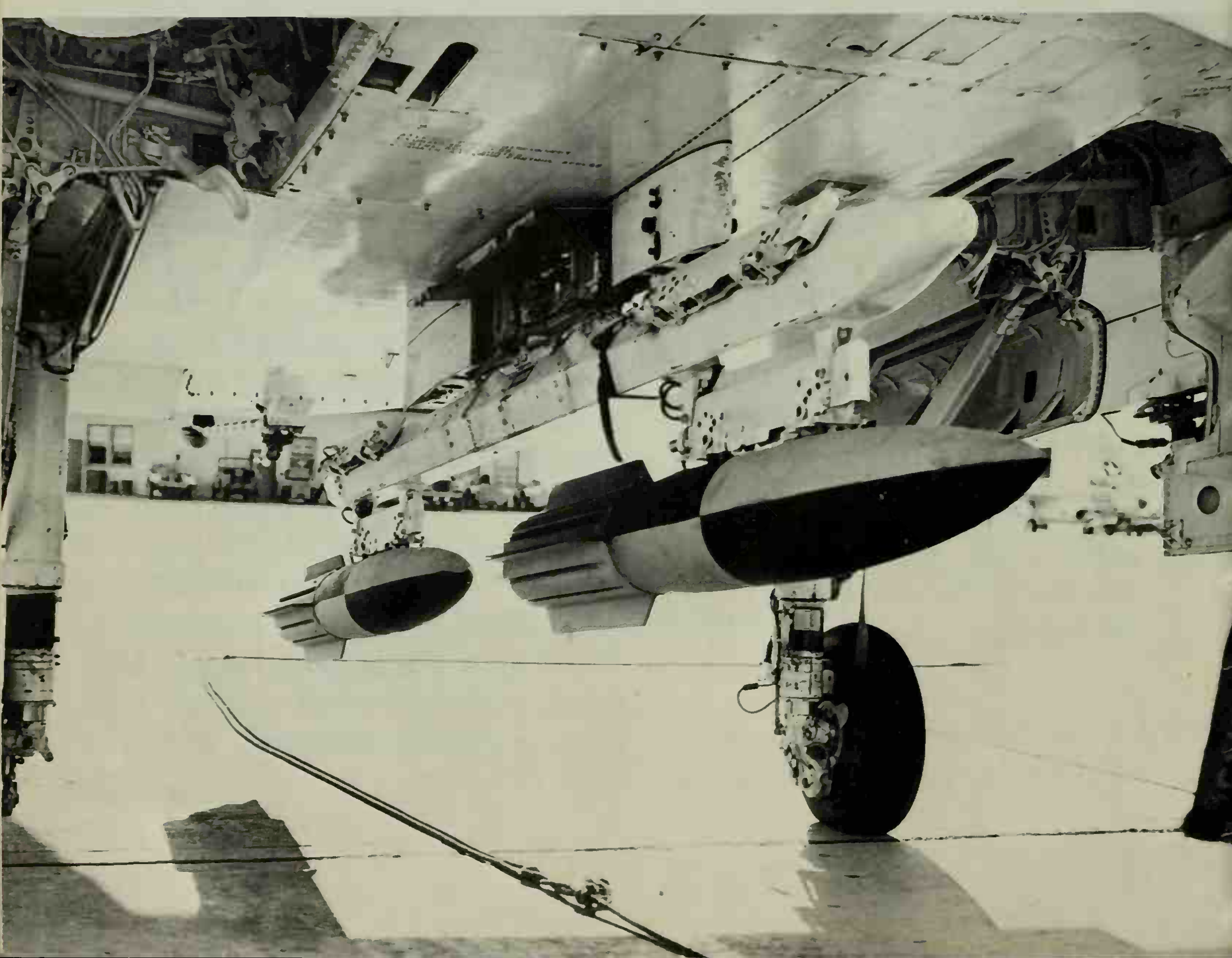
Construction: similar to *Sparrow III*

Remarks: high-explosive warhead; built to be fired by attack aircraft against enemy radar-controlled air defenses and other radar installations

Shrike was designed to fill the need for an air-to-surface missile to be launched by Navy fighter and attack aircraft. The missile has a special homing capability against radar installations, and is considered a particularly sophisticated weapons system. The Naval Ordnance Test Station is the development agency for the program. Texas Instruments, Inc., is prime contractor for engineering and manufacturing services for guidance and control subsystems. Some of the features of this missile include high speed, a high-powered warhead with good accuracy, moderate cost and high reliability.

Navy A-4B Skyhawk with *Rockeye*, an antitank weapon.

Navy *Snakeye* retarded bombs mounted in tandem under the belly of a jet fighter.



WALLEYE (Navy)

Type: guided air-to-surface bomb
Propulsion: free-fall; no motor engine
Guidance: television contrast homing guided by pilot after launch
Performance: range of several miles
Construction: 1,000-pound bomb equipped with movable fins
Remarks: high-explosive warhead; highly accurate; carried by Navy attack aircraft

Walleye is only one of several new semiguided bombs developed by the Navy since 1957 in what is called the EYE weapons series. For example, on several of its attack and fighter planes the Navy has used the *Gladeye* universal weapons dispenser. This weapons system is believed to be capable of carrying sophisticated armament and not necessarily explosives. Another EYE development is the *Snakeye* bomb, designed for conventional low-level attacks. This bomb has a folding tailfin device which deploys as soon as the bomb is dropped. The deployed fins produce drag and slow the descent of the bomb, allowing the delivery plane time to clear the impact area and avoid being hit by fragments from its own bomb. The EYE weapons were designed and developed by the Naval Ordnance Test Station, China Lake, California. Several of the weapons are currently in use by the Navy in all parts of the world.

ZUNI (Navy)

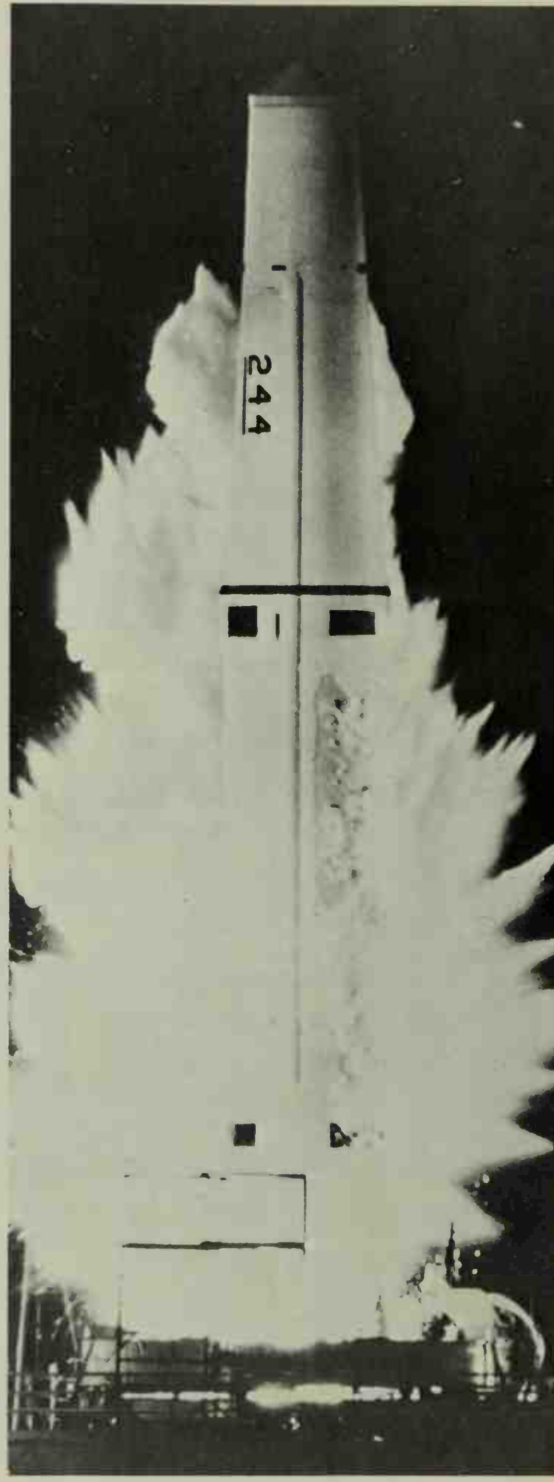
Type: air-to-surface rocket
Propulsion: solid-propellant rocket
Guidance: none
Performance: range 5 miles; twice the speed of sound
Construction: folding-fin, all-weather rocket; length 9.2 feet; diameter 5 inches; weight 107 pounds
Remarks: highly effective against ground targets; used extensively by many Navy aircraft; high-explosive warhead

Probably, more Zuni rockets have been fired than any other rocket in the United States. This high-punch combat rocket has been in mass production for many years and has been termed one of the most reliable weapon systems in our entire arsenal. All Navy pilots of today have had the opportunity to practice with live Zunis at their target ranges. Competition in marksmanship is frequently arranged by the Navy for its pilots, and teams from different carrier squadrons fire Zunis at surface targets for various prizes and trophies. The Zuni has become so common as an attack weapon against surface targets, that it can be used by virtually all Navy combat aircraft. It is simple and rugged, extremely fast and very effective.

ANTISATELLITE WEAPON
(Air Force)

Type: surface-launched missile for destruction of hostile spacecraft
Propulsion: *Thor* and *Thrust-Augmented Thor* used as boosters with *Agena D* second stage; final homing toward target by radar-guided third stage
Guidance: radar homing coupled to throttleable third-stage propulsion system
Performance: classified
Construction: configuration of *Thor* family of missiles is known; no other details released
Remarks: missile developed as insurance against any enemy space threat

It is not known whether the United States has any operational weapons in her arsenal which could knock any hostile satellites out of the skies. But so much has been written about the possible use of satellites as weapons carriers that it may be assumed that the military have been working on various kinds of antisatellite weapons for many years. The only such system which has been mentioned publicly (without release of any details) is the *antisatellite weapon* of the Air Force. Most space weapons developed by the Air Force—such as detection satellites for spotting of enemy rocket launchings—are classified, but it is generally known that the Air Force is working on many different systems in these areas.



Liquid-propellant surface-to-surface *Thor* ballistic missile is fired from Cape Kennedy. Modified *Thors* have been used extensively as boosters for many satellites.

A "super" *Thor* almost twice as powerful as the standard model. In addition to its main liquid-propellant engine this rocket gets extra boost from three solid-propellant motors strapped on the outside.

BOMARC (Air Force)

(CIM-10A and 10B)

Type: surface-to-air missile

Propulsion: solid-propellant booster rocket plus ramjet sustainer

Guidance: radio command during first phase of flight; then active radar homing on target

Performance: range over 200 miles; B-model range 400 miles; two-and-a-half times the speed of sound; altitude 68,000 feet; B model over 90,000 feet

Construction: length 46.9 feet; B model 45 feet; wingspan 18.2 feet; diameter 35 inches; weight 15,000 pounds

Remarks: nuclear warhead; deployed in great numbers in the United States and Canada

The Bomarc gives the Air Defense Command the capability of engaging and destroying enemy attack aircraft far out from a defended target. Its range of over 200 nautical miles makes the defense of large areas possible. The missile became operational in 1959 at McGuire Air Force Base, and it has since been deployed at several bases in New Jersey, New York, Massachusetts, Maine, Virginia, Michigan and Minnesota. Two squadrons were based in Canada in 1962. It has been demonstrated that the target of a Bomarc can be changed while the missile is in flight. Supersonic missiles and target drones flying at great speeds have been practice targets for the Bomarc.

Mobile launcher with three *Hawk* surface-to-air missiles guarding the Panama Canal at Fort Amador on Flamenco Island.

Bomarc surface-to-air defense missile blasts off. This Air Force weapon takes off with the help of a solid-propellant rocket, but a ramjet is the main powerplant.

HAWK (Army)

(MIM-23A)

Type: surface-to-air defense missile against low-flying aircraft

Propulsion: solid-propellant dual-stage rockets

Guidance: semiactive radar homing

Performance: range 22 miles; supersonic speed; altitude from 100 to 45,000 feet

Construction: length 16.8 feet; diameter 14 inches; weight 1,275 pounds; 4 fins

Remarks: high-explosive warhead; used in Europe, Panama, Okinawa, Vietnam and the United States

Hawk is unique when compared to other missile systems because of its ability to engage extremely low-flying targets and its capability to maintain a rapid rate of fire. The Hawk system is simple, rugged and highly mobile. It is air-transportable by helicopter and medium-sized aircraft, and is easy to maintain. When fired against enemy aircraft, the missile actually streaks to an altitude higher than that of the enemy plane and then dives on it from above. The first Hawk battalion was activated in June, 1959. The system complements the defense provided by other surface-to-air missiles (such as the *Nike*) wherever its extreme low-altitude capability is required.

MAULER (Army)

(XMIM-46A)

Type: surface-to-air antiaircraft/ antimissile system

Propulsion: single-stage solid-propellant rocket

Guidance: sky-sweeping acquisition radar; target-illuminating pinpoint radar; then infrared homing for final flight phase

Performance: capable of intercepting small frontline ballistic missiles and supersonic aircraft across a battlefield

Construction: dart-shaped; length about 6 feet; diameter 5 inches; weight 120 pounds

Remarks: field system has three crew members; rocket is fully air-transportable; each firing unit has nine missiles, three rows of three missiles each

Mauler is a highly mobile, all-weather, guided missile system designed to travel with fast-moving Army units in the field. The carrier vehicle can keep up with other fast-moving infantry units, such as artillery, tanks, jeeps and trucks. The missile system can defend the troops and their convoy of other vehicles and equipment against high-performance tactical aircraft, battlefield short-range missiles and rockets. The Mauler missiles can be launched as a barrage-type weapon against the enemy. The system is developed for the Army Missile Command, Huntsville, Alabama, with General Dynamics Corporation as prime contractor. The self-propelled tracked Mauler carrier vehicle is an XM-546.

NIKE-HERCULES (Army)

(MIM-14B)

Type: surface-to-air air-defense missile

Propulsion: two-stage solid-propellant rocket

Guidance: command type; low-power acquisition as well as high-power is used; target tracking and missile tracking in conjunction with electronic data-processing equipment are used

Performance: range over 75 miles; altitude 100,000 feet; three times the speed of sound

Construction: two-stage; length 41 feet; diameter 31.5 inches; weight 10,000 pounds

Remarks: deployed throughout the United States for defense of our cities and strategic targets; also used on Formosa and in Europe; nuclear warhead

Nike-Hercules has successfully engaged targets traveling more than 2,000 miles per hour, as well as other targets at altitudes over 150,000 feet. A major advance in the Nike family of supersonic antiaircraft missiles, the Hercules is capable of performance many times greater than its predecessor, the *Nike-Ajax*. Each missile battery is a completely autonomous unit, capable of acquiring, tracking and engaging supersonic bombers and air-breathing missiles. In 1957 the Army began to train its personnel in handling Hercules, and the system became operational in June, 1958. It is now widely deployed in the United States and overseas.

NIKE-X SPRINT (Army)

Type: surface-to-air antimissile missile

Propulsion: high-acceleration solid-propellant rocket

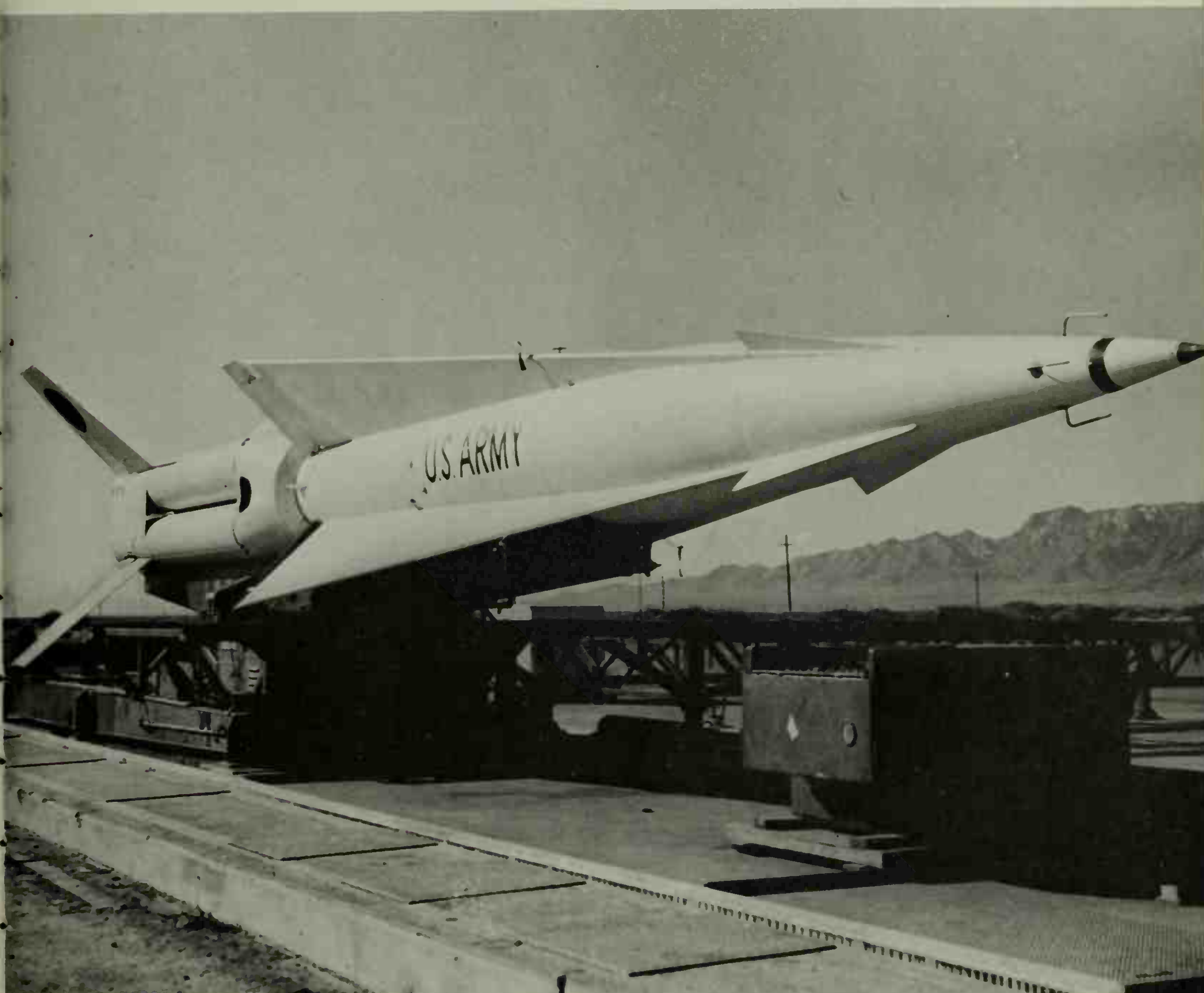
Guidance: command type; mixed with Zeus missiles in batteries to be controlled by multifunction array radar

Performance: classified

Construction: classified

Remarks: designed to attack enemy ballistic missiles at low altitude after decoys have been identified

Nike-X is perhaps the most advanced of the Army missiles. In connection with the Zeus program, the most expensive of all Army missile programs, the Army has investigated advanced radar and antimissile missile configurations. Further study of these design features continues, while the early phase has been called Nike-X. Testing of the Nike-Zeus system has taken place at Kwajalein Island in the Pacific. Among the design and hardware developments included in the Nike-X task have been advanced radar, the Sprint third-stage missile and a large number of components already developed in the Zeus program. The Nike-Zeus Project Manager of the United States Army Matériel Command, Redstone Arsenal, Alabama, directs the Nike-Zeus program. The systems contractor is the Western Electric Company. Study work on the Sprint has been or is under way at the Martin Company, Douglas Aircraft Company and North American Aviation, Inc.



Nike-Hercules surface-to-air rocket in alert position at the Army's proving ground at White Sands, New Mexico.

One of the fastest missiles in existence, the *Sprint* surface-to-air two-stage rocket. It is designed to complement the *Zeus* and is built for the same purpose, except that the *Sprint* is much faster.

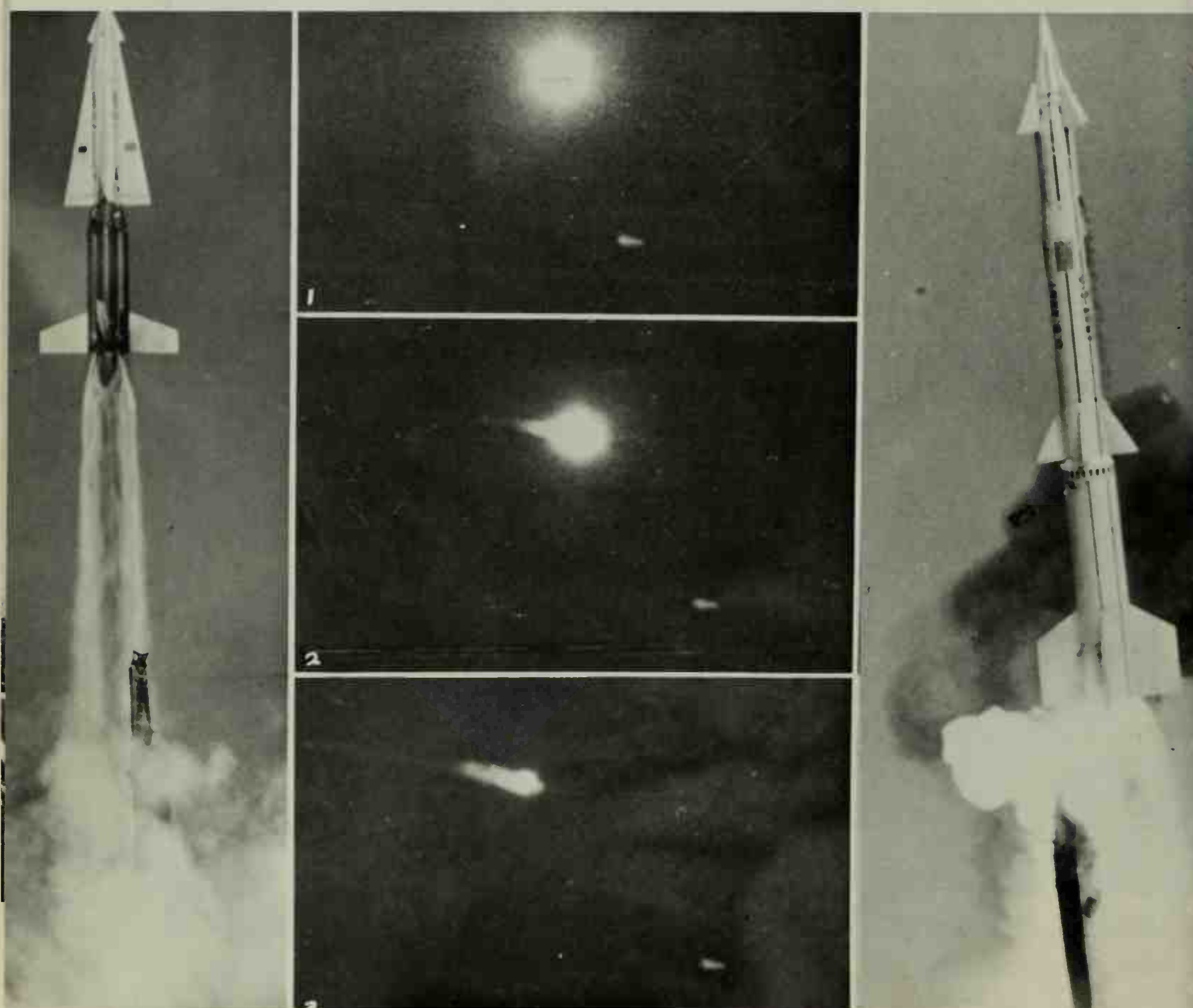
NIKE-X ZEUS (Army)

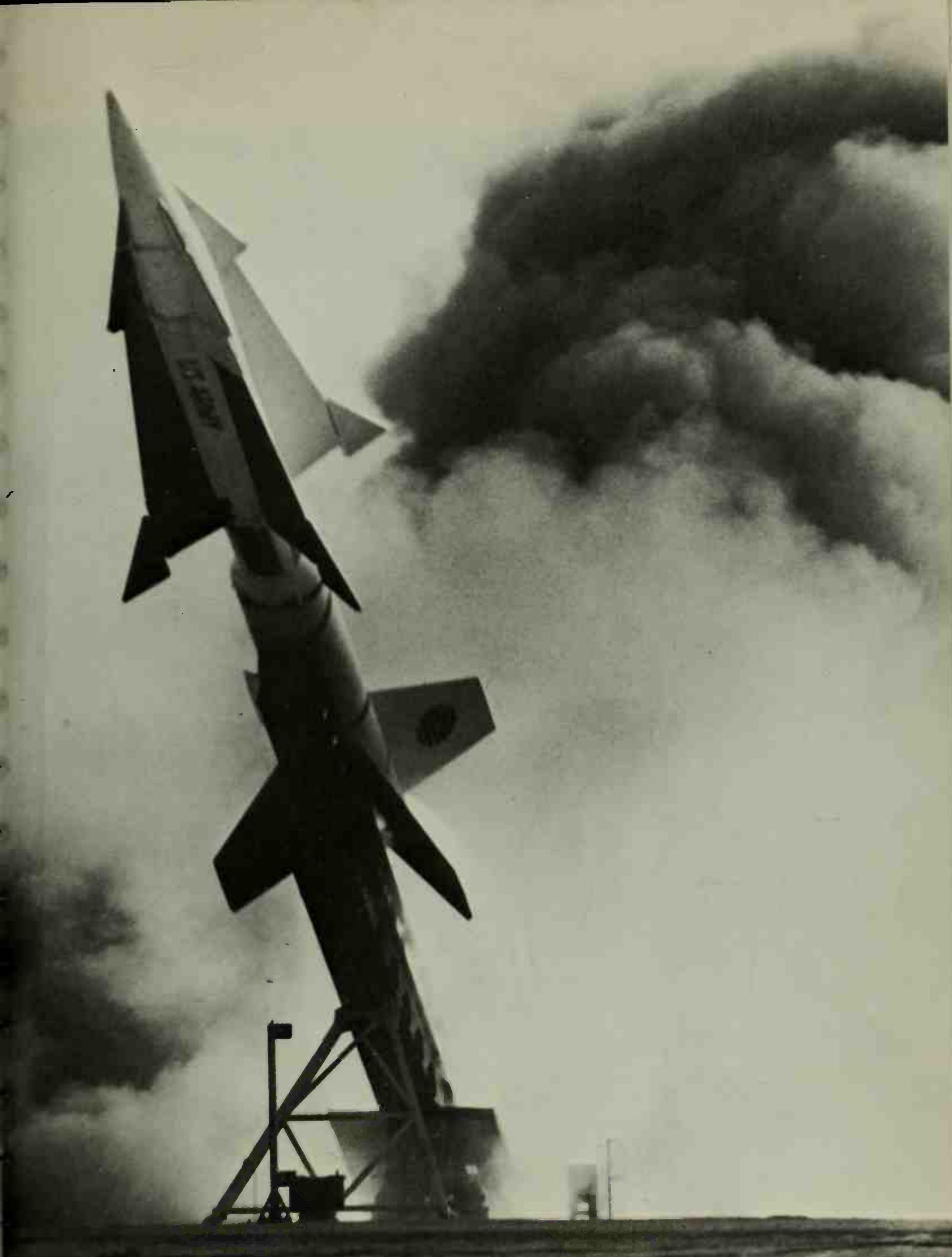
Type: surface-to-air antimissile missile
Propulsion: three-stage solid-propellant rockets
Guidance: command system using acquisition radar, target-track radar and missile-track radar in combination with electronic data-processing equipment
Performance: range over 200 miles; four times the speed of sound; warhead equipped with jet device for maneuvering in space toward target
Construction: length 48.3 feet; first-stage diameter 36 inches; fin-span 10 feet; weight 22,800 pounds
Remarks: nuclear warhead; missile has scored many successful practice kills; is part of the Army's Nike-X "mix family" of antimissile missiles

Nike-Zeus weapon system has as its mission the defense of continental United States against intercontinental ballistic missiles that pose a threat. The system uses radars and electronic computers in a fully automatic sequence to detect, track, intercept and destroy attacking ballistic missiles. The system's target-tracking radar has proved that it can track ICBM nose cones in flight. Since early 1961, the Zeus radar on Ascension Island in the South Atlantic has been used successfully to track ICBMs launched from Cape Kennedy. Many other tests of the missile and the weapon system have been conducted under many different conditions, with launchings originating at all three of the national missile ranges.

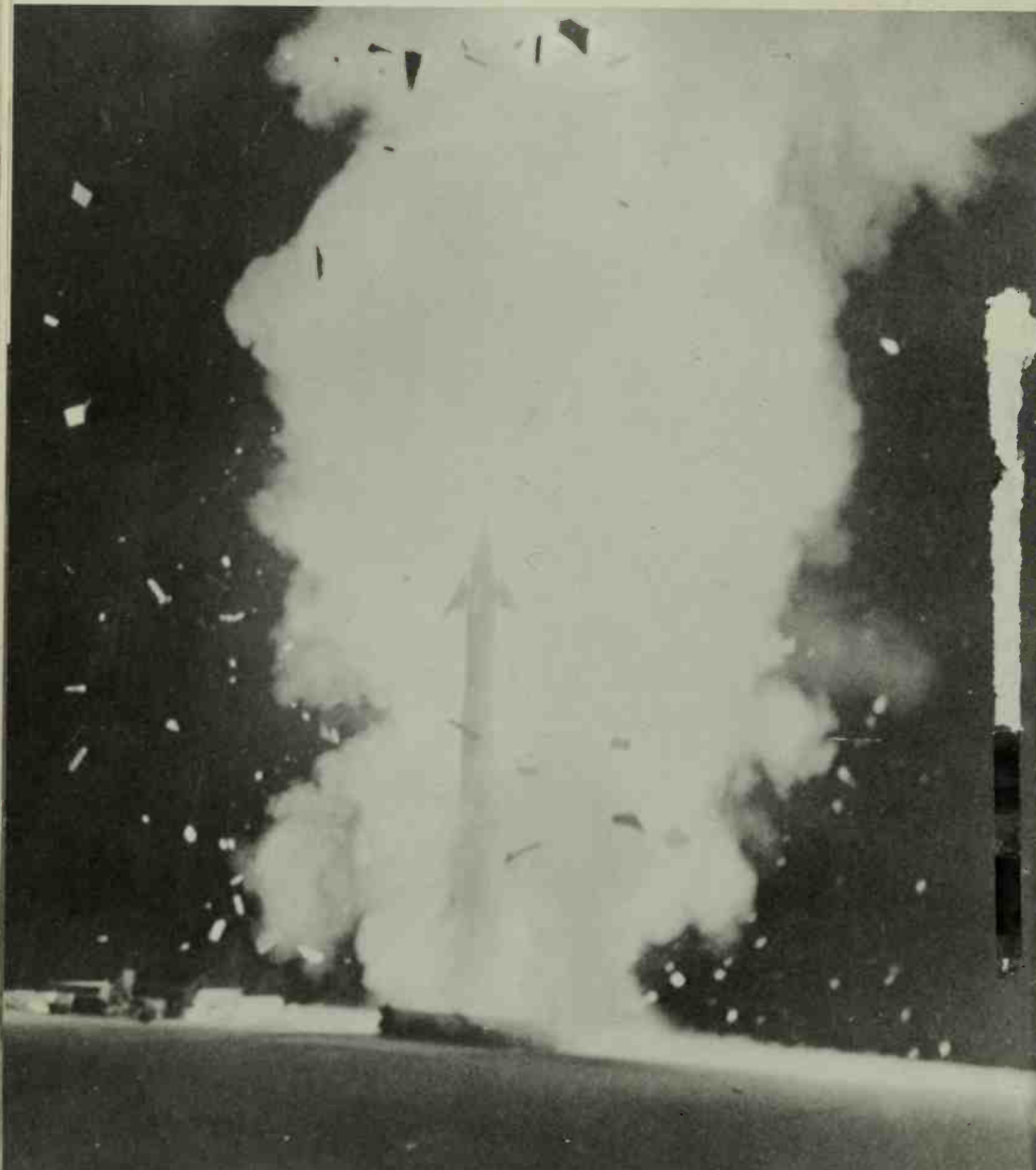
Early test model of *Nike-Zeus* surface-to-air rocket. This weapon is designed to knock enemy missiles out of the sky.

From a *Nike-Zeus* test. At left is the launching of the practice target, a *Hercules.* At right is the *Zeus* at blastoff. Center from top to bottom shows the bursting spotting charge in the *Zeus* at closest point of intercept and subsequent flight of the target missile. The spotting charge marks the position of *Zeus* at the time when a live warhead would have burst.





Nike-Zeus roars aloft on its hunt for the enemy. The two-stage rocket represents the most expensive and most elaborate of all Army missile programs.



This looks like an accident — an explosion on the pad. But it is not. The *Nike-Zeus* is merely blowing its top, blasting away a protective cover which shields it, while in its launch cell, from adverse weather. Moments later the missile itself is fired.

REDEYE (Army)

(MIM-43)

Type: shoulder-fired antiaircraft rocket

Propulsion: single-stage solid-propellant rocket

Guidance: infrared

Performance: range classified; supersonic speed

Construction: bazooka-type; length 44 inches; diameter 2.75 inches; weight 28 pounds

Remarks: infantry field weapon; used by Army and Marines

Redeye is one in a series of light, modern infantry weapons developed by the Army. During World War II the foot soldier did not have any truly effective weapons with which to protect himself against low-flying enemy aircraft. Antiaircraft guns were too heavy and cumbersome and could not always follow the infantry as it advanced in the field. The Army Missile Command, with the cooperation of the Marine Corps, decided to develop a bazooka-type weapon system that was light enough for one single soldier to operate against low-flying aircraft, and the result was the Redeye. It is shoulder-fired and gives the individual soldier in forward areas a defense against attack by aircraft, which he did not have before. The prime contractor for the Redeye is the General Dynamics Corporation.

acrosse infantry missile designed to knock down low-flying enemy aircraft.

TALOS (Navy)

(RIM-8E)

Type: surface-to-air missile for long-range fleet air defense

Propulsion: solid-propellant rocket first stage; ramjet sustainer

Guidance: beam-rider to target area; then semiactive homing for final flight phase

Performance: range over 65 miles; two-and-a-half times the speed of sound; altitude over 90,000 feet

Construction: two stages; overall length about 30 feet; diameter about 30 inches; weight 7,000 pounds

Remarks: nuclear or high-explosive warhead; in use by 6 Navy cruisers

Talos is primarily a surface-to-air guided missile, but it can be used effectively against ships and shore targets. Talos was first fired at sea in February, 1959, from USS *Galveston*, a cruiser armed with guided missiles. Two sister ships and the nuclear-powered USS *Long Beach* have also successfully fired Talos missiles at sea, and three more cruisers have been converted to use this missile system as their principal armament. The missile was developed by the Applied Physics Laboratory of the Johns Hopkins University in the early fifties. It represents a decade and a half of research and development to provide atomic-age weapons for the United States fleet. Prime contractor for the missile is the Bendix Corporation.

TARTAR (Navy)

(RIM-24B)

Type: surface-to-air fleet defense missile

Propulsion: dual-burn solid-propellant rocket

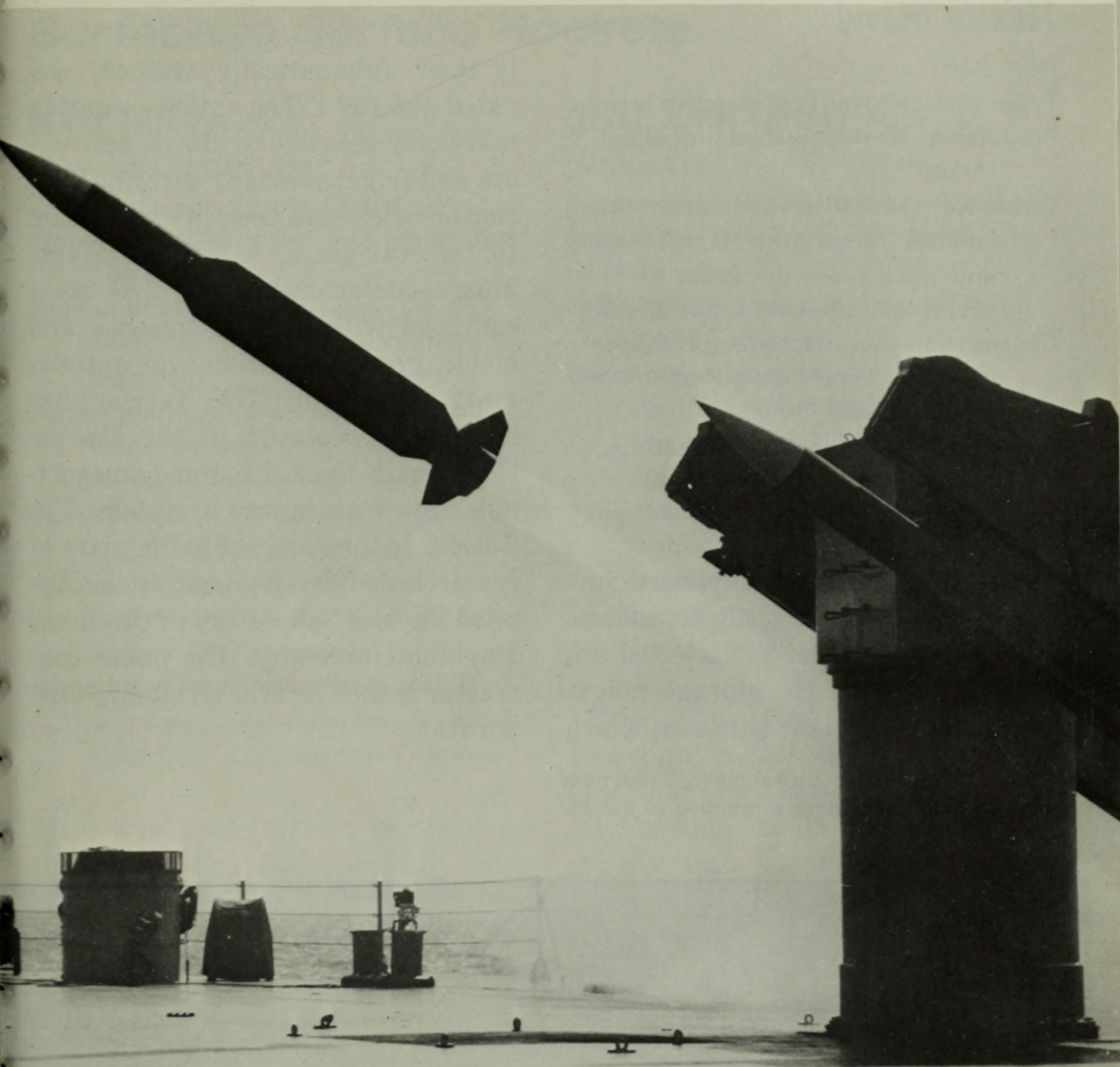
Guidance: semiactive radar beam-riding

Performance: range over 10 miles; twice the speed of sound

Construction: single stage; length 15 feet; diameter about 18 inches; weight about 1,500 pounds

Remarks: high-explosive warhead; in use on more than 20 destroyers and cruisers

Tartar is a particularly compact weapon system designed to serve as the primary antiaircraft battery aboard destroyers armed with guided missiles and as the secondary battery on certain cruisers. The missile has been programmed for some twenty-five destroyers. Three cruisers and four destroyer-escort types have been built or converted to use the Tartar. The missile acts as an antiaircraft shield against attacks from both high and low altitudes. Early in 1962, the Navy awarded a contract for the first three of a new type of guided-missile escort ship (DEG), to be equipped with Tartar missiles. These versatile ships are designed to operate as part of a hunter-killer group, to protect amphibious forces and to patrol coastal waters for missile-firing submarines. Prime contractor for the Tartar is the General Dynamics Corporation.



Tartar surface-to-air rocket at launch. This missile is used by destroyers and cruisers as antiaircraft weapons.

TERRIER (Navy)

(RIM-24B)
Type: surface-to-air fleet defense missile
Propulsion: two-stage solid-propellant rockets
Guidance: semiactive radar beam-riding
Performance: range over 10 miles; two-and-a-half times the speed of sound; altitude over 65,000 feet
Construction: two-stage; length 27 feet; diameter 1 foot; weight about 3,000 pounds
Remarks: high-explosive warhead; in use on almost 40 Navy ships

Terrier was the first shipboard surface-to-air guided missile to become operational. Missiles are selected automatically from the storage magazine and loaded on the launcher, which is then automatically trained, elevated and fired. The entire operation takes only seconds. Cruisers, destroyers and frigates armed with the Terrier missiles have been in commission for several years. A few years ago, Marine detachments on land were equipped with Terrier missiles and mobile ground launchers for antiaircraft protection. The Terrier has since been replaced in the Marine Corps with the helicopter-transportable *Hawk* antiaircraft system. The Terrier is the result of eight years of research and development by the Applied Physics Laboratory of the Johns Hopkins University. The prime contractor is the General Dynamics Corporation.

Terrier surface-to-air rocket being fired from USS *Constellation* under a practice in the Atlantic Ocean.

Surface to Surface Rockets

MACE (Air Force)

(MGM-13A; CGM-13B)

Type: surface-to-surface missile

Propulsion: solid-propellant booster plus J33 turbojet

Guidance: automatic terrain radar and navigator; B model has inertial warhead

Performance: A-model range over 650 miles; B-model range over 1,200 miles; altitude over 40,000 feet

Construction: pilotless aircraft type; length 44 feet; wingspan 22.5 feet; height 9.5 feet; A-model-weight 14,000 pounds; B-model-weight 18,000 pounds

Remarks: A model fired from mobile launcher, used in Europe; B model fired from pad, used on Okinawa

Mace was developed as a successor to the *Matador* surface-to-surface missile. It has been in use since 1957, and test flights of an advanced version began in 1960. Several successful tests have been conducted from underground hardened launch sites. One such test was a "hot-hold" test, which is roughly equivalent to holding a cocked pistol ready for immediate firing. Having already completed the extensive checkout and countdown, the ground crew can then keep the weapon in complete readiness during the entire hot-hold period. The Martin Company is prime contractor for Mace's assembly and test.

LITTLE JOHN (Army)

(MGR-3A)

Type: surface-to-surface support rocket

Propulsion: solid-propellant rocket

Guidance: free-flight

Performance: supersonic speed; range over 10 miles

Construction: single-stage steel/aluminum body; length 14.5 feet; diameter 12.4 inches; weight 800 pounds

Remarks: nuclear or high-explosive warhead; used by infantry to supplement artillery in airborne operations; may be replaced by *Lance* missile

Little John is an advanced Army free-flight rocket which has been operational for several years. This mighty mite can be moved easily and swiftly into battle sites either by ground vehicles or by helicopter. It can be put into launching position, aimed and armed in a few minutes. As a ballistic missile, the Little John operates somewhat like an arrow. Armed and fired, it is a completely free-flight weapon and its path cannot be altered by the enemy. The missile lacks the built-in guidance system of a true missile. But Little John is very unlike an arrow in that its shaft can carry a nuclear warhead. Little John has been operational with Army airborne units for several years, but it is likely to be replaced by the *Lance*.

Little John is one of the Army's standard surface-to-surface rockets. It is a single-stage solid-propellant missile.

LANCE (Army)

(XMGM-52)

Type: surface-to-surface division support rocket

Propulsion: prepackaged storable liquid rocket system

Guidance: inertial

Performance: range between 3 and 30 miles

Construction: lightweight for high mobility; helicopter-transportable

Remarks: conventional, chemical or nuclear warheads; will replace *Honest John* and perhaps *Little John*

Lance, in its early stage of development and test, was referred to as Missile B. It is a highly mobile division-support missile with design features which allow it to complement conventional artillery and to extend the division commander's capability for supporting fire on the battlefield. Lance is scheduled to replace the *Lacrosse* guided missile and the *Honest John* rocket and perhaps the *Little John.* Early in 1962 contractors were asked to submit proposals for the new missile. In November, 1962, Ling-Temco-Vought was selected as prime contractor for development and initial production of the missile system. The Lance system is self-supported in that the missile is carried and launched by its own mobile, track-mounted vehicle. It can be moved into firing position quickly and fired with great accuracy.

Soldiers getting ready to fire the *Lance* surface-to-surface rocket at the Army proving ground at White Sands.

HONEST JOHN (Army)

(MGR-1)

Type: surface-to-surface rocket
Propulsion: single-stage solid-propellant rocket
Guidance: spin-stabilized by small spin rockets; ballistic free-flight
Performance: range 12 miles; speed less than twice the speed of sound
Construction: length 24.8 feet; diameter 30 inches; weight 4,500 pounds
Remarks: nuclear or high-explosive warhead; operational in the United States and in NATO countries; to be replaced by *Lance* missile

Honest John is just about the oldest operational Army rocket. A decade seems like an eon in the missile age, yet the Honest John, which was introduced some fifteen years ago, is still in use as a battlefield rocket. The rocket is particularly suitable for short-range field use up to twelve miles, and it is being used by NATO countries because it is a rugged, highly transportable rocket. It can carry either conventional or nuclear warheads in its big nose cone. Honest John is spin-stabilized by the deployment of small solid-propellant rocket motors mounted on the body sideways. Its prime contractor is Douglas Aircraft Company.

ENTAC (Army)

(MGM-32A)

Type: antitank missile
Propulsion: solid-propellant rocket
Guidance: wire-guided
Performance: range 6,600 feet; speed about 180 miles per hour
Construction: length 32 inches; diameter 5.5 inches; weight 27 pounds
Remarks: high-explosive shaped charge; missile developed in France; will be succeeded by *Tow* missile

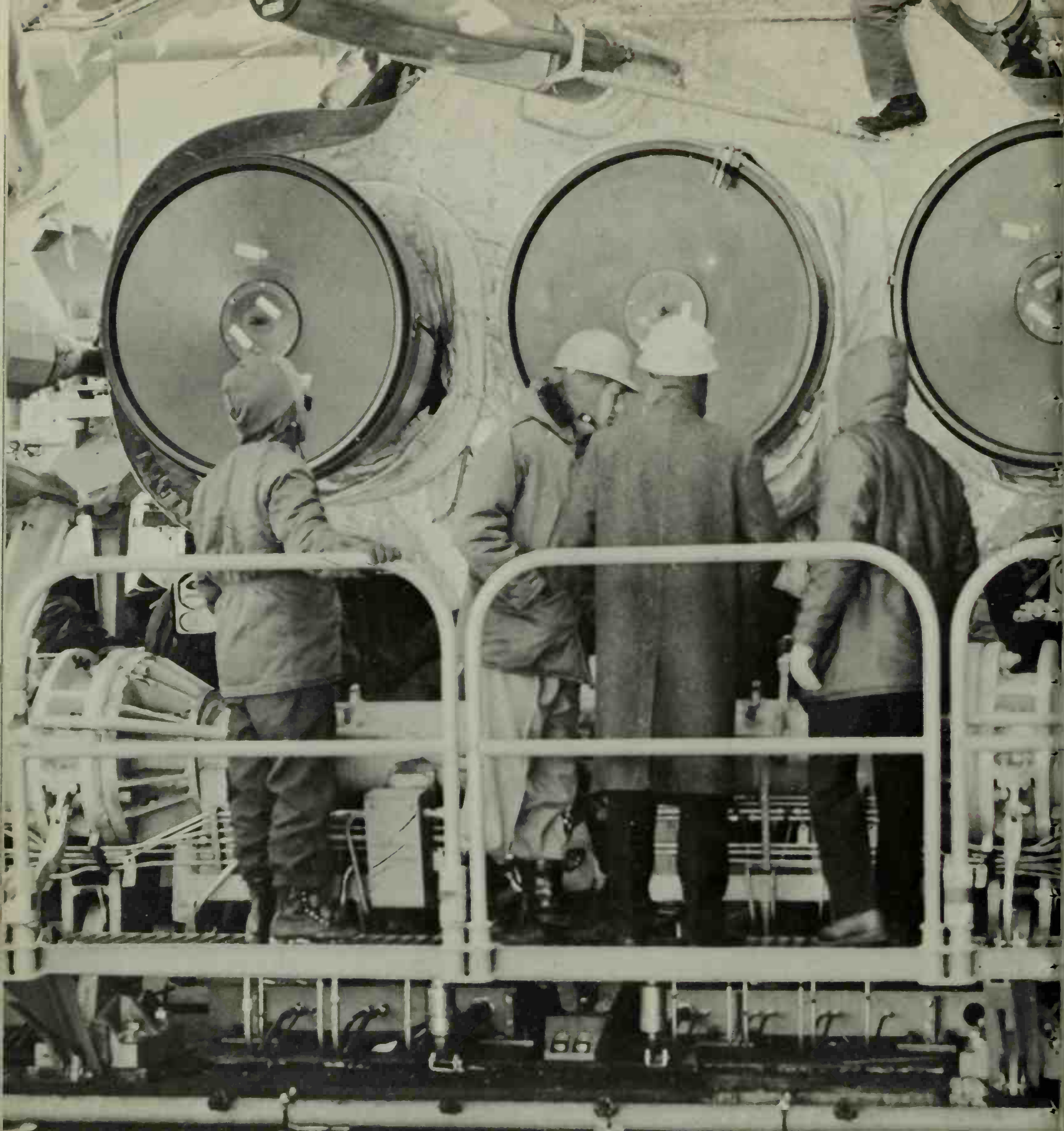
Entac is small, light and suitable for use against armored vehicles and tanks. The missile is directed toward the target by an operator, who maneuvers a control stick to send the appropriate correction commands through wires payed out from the missile as it flies toward the enemy. The Entac, like the *SS-10* and *SS-11*, is a French import. It was developed by the French Army, and the missile's name is a contraction of the identifying French description: Engin Teleguide Anti-Char (*char* is French for "tank"). The United States Army decided to buy the Entac in 1961. The selection of this missile followed an evaluation of available U.S. and NATO antitank weapon systems. As Entac equipment becomes available, the *SS-10* will be phased out.

Davy Crockett surface-to-surface rocket being readied for firing during training at Fort Bragg, North Carolina.

DAVY CROCKETT (Army)

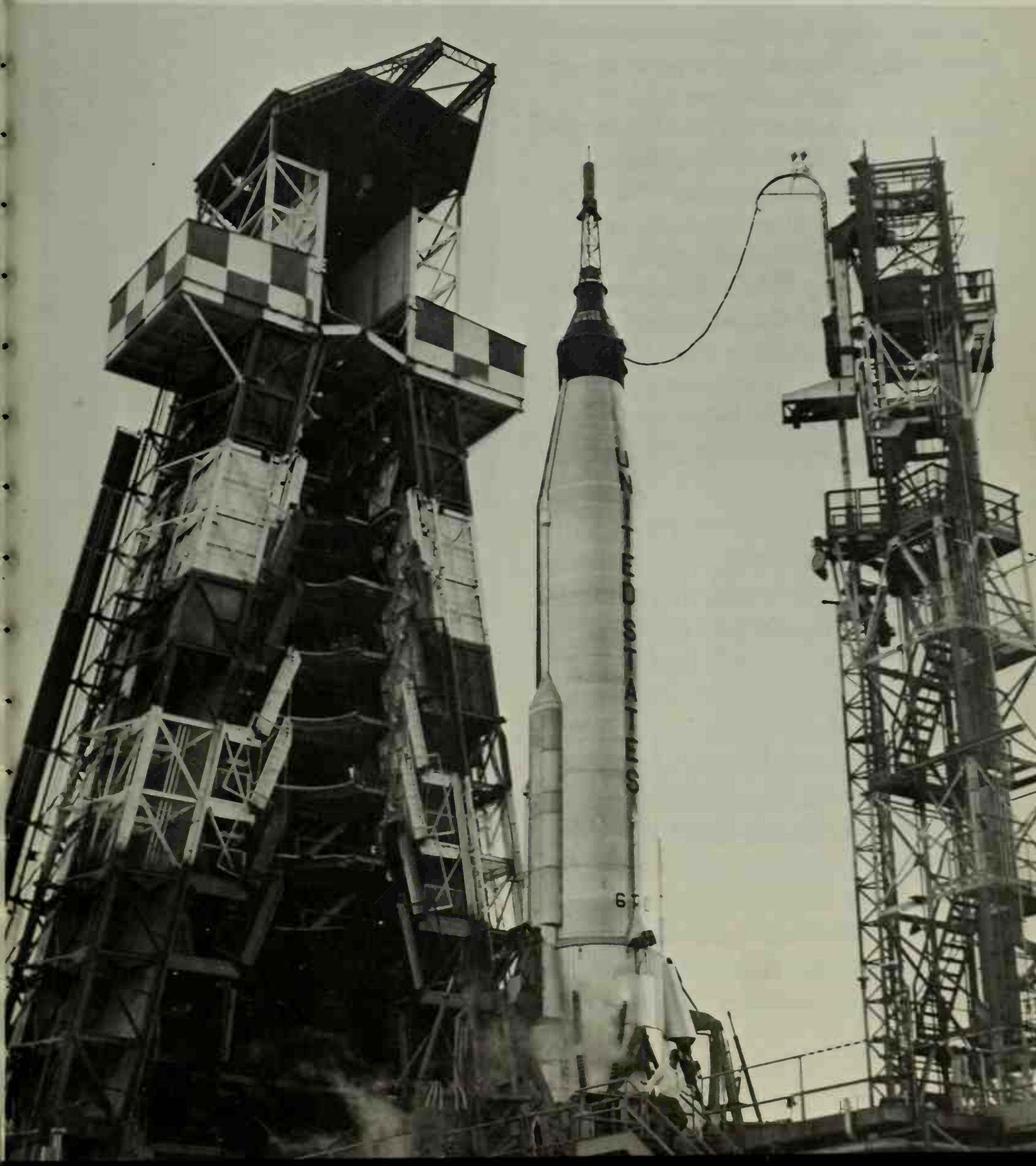
Type: surface-to-surface tactical nuclear support weapon
Propulsion: solid-propellant rocket
Guidance: free-flight
Performance: classified
Construction: 279-mm. super caliber shell fired from either 120-mm. or 155-mm. recoilless rifles
Remarks: small nuclear warhead

Davy Crockett is considered one of the modern infantry's most dangerous weapon. Fitted with a small nuclear warhead, the Davy Crockett is a missile with a big punch. It is carried by foot soldiers in the field and is transportable by almost any vehicle, including helicopters and aircraft. Weapons such as the Davy Crockett have changed the entire concept of infantry and battlefield warfare, because one single Davy Crockett is capable of wiping out entire concentrations of enemy equipment, such as missile batteries, airfields or bridges. The solid-propellant rocket weapon is designed to fit standard 120-mm. and 155-mm. recoilless rifles. This high-powered Army missile can be operated by two or three soldiers.



The aft end of an *Atlas* missile being checked by Air Force missile men. This model *Atlas* is fitted with three engines.

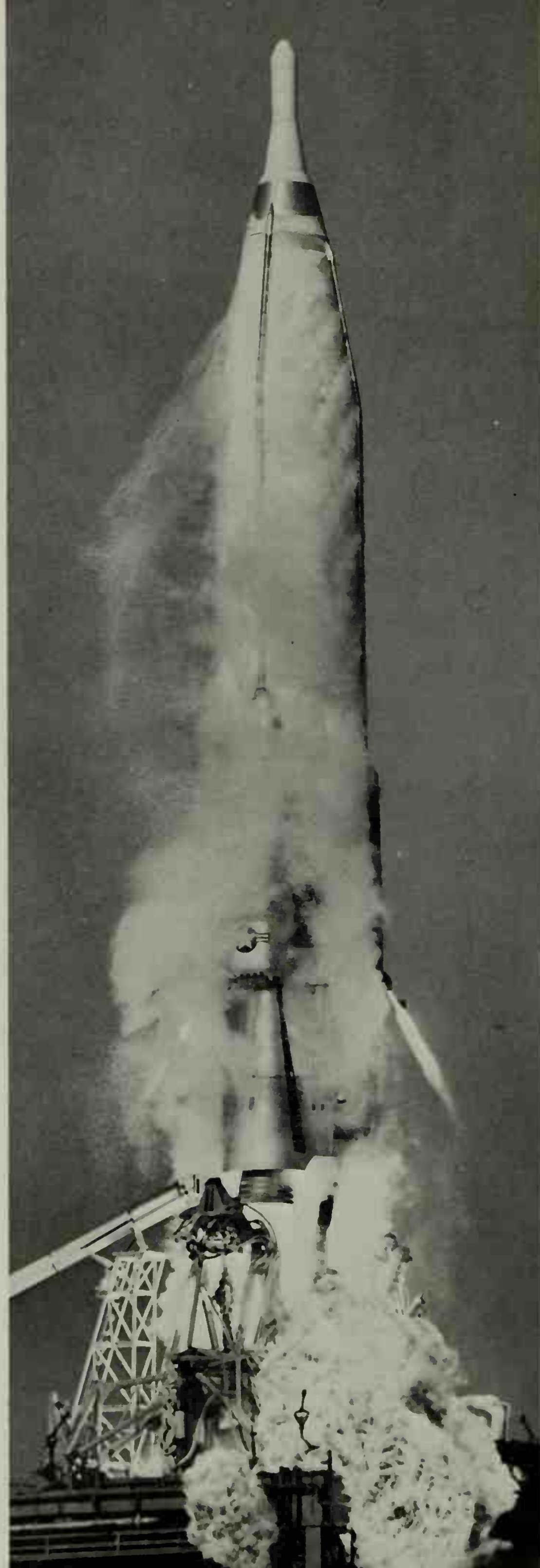
Early model *Atlas* intercontinental ballistic missile being readied for the job of orbiting a *Mercury* space capsule from Cape Kennedy.



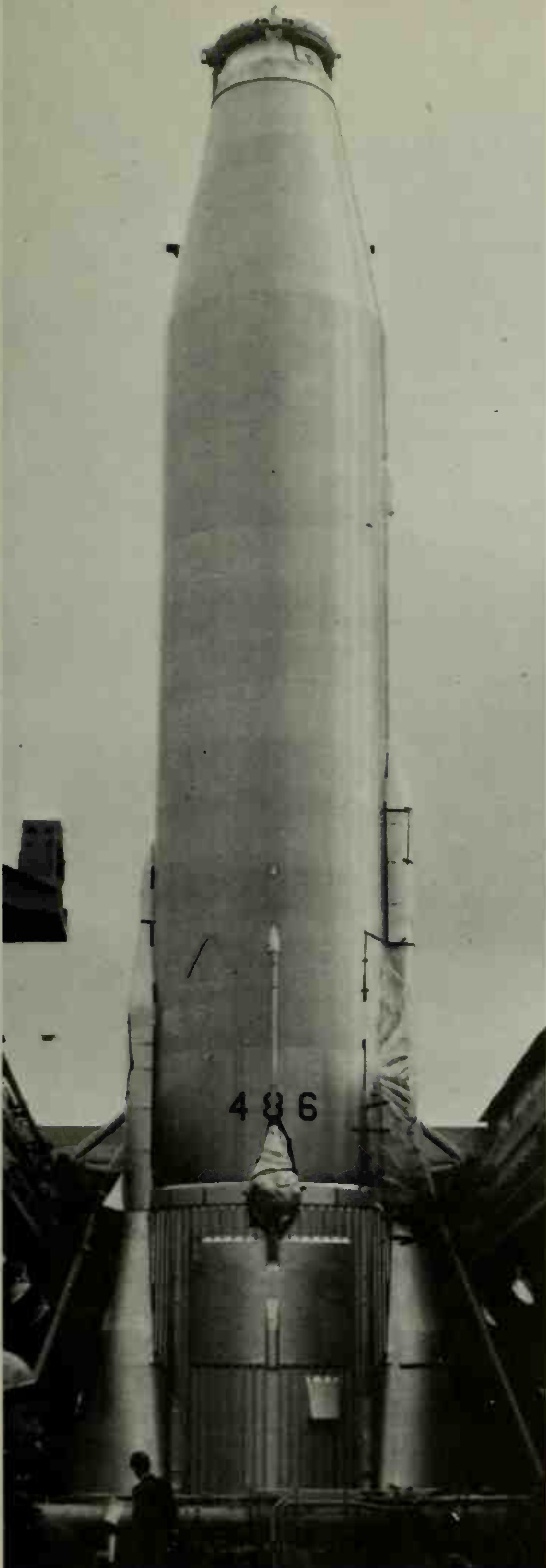
ATLAS (Air Force)

(CGM-16D, E; HGM-16F)
Type: intercontinental ballistic missile
Propulsion: two liquid-propellant rocket engines in booster stage; one liquid-propellant rocket engine in sustainer stage; propellants are RP-1 (kerosene) and liquid oxygen
Guidance: radio-inertial for D models; all-inertial for remaining models
Performance: range 9,000 miles; speed over 16,000 miles per hour
Construction: length 82.5 feet; base diameter 16 feet; center section diameter 10 feet; weight 269,000 pounds; built as stainless-steel pressurized tankage missile
Remarks: nuclear warhead; phaseout of early models began in 1965; 13 squadrons with 129 missiles in operation at beginning of 1965; used extensively as booster for satellites and space probes

Atlas was the first of the United States intercontinental ballistic missiles to become operational. It has also been used extensively as a booster for many nonmilitary space shots. Within the first few minutes of its flight, the Atlas is lifted well into its trajectory, and the booster engines are jettisoned. The missile is then accelerated by the sustainer engine until a speed of over 15,000 miles per hour has been reached. At this time the sustainer engine is shut off, and the vernier rockets are used to trim the speed to the exact amount of thrust required.



Atlas with simulated nuclear warhead takes off. Small rockets on the side of the missile firing at an angle are called vernier rockets. They are used for added stability during the early or late launch phase.



Latest model *Atlas* ICBM is lowered into its underground launching pit, called a missile silo.

ASROC (Navy)

(RUR-5A)

Type: antisubmarine rocket-boosted torpedo

Propulsion: solid-propellant rocket in first stage; torpedo in second stage

Guidance: ballistic flight path; then sonar detection and homing in the torpedo stage

Performance: approximately supersonic speed; range between 1,800 yards and 8 miles

Remarks: *Mark 44* homing torpedo used; nuclear warhead or conventional depth charge

The torpedo is an old weapon which was used extensively in both world wars. Its limitations included that in most cases the torpedo must be fired at fairly close range, because the launching crew must visually see the enemy and aim the torpedo at him accordingly. For many years engineers tried to improve the range and guidance systems for torpedoes, and one of the major breakthroughs in this respect was introduced with the Asroc. If a vessel carrying this weapon can obtain pinpoint location of an enemy, say, from an airplane, the Asroc can be fired for a distance as far as eight miles. A modern torpedo is flown through the air, like a ballistic missile, boosted to almost supersonic speed by a solid-propellant rocket. The booster separates, and the torpedo reenters the water and will home in on the enemy.

ASTOR (Navy)

Type: rocket-boosted antisubmarine torpedo
Propulsion: solid-propellant booster rocket
Guidance: wire-guided
Performance: range about 11 miles
Construction: length 20 feet less booster rocket; weight about 2,000 pounds
Remarks: nuclear warhead; *Mark 45* torpedo used; to be used by hunter-killer submarines

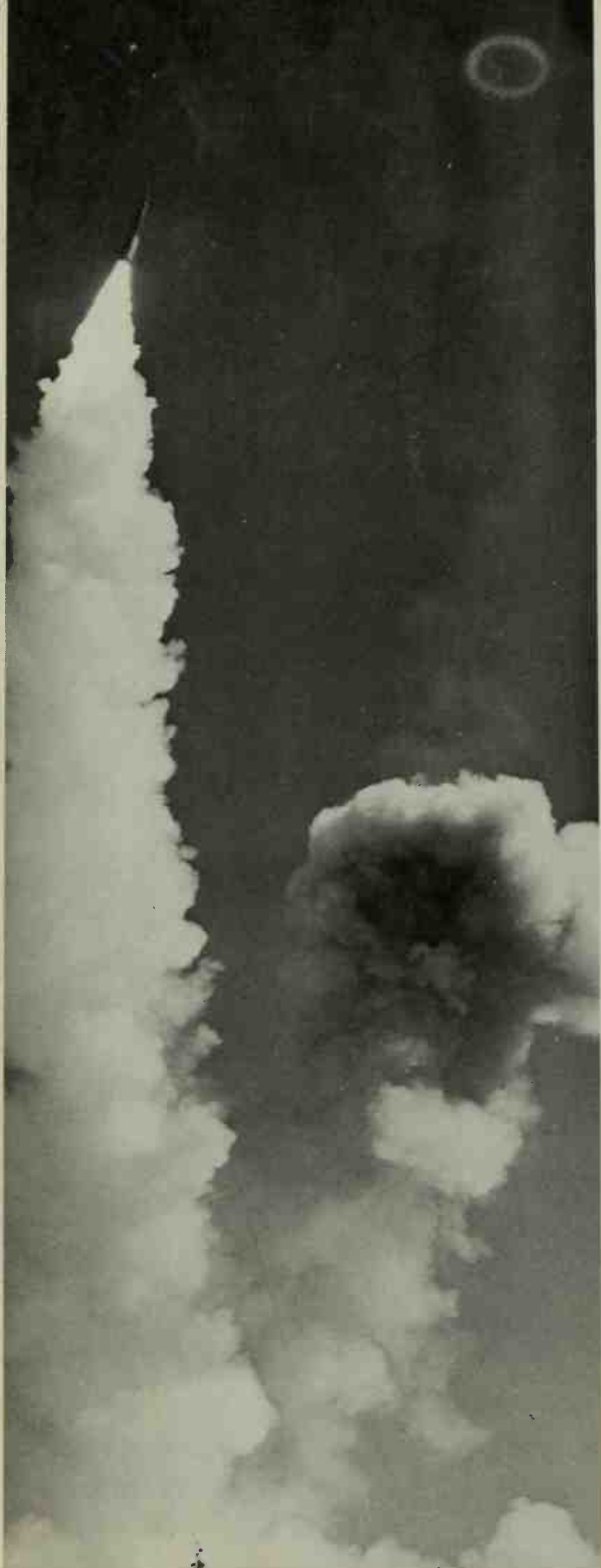
The idea of launching rockets from underwater—from submerged submarines—was conceived by two German brothers, Fritz and Ernst Steinhoff, during World War II. They experimented with the firing of solid-propellant rockets from a steel launching rack on the deck of a submarine. The principle was proved as early as 1942, but the German authorities did not pursue the idea, although it could have provided them with a weapons system with which they could have hit targets on land and cities such as New York from a submarine way off the coast. But the United States Navy soon realized the importance of such rocket systems, and much development has taken place in this weapons category. It has produced such rocket systems as the *Astor*, *Subroc* and *Polaris.*

ALFA (Navy)

(RUR-4)
Type: antisubmarine rocket-boosted depth charge
Propulsion: solid-propellant rocket
Guidance: free-flight
Performance: range 1,000 yards
Construction: length 8.5 feet; diameter 12.75 inches; weight 500 pounds
Remarks: high-explosive depth charge; launched from turret-mounted guns; in use by cruisers and destroyers

Alfa is—like *Asroc*—based on the principle of rocket-boosting for increased range. While Asroc is a torpedo weapon, Alfa is a depth-charge weapon. It can be fired in quick sequence from the turret-mounted guns on cruisers and destroyers. The Alfa weapon system gives the Navy the capability of attacking enemy submarines at a range up to 1,000 yards. Thus, destroyers and cruisers can commence hunter-killer tasks much quicker and much sooner than with conventional depth-charge equipment. It also means that enemy submarines must stay at least 1,000 yards away before launching any attack against a ship fitted with Alfa weapons and still be reasonably sure of getting away.

Able antisubmarine rocket with conventional warhead is used by the Navy's surface ships against enemy submarines.



A fluffy smoke ring drifting skyward is about to be overtaken by a solid-propellant *Minuteman* intercontinental ballistic missile at Cape Kennedy.

MINUTEMAN (Air Force)

(LGM-30A, B, F)

Type: intercontinental ballistic missile

Propulsion: three-stage solid-propellant rocket system

Guidance: all-inertial

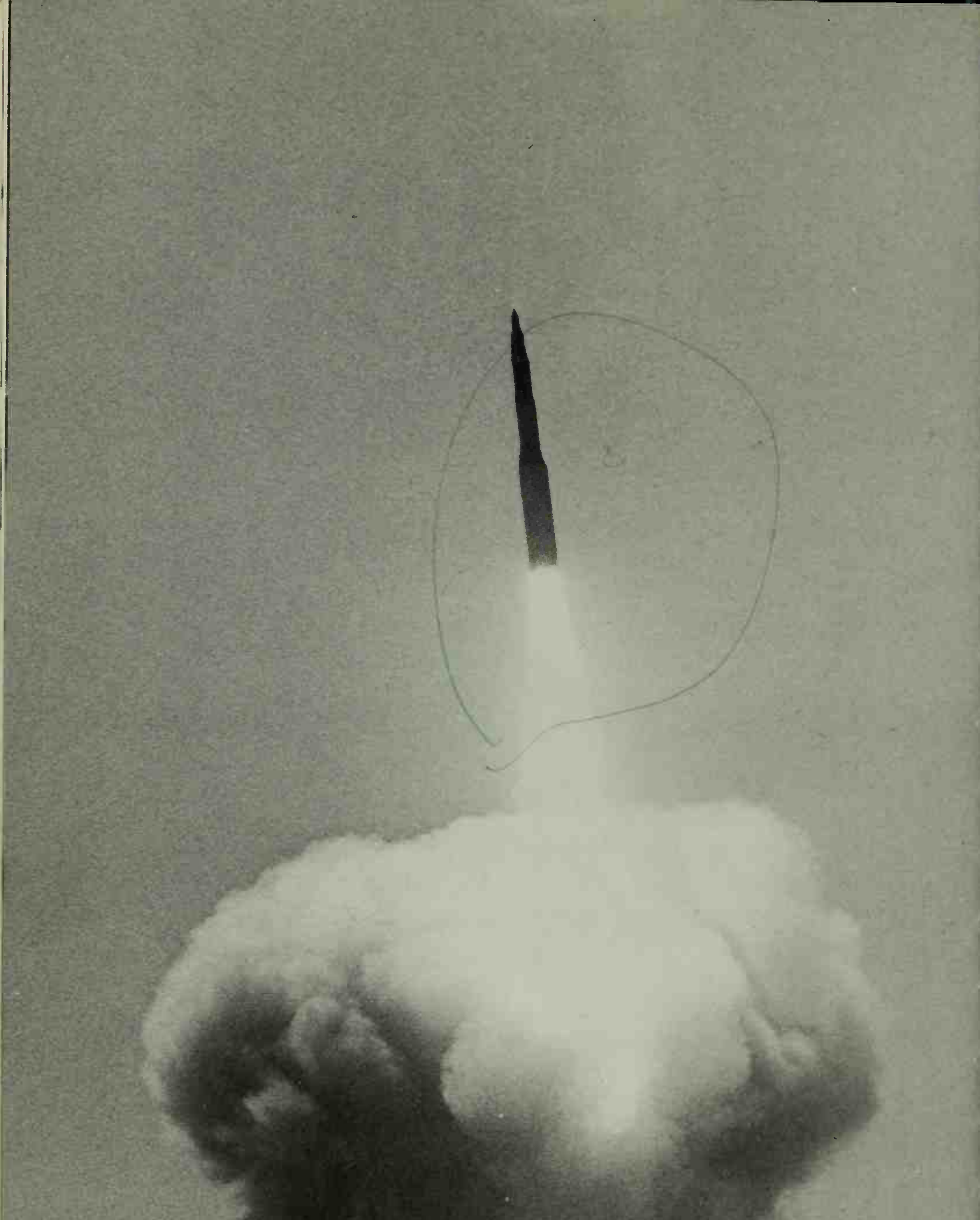
Performance: range 6,300 miles; speed over 15,000 miles per hour

Construction: three stages; first 53.7 feet in length, second 55.9 feet and third 59.8 feet; diameter 6.2 feet; weight 69,000 pounds

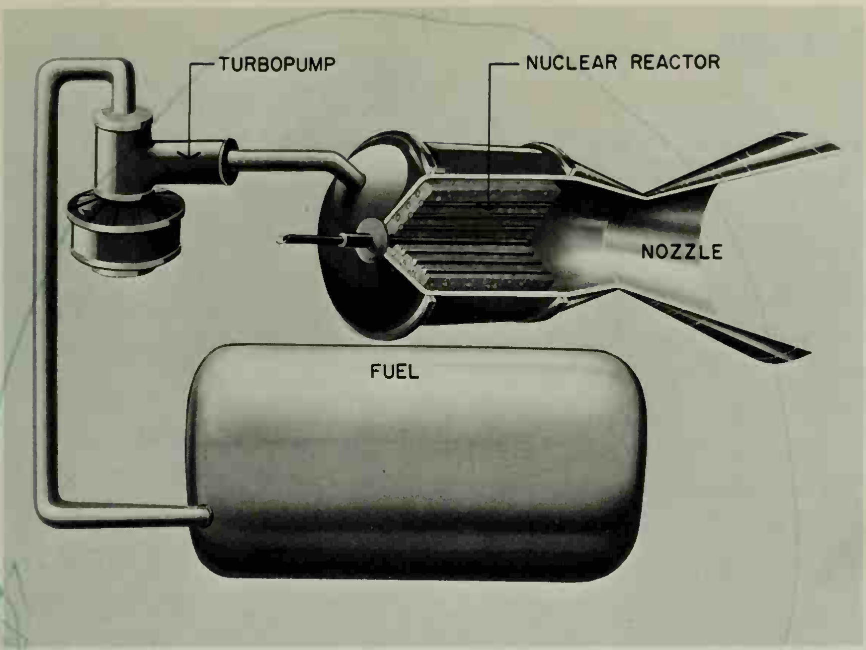
Remarks: 1,000 Minuteman missiles operational in silos throughout the United States; nuclear warheads reported to be in the one-megaton class

Minuteman, often referred to as a second-generation ICBM, has been designed for deployment at hardened and dispersed missile silos. It is lowered into an underground, blast-proof silo for a long period of time without losing its alert status. In case extensive maintenance is required, the missile will be returned to a central maintenance facility, and the silo will receive another missile. Minuteman became operational in December, 1962. Development of the program was conducted by the Ballistic Systems Division of the Air Force Systems Command. At one time the idea of firing the missile from railroad cars was contemplated, but the idea was found to be unwarranted and that phase of the program terminated. One thousand Minuteman missiles are now in our arsenal.

Minuteman fired from Vandenberg Air Force Base in California. This missile has become the Air Force's "ultimate" long-range rocket, replacing *Titan* and *Atlas*.



Three-stage *Minuteman* on its way. About 1,000 *Minutemen* have been authorized. They are being placed in underground silos throughout the United States.



Scientists are now working on nuclear-powered rocket systems. This diagram shows how a nuclear rocket works. / *Rocketdyne*

MMRBM (Air Force)

Type: mobile medium-range ballistic missile
Propulsion: two-stage solid-propellant rocket
Guidance: stellar-inertial
Performance: range 300 to 1,500 miles; supersonic
Construction: length about 30 feet; weight 11,000 pounds
Remarks: nuclear warhead; extremely mobile; designed to be carried by truck

MMRBM (mobile midrange ballistic missile) is a system development intended for deployment against targets at various ranges from the maximum range of the *Pershing* to the minimum feasible ranges of intercontinental missiles. Design features include a launch capability on land and on surface ships. Consequently, the MMRBM development program has been a joint Air Force-Navy program under management of the Ballistic Systems Division of the Air Force Systems Command. Until the development of the MMRBM, there existed a gap in the United States missile capability; included in our missile arsenal were missiles of many kinds with varying ranges up to 400 miles and other missiles designed for ranges between 1,500 and 9,000 miles. With the introduction of the MMRBM, the United States now can cover all ranges from a few hundred yards to halfway around the globe.

PERSHING (Army)

(MGM-31A)

Type: two-stage ballistic missile

Propulsion: solid-propellant rocket, two stages

Guidance: inertial

Performance: range 100 to 400 miles; supersonic speed

Construction: length 35 feet; diameter 40 inches; weight 10,000 pounds

Remarks: this missile has replaced the Army's *Redstone* missile; the system is carried on four tracked vehicles; nuclear warhead

Pershing is built to perform with great accuracy in all kinds of weather in support of the field army. Its selective range makes possible the destruction of targets close to or far from the launch site. The missile's inertial guidance system is immune to any known countermeasures. The entire system is transportable. The firing unit is carried by four tracked vehicles and can roam a wide battle area regardless of whether there are roads. The missile is fired from a mobile unit that serves as both transporter, erector and launcher. It can be launched in a matter of minutes once it has reached a suitable and applicable launching site. The first Pershing missile battalion was activated in June, 1962. The Martin Company is the systems contractor for the missile.

Army Chinook helicopter has brought a *Pershing* surface-to-surface missile to the frontline troops, demonstrating the transportability of modern infantry weapons.

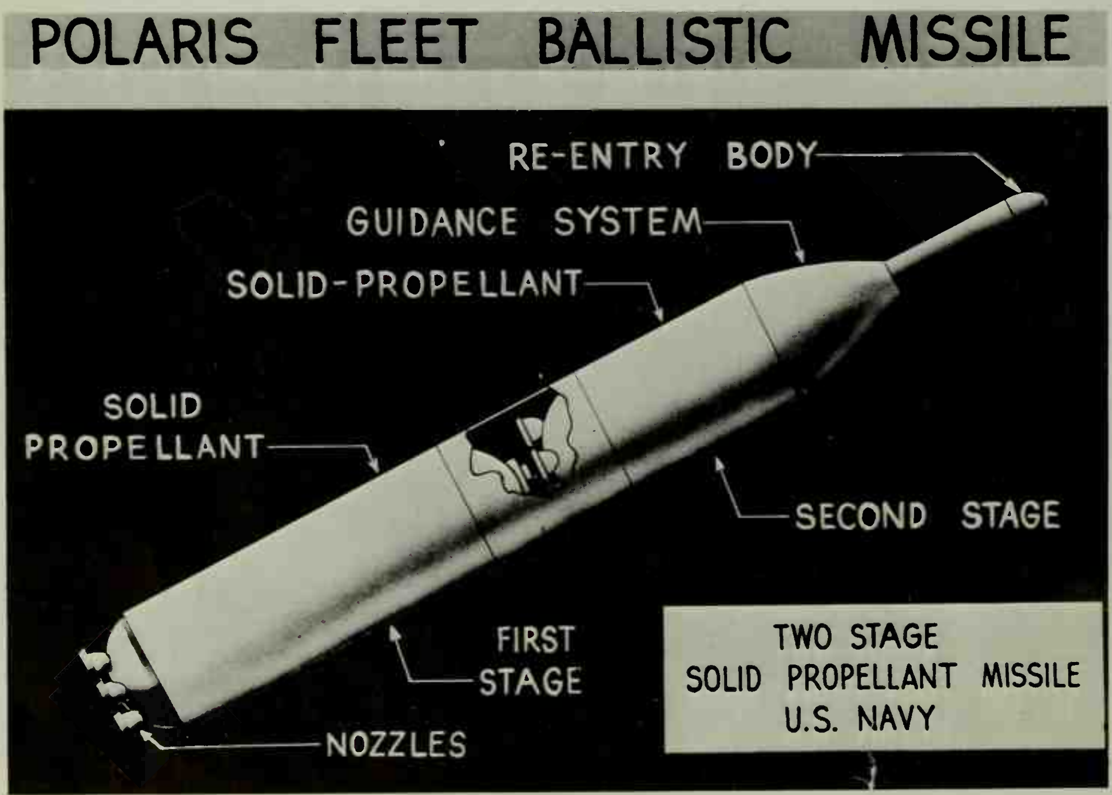
Pershing in go-position on its mobile launcher, a three-in-one vehicle called a transporter-erector-launcher.

POLARIS (Navy)

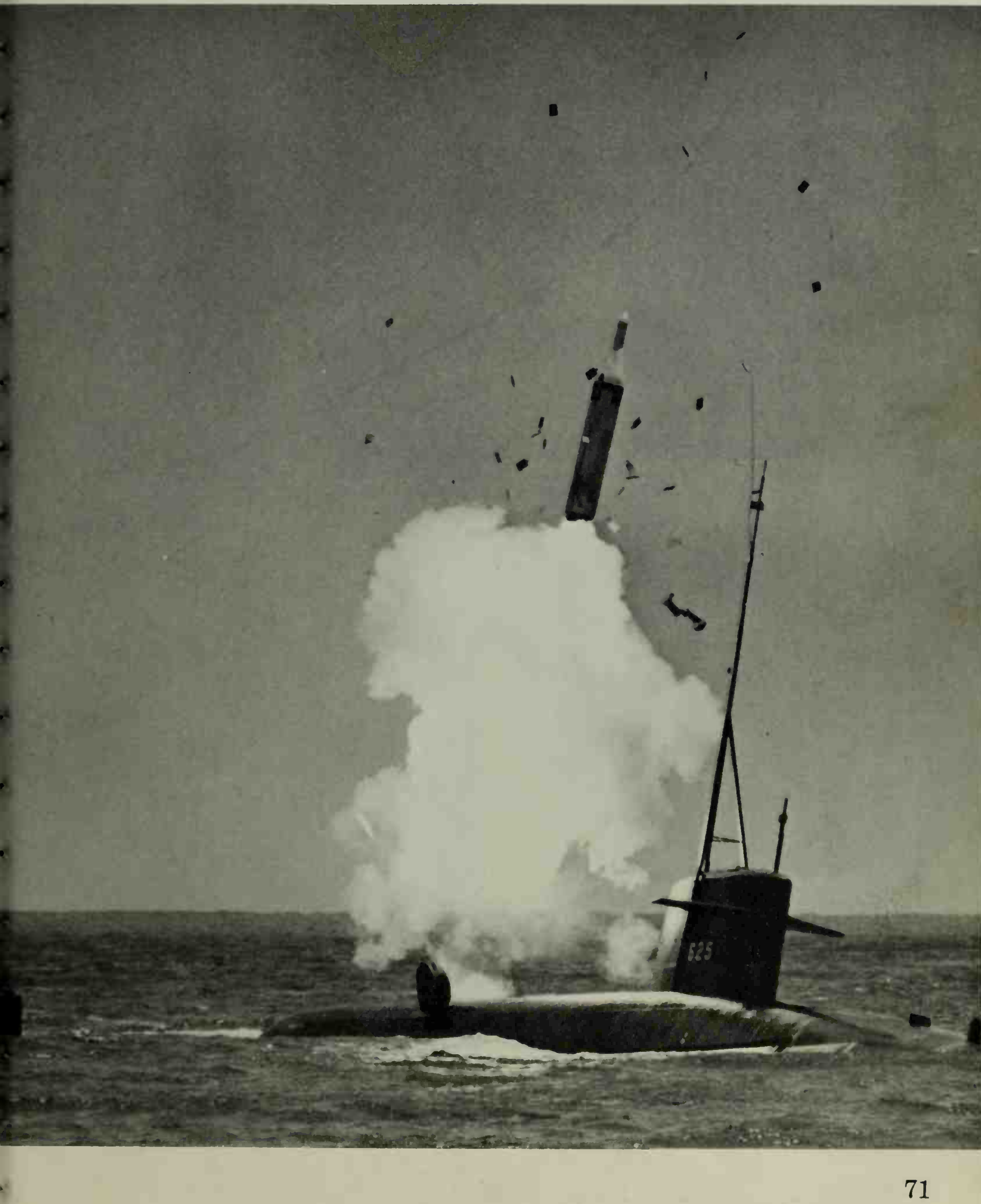
(UGM-27 A, B, C)
Type: underwater-to-surface ballistic missile
Propulsion: solid-propellant rocket
Guidance: all-inertial
Performance: model A-1 range 1,200 miles; model A-2 range 1,500 miles; model A-3 range 2,500 miles; speed about 8,000 miles per hour
Construction: model A-1 length 28 feet; weight 28,000 pounds; models A-2 and A-3 length 30.5 feet; diameter 4.5 feet; weight 30,000 pounds
Remarks: carried on nuclear-powered submarines in vertical position; 16 missiles per submarine; nuclear warhead; more than 40 submarines for Polaris to be completed by 1967

Polaris is possibly the most sophisticated of all United States ballistic missiles in that its launching platform, the submarine, is always on the move and almost impossible to track and attack for a counterweapon. The fleet ballistic missile weapon system is now part of the Atlantic Command. Support facilities are located at Portsmouth, New Hampshire; New London, Connecticut; and Charleston, South Carolina. Similar facilities for the Pacific area include Bremerton and Bangor, Washington; Pearl Harbor, Hawaii; and Guam. Polaris submarines are named after American statesmen, patriots and heroes, for example USS *George Washington,* USS *Patrick Henry* and USS *Stonewall Jackson.*

Schematic drawing of the Navy's midrange ballistic *Polaris* missile.



Test firing of a *Polaris* from a semisurfaced submarine in tilted position. Objects flying through the air are launch adapters designed to detach themselves once the missile leaves its launching tube.



Early model of 1,500-mile-range *Polaris* being fired from a submerged submarine.

New model *A-3 Polaris* with a range of 2,500 miles being readied for test firing.

Actual test from underwater position of the *Polaris A-3*. More than half of the Navy's 41 rocket submarines will be equipped with this missile.

Polaris A-3 blasts off from Cape Kennedy. The missile reaches a top speed of 8,000 miles per hour.

Sergeant surface-to-surface standard infantry rocket. This missile has replaced an older Army missile called the *Corporal*.

SERGEANT (Army)

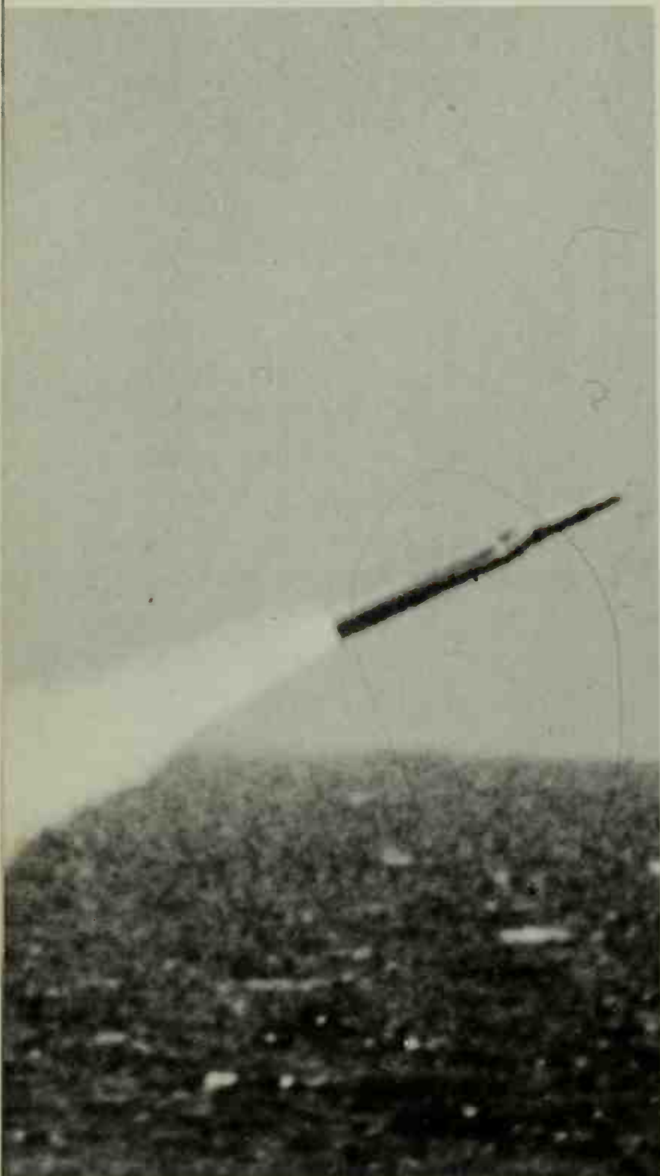
(MGM-29A)
Type: single-stage ballistic missile
Propulsion: solid-propellant rocket
Guidance: inertial
Performance: range 25 to 75 miles; supersonic speed
Construction: length 34.5 feet; diameter 31 inches; weight 10,000 pounds
Remarks: nuclear warhead; missile designed to replace the Army's *Corporal* missile

Sergeant, a ballistic missile, is designed to strike deep into enemy territory. Its inertial guidance system makes it immune to countermeasures. The system is air-transportable, can be emplaced rapidly, and can be fired by a comparatively small crew in all conditions of weather and terrain. Sergeant is more mobile and reliable than *Corporal*, which it has replaced. Research and development firings of the Sergeant ended in 1961. The first operational missile fired by a tactical army unit took place in 1962. Sergeant is in production at the Sperry Utah Engineering Laboratory under the technical supervision of the Army Missile Command. Sergeant missile battalions are in training at Fort Sill, Oklahoma.

SHILLELAGH (Army)

(MGM-51A)
Type: infantry support missile
Propulsion: solid-propellant rocket
Guidance: command type
Performance: classified
Construction: diameter 152 mm.; weight 40 pounds
Remarks: designed to be used against tanks, pillboxes and other hardpoint targets; possibly also to be fired from helicopters; high-explosive warhead

Shillelagh falls in the category of truly modern infantry weapons. It has been developed for the main purpose of destroying armor and field fortifications from mobile vehicles. In fact, Shillelagh has become the main armament for combat vehicles because of its effective firepower. It also has applications as an infantry close-support weapon. It is fired from a turret-type launching mechanism. Reportedly, the missile is being evaluated by the Army as a helicopter weapon as well. The prime contractor for the Shillelagh weapon system is the Ford Motor Company.

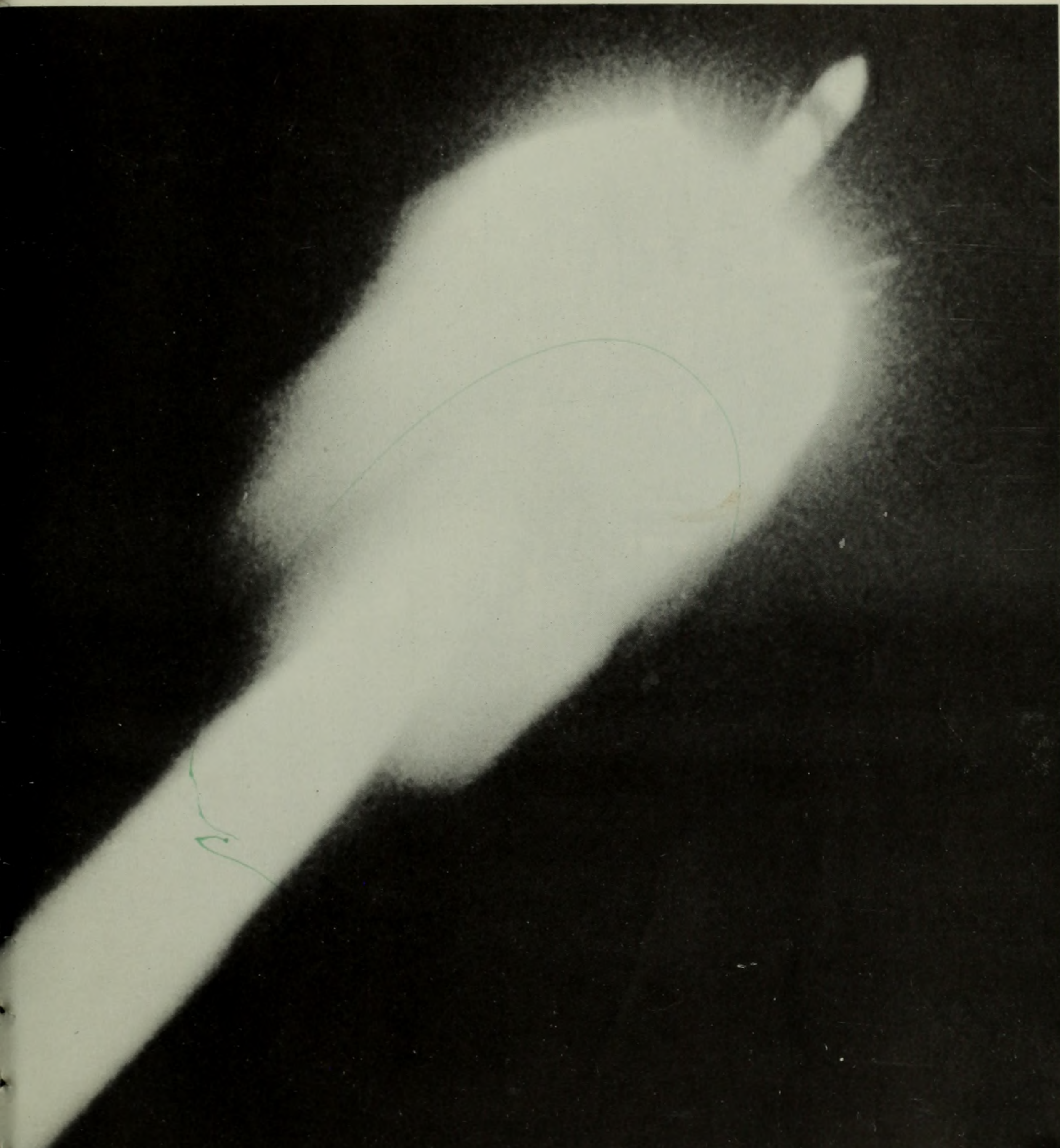


Subroc antisubmarine rocket is fired from submerged submarines against enemy subs. This weapon is capable of carrying nuclear depth bombs and provides a major breakthrough in meeting the threat of missile-firing enemy submarines.

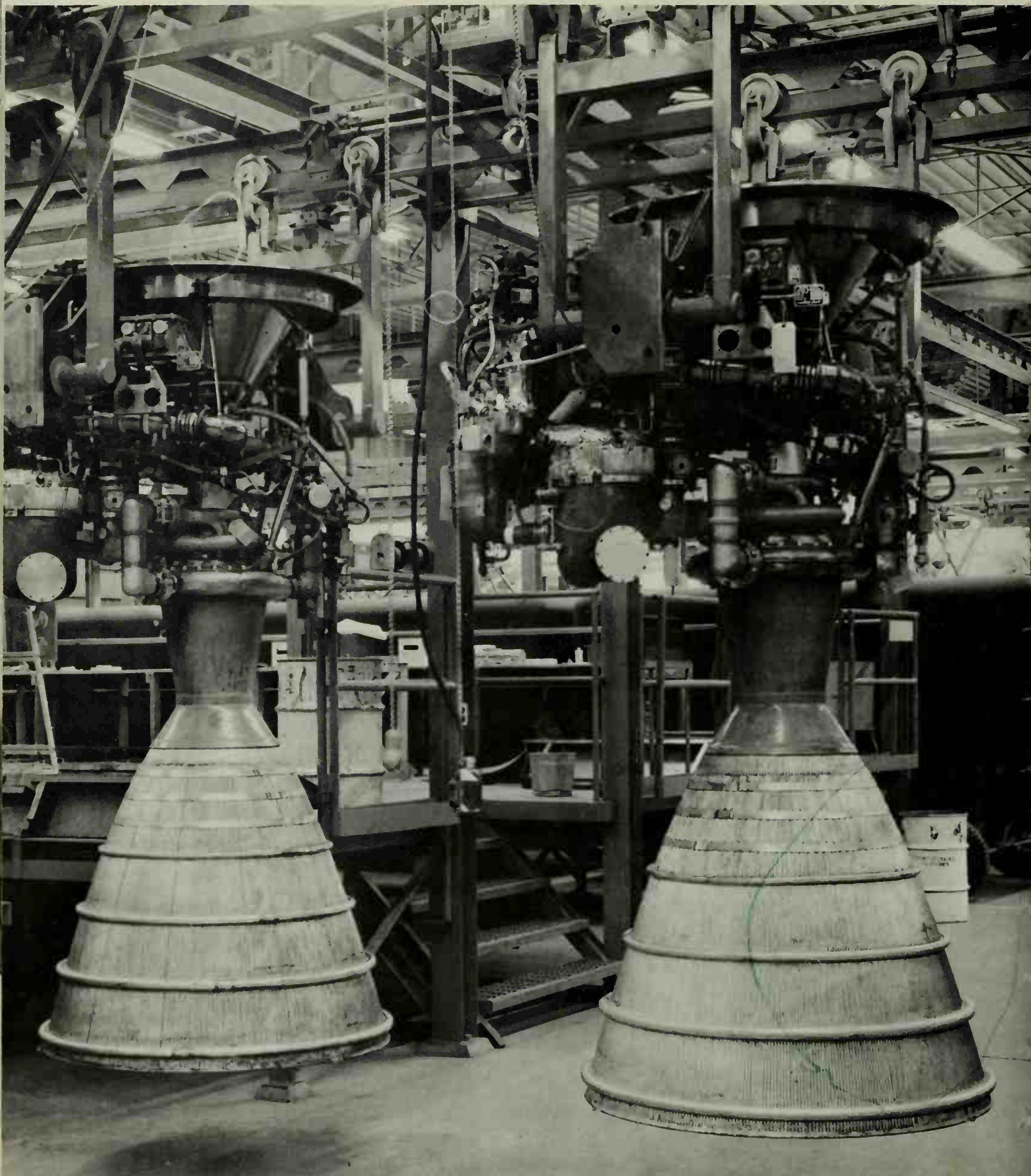
SUBROC (Navy)

(UUM-44A)
Type: antisubmarine rocket
Propulsion: solid-propellant rocket
Guidance: inertial
Performance: range 25 to 30 miles
Construction: length 21 feet; diameter 21 inches; weight 4,000 pounds
Remarks: fired from submarine torpedo tubes; leaves water in flight, re-enters water and seeks out enemy submarine; high-explosive or nuclear warhead

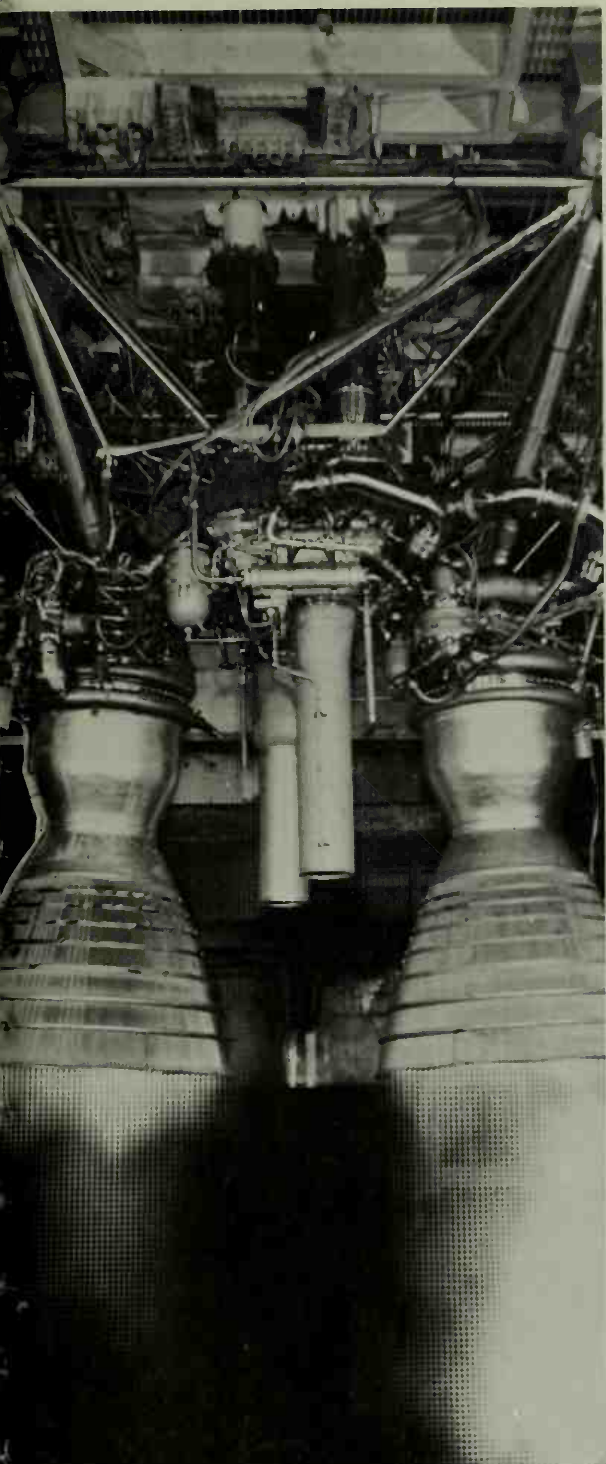
Subroc was developed as a weapon for antisubmarine warfare. The control system can detect a submarine at long range, compute its course and speed and launch the missile. The missile is launched from the torpedo tube of a submerged submarine. The missile travels to the surface, is propelled through the air on a programmed flight, then re-enters the water where it continues on to the target submarine. Subroc supplies ranges greatly in excess of present antisubmarine torpedo ranges. The prime contractor for this advanced missile system is the Goodyear Aircraft Corporation, under the direction of the Naval Ordnance Laboratory, White Oak, Maryland.



Separation of *Subroc* depth-bomb stage from its solid-propellant booster.



Twin engines for a *Titan* missile first stage. After thorough checkout the engines are ready to be test fired on the static test stand.
/ *Aerojet*



Titan twins on the test stand burning at full speed. Note the complexity of controls, fuel lines and valve systems. / *Aerojet*

TITAN I (Air Force)

(HGM-25A)

Type: intercontinental ballistic missile

Propulsion: two-stage liquid-propellant rocket

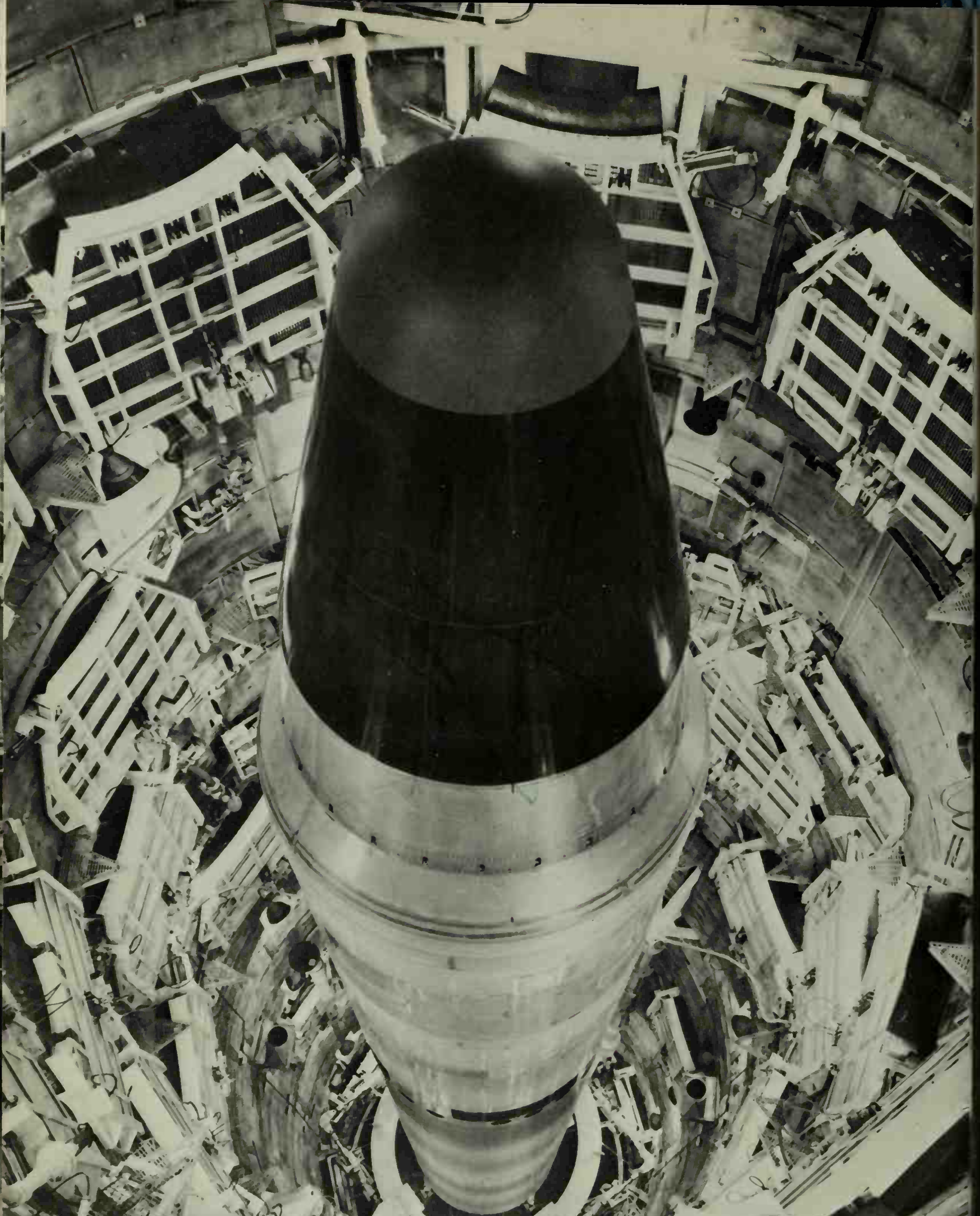
Guidance: radio-inertial

Performance: range 6,300 miles; speed 16,000 miles per hour; altitude 920 miles

Construction: length 98 feet; first stage diameter 10 feet; second stage diameter 8 feet; weight 220,000 pounds; twin engines in first stage; single engine in second stage

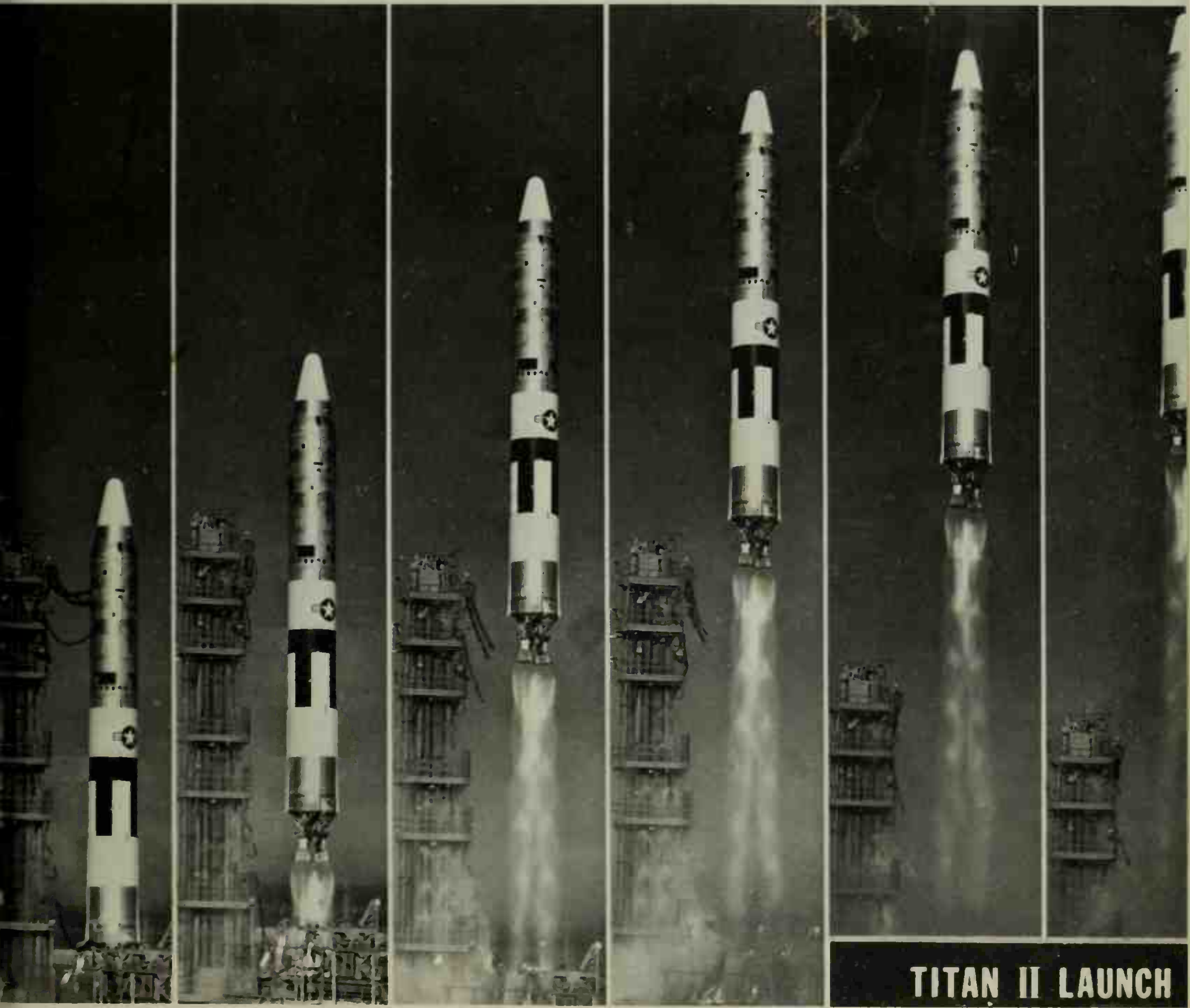
Remarks: nuclear warhead of about 15 megatons; missile to be replaced by *Titan III* and *Minuteman*

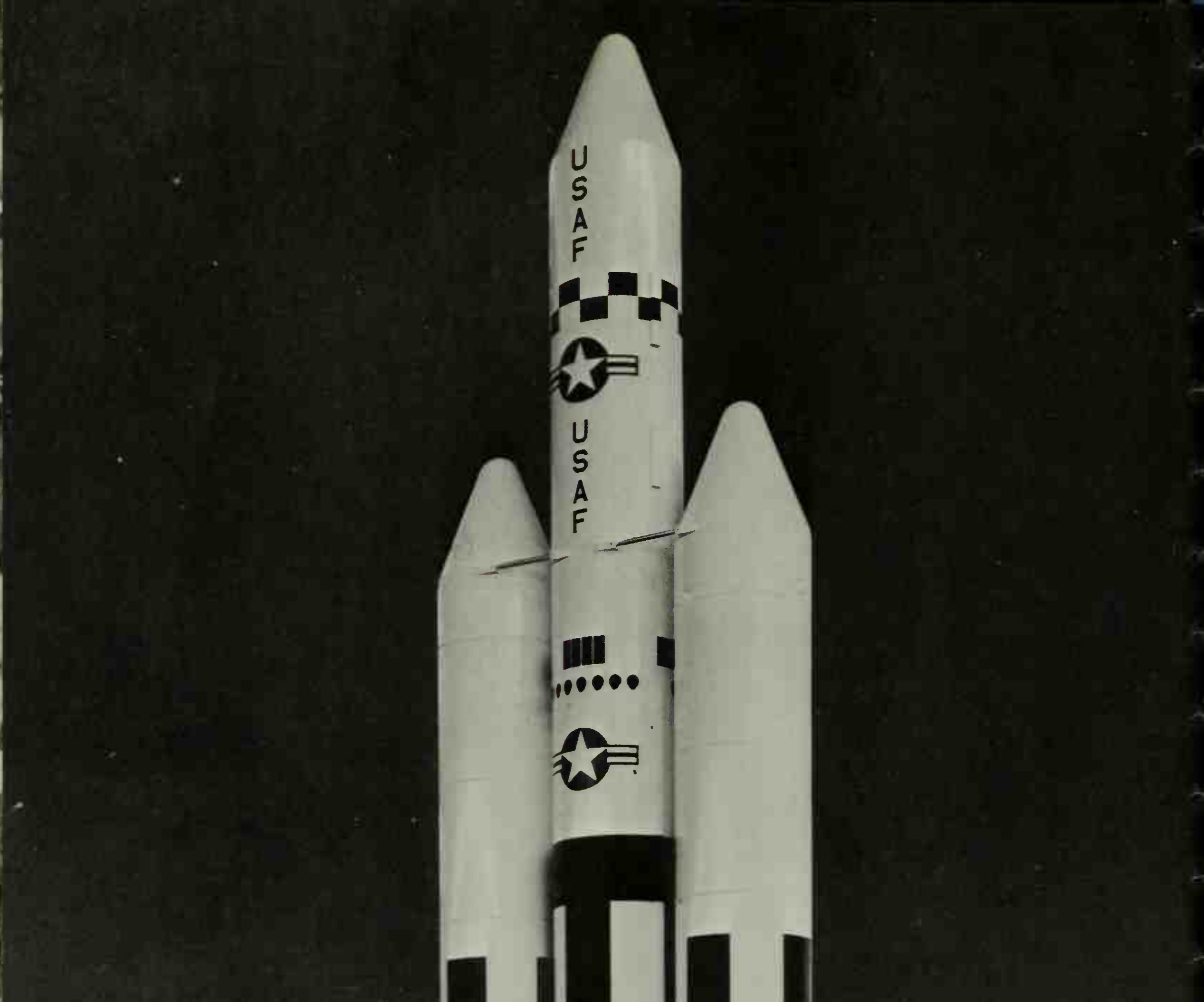
In August, 1960, the first operational prototype Titan I was tested successfully in a 5,000-mile flight from Cape Kennedy. Many tests followed, until the first complex of this new type of ICBM was accepted as operational by the Strategic Air Command. By 1962 several Titan I squadrons were operational; the missiles were deployed in hardened bases in South Dakota, Colorado, Idaho, Washington and California. Like all ICBMs, the Titan I was designed to travel toward its targets in a ballistic path across the Arctic. It is being or has been phased out, to be replaced by even more advanced ICBMs. The prime contractor for airframe assembly was the Martin Company.



Titan II intercontinental ballistic missile in its silo, 150 feet deep. This rocket is also used in the *Gemini* space program as a booster.

The first few seconds of a *Titan* launch. *Titan*'s first stage develops 430,000 pounds of thrust; the second stage develops 100,000 pounds of thrust.





Model of *Titan III* is designed as a standard space launch system for future Air Force satellites and space capsules. It uses a main liquid-propellant rocket system as well as strapped-on solid boosters. / *Martin*

TITAN II (Air Force)

(LGM-25C)
Type: intercontinental ballistic missile
Propulsion: two-stage liquid-propellant rocket
Guidance: inertial
Performance: range over 6,300 miles; speed over 16,000 miles per hour
Construction: length 103 feet; diameter 10 feet; weight 330,000 pounds; twin engines in first stage using nitrogen tetroxide and a 50/50 mixture of hydrazine and exotic fuel; 430,000 pounds of thrust in first stage; 100,000 pounds of thrust in second stage
Remarks: nuclear warhead of about 20 megatons; largest U.S. military missile until *Titan III* becomes operational; used as booster for *Gemini* space capsules

Development of Titan II was initiated in June, 1960, when the Air Force awarded a contract to the Martin Company for an advanced version of the Titan weapon system. By July, 1962, three of the new missiles had made successful flights down the Atlantic missile range from Cape Kennedy. During the initial part of the flight, Titan II can be recognized by a bright glow visible as the missile moves away from the launch pad, in contrast to the fiery tail associated with launches of earlier ICBMs. The glow results from the storable liquid propellants used in the missile. These may be kept in ready-to-fire condition for long periods of time at ordinary temperatures.

TOW (Army)

Type: antitank missile
Propulsion: two-stage solid-propellant rocket
Guidance: wire-guided through a link in optical sight
Performance: classified
Construction: launched from tube; optically tracked; weight 160 pounds
Remarks: replacement for *Entac;* high-explosive shaped charge; first-stage rocket ejects missile from tube; second stage then ignites and carries missile to target

Tow is the designation for one of the Army's newest antitank missiles. It is a tube-launched, optically tracked, wire-guided, heavy-assault weapon system capable of being operated by infantry for the purpose of destroying armored or hard targets. In 1962 three industrial firms and the Harry Diamond Laboratories conducted comparative feasibility studies and component development. The companies were the Hughes Aircraft Company, McDonnell Aircraft Company and the Martin Company. Following evaluation of the studies, Hughes was selected to start the actual development of the missile. It will greatly increase the foot soldier's capability to destroy enemy tanks in the battlefield.

Dart antitank missile is guided toward its target by a trailing telephone wire through which the launch soldier can give it directions.

Mobile air defense missile carrier with radar and launcher for salvos of twelve *Mauler* rockets.

Glossary

Air Force Missile Development Center (AFMDC) — An ARDC center at Holloman Air Force Base, New Mexico. Conducts research, development, test and evaluation in areas of guided missiles, space biology and test range instrumentation.

Air Force Missile Test Center (AFMTC) — An ARDC center at Patrick Air Force Base, Florida. Operates the Atlantic missile range for the Department of Defense. Conducts flight tests of aerodynamic and ballistic missiles.

air-launched ballistic missile (ALBM) — a weapon, generally utilizing a solid propellant, which is carried aloft and launched from an aircraft.

aircraft rocket — A rocket-powered missile carried by, and launched from, an aircraft. It may be guided or unguided.

alcohol — Ethyl alcohol (C_2H_5OH) or methyl alcohol (CH_3OH), used with liquid oxygen as a bipropellant. (Ethyl alcohol and liquid oxygen were used in the German V-2).

anti-G suit — a tight flying suit that covers parts of body below the heart and is designed to retard the flow of blood to the lower body in reaction to acceleration or deceleration. An antiblackout suit. Bladders or other devices may be incorporated to inflate and increase bodily constriction as the G force increases.

antisatellite missile — A missile designed to destroy an orbiting satellite.

apogee — The point or position at which a moon or an artificial satellite in its orbit is farthest from its primary.

artificial earth satellite — A man-made satellite, as distinguished from the moon. Usually called *earth satellite.*

astrionics — The science of adapting electronics to aerospace flight.

astrogation — Navigating in space.

astronaut — One who flies or navigates through space.

astronautics — The art or science of designing, building, or operating space vehicles.

atmospheric braking — The action of atmospheric drag in decelerating a body that is approaching a planet. Can be deliberately used, where sufficient atmosphere exists, to lose much of the vehicle velocity before landing.

backout — Reversing the countdown sequence because of the failure of a component in the missile or a hold of unacceptable duration. Most serious task during backout is removal of the propellants from missile tanks. Used in contexts where the countdown has been discontinued.

ballistic missile — Missile that travels in a path influenced only by the missile's own inertia or forward speed, its weight, the gravity pull of the earth and wind condition. A ballistic missile is only influenced by its guidance mechanisms during takeoff and while its power plants are working, much like a shell from a gun. Once the shell leaves the gun barrel, the shell travels in a ballistic path or trajectory determined by the factors above.

ballistic missile interceptor — An interceptor, specifically an explosive rocket missile, designed to home upon, and destroy, a ballistic missile in flight. This term is sometimes used as a synonym of *anti-missile missile.*

ballistic trajectory — The curved portion of a missile trajectory traced after the propulsive force is cut off and the body is acted upon only by gravity, aerodynamic drag and wind.

biosatellite — A satellite designed to carry an animal or plant, or a satellite that carries an animal or plant.

bird — A figurative name for a missile, earth satellite, or other inanimate object that flies.

blockhouse — A building, usually heavily reinforced to withstand blast and heat, that houses the electronic controls and equipment for preparing and launching a missile, together with auxiliary apparatus.

blowoff — Separation of an instrument section or package from the remainder of the rocket vehicle by application of explosive force, to retrieve the instruments after they have collected the required information.

boil-off — The vaporization of liquid oxygen as the temperature of the propellant mass rises during exposure to ambient conditions of the missile tank or other containers.

booster — An engine that assists the normal propulsive system of a missile or other vehicle. A booster may be incorporated in the first stage of a missile to give more power for takeoff.

brain — Generally refers to the man-made kind — the navigational units or electronic data-processing systems.

burnout — The point in time or in the missile trajectory when propellant is exhausted or its flow is cut off, resulting in end of combustion of fuels in the rocket engine.

capsule — A small, sealed, pressurized cabin with an acceptable environment, usually for containing a man or animal for extremely high-altitude flights, orbital space flight, or emergency escape.

captive firing — Test firing of a complete missile where all or any part of the propulsion system is operated at full or partial thrust while the missile is restrained in the test stand.

carrier rocket — A rocket vehicle used to carry something, as in the "carrier rocket" of the first artificial earth satellite.

checkout — A sequence of operational and calibrational tests needed to determine the conditions and status of a weapons system.

circuitry — The system of electric or electronic circuits used in a missile system or subsystem.

circular velocity —Critical velocity at which a satellite will move in a circular orbit around its primary. Circular velocity is a special case of orbital velocity and one which is not likely to be obtained in practice due to accuracy of control needed.

circumlunar — Trips or missions in which a vehicle will circle the moon and return to earth.

cislunar space — Space between the earth and the orbit of the moon.

cluster — Two or more engines bound together so as to function as one propulsive unit.

countdown — (1) The step-by-step process leading to missile launching. It is performed in accordance with a predesigned time schedule, measured in terms of T-time (T minus time prior to initiation of engine start sequence and T plus time thereafter). (2) Also used to describe the step-by-step process leading to captive tests, battleship tank tests, flight readiness firings and mock firings.

destructor — An explosive or other device for destroying a missile or one of its components intentionally.

downrange — In a direction away from the launch site and along the line of a missile test range.

engines, power plants (*see also* **rockets**) — Propulsion system that drives a missile or an airplane, such as a turbojet engine, turboprop engine, pulsejet, ramjet or rocket. Turbojets depend on the atmosphere to support combustion of the fuel and get push by sending high-velocity gases out of the tail pipe. They use turbines solely to drive compressors that concentrate great volumes of air in the burning pots. The turboprop is like the turbojet but uses the turbine to drive not only the compressor but a conventional propeller as well. It kicks a lot less hot high-speed gas out of the tail pipe as a result and gets most of its power out of the propeller. Pulsejet and ramjet, basically, have no moving parts. Instead they are very carefully designed stovepipes wherein air is compressed and mixed with fuel, then ignited and "ejected" to give forward thrust. Rocket principle described under **rocket.**

escape velocity — The speed a body must attain to overcome a gravitational field, such as that of earth, and thus theoretically travel on to infinity. The velocity of escape at the earth's surface is 36,700 feet per second. A practical manned space craft would travel the atmosphere at a lower velocity and accelerate to escape velocity beyond in order to avoid unacceptably rapid initial acceleration and high skin temperature from aerodynamic heating.

exotic fuel — Unusual fuel combinations for aircraft and rocket use with the purpose of attaining far greater thrust.

fallback area — At certain missile sites, an area to which technicians and others fall back once the missile is readied for firing.

flame bucket — An opening built into the pads of some rockets into which the hot gases of the rocket pour as thrust is built up. The flame bucket is directly under the rocket positioned for launch. One of its sides turns inward to form the flame deflector; the opposite side is open.

gantry — Crane-type structure, with platforms on different levels, used to erect, assemble, and service large missiles; may be placed directly over the launching site and rolled away just before firing. Short for *gantry crane* or *gantry scaffold.*

gimbaled motor — A rocket motor mounted on a gimbal, i.e., on a contrivance having two mutually perpendicular axes of rotation, so as to obtain pitching and yawing correction moments.

go-no-go — Of a missile launch: so controlled at the end of the countdown as to permit an instantaneous change in decision on whether to launch or not to launch.

ground support equipment — All ground equipment that is part of the complete weapons system and that must be furnished to ensure complete support of the weapons system. Included are all implements or devices required to inspect, test, adjust, calibrate, assemble, disassemble, transport, safeguard, record, store, actuate, service, launch and otherwise support and maintain the functional operating status of a weapons system, subsystem, end item or component.

guidance

fin stabilization: the simplest method of guiding a rocket or missile in flight where aerodynamic surface fins are mounted on the body of the rocket or missile (usually at the aft end) for stabilizing its flight path and to prevent it from tumbling.

radar control: radio transmitters located in the missile send out signals to the target that are reflected back to the missile. Timing of the signals to the target and back to the missile makes it possible to determine the distance, altitude and direction of motion of the target. Control systems in the missile, operating with radar, use this information in guiding the missile to the target.

radar beam: radio signals from a radar transmitter on the ground or in an aircraft or missile traveling similar to beams of light. The radar beam is reflected from any object (clouds, land, sea, etc.) the same as light is reflected from a mirror. The missile follows this reflected beam to reach its destination.

celestial: a method of guiding a missile over great distances by reference to the positions of celestial bodies (usually bright stars). Optical instruments remain pointed to certain stars during the flight (the position of the celestial bodies from any point on the earth and at any time is accurately known), enabling instruments to determine the location of the missile at all times.

inertial: guidance method that usually consists of two or more gyros set in motion as a reference system for the rocket or missile. Individual gyros are used to control the direction, flight path and spinning of the vehicle. The resistance of the spinning gyros to being influenced holds the rocket or missile to its previously plotted flight path (*see also* **gyro**).

infrared: a guidance method operating on the detection of heat (radiation) waves from a target. Sensitive instruments in the nose of the rocket or missile pick up the heat waves (such as engine exhausts) and through a connected control system guide it to the target.

gyro — The gyroscope is a wheel or disk mounted to spin rapidly about an axis, and also free to rotate about one or two axes perpendicular to each other and to the axis of spin. Because the gyro tends to maintain a stable plane it can be used as a stabilizer, offering resistance to any foreign force acting upon it. It is used to resist the rolling or tilting of missiles in flight. It is often referred to as the "automatic pilot" in many missile guidance systems.

hardened (hard base) — Made hard, as with concrete or earth, to withstand overpressure of nuclear attack or other blast, e.g., hard base, hard structure.

hypergolic propellant — A rocket propellant that ignites spontaneously upon contact with an oxidizer.

launch pad — A concrete or other hard surface area on which a missile launcher is positioned.

liquid oxygen — Oxygen supercooled and kept under pressure so that its physical state is liquid. Used as an oxidizer in a liquid-fuel rocket.

lunar orbit — The orbit of a body placed in orbit about the moon.

multistage rocket — A rocket having two or more thrust-producing units, each used for a different stage of the rocket's flight.

orbit — The path described by a celestial body in its revolutions around another body.

payload, warhead — Instrumentation for measuring atmospheric phenomena, radio transmitters, cameras, etc. make up the *payload* in a sounding or research rocket. Instrumentation usually is mounted in the rocket's nose. The explosive charge and fuze in a military missile, always carried in the nose, represent the missile's *warhead*.

perigee — The point at which a moon or an artificial satellite in its orbit is closest to its primary.

probe — A thing used to explore, examine, and test the nature of something, especially a test sphere, earth satellite or other instrumented vehicle used to penetrate outer space and made to report back information on conditions encountered; specifically an instrumented vehicle that moves close to, around, or upon a spatial body, and reports back to the earth, by telemetry or by other means, such information about the body under surveillance as is obtained from the particular instruments in use.

recovery — The act of retrieving a portion of a launched missile or satellite which has survived re-entry.

re-entry — The return of a ballistic missile or other object into the sensible atmosphere.

re-entry nose cone — A nose cone designed especially for re-entry, consisting of one or more chambers protected by an outer shield.

rocket — A reaction engine, the motion principle of which is based on Newton's third law (a force in one direction always creates an equal force in the opposite direction), always carries with it oxygen to sustain burning instead of sucking in air from the atmosphere. Thus, the rocket can work in the vacuum of space. Rockets burn liquid or solid propellants: for example, alcohol (liquid fuel) plus liquid oxygen (oxidizer, oxident), or aluminum (solid fuel) plus ammonium nitrate (oxidizer).

rockets

research or sounding rockets: rocket-powered missiles that carry instruments to high altitudes for measuring atmospheric data, such as cosmic radiation, ultraviolet intensity, temperatures, etc.

booster rockets, auxiliary rockets: rocket engines that are mounted on airplanes or on missiles to give initial boost during takeoff. Booster rockets usually are jettisoned or dropped after the plane or the missile becomes airborne.

operational rockets, or missiles: usually refers to missiles that are in service and/or production by the Army, Navy or Air Force.

stage rockets, step rockets: rocket vehicles consisting of two or more stages, i.e., one smaller rocket mounted on top of another bigger one. Individual stages are dropped after propellants have been burned. Technique is used to obtain maximum speed in a short time.

rocket sled — A vehicle traveling along a set of rails, much like train rails, and powered by rocket motors. Rocket sleds are used to study high stress or high accelerations on humans and also on components, such as electronic gear, designed for missile guidance systems, etc.

separation — The event which occurs when a full-stage, half-stage, warhead, or re-entry vehicle is separated from the remainder of the vehicle.

silo — A missile shelter that consists of a hardened vertical hole in the ground with facilities either for lifting the missile to a launch position, or for the direct launch from the shelter.

skirt fog — The cloud of steam and water that surrounds the engines of a missile being launched from a wet emplacement.

sloshing — The back-and-forth splashing of a liquid fuel in its tank, creating problems of stability and control in the vehicle.

specific impulse — A means of determining rocket performance. It is equivalent to the effective exhaust velocity divided by gravity, expressed in pounds per second.

spin stabilized — Directional stability of a projectile obtained by the action of gyroscopic forces which result from spinning of the body about its axis of symmetry.

static firing — The firing of a rocket motor or engine in a hold-down position to measure thrust and accomplish other tests.

target drone — An unmanned aircraft or a missile used as a target for testing interception equipment and procedures.

trajectory — The path that a rocket or missile travels from point of launch to point of impact. Usually refers to ballistic missiles. Also the route of the course.

Abbreviations in Rocketry

AAM	air-to-air missile
ALBM	air-launched ballistic missile
ATM	antitank missile
ASM	air-to-surface missile
FBM	fleet-ballistic missile
GAR	guided aircraft rocket
ICBM	intercontinental ballistic missile
ICBM	intermediate-range ballistic missile
LP (R)	liquid-propellant (rocket)
MRBM	medium-range ballistic missile
MMRBM	mobile midrange ballistic missile
PJ	pulsejet
RJ	ramjet
SP (R)	solid-propellant (rocket)
SAM	surface-to-air missile
SRBM	short-range ballistic missile
SSBM	surface-to-surface ballistic missile
SSM	surface-to-surface missile
TJ	turbojet
USM	underwater-to-surface missile
UUM	underwater-to-underwater missile

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ERIK BERGAUST has been observing and writing about aviation, rocket and space flight development for the major part of his career. A native of Norway, he came to the United States in 1949 after a number of years' experience in aviation writing, editing and public relations work. He has been a project engineer for several aeronautical and missile engineering companies in this country and has also been the editor of several magazines. The author has published over twenty books for Putnam's, his latest being *Illustrated Space Encyclopedia.*