Missiles (*Continued*)

just like airplanes; others have only stabilizing fins; some are steered by moving the engine (i.e., if the exhaust is pointed in one direction, the reaction is in the opposite direction). The control system does the mechanical steering of the missile, but it's the guidance system that tells it which way to steer.

How many kinds of guidance systems are there?

Four basic kinds: radar, homing, inertial, and celestial.

1. Radar is a complicated electronics system which, in simple terms, sends out radio signals that bounce off an object and "echo" back. Timing of the cycle automatically determines the object's location, speed, and direction. There are three kinds of radar: command, beam, and homing.

In command radar, both the missile and its target are tracked and the impact point computed. Commands are sent to the missile's control system to keep it on course. In beam radar, a continuous signal is aimed at the target and the missile rides down this "beam." In homing radar, the missile carries its own radar, sends out its own signals and homes in on the reflected echo.

The advantage of command and beam radar is that these units can be operated from the ground or from an airplane, eliminating much equipment from the missile itself. A disadvantage of radar is that its signals can sometimes be "jammed" by the enemy, throwing a missile off course.

2. Other homing devices have instruments that are sensitive to heat, light, or sound. Mounted in the missile, they can home in on the source of these impulses. Infrared systems, for instance, can home in on the heat from an airplane's engine. Limited in range, homing systems are confined to smaller missiles, although they can be used in combination with others—for example, radar can direct a missile close to a target where the homing device takes over.

3. Inertial systems (from "inertia," or stationary) use gyroscopes which, when spinning, tend to resist any change in direction. These "floating platforms" are mounted in the missiles and set before take-off. In flight, they note any deviation from the prescribed course, automatically sending correctional signals to the control system. An advantage is their immunity from any outside interference; a disadvantage is that gyros, because of friction on the bearings, tend to drift off course after extended periods of time.

4. Celestial systems are guided by the stars. Optical instruments mounted in the missile are pointed at known stars which, as far as the earth is concerned, are "fixed" in space. If the missile drifts off course, the optics relay this information to the control system. Celestial systems will probably guide future space missiles because there is almost no limit to their range.

How many kinds of payloads are there?

Two at present. In military missiles the payload, of course, is an explosive warhead, in some cases an atomic explosive. In experimental missiles, including the multistage satellite launchers, the payload is a package of instruments which gather information for future launchings. Within a few years, a third kind of payload will be launched—man himself.

How many kinds of missiles are there?

Too many to list. Some are still on the drawing boards, others are already obsolete. Some are test vehicles, used only for research. The best way to classify them is according to their purpose. All of the following are either operational or in the development stage. Note the kinds of engines and guidance systems each uses.

Air-to-air missiles—These are the "intelligent" bullets, fired from one airplane against another. Examples are the Air Force's *Falcon* and the Navy's *Sidewinder*, which both use solid-fuel rocket engines and infrared homing guidance systems. Another one of interest: the Air Force's *Genie*, the smallest missile with an atomic warhead, intended to destroy whole fleets of enemy bombers.

Air-to-ground—These are long-range bombs, launched from airplanes into ground targets or ships. They include the Air Force's *Rascal* (liquid rocket, homing radar) and the Navy's *Petrel* (turbojet, homing radar).

Ground-to-air—Antiaircraft weapons, launched from land or ships against airplanes. Most are short-range types for defense of specific areas: the Army's *Nike* (solid rocket, command radar) and the Navy's *Talos* (ramjet, beam radar). Long-range types, like the Air Force's *Bomarc* (ramjet, beam radar), are "pilotless airplanes" that seek and destroy enemy aircraft up to 300 miles away.

With one exception, all of the above missiles are guided missiles. (The *Genie* is unguided). A different type of missile enters into the next group.

Ground-to-ground—This is the largest and most important group. It includes both guided missiles and the highly publicized ballistic missiles (the IRBMs and ICBMs). The basic difference is that guided missiles are guided throughout their flight, right up to the point of impact. Ballistic missiles are guided only during the initial portion of their flight when their engines are operating, and are "free falling" projectiles the rest of the way, just like artillery shells. Their engines are so powerful, however, that they can accelerate up to 15,000 m.p.h. in the first few moments of flight.

Short-range types are all Army weapons, replacing front-line artillery. Guided missiles in this class include the *Dart*, a solid-rocket antitank weapon with a range of about 1,000 yards; and the *LaCrosse*, a solid-rocket antipillbox weapon with a range of 20 miles. Ballistic missiles include the *Sergeant*, a 100-mile projectile (solid rocket, inertial guidance), and the 200-mile *Redstone* (liquid rocket, inertial guidance).

Intermediate-range guided missiles (up to 1,500 miles) include the Air Force's *Matador* and the Navy's *Regulus* (both use turbojets, inertial guidance). Intermediate-range ballistic missiles (the IRBMs) include the Air Force's *Thor* and the Army's *Jupiter* (both use liquid rockets, inertial guidance); and the Navy's unique *Polaris* (solid rocket, inertial guidance), to be launched from submerged submarines.

Intercontinental-range missiles (up to 5,000 miles) are all Air Force weapons. Guided missiles in this class include the *Snark* (turbojet, inertial guidance). Intercontinental ballistic missiles (the ICBM's) include the *Atlas* and *Titan* (both use liquid rockets, inertial guidance).

What is a multistage missile?

Simply, it's two or more missiles stacked on top of one another. The purpose is to extend the missile's speed and range by firing the second stage where the first one leaves off, and to lighten the missile's weight en route by dropping each stage as it completes firing. The best known multistage missiles are the satellite launchers. The Army's *Jupiter-C*, for instance, which threw America's first satellite into orbit, used an elongated *Redstone* as its first stage, a cluster of 11 modified *Sergeants* as the second stage, three as the third stage, and one in the final stage with the satellite.