ENGINEERING

Device Guides Missiles

"Inertial Guidance" is the name given to a system for guiding aircraft, ships and missiles in which a spinning gyro replaces the stars, compasses, radio or radar now in use.

➤ A SELF-CONTAINED system of navigation that makes it possible for aircraft, ships, and missiles to operate without compasses, radio, radar or a glimpse of the earth, sun or stars, was discussed in detail for the first time at the Instrumentation Laboratory of the Massachusetts Institute of Technology in Cambridge.

Known as "Inertial Guidance," the new system has wide applications to military navigation and fire control.

Although the military applications are still highly classified, much of the basic work on inertial guidance has now been declassified. Dr. Charles Stark Draper, head of the department of aeronautical engineering, M.I.T., and director of the Instrumentation Laboratory, together with Dr. Walter Wrigley, professor of aeronautical engineering and education director of the Laboratory, have been largely responsible for the recent development of inertial guidance.

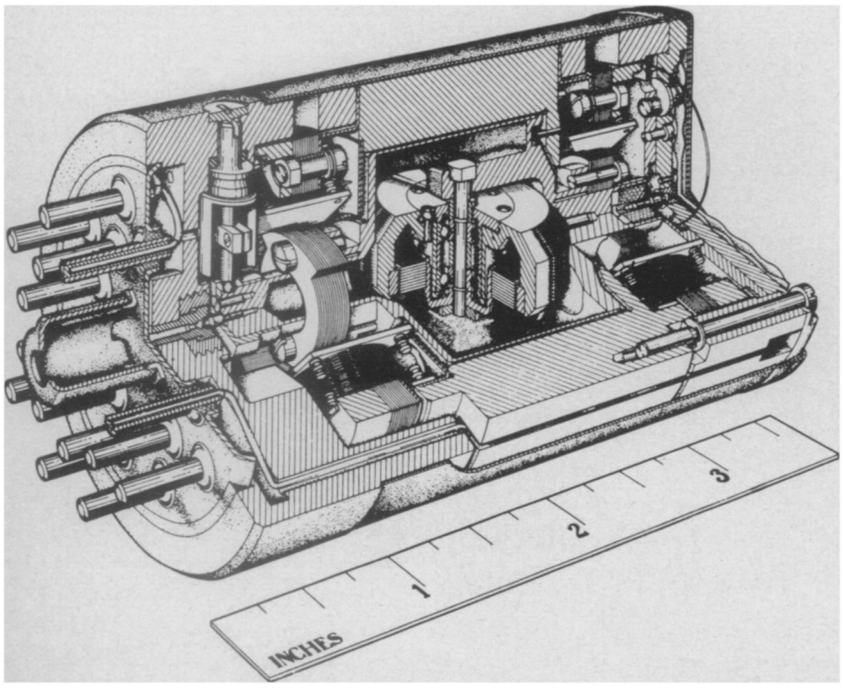
Inertial navigation is of particular importance to the military because it is jamproof. Enemy electronic jamming stations cannot touch it. Weather, sunspots and magnetic fields do not interfere with it.

An inertial guidance system receives no information at all from outside the vehicle. Instead, the system keeps track of its position on the earth by consulting its own small packages of specially designed gyroscopes and pendulums.

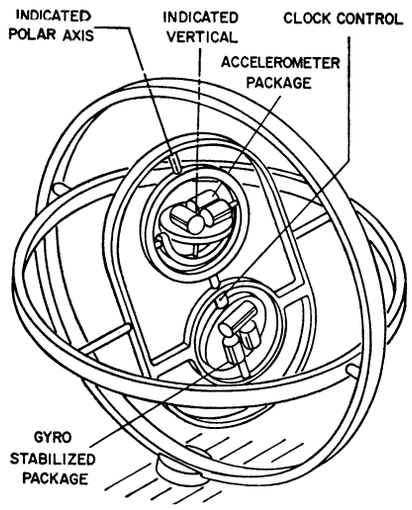
The inertial guidance system developed at the Instrumentation Laboratory is able to determine its own position automatically and guide an aircraft to its destination without any supervision by the pilot. The first automatic coast-to-coast flight from Boston to Los Angeles was made successfully in 1953, it can now be revealed. Since then the efficiency of the equipment has been improved until now inertial guidance is certainly accurate enough to pilot any kind of craft to any spot on earth.

Inertial guidance is sure to be a part of the navigation system on the space ship that makes the first flight to the moon or Mars.

Inertial navigation can be explained as like ordinary celestial navigation, with a gyroscope instead of a star. It has been called "astronomy in a closet."



INTEGRATING GYRO—This cutaway diagram shows the gyro wheel enclosed in a double shell to form a unit called a HIG, a hermetically sealed integrating gyro. Electrically driven, the gyro wheel spins at a rate of 12,000 revolutions per minute.



INERTIAL GUIDANCE — The elements which make up one type of inertial guidance system are shown in this schematic drawing. Systems such as this have been proved accurate enough to be used for guiding craft at this time.

A spinning gyroscope, properly mounted so that it is free to rotate, will keep a fixed direction in space, regardless of the motion of the base on which it is mounted. Thus a free gyroscope mounted on the earth appears to rotate slowly, making one revolution every 24 hours, in the same way that the fixed stars appear to rotate. Actually, both the gyroscope and the stars remain in the same position while the earth rotates.

The gyroscope is said to hold its position in "inertial space," the space described by Newton's Laws of Motion. "Earth space," fixed to our earth, differs from inertial space because of the rotation of the earth. The earth rotates so slowly we ordinarily do not notice the difference between earth space and inertial space. Highly precise measurements can be made to detect this difference, however, and this makes inertial guidance possible.

The inertial guidance systems developed at the Instrumentation Laboratory use a gyroscope package that is aligned with the local vertical, the "up-and-down" direction, at the beginning of the trip. Thereafter, regardless of how it is carried by the earth or the aircraft, the direction of the axis of spin remains the same. This gives information of how the direction of the aircraft has changed since the flight began.

Another kind of instrument is also used to give the direction of the local vertical at any point during flight. This would be easy to do with an ordinary pendulum if the aircraft were stationary. For use in moving craft the Instrumentation Laboratory has developed a special device, known

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Device Guides Missiles

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as the Schuler-tuned pendulum, which can indicate the vertical regardless of the acceleration of the aircraft with respect to the earth.

Schuler-tuned pendulums are based on a principle first proposed by Dr. M. Schuler of Germany more than 30 years ago. The devices developed by the Instrumentation Laboratory employ accelerometers in a complicated feedback design.

The inertial guidance system can determine the latitude and longitude of the aircraft by measuring the angle between the vertical at the beginning of the flight, indicated by the gyroscope, and the vertical at any moment during the flight, indicated by the Schuler-tuned pendulum, and using a clock to correct for the rotation of the earth. The system determines position automatically and continuously, and guides the aircraft to its destination.

The gyroscopes and pendulums used in inertial guidance are complex and fantastically precise instruments. The smallest one shown in the diagram (see p. 259) is no bigger than a medium sized spool of thread.

The gyroscope is a delicate gyro wheel, enclosed in a complicated double shell. Constructed with greater precision than a fine watch, it forms a unit about the size of a tomato can, called a HIG (Hermetically-sealed Integrating Gyro). The electrically driven gyro wheel spins at a rate of 12,000 revolutions per minute, which is fast, but not extremely fast. The wheel is enclosed in an inner cylinder, which is called a float.

A thin layer of heavy, molasses-like fluid fills the space between the float and the outer cylinder, and the float actually floats in the fluid. Because the float is suspended in fluid, it pivots on sapphire bearings that are virtually frictionless.

The floated gyro is far more accurate than any other kind of gyro, and constitutes a major advance in gyro technology.

Three gyros are used, mounted in a package with their spin axes at right angles to each other. The package is mounted on gimbals so that it can rotate freely in all directions.

The three accelerometers used in the Schuler-tuned pendulum are mounted in a package of similar shape and size.

Other parts of the inertial guidance system make allowance for the roll, pitch and yaw of the aircraft, and calculate automatically the earth's rotation.

Science News Letter, April 27, 1957

MEDICINE

Measure Blood Flow

➤ MEASURING abdominal blood flow may disclose what happens to the body's circulation during serious shock, members of the New York Heart Association's annual science writers' tour learned from Dr. Stanley E. Bradley, Columbia University College of Physicians and Surgeons.

Dr. Bradley and his associates have worked on blood flow for 12 years and have developed widely used techniques for measuring the blood in the viscera, the abdominal area that includes the digestive tract, pancreas, spleen and liver.

In their present study of shock for the U. S. Army, Dr. Bradley's group hopes to find out if this visceral blood flow falls down in patients undergoing shock. One theory is that the visceral "bed" may dilate or expand, trap blood and cause the injured person to "bleed into it." There is not much evidence so far that this occurs but such "trapping" might be found elsewhere in the body, they reported.

The viscera holds about 20% of the body's blood volume and is the area for food digestion and waste elimination. It also plays an important part in blood circulation, probably being the reservoir from which the body sends supplies of blood to meet the crisis of hemorrhage, or bleeding.

Some researchers believe that after severe hemorrhage, too much blood may accumulate in the abdomen and result in irreversible shock.

By tracing the path of blood through the viscera with radioactive iodine, Dr. Bradley found that about one and a half quarts of blood are held in this area. This entire amount is estimated to be completely changed about once a minute, he reported.

Science News Letter, April 27, 1957

Do You Know?

Cooking utensils, sink tops and other household items that are often made of stainless steel may in a few years be made of *titanium*.

The worst U. S. outbreak of *gypsy moth* on record occurred in 1953, possibly due in part to hurricanes along the New England coast in 1948 that carried caterpillars to previously uninfested areas.

Witchweed, a small, harmless-looking weed with reddish flowers, does its damage below ground, by penetrating the host plants' roots.