

## GYROSCOPE AND ITS APPLICATIONS

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### Abstract

This article discusses the history of gyroscopes, their main properties, types, and applications in various fields of technology and weapons. It also highlights the main components of a gyroscope and its drawbacks.

**Keywords:** Direction, rotation, gyroscope, stabilization, navigation, control, device, gyroscopic effect.

### Introduction

Before the invention of the gyroscope, humanity used various methods to determine the direction in space. Since ancient times, people have been using visual cues from distant objects, such as the Sun, to navigate. The first devices based on gravity, such as a plumb bob and a level, were also developed in ancient times.

The gyroscope was invented by John Bonenberger and published a description of his invention in 1817. However, the French mathematician Poisson mentioned Bonenberger as the inventor of this device back in 1813. The main part of the Bonenberger gyroscope was a rotating massive ball in a gimbal.

In 1832, the American Walter R. Johnson came up with a gyroscope with a rotating disk. The French scientist Laplace recommended this device for educational purposes. In 1852, the French scientist Foucault improved the gyroscope and used it for the first time as a device that shows changes in direction (in this case, the Earth's direction), a year after the invention of the Foucault pendulum, which is also based on the conservation of angular momentum. It was Foucault who coined the term "gyroscope." Like Bonenberger, Foucault used a gimbal suspension.

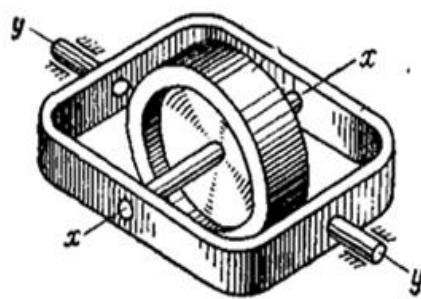
In the second half of the 19<sup>th</sup> century, it was proposed to use an electric motor to accelerate and maintain the rotation of a gyroscope. The first practical application

of a gyroscope was made in the 1880s by the engineer Aubrey to stabilize the course of a torpedo. In the 20<sup>th</sup> century, gyroscopes were used in aircraft, rockets, and submarines instead of or in conjunction with a compass.

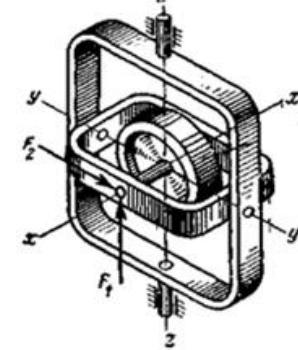
If you've ever wondered about how a gyroscope works, you're not alone. This fascinating device finds applications in various fields, from aviation to mobile phones. Understanding how a gyroscope works will help you appreciate how it provides stability and accuracy in the technology we encounter every day.

A gyroscope is a massive, symmetrical body that rotates at high speeds around its axis of symmetry.

The main types of gyroscopes based on the number of degrees of freedom: two-degree 1-Fig), three-degree (2-Fig). The main two types of gyroscopes based on the principle of operation: mechanical gyroscopes, optical gyroscopes.



1-Fig.



2-Fig.

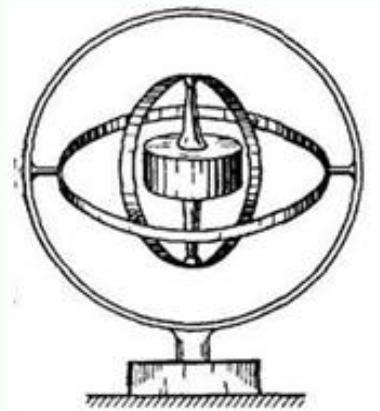
Gyroscopes are based on a simple but powerful principle: it is easier for a rotating body to maintain its direction. This property makes them indispensable in navigation and control systems. By understanding how a gyroscope works and what it is used for, you can gain a deeper understanding of how modern technology operates behind the scenes, providing comfort and safety in your daily life.

The basic properties of a gyroscope. If the friction in the bearings is sufficiently small, the device acquires the following property: regardless of how the base rotates, the rotor axis remains fixed in inertial space.

Precession is the rotation of the device when it is subjected to an external force. It is based on the Resale theorem, which states that the angular velocity of precession is equal to the ratio of the equatorial component of the external force to the intrinsic kinetic moment.

Nutation is the irregular motion of a rotating rigid body due to inertia, which typically manifests as small oscillations.

Gyroscopic moment - is called the total moment of the counteraction forces of the gyroscope arising during its precession.



The advantage of the gyroscope over the more ancient devices is that it works correctly in difficult conditions (poor visibility, shaking, electromagnetic interference). Due to this, it became indispensable in mine surveying, space exploration, aviation. However, the gyroscope quickly stopped due to friction. Understanding the principle of operation of a gyroscope requires knowledge of its structure and mechanism of action. A gyroscope consists of a rotor that rotates around its axis, and a system that stabilizes its position. It is important to note that the angle and speed of rotation determine the behavior of a gyroscope.

Gyroscopes, using the laws of physics, have become an important element in engineering and science, as they provide stability and accuracy in orientation measurements.

Different types of gyroscopes may have different designs, but there are several key components that are common to most of them. Let's take a closer look at each of them.

The main components of a gyroscope. The rotor is the rotating part of the gyroscope that is responsible for its inertial properties. The most significant characteristic of the rotor is its moment of inertia, which determines the stability of the gyroscope's position during rotation.

The housing protects the rotor and other internal components from external influences. It also provides the necessary structural rigidity, which is important for accurate measurements.

The bearings allow the rotor to rotate with minimal energy loss. The better the bearings, the less friction and the faster the rotation, which increases the accuracy of the gyroscope.

Motion sensors measure changes in angle and rotation speed. Modern gyroscopes use various types of sensors, including MEMS (microelectromechanical systems), which are highly sensitive and compact.

Electronics - processes data received from sensors. This part is responsible for data filtering algorithms and error compensation, ensuring the accuracy of measurements.

Power supply - ensures the functionality of all gyroscope components. Depending on the design, the power supply can be a conventional battery or a built-in power source.

By understanding the main components of a gyroscope, it is possible to gain a better understanding of its working principles and their practical applications in various fields, from aviation to mobile electronics. Each of these elements contributes to the accuracy and reliability of the gyroscope, making it an indispensable tool in today's technological world.

In general, gyroscopes can be classified based on various criteria, including their design, operating principle, and application. Magnetic field-based gyroscopes: These gyroscopes utilize magnetic properties to determine orientation and position.

Gyroscopes play a key role in aviation navigation and control. Their ability to determine orientation and angle makes them an integral part of modern aviation systems. With the help of gyroscopes, pilots can accurately control the aircraft, ensuring a high level of safety and reliability. Gyroscopes not only aid in navigation but are also crucial for aircraft control. They provide dynamic stabilization and help pilots make more informed decisions during flight.

The gyroscopic effect is widely used for stabilizing flying projectiles. Forces act on a non-rotating projectile, turning it so that it flies towards the target with its tail rather than its head, losing speed and armor penetration.

Currently, gyroscopic devices are widely used for automatic control of aircraft, ships, determining the course of movement of combat vehicles, and automatic stabilization of the target of tank guns during their movement. The accuracy of tank gun fire is determined by the laws of ballistics, and knowledge of these laws is essential for successful fire training.

Laser gyroscopes are used in foreign measuring devices, ground-based orientation systems, air and space orientation systems, and in the development of free-platform inertial navigation systems (FINS). However, laser gyroscopes also have some drawbacks. These include the need to equip the device with a number of auxiliary systems, calibration difficulties, etc. Their presence allows us to conclude that a laser gyroscope cannot completely replace a rotary gyroscope. Directional gyroscopes are gyroscopic devices designed to maintain a specified direction of movement and rotate an object by a certain angle. Directional gyroscopes are also known as gyrocompasses, gyro azimuths, and heading gyroscopes.

The future of gyroscopes is associated with several key trends: Reduced size and weight: New technologies enable the production of smaller and lighter gyroscopes with high performance, making them ideal for use in mobile devices and wearable electronics.

Increased accuracy: The use of new materials and technologies allows for the creation of gyroscopes that can operate in challenging environments while maintaining high measurement accuracy.

The introduction of new technologies and innovations will continue to transform this field, opening up new possibilities for creating more accurate, reliable, and versatile navigation systems. This, in turn, will improve the quality of both traditional vehicles and emerging technologies such as autonomous cars and unmanned aerial vehicles.

As technology continues to evolve, it is important to stay informed about the latest trends and rely on proven advice and recommendations. This is the only way to avoid common mistakes and make the most of the capabilities of gyroscopes in various applications.

Gyroscopes are widely used in various fields. In aviation, they are used to stabilize the course and angle of flight. In cars, gyroscopes are used in stability systems. In smartphones, gyroscopes help determine the position of the screen, and in video games and virtual reality, they provide smooth motion. Gyroscopes are also used in robotics, navigation systems, and spacecraft, highlighting their importance in modern technology.

The gyroscope is most often used as a sensitive element of indicating gyroscopic devices and as a sensor of angle of rotation or angular velocity for automatic control devices. Subsequently - almost every long-distance sea vessel is equipped

with a gyrocompass for manual or automatic control of the vessel, some are equipped with gyro stabilizers.

In the fire control systems of naval artillery, there are many additional gyroscopes that provide a stable reference system or measure angular velocities. Without gyroscopes, it is impossible to automatically control torpedoes. Airplanes and helicopters are equipped with gyroscopic instruments that provide reliable information for stabilization and navigation systems. These instruments include the airborne horizon, the gyro vertical, and the gyroscopic roll and turn indicator. Gyroscopes can be used as indicators or as sensors for autopilots. Many aircraft are equipped with gyro-stabilized magnetic compasses and other equipment, such as navigation sights, gyro-camera, gyro-sextant. In military aviation, gyroscopes are also used in air shooting and bombing sights.

The properties of a gyroscope are also used to stabilize the horizontal in high-speed border boats. When the boat reaches high speeds and there are large waves on the water surface, a powerful gyroscope is activated to dampen the impact of the waves on the boat's hull and prevent excessive bouncing. Gyrocompasses are essential in fields such as space exploration and mine surveying.

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