Gyros Inside Indicators

Figures 5-4 and 5-5 illustrate how gyros can be used inside indicators mounted directly on the flight instrument panel. Figure 5-4 shows a gyro mounted with its spin axis vertical. Bearings and gimbals give it freedom of motion in three axes.

The bearings at the top of the illustration, along the fore and aft line of the airplane, give it freedom along the X axis, therefore banking the airplane does not affect it. The bearings on the Y axis prevent it from being affected by the pitching of the airplane, within the limits of the stops provided.

The bearings on the rotor axis itself prevent it from being affected by the turning of the airplane. A horizon indicator coupled to the inner gimbal shows the pitch and roll attitudes of the airplane.

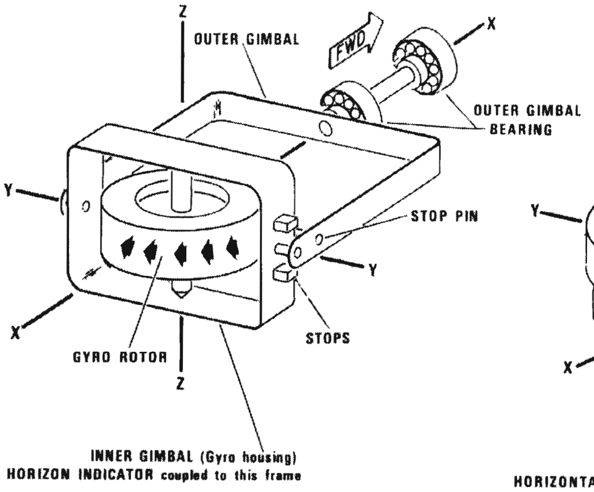
The gyro in Figure 5-5 has its spin axis horizontal. It also has freedom of motion in three axes. A compass indicator card is attached to the vertical gimbal. As long as the spin axis has the correct end pointed north, the indication read by the pilot is the compass heading of the airplane.

This type of gyro needs repeated manual heading correction, since it has no automatic correction system. It is generally useful for periods up to 15 or 20 minutes. During periods of level flight the pilot must manually correct it using information from his magnetic compass.

The vertical gyro has a gravity operated erection system which keeps its spin axis vertical, and the compass gyro has a similar system maintaining its gyro axis horizontal.

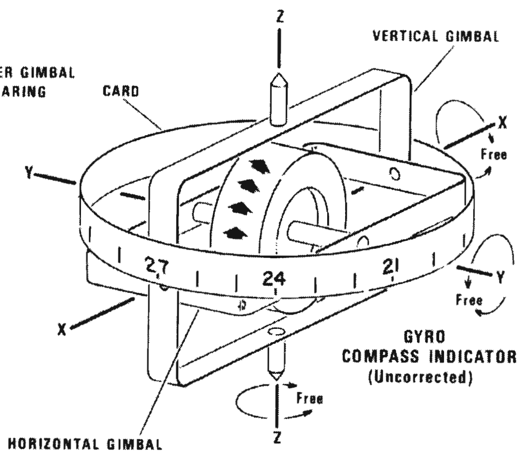
The uncorrected gyro compass indicators are no longer used in commercial airplanes. Instead, large expensive gyros are mounted not too far from the center of gravity and control remote indicators on the flight instrument panels.

Figure 5-4



VERTICAL GYRO for HORIZON INDICATION

Figure 5-5



Gyro Horizon Indicator No. 1

Figures 5-6 through 5-14 illustrate the indications given by a gyro horizon indicator for a variety of airplane attitudes. The inner portion of this indicator (and most others) is a movable part of a sphere. A heavy black line represents the horizon, and separates the light colored upper half from the dark colored lower half The "W" with a dot in the center and horizontal bars extending from the sides represents the airplane. This symbol is in a fixed position in front of the sphere.

Figure 5-6 shows the airplane flying wings level ("W" bars parallel with the horizon), and 6° nose down. Pitch attitude is read on the scale drawn on the sphere, at the point where the dot in the middle of the "W" is showing. In this case it is at the 6° position below the horizon.

Figure 5-7 shows the airplane flying wings level ("W" bars parallel with the horizon), and nose on the horizon ("W" dot on horizon line).

Figure 5-8 shows the airplane flying wings level ("W" bars parallel to the horizon), and 6° nose up ("W" dot at the 6° position above the horizon).

Figure 5-6

Figure 5-7

Figure 5-8

Gyro Horizon Indicator No. 2

In Figures 5-9 and 5-10 the case of the indicator has been banked along with the airplane to show how it would look to us if we could see through the airplane body to the instrument panel.

In Figures 5-11 through 5-14 the indicator is drawn to show how it appears to the pilot in the airplane.

In Figure 5-9 the pilot sees that his left wing is lower than his right wing and that the nose of the airplane is 6° below the horizon. The pilot reads his bank angle at the top of the indicator. The index at the top of the indicator is three spaces off to the right of center. Since each space represents 10° he is in a 30° left bank.

In Figure 5-10 the airplane is 6° nose down, while in a 30° right bank.

In Figure 5-11, the airplane nose is on the horizon, and the left wing is down 30°.

In Figure 5-12, the airplane nose is also on the horizon, but the right wing is down 30°.

In Figure 5-13, the airplane nose is above the horizon by 6°, while in a 30° left bank.

In Figure 5-14, the airplane nose is above the horizon 6°, while in a 30° right bank.

Figure 5-9

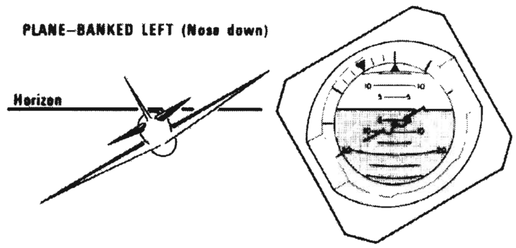


Figure 5-10

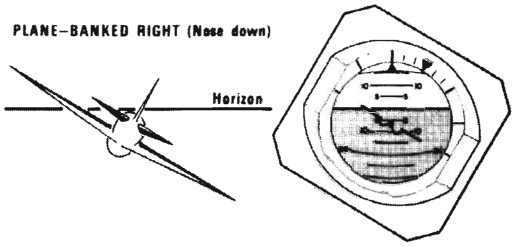


Figure 5-11

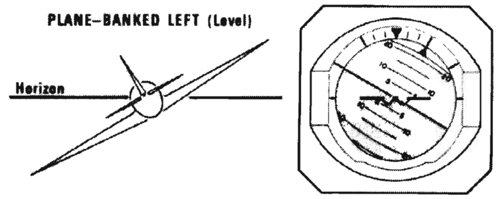


Figure 5-12

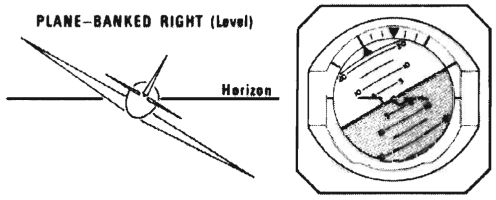


Figure 5-13

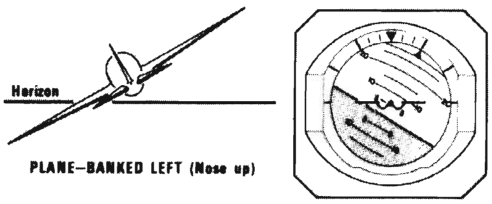
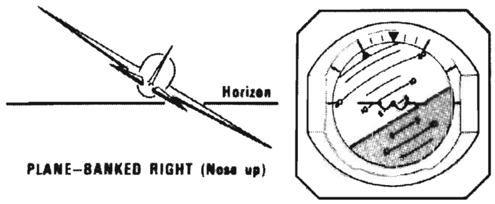


Figure 5-14



Remote Gyro Horizon

Figures 5-15 through 5-18 are photographs of a late model gyro horizon indicator. It is an integrated instrument showing not only airplane pitch and roll attitude, but other indications as well.

At the extreme bottom is a slip indicator. This is a simple device, with a ball enclosed in a curved tube filled with a damping fluid, and a center position indicated. If the ball is not centered, the aircraft is slipping or skidding to one side or the other, a situation which is infrequent in commercial aircraft.

Just above that is a rate of turn indicator so calibrated that if the needle is directly below one of the outside dots, the airplane is turning at a rate of 180° per minute in the direction indicated.

On the right is a glideslope deviation indicator.

On the left is a speed error indicator showing whether the airplane is traveling faster or slower than a preselected speed.

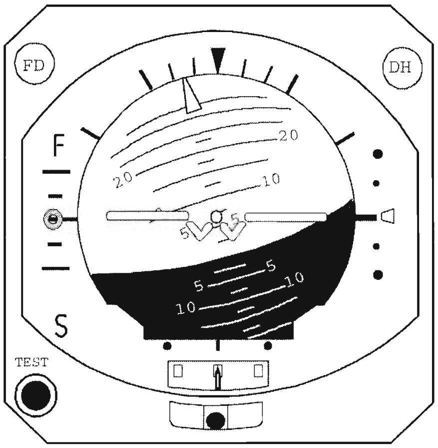
The upper right corner has a decision light showing when a preselected radio altitude above the runway has been reached on descent.

On the left is a light which indicates whether a flight director is turned on. The flight director command hart also part of this instrument, are retracted from view in these pictures.

There is provided a failure warning flag for each indication.

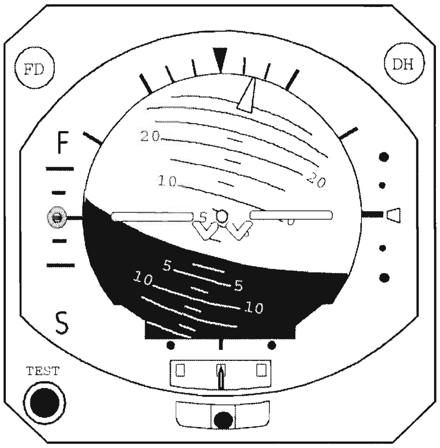
At the lower left is the push-to-test button.

Figure 5-15



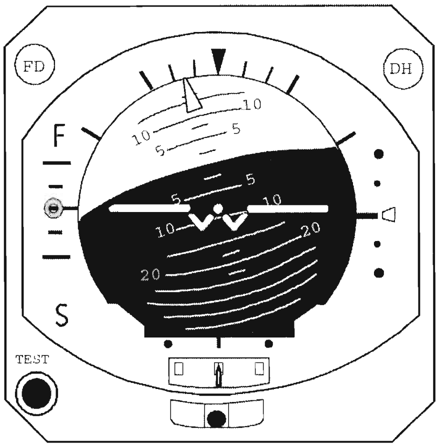
PLANE–NOSE UP (Right wing down)

Figure 5-16



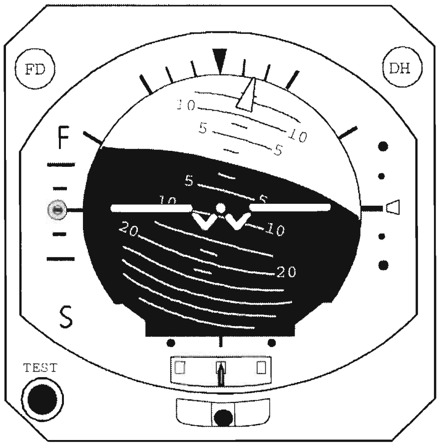
PLANE–NOSE UP (Left wing down)

Figure 5-17



PLANE–NOSE DOWN (Right wing down)

Figure 5-18



PLANE–NOSE DOWN (Left wing down)

Remote Vertical Gyro Schematic

Figure 5-19 is a remote vertical gyro. It is called a vertical gyro because its spin axis is automatically maintained vertically by gravity sensing pitch and roll erection systems. The torquers and synchros are not drawn, only their position is indicated.

The black arrow pointing forward indicates that the inner gimbal bearing shafts must be aligned with the fore and aft line of the airplane. This is so that the roll synchro will not be affected by pitch attitude changes, and the pitch synchro will not be affected by roll attitude changes.

In order to maintain the spin axis vertically, two erection systems must be used, one in the roll axis and one in the pitch axis. The obstinate reaction of a gyro to an applied force (Figure 5-1) makes it necessary to use erection forces at right angles to the desired direction of motion. This accounts for the pitch erection torquer mounted in the roll axis, and the roll erection torquer mounted in the pitch axis.

A torquer is a frustrated motor. It never gets to turn anything, not even itself; but when called upon to do so, will try. A gravity sensing liquid switch, constructed on the principle of a carpenter's level, provides power to the torquer when the switch is not level. The torquer then provides the force to erect the spin axis vertically in one axis.

Roll erection torquing is cut off when the bank angle exceeds about 6° to eliminate the tendency to erect to a false sense of vertical.

Two types of signals are developed from the roll and pitch transmit synchros. The three legged signal is unambiguous in that any attitude through 360° could not be mistaken for any other attitude. These signals are always used for controlling gyro horizon indicators. They will also be used by any other system where an unambiguous signal may be desired. The two legged error signals will be nulls when the airplane is wings level and has its nose on the horizon. For example, the roll transmit synchro is positioned in the gyro so that when the airplane is wings level, the voltages developed on the two upper legs of the roll synchro are equal. There is, therefore, a null signal between them.

An isolation transformer is used in the output to lessen possible bad effects on the three legged signal. If the airplane is banked to the right, these voltages are no longer equal, and the difference will be of one phase. If the airplane is banked to the left, the voltages are no longer equal and the difference will be of the other phase. Pitch error signals are developed similarly.

These error signals are ambiguous. For example, the phase and amplitude of a 5° right bank signal is the same as the phase and amplitude of a 175° right bank signal. Also, the phase and amplitude of an 85° right bank signal is the same as the phase and amplitude of a 95° right bank signal.

Every signal developed has a twin at another attitude. However, within the first 90° of bank angle or pitch attitude, there is no ambiguity. Since commercial aircraft never bank or pitch beyond 90°, some less critical systems can use these error signals, which are frequently more convenient.

Figure 5-19