Duplicate

EO 20-20BF-2

ROYAL CANADIAN AIR FORCE

OPERATING & MAINTENANCE INSTRUCTIONS

GYRO HORIZON INDICATORS TYPES AN5736-1, AN5736-1A & AN5736-L1A

(SPERRY)

ISSUED ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

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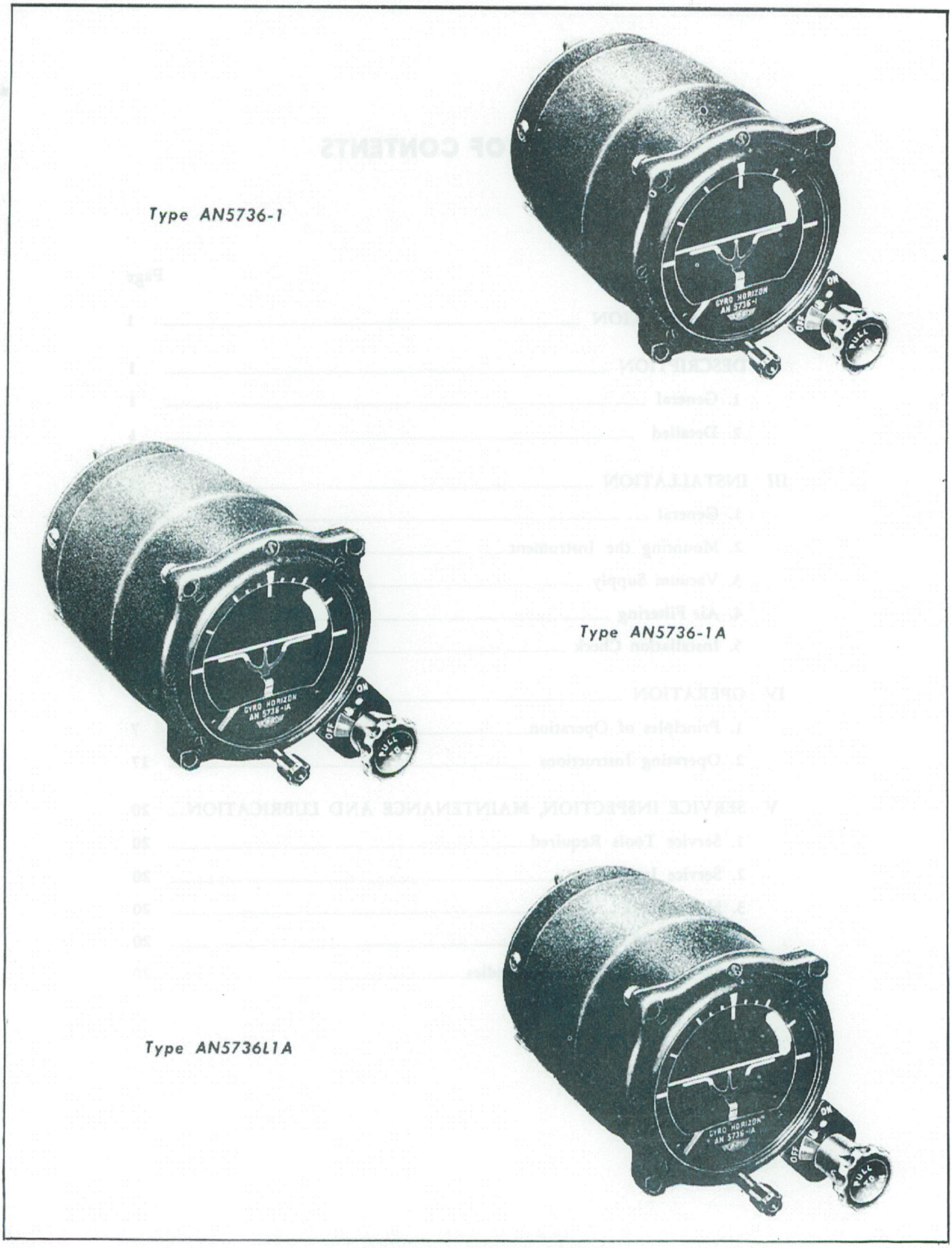


Figure 1—Gyro Horizon Indicators

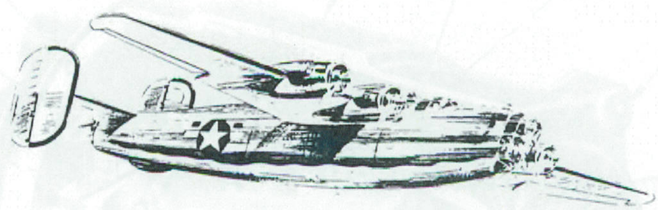
SECTION I
INTRODUCTION

1. This handbook is issued as the general basic instruction for the equipment involved.

2. This handbook contains descriptive data, and instructions for the installation, operation, service inspection, maintenance, and lubrication of the following Gyro Horizon Indicators, manufactured by the Sperry Gyroscope Company, Incorporated, Great Neck, Long Island, New York:

Sperry Part No.	*AN Type*
656768	AN5736-1
656768	AN5736-1A
656768	AN5736L1A

3. Handbook EO 20-20BF-3 contains the overhaul instructions, and Handbook EO 20-20BF-4 is the parts catalog.



SECTION II
DESCRIPTION

1. GENERAL.

The Gyro Horizon Indicator is an aircraft flight instrument that provides the pilot with a constant visual indication of the aircraft's attitude relative to the earth. The air-driven gyro rotor rotates with its spin axis in an upright position. Due to gyroscopic inertia, the gyro maintains the vertical position as the aircraft rolls or pitches. This produces relative motion between the gyro and the instrument case which is shown on the face of the instrument by displacement between the miniature airplane and the horizon bar. (See figure 1.) The relation of the miniature airplane to the horizon bar furnishes an indication of the attitude of the aircraft in roll and pitch. Thus the pilot's "sensing" of the gyro horizon's indications is the same as the interpretation of the relation between the wings of the airplane and the natural horizon during contact flight; level flight is maintained by keeping the miniature airplane aligned with the horizon bar.

2. DETAILED.

(See figures 2 to 7.)

a. The Gyro Horizon Indicator is composed of the following principal assemblies: The gyro and pendulum unit assembly (B, figure 2), and the horizon bar and gimbal ring assembly (E). These two assemblies combined are called the sensitive element assembly, which is enclosed in the air tight compartment formed by the case (C), the bezel assembly (A), and the case cover (D).

b. The sensitive element assembly is mounted on the longitudinal axis (X) on pivots at the front and rear of the gimbal ring and is free to rotate 100 degrees either side of the horizontal. The gyro and pendulum unit assembly, which is referred to as the gyro, is mounted on the lateral axis (Y) on pivots in the gimbal ring and is free to rotate 70 degrees either side of the horizontal. The gyro rotor shaft, which is hollow, rotates on double-race bearings mounted in the top and bottom of the gyro housing and spins about an axis (Z′) which is inclined 2½ degrees to the vertical axis (Z). Therefore, the gyro rotor is universally mounted, having freedom about all three axes. A compression strut (11, figure 3) is installed in the hollow rotor shaft for the purpose of adjusting the bearin, load and providing compensation for contraction of the rotor housing at low temperatures.

c. The pointer bar (12, figure 2) is pivoted at the rear of the gimbal ring on the shaft (10). The pointer guide arm (11) protrudes from the gyro housing, through the semicircular slot in the gimbal ring, into the rectangular slot in the pointer bar. The horizon bar (4), visible on the face of the instrument, is attached to the pointer bar.

d. The horizon dial (14, figure 2), containing the bank pointer (7), is attached to the gimbal ring. The bezel dial, which is part of the bezel (front panel) assembly, contains the miniature airplane (5) the bank scale (8), and the horizon bar index (6). Operation of the adjusting knob (3) raises or lowers the height of the miniature airplane.

e. By means of the cage knob (1, figure 2), marked "PULL TO TURN," the gyro may be caged or secured in its normal position within the case, during maneuvers which would exceed its operating limits of 70 degrees climb or glide, and 100 degrees right or left bank. When the knob is at the position marked "ON," the Gyro-Horizon Indicator is operating; when the knob is at the "OFF" position, the indicator is caged and not operating. In the "OFF" position a red cage-flag warning indicator marked "CAGED" appears in the bezel assembly. (See figure 1.) This safety feature warns the pilot when the instrument is caged or par-

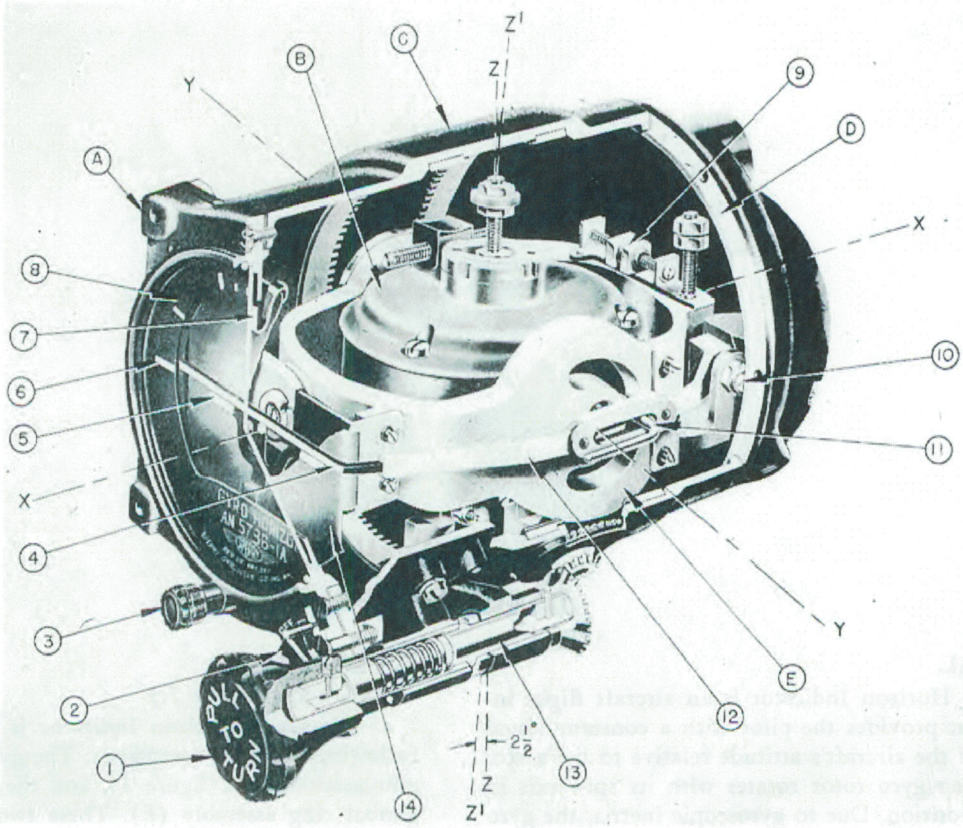


Figure 2—Cutaway View

A. Bezel Assembly
B. Gyro and Pendulum Unit Assembly
C. Case
D. Case Cover
E. Horizon Bar and Gimbal Ring Assembly
1. Cage Knob
2. Cage Dial Assembly
3. Miniature Airplane Adjusting Knob
4. Horizon Bar
5. Miniature Airplane
6. Horizon Bar Index
7. Bank Pointer
8. Bank Scale
9. Calibration Adjustment Assembly
10. Pointer Bar Shaft
11. Pointer Guide Arm
12. Pointer Bar
13. Caging Assembly (External)
14. Dial
X. Longitudinal Axis
Y. Lateral Axis
Z. Vertical Axis
Z′. Gyro Spin Axis

tially uncaged; the mechanism is so designed that the cage flag will not disappear from view until the caging knob has been turned almost all the way to the "ON" position.

f. The pendulum unit assembly (3, figure 3), for controlling erection of the gyro, is attached to the bottom of the gyro housing. The pendulum body supports four pendulum plates mounted on two shafts which are at right angles to each other so that the plates are free to swing in pairs. One pair of pendulum plates is attached to a shaft which is approximately parallel to the longitudinal axis (X). The other pair of plates is attached to a shaft which is parallel to the lateral axis (Y). The shaft on the longitudinal axis has a hole in it permitting the shaft on the lateral axis to pass through it. This hole is large enough to permit the shafts to rotate independently without interference. One side of each plate is cut to a knife edge and under the knife edge on each plate is a small air port in the pendulum body. The action of the plates, relative to the air ports in the pendulum body, controls the flow of air from the ports. The reaction of the air flowing from the ports supplies the force necessary to cause precession and automatically keeps the gyro upright.

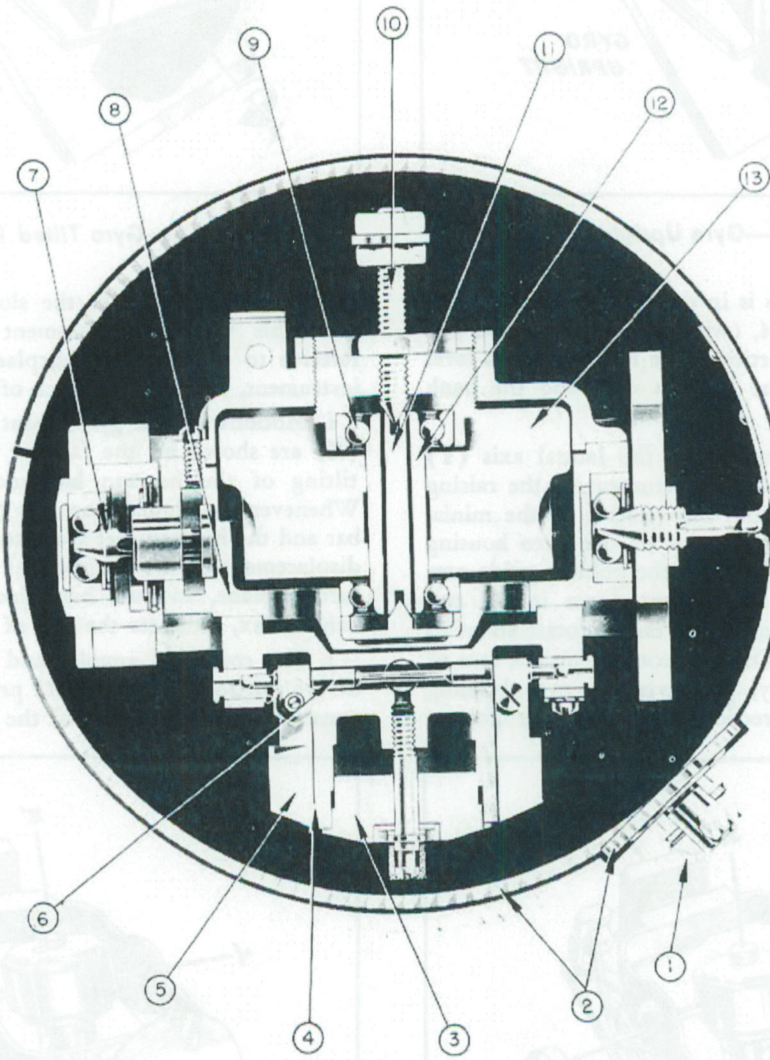


Figure 3—Sectional View, End

1. Caging Pinion (external)
2. Caging Gears (internal)
3. Pendulum Body
4. Pendulum Plate Knife Edge
5. Pendulum Plate
6. Pendulum Plate Shaft
7. Air Pivot
8. Gyro Housing
9. Ball Bearing (double race)
10. Strut Screw
11. Compression Strut
12. Rotor Shaft (hollow)
13. Rotor.

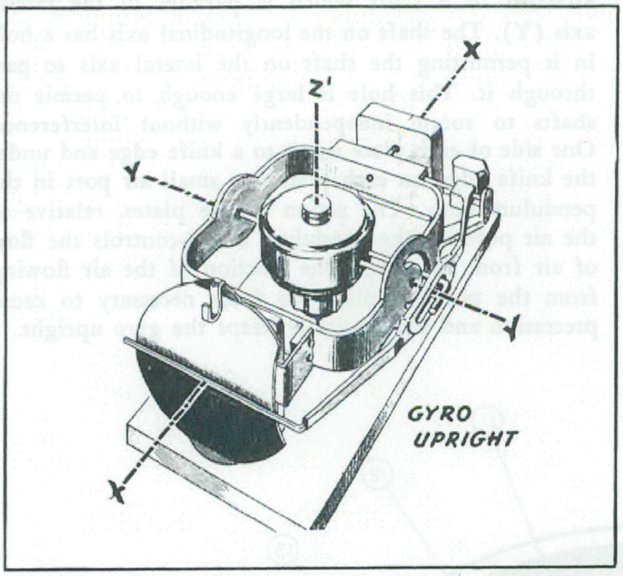


Figure 4—Gyro Upright

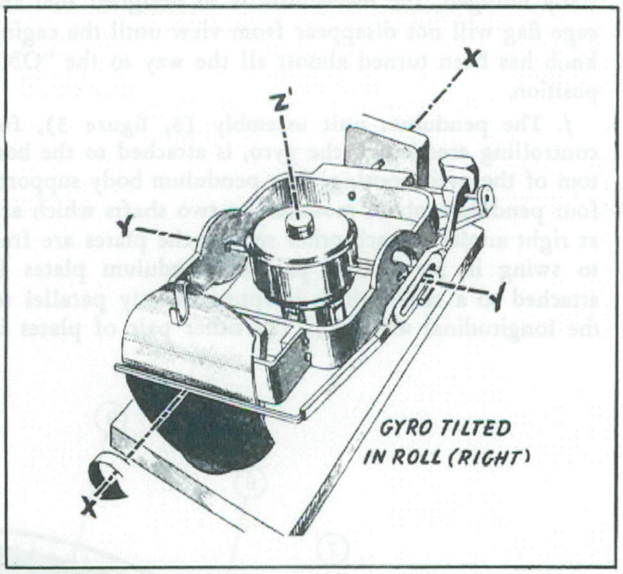


Figure 6—Gyro Tilted in Roll (Right)

g. Whenever the gyro is in the normal upright position as shown in figure 4, (with its spin axis tilted just 2½ degrees from the vertical), the horizon bar is level and in the center of the horizon dial, and the bank indicator is vertical.

h. Motions of the gyro about the lateral axis (Y) are shown on the face of the instrument by the raising or lowering of the horizon bar relative to the miniature airplane. Whenever the top of the gyro housing tilts toward the rear (figure 5), the pointer guide arm rotates with the gyro and pushes down in the rectangular slot, causing the pointer bar to rotate about its shaft. This action lowers the horizon bar on the face of the instrument. Similarly, whenever the gyro housing tilts in the opposite direction (forward), the pointer guide arm pushes up in the slot, raising the horizon bar. This vertical displacement of the horizon bar, relative to the miniature airplane on the face of the instrument, indicates the pitch of the aircraft.

i. Motions of the gyro about the longitudinal axis (X) are shown on the face of the instrument by the tilting of the horizon bar and the bank indicator. Whenever the gimbal ring tilts (figure 6), the horizon bar and the horizon dial are tilted with it. This angular displacement of the horizon bar relative to the miniature airplane, and the bank indicator relative to the bank index, indicates the roll of the aircraft.

j. The combined angular and vertical displacements of the horizon bar (figure 7) provide the pilot with a constant visual indication of the aircraft's attitude.

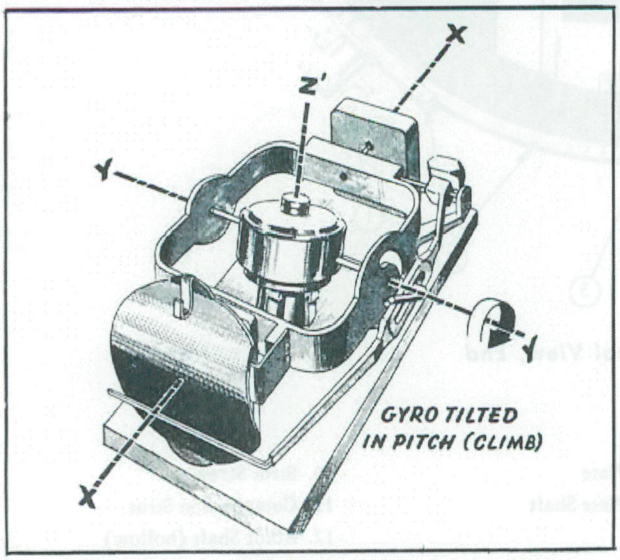


Figure 5—Gyro Tilted in Pitch (Climb)

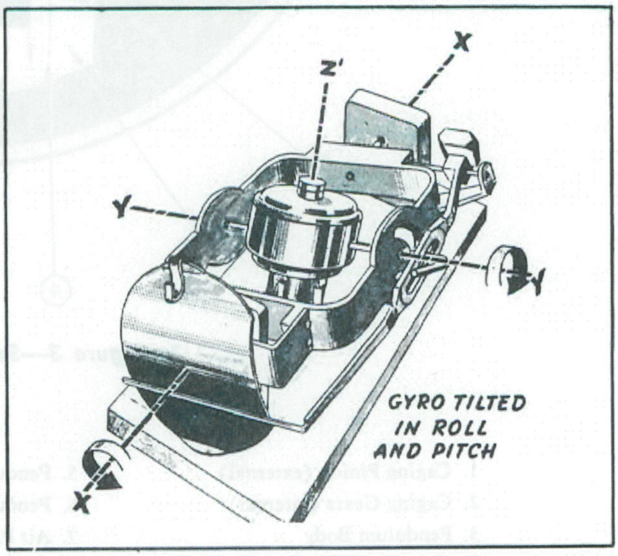


Figure 7—Gyro Tilted in Roll and Pitch

SECTION III
INSTALLATION

1. GENERAL.

Install the gyro-horizon indicator in a shock-mounted instrument panel so that the face of the instrument is vertical when the airplane is in its normal cruising attitude. The instrument also must be level laterally. Figure 8 shows the clearance and mounting dimensions.

2. MOUNTING THE INSTRUMENT.

a. Make the panel cut-out and drill the mounting holes as shown at the lower left of figure 8.

b. When attaching the instrument to the panel, use the three (.190-inch) 10-32 x $\frac{7}{8}$-inch round-head, brass machine screws and washers supplied for the purpose. Before inserting screws make certain that all mounting bosses touch the panel so that the instrument will not be strained when the attaching screws are tightened; *the panel must be flat.* Tighten the screws evenly.

3. VACUUM SUPPLY.

a. Connect the instrument to an engine-driven vacuum pump as shown in figure 9 (or to a venturi tube, if the airplane is not equipped with a vacuum pump), using a flexible hose connector installed in the most convenient of the three outlets on the back of the instrument. Keep the unused outlets tightly plugged. *Do not use the plastic shipping plugs.*

b. A vacuum regulator or relief valve should be used to limit the suction at the instrument to $4 \pm 1/4$ inches of mercury at cruising speed.

4. AIR FILTERING.

a. Remove the shipping plug from the opening at the rear, marked "AIR INLET."

b. If possible, an external air filter should be used in the system, as shown by dotted lines in figure 9. Install it as close to the instrument as possible, using a flexible hose connector in the "AIR INLET" opening.

Note

The filter adapter cover on the back of the instrument provides a means of connecting the instrument to a central air filter. If the installation does not include a central air filter,

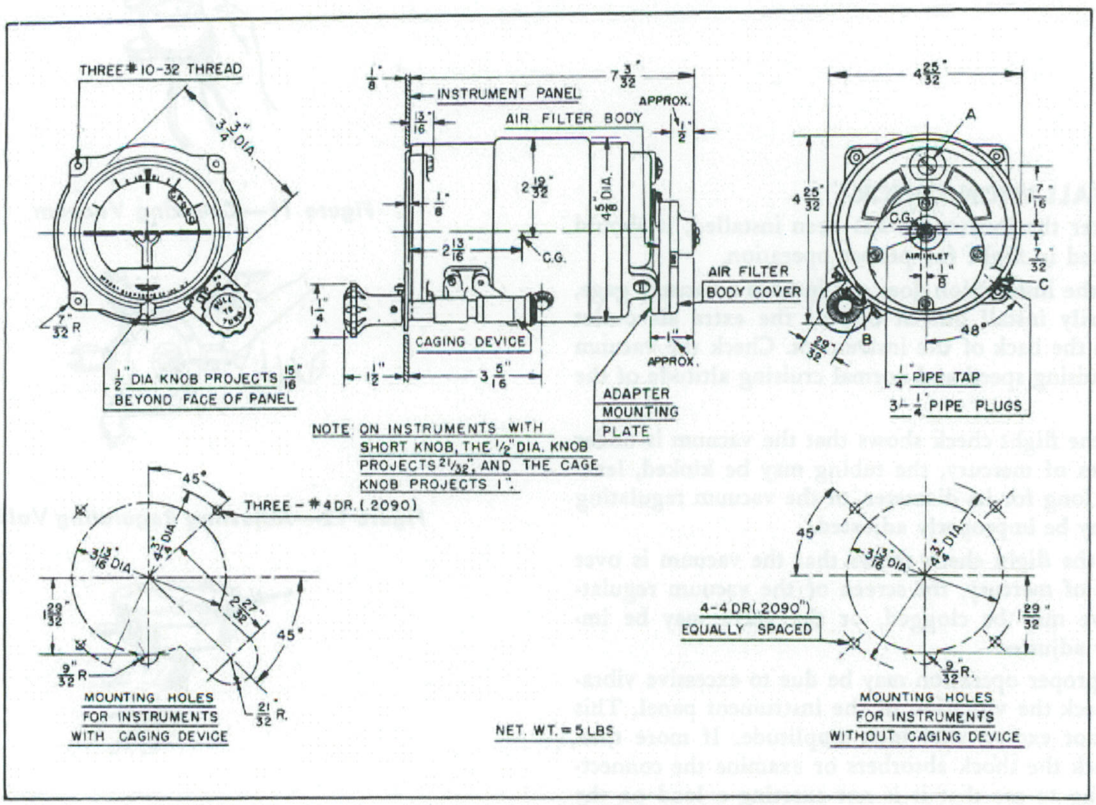


Figure 8—Outline Drawing

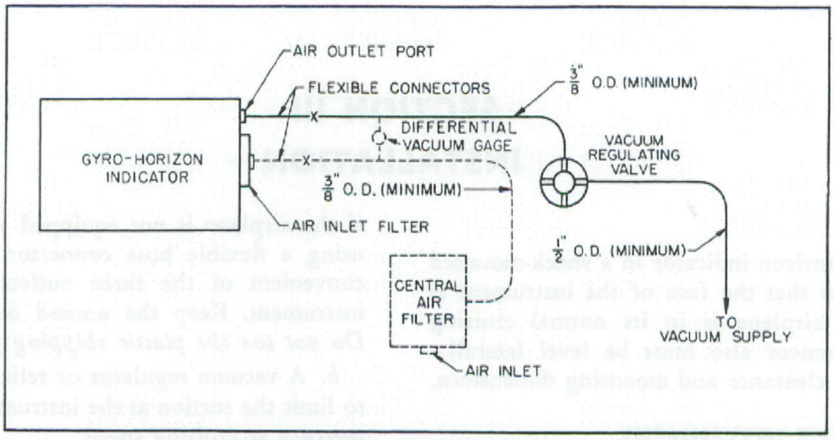


Figure 9—Connection Drawing

the filter adapter cover serves no purpose.

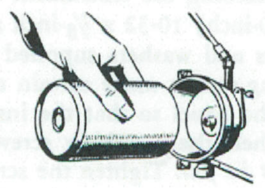


Figure 10—Removing Central Air Filter

Figure 11—Checking Vacuum

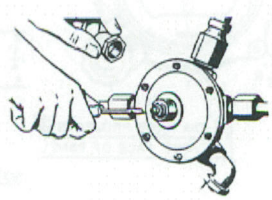


Figure 12—Adjusting Regulating Valve

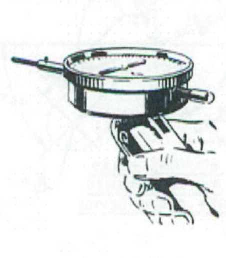


Figure 13—Checking Vibration

5. INSTALLATION CHECK.

a. After the instrument has been installed, it should be checked in flight for proper operation.

b. If the installation does not include a vacuum gage, temporarily install one at one of the extra air outlet ports on the back of the instrument. Check the vacuum at the cruising speed and normal cruising altitude of the aircraft.

c. If the flight check shows that the vacuum is under 3.5 inches of mercury, the tubing may be kinked, leaking, too long for its diameter, or the vacuum regulating valve may be improperly adjusted.

d. If the flight check shows that the vacuum is over 5 inches of mercury, the screen of the vacuum regulating valve may be clogged, or the valve may be improperly adjusted.

e. Improper operation may be due to excessive vibration. Check the vibration of the instrument panel. This should not exceed .004 inch amplitude. If more than this, check the shock absorbers or examine the connecting tubing to see that it is not exerting a load on the shock absorber mountings.

SECTION IV
OPERATION

1. PRINCIPLES OF OPERATION.

a. ESTABLISHING A REFERENCE.

(1) The driver of an automobile arrives at his destination by reference to geographic surroundings. That is, he has visual contact with roads, road signs, bridges, mountains, etc., by which he can establish the proper direction to his destination—and direction is all he has to worry about. (See figure 14.)

(2) Visibility permitting, the airplane pilot establishes the direction to his destination in the same manner—by visual contact with the earth's terrain and the objects on its surface. (See figure 15.) However, the pilot has more than direction to worry about; in addition he must also keep the airplane level by reference to the horizon—the horizontal line where the sky and earth appear to meet. At night the pilot may refer to celestial bodies, airway beacons, city lights, etc. This type of flying is known as piloting or contact flying.

(3) In order to use these references, the pilot must see them. When the weather closes in, he must rely on other means. (See figure 16.) To fly a straight course, the magnetic compass may be referred to, but under certain conditions its indications are erratic and therefore undependable. To keep the plane level, the pilot must depend on his sense of balance. Also, his senses tell him whether he is rising or falling rapidly.

(4) In the early days, pilots called this type of aerial navigation "flying by the seat of the pants." However, the senses can not always be relied on; often they lie. For instance, when looking down a railroad track, the eyes tell us the rails meet. Also, when touching ice, the momentary sensation may be one of heat.

Figure 15—Contact Flying

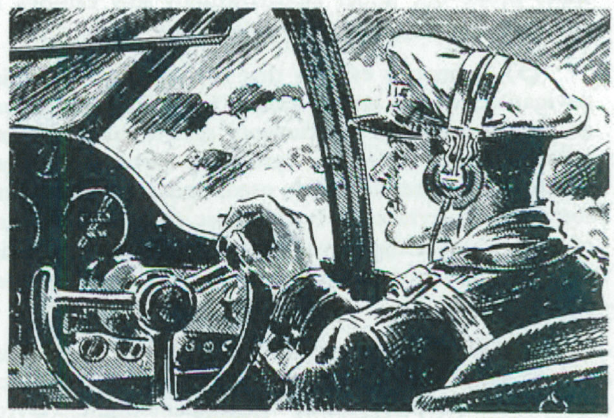


Figure 16—Poor Visibility

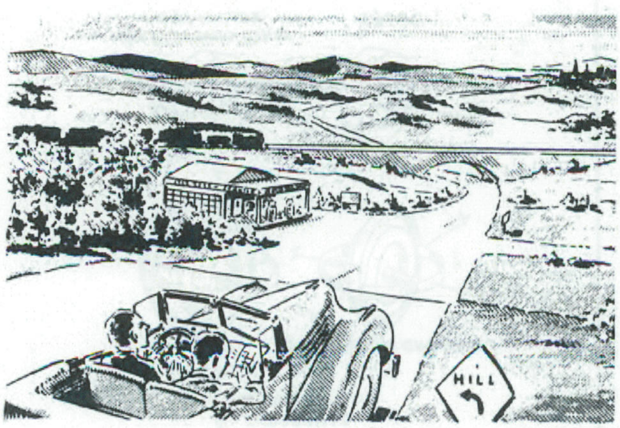


Figure 14—Establishing Direction

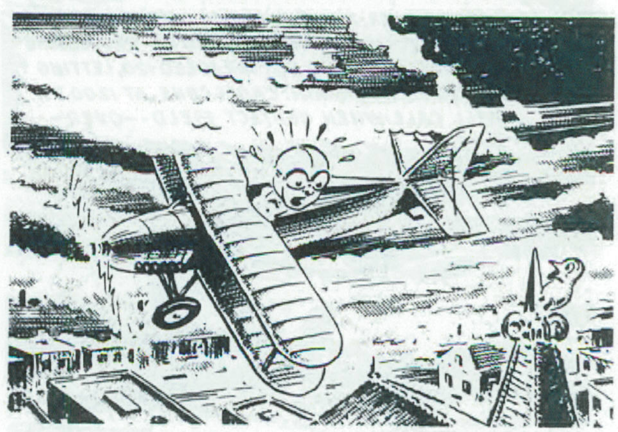


Figure 17—Blind Flight

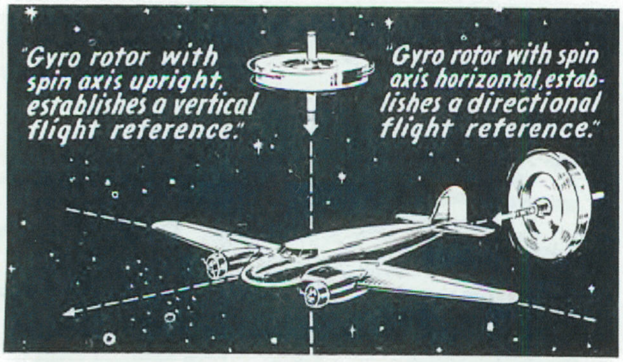


Figure 18—Gyroscopic References

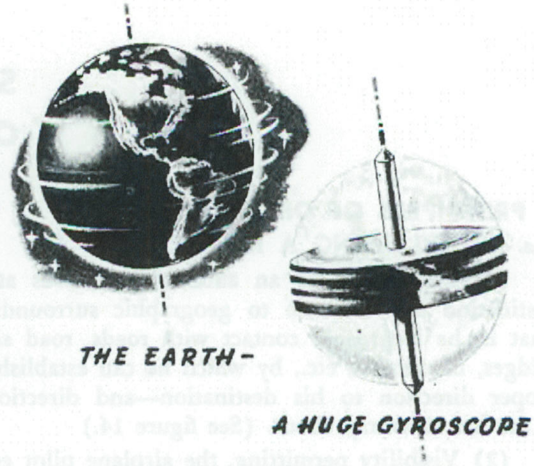


Figure 20—The Earth—A Gyroscope

Likewise, the senses can not always differentiate between the push on "the seat of the pants" due to acceleration forces or that due to gravity. Consequently, in soupy weather, when engaged in what the early pilots called "blind flight," these air pioneers sometimes broke out under embarrassingly low ceilings in embarrassing attitudes. (See figure 17.)

(5) It became evident that for any kind of aerial navigation, except under contact conditions, there was an urgent need for instruments that would establish reliable flight references. Gyroscopic instruments were developed as a result of this need, because the spinning rotor of the gyroscope is the most satisfactory means of establishing a flight reference or index that is undisturbed by the movements of the supporting body. (See figure 18.)

(6) Today, the phrase "blind flying" is a misnomer. Aerial navigation of this kind is an exact science, more properly called "instrument flight." Gyroscopic instruments, combined with other modern flight instruments, take the blindness out of flying. They provide accurate and reliable indications of the airplane's direction of flight as well as its attitude and position with respect to the earth—even though rain, sleet, fog, or clouds may obscure the earth from view. (See figure 19.)

b. THE GYROSCOPE.

(1) There is no mystery about the gyroscope. The sphere on which we live is similar to a huge gyroscope rotor spinning freely in space about an imaginary axis through its poles. (See figure 20.) By reason of its rapidity of rotation, the earth maintains its position in the universe, remaining constantly in the same plane of rotation with the poles pointing approximately in a constant direction in space.

(2) A gyroscope may be defined as a mechanical system containing a rotor, universally mounted, so that the rotor has three axes of freedom. The rotor (figure 21) is free to spin about axis X on bearings in the

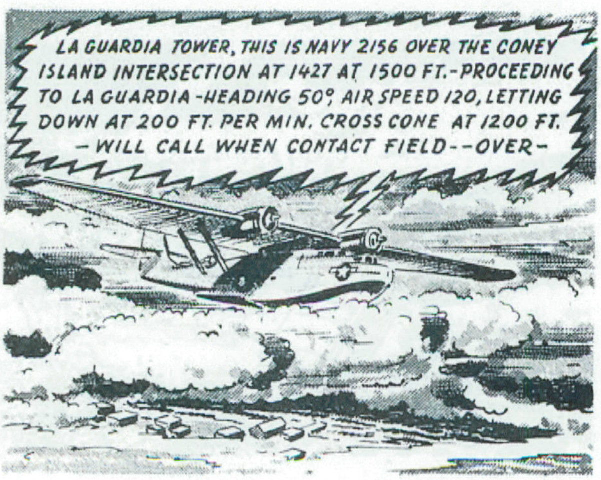


Figure 19—Instrument Flight

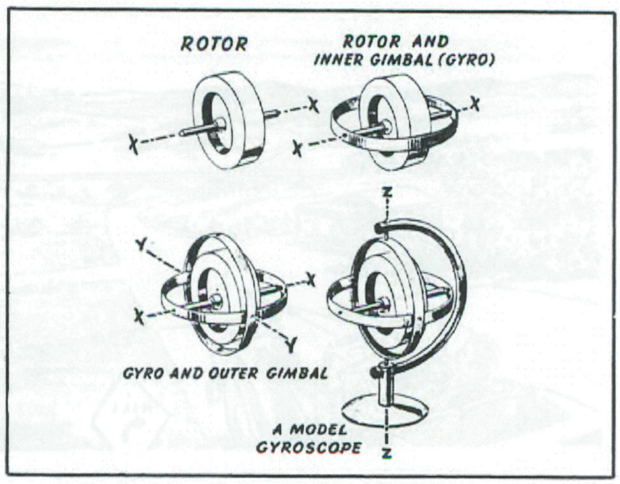


Figure 21—Elements of a Gyroscope

inner ring. The inner ring is free to turn about axis Y on pivots in the outer ring. These rings are known as gimbal rings. The outer ring is free to turn about axis Z on pivots in the support. When the gyroscope is in its normal position, all the axes are at right angles to each other and intersect at the center of gravity of the rotor. That is, axis X is at right angles to axis Y, and axis Z is at right angles to both axes X and Y.

(3) A mechanical system of this kind is referred to as a gyroscope—a rotor, mounted so that it is free to spin and assume any position in space. However, such a system will not exhibit the properties of a gyroscope unless the rotor is spinning. This may be demonstrated as follows: With the rotor at rest, hang a weight on the inner gimbal ring. The ring can offer no resistance to the force of the weight and it will be tipped over, displacing the rotor about the horizontal axis in the line of the torque (turning force) applied by the weight. (See figure 22.)

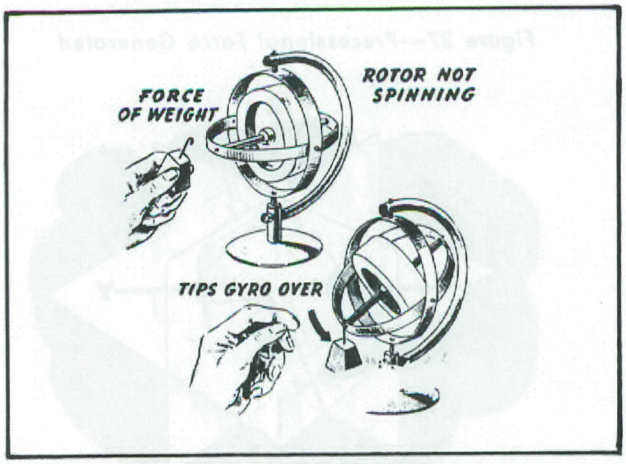


Figure 22—Gyro Rotor at Rest

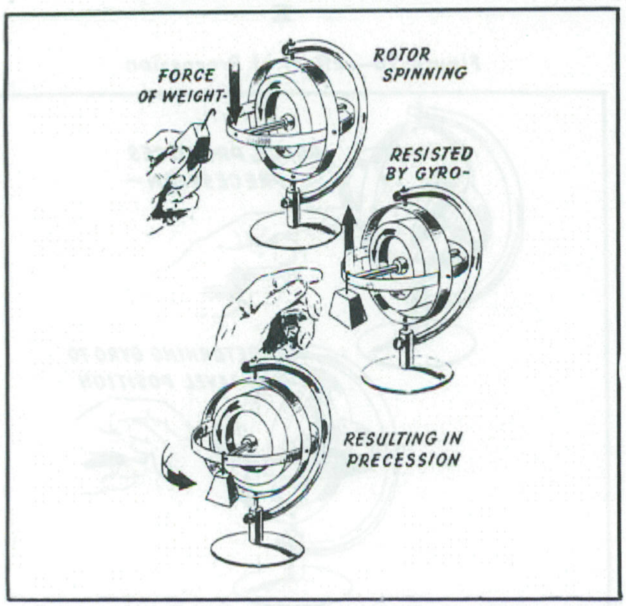


Figure 23—Gyro Rotor Spinning

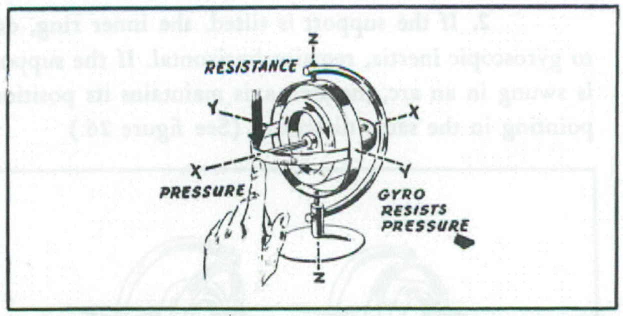


Figure 24—Gyro Resists Pressure

(4) Start the rotor spinning at a high speed, counterclockwise as viewed by the observer, and repeat the experiment. Now the system becomes a true gyroscope, exhibiting the two fundamental properties, gyroscopic inertia and precession. The ring will resist the weight and support it, demonstrating the property of gyroscopic inertia, sometimes called rigidity. Therefore, the force applied by the weight produces no motion about the horizontal axis, but the motion occurs about the vertical axis. This causes the vertical ring to rotate, displacing the rotor about the vertical axis, demonstrating precession. (See figure 23.)

(5) Thus, the two fundamental properties of the gyroscope may be defined as follows:

(a) Gyroscopic inertia is that property of the gyroscope which resists any force tending to displace the rotor from its plane of rotation.

Note

The forces on a gyroscope may be represented graphically as acting on the rotor itself, spinning freely in space with a plane containing each of the axes of freedom.

1. For example, when a force is applied upward on the inner ring (figure 24), the force may be visualized as applied in an arc about axis Y until it contacts the rim of the rotor at F. (See figure 25.) The effect produced by the force (F) is equivalent to that produced by the force applied upward to the inner ring. The force (F) is opposed by the resistance of gyroscopic inertia, preventing the rotor from being displaced about axis Y from its original plane of rotation.

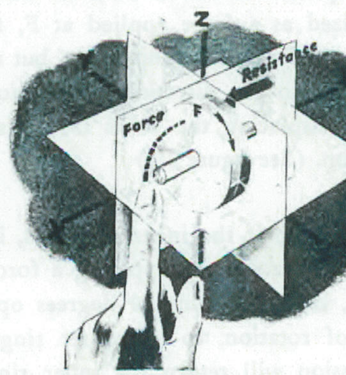


Figure 25—Transmission of Force

2. If the support is tilted, the inner ring, due to gyroscopic inertia, remains horizontal. If the support is swung in an arc, the spin axis maintains its position, pointing in the same direction. (See figure 26.)

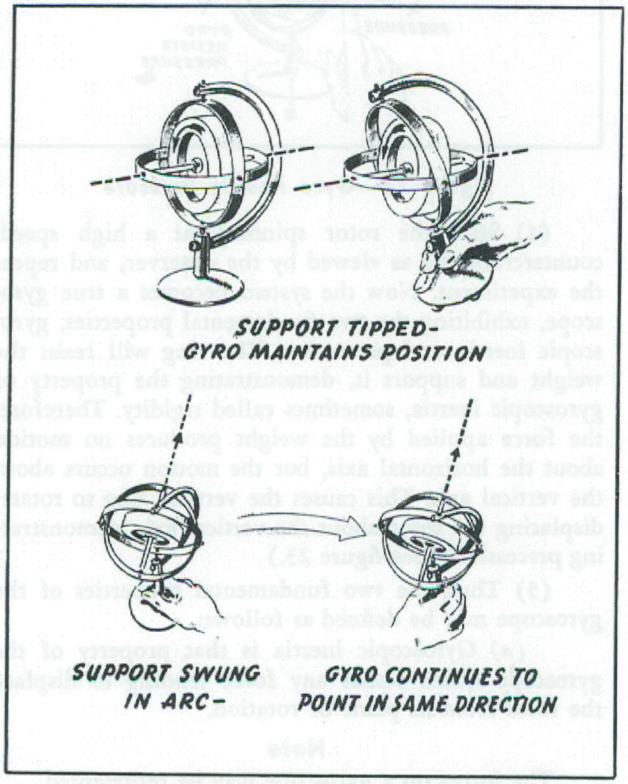


Figure 26—Gyroscopic Inertia

(b) Gyroscopic precession is that property which causes the rotor to be displaced, not in line with the applied force, but 90 degrees away in the direction of rotation of the rotor.

1. For example, when pressure is applied upward to the inner ring, and with the rotor spinning clockwise as viewed by the operator, the effect of precession can be predetermined as follows: The pressure may be visualized as a force applied at F, figure 27. Motion does not take place at this point, but at a point 90 degrees away, in the direction of rotation of the rotor, at (P), displacing the rotor from its original plane of rotation. (See figure 28.)

2. Conversely, if the inner ring tips, it may be returned to the horizontal by applying a force, not to the inner ring, but at a point 90 degrees opposite to the direction of rotation, to the outer ring. In this manner, precession will return the inner ring to the horizontal position. (See figure 29.)

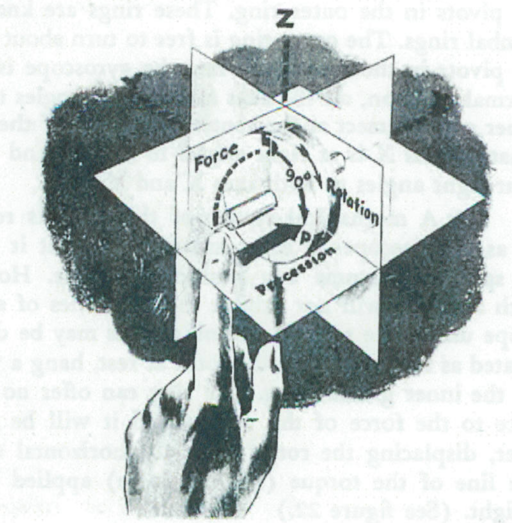


Figure 27—Processional Force Generated

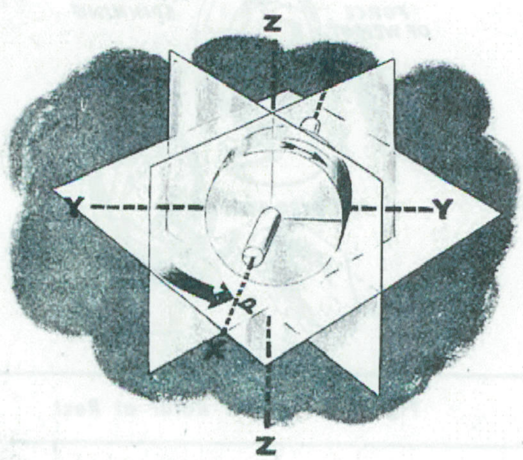


Figure 28—Effect of Precession

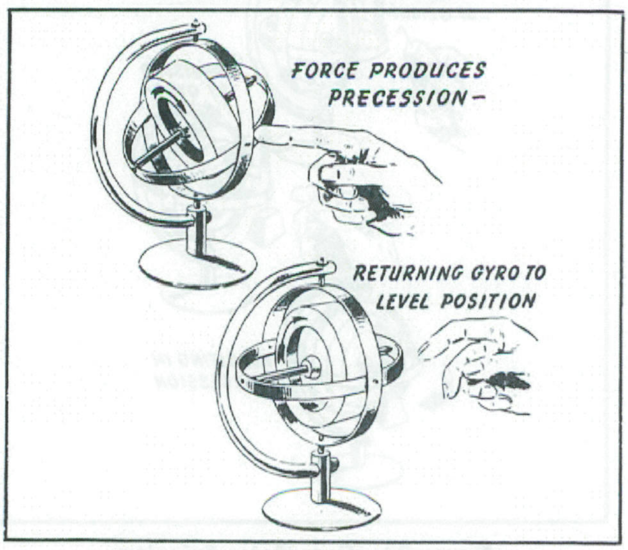


Figure 29—Precession Levels Gyro

(6) These two fundamental properties, gyroscopic inertia and precession, are utilized in gyroscopic instruments: Gyroscopic inertia—to establish a reference in space, unaffected by movement of the supporting body; and precession—to control the effects of the earth's rotation, bearing friction, and unbalance, maintaining the reference in the required position. (See figure 30.)

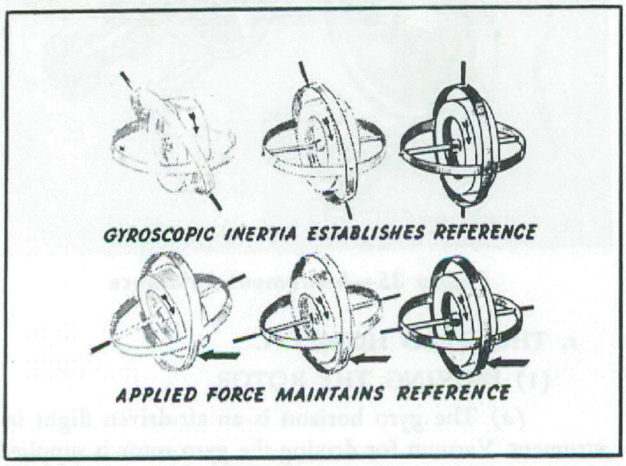


Figure 30—Using Inertia and Precession

(7) As the earth rotates, the spin axis, due to gyroscopic inertia, maintains its position in space in the same manner as when the support of the gyroscope is tipped or turned by hand. For example, imagine a gyroscope at the equator with the spin axis horizontal and pointed in an east-west direction. (See figure 31.) The earth turns in the direction of the arrow, or clockwise, with an angular velocity of one revolution every 24 hours. To an observer out in space, the spin axis appears to maintain its position, pointing east; but to an observer on the earth, the spin axis appears gradually to tilt or drift.

(*a*) At the end of 3 hours, the spin axis has tilted 45 degrees, and at the end of 6 hours, the spin axis has tilted 90 degrees, or is in a vertical position. At the end of 12 hours, the spin axis again is horizontal but pointing west, and at the end of 24 hours it is back where it started. (See figure 32.)

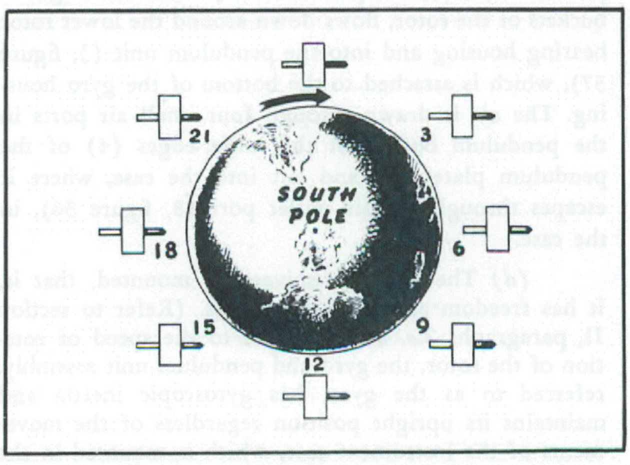


Figure 31—Spin Axis Fixed in Space

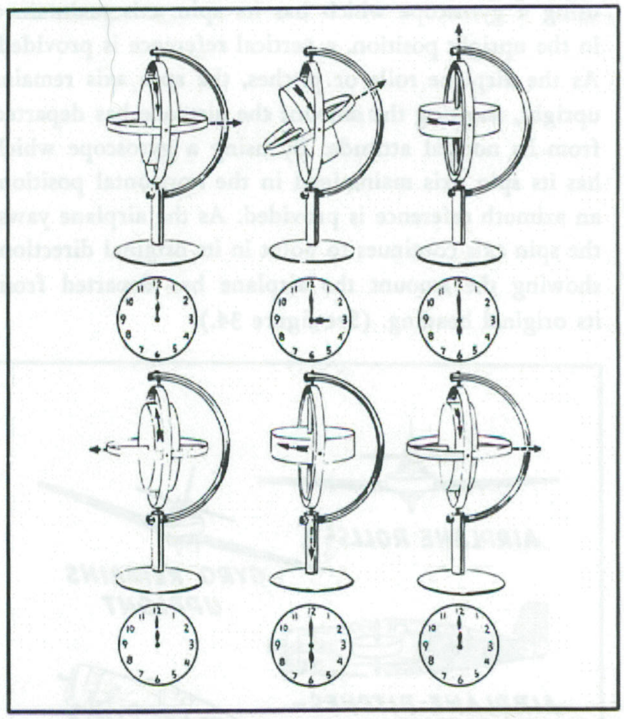


Figure 32—Apparent Drift of Spin Axis

(*b*) Thus it is evident that since the spin axis maintains its position in space, this action relative to the earth, produces the apparent drift. To minimize this effect and overcome the effect of bearing friction and slight unbalance, the gyroscope must be provided with a device which maintains the spin axis in the required position. Whenever drift occurs, a force is automatically applied, causing precession to return the spin axis to its normal position, maintaining an accurate reference. (See figure 33.)

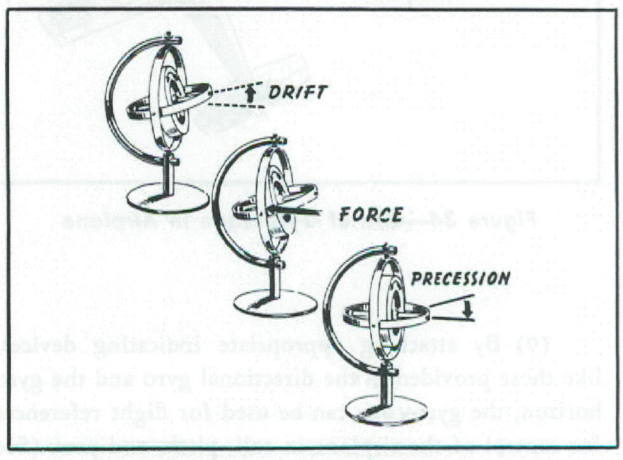


Figure 33—Controlling Apparent Drift

(8) When a gyroscope is mounted in an airplane, the spin axis, due to gyroscopic inertia maintains its position in space, regardless of the movements of the airplane and the airplane rotates about the gyro. By using a gyroscope which has its spin axis maintained in the upright position, a vertical reference is provided. As the airplane rolls or pitches, the spin axis remains upright, showing the amount the airplane has departed from its normal attitude. By using a gyroscope which has its spin axis maintained in the horizontal position, an azimuth reference is provided. As the airplane yaws, the spin axis continues to point in its original direction, showing the amount the airplane has departed from its original heading. (See figure 34.)

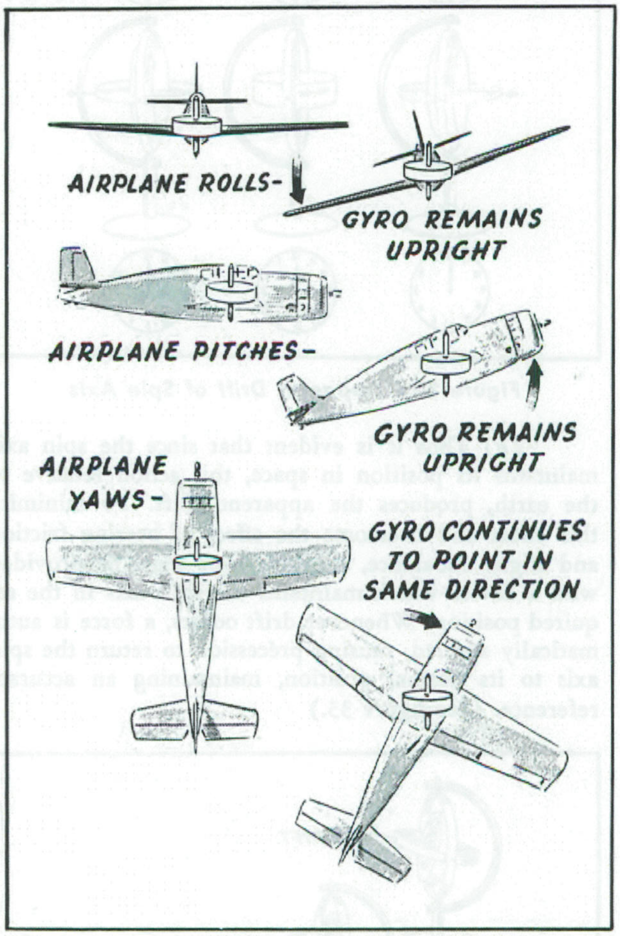


Figure 34—Use of Gyroscope in Airplane

(9) By attaching appropriate indicating devices, like those provided in the directional gyro and the gyro horizon, the gyroscope can be used for flight references for control of the airplane in roll, pitch, and yaw. (See figure 35.)

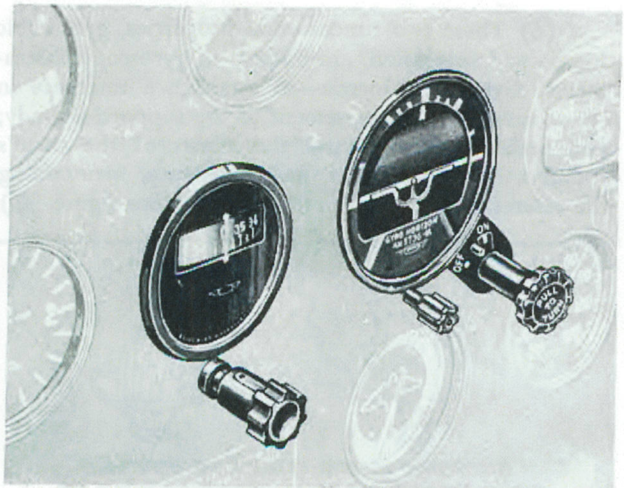


Figure 35—Instrument Reference

c. THE GYRO HORIZON.

(1) DRIVING THE ROTOR.

(a) The gyro horizon is an air-driven flight instrument. Vacuum for driving the gyro rotor is supplied by an engine driven vacuum pump, or in some installations, by a venturi tube. The vacuum supply line is connected to an air outlet port (8, figure 36), in the airtight case.

(b) When suction is applied to the air outlet port, the case is evacuated, causing air to enter the case through the filter (10). The filtered air flows around the air pivot (12) and enters the channel (9) in the gimbal ring. This channel conducts the air flow to the air pivot (6) in the gyro housing, where it divides and flows into each of the channels in the gyro housing. Each of these channels terminates in a small nozzle which directs air at high velocity against the rotor (7).

(c) The rotor has small buckets cut in its periphery, similar to those in a turbine wheel. The air striking the buckets causes the rotor to revolve at approximately 15,000 rpm. The air, after striking the buckets of the rotor, flows down around the lower rotor bearing housing and into the pendulum unit (3, figure 37), which is attached to the bottom of the gyro housing. The air is drawn through four small air ports in the pendulum body past the knife edges (4) of the pendulum plates (5) and out into the case, where it escapes through the air outlet port (8, figure 36), in the case.

(d) The rotor is universally mounted, that is, it has freedom about all three axes. (Refer to section II, paragraphs 2.*a.* and *b.*) Due to the speed of rotation of the rotor, the gyro and pendulum unit assembly, referred to as the gyro, has gyroscopic inertia and maintains its upright position regardless of the movements of the instrument case, which is mounted in the instrument panel of the aircraft.

KEY TO FIGURE 36

1. Cage Knob
2. Miniature Airplane Adjusting Knob
3. Miniature Airplane
4. Gimbal Ring
5. Caging Gears
6. Air Pivot (Gyro Housing)
7. Gyro Rotor
8. Air Outlet Port
9. Air Channel (Gimbal Ring)
10. Air Inlet Filter
11. Air Inlet Port
12. Air Pivot (Gimbal Ring)
13. Gyro Housing
14. Cage Flag

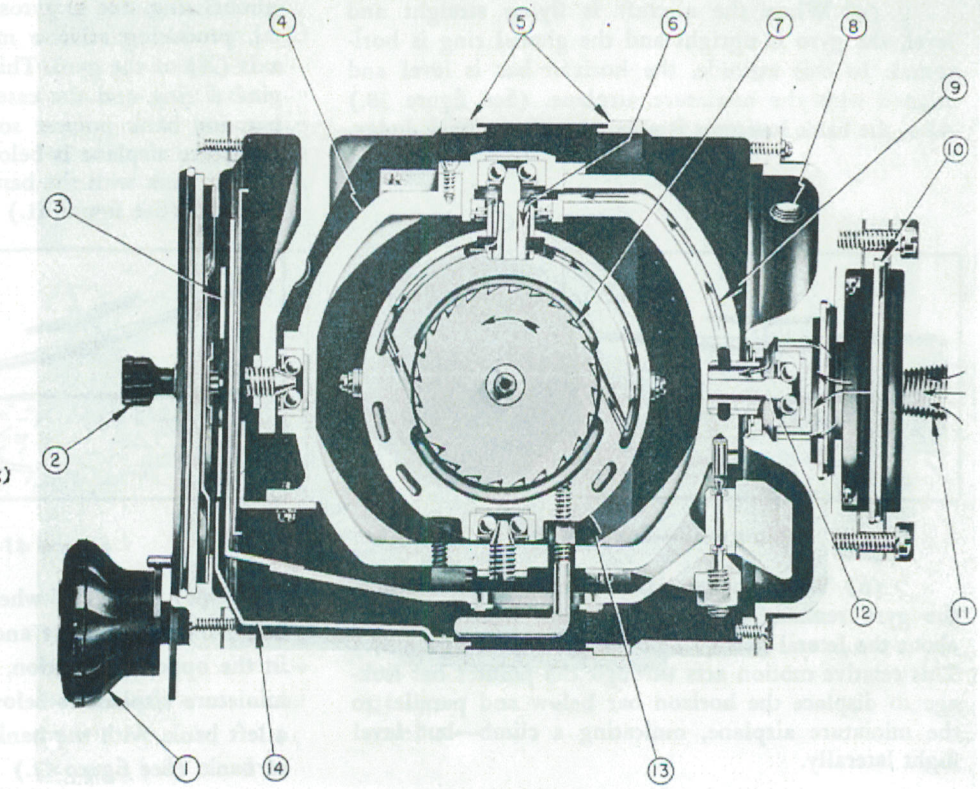


Figure 36—Sectional View, Top

KEY TO FIGURE 37

1. Caging Pinion (External)
2. Caging Gears (Internal)
3. Pendulum Unit Assembly
4. Pendulum Plate Knife Edge
5. Pendulum Plate
6. Pendulum Plate Shaft
7. Air Pivot (Gyro Housing)
8. Gyro Housing
9. Ball Bearing (Double Race)
10. Strut Screw
11. Compression Strut
12. Rotor Shaft (Hollow)
13. Rotor

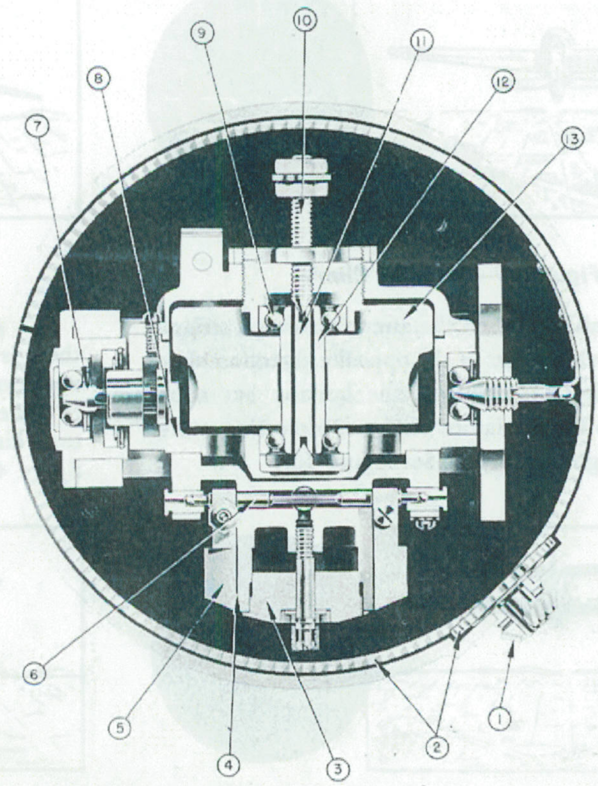


Figure 37—Sectional View, End

(2) PERFORMANCE IN FLIGHT.

(a) When the aircraft is flying straight and level, the gyro is upright and the gimbal ring is horizontal. In this attitude, the horizon bar is level and aligned with the miniature airplane. (See figure 38.) Also, the bank indicator is aligned with the bank index.

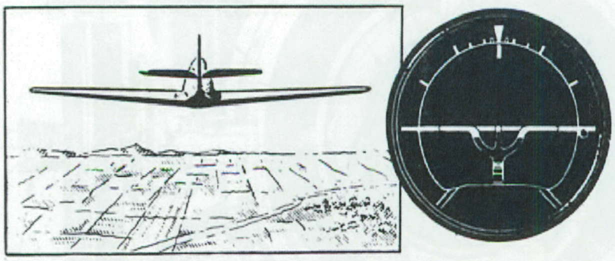


Figure 38—Level Flight

(b) When the aircraft makes a straight climb, the gyro remains upright, producing relative motion about the lateral axis (Y) of the gyro. (See figure 39.) This relative motion acts through the pointer bar linkage to displace the horizon bar below and parallel to the miniature airplane, indicating a climb—but level flight laterally.

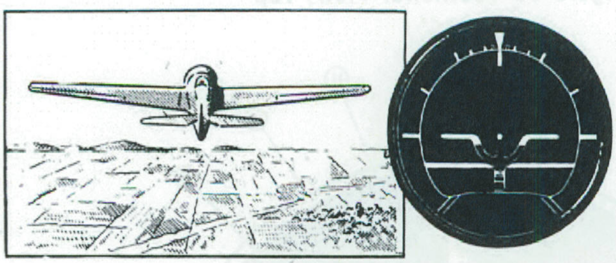


Figure 39—Straight Climb

(c) Similarly, when the aircraft makes a straight dive, the relative motion in the opposite direction about the lateral axis (Y), displaces the horizon bar above and parallel to the miniature airplane, indicating a dive —but level flight laterally. (See figure 40.)

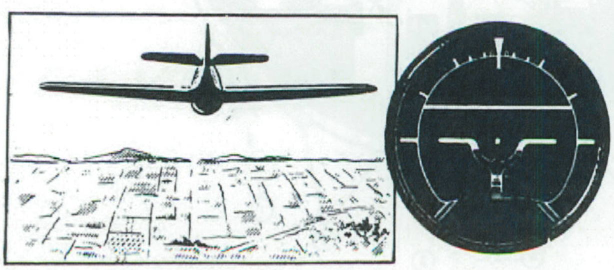


Figure 40—Straight Dive

(d) When the aircraft makes a right bank, the gimbal ring, due to gyroscopic inertia, remains horizontal, producing relative motion about the longitudinal axis (X) of the gyro. This relative motion between the gimbal ring and the case, appears to tip the horizon bar and bank pointer so that the right wing of the miniature airplane is below the horizon bar, indicating a right bank with the bank pointer showing the degree of bank. (See figure 41.)

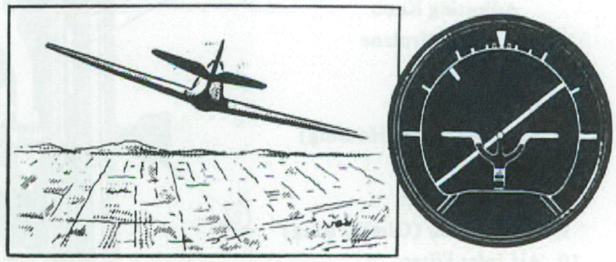


Figure 41—Right Bank

(e) Similarly, when the aircraft makes a left bank, the horizon bar and bank pointer appear to tip in the opposite direction, so that the left wing of the miniature airplane is below the horizon bar, indicating a left bank, with the bank pointer showing the degree of bank. (See figure 42.)

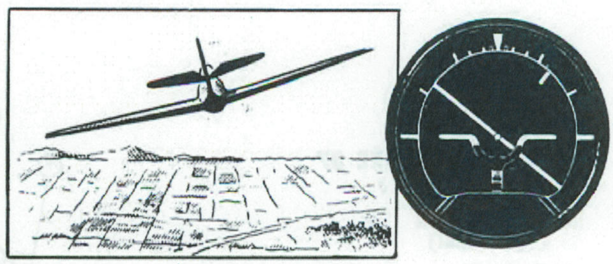


Figure 42—Left Bank

(f) If the aircraft does a climbing right turn, there is combined relative motion about both the lateral and longitudinal axes of the gyro. This motion appears to lower and tip the horizon bar relative to the miniature airplane, indicating a climbing right turn. (See figure 43.)

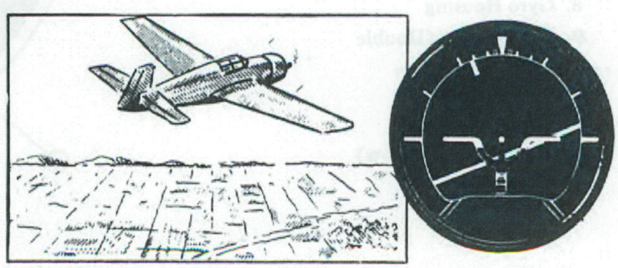


Figure 43—Climbing Right Turn

(*g*) Likewise, if the aircraft does a diving left turn, the horizon bar appears to be raised and tipped in the opposite direction relative to the miniature airplane, indicating a diving left turn. (See figure 44.)

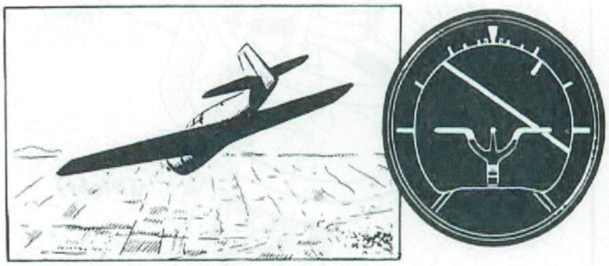


Figure 44—Diving Left Turn

(*h*) Therefore the gyro horizon provides an indication, within limits of any attitude of the aircraft.

(3) CONTROLLING GYRO DRIFT.

(*a*) Bearing friction and slight unbalance which can not be entirely eliminated, apply forces to the gyro which cause the gyro to drift from its upright position. Also, a free gyro, because it maintains its position relative to space and not relative to the earth, appears to drift due to the earth's rotation. (Refer to this section, paragraph 1.*b.*) To establish a reliable vertical flight reference, this drift must be overcome by forcing the gyro to remain upright with respect to the earth. This is the function of the pendulum unit assembly attached to the bottom of the gyro housing as shown in figure 37.

(*b*) If the gyro starts to drift from the upright position, a force is automatically applied in the proper direction and about the proper axis—utilizing the principle of precession—to return the gyro to the upright position.

(*c*) The pendulum unit assembly mounts four pendulum plates as shown schematically in figure 45. These plates, which are slotted, are each clamped by a screw in pairs on two intersecting shafts, one shaft approximately parallel to the longitudinal axis (X) of the gyro and the other shaft parallel to the lateral axis (Y). The pivot ends of each shaft are mounted in bearings in the pendulum body. (See figure 37.) Each pair of plates may be balanced by adjusting the position of the balancing nut on the plate clamping screw. In the sides of the pendulum body are four small air ports, one under each plate.

(*d*) The air for driving the rotor is exhausted through these four air ports. The reaction of the air, as it flows through the ports, applies a force to the pendulum body. The plates, due to their pendulosity, always hang in a vertical position. This principle is utilized to govern the flow of air from the air ports and therefore controls the forces applied to the gyro by the reaction of the air.

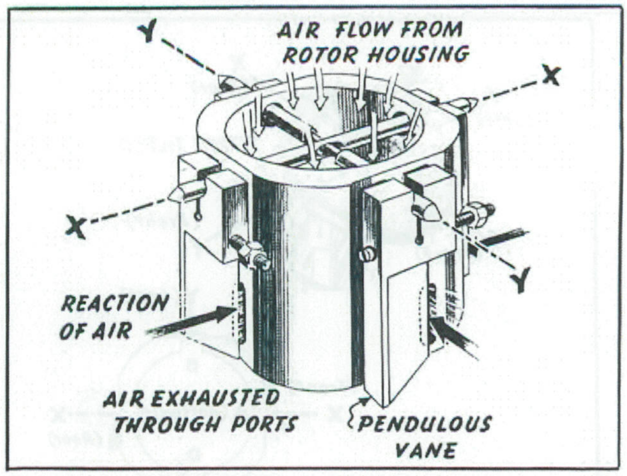


Figure 45—Operation of Pendulum Unit

(*e*) When the gyro is in its normal upright position, the knife edges on the plates bisect each of the ports, making all four port openings equal. The reaction of the air flowing from the ports is proportional to the size of the port opening. When all four port openings are equal, all four reactions (A, B, C, and D) are equal and the resultant forces about each axis are in balance, as shown schematically in figure 46.

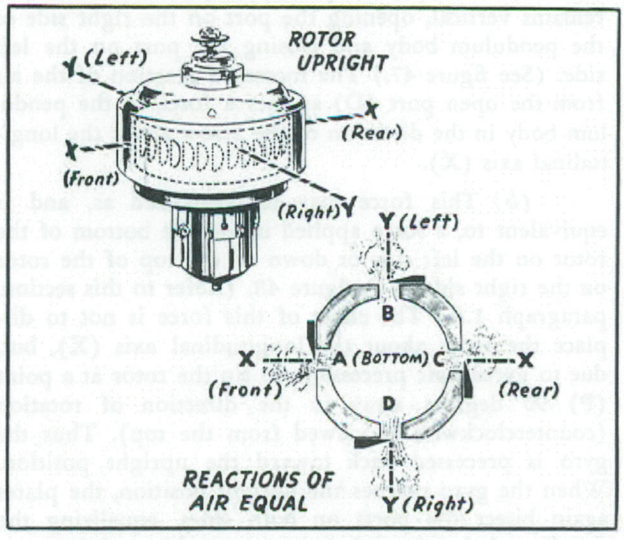


Figure 46—Gyro Upright

(*f*) When the gyro tilts, the plates remain vertical due to gravity. This action decreases the port opening on one side of the pendulum body and increases the port opening on the opposite side. Therefore, the reaction is increased on the side with the greater opening and decreased on the side with the smaller opening, producing a resultant force which is in the direction of the greater reaction. This force causes the gyro to precess, not about the axis where the force is applied, but about the other axis at right angles to the force, returning the gyro to the upright position.

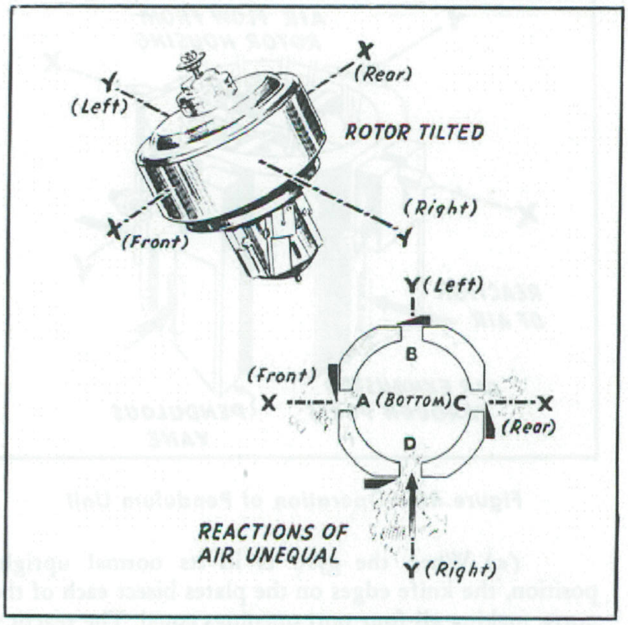


Figure 47—Gyro Tilted

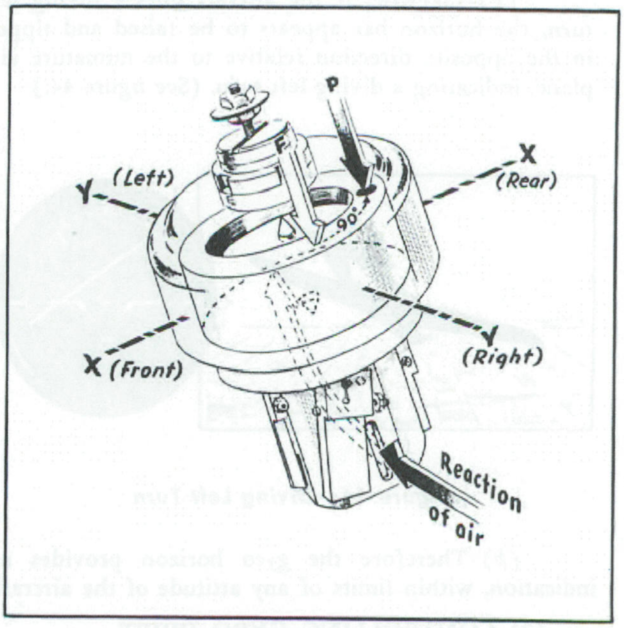


Figure 48—Erection of Gyro

(g) For example, if the top of the gyro tips from the upright position toward the front of the instrument, the pair of plates on the lateral axis (Y) remains vertical, opening the port on the right side of the pendulum body and closing the port on the left side. (See figure 47.) The increased reaction of the air from the open port (D) applies a force to the pendulum body in the direction of the arrow about the longitudinal axis (X).

(h) This force may be visualized as, and is equivalent to, a force applied up on the bottom of the rotor on the left side or down on the top of the rotor on the right side at F, figure 48. (Refer to this section, paragraph 1.b.) The effect of this force is not to displace the rotor about the longitudinal axis (X), but, due to gyroscopic precession, to tip the rotor at a point (P) 90 degrees away in the direction of rotation (counterclockwise as viewed from the top). Thus the gyro is precessed back toward the upright position. When the gyro reaches the upright position, the plates again bisect the ports on both sides, equalizing the reaction of the air, and the gyro remains upright.

(i) A similar action occurs if the top of the gyro tips toward the rear of the instrument. The port on the left side of the pendulum body is opened and the one on the right side is closed. The effect of the reaction from the air is to precess the gyro back to the upright position, where the air ports are bisected by the plates and the reactions from the air are therefore in balance.

(j) Likewise, if the gyro and gimbal ring assembly tips from the upright position to the right about the longitudinal axis (X), the front port is closed and the rear port is opened. The reaction of the air from the rear port is equivalent to applying a force upward to the rim of the rotor at the front. Precession does not take place from this point, but from a point 90 degrees away in the direction of rotation of the rotor. Therefore, the gyro and the gimbal ring precesses to the left about the longitudinal axis until it is again upright.

(k) Obviously, the gyro may simultaneously tip from the upright position about both axes, in which case both pairs of plates are in operation and the gyro is precessed back to the vertical about both axes, establishing a reliable vertical flight reference.

(l) Acceleration forces acting on the gyro and the pendulum plates during turns, cause the gyro to precess from the required upright position. This has the effect of producing errors in the readings of the instrument both during turns and at the completion of turns. The errors can be corrected by inclining the top of the gyro toward the rear of the instrument. By varying the amount of inclination, the turn errors for any specified rate of turn may be corrected. In the gyro horizon, the turn errors introduced by a standard rate turn (180 degrees per minute) are eliminated by inclining the gyro 2½ degrees. This inclination of the gyro is accomplished by positioning the balancing nuts on the pendulum plates on the lateral axis (Y), so that the plates hang at 2½-degree angle instead of vertical. Thus the air ports on the lateral axis will not be bisected when the gyro is in the vertical position, but only when it is inclined 2½ degrees, forcing the gyro to assume this inclination. In this manner, turn errors introduced by a turn at the rate of 180 degrees per minute are eliminated, establishing a true vertical flight reference during a standard rate turn.

2. OPERATING INSTRUCTIONS.

a. GENERAL.

(1) The gyro horizon provides a constant and positive indication of the plane's attitude with respect to the earth.

(2) When the engine is started and the vacuum pump starts drawing air through the instrument, the horizon bar will immediately begin to assume its operating position close to the center of the dial. As the gyro rotor gains speed, the bar may oscillate for a brief period, but this oscillation will cease before the gyro rotor comes up to its normal, operating speed.

(3) If the gyro horizon is to be used in an instrument take-off, do not take off until the gyro rotor has come up to speed and the horizon bar has settled out.

(4) On the ground, the settled-out position of the horizon bar relative to the miniature airplane will vary according to the type of undercarriage on the aircraft. If the aircraft has a tail wheel or skid, the horizon bar will assume a position below the miniature airplane as though the aircraft were in a climb. (See figure 49.) If the aircraft has a tricycle landing gear, the horizon bar will be almost in line with the miniature airplane—just as it would be in level flight. (See figure 50.)

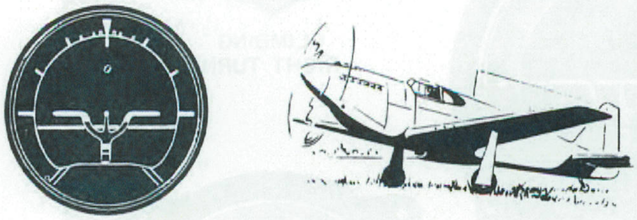


Figure 49—Indication—Tail-Skid Aircraft

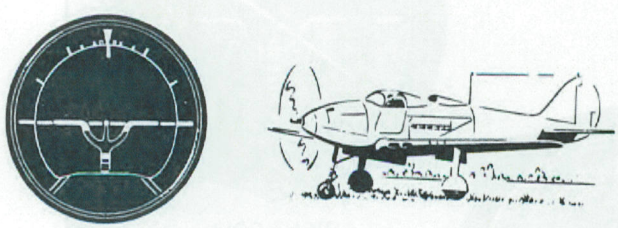


Figure 50—Indication—Tricycle Landing Gear

b. STARTING.

(1) Starting the aircraft engine starts the vaccum pump which supplies the air for driving the gyro rotor. Allow about 5 minutes for the gyro rotor to come up to speed. (See figure 51.)

(2) If the vacuum is supplied by venturi tubes, 5 or 6 minutes will be needed *after take-off* for the gyro to attain the required speed before the instrument can be used. (See figure 52.)

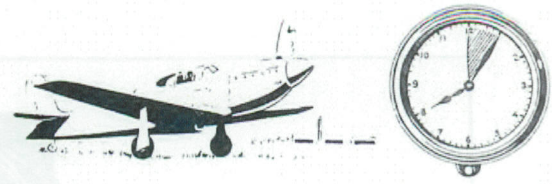


Figure 51—Ground Warm-Up Time

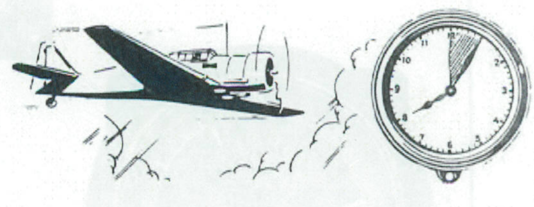


Figure 52—Flying Time (Venturi Tube)

c. USING THE INSTRUMENT.

(1) Using the gyro horizon during instrument flight is so much like using the natural horizon during contact flight, that there is nothing new to learn. The minature airplane is visualized as representing the aircraft in flight, flying toward the horizon—represented by the horizon bar. That is, the position of the miniature airplane relative to the horizon bar represents the attitude of the aircraft relative to the natural horizon. In flight, just before using the indications of the instrument, the height of the miniature airplane should be adjusted to the level flight condition. This height may vary slightly from day to day as loading and other conditions change and should be checked at every flight.

(2) When the miniature airplane is aligned with the horizon bar, the aircraft is in level flight, both laterally and longitudinally; the aircraft is neither banking, diving, nor climbing. Whenever the miniature airplane is above the horizon bar, the aircraft is climbing, and whenever the miniature airplane is below the horizon bar the aircraft is diving. Whenever the miniature airplane is tilted relative to the horizon bar, the aircraft is banking. The miniature airplane tilts to the right for a right bank and to the left for a left bank, just as the aircraft does. In addition, the bank indicator at the top of the dial indicates the amount of bank on the bank scale. Combinations of these movements, tilting and displacement of the miniature airplane relative to the horizon bar, give indications of any attitude of the aircraft within the operating limits of the instrument. (Refer to this section, paragraph 2.*d.*). Indications of the instrument for various attitudes of flight are shown in figure 53.

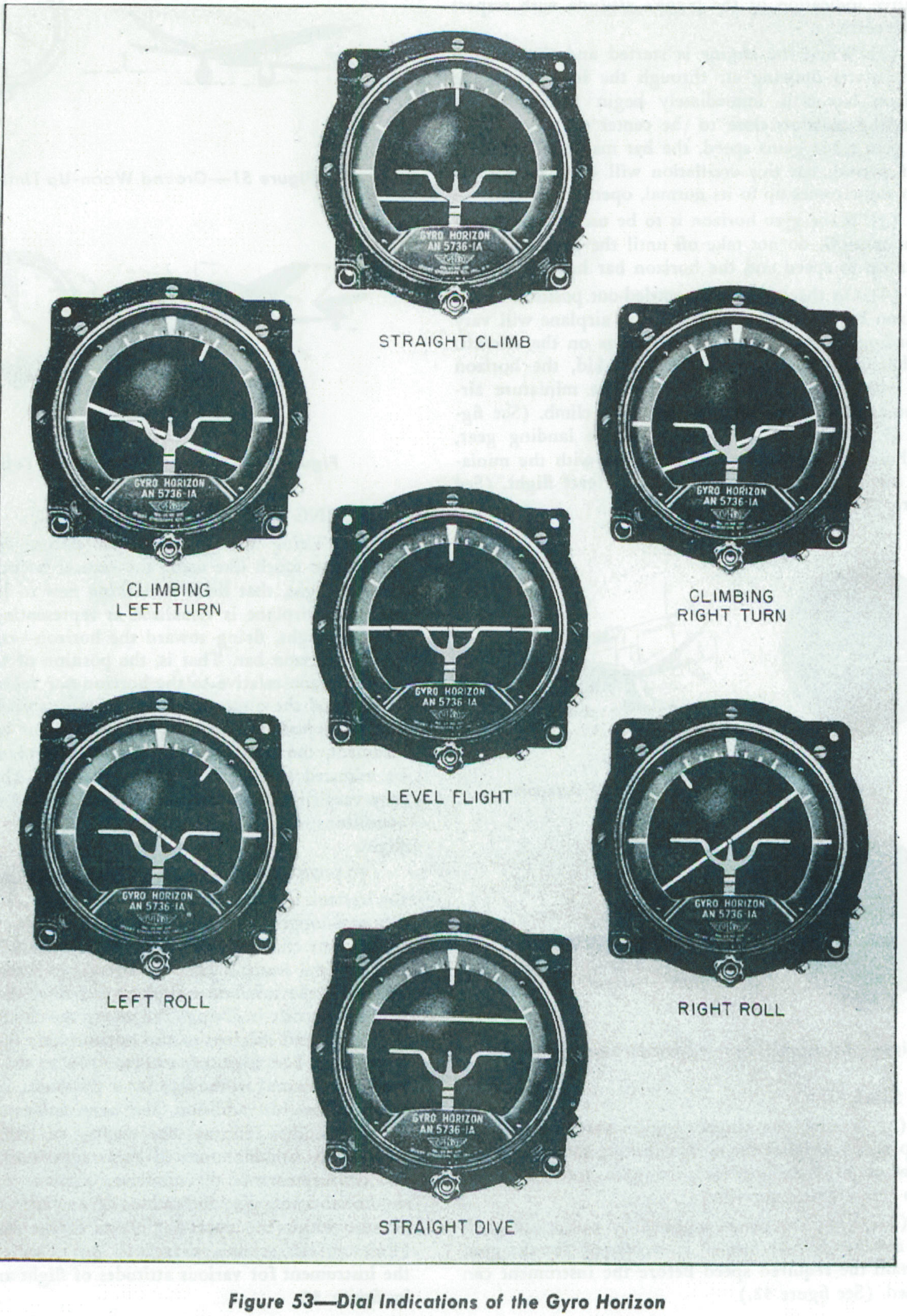


Figure 53—Dial Indications of the Gyro Horizon

d. OPERATING LIMITS.

(1) The operating limits (from level flight) for the gyro horizon are 70 degrees climb or dive and 100 degrees right or left bank. (See figure 54.) If the aircraft engages in maneuvers which exceed these angles, the gyro will strike its stops and upset.

CAUTION

The gyro horizon should never be caged except when setting it or when engaging in maneuvers that may exceed its operating limits.

(2) If the operating limits are exceeded, the horizon bar may swing rapidly from one extreme to the other, and it will be necessary to fly straight and level while the horizon bar is reset to its normal position before the indications of the instrument can be used again. This resetting is accomplished by caging the instrument and then uncaging it while the aircraft is in level flight.

e. TURN INDICATIONS. — Turns, except those made at the standard rate of turn — 180 degrees per minute—affect the gyro horizon, causing a temporary misindication commonly referred to as turn error. This turn error causes a slight displacement of the horizon bar from the normal position. This displacement is dependent on the rate and amount of turn, but, even in extreme conditions, seldom exceeds 3 to 6 degrees in roll or pitch. For a 180-degree-per-minute turn there will be no turn error at all because the gyro horizon is designed to eliminate misindications for this standard, commonly used rate of turn (gyro tilted 2½ degrees from vertical axis).

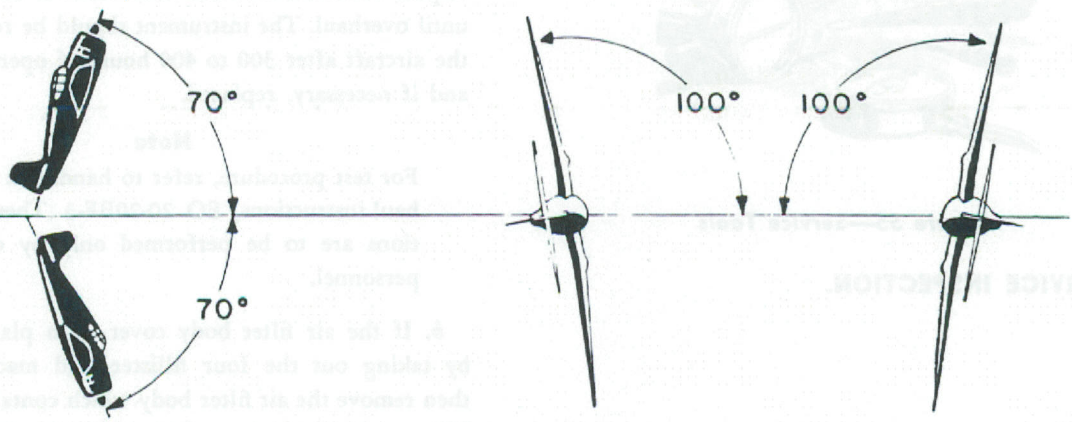


Figure 54—Operating Limits

SECTION V
SERVICE INSPECTION, MAINTENANCE, AND LUBRICATION

1. SERVICE TOOLS REQUIRED.

There are no special tools required for the servicing of the gyro horizon. However, in addition to the usual service tools, a vacuum gauge for checking the vacuum supply to the instrument, and a vibrometer for checking the vibration of the instrument panel should be available. (See figure 55.)

Figure 55—Service Tools

2. SERVICE INSPECTION.

DAILY Inspection

Inspect the cover glass for cleanliness and damage.

SPECIAL Inspection
(Adverse Conditions)

The air filter on the back of the instrument is replaced approximately every 50 hours of normal operation. However, when operating in localities where there is an excessive amount of sand and dirt in the air, the filter should be inspected, and, if necessary, replaced at more frequent intervals. Under extremely dusty conditions it may be necessary to inspect the filter daily.

Minor Inspection

Inspect the instrument for broken or loose cover glass. Inspect the instrument for security of mounting.

Major Inspection

Inspect the vacuum line tubing connections for security, and hose connections for flexibility. Inspect the face of the instrument for discolored or chipped luminescent markings. Inspect the air intake filter for cleanliness and replace if necessary.

3. MAINTENANCE.

a. The gyro horizon, if properly installed, should not require maintenance other than renewal of the air filter until overhaul. The instrument should be removed from the aircraft after 300 to 400 hours of operation, tested, and if necessary, replaced.

Note

For test procedure, refer to handbook of overhaul instructions, EO 20-20BF-3 These operations are to be performed only by qualified personnel.

b. If the air filter body cover is in place remove it by taking out the four fillister-head machine screws, then remove the air filter body which contains the filter. Lift out the snap ring which holds the filter assembly in place and remove the filter. Put the new filter assembly in place and replace the snap ring. Replace the air filter body, (and the air filter body cover, if so installed) and secure it with the screws.

c. Other possible troubles encountered may be: Improper vacuum supply or excessive vibration of the instrument.

d. As a guide in ascertaining and correcting operational difficulties, refer to this section, paragraph 5.

4. LUBRICATION.

The shafts and bearings of the instrument are lubricated before assembly and no further lubrication should be required until the instrument is overhauled.

5. SERVICE TROUBLES AND REMEDIES.

Note

Troubles may usually be attributed to any or all of the following three causes: (1) vacuum supply too low or too high; (2) a clogged or dirty air filter; (3) excessive vibration.

TROUBLE	Probable Cause	Remedy
HORIZON BAR FAILS TO RESPOND	Air filter dirty (high vacuum indication if used with non-differential gage; low indication on differential gage)	Examine filter. Clean or replace if necessary.
	Insufficient vacuum — resulting from the following:	Correct insufficient vacuum as follows:
	Vacuum regulating valve improperly adjusted	Adjust vacuum regulating valve.
	Vacuum line kinked, leaking or too long for its diameter	Locate and repair; check for collapsed inner wall of flexible hose.
	Faulty vacuum gage	Check calibration of gage.
	Pump or venturi failure	Repair or replace pump or venturi.
HORIZON BAR DOES NOT SETTLE	Insufficient vacuum	Correct for insufficient vacuum as outlined above.
	Excessive vibration	Test with vibrometer. If amplitude is more than .004 inch, examine shock mounts and replace if necessary. Examine installation to determine whether flexible hose connections are restricting movement of instrument.
	Defective mechanism	Remove instrument from airplane. Dissassemble, inspect, and make necessary repairs.
HORIZON BAR OSCILLATES OR VIBRATES EXCESSIVELY	Improper vacuum, resulting from the following:	Correct for improper vacuum as follows:
	Air filter dirty	Examine filter, clean or replace if necessary.
	Vacuum regulating valve improperly adjusted	Adjust vacuum regulating valve.
	Faulty vacuum gage	Check calibration of gage.
	Excessive vibration	Test with vibrometer. If amplitude is more than .004 inch, examine shock mounts and replace if necessary. Examine installation to determinate whether flexible hose connections are restricting movement of instrument.
	Defective mechanism	Remove instrument from airplane. Disassemble, inspect, and make necessary repairs.