HANDBOOK OF INSTRUCTIONS

(with Parts List)

for the

INSPECTION, MAINTENANCE and REPAIR

of the

SPERRY GYRO-HORIZON
and the
SPERRY DIRECTIONAL GYRO

Instructions No. 15-330

October, 1936

Sperry Gyroscope Company, Inc.
Manhattan Bridge Plaza
Brooklyn, New York

FOREWORD

This instruction book has been prepared especially for authorized instrument service men who have at their disposal the special tools and fixtures necessary for disassembling, inspecting and calibrating Gyro-Horizons and Directional Gyros. Its chief purpose is to provide instruction in the repair of these instruments. In order that those who repair them may have a proper understanding of how they function, how they are installed and how they are used, however, information in regard to their operating principles, installation and use has been included.

Instructions for the repair of the Gyro-Horizon are given in Part I and for the Directional Gyro in Part II. In order to avoid duplication, procedure which is common to both instruments, such as "Inspection and Care of Pivots and Bearings", "Dynamic Balance of the Rotor", etc. is given only in Part I. Installation and Operating instructions follow the instructions for repairing each instrument. Special instructions for shock-absorbing instrument panels are contained in Part III.

Those who are confronted with special problems are invited to consult the Aeronautical Service Department of the Sperry Gyroscope Company, Inc., Brooklyn, New York, or any of the following representatives:

J. A. Tison
414 Rockefeller Bldg.,
Cleveland, Ohio

J. F. McConkey
58 Main Street
San Francisco, Calif.

H. S. Burtis
2737 First Avenue South
Seattle, Wash.

W. I. Selover
1316 West G Street
Wilmington (Los Angeles) Calif.

E. C. Wehrgandt
9601 South Leavitt St.
Chicago, Ill.

Pacific Airmotive Corp.
Union Airport
Burbank, Calif.

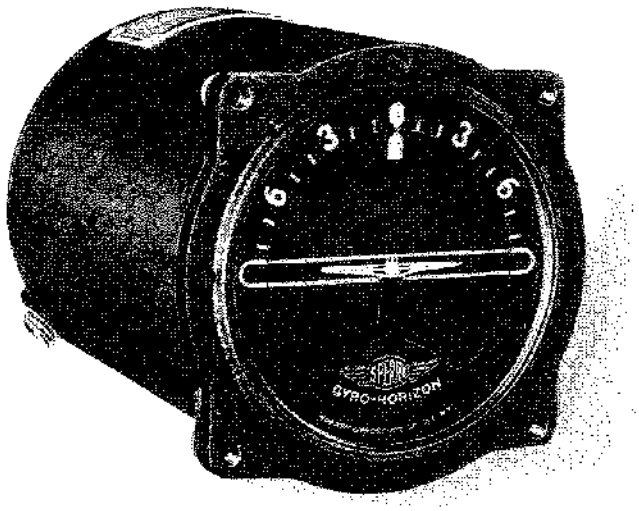


FIGURE 1 THE STANDARD GYRO-HORIZON

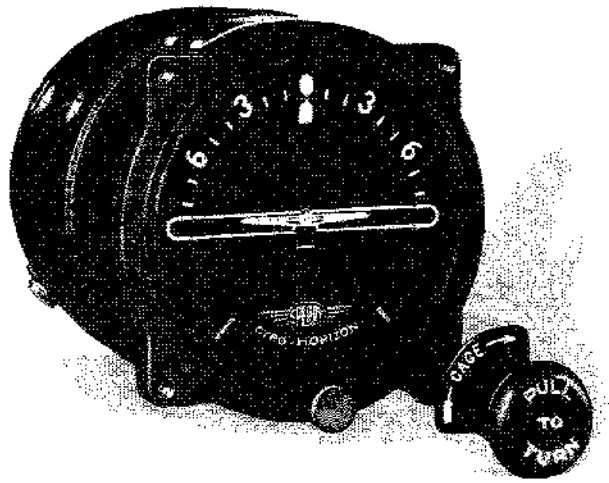


FIGURE 2 THE GYRO-HORIZON WITH CAGING DEVICE

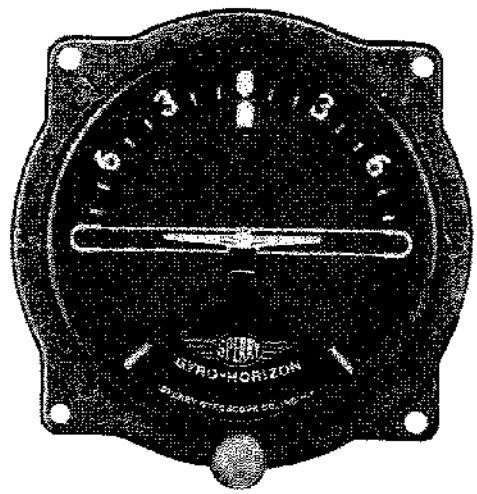


FIGURE 3 THE GYRO-HORIZON WITH ADJUSTABLE AIRPLANE

C O N T E N T S

C O N T E N T S (Cont'd.)

C O N T E N T S (Cont'd.)

LIST OF ILLUSTRATIONS

* Gyro-Horizon with Caging Device

LIST OF ILLUSTRATIONS

REPAIR OF THE GYRO-HORIZON

PART I

INTRODUCTION

An airplane pilot has three "senses" which are affected by the position of the airplane in relation to the horizontal: (1) His eyes, which use the natural horizon or some other reference to keep the plane in normal flight; (2) his inner ear, which is really a minute form of liquid level; (3) his "deep muscle sense", or the feel of his own weight.

If poor visibility prevents the use of the eyes to keep the plane in normal flight, it has been found that the deep muscle sense and the inner ear cannot cope with the problem of defining the horizontal. This is due to several causes, the most important being that these senses naturally indicate the pull of gravity and cannot distinguish between that pull and the pull of other forces which act on them, such as centrifugal force and longitudinal acceleration forces.

Unless he can use his sense of vision to determine his attitude with respect to the horizon, the pilot's sense of balance is confused and his spacial orientation is inaccurate. Even birds, when blind-folded and released, are unable to continue flying normally, but will flutter to the ground in a manner entirely foreign to natural flight.

As the natural horizon is the reference which a pilot instinctively uses, the Gyro-Horizon was designed to afford the nearest thing to it -- an artificial horizon within the cockpit of the airplane. By means of a miniature airplane and a gyro-actuated horizon bar, it shows the pilot what he would see if he could see outside the airplane, i.e., whether the plane is banking, climbing or gliding, or whether it is flying level. By observing the Gyro-Horizon, the pilot can accurately visualize his airplane in whatever lateral or longitudinal attitude he places it. The Gyro-Horizon is a direct reading indicator of flight attitude for bank, climb and glide.

The standard Gyro-Horizon is shown in Fig. 1. For use in military airplanes or others which are called upon for considerable maneuvering or stunting, a Gyro-Horizon with a caging device, as shown in Fig. 2 can be supplied. The caging device affords a means of quickly regaining the use of the instrument at the conclusion of rolls, loops and other maneuvers.

The Gyro-Horizon can be supplied, if desired, with adjustable miniature airplane, as shown in Fig. 3. If it is necessary to fly the airplane with the nose high or low, the adjustable airplane of the Gyro-Horizon may be raised or lowered by a turn of the knob at the bottom of the dial to centralize it on the horizon bar.

DESCRIPTION

The purpose of the Gyro-Horizon is to establish a fixed reference for maintaining flight attitude. The gyroscope (which is simply a spinning wheel mounted so its axle can be pointed in any direction) affords the best way of obtaining this reference without excessive size and weight.

The Gyro-Horizon is operated by vacuum at 4 inches Hg. supplied by means of a venturi tube or by an engine-driven vacuum pump. The gyro or rotor is mounted in the case 1 and spins at approximately 10,000 r.p.m. about a vertical axis in the direction shown by the arrow. The gyro obeys a fundamental gyroscopic principle - rigidity in space. An indication from the gyro is picked up and brought around to the face of the instrument by a horizon bar 2 which is actuated by a pin 3 protruding from the case through a slot in the gimbal ring 4. A small airplane silhouette on the instrument dial is observed by the pilot in relation to the horizon bar in the same manner as he would observe the forward part of his own airplane in relation to the natural horizon in clear weather. (See Fig. 4)

Any tendency of the gyro to depart from its true position (which might be caused by acceleration forces or by friction) is corrected by the pendulum assembly shown in the sketches, Fig. 5. Four pendulous vanes, one of which is shown at A, are suspended from the underside of the gyro housing. Each one of these vanes partially covers one of the four air ports B that exhaust the air from the gyro compartment, as shown at the left. If the gyro departs from its upright position, gravity holds the vanes vertical, and one vane closes one port, while the opposite vane opens its port, as shown at the right. The reaction of air emitted from this open port moves the gyro, in the direction C, back to its normal position. The corrective movement, C, which is at right angles to the air force, is called "Precession" and is characteristic of all gyroscopes.

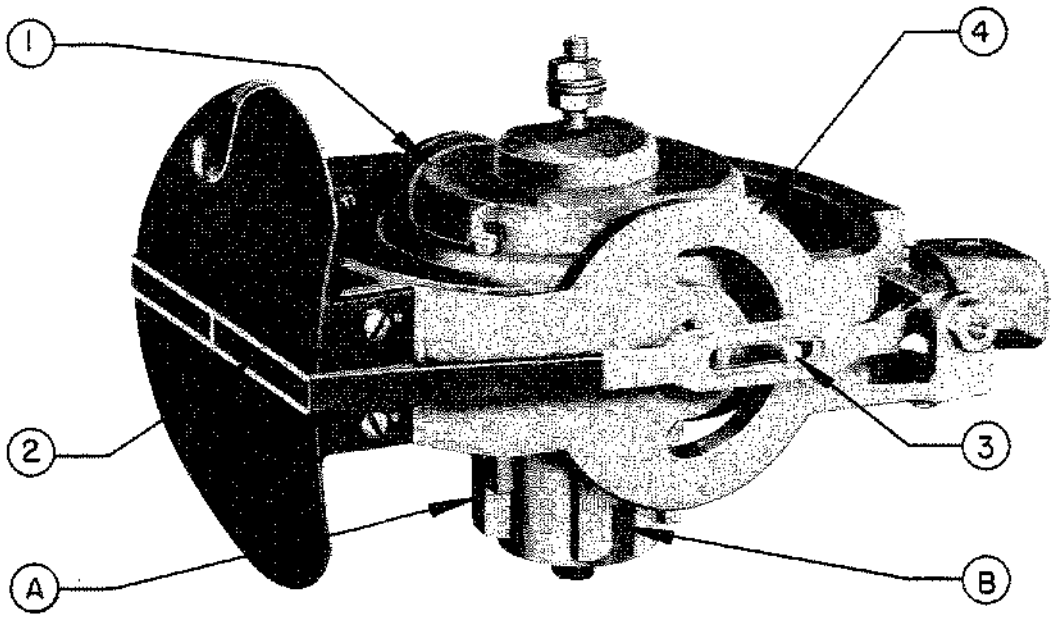


FIGURE 4 PRINCIPAL PARTS OF THE GYRO-HORIZON

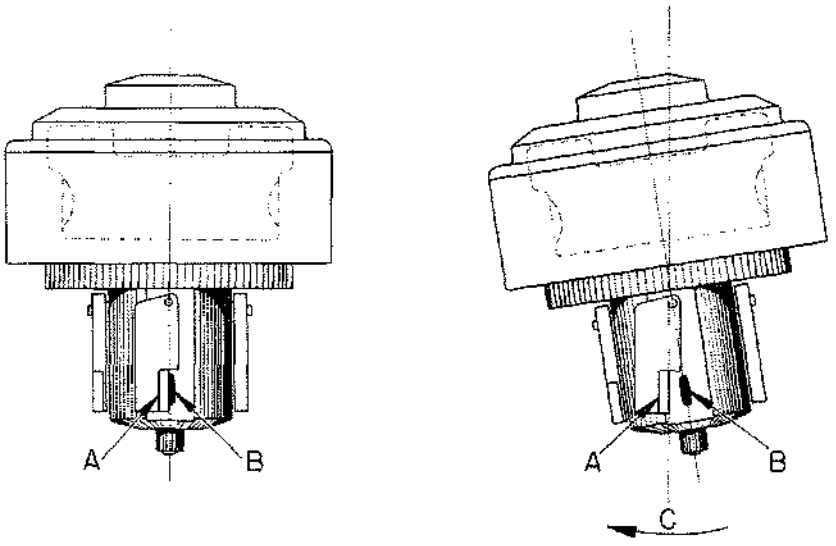


FIGURE 5 ERECTING ACTION OF THE PENDULOUS VANES OF THE GYRO-HORIZON

Figs. 6, 7 and 8, respectively, show the end view,plan view and side view of the Gyro-Horizon.

Outline drawings of the standard Gyro-Horizon and the Gyro-Horizon with caging device are included in the instructions for installation at the end of Part I.

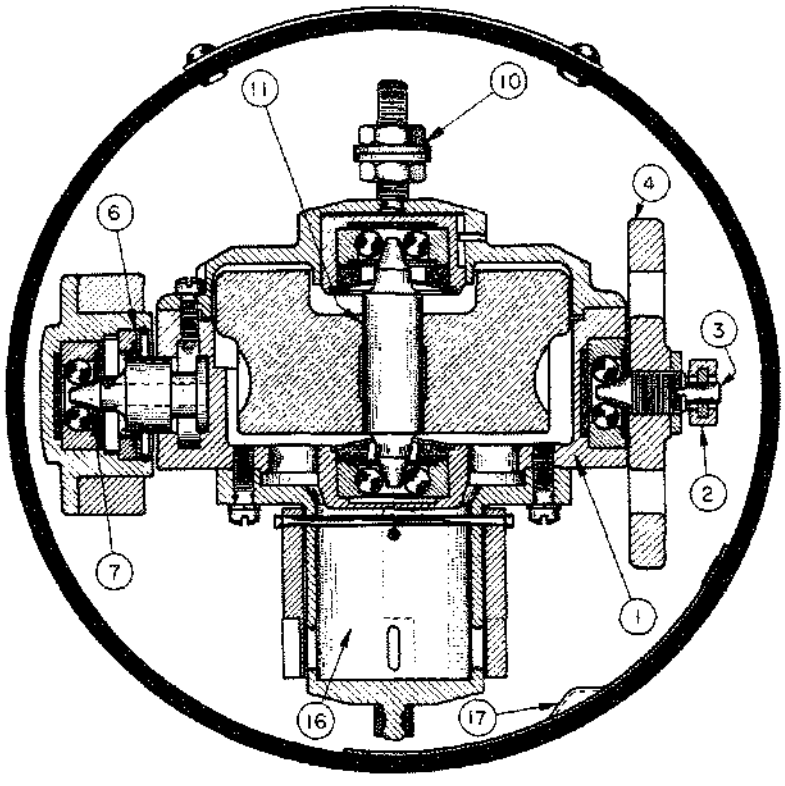


FIGURE 6 END VIEW OF THE GYRO-HORIZON

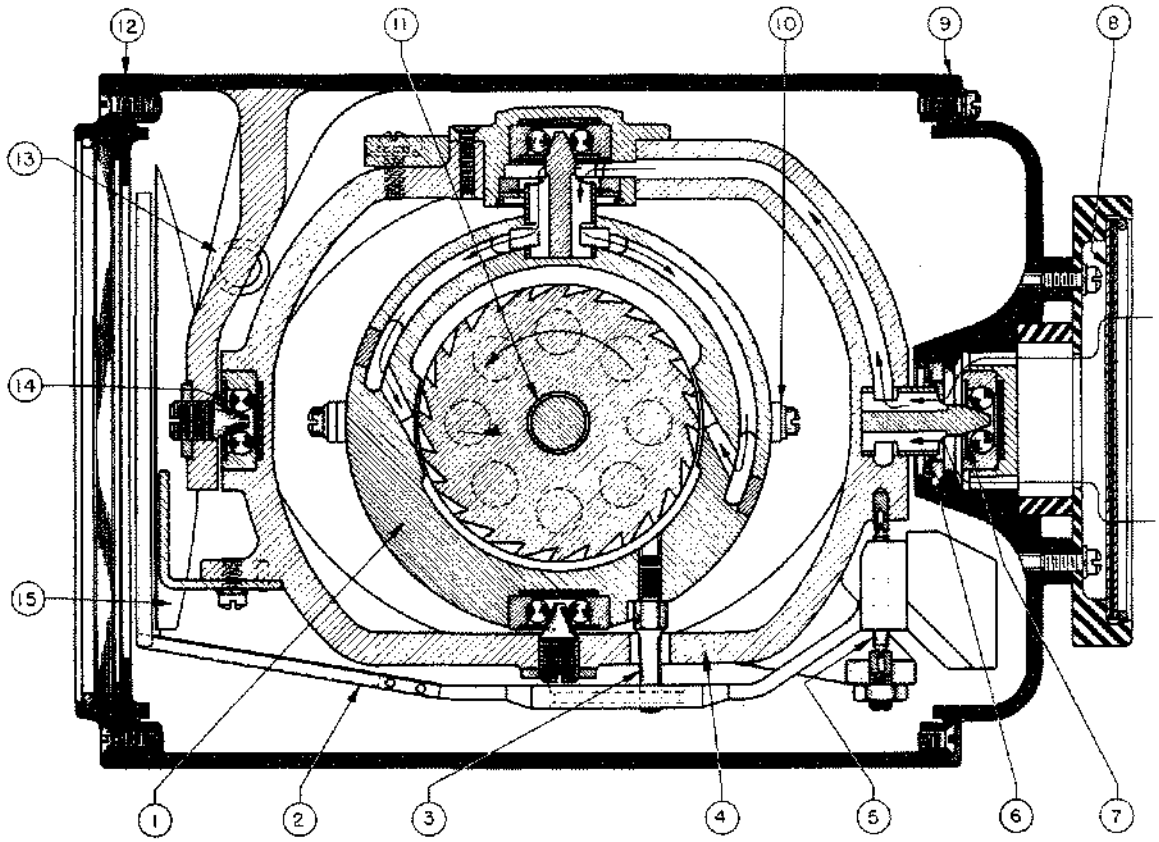


FIGURE 7 PLAN VIEW OF THE GYRO-HORIZON

1. Rotor Case
2. Horizon Bar
3. Guide Pin
4. Gimbal Ring
5. Horizon Bar Pivot
6. Air Seal Assembly
7. Air Pivot and Bearings
8. Filter
9. Rear Cover
10. Balance and Calibration Weights
11. Rotor and Shaft
12. Front Cover
13. Rubber Bumpers
14. Screw Pivot and Bearings
15. Dial
16. Pendulum Assembly
17. Shipping Lock
18. Vacuum Connection (plug)

THE PRINCIPAL PARTS SHOWN IN FIGS. 6, 7 and 8.

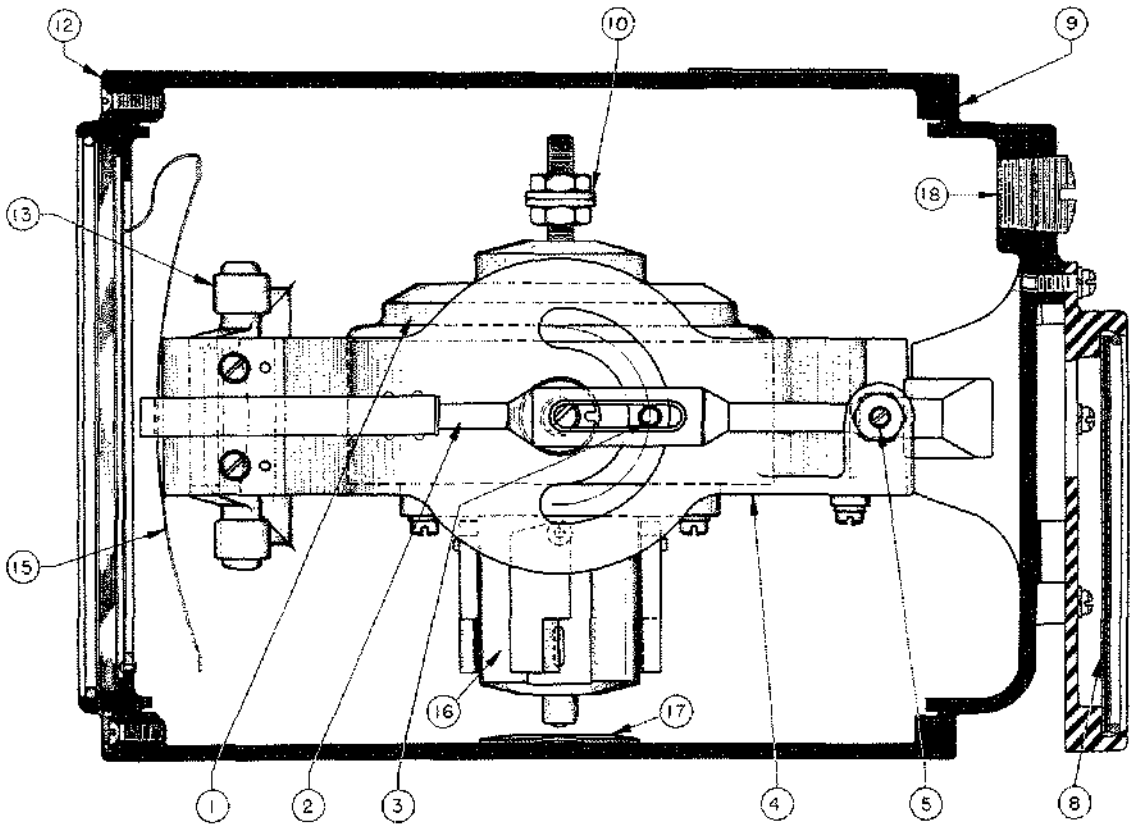


FIGURE 6 SIDE VIEW OF THE GYRO-HORIZON

LUBRICATION

The shafts, pivots and ball bearings of the instrument are lubricated before assembly in the case and no further lubrication should be attempted unless the necessary tools and fixtures for inspection and assembly are available. These tools are listed on Page 107. It should be remembered, however, that continuous use of the instrument in hot climates increases the evaporation of the oil and replenishing may become necessary.

At regular intervals such as engine change periods it is advisable to have the instrument removed from the airplane and inspected -- only, however, by an authorized instrument service man who has at his disposal the special tools and fixtures necessary for disassembly, inspection and calibration of Gyro-Horizons. Otherwise, the instrument should be returned to the Sperry Gyroscope Company for inspection.

RETURNING TO THE FACTORY

Before shipping, remove cadmium plated (white) case screw from rear cover of instrument case and insert special lock screw in accordance with the instructions contained in the bag in which the screw is kept. If instrument has caging device, be sure that it is caged. Pack the instrument carefully, preferably in the same box in which it was received, or in one similar to it.

INSPECTION AND MAINTENANCE

1. Rather than take a particular instrument and explain how to overcome any small erroneous conditions, we will explain the necessary procedure to disassemble, reassemble and calibrate Gyro-Horizons and Directional Gyros from start to finish. In this way you will become entirely familiar with the instruments and will be in a position to inspect and apply the correct procedure to any particular part to be repaired. Before attempting to disassemble an instrument, read carefully the following general instructions. The order of procedure which is given in this book should be followed throughout.

2. The instructions contained herein are intended to serve only as a guide in carrying out the various operations. Infinite patience and attention to detail is essential every step of the way. Many of the minor routine operations, which are obviously familiar to competent instrument men have been omitted. Bear in mind, however, that every part of the equipment must be carefully cleaned and thoroughly inspected before replacement or reassembly.

INSTRUMENT REPAIR ROOM OR SHOP

1. Select a room that can be kept free from dirt and grit. It must be dry at all times and should be free from vibration. Never try to repair a Gyro-Horizon or a Directional Gyro in a main hangar storage area or in the open. An air conditioned room is recommended.

2. The work-bench or table should be firm and fairly level.

3. The following tools should be available

Last Word indicator, .001 inch
Surface gauge
Bench plate, 2" x 12" x 18", planed or ground true
Sensitive drill press
Bench lathe, 1/2" collet capacity or more
Set of special tools and fixtures supplied by the Sperry Gyroscope Company, Inc.

4. Dry air at a pressure of at least 3-1/2" mercury and also a source of vacuum of at least 3-1/2" mercury should be available at the instrument room.

5. A pump capacity of approximately 10 cubic feet per minute at 4" Hg. will operate from 2 to 3 Gyro-Horizons and from 1 to 4 Directional Gyros. The air supply of 3-1/2" mercury of pressure is used principally for calibrating the Gyro-Horizon prior to assembly in its case.

6. Dry air at a pressure of at least 35 lbs. per square inch should also be available for drying when cleaning pivots and other parts and for spinning the rotors for the dynamic balance.

7. We recommend that spare parts be stored in glass jars in the instrument room rather than in a large general storeroom. If stored in the instrument room the instrument man can keep a constant watch to prevent rust or improper handling. See Fig. 9.

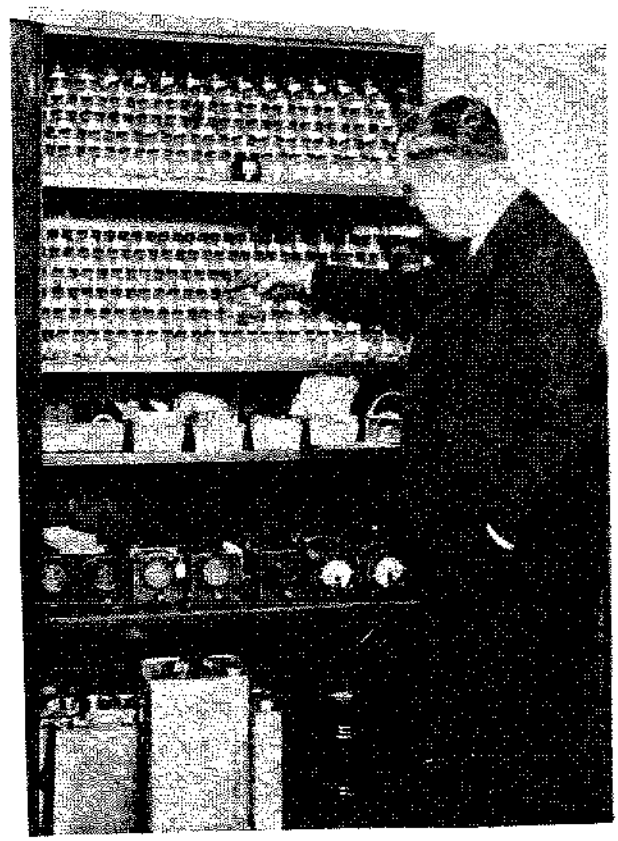


FIGURE 9 METHOD OF STORING SMALL PARTS IN GLASS JARS

CARE OF TOOLS AND FIXTURES

1. Tools and fixtures necessary for the complete repair of the instruments are listed on Page 107. Repair should not be attempted without the complete set of fixtures. As these fixtures have been carefully designed and manufactured, it is imperative that they receive the best of care.

2. When not in use, all pivots, bearings and parts used in the assembly of the instrument must be clean and protected from dirt and rust, by covering with a rust preventative, as follows:

Fixture Pivots - Coat with Rust Veto.

Fixture Bearings - Fill with Special Instrument Oil and cover with tissue paper disc. These discs to be 5/8-inch in diameter.

3. Bear in mind that a particle of dust or dirt on any surface of a fixture that comes in contact with the instrument will cause the fixture to become useless as long as the condition exists. When fixtures are put into service they should be washed thoroughly with Varsol and dried with dry air. Pivots should then be wiped with soft tissue paper.

4. Oil should be used as referred to in the instructions.

5. A list of recommended miscellaneous materials and their use follows.

MISCELLANEOUS MATERIALS AND THEIR USE

Alcoa Thread Lubricant

Aluminum Co. of America
Pittsburgh, Pa.

Use on all screws and pipe threads. Use between front and rear case covers of Gyro-Horizon in final assembly. Use between lower bearing housing and case of Directional Gyro.

Vulcatex

A. C. Horn Company
Long Island City, N. Y.

Use as a temporary counterweight when balancing. Use when calibrating the Directional Gyro to insure an airtight joint between the bezel glass and the front of the case.

Black Elastic Seam Composition

H. B. Fred Kuhls
Brooklyn, N. Y.

Use mixed with Vulcatex 50-50) between the bezel glass and the front of the case during final assembly.

Copad Varnish (thinned to proper consistency)

Sterling Varnish Co.
Haysville, Pa.

Use on gyro housings,gimbal rings and vertical rings where surfaces have become marred or scratched.

Special Instrument Oil

Sperry Gyroscope Co., Inc.
Brooklyn, N. Y.

Use on bearings and pivots as instructed, and in pump T-22696.

Black Lacquer "Zapon"
Zaponoid Black XE-70

The Zapon Company
New York, N. Y.

Use on bezel, case, or other outer parts where the old paint has been marred or scratched.

Rust Veto No. A-5

E. F. Houghton Co.
Philadelphia, Pa.

Apply to all pivots in storage and use in making up lapping compound.

Varsol

Colonial Beacon Oil Co.
Brooklyn, N. Y.

Use for washing all bearings, pivots and other parts before assembly.

Levigated Alumina

The Norton Company
Worcester, Mass.

Use mixed with Houghton's Rust Veto to make up compound for lapping pivots.

DO'S AND DON'T'S

1. Don't fit bearings too tight in recess. A light press fit is sufficient.

2. Don't use too much oil. Use what will stay on the bearing and no more. In Sperry instruments, oil is 20% lubrication and 80% rust proofing.

3. Don't fail to touch up the case with black lacquer. The boss may not know the good work you did on the inside and will form his opinion from the outside appearances.

4. Don't mishandle the fixtures. They are precision tools and expensive to build.

5. Grease the pivots and oil the bearings of the fixtures when you are through with them. A speck of rust will ruin a bearing or pivot.

6. Don't get finger marks on the dial.

7. Don't screw the pivots in too tight. They are easily pitted and are hard to relap. Treat them easy.

8. Don't mix the balls of different shipments. All balls of a single shipment are sized to .00001 inch but different shipments will be of different size. The important thing is to have the five balls in a bearing all the <u>same size</u>.

9. Don't make an adjustment till sure you are right. The man who put it that way knew his job.

10. Don't lose patience when you get a tough one. If the man that built it could make it work, you can.

11. Keep your bench and tools <u>clean</u>. A speck of dirt can ruin a day's work.

12. Don't be satisfied with 'good enough'. It takes great care and good work to make a good instrument.

13. Don't fail to use thread lubricant on screws and joints.

14. Don't lay the rotor and housing assembly on the bench plate where it can be knocked over or lay it down too hard. The pivots are easily pitted.

15. Don't use more lead than necessary in balancing.

16. Cut the lead weights as symmetrical as possible. It makes a more workman-like job.

17. Don't realign the pointer unless you have made a change in it. It was bent that way for a reason.

18. Don't remove the shaft from the rotor unless clearly necessary. They can be ground and lapped without being removed.

19. Use plenty of cleaning fluid. It is cheaper than work spoiled by dirt.

20. Change the oil in the pump occasionally. Put in new filter cloths.

21. Don't use the paper oil pads a second time.

22. Don't scratch lines on wall of bearing recess to make the bearing fit. Get the special tool for this purpose.

23. Good fixtures and tools cannot take the place of common sense. T H I N K!

OPERATION NO. 1

TO REMOVE INSTRUMENT FROM CASE

1. To remove the instrument from the case requires extreme care. Before proceeding, study Figs. 10, 11 and 12.

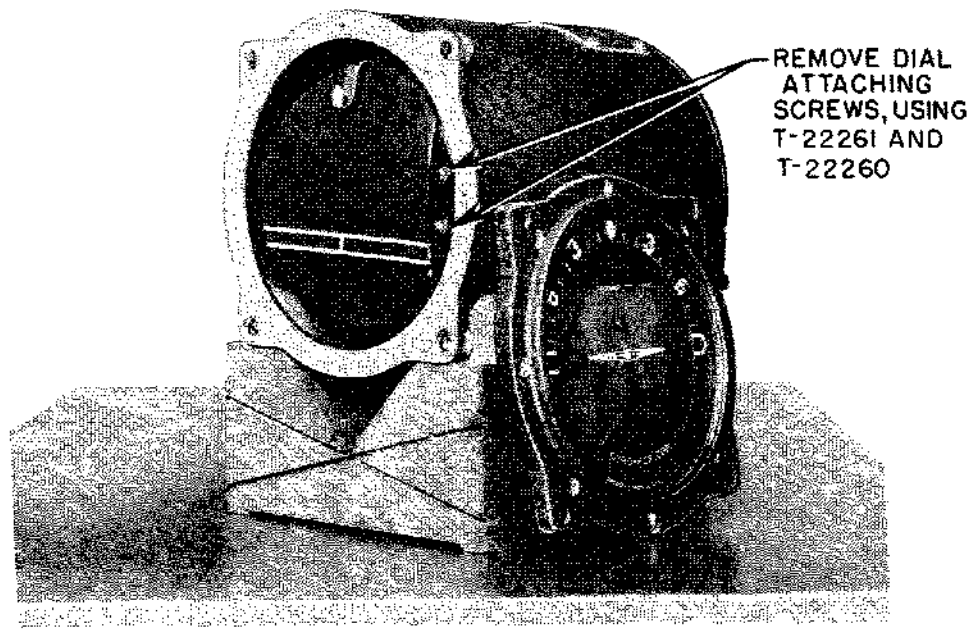


FIGURE 10 INSTRUMENT RESTING IN V-BLOCK WITH FRONT COVER REMOVED PREPARATORY TO REMOVAL OF INSTRUMENT FROM CASE

2. Remove the bezel assembly (front cover) by taking out the eight attaching screws. (One of these is a flat-head screw sealed with wax and stamped.)

3. Rest the instrument on a wooden V-block as shown in Fig. 10, and remove the dial by taking out the two screws and lockwashers (at the right directly behind the dial). Loosen with special off-set screw-driver, T-22261, and continue operation with geared, off-set screw-driver, T-22260.

4. Place the instrument face down on its front cover to protect the pointer bar as shown in Fig. 11.

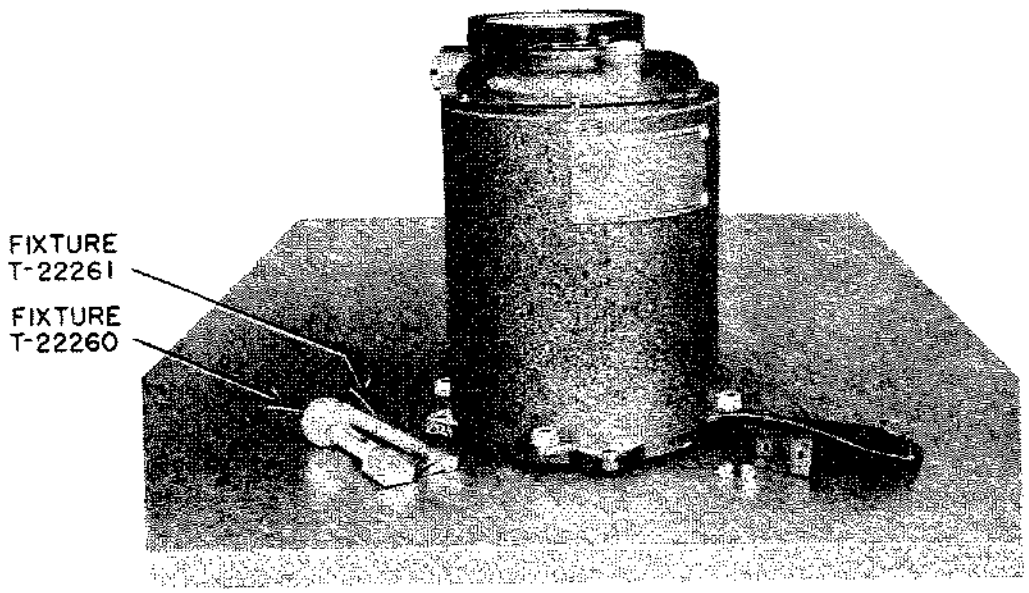


FIGURE 11 INSTRUMENT RESTING ON ITS FRONT COVER TO PROTECT POINTER BAR WHILE REAR COVER IS BEING REMOVED

5. Remove rear cover of case by taking out the six (6) attaching screws (one of these is a flat-head screw sealed with wax and stamped). The instrument is now ready to be removed from the case. (See Fig. 12.)

6. Grasp the gimbal, as shown, and with the thumb and forefinger tilt the gyro and pendulum assembly until the pointer bar is clear of the bracket within the case. A slight tilting movement will bring the pointer bar clear of the bracket. Now draw the instrument back until the gimbal bearing housing is in line with the recessed flange at the rear of the case. The instrument can now be withdrawn, taking care that the pointer does not come in contact with the end of the case.

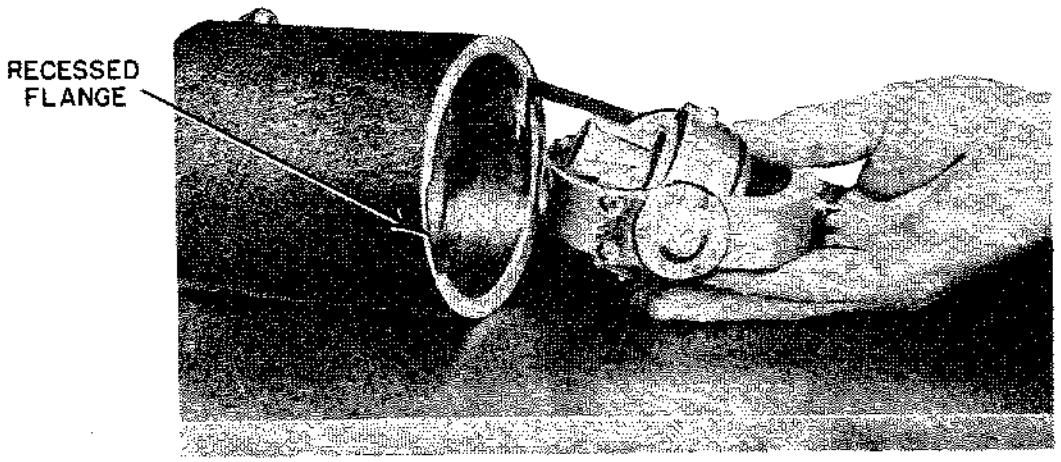


FIGURE 12 REMOVING THE INSTRUMENT FROM THE CASE

OPERATION NO. 1A

1. For Gyro-Horizons with caging device, it will be necessary, first, to remove the caging knob and dial from the front of the instrument. The instrument is withdrawn from the case as follows:

2. With the right hand inserted in the top of the case, hold the gyro housing and gimbal ring firmly and with the left hand raise the case off the V-block and turn it so that the front of the case is up. Care must be taken to prevent injury to the pivot in the front or to the pointer bar. See that the instrument is uncaged. (Turn bevel gear on outside of case to the fully uncaged position.) Holding the gyro securely, carefully turn the case clockwise one quarter of a turn. This will bring the pointer guide arm on the right-hand side of the instrument in line with the smaller of the two recessed portions of the back of the case. Carefully tilt the gyro housing so that the pointer bar clears the bracket in the front of the case, and then withdraw the instrument, observing through the front of the case to make sure that no part of it scrapes the walls and that the pointer does not come in contact with the end of the case.

OPERATION NO. 2

TO DISASSEMBLE THE INSTRUMENT

1. Hold instrument in the left hand, taking care not to damage the pointer, and proceed with disassembly as follows: (See Fig. 13.)

2. Remove pointer by loosening locknut and unscrewing pointer pivot screw.

3. Remove pointer guide pin, using wrench T-20000.

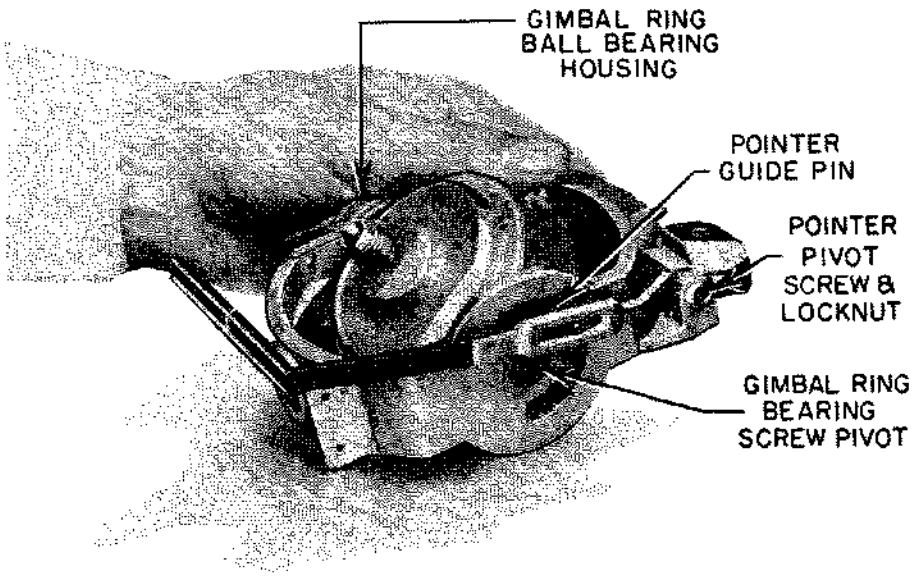


FIGURE 13 THE INSTRUMENT READY FOR DISASSEMBLY

3a. In order to remove the pointer guide pin from a Horizon which has the caging device, it will be necessary to bend the shank of a 7/32" open end wrench to conform to the curve of the gyro housing and to loosen the locking screw underneath the housing.

4. Remove gyro and pendulum unit assembly as follows:

(a) Remove ball bearing housing from gimbal ring by taking out the three flat-head countersunk screws, holding the gyro and pendulum unit with one hand to prevent injury.

(b) Loosen gimbal bearing screw pivot locknut with wrench T-20080, and partly unscrew the pivot. The gyro and pendulum unit can now be lifted out of the gimbal ring.

NOTE: Do not disassemble the rotor housing at this time. Put it in a safe place until ready for inspection and repair.

OPERATION NO. 2

INSPECTION AND CARE OF PIVOTS AND BEARINGS

Dirt and moisture as well as rough handling (a severe jar) or a combination of these will, in time, cause shaft and pivots to become pitted, rusty or damaged,any of which will cause an instrument to function improperly. Avoid handling of balls, races and pivots with fingers. Use tweezers.

1. With a 10-X magnifying glass, examine closely all pivots, shafts and bearing races and balls in the assembly to be repaired.

2. Balls and pivots that appear to have been roughened should not be used again. Pivots that show even minute flat surfaces or flaws should be replaced with new ones. If not too badly damaged, pivots may be reground and lapped.

NOTE: Discard any parts that show wear, rust, or dents. Discard the old paper oil pads.

3. Too much cannot be said regarding the cleanliness of shafts, pivots and bearings. Use only the special pump, T-22696, for cleaning ball bearings and do it as follows:

4. After the balls and race have been inspected, reassemble the bearing and place it over the four studs on the cone-shaped part of the pump. Place the housing over the bearing, and push it down several times. This will flood the bearing with clean oil after which it will be ready for reassembly or for storage. Keep the pump T-22696 filled with Special Instrument Oil.

5. Shaft, pivots and other polished surfaces should be carefully cleaned with Varsol and wiped dry.

6. If, during the course of assembly,the operations are interrupted for an appreciable period, all bearings and all pivots should be lubricated with Rust Veto. When operations are resumed, clean with Varsol, dry thoroughly, and apply Special Instrument Oil.

7. Never place new shafts, pivots or bearings loose in a box with other parts. A slight scratch or a particle of rust will affect their operation.

8. Spare shafts and pivots should be well covered with Rust Veto, wrapped in paper and stored in tightly covered glass jars.

9. Bearings may be kept in small glass jars with tight fitting covers, the bearings to be immersed completely in Special Instrument Oil.

NOTE: In carrying out the following operations always bear in mind:

Before inserting a bearing in a receptacle or housing, clean both the bearing and the housing.

Before inserting a pivot in a recess, clean both the pivot and the recess.

Before using a fixture, clean it thoroughly.

When reassembling an instrument, apply thread lubricant to the threads of the screws, and see that all screws are screwed in tight except when otherwise instructed.

GRINDING AND LAPPING THE PIVOTS

1. For grinding, an ordinary bench lathe may be used,screw pivots being held in a 1/4" chuck, shaft pivots in an 11/32" chuck and air pivots in a 7/16" chuck. The lathe should be operated at a moderate speed. The pivots must run perfectly true. Use an India Stone of fine grade on the pivot surface, lubricating as necessary with Special Instrument Oil. After each grinding operation, examine the pivot carefully with the aid of a 10-X magnifying glass. All pits must be removed before a pivot is in suitable condition for lapping.

2. The purpose of lapping the pivots is to ensure that they are perfectly smooth and round. For lapping, a bench type drill-press is used, operated at a speed of 1400 to 1600 r.p.m. The drill spindle must run true and without vibration or looseness. The machined table of the drill press must be square with the spindle within a tolerance of three thousandths of an inch. We recommend the use of a sensitive drill press made by Adolph Muehlmatt, Cincinnati, Ohio (No. 3 drill press with drive to give correct speed). One fixture T-23150 may be used for all pivots. The receptacle on one end of the fixture is made to fit the rotor of the Directional Gyro and the receptacle in the other end to fit the rotor of the Gyro-Horizon. Fixture T-23150 also includes a special holder with split bushings of different sizes in which screw pivots and air pivots may be inserted.

3. To insert screw pivots and air pivots in the fixture, proceed as follows:

A. For screw pivots, place two pivots, back to back with a spacer between them in the split bushing. If the pivots are short, they will protrude from the bushing on either side so that one or two threads are visible.

B. Insert the bushing and pivots in fixture T-23150 from the side which has the larger diameter opening and push the bushing in as far as it will go.

C. Place the fixture on a brass ring or other support which will hold the fixture securely without interfering with the pivot and bushing when the bushing is tapped in.

D. Place the brass plug or plunger over the top of the bushing,making sure that the brass plug rests concentrically on top surface of bushing without touching the pivot, and drive the bushing into the fixture by tapping it once sharply with a hammer. The assembly may

now be inserted in the proper receptacle and placed on the drill press for lapping.

NOTE: If pivots of greater length are to be lapped, the spacer will not be required--or if an even longer pivot is inserted it may be that only one pivot can be inserted at a time.

Air pivots are inserted in the same manner, but a larger bushing is used and no spacer is necessary.

4. Rotor shaft pivots are lapped without removing them from the rotor. It is only necessary to place the rotor and shaft assembly in its proper receptacle in fixture T-23150 and place the fixture on the machined surface of the drill press.

5. The air pivot in the Gyro-Horizon gimbal ring and rotor housing can also be lapped without being removed. This is done as follows: drill a #30 (.128"hole) in the exact center of the drill press table, 5/16" deep. Insert a male plug, T-21506, in the bearing recess opposite the pivot to be lapped. It will be necessary to make certain that the hole in the drill press table and the drill spindle are in alignment before starting to lap. Obtain two pieces of 1/8" drill rod, one piece approximately 5-1/2 inches long and the other approximately 7 inches long. If lapping the pivot in the gimbal ring, chuck the longer piece of drill rod in the drill chuck, making certain that it runs true. The drill press table can then be swung around and brought into alignment with this rod. If the rotor housing pivot is being lapped, use the shorter rod for bringing table into alignment. The rod is then removed and the lap inserted in the chuck. Now insert the end of the male plug in the hole in the drill press table. This will hold housing or gimbal in vertical position. Apply the lapping compound and proceed with the lapping in accordance with the following instructions.

6. Two laps are used, a roughing lap and a finishing lap. These laps are made of boxwood and are shown in Fig. 14. Instructions for making these laps are given on page 18.

CAUTION: The use of the roughing lap alone is not sufficient. To assure roundness of the pivot the finishing lap must always be used.

7. The lapping compound is Levigated Alumina. This can be obtained from the Norton Company, Worcester, Mass. For the roughing compound (used with the first lap) mix as follows: to 1/2 oz. of Houghton's Rust Veto or a light grease, add approximately a heaping teaspoonful of the Levigated Alumina and mix thoroughly. Thin this mixture slightly with Special Instrument Oil. Experience will show the proper thickness for the compound. It should never be thin enough for the Levigated Alumina to settle out. The finishing compound is also a mixture of Houghton's Rust Veto and Levigated Alumina and is mixed as follows: Fill a 4 oz. screw-cap jar three-quarters full of Houghton's Rust Veto. Add Special Instrument Oil until jar is nearly full. Heat the jar and contents until the Rust Veto and the Special Instrument Oil are thoroughly mixed and fluid. To this mixture add two teaspoonfuls of Levigated Alumina and stir until mixed thoroughly. Allow the mixture to cool without further stirring. This allows the coarser particles to settle to the bottom of the jar and the finer particles to remain in suspension. It may be necessary to stir the mixture slightly while cooling, but never so much that the coarser particles of the Levigated Alumina are held in suspension in the compound when it has entirely cooled. When mixed correctly, the compound will be a uniform light brown color. There will be a layer of the coarser particles in the bottom of the jar and the compound will be so thick that it will barely pour or run.

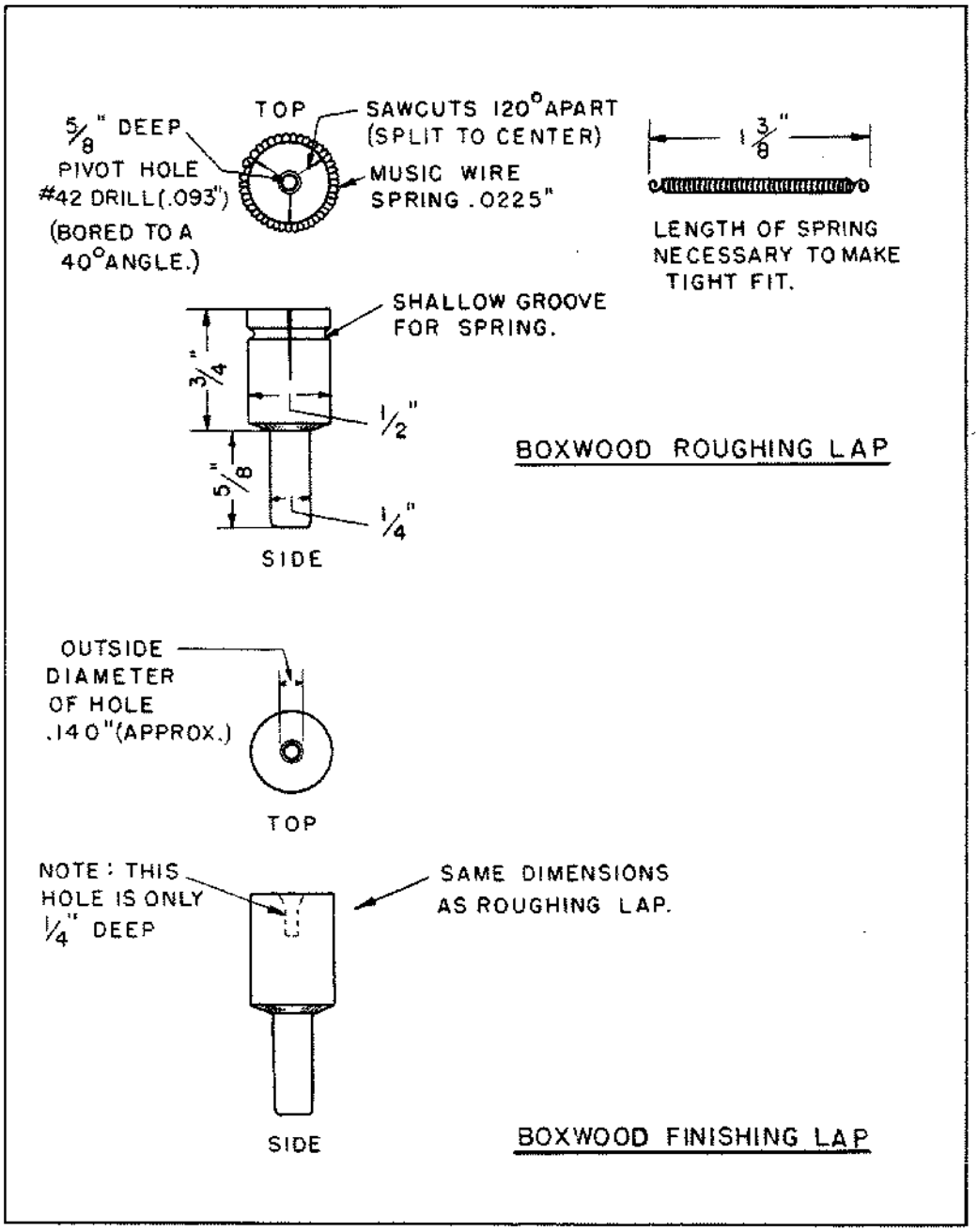


FIGURE 14 PRINCIPAL DIMENSIONS OF THE LAPS

8. Place the roughing lap in the chuck, and adjust the machined surface of the drill press so that when the lap touches the top of the pivot as it rests in fixture T-23150 on the machined surface of the drill press, the drill press lever is approximately 30 degrees below the horizontal. See Fig. 15.

9. Be sure the lap fits down over the pivot centrally. Then start the drill press and lower the lever to a point where the lap is just above the pivot. Apply a small amount of

the roughing compound to the pivot. Start turning the rotor either clockwise or counter-clockwise (whichever is most convenient)with the thumb and middle finger of the left hand. With the right hand alternately raise and lower the drill press lever so as to spread the lap a very slight amount as it comes down over the pivot. The strokes should be approximately the way one would count rather slowly - one, two, three, four, etc. and on each up-stroke the rotor should be given a fraction of a turn. At 100 strokes, stop lapping, clean off the pivot thoroughly and examine with a 10-X magnifying glass. All grinding marks must be removed and it should be noted particularly if the band is fairly sharp at its edges as this is an indication as to whether the lap is being brought down with too great a force and in consequence, spreading too much. If any grinding marks or scratches remain, repeat the lapping for fifty more strokes. Again clean off the pivot thoroughly and examine with magnifying glass. Repeat this procedure until all grinding marks and scratches are removed. It will be noted that there are very fine hair line scratches across the face of the lapped band. It is not intended that these be gotten out with the roughing lap, as its purpose is to prepare the pivot for finishing by removing the grinding marks and the large scratches.

CAUTION: If so much lapping is required that a distinct shoulder is made at the edge of the lapping band, remind the pivot.

10. When all defects are removed, take the roughing lap out of the drill press and insert the finishing lap.

11. Start the drill press and with a small wire loop apply a small amount of the finishing compound to the pivot. Start lapping as described above, applying a slight amount of pressure to the lap on each stroke. At the end of 25 strokes remove the pivot, clean it thoroughly and examine it with a 10-X magnifying glass. If the operations have been

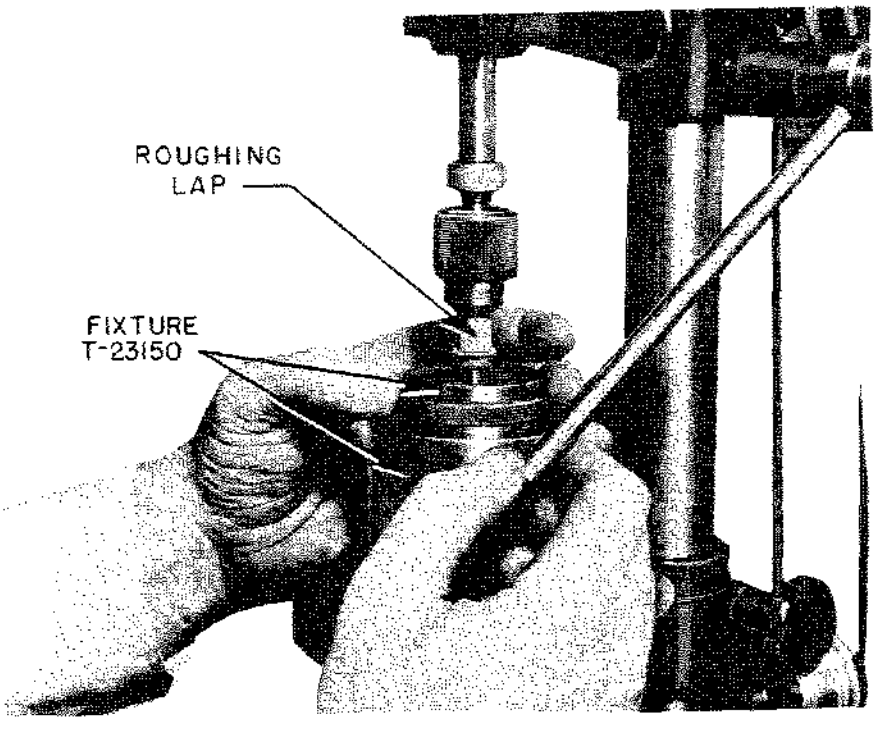


FIGURE 15 METHOD OF LAPPING PIVOTS

done correctly the band will be approximately .050 inch wide, the edges will be sharp and the surface will be highly polished, with very faint waviness or concentric bands around the pivot.

12. Examine the pivot very carefully for small pits or holes in the steel itself. Check the lapped surface with ball path checking gauge T-62462 and a magnifying glass. Any imperfections outside the gauge can be disregarded. The combination of split and solid laps gives a finish which is perfectly round and with a minimum of waviness. This very faint waviness produced with the finishing lap is to be desired, but care should be taken that it is never more than can be barely seen with the magnifying glass.

13. As an added caution, never lap one pivot more than fifty strokes with the finishing lap. As a rule, twenty to thirty strokes are all that will be required.

14. When finished lapping, clean the pivot carefully with tissue paper, and if it is not to be used immediately in reassembling the instrument, coat the pivot thoroughly with Rust Veto and put it in a safe place.

INSTRUCTIONS FOR MAKING THE LAPS

1. The first, or roughing lap, is made of boxwood to the dimensions shown in Fig.14. The sawcuts are made 120 degrees apart and are only for the purpose of guiding the splitting of the lap. They should never be so deep that they touch the lapping surface. It is best to turn the lap, bore out the angle for the pivot (40 degrees) and turn the shallow groove for the spring, and then with a jeweler's saw make the three cuts. With a heavy knife, carefully split the lap at these points, and then put the spring in place. The spring is wound from .0225 inch music wire on a 1/16 inch arbor or length of drill rod. Make it of such a length that it is difficult to stretch it over the lap with the fingers.

2. The finishing lap is made exactly the same except that the lap is left solid instead of being slotted and split, and, of course, no spring is used.

OPERATION NO. 4

INSPECTION, ALIGNMENT AND BALANCE OF THE POINTER

1. When a Gyro-Horizon is disassembled for repair, the pointer must be carefully inspected.

2. Pointer shaft pivot bearing surfaces must be smooth and free from rust. Rust or worn spots will increase friction, thereby affecting the free movement of the pointer.

3. If shaft is pitted, rusty, or worn, it will be necessary to replace it with a new one.

4. In handling the pointer, be careful not to injure the radium luminous paint on the bar.

POINTER SHAFT RENEWAL

1. If it should be necessary to remove a pointer shaft and install a new one, proceed as follows:

2. With the pointer resting on the receptacle T-27464 as shown in Fig. 16, the shaft may be driven out of the pointer with the aid of a piece of drill rod approximately 1-1/2 inches long and of a diameter slightly less than the diameter of the shaft. One end of the rod must be countersunk to conform to the angle of the pivot.

3. To install a new shaft, place the pointer on fixture T-27464 as before. Start the shaft in the hole with the fingers, then place fixture T-21517 over the top of the shaft and with a hammer carefully tap it into the hole in the pointer. Be sure that the shaft lines up exactly with hole and enters straight without shearing the side walls.

NOTE: If the shaft does not fit tightly in the hole, remove it, and punch the outside of the pointer, using a 5/32 inch flat-face punch in two places on each side (see Fig. 16) to close the hole slightly. Then insert the shaft as described above and tap it into place. The shaft must have a tight fit in the pointer hole.

4. The distance that the shaft protrudes from the pointer, measuring from the tip of the shaft to the pointer surface on the upper side when the bar is pointed up, should be approximately 1/8-inch. (See Fig. 16.)

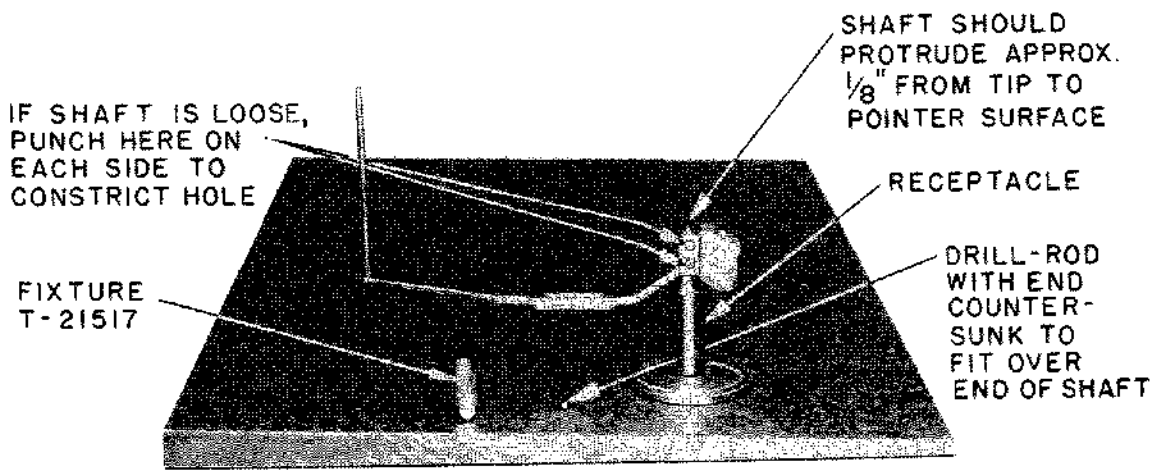


FIGURE 16 METHOD OF SUPPORTING THE POINTER FOR POINTER SHAFT RENEWAL

ALIGNMENT (See Fig. 17.)

1. Clean fixture T-21529, pointer shaft pivots, and slot, with Varsol and dry.

2. Slide gauge plug (A) for pointer slot, out as far as it will go. Place pointer shaft pivots in screw pivot holders, and adjust carefully so that pointer bar is parallel to and just touches both faces (base and side) of gauge (B). The pointer should just touch the raised shoulder of the gauge as shown at C. Pointer should fit snugly in pivot holders without play. Move gauge plug (A) carefully until it passes through pivot slot.

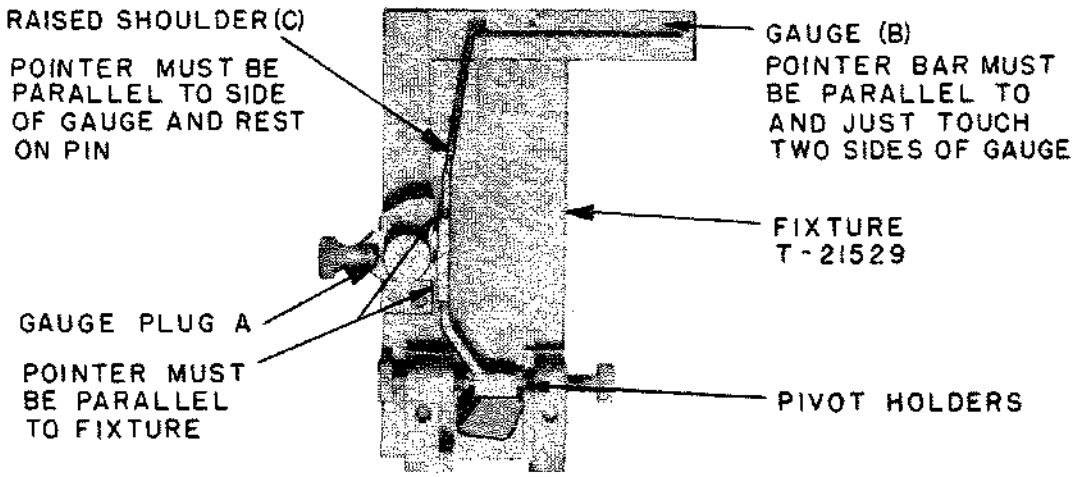


FIGURE 17 ALIGNING THE POINTER

3. If necessary the pointer may be bent slightly to secure proper alignment, but extreme caution should be exercised as it can easily be broken. See that the guide pin enters the slot easily without binding and with not more than .001 inch clearance. If more than .001 inch clearance is noted, it will be necessary to close up the slot by carefully squeezing the sides together in a smooth jaw vise. See Fig. 18. If slot is too narrow it will be necessary to grind out the sides with a flat India oil stone. Always exercise extreme caution to keep the sides of the slot parallel.

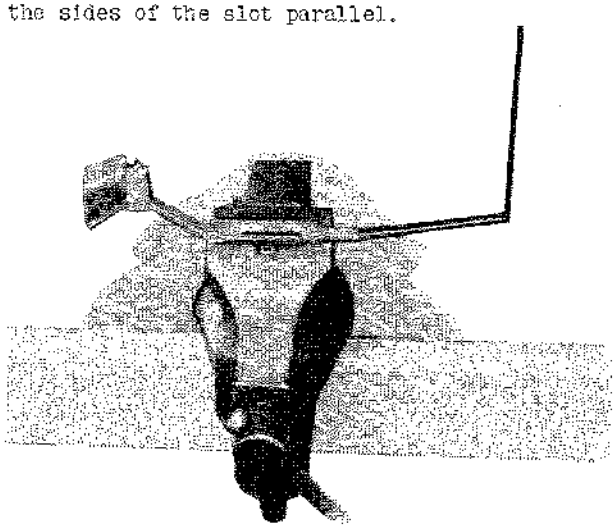


FIGURE 18 METHOD OF CLOSING UP POINTER SLOT TO OBTAIN PROPER CLEARANCE WITH POINTER GUIDE PIN

BALANCE

1. Clean fixture T-19645 and pointer pivots with Varsol and dry.

2. Place pointer with shaft bearing surfaces resting on knife edges of fixture T-19645 as shown in Fig. 19, and protect from drafts while balancing, as a very slight disturbance will keep the pointer swinging continuously.

3. The pointer should be balanced in two positions, position No. 1 as shown in Fig.20, with the pointer bar uppermost, and position No. 2, as shown in Fig. 21, with the pointer bar horizontal. In Fig.20 the weight of the entire pointer may be considered to be divided bilaterally as indicated by the dotted line. If the pointer will not remain as shown, with the bar uppermost, the weight is not equally divided, and it will be necessary to add or remove weight from one side or the other of the lead counterweight, at A or B.

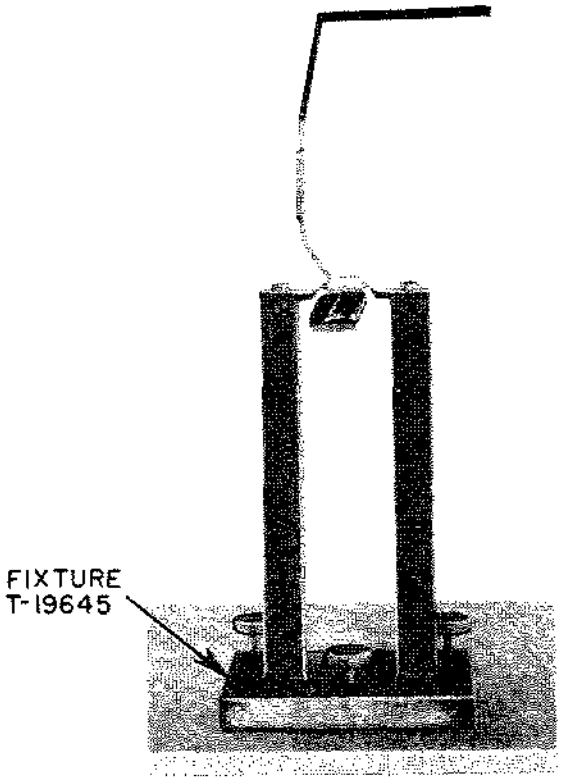


FIGURE 19 BALANCING THE POINTER

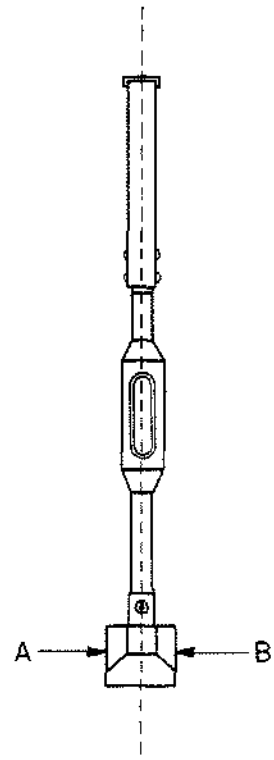


FIGURE 20 BALANCE OF THE POINTER BAR IN POSITION NO. 1, VERTICAL

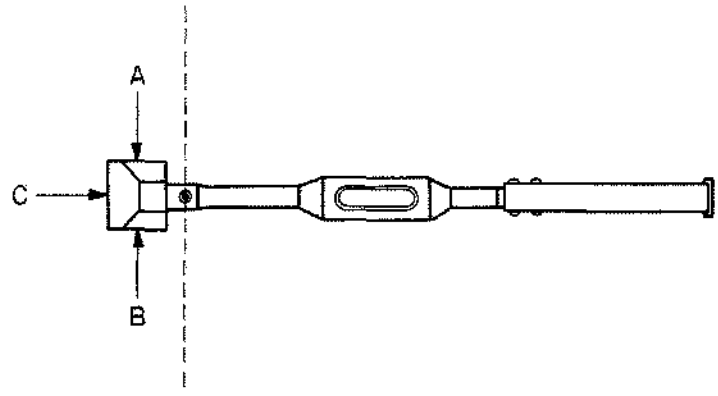


FIGURE 21 BALANCE OF THE POINTER BAR IN POSITION NO. 2, HORIZONTAL

When pointer remains vertical it is balanced in position No. 1. To balance the pointer in position No. 2 as shown in Fig. 21, remove or add equal amounts of lead at A and B or at C, the bottom of the counterweight, until the pointer remains horizontal. Recheck in position No. 1 to see that the pointer still remains vertical. If it does not remain vertical, weight has been removed unequally, and this condition must be rectified, starting with the balance in position No. 1 and No. 2 as described. When the pointer will remain in these two positions it will remain in all intermediate positions and may be considered properly balanced.

OPERATION NO. 5

INSPECTION, REPAIR AND BALANCE OF THE GIMBAL RING

1. Remove the bearing from the gimbal ring using bearing extractor, T-21510. Inspect as described in Operation No. 3, Page 13.

2. Inspect the air pivot for defects and if necessary to install a new one, proceed as follows:

3. Place female plug, T-20787 in bearing recess. Grip the shoulder of the pivot in a 7/16-inch spring collet in a bench lathe. Slide tail stock center into female plug, allowing tail stock to rest free on bed of lathe. With the lathe spindle locked and the pivot shoulder gripped tightly, slowly turn the gimbal ring and pull back at the same time until the pivot is removed.

4. Champfer the edges of a new air pivot slightly with an India oil stone to prevent shearing the walls of the recess as the pivot is pressed into place.

5. Clean fixture, T-22238 and plug T-22240 with Varsol and dry thoroughly.

6. Remove female plug, T-20787, and place the gimbal ring in fixture, T-22238 so that the ball bearing recess fits over the stud in the end of the fixture.

7. Clean the air pivot, oil the shoulders with Special Instrument Oil, and place in the recessed end of the plug, T-22240. Insert through guide hole in fixture, seeing that the pivot enters squarely in recess of gimbal ring.

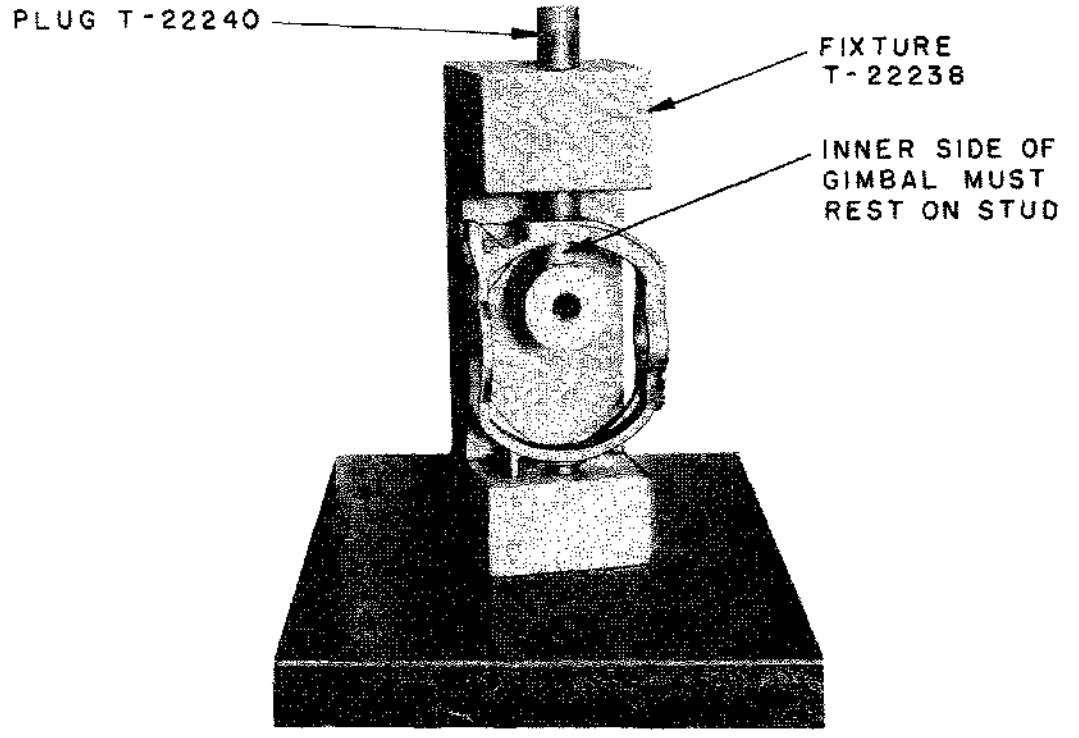


FIGURE 22 INSTALLING THE AIR PIVOT IN THE GIMBAL RING

8. Turn the fixture on end with plug uppermost (see Fig. 22) and press pivot into place with an arbor press or tap into place with a lead hammer. CAUTION: Be sure that the pivot is seated firmly in the bottom of the recess.

9. Check to insure that the pivot is tight enough in the recess, using fixture T-22023 as shown in Fig. 23. The three prongs are inserted in the holes of the pivot and the movable arm which is connected with the spring is turned until it just touches the stop. The pivot must not move. If it does move there are two ways of tightening it in the recess. The first and best way is to remove the pivot and plate the shoulders so as to increase the diameter. The second method is to peen in the metal around the pivot with a very small flat-faced punch (1/32 inch or slightly smaller). Care must be exercised not to peen the metal in excessively or distort the gimbal ring.

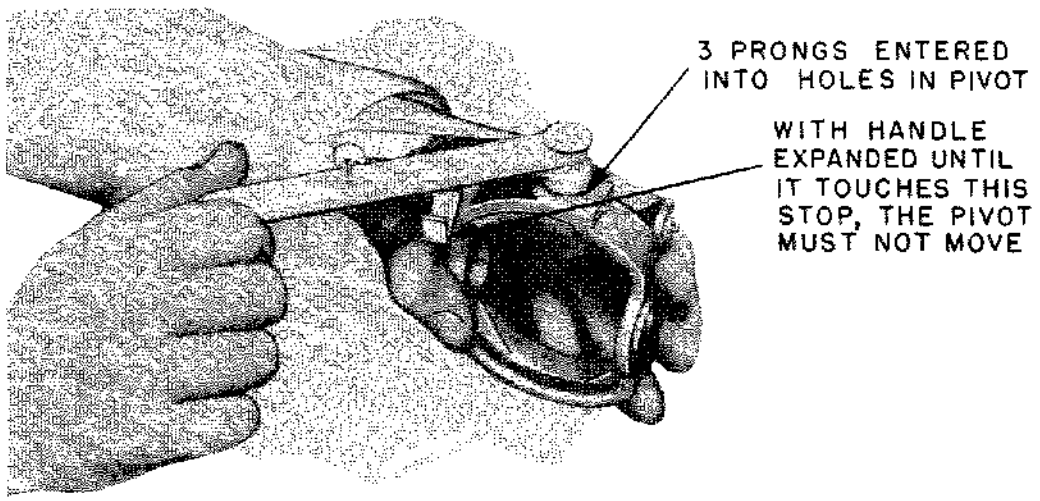


FIGURE 23 CHECKING TO INSURE THAT THE AIR PIVOT FITS TIGHTLY IN THE RECESS

TO INDICATE GIMBAL RING PIVOT FOR CONCENTRICITY

1. Place female plug, T-20787, in bearing recess in gimbal ring, place gimbal ring in fixture, T-19660, and screw in adjusting screw until gimbal ring is free to turn without end play, and without binding. Indicate large diameter of pivot, turning the gimbal ring in the fixture. The indicator should not show a greater variation than .001" all around. Turn gimbal ring 45 degrees on each side of the horizontal (its operating position) and indicate as before. The tolerance in this case must be within .0005". (See Fig. 24.)

2. If greater errors are shown, remove the gimbal ring from the fixture, place a bakelite block against the shoulder of the pivot at the high spot and tap the block lightly with a hammer in order to move the pivot into better alignment. (See Fig.25) Check for tightness, using fixture T-22023, as instructed in paragraph 9, above, and replace in fixture T-19660, to indicate again. Repeat operations until pivot is found to be within the limits given.

NOTE: The concentricity of the gimbal ring pivot can be held within .0002" by using a little care in straightening the pivot with the bakelite block and hammer. Wherever tolerances are noted, they represent the maximum limit permissible. With a little extra care the tolerances can be held almost to zero.

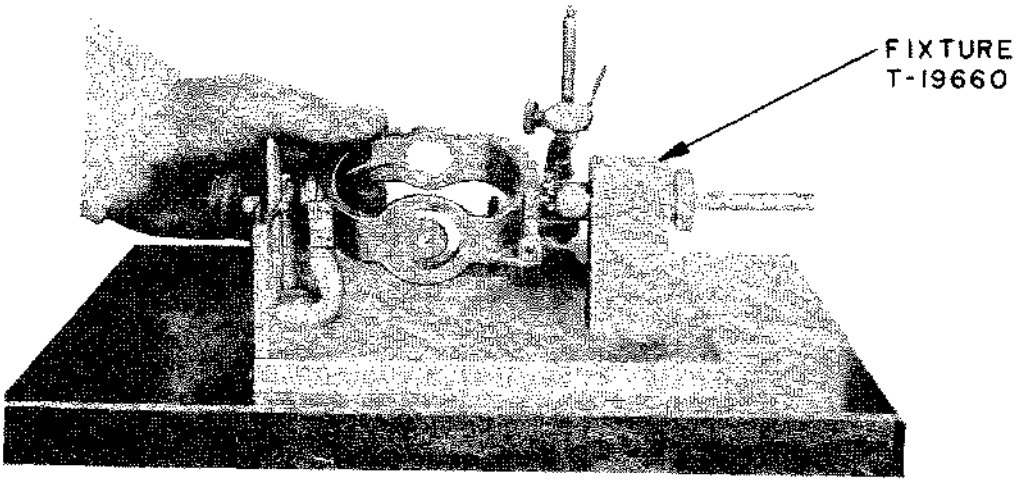


FIGURE 24 CHECKING THE CONCENTRICITY OF THE AIR PIVOT IN THE GIMBAL RING TOLERANCE, .0005 INCH.

TO REPLACE BEARING IN OPPOSITE END OF GIMBAL RING

1. Remove female plug T-20787 and replace bearing as follows:

2. Clean recess in gimbal ring with Varsol and dry. Make sure that bearing race fits properly in recess before inserting assembled bearing. Insert the two paper oil pads. Saturate with Special Instrument Oil.

3. Flush out the assembled and inspected bearing with the special pump, T-22696. Press assembled bearing into recess, with retaining washer out, and be sure that bearing and oil pads are thoroughly saturated with Special Instrument Oil.

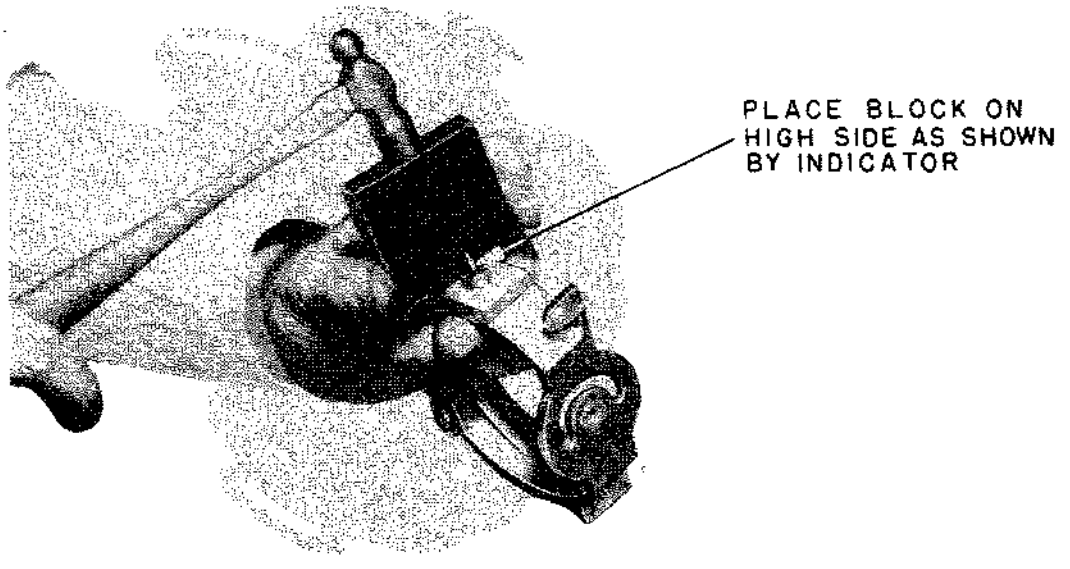


FIGURE 25 METHOD OF ALIGNING THE AIR PIVOT IN THE GIMBAL RING

PREPARING GIMBAL RING FOR BALANCING

1. Place gimbal ring assembly in fixture T-19660, and screw in adjusting screw until the gimbal ring has barely perceptible side play. There must be NO BINDING.

NOTE: When using fixture T-19660 for other than calibrating purposes, be sure to remove air retainer ring case from the adjusting screw plug of the fixture.

2. Install gimbal screw pivot and locknut in side of gimbal ring and screw pivot in flush with face of locknut.

3. Attach dial, fitting over dowel pins with two attaching screws and lockwashers.

4. Attach the pointer, placing the shaft between the pointer bearings and screwing in on the threaded bearing until the pointer is held firmly across the center of the dial. Tighten locknut with fingers.

NOTE: The pointer bearings should be inspected for rust and wear and replaced if necessary. The fixed bearing can be withdrawn with pliers and a new one pressed in. This will seldom be necessary, however.

The pointer should clear the gimbal ring and dial at all points but should not be more than 9/32 inch from the gimbal ring as measured from the outside of the pointer to the face of the gimbal ring at the guide pin slot.

5. Replace gimbal ball bearing housing as follows: Clean thoroughly with Varsol and dry. Insert two new paper oil pads. Flush out the assembled bearing with special pump T-22696. Press ball bearing assembly into place, spring retaining washer out. Be sure that bearing fits snugly and bottoms in the recess, but is not so tight that insertion and withdrawal is difficult. Insert aluminum ring (air retainer washer, large) being sure that countersunk recess in ring is facing out. Insert air seal ring (flat washer) into countersunk recess in ring, first making sure that it fits easily over the pivot in the gyro housing and is perfectly flat. The clearance between the air seal ring and the pivot should be not more than .0005 inch. Add air retainer washer (small) and insert spring locking ring. Saturate oil pads with Special Instrument Oil. Do not allow oil to get on the air seal ring.

6. When assembly is complete, be sure that the air seal ring does not stick between the retaining washers. It should fall of its own weight, when assembly is held in a vertical plane and turned one way or the other. Air seal ring must be perfectly flat.

7. Attach housing assembly to gimbal ring with three flat-head attaching screws.

NOTE: AIR SLOT IN SIDE OF HOUSING MUST BE IN LINE WITH AIR SLOT IN GIMBAL RING.

8. Be sure that spacing shims are in place, with holes in line with holes in housing.

9. Inspect lead weight on under side of pointer supporting arm of gimbal ring and if necessary replace. This weight should be approximately 1/16 inch thick and 5/16 inch in diameter.

BALANCING THE GIMBAL RING

1. The gimbal ring must be balanced so that it will remain in any position. This is accomplished by adding or removing lead from the balancing weight on the left-hand side of the gimbal (facing the dial). In normal repair, it is seldom necessary to replace this weight but for the sake of illustration we will assume that a new one has been attached.

2. Turn the gimbal ring so that the pointer bar is vertical (see Fig.26) and tap base of fixture with rubber hammer. The gimbal ring will swing to one side and come to rest with its heavy side down. Remove weight from this point until the gimbal ring will stand in the vertical position.

3. Turn the gimbal ring so that the pointer bar is horizontal and tap the base of the fixture with the rubber hammer. The left side of the gimbal ring will normally be heavy and it will be necessary to remove lead equally from the top and the bottom of the lead weight or from centre until the gimbal ring will stand in this position. (See Fig. 27.)

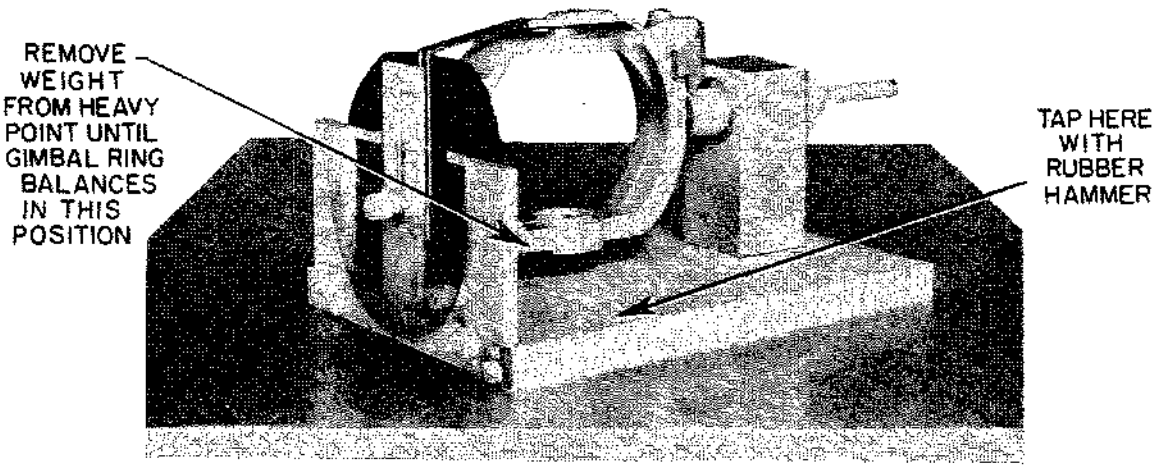


FIGURE 26 BALANCING THE GIMBAL RING, POINTER BAR VERTICAL

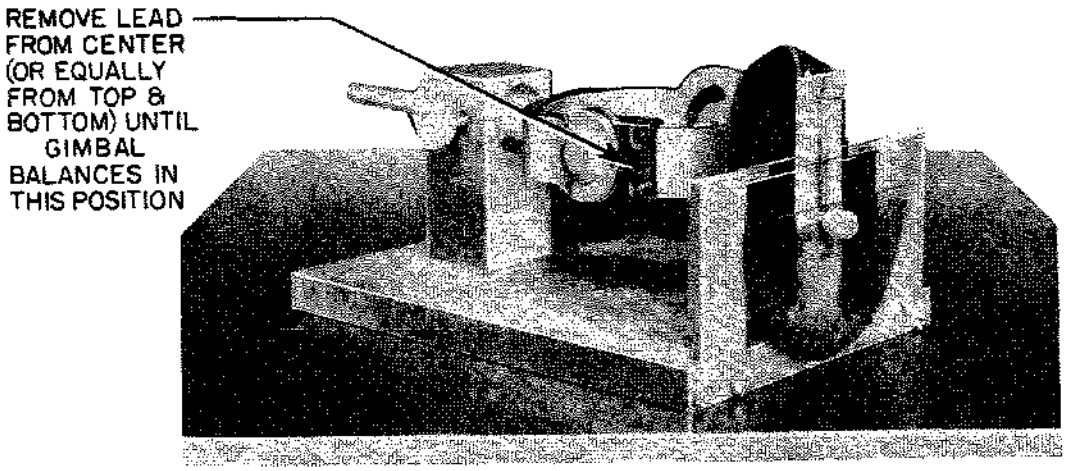


FIGURE 27 BALANCING THE GIMBAL RING, POINTER BAR HORIZONTAL

4. Recheck the balance in the vertical position.

NOTE: The gimbal ring must remain in any position when base of fixture is tapped with rubber hammer. If necessary lead can be added with a soldering iron, but care should be exercised to remove all trace of the flux. When balancing, the pointer bar must be exactly in the centre of the dial.

5. When the balance is complete, coat the lead weight with Copad varnish. Leave the gimbal assembly in the balancing fixture and place the complete assembly in the tool cabinet or where it will be safe and protected from dust and dirt until needed for further assembly.

OPERATION NO. 6

DISASSEMBLY OF GYRO HOUSING

1. Take out the four screws at the bottom of the gyro housing, remove the pendulum assembly and put it to one side until ready for inspection and reassembly.

2. Remove the three screws from rotor housing cap and take out the rotor. Lay the rotor housing and cap aside until ready for inspection and reassembly.

NOTE: Protect the air pivot from rust with coating of Rust Veto and cover bearings with tissue paper discs.

OPERATION NO. 7

REPAIR AND BALANCE OF THE ROTOR

1. The rotor assembly can be considered the most vital part of the instrument and for this reason the instrument repair man is cautioned that too much care cannot be taken in its reassembly and balance. A certain amount of experience is necessary before one becomes proficient in the different operations, but at all times the greatest pains and care should be exercised.

2. Inspect the rotor and shaft (see Operation No. 3) and, if necessary, remove the shaft from the rotor as follows:

TO REMOVE THE SHAFT

1. Remove both receptacles from fixture, T-21141 (arbor press) and fasten the fixture securely to the bench in a place where it may be left permanently in position.

2. Place the rotor on the machined surface of the press, and with fixture, T-21514, seated on the shoulder of the shaft, press the shaft out of the rotor. Do not allow fixture, T-21514, to scrape the walls of the rotor as it passes through.

CAUTION: Never remove shaft from rotor unless absolutely necessary.

TO REPLACE THE SHAFT

1. Place the two receptacles on the machined surface of the arbor press T-21141. The receptacles fit over two dowels in the press. Clean the receptacles with Varsol and wipe dry. (For Directional Gyros place the larger of the two receptacles on the arbor press and center one of the special small brass washers or spacers in the bottom of the receptacle.)

2. Clean the rotor thoroughly dipping in Varsol. Dry with soft tissue paper and air jet.

3. Place the rotor in the receptacle, bucket side down. (Directional Gyro rotors, either side down.)

4. Champfer the shoulder of the shaft with an oil stone to prevent shearing the wall of the rotor as the shaft is pressed in.

5. Clean the shaft with Varsol and dry with tissue paper. Lubricate with Special Instrument Oil.

6. Insert shaft in special, rotor-shaft sleeve guide on the lower end of the arbor press ram with the champfered shoulder of the shaft down. By means of the arbor press lever, lower the shaft gently until it starts to enter the rotor. (See Fig. 28). Press shaft in one quarter of its length. Slack off slightly on the lever and turn the rotor one quarter turn. Continue pressing the shaft in, one quarter of its length each time, turning the rotor one quarter turn between each operation until the shaft is home.

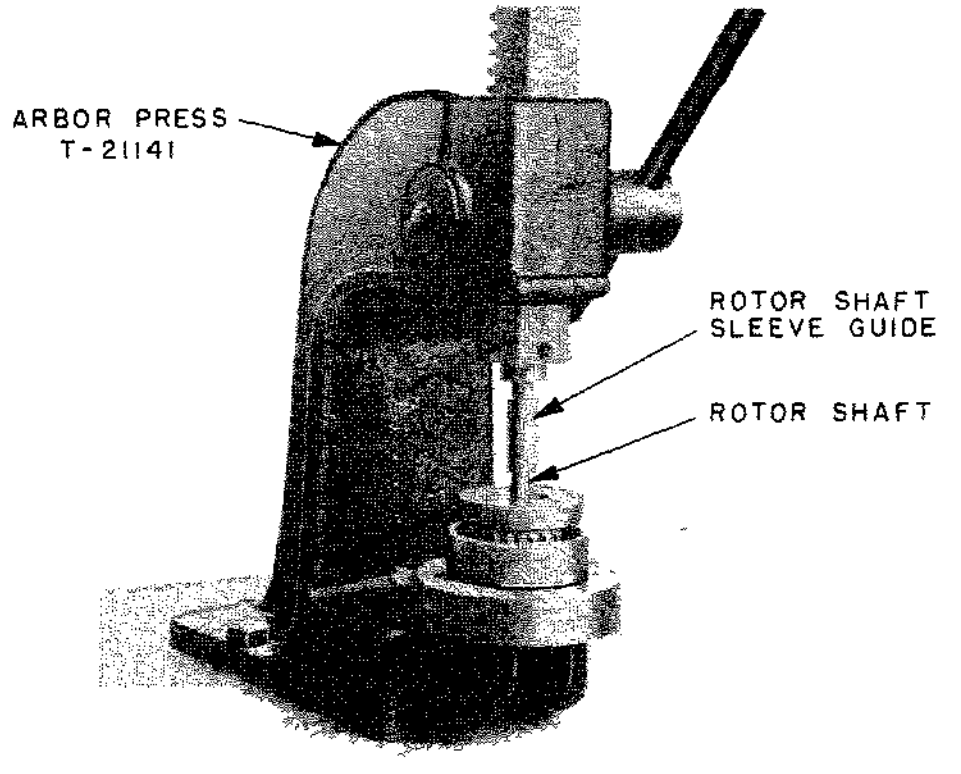


FIGURE 28 PRESSING THE SHAFT INTO THE ROTOR

NOTE: For Gyro-Horizons, the position of the shaft in the rotor is checked with gauge, T-22671. The inner or sliding part of the gauge must be flush with the outer part when applied to bucket end. If necessary to move the shaft a slight amount to meet this condition, it can best be accomplished by placing the rotor in the receptacle of the arbor press with the high side up, and while applying a moderate pressure on the shaft, tapping the top of the ram with a fibre mallet. In this way the shaft can be moved a very small amount at a time.

For Directional Gyros, the position of the shaft in the rotor is checked with gauge T-22672. The inner or sliding part of the gauge must be flush with the outer part when applied to each side of the rotor.

CHECKING THE CONCENTRICITY OF THE ROTOR

1. Before balancing the rotor it is necessary to indicate the outside diameter in order to determine concentricity.

2. Place the rotor in fixture T-19661 and tighten the adjusting screw until the rotor has no end-play between the bearings, yet does not bind. (See Fig. 29.)

3. Use a standard indicator at the top surface and two sides of the rotor, revolving the rotor slowly. If any of these surfaces varies more than .0005" during a complete revolution of the rotor, we advise that the rotor and shaft be returned to the factory,where special equipment is available for rectifying this condition.

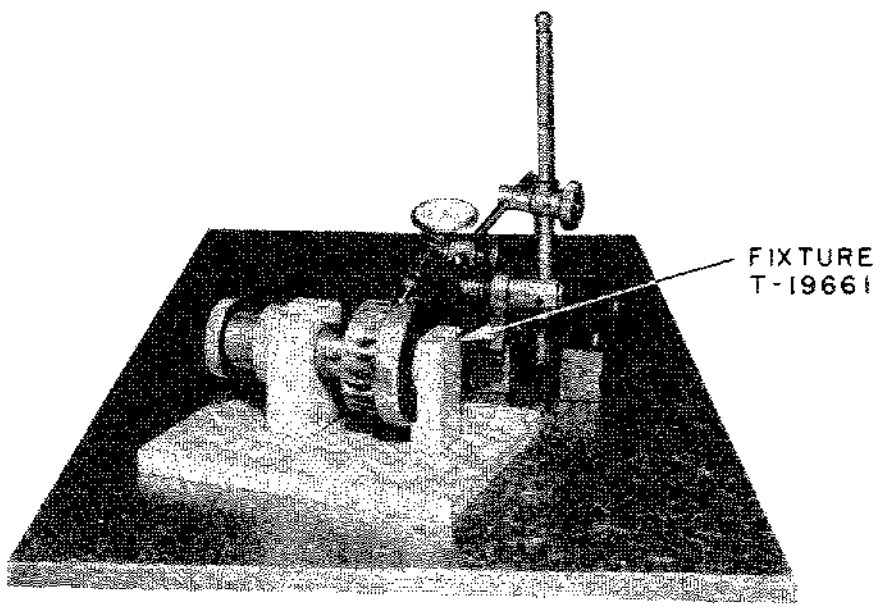


FIGURE 29 CHECKING THE CONCENTRICITY OF THE ROTOR
TOLERANCE, .0005 INCH

DYNAMIC BALANCE OF THE ROTOR

1. If it were possible to machine the rotor perfectly true and have the material perfectly homogeneous, dynamic balance would not be necessary. This can not be obtained in practice, however, as the rotor is always slightly eccentric and the material has some portions that are heavier than others. The dynamic balance consists of finding these heavy portions or places by counter-balancing them with Vulcatex putty and then drilling or removing material from the wheel at these heavy spots. The heavy spot on one side of the wheel is no indication for the opposite side so each side of the wheel will have to be treated as a separate problem, but at the same time working the two together.

2. The results which will be obtained in dynamic balancing depend largely upon the experience of the balancer and upon his sense of feeling in detecting unbalanced conditions. In addition, no two rotors will present the same problem. Therefore, rather than attempt to set down any hard and fast instructions, we will simply outline the procedure which should, in general, be followed. Considerable experience will have to be acquired before one will be able to make the dynamic balance quickly and with the degree of accuracy reached at the factory.

3. Clean two inspected bearings (Part No. 125820) with the special pump, T-22696, and insert them in the sliding bearing housings of fixture T-22496. Holding the fixture in the left hand with locking screws up and toward the right, adjust the lower sliding housing so that it projects approximately 5/16 inch inside of ring, and tighten the knurled locking screw. Holding the rotor in the palm of the left hand and the fixture in the right hand, carefully lower the fixture until bearings and pivots are in line and lower pivot is resting on the lower bearing. Carefully lower the upper bearing onto upper pivot, turning the housing as the pivot enters the bearing. Care should be exercised that the upper housing does not snap into place, as this will injure the pivot or the bearing. Holding the fixture carefully in the left hand with the loose housing uppermost, revolve the rotor with a slight stroke of the hand, and pressing the upper bearing housing down slightly and turning it at the same time to prevent any possibility of end-play, tighten the locking screw. At this time it may be well to caution the operator that bearings and pivots must be scrupulously clean. Bearings must be the best and pivots must be lapped as described in operation No. 3.

4. Holding the fixture firmly in the left hand, as shown in Fig. 32, apply a jet of

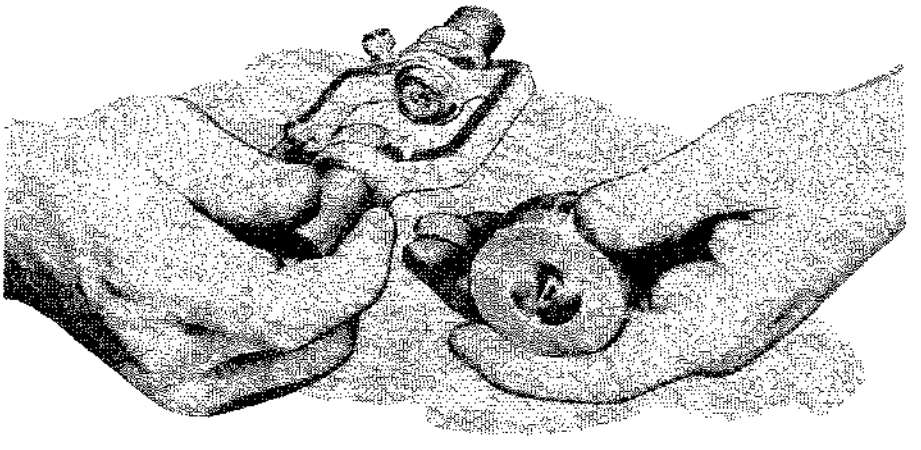


FIGURE 30 PLACING THE ROTOR IN FIXTURE T-22496 FOR THE DYNAMIC BALANCE

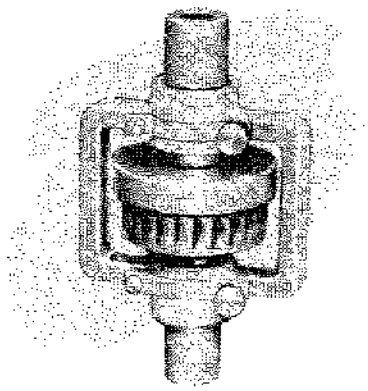


FIGURE 31 ROTOR IN FIXTURE T-22496 READY FOR THE DYNAMIC BALANCE

air to the buckets of the rotor for a few seconds. If air at a pressure of approximately 35 lbs. per square inch is used from a nozzle 1/16 inch in diameter four or five seconds is enough to give the rotor sufficient speed for the first check. Never overspeed the rotor, as a badly out of balance condition at high speed will injure the bearings or pivots.

5. Hold the fixture firmly between the thumb and forefinger as shown in Fig. 32. Any vibration which is felt is caused by an out of balance condition dynamically. If a rotor which is known to be in good dynamic balance is available, it is advisable to experiment so as to learn the feel of dynamic unbalance. To do this, place the rotor in the fixture, spin it as described above, and feel for vibration. Now throw the rotor out of balance by applying a small piece of vulcatex to the face of the rotor near the rim, spin the rotor again, and note the vibration.

6. To continue with the balance, stop the rotor and apply a small amount of Vulcatex (about the size of a 1/8 inch ball) to the face of the rotor near the rim on the end at which the greatest vibration was noticed. Again apply the air jet to the rotor and note whether the vibrations have been increased or decreased. If increased, move the Vulcatex 180° around the face of the rotor and again check for vibration. If vibration is the same, move Vulcatex 90° from starting point and repeat check. At one of these four points it will be noted that vibration is reduced. Shift the Vulcatex a slight amount each side of this point or until no further improvement can be made with the amount of Vulcatex origin-

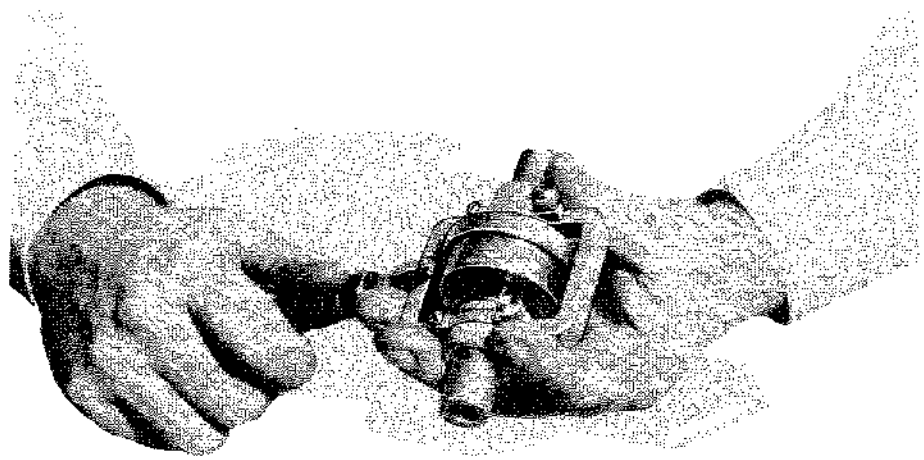


FIGURE 32 SPINNING THE ROTOR FOR THE DYNAMIC BALANCE

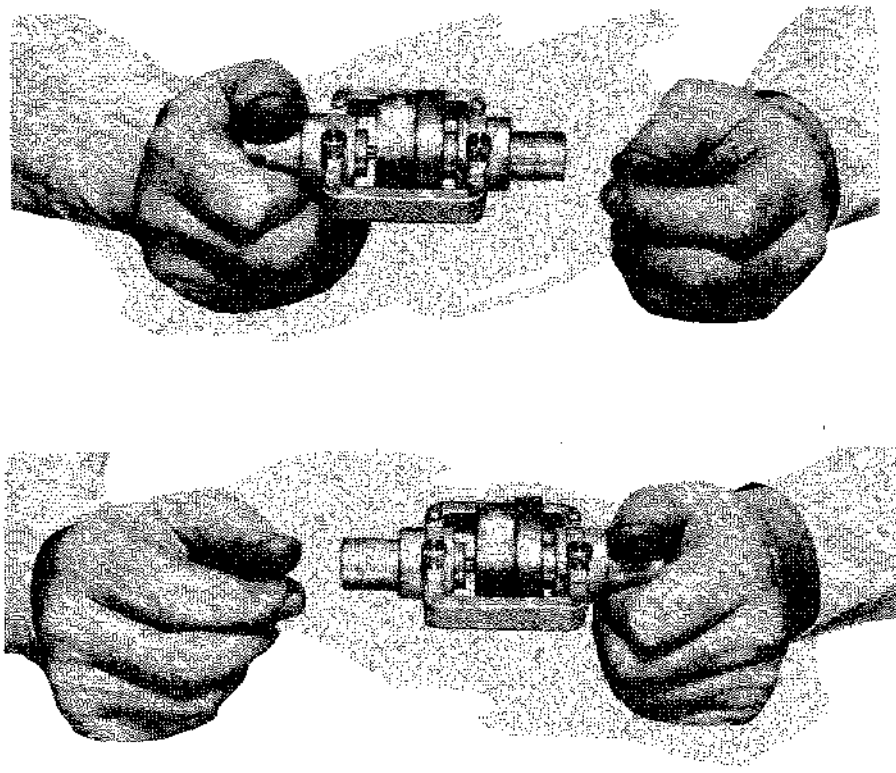


FIGURE 33 METHODS OF HOLDING THE ASSEMBLY WHEN FEELING FOR DYNAMIC UNBALANCE

ally started with. When this point is found and vibration is still present, remove or add Vulcatex until no vibration can be felt. Treat the opposite face of the rotor in the same manner. It will be noticed that changing weight on one side of rotor affects the balance on opposite side a slight amount. Continue changing the Vulcatex on the two sides of the rotor until no further improvement can be made.

7. When satisfied with the feel of the rotor, remove it from the fixture and holding it level with the eye, sight across the face of the rotor and mark a line with a pencil, exactly opposite the Vulcatex. This pencil line marks the heavy spot of the rotor and the place where it is necessary to remove weight. Make a centerpunch mark at a point on this line (3/4-inch out from the center for Gyro-Horizons, and 3/32-inch in from the rim for Directional Gyros).

8. Proceed in the same manner, marking the heavy point on the opposite face of the rotor. Drill at these points, using a #36 drill and removing an amount of material which is approximately half the volume of the Vulcatex.

9. Clean the rotor and pivots thoroughly with Varsol, dry, and replace in fixture. Repeat the procedure outlined above, note vibration, and re-drill if necessary. When satisfied with the feel of the rotor, apply the air jet long enough to bring the rotor up to or slightly in excess of its normal operating speed. Again feel for vibration and correct as outlined before. The rotor cannot be considered as properly balanced dynamically until it will run smoothly with no discernable vibration at its normal operating speed.

NOTE: Make two discs of brass with a diameter slightly less than that of the bearing and approximately 1/32 inch thick. Insert them back of the bearings in the sliding housings of the fixture T-22496. These discs will prevent dirt from entering the bearings while the fixture is not in use, and also will make it easier to flush out the bearings with the special pump.

OPERATION NO. 3

PREPARING THE ROTOR HOUSING FOR THE ROTOR

1. Remove and inspect the two ball bearing assemblies and lay them aside in a safe place, marking them for replacement in their respective recesses.

CAUTION: Never remove an air pivot unless damaged beyond repair. See Operation No. 3.

2. Inspect air pivot for defects and if necessary to install a new one,proceed as follows:

3. Place female plug, T-20757, in bearing recess. Grip the shoulder of the pivot in a 7/16-inch spring collet, in a bench lathe. Slide tail stock center into female plug, allowing tail stock to rest free on bed of lathe. With the lathe spindle locked and the pivot shoulder gripped tightly, slowly turn the rotor housing and pull back at the same time until the pivot is removed.

4. Champfer the edges of a new air pivot slightly with an India oil stone to prevent shearing the walls of the recess as the pivot is pressed into place.

5. Clean fixture, T-22239, and plug, T-22240, with Varsol and dry thoroughly.

6. Remove female plug, T-20787, and place the rotor housing in fixture T-22239 so that the ball bearing recess fits over the stud in the end of the fixture.

7. Clean the air pivot, oil the shoulders with Special Instrument Oil, and place in the recessed end of the plug T-22240. Insert through guide hole in fixture, seeing that the pivot enters squarely in recess of rotor housing.

8. Turn the fixture on end with plug uppermost, (see Fig.34) and press pivot into place with an arbor press or tap into place with a lead hammer. CAUTION: Be sure that the pivot is seated firmly in the bottom of the recess.

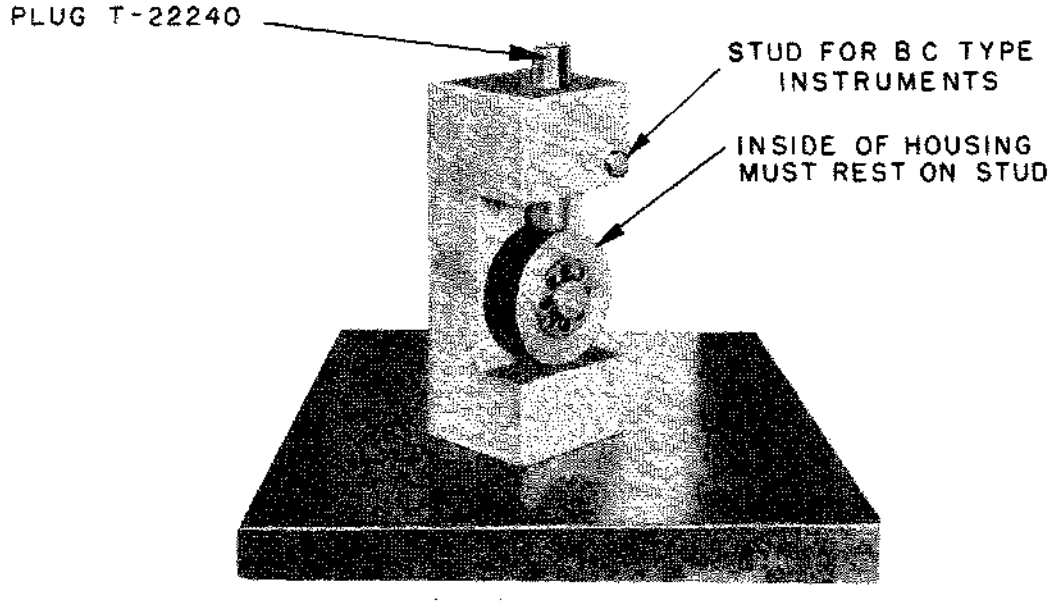


FIGURE 34 INSTALLING THE AIR PIVOT IN THE ROTOR HOUSING

9. Check to insure that the pivot is tight enough in the recess, using fixture T-22023 as shown in Fig. 23. The three prongs are inserted in the holes of the pivot and the movable arm which is connected with the spring is turned until it just touches the stop. The pivot must not move. If it does move there are two ways of tightening it in the recess. The first and best way is to remove the pivot and plate the shoulders so as to increase the diameter. The second method is to pean in the metal around the pivot with a very small flat-faced punch (1/32 inch or slightly smaller). Care must be exercised not to pean the metal in excessively or distort the gyro housing.

TO INDICATE GYRO HOUSING PIVOT FOR CONCENTRICITY

NOTE: Even if a pivot is found, after inspection, to be in perfect condition, so that it does not have to be removed, it is always best to indicate the pivot for concentricity before reassembling the instrument. The procedure is as follows:

1. Insert female plug,T-20787, in bearing recess in gyro housing with shoulder end out.

2. Place gyro housing in fixture T-19647 and screw in adjusting screw until housing is free to turn without end-play and without binding. Indicate large diameter of pivot, turning the housing completely around. The indicator should not show a greater variation than .001" for one complete turn. Turn housing 45 degrees on each side of the vertical (its operating position) and indicate as before. The tolerance in this case must be within .0005". (See Fig. 35.)

3. If greater errors are shown, remove the gyro housing from the fixture, place a bakelite block against the shoulder of the pivot at the high spot and tap the block lightly with a hammer in order to move the pivot into better alignment. This may be done in the same manner as described for the gimbal ring air pivot, paragraph 2, page 24. Check for tightness, using fixture T-22023 as instructed previously (see paragraph 9, page 35) and place in fixture T-19647 to indicate again. Repeat operations until pivot is found to be within the limits given.

NOTE: The concentricity of the gyro housing pivot can be held within .0002" by using a little care in straightening the pivot with the bakelite block and hammer. Wherever tolerances are noted, they represent the maximum limit permissible. With a little extra care the tolerances can be held almost to zero.

TO REPLACE ROTOR BEARING IN GYRO HOUSING

1. Wash the rotor housing thoroughly in Varsol and dry. Insert one paper oil pad in bottom recess and press in a selected bearing, using a brass punch of approximately .600-inch diameter to make certain that the bearing is seated firmly on the bottom of the recess. Wash the felt oil pad and insert over bearing making certain that no hairs from the felt touch the bearing surfaces. Insert the retaining plate in the recess with the convex side up and stake in place at three points. Saturate the bearing and oil pads with Special Instrument Oil.

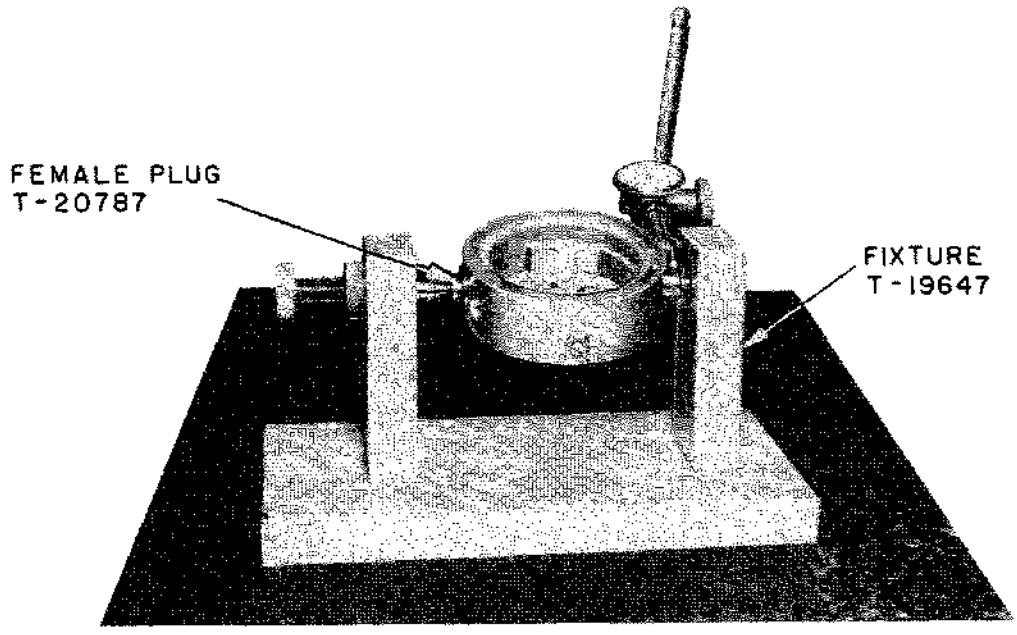


FIGURE 35 CHECKING THE CONCENTRICITY OF THE AIR PIVOT IN THE ROTOR HOUSING. TOLERANCE, .0005 INCH.

HOUSING UPPER BEARING PLATE

1. Remove bearing from bearing housing for inspection as follows:

2. Clean housing and oil-pad thoroughly with Varsol and dry, inspect bearing as described in Operation No. 3, page 13, and reassemble, making sure that the aluminum retaining plate is cupped down and that no hairs from the felt oil pad are touching the bearing surfaces. Stake the plate in place at three equidistant points. Flush out the complete assembly with pump and shake out excess oil.

3. Clean inside of bearing housing recess with Varsol and dry thoroughly. Place five clean shims in the bottom of the recess and insert spring washer. Slide bearing housing assembly into recess, first lubricating with a small amount of Special Instrument Oil. Make sure that key way is in line with small dowel pin. The housing should have no play but should still have an easy, sliding fit. The spring washer should push the housing out again after it is compressed.

OPERATION NO. 9

ADJUSTING THE ROTOR IN THE HOUSING

1. Great care must be exercised when adjusting rotor in housing not to exert too much pressure on bearings and pivots, as they are easily damaged, and to make certain that all dirt is excluded.

2. Place the upper bearing plate, including the bearing, on the gyro housing, over the rotor.

3. Hold the upper bearing plate and housing together and shake gently to feel for end-play. If there is end-play, add another shim. If too tight, remove one shim or remove a thick one and add a thin one. Use holes on under side of housing to check whether rotor turns freely. The rotor must be tried until it has been determined that there is no end-play and that the rotor is free.

COAST TEST

For this test, the gyro must be upright in normal operating position.

1. Fit a rubber tube over large diameter of air pivot and connect to a manometer and air line having a pressure equal to 8-1/2 inches of mercury.

2. Turn on air supply slowly. The rotor should start revolving when the mercury registers from .2 to .4 inches. Run the rotor for five minutes at a pressure equal to 8-1/2 inches of mercury. Cut off air. Check time it takes for rotor to come to a standstill. This must be between 8 and 10 minutes. If less than 8 minutes, the rotor is too tight in the bearings. Change shims and repeat test until the coast is within the limits specified.

3. With rotor running at operating speed, listen to its sound, using a screw-driver as a stethoscope. This should be a smooth, swishing sound. If noisy, it is due to bearings or pivots not being in perfect condition, and should be rectified before further assembly is attempted.

OPERATION NO. 10

REPLACING THE PENDULUM ASSEMBLY

Clean pendulum assembly thoroughly with Varsol and dry.

1. Insert gauge T-20594 through any one of the four elongated holes with the recessed side facing the bevelled edge of the vane. The end of the gauge will protrude through the elongated hole on the opposite side and pass the bevelled edge of the vane on that side. The bevelled edge of both the vanes should just touch the gauge surfaces. Bend, if necessary, to make this so. Repeat test for the other pair of vanes. (See Fig. 36.)

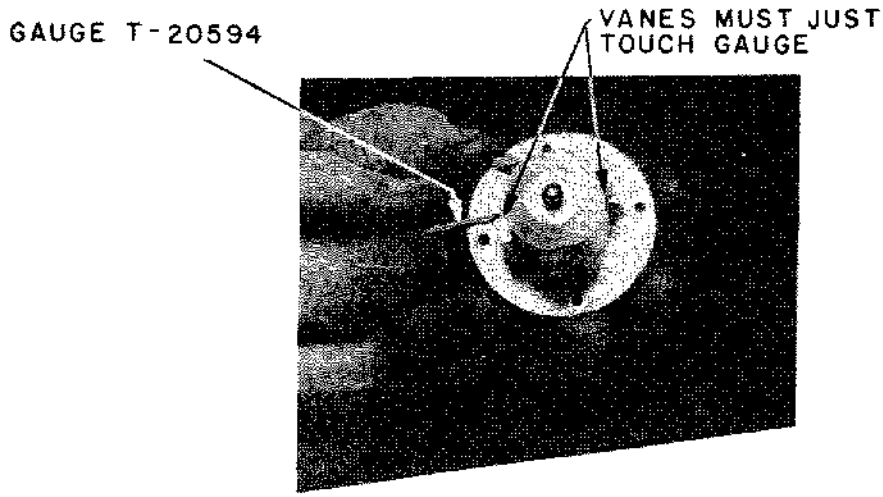


FIGURE 36 CHECKING THE VANES OF THE PENDULUM ASSEMBLY

2. Check the end-play of the vanes. This should be barely perceptible.

3. With pendulum assembly held with vanes pointing down at an angle of approximately 45 degrees, see that the upper vane clears the surface. The vanes must swing perfectly free and must not clear the pendulum body at the holes by more than is necessary to give perfect freedom. Bend the vanes as necessary but be careful not to break the solder.

4. Attach the pendulum assembly to the bottom of the gyro-housing using the four attaching screws and lockwashers.

NOTE: Never use screws longer than 3/8 inches, as longer screws will interfere with the rotor.

5. Make sure that rubber bumper is in good condition and is firmly attached to the bottom of the pendulum assembly.

6. Remove female plug, T-20787, from bearing recess and replace bearing as follows:

7. Clean recess with Varsol, dry and insert two new paper oil pads. Install a clean and inspected bearing in the recess, making sure that it does not fit too tight. A light press fit is sufficient. Use fixture T-23736 and under no circumstances should any other method be attempted.

OPERATION NO. 11

BALANCING THE GYRO HOUSING AND PENDULUM ASSEMBLY

1. Replace pointer guide pin in gyro housing, using Alcoa Thread Lubricant to prevent seizing, and tighten with wrench T-20060. Attach small lead balancing weights, two on the front side (dial side) of gyro housing, and one on the rear side of gyro housing, in a vertical position, using thread lubricant on threads of attaching screws. These screws have lockwashers.

2. Place gyro housing and pendulum assembly in fixture T-19847 and screw in adjusting screw until assembly is free to turn without binding and without end-play. (See Fig. 37).

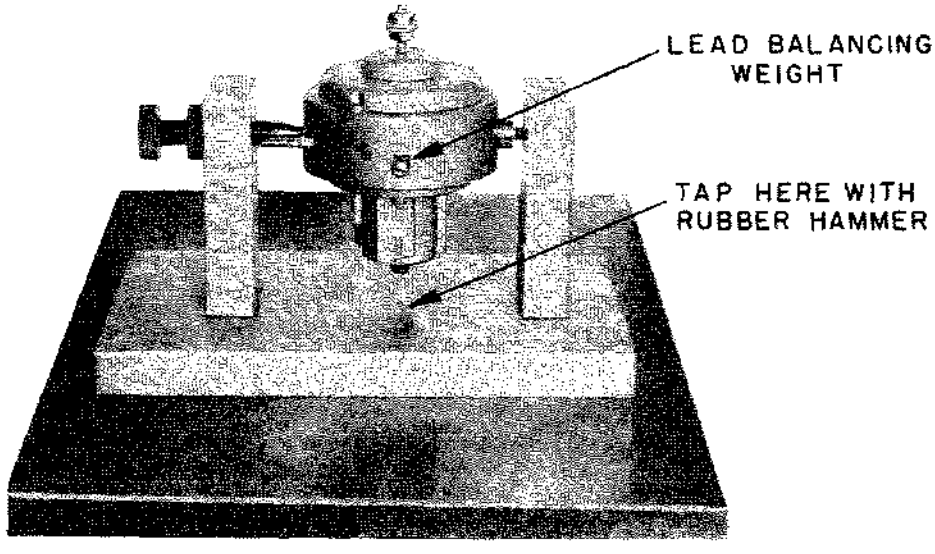


FIGURE 37 BALANCING THE GYRO HOUSING AND PENDULUM ASSEMBLY, VERTICAL POSITION

3. With pendulum assembly down, remove lead from heavy side of gyro-housing until the assembly will come to rest at equal distances each side of the vertical when base of fixture is tapped with rubber hammer.

NOTE: Due to the pendulous vanes, the assembly will not stand vertical, but must be balanced so that it stands equal distances on each side.

4. Place special counterweight, T-21022, on threads of balancing stud as close as possible to top of housing (see Fig. 38). Move locknuts and washers until assembly will stand perfectly horizontal on either side when base of fixture is tapped with rubber hammer. It will be necessary at times to add or remove washers, but the use of more than five washers should be avoided as this is an indication that the rotor is not properly located on its shaft. Recheck the vertical balance.

5. Remove special counterweight.

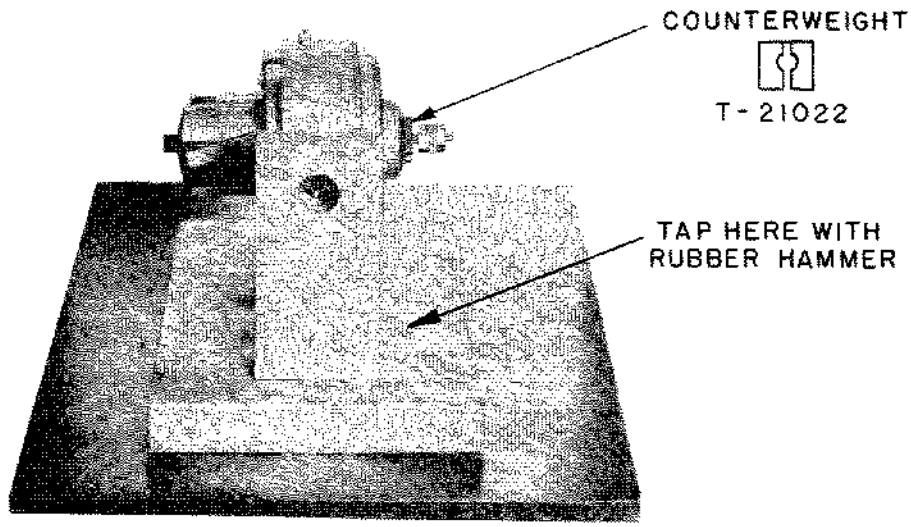


FIGURE 38 BALANCING THE GYRO HOUSING AND PENDULUM ASSEMBLY, HORIZONTAL POSITION, WITH COUNTERWEIGHT ON BALANCING STUD

NOTE: Unless further assembly is undertaken immediately, place tissue paper disc over the ball bearing in the side of the housing and coat pivot with Rust Veto.

OPERATION NO. 11A

For Gyro-Horizons with caging device the procedure is as follows:

1. Replace pointer guide pin in gyro-housing with the caging arm approximately horizontal and over the bearing in the side of the housing. Use thread lubricant to prevent seizing and tighten with a 7/32" wrench as described in Operation No. 2, paragraph 3a.

2. Attach small lead balancing weights, two on the front side (dial side) of gyro-housing), and one on the rear side, in a vertical position, using Alcoa Thread Lubricant on threads of attaching screws. These screws have lockwashers.

3. Place gyro-housing and pendulum assembly in fixture T-26405 and screw in adjusting screw until assembly is free to turn without binding and without end play. Place fixture T-26405 on its side as shown in Fig. 39.

4. With pendulum assembly down, remove lead from heavy side of gyro-housing until the assembly will come to rest at equal distances each side of the vertical when base of fixture is tapped with rubber hammer.

NOTE: Due to the pendulous vanes, the assembly will not stand vertical, but must be balanced so that it stands equal distances on each side of the vertical.

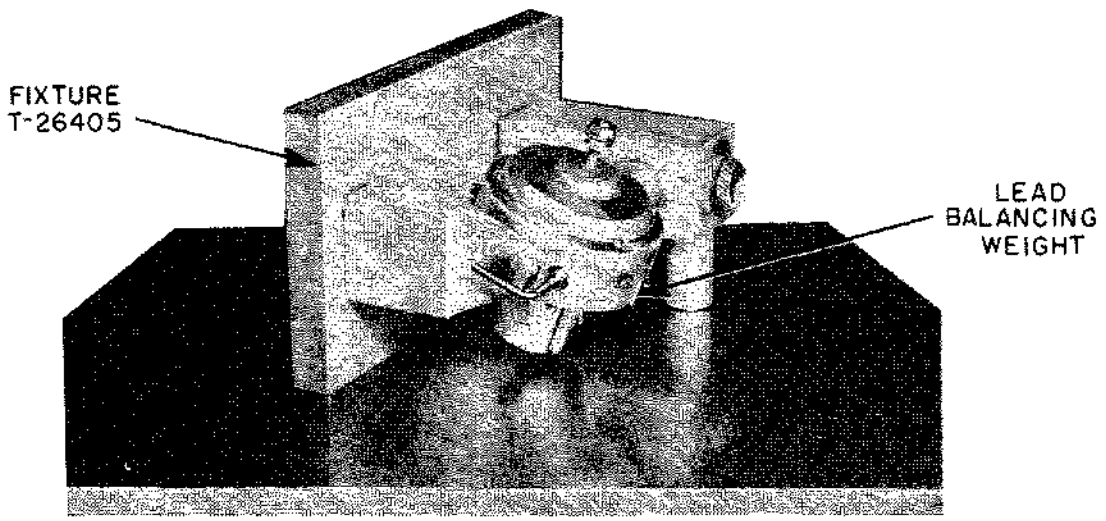


FIGURE 38 BALANCING THE GYRO HOUSING AND PENDULUM ASSEMBLY, VERTICAL POSITION (GYRO-HORIZON WITH CAGING DEVICE)

5. With fixture upright as shown in Fig. 40, place special counterweight, T-21022,on threads of balancing stud as close as possible to top of housing (see Fig. 40). Move locknuts and washers until assembly will stand perfectly horizontal on either side when base of fixture is tapped with rubber hammer. It will be necessary at times to add or remove washers, but the use of more than five washers should be avoided as this is an indication that the rotor is not properly located on its shaft. Recheck the vertical balance.

6. Remove special counterweight.

NOTE: Unless further assembly is undertaken immediately, place tissue paper disc over the ball bearing in the side of the housing and coat the pivot with Rust Veto.

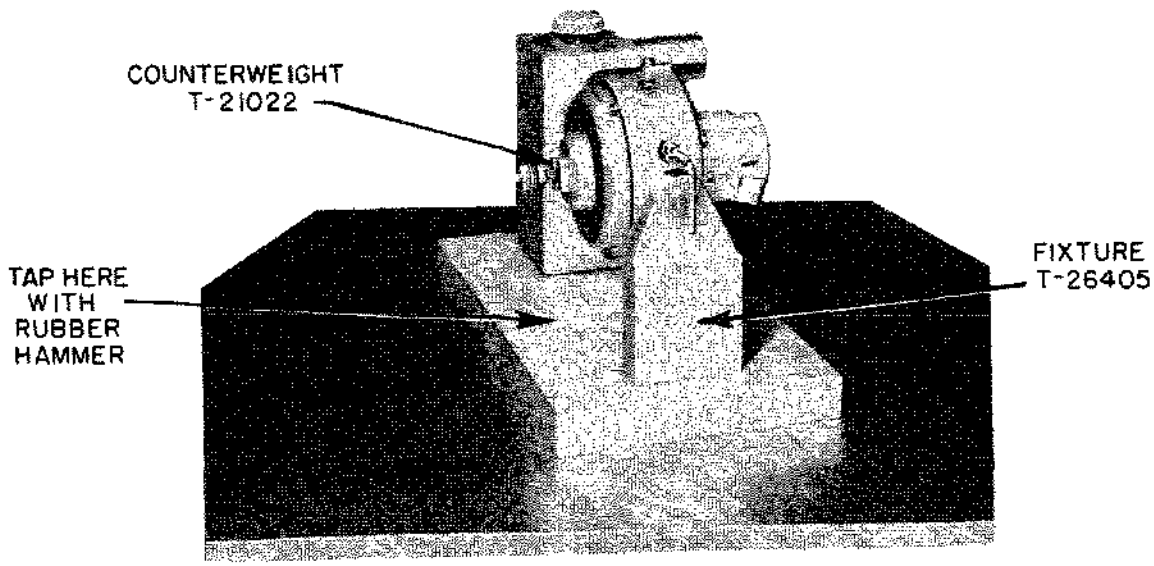


FIGURE 40 BALANCING THE GYRO HOUSING AND PENDULUM ASSEMBLY, HORIZONTAL POSITION (GYRO-HORIZON WITH CAGING DEVICE)

OPERATION NO. 12

ASSEMBLING THE GYRO-HOUSING IN THE GIMBAL RING

1. With gimbal ring in fixture T-19660 remove pointer, unscrew gimbal ring pivot until it is nearly out of ring, and remove gimbal ring bearing housing.

2. Remove pointer guide pin from gyro housing. Insert pivot in the gimbal ring bearing housing opening, and raise the housing into the gimbal ring. When the bearing is in line, screw the gimbal pivot in.

3. The gimbal ring bearing housing may then be inserted. Be sure that the air slot in the housing is in line with the air slot in the gimbal ring and that the air seal ring (flat washer) is perfectly free and fits easily over the pivot. It must fall of its own weight. Be careful not to injure the air seal ring when the pivot enters the gyro-housing bearing. The clearance between the air seal ring and the pivot should not be more than .0005 inch. Insert and tighten the three bearing housing attaching screws. Screw the pivot in carefully until the side-play barely disappears. Tighten the pivot locknut.

4. Screw pointer guide pin into side of gyro-housing, using special wrench T-20060. Lubricate pointer pivots with Special Instrument Oil applied with a tooth pick.

5. Attach pointer to gimbal ring by placing shaft between pivots with slot over guide pin, and then tightening the screw pivot and locknut. The pointer shaft should have approximately .001" end-play, by feel, between the pivots to insure proper functioning.

6. There must be a very slight amount of play between pointer guide pin and pointer slot in all positions. This should be approximately .001".

7. The pointer and pointer bar must be entirely clear of the dial and gimbal ring.

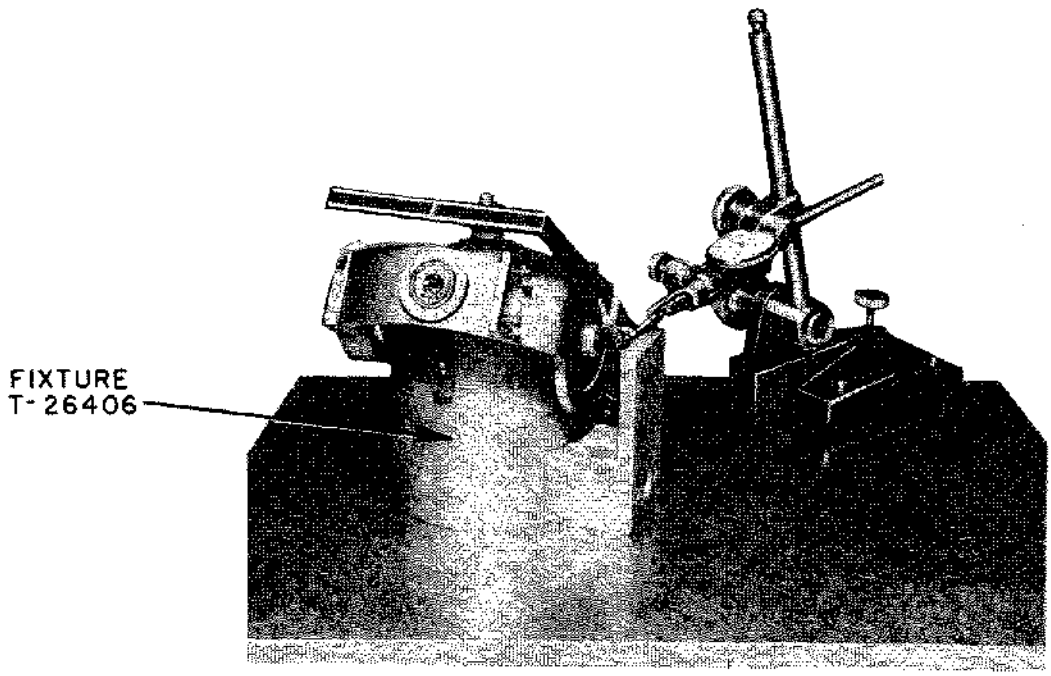


FIGURE 41 INDICATING THE CAGING ARM. TOLERANCE, .001 INCH (GYRO-HORIZON WITH CAGING DEVICE)

7a. For Gyro-Horizons with caging device, the assembly should be removed from fixture T-19660 and the caging arm of the pointer guide pin should be indicated as follows. Rest the gyro-housing in fixture T-28406 as shown in Fig. 41, and indicate the top surface of the caging arm. The indicator should not show a variation of more than .001" as the ball is moved over the top of the caging arm from front to back. The clearance between the caging arm and the side of the fixture should be approximately .015". When caging arm indicates within .001", tighten nut on pointer guide pin and tighten small locking screw on under side of gyro-housing. Recheck caging arm with indicator to see that it is still within the required tolerance. Several attempts may be necessary before the caging arm indicates correctly when both the nut and the locking screw are tight. Replace the assembly in fixture T-19660 and proceed with the assembly as follows:

8. See that the gyro housing is free to move either way until the rubber stop on the bottom of the pendulum assembly touches the bottom of the gimbal ring, and that the pointer guide pin moves freely in the slot.

9. With the pointer attached, the gimbal ring should swing equal amounts each side of the vertical. Tap on the base of the fixture with a rubber hammer and if the gimbal ring swings down on one side it is evident the gyro housing and pendulum assembly is not centered in the gimbal ring. See Fig. 42.

10. When this is the case, loosen locknut and back out screw pivot one half a turn. Remove gimbal ring bearing housing and add or remove shims, as the case may be. Replace the bearing housing and tighten screw pivot as previously explained. Be sure that shims lie perfectly flat with holes in line with screw holes in bearing housing. Continue in this manner until the gimbal will balance so that it stands approximately equal distances from the vertical on each side. It is difficult to obtain a perfect balance and it is preferable to have the assembly slightly heavier on the side of the lead weight as this will assist in calibration.

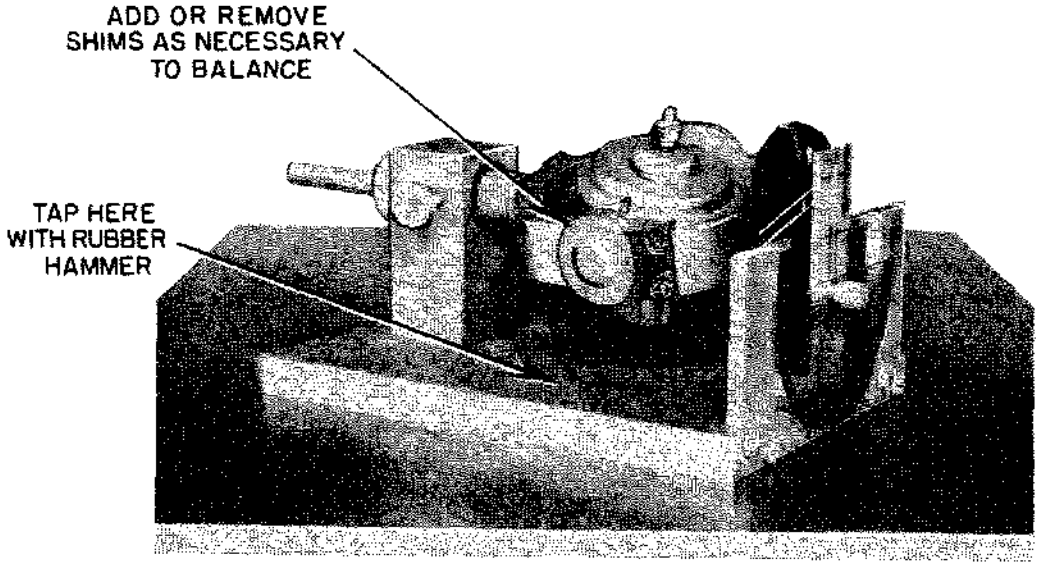


FIGURE 42 CENTRALIZING THE GYRO HOUSING IN THE GIMBAL RING

NOTE: By the use of the following shims the bearing housing may be moved in or out to centralize the gyro housing and pendulum assembly in the gimbal ring.

Shim, Part #124234 paper ----- .001-inch thick
Shim, Part #127178 aluminum -- .002-inch thick
Shim, Part #127177 aluminum -- .005-inch thick

11. With the balance completed, recheck for play in the gyro-housing bearings. There must be NO PLAY yet the assembly must be perfectly free. Check this freedom by holding the gimbal ring horizontal and turning the gyro-housing as far as it will go and releasing it. Count the number of swings it makes. With the instrument completely assembled, this should be a minimum of three half-swings. Observe the manner in which it comes to rest as this will be an indication of whether the bearings and pivots are in perfect condition and free from dirt.

OPERATION NO. 13

CALIBRATING (INSTRUMENT IN FIXTURE)

1. The purpose of calibrating the Gyro-Horizon is to insure that the pointer bar will come to rest horizontally at the center of the dial from specified positions, in approximately equal lengths of time. Any instrument which has been removed from its case must be calibrated both out of, and in the case.

2. The air retainer assembly is placed on the adjusting screw of fixture T-19660. As previously mentioned this assembly was removed while the gimbal ring was being balanced. The air retainer assembly rings must be cleaned with Varsol until there is no trace of dirt or oil, and must be free to fall of their own weight. It is good practice to flush out the fixture bearing at this time and shake off excess oil. Adjust the bearing until the instrument is free to turn without play and without binding. A very slight amount of side-play is permissible at this point, but under no conditions must there be end-play.

3. Connect the instrument to a manometer and an air line as shown in Fig. 43.

4. Start air slowly and bring up to 3-1/2 inches of mercury. Let instrument run for five minutes.

5. The pointer bar may vibrate or "shimmy" after the air is turned on. This will stop as the rotor comes up to speed.

6. If the instrument is properly balanced, the pointer bar should settle fairly level, and close to the centre line of the fixture.

POINTER BAR HORIZONTAL

1. Tilt the gyro housing forward until the pointer bar is raised 7/8 inch above the centreline of the fixture, as measured from centreline of fixture to centreline of pointer bar.

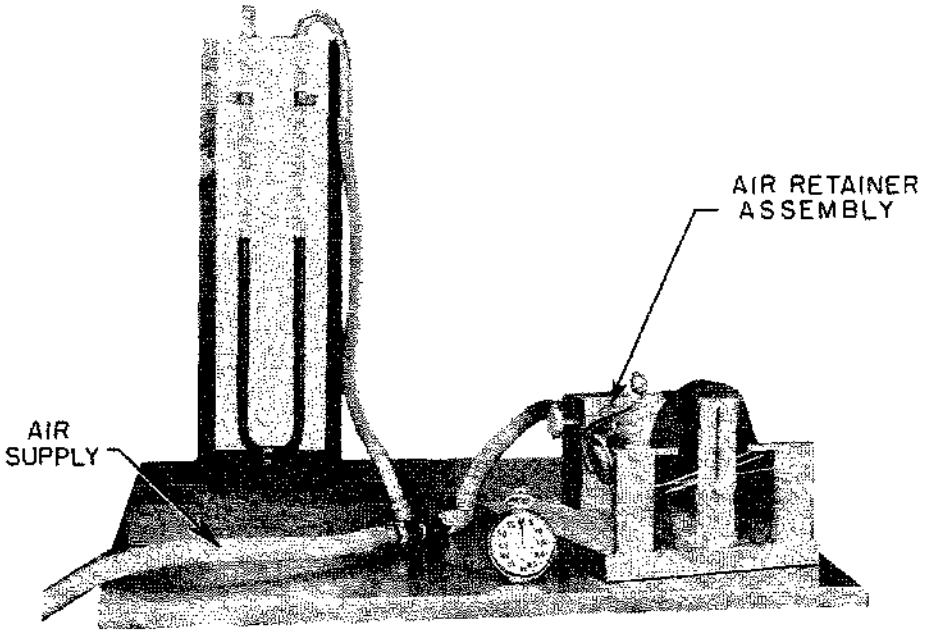


FIGURE 43 INSTRUMENT CONNECTED TO AIR LINE FOR CALIBRATION IN FIXTURE

NOTE: Moving the gyro housing forward or backward will cause the gimbal ring to tilt due to the precessional forces which are generated. Straighten the gimbal ring while holding the gyro housing in its tilted position.

2. If the pointer bar tilts immediately as it returns to its settling point, it will be necessary to adjust the balancing nuts on the upper housing plate as described in Condition No. 1 of Fig. 44.

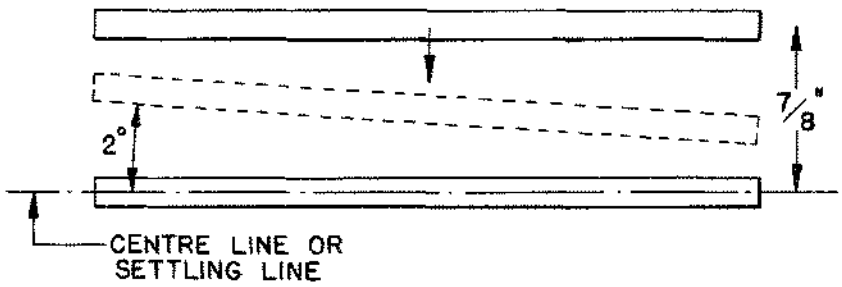
3. Repeat the operation described in paragraph 1, but start the test with the pointer bar 7/8 inch below the centreline of the fixture and parallel to it.

4. If necessary, correct for tilt as described in Condition No. 2 of Fig. 44.

5. If there is no tilt, or after the tilt has been removed by adjusting the balancing nuts, first check the time required for the pointer bar to return when it is displaced 7/8-inch above the centreline, and then check the time it takes to return when displaced 7/8-inch below the centreline.

6. The time is normally between 3 and 4 minutes, and under ideal conditions should be the same for both displacements. If a greater difference than 1/4 of a minute is noted, it will be necessary to add or remove weight as described in A of Fig. 45.

NOTE: The pointer bar may not settle directly behind the centreline of the fixture, but care should be exercised to see that the bar always settles in the same place. If it does not return to the same place, friction is present and will have to be reduced before further calibration is attempted. A difference of 1/64 of an inch is permissible.

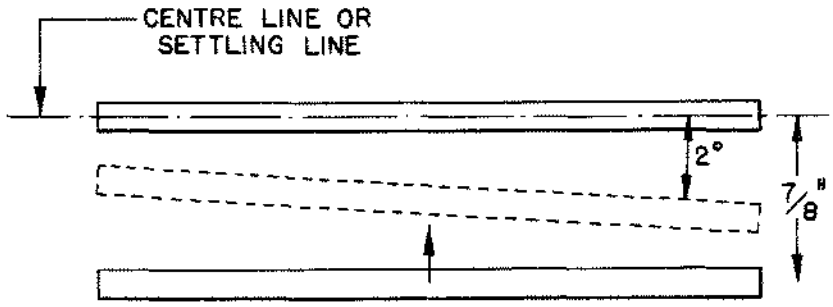


CONDITION NO. 1, (HORIZONTAL)

POINTER BAR DESCENDING

If, before settling, Pointer Bar tilts clockwise more than 2° gyro housing is top heavy. To adjust, screw balancing nuts on stud in upper housing plate DOWN.

NOTE: If pointer bar tilts counter-clockwise, gyro housing is bottom heavy. To adjust, screw balancing nuts UP.



CONDITION NO. 2, (HORIZONTAL)

POINTER BAR RISING

If, before settling, Pointer Bar tilts clockwise more than 2° gyro housing is bottom heavy. To adjust screw balancing nuts on stud in upper housing plate UP.

NOTE: If pointer bar tilts counter-clockwise, gyro housing is top heavy. To adjust, screw balancing nuts DOWN.

NOTE: Friction in the gyro housing bearings where it rests in the gimbal ring will cause the bar to tilt. If tilt is excessive, check for friction in this axis.

FIGURE 44 ADJUSTMENTS NECESSARY TO COMPENSATE FOR SETTLING ACTION OF POINTER BAR FOR DISPLACEMENTS ABOVE AND BELOW CENTRELINE

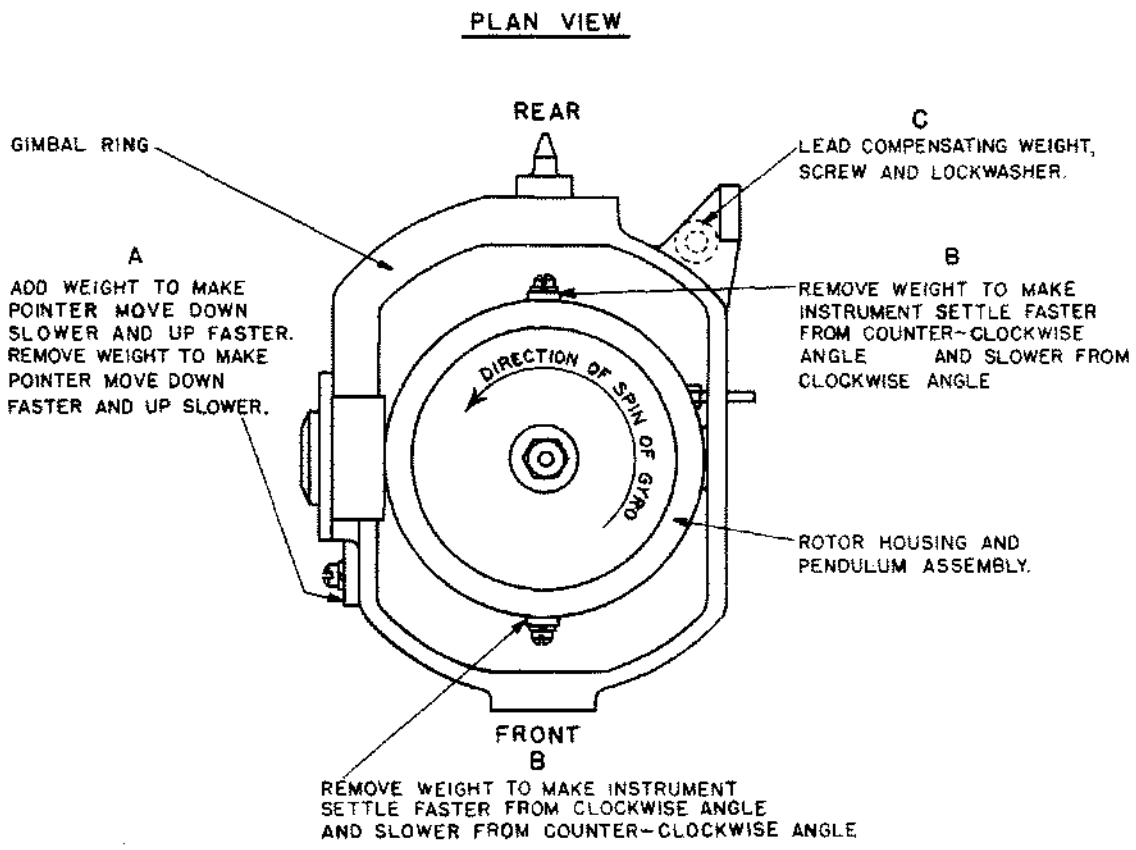


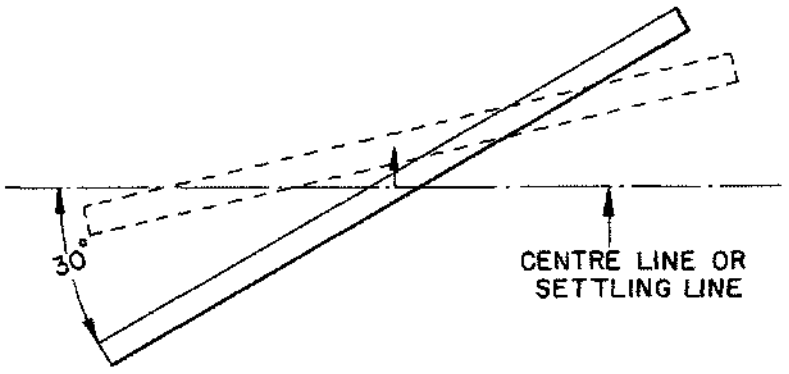
FIGURE 45 ADJUSTMENTS NECESSARY TO COMPENSATE FOR SETTLING TIME OF POINTER BAR

POINTER BAR TILTED 30 DEGREES

1. Turn the protractor on the front of fixture T-19660 clockwise and set it at a 30 degree angle from the horizontal. To set it accurately, place the 0 degree mark of the protractor at the 30 degree line inscribed on the right-hand side of the fixture,and place the 120 degree mark of protractor at the 30 degree line on the left-hand side of the fixture. This will bring the centre of the protractor in line with the centreline of the instrument.

2. Tilt the gimbal ring clockwise so that the centreline of the pointer bar lies directly behind the line of the protractor. Note the time required for the pointer bar to return to its original settling position.

3. Now turn the protractor counter-clockwise and set it at a 30 degree angle from the horizontal. Tilt the gimbal ring counter-clockwise so that the pointer bar lies directly behind the line of the protractor, and note the time required for the pointer bar to return to its original settling position. The time is normally from 3 to 4 minutes, and under ideal conditions should be the same in both cases. If a greater difference than 1/4 of a minute is noted, it will be necessary to add or remove weight as described in B of Fig. 45.

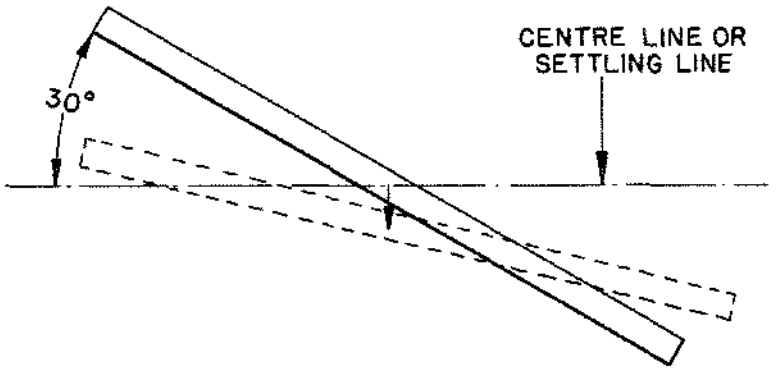


CONDITION No. 3, (TILTED)

POINTER BAR SETTLING FROM COUNTER-CLOCKWISE DISPLACEMENT

If, before settling, pointer bar rises more than 1/16" at centre, remove weight from TOP and add to BOTTOM of lead weight on left hand side of gimbal ring or screw balancing nuts DOWN.

NOTE: If pointer bar falls more than 1/16", remove weight from BOTTOM and add to TOP of lead weight, or screw balancing nuts UP.



CONDITION NO. 4, (TILTED)

POINTER BAR SETTLING FROM CLOCKWISE DISPLACEMENT

If, before settling, pointer bar falls more than 1/16" at centre,remove weight from BOTTOM and add to TOP of lead weight on left hand side of gimbal ring or screw balancing nuts UP.

NOTE: If pointer bar rises more than 1/16", remove weight from TOP and add to BOTTOM of lead weight or screw balancing nuts DOWN.

NOTE: Friction in the gimbal ring bearings (front and rear) or in the air ring assembly of the fixture will cause the pointer bar to rise or fall. If rise or fall of bar is excessive, check for friction at these points.

FIGURE 46 ADJUSTMENTS NECESSARY TO COMPENSATE FOR SETTLING ACTION OF POINTER BAR FOR ANGULAR DISPLACEMENTS

NOTE: When settling from the clockwise and the counterclockwise angles, the pointer bar should not rise or fall more than 1/16-inch. If the bar does rise or fall more than 1/16-inch, it will be necessary to adjust the balancing nuts on the upper housing plate or alter the lead weight on the left-hand side of the gimbal ring as described in Condition No. 3 and Condition No. 4, Fig. 46.

If the settling time of the pointer bar from the horizontal positions (7/8-inch above and below the centreline) and from the tilted positions (30-degree clockwise and counter-clockwise angles) exceed five minutes, it will be necessary to make a correction on the pendulum assembly to speed up the settling time. As a rule it will be found that the settling time from the tilted positions will be within the limits specified, but that the settling time from the horizontal positions may be longer. To correct for this condition, it is necessary to force more air out of the ports controlling the up and down settling, i.e., A-A_1 in Fig. 47. This is accomplished by restricting the air flow through the other pair of ports B-B_1 in Fig. 47, in the following manner:

As noted in the instructions for replacing the pendulum assembly, page 38,the vanes were set with the gauge T-20594 so that when one port is completely closed the opposite port is completely open. If a pair of the vanes is closed in slightly, one port will be completely closed while the port on the opposite side will still lack a small amount of being completely open. The flow of air from this pair of ports will, therefore, be restricted while the flow of air from the other pair of ports

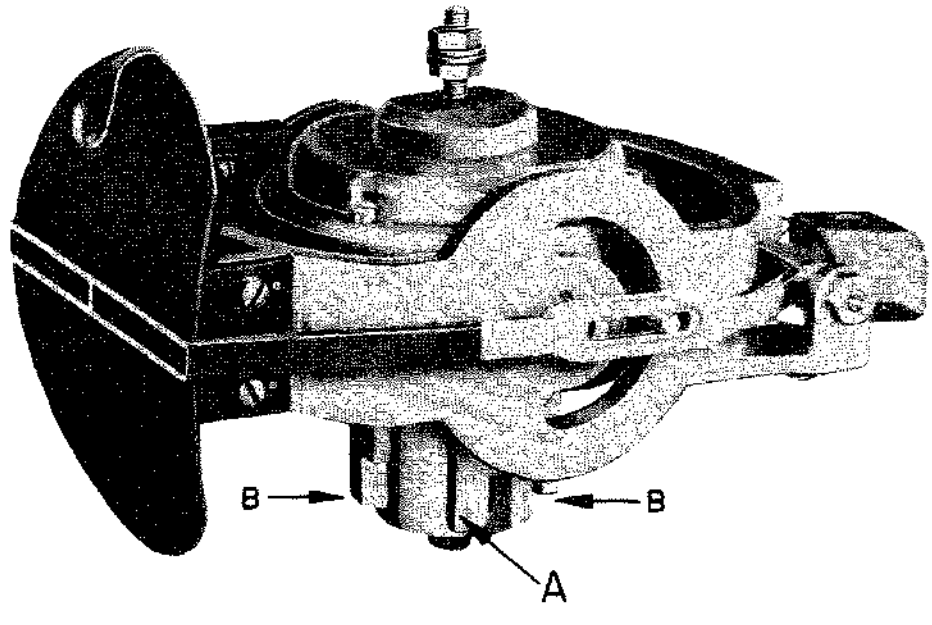


FIGURE 47 ADJUSTMENTS NECESSARY FOR SPEEDING UP THE SETTLING TIME FROM THE HORIZONTAL DISPLACEMENTS AND RETARDING THE SETTLING TIME FROM THE ANGULAR DISPLACEMENTS, OR VICE VERSA.

will be correspondingly increased, creating a slightly greater reaction in the desired direction and causing the instrument to settle faster. To close in the vanes, squeeze them together slightly, being careful not to break the solder.

If the opposite condition exists, i.e., if the instrument requires more than five minutes to settle from the angular displacements, it will be necessary to close in slightly the two side vanes.

After bending the vanes be sure that they still swing perfectly free and do not scrape against the pendulum body.

4. If the pointer bar does not settle exactly behind the centreline of the fixture, it will be necessary to bend it until this condition is met. To do this, one must exercise great care. Grasp the pointer with parallel jaw pliers between pointer bar rivets and guide pin slot and bend as required. Repeat the operation if necessary until the instrument settles with the pointer bar exactly behind the centreline of the fixture.

5. As a final check of the instrument in the fixture, repeat the tests, first displacing the pointer bar 7/8-inch above the centreline and 7/8-inch below the centreline and then tilting the pointer bar 30 degrees clockwise and 30 degrees counter-clockwise. Note that the pointer bar settles within 3 to 4 minutes from each of the four positions, that the settling time coincides (1) within 1/4 of a minute when the pointer bar is displaced above and below the centreline, and (2) within 1/4 of a minute when the pointer bar is tilted clockwise and counter-clockwise.

OPERATION NO. 14

REPLACING THE INSTRUMENT IN ITS CASE

1. To remove grease or finger marks from luminous pointer bar rub front of pointer bar and banking indicator lightly with a clean, damp cloth to which a small amount of Ivory Soap has been applied. This will remove grease or dirt without injury to the lacquer or radium luminous compound. Polish lightly with a clean, dry cloth.

2. Clean case and covers thoroughly, blow out and dry. Remove the snap ring that retains the filter disc at the back of the case. Remove the filter disc and replace with a new one. New discs may be obtained from the Sperry Gyroscope Company, Inc. Inspect pivot in case bracket, clean with Varsol and dry. Screw pivot half-way into bracket. See that two rubber bumpers are in place and in good condition on case bracket bars.

3. The ball bearing in the rear of the instrument case should be inspected carefully and cleaned before replacing the instrument in the case. To do this, clean the bearing recess thoroughly with Varsol and dry. Insert two paper oil pads. Flush out the assembled bearing with the special pump T-22696, and then press the ball-bearing assembly into place, spring retaining washer out. Insert aluminum ring (air retainer washer, large) with the countersunk recess in the ring facing out. Insert air seal ring (flat washer) into countersunk recess in ring, first making sure that it will fit easily over the pivot and is perfectly flat. The clearance between the air seal ring and the pivot should be not more than .0005". Add air retainer washer (small) and insert spring locking ring. Saturate oil pads with Special Instrument Oil, but do not allow any oil to get on the air seal ring.

NOTE: When assembly is complete be sure that the air seal ring does not stick between the

retaining washers. It should fall of its own weight when assembly is held in a vertical plane and turned one way or the other.

4. Hold case in left hand with bracket end up and recessed flange at bottom toward you. (For Gyro-Horizons with caging device, see that the caging mechanism is turned to its full uncaged position.) Hold instrument in right hand with pendulum assembly up. Gently raise instrument into case, watching through front end to see that ball bearing housing in side of gimbal ring passes through recessed flange, and that pointer does not scrape opposite side of case. As the bearing in the front end of the gimbal ring approaches the pivot in the case bracket, tilt pendulum assembly forward slightly. This will move pointer away from bracket and permit gimbal bearing to be moved into place on pivot. See Fig. 48. Carefully turn complete assembly upside down (face down) and rest the case on front cover, so as to protect the pointer bar.

5. Coat rear face of case lightly and evenly with Alcoa thread lubricant and coat threads of attaching screws. Replace rear cover, fitting bearing carefully over gimbal ring pivot, so as not to damage air seal ring. The opening between the screen cover plate and the rear cover of the case must be toward the bottom when the case is held in its normal operating position.

6. Place the case on its end, and tighten the pivot in case bracket until the side play of the instrument is approximately .0005", by feel, and tighten locknut. See that pointer is clear of side of case in all positions, and that gyro housing and pendulum assembly is free to move without obstruction.

7. Replace the dial, using special geared off-set screw-driver T-22260 to screw in the two attaching screws (with lockwashers) and T-22261 to tighten them.

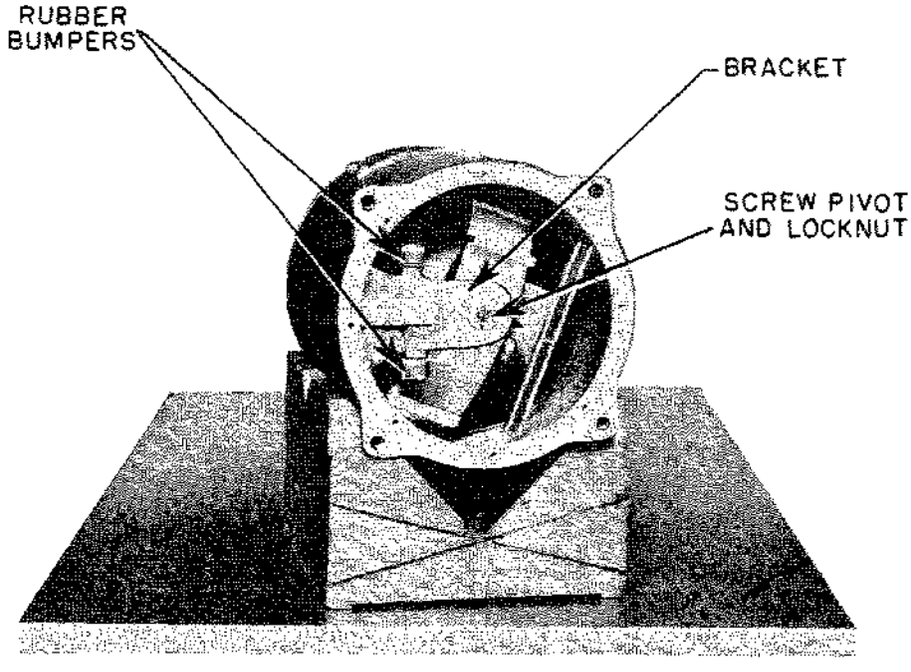


FIGURE 48 REPLACING THE INSTRUMENT IN THE CASE

8. With instrument case facing you, place front cover against front of case so that top of small airplane wing is parallel to pointer bar. The luminous pointer at the top of the dial must coincide with the zero mark (top centre of front cover). If it does not, bend it slightly at a point near the dial. (See Fig. 49.)

9. Coat front face of case lightly and evenly with Alcoa thread lubricant and coat threads of attaching screws. Replace front cover. (For Gyro-Horizons with caging device, replace caging dial and caging knob.)

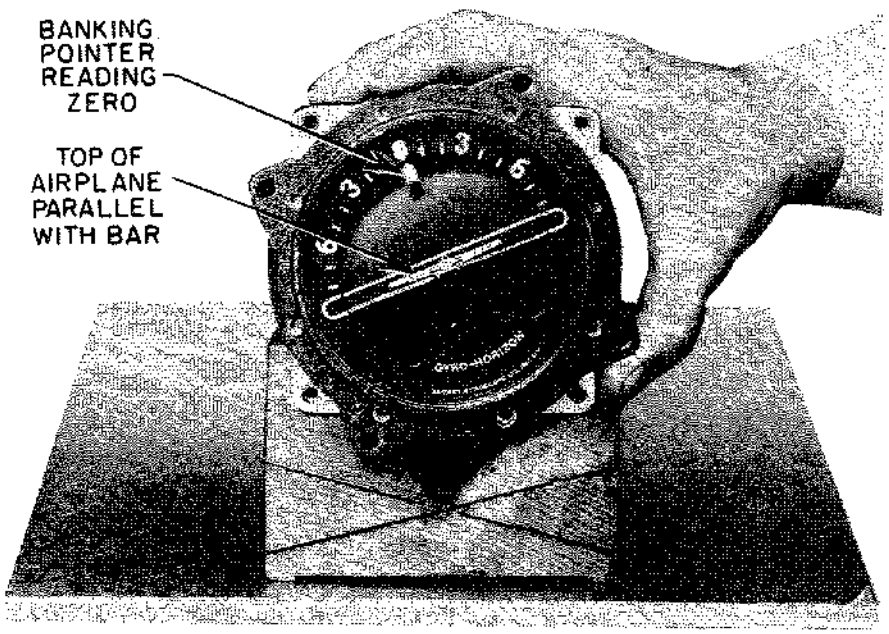


FIGURE 49 CHECKING THE ALIGNMENT OF THE POINTER BAR AND THE BANKING INDICATOR BEFORE REPLACING THE FRONT COVER

OPERATION NO. 15

CALIBRATION (INSTRUMENT IN THE CASE)

1. Place instrument in calibrating fixture, T-23301, in level, operating position, and connect to vacuum line, attaching tubing to one of the fittings at rear cover of case. The other fittings must be plugged. Run the gyro at least five minutes, with vacuum equal to 3-1/2" of mercury. (See Fig. 50.)

NOTE: The mounting plate of calibrating fixture T-23301 must be milled out to permit insertion of caging shaft.

POINTER BAR HORIZONTAL

1. Release the three clamps and lift the instrument and bracket from the frame. Holding the instrument level and square with front of fixture, roll or turn it very slowly in a counter-clockwise direction until you feel the gimbal ring touch the rubber bumper. Continue turning slowly until the pointer bar travels slightly past the tip of the luminous

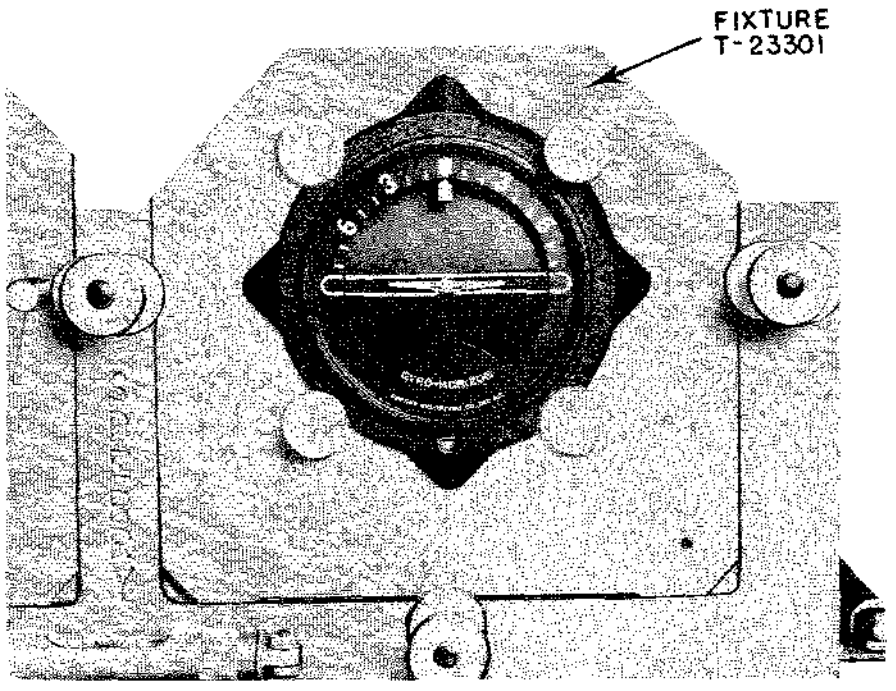


FIGURE 50 THE INSTRUMENT IN FIXTURE T-23301 READY FOR FINAL CALIBRATION

airplane wing. Turn the case carefully back to its original position and re-clamp it in the fixture. The pointer bar will now be horizontal and raised slightly more than 7/8" above the settling position.

2. Check the time the pointer bar requires to settle from exactly 7/8-inch above the settling position. The settling time should be between 3 and 6 minutes, and the pointer bar should not incline more than 2 degrees from the horizontal while settling.

3. When the instrument has settled, turn the case as described in paragraph 1,but this time in a clockwise direction, and return it to the calibrating frame. This will bring the pointer bar slightly more than 7/8-inch below the settling position. Check settling time and inclination as before.

4. Under ideal conditions, the time required for the pointer bar to settle will be equal in both instances, the pointer bar will settle in exact alignment with the reference marks at the sides of the dial, and the banking pointer will indicate zero.

5. If the settling times are equal but the pointer bar settles at an angle, it will be necessary to remove the front cover and twist the pointer slightly to correct it.

NOTE: If the pointer bar settles level but the banking pointer is slightly off, it will be necessary to bend the banking pointer slightly to correct it. Be sure that the banking pointer clears the glass and that the pointer is approximately 1/32" from the bezel face dial.

6. If the pointer bar returns more rapidly from 7/8-inch above the settling point than it does from 7/8-inch below the settling point, and the pointer bar settles low, it will be necessary to remove the rear cover of the case and cut a small amount of lead from the weight on the lower side of the pointer supporting arm, C in Fig. 45.

7. Replace the rear cover and recheck the settling time of the pointer bar from the two positions. Slowing up the settling time from 7/8-inch above or speeding up the settling time from 7/8-inch below will cause the pointer bar to settle higher.

8. If the pointer bar returns more rapidly from 7/8-inch below the settling point than it does from 7/8-inch above and the pointer bar settles high, the conditions are reversed and it will be necessary to add a small amount of lead to the weight on the lower side of the pointer supporting arm.

9. If the pointer bar returns more rapidly from above than it does from below and settles high, it will be necessary to remove the instrument from the case, replace it in fixture T-19660 and bend the pointer down as needed. If conditions are reversed, bend the pointer up.

NOTE: If the pointer bar tilts in settling from 7/8-inch above or 7/8-inch below the settling point it will be necessary to remove the rear cover and adjust the balancing nuts on the top of the gyro housing in accordance with Fig. 44, Condition No. 1.

10. If the settling time of the pointer bar is less than 3 minutes or more than 6 minutes, it will be necessary to take off the rear cover and remove the pendulum assembly, marking its position in relation to the gyro housing so that it may be put back the same way. With the pendulum assembly removed from the instrument, bend the vanes slightly in accordance with the instructions given for this operation on pages 49 and 50.

POINTER BAR TILTED 30 DEGREES

1. Lift the instrument from the fixture and turn the case 90 degrees counter-clockwise, as viewed from above, about its vertical axis. Then roll the case clockwise about its horizontal axis until the pointer bar travels slightly past the tip of the luminous airplane wing. Return the instrument carefully to the fixture. The turning and rolling action will leave the pointer bar tilted counter-clockwise slightly more than 30 degrees.

2. Check the settling time of the pointer bar from exactly 30 degrees as indicated by the banking pointer. The settling time should be between 3 and 6 minutes.

3. When the instrument has settled, repeat the procedure described in paragraph 1, but this time, roll the case counter-clockwise about its horizontal axis. This will leave the pointer bar tilted slightly more than 30 degrees, but this time in a clockwise direction.

4. Check the settling time as before, from exactly 30 degrees as indicated by the banking pointer.

5. Under ideal conditions, the settling time of the pointer bar from both the angular displacements will be the same, and the pointer bar will not rise or fall as it returns to the settling point.

6. If the pointer bar settles faster from the clockwise displacement (slower from the counter-clockwise displacement) it will be necessary to remove the rear cover and cut a small amount of lead from the weight on the rear of the gyro housing, see B in Fig. 45. If the reverse is true add weight at B, Fig. 45.

7. If the pointer bar rises or falls more than 1/16-inch as it settles, it will be necessary to remove the rear cover of the case and adjust the balancing nuts on the top of the gyro housing in accordance with the instructions given in Fig. 46.

NOTE: With the instrument in the case, the most important thing to observe is that the bar returns exactly to the same position from the different displacements and settles directly on the centreline. For instance, if the settling time down is 3-1/2 minutes and the settling time up is 5-1/2 minutes, and the bar returns to the centreline each time, the instrument may be considered passable. The same is true of the two angles. Under no circumstances, however, should the time be less than 3 minutes or more than 6 minutes.

In adding weight, a soldering iron can be used, but extreme caution must be exercised not to drop particles of solder into the case.

8. When the settling movements of the pointer bar from the four positions conform to the specifications given, the instrument may be considered properly calibrated.

INSTALLATION

INSPECTION OF INSTRUMENTS RECEIVED FROM THE FACTORY

All instruments are carefully inspected before leaving the factory. They are shipped in packing cases specially designed to minimize the possibility of damage in transit. While in transit, however, the instruments may be subjected to conditions which are beyond the control of this Company. We have included, therefore, special instructions for inspecting and testing, and recommend that these instructions be carefully followed if the instruments show any evidence of having been mishandled during shipment. The equipment necessary for making these tests is available at most air transport companies or at our Service Stations (see list on Foreword page). It should be understood that conditions necessitating these tests are exceptional. Ordinarily, the purchaser may disregard them and proceed at once with the installation of the instruments.

1. Place the instrument on a testing block in a level position or in fixture T-23301 and connect it to a vacuum pump and a manometer by means of rubber tubing. (The outlets not used must be kept plugged.)

2. Check the instrument as described in Operation No. 15, noting whether the pointer bar returns from the horizontal displacements and from the angular displacements as specified in paragraphs 2 and 3, page 53, and in paragraphs 2, 3 and 4 page 54 respectively. If the pointer bar does not return to the centreline after each displacement or if it does not settle within the times specified in Operation No. 15 no adjustments should be attempted, but the instrument should be returned to the factory. If the pointer bar settles as specified in Operation No. 15, the instrument is ready for installation.

INSTALLING THE GYRO-HORIZON

1. The Gyro-Horizon should be installed, preferably,directly in front of the pilot and close to the Directional Gyro so that the eye will have only a short distance to travel between the indications of the two instruments. The Gyro-Horizon must be mounted so that its dial is vertical when the airplane is in normal flight. The wing of the miniature airplane on the dial must be horizontal.

2. Make sure that the holes in the panel are large enough to permit the instrument to be inserted and fastened without binding. (See outline drawings, Figs. 51 and 52.)

3. When attaching the instrument to the panel, make sure that all four corners touch the panel. If the panel should be warped or uneven, place shims or washers between the panel and the corner of the instrument that does not touch. This will prevent the instrument from being strained when the attaching screws are tightened.

4. The Gyro-Horizon is fitted with self-locking nuts so that it is only necessary to insert the four attaching screws from the front and tighten them with a screw-driver.

INSTALLING THE VENTURI TUBE

1. The venturi tube is designed for use in any airplane which has a cruising speed of 75 miles (120 km.) per hour or over.

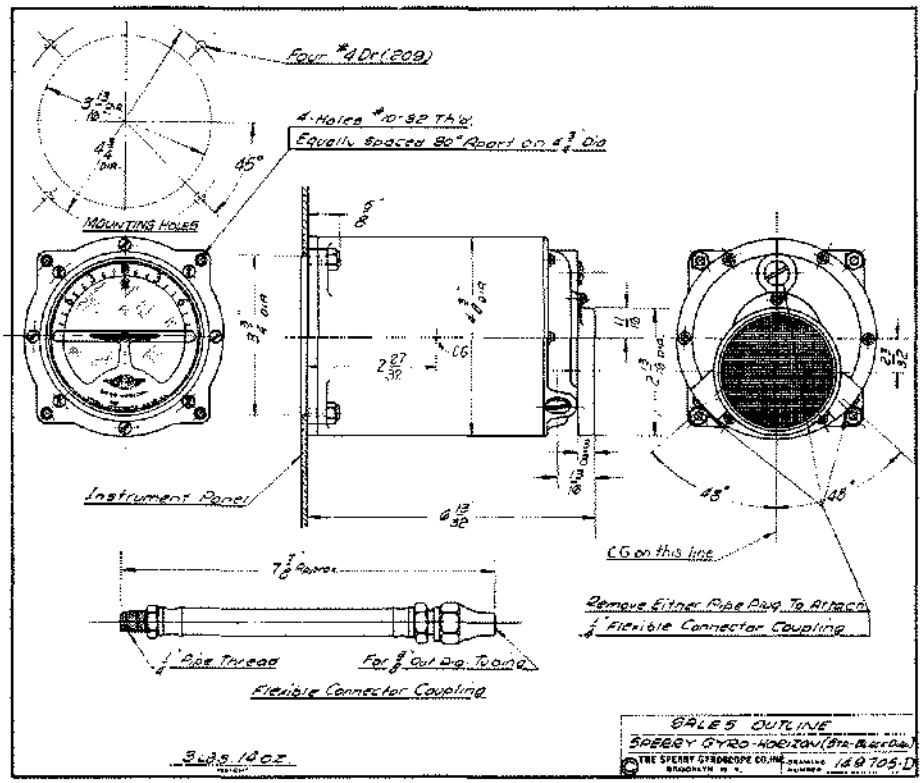


FIGURE 51 OUTLINE DRAWING OF THE STANDARD GYRO-HORIZON

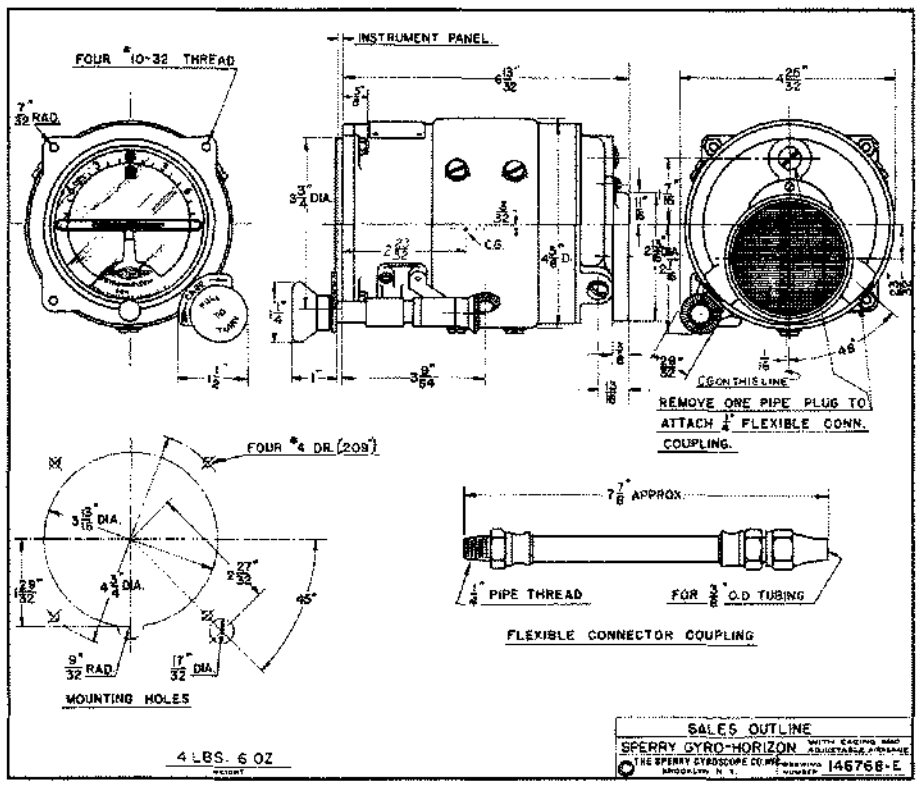


FIGURE 52 OUTLINE DRAWING OF THE GYRO-HORIZON WITH CAGING DEVICE

2. Mount the venturi tube in the slip-stream of the propeller, with the arrow on its nameplate pointing in the direction of flight. See Fig. 58. The venturi tube should be placed as close as possible to the instrument it is to operate, so as to keep the amount of connecting tubing to a minimum. The venturi tube must produce a vacuum of not less than 3" and not more than 5" of mercury at the instrument when the airplane is flying at cruising speed. The ideal vacuum is 4" of mercury at cruising speed.

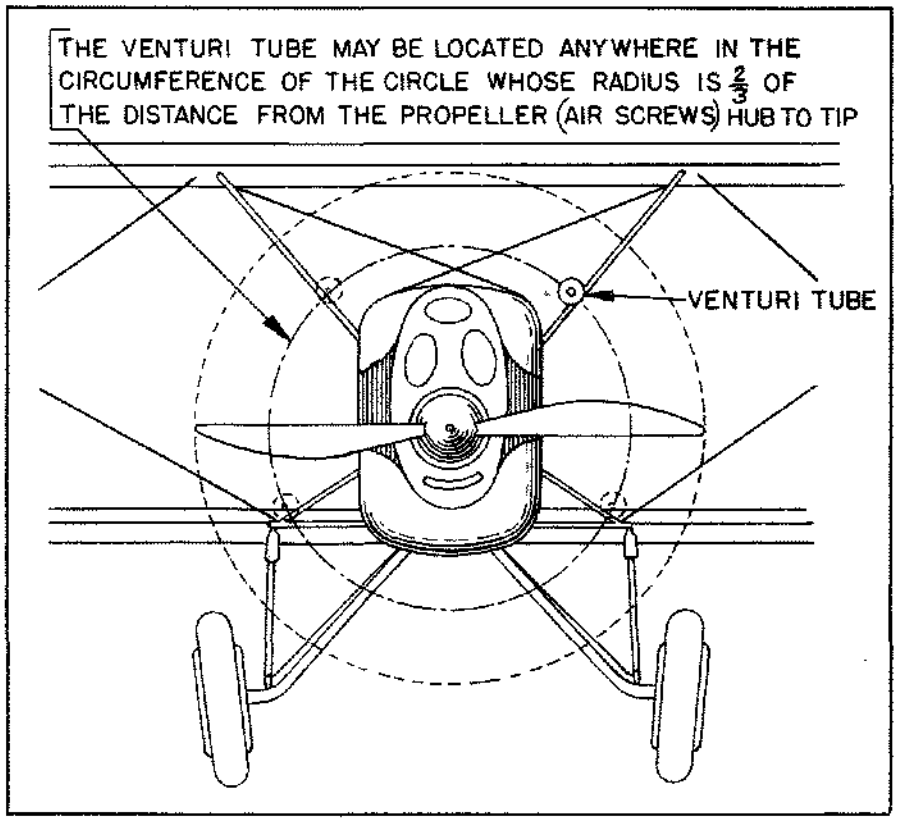


FIGURE 58 LOCATING THE VENTURI TUBE

INSTALLING THE TUBING

1. Twelve feet of 5/16" I.D. tubing is supplied with each instrument. If a greater length is necessary, the tubing must be of larger diameter. For lengths from 12 to 25 ft. use 3/8" I.D. tubing. Lengths of tubing greater than 25 feet require special consideration and the Sperry Gyroscope Company, Inc., should be consulted.

2. A flexible connector is supplied for connecting the tubing to the instrument. The 1/4" pipe-threaded end of the flexible connector should be screwed into the instrument at either of the two outlets - whichever is most convenient. The outlet not used should be kept plugged.

3. When making connections, be sure ends of tubing are cut off and all burrs removed. With the flare type fittings supplied, it is necessary to remove the thimble portion and slide it onto the tubing with its threaded end toward the end of the tubing to be flared. Use standard flaring tools, or equivalents, to obtain a proper fit with the tapered portions of the fittings. Tighten nut carefully. Excessive tightening may damage the flared end of the tubing and cause leaks.

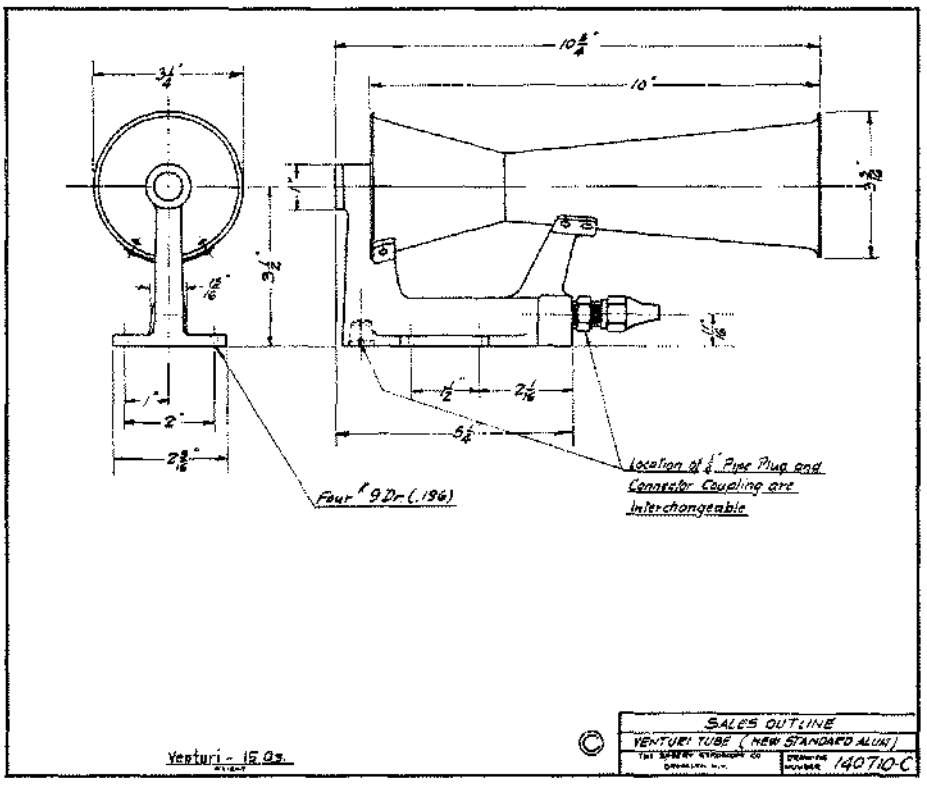


FIGURE 54 OUTLINE DRAWING OF THE VENTURI TUBE

4. Make sure that the tubing is not pinched or kinked and is suitably clipped to prevent breakage due to vibration.

FLIGHT TESTS

1. When the installation is completed, the vacuum must be checked in flight by means of a mercury manometer or a vacuum gauge.

2. Unscrew the pipe plug from one of the extra outlets on the instrument case and screw in a fitting to which a piece of rubber hose about three feet long is attached. To the other end of the hose, attach a mercury manometer or vacuum gauge.

NOTE: When finished with the test, remove gauge, hose and fitting, and MAKE SURE THAT PIPE PLUG IS REPLACED AND TIGHTENED.

3. Fly the airplane to an altitude of about 2000 feet and check vacuum as indicated by gauge when the airplane is flying at cruising speed. The following interpretations may be placed on different gauge readings:

Vacuum too low - under 3" at cruising speed.

1. Venturi in poor location.
2. Tubing too long or too small.
3. Leaks in connections.
4. Kinks or restrictions in tubing.
5. Vacuum pump not operating properly. Repair or replace.

Vacuum too high - over 5" at cruising speed. This may occur on high speed planes.	1. Relocate the venturi outside the propeller slip-stream. 2. Insert in air line a relief or reducing valve adjusted to 4" mercury vacuum.

NOTE: On fast airplanes where excessive suction is created by the venturi tube, a relief valve must be placed in the air line, as close to the panel as possible,and adjusted to produce a vacuum equal to 4" of mercury at the instrument.

RELIEF VALVE

1. For Gyro-Horizons which are to be operated by an engine-driven vacuum pump, a relief valve is supplied in order to prevent too high a vacuum at the instrument. The relief valve should be mounted in the air line where it is accessible for adjustment, preferably near the instrument panel, or if convenient, mounted on the instrument panel, in a vertical position (screen side down). To vary adjustment, loosen lockmut and screw stud to the right to increase vacuum and to the left to decrease vacuum.

2. The outlets on the valve are marked "P" for pump or other vacuum supply. "T" and "B" for Turn and Bank Indicator, "G" for Directional Gyro and "H" for Gyro-Horizon. Connect the line leading from the venturi tube to the outlet "P". One relief valve suffices for both Directional Gyro and Gyro-Horizon, the tubing from the two venturis being connected to the "P" outlet by means of a "T" or "Y" fitting. The "T" and "B" (Turn and Bank Indicator) outlet on the relief valve should be kept plugged. If Gyro-Horizon alone is used connect venturi tubing to outlet "P", connect Gyro-Horizon tubing to outlet "H", and plug outlet "G",and "T" and "B".

3. For installations where relief valve is supplied, the following additional interpretations may be placed upon manometer readings at vacuum test:

Vacuum too low, i.e., under 3-1/2" at cruising speed.	1. Relief valve not properly regulated or valve not seating properly.
Vacuum too high, i.e., over 5-1/2" at cruising speed.	1. Relief valve not properly regulated. 2. Dirt clogging air intake screen on relief valve.

TO RENEW FILTER DISC

1. Dirt clogging the air intake filter on the back of the instrument case will also cause high vacuum readings. Lift out the snap ring that retains the filter disc at the back of the case. Remove the filter disc and replace with a new one. New filter discs may be obtained from the Sperry Gyroscope Company, Inc.

IMPORTANT: UNDER NO CONDITION SHOULD THE GYRO-HORIZON BE TAKEN APART BY ANYONE NOT AUTHORIZED TO DO SO.

LEVELLING THE INSTRUMENT

1. With the airplane flying in calm air in its normal flight attitude, adjust the instrument on the panel so that it is exactly level longitudinally and laterally.

2. If the face of the Gyro-Horizon is not exactly vertical, remove the four attaching screws and add shims (the same thickness on each side) between the Gyro-Horizon and the panel at top or bottom holes as required, to line up the horizon bar with the indices at each side.

3. By slightly elongating the holes in the instrument panel, the Gyro-Horizon can be turned right or left sufficiently to align the pointer with the index at the top of the dial.

4. If facilities are available, the instrument may be levelled without flying the airplane (see Fig. 55). In this case, the tail of the airplane is raised until it is in normal flying position. Check with a spirit level to insure that the airplane is level longitudinally and laterally. Then adjust the instrument on the panel as described above. A vacuum pump adjusted to supply a vacuum equal to 4" Hg. is used to operate the instrument.

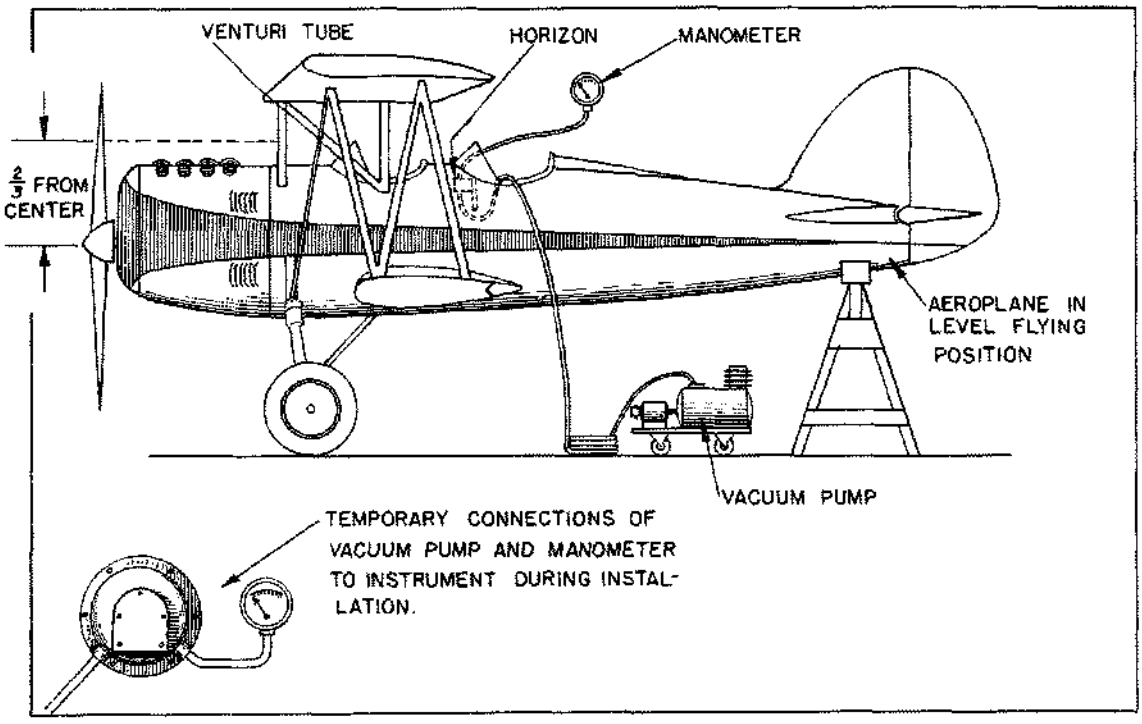


FIGURE 55 METHOD OF LEVELLING THE INSTRUMENT WITH THE AIRPLANE ON THE GROUND

OPERATION (FLIGHT INSTRUCTIONS)

1. The Gyro-Horizon provides a horizon bar, which remains coincident with the natural horizon through all the usual maneuvers of banks, climbs, glides or turns. It has no time lag, and the pilot can manipulate his controls to bring his ship to any desired attitude by noting the relation of the miniature airplane with respect to the horizon bar. Wing low, climb or glide is shown by this instrument in exactly the same relation as when using the natural horizon. (See Fig. 56.)

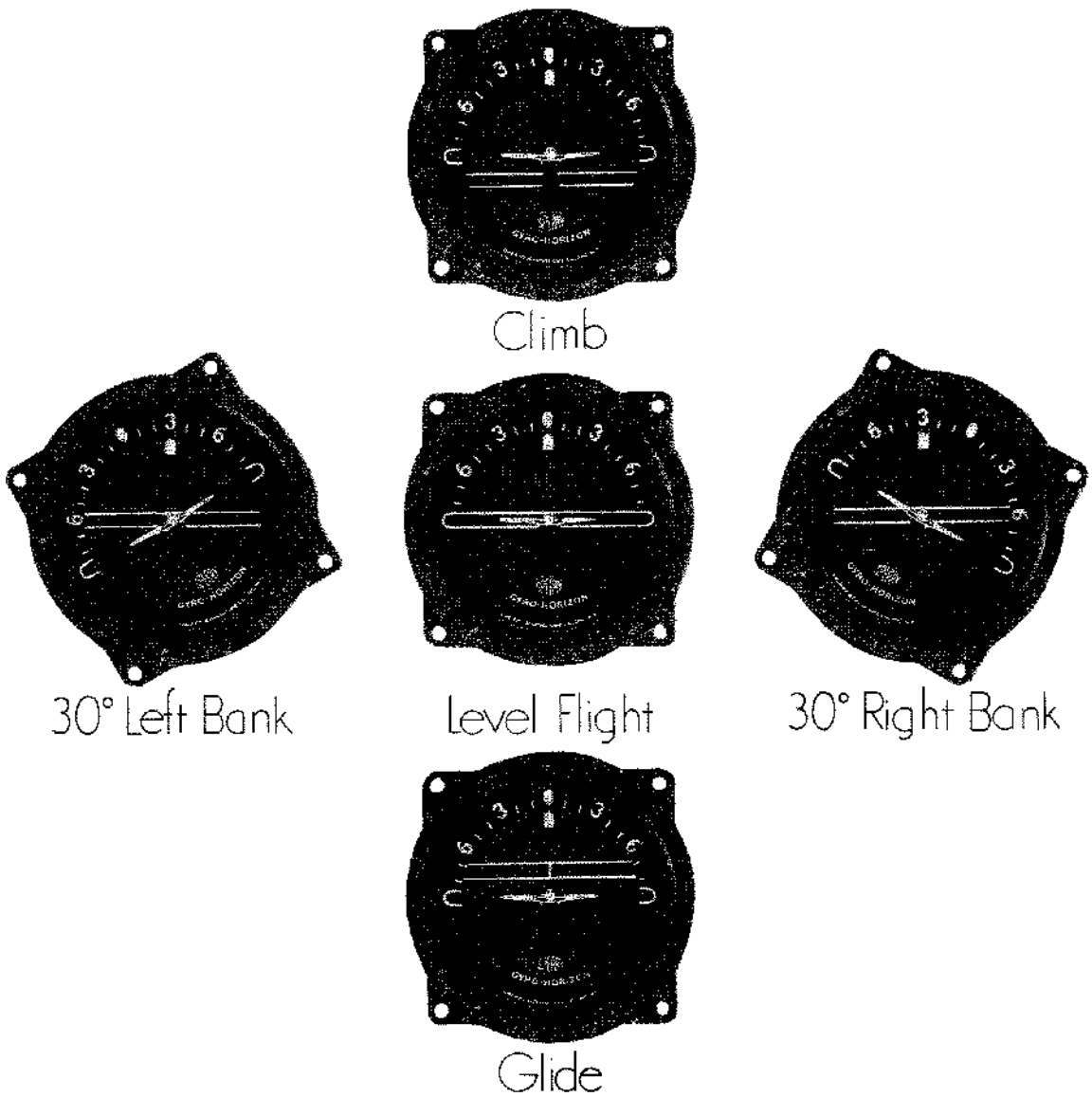


FIGURE 56 INDICATIONS OF THE GYRO-HORIZON FOR FIVE ATTITUDES OF FLIGHT

2. Extremely accurate lateral control can be maintained when climbing or gliding by watching the pointer on the banking indicator at the top of the Gyro-Horizon dial.

3. Banks up to 90 degrees, and climbs or glides up to 60 degrees are within the operating limits of the instrument.

4. The Gyro-Horizon is driven by the air evacuated from its case at a vacuum of 3-1/2" of mercury. When this vacuum is supplied by a venturi tube, three to four minutes will be required after the take-off to permit the gyro to attain its necessary speed.

CAUTION: Acrobatics should not be performed with the standard Gyro-Horizon. The model equipped with a caging device is available for military airplanes or private airplanes which may engage in acrobatics. With this model the gyro should be caged prior to acrobatics and released after completion when the airplane is levelled out. Any discrepancy in position of the horizon bar at the time of release will be corrected within a minute or two.

IMPROPER OPERATION

1. Improper operation is usually caused by (1) clogged intake filter, (2) excessive vibration, or (3) improper supply of vacuum.

2. If the instrument does not function properly check (1) filter disc to be sure that it is clean, (2) the vibration at the instrument board, and (3) the vacuum supply, before removing the instrument from the airplane. The indications of malfunction are charted as follows:

Troubles	Causes	Remedies
Bar fails to respond.	1. No vacuum supplied by venturi.	1. Examine venturi and tubing for leaks or stoppage.
	2. Air filter disc dirty reducing air flow.	2. Examine filter disc at rear of instrument case, and replace if necessary.
	3. Leaks in instrument case.	3. See that all screws in instrument case are in place and tight.
Bar does not settle level.	1. Excessive vibration.	1. Check instrument board with vibrometer and if vibration is more than .004", shock panel in accordance with special instructions, Part III.
	2. Low vacuum.	2. Check vacuum in accordance with installation instructions and if necessary, shift venturi, shorten tubing, remove kinks, or repair leaky connections as required.
	3. Air filter disc dirty reducing air flow.	3. Examine filter disc at rear of instrument case and replace if necessary.
	4. Worn pivots or bearings.	4. Remove instrument from airplane and repair, provided that the special tools and fixtures are available.

Bar oscillates or shimmies continuously.	1. Excessive vibration.	1. Check instrument board with vibrometer and if vibration is more than .004" shock panel in accordance with special instructions, Part III.
	2. Vacuum too high.	2. Check vacuum in accordance with installation instructions and if necessary, shift venturi to reduce vacuum.
	3. Worn rotor shaft or bearings.	3. Remove instrument from the airplane and repair, provided that the special tools and fixtures are available.