MOONEY "POSITIVE CONTROL"

OPERATION & SERVICE INSTRUCTION MANUAL

No. 11968

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TULSA, OKLAHOMA

11968
Issue D
5/30/01

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1. INTRODUCTION

1.1 The purpose of this manual is to assist service and maintenance personnel in testing and calibration, upon completing an installation, as well as, troubleshooting and maintenance of the "PC". Table "A" list the most probable troubles that may be reported and what procedures must be taken to isolate and correct the cause of malfunction. Paragraph #9 provides a step by step procedure for system analysis in the event that Table "A" does not cover the procedure.

1.2 Reference should be made to separate Ground Test Procedures for ground checking operation of the unit, proper vacuum settings, leaks and command functions. Reference should be made to operating instructions for proper in-flight checking and setting of the unit.

1.3 This manual is concerned primarily with the "PC" two axis system. No reference is made herein to the Dynertial Pitch Control (Elevator Control) or the Magnetic Heading Lock, as both of these items are described and dealt with in separate operating and service instruction manuals (Manuals 11968-2 & 11968-1 respectively).

1.4 This manual was automated on May 30, 2001. Changes were made only to correct typographical errors and to clarify content.

2. SYSTEM DESCRIPTION

2.1 General

The system is a pneumatically operated two axis automatic control device, (which senses both roll and yaw) deriving its source of power from the aircraft engine driven vacuum pump. The system consists basically of a Gyro Sense Element which meters vacuum pressure to a cylinder/piston servo assembly. On all aircraft upon which this system is installed these servos are attached to the aileron and rudder controls, providing for a dual control system.

The Brittain Lateral Stability Augmentation System is intended to maintain lateral stability and prevent excessive changes in heading and airplane gyrations in turbulent air, without pilot control.

2.2 Operation

Stability and control of the airplane about both the roll and yaw axis is obtained by the Rate Gyro Assembly mounted at a predetermined angle. This permits a part of the rolling rate and a part of the yawing rate to act on the sensitive Gyro Rotor Element, thus producing an output signal. In this manner, a single Gyro Element is sensing motion about tow axis, roll and yaw, and thereby providing a basic two axis system.

2. SYSTEM DESCRIPTION (CONTINUED)

2.2 Operation (Continued)

Rolling or yawing rates of the airplane caused by wind gusts, out-of-trim conditions or air speed changes displace the Rate Gyro. The resulting output signal is coupled to a patented spool-sleeve type rotary valve. The spool is rotated inside the sleeve in proportion to both yawing and rolling rates of the airplane. The spool moves to a location between the vacuum supply port and one of the output ports. The other output port is opened to atmosphere, bleeding the vacuum. The resulting vacuum differential is directed to the proper pneumatically operated servo so as to correct the original roll or yaw error. In straight and level flight, the vacuum differential is zero and the servos are balanced with respect to right and left.

Provisions have been made in his system to allow for a roll trim pilot function. This roll trim may be used to compensate for asymmetrical fuel and passenger loading and to optimize system performance in climb, cruise and let-down configurations. During normal single engine aircraft operation in low speed climb, it is necessary to utilize a combination of right rudder/aileron control to maintain wing level flight. Displacing the Roll Trim Knob to the right will partially compensate for this condition. Likewise, during high speed descent the normal left rudder/aileron trim required may be accomplished by displacing the Roll Trim Valve to the left. However, the application of the Roll Trim Valve is not intended to compensate for a lack of proper rigging of the aircraft control system. If the aircraft is properly trimmed and rigged, by means of proper roll trim adjustment, the unit will maintain an average heading over a long period of time, however, the unit will not maintain an absolute Pre-selected heading without the addition of the Magnetic Heading Lock. For optimum performance the aircraft must be rigged to fly needle-ball centered.

The system disconnect push-button, located in the control wheel, operates a pneumatic relay which provides vacuum to the Rate Gyro Valve. When the push button is depressed, the servo vacuum supply is relieved and the system is immediately inoperative. The pilot may then command turns in the normal manner without overriding the system. Releasing the push button automatically re-activates the system. However, normal maneuvers may be readily accomplished without depressing the disconnect button, as overpower forces are small and no damage will result to either the aircraft or the "PC" system.

3. GROUND TEST PROCEDURE

Make certain the installation has been accomplished in accordance with the appropriate installation manual before starting engine or conducting flight test. Perform the following ground tests and procedure.

3. **GROUND TEST PROCEDURE (CONTINUED)**

3.1 All vacuum lines must be free of kinks and sharp bends. Make certain that lines have been purged or blown free of any possible foreign particles before operating the "PC" system. **NOTE:** Do not operate the system at any time if lines are disconnected from servo units. Also, do not fly aircraft with servo unit bibs capped or lines plugged when they are connected to servo units.

3.2 Aircraft Vacuum (Primary Vacuum)

Start the aircraft's engine and increase the RMP to 1700. If desired an external vacuum pump may be utilized if the vacuum source is attached to the engine side of the aircraft vacuum relief valve. Adjust the aircraft's vacuum relief valve to 4.75 ± .25" on the gyro horizon or Directional Gyro case.

NOTE: Primary vacuum of the "PC" system may be slightly lower when read at the remote gyro (See Figure 3). Make certain relief valve or regulator is properly functioning.

3.3 Cut-Off Valve Operation

The pneumatic cut-off valve mounted in the control wheel actuates the pneumatic relay sequencing vacuum to the rate gyro valve.

PILOT VALVE

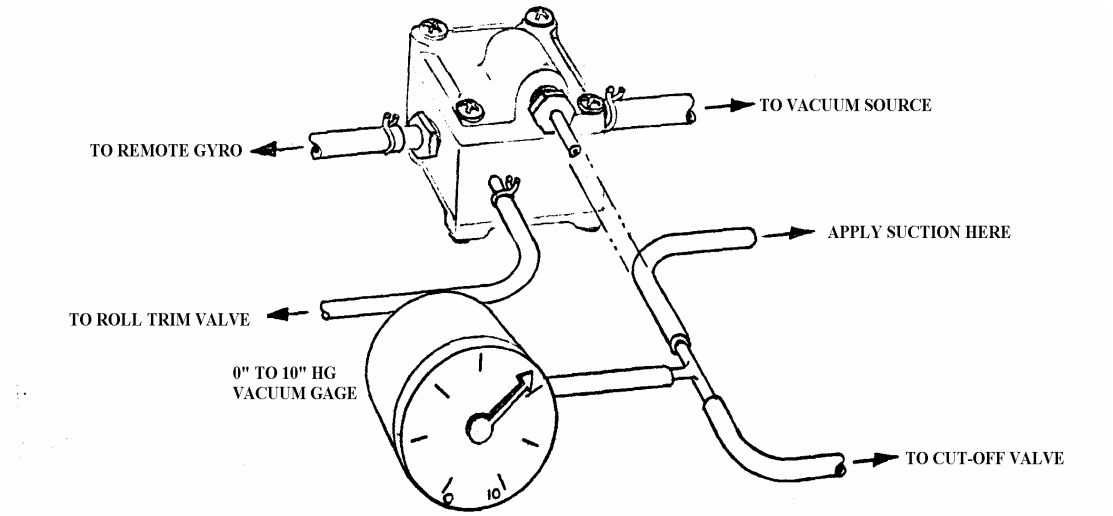


FIGURE 1

Disconnect gray line at pilot valve. Insert a tee, as per Figure 1, with a suction gauge on one side and other line

3. GROUND TEST PROCEDURE (CONTINUED)

3.3 Cut-Off Valve Operation (Continued)

Open so that suction can be applied.

Apply about 5" Hg. suction. Valve should not leak more than 2" Hg. in thirty seconds.

Depress valve and vacuum should drop immediately, proving that tubing in control wheel and valve are not restricted.

Upon release of valve, button should return immediately to its normal position.

3.4 Pilot Valve Operation

Pilot Valve is in effect a pneumatic relay that shuts off the vacuum supply to Rate Gyro Valve when Cut-Off valve is depressed and at the same time relieves the vacuum in the servos so that the "PC" system does not load the controls when system is cut off.

3.4.1 Proper Pilot Valve Operation

To test pilot valve, disconnect the gray line as per Figure 2 on the sequenced vacuum side and plumb a 0-10" vacuum gauge. With vacuum on the system and cut-off valve not depressed, reading on gauge (with primary vacuum at 4.5" Hg.) should be 4.0" Hg. +.

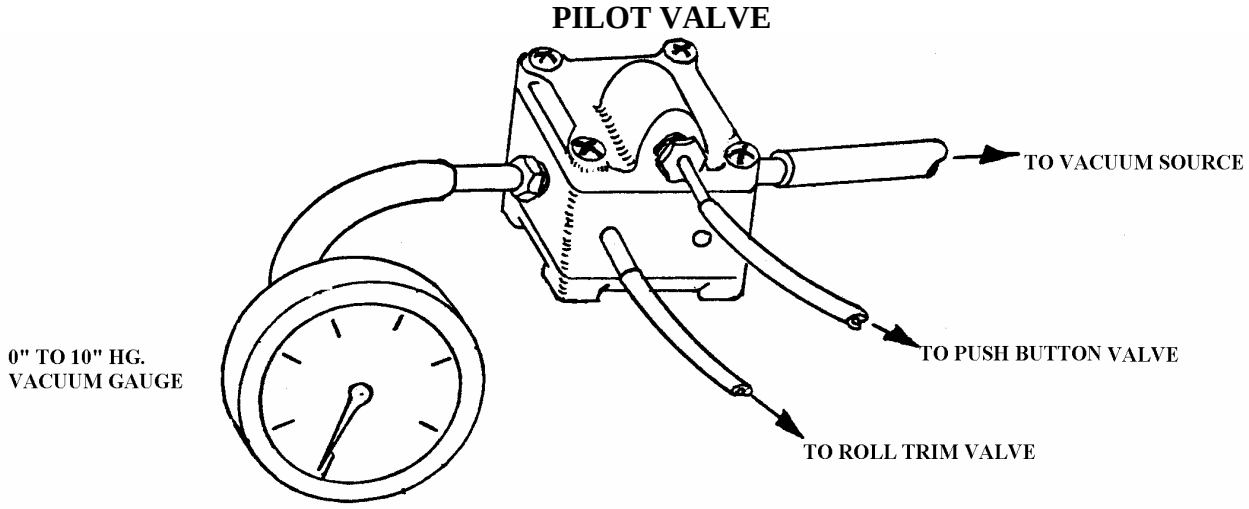


FIGURE 2

3. **GROUND TEST PROCEDURE (CONTINUED)**

3.4 Pilot Valve Operation (Continued)

3.4.1 Proper Pilot Valve Operation (Continued)

Upon depressing Cut-Off Valve, gauge should drop to 0" Hg. If vacuum is not relieved and a reading on the gauge remains, pilot valve is not shutting off completely and should be replaced.

3.5 Primary Vacuum Reading

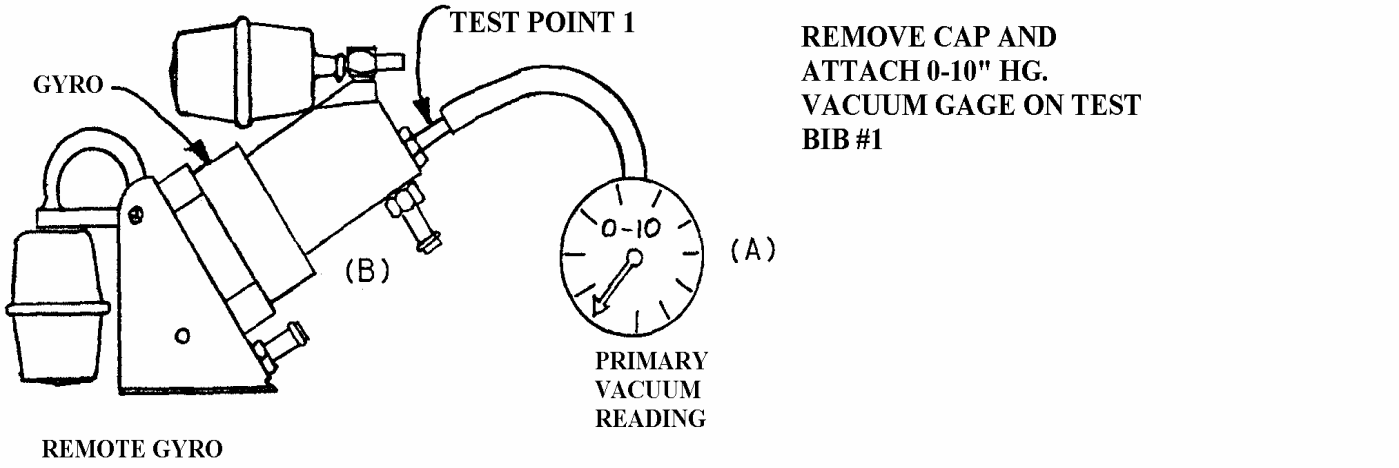


FIGURE 3

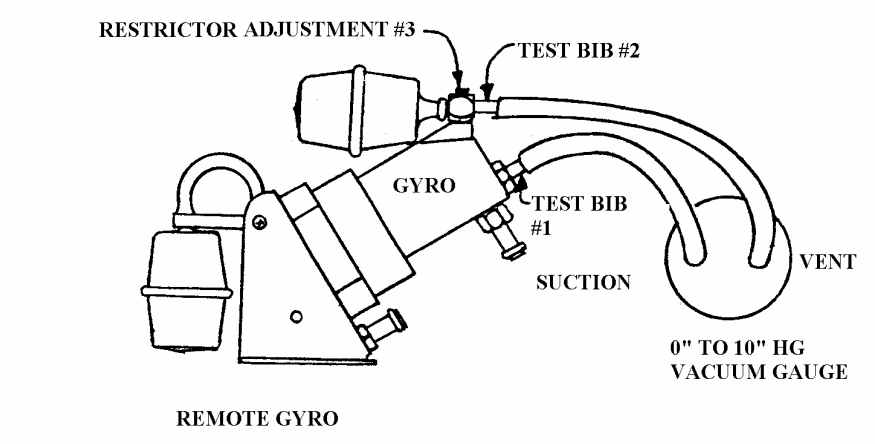
(A) Test vacuum gauge to read "Primary Vacuum".
(B) LSA-1 Gyro

3.6 Gyro Rotor Speed Adjustment

3.6.1 To assure proper Gyro response it is necessary that the Gyro Rotor be operated at the proper rotor speed. Fast rotor speed will cause over-active corrections, slow rotor speed will cause sluggish corrections. Rotor speed can be checked by the following test. (Vacuum reading of 3.5" + 1.0" - 0" Hg. is recommended for proper operation). (If group I or group II autopilot is installed, a vacuum of 4" Hg. + .1" - 0" Hg. is recommended).

3.6 Gyro Rotor Speed Adjustment (Continued)

3.6.1 (Continued)



Install a 0-10" Hg. Vacuum gauge as shown. Connect the vent side to test bib #2. Connect the suction side to test bib #1. The vacuum gage will indicate the vacuum across the rotor which controls the rotor speed (3.5" + 1.0" - 0" Hg.) See paragraph 3.6.2 for adjustment procedure.

FIGURE 4

3.6.2 To change the rotor speed: Adjust point #3 (Figure 4) to obtain the required 3.5" Hg. + 1.0" - 0" on vacuum gauge. (4" Hg. + .1" - 0" Hg. if autopilot is installed). Clockwise rotation of adjustment #3 will decrease the vacuum reading.

NOTE: This adjustment is EXTREMELY IMPORTANT, and care should be taken to make certain this adjustment is completed.

3.7 Replace the test bib caps and make certain that no leaks exist around these caps. Manually displace the Roll Trim Knob counter-clockwise as far as possible. The control wheel should tend to turn to the left. Turn the Roll Trim Valve fully clockwise and the control wheel should tend to turn to the right. Center the Roll Trim Valve. During taxi operations the control wheel will tend to turn opposite to the aircraft if gyro is properly phased.

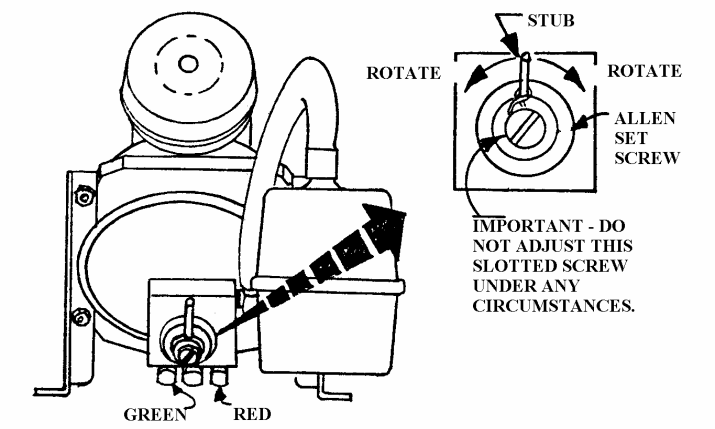
4. ROLL/YAW SYSTEM

4.1 Rate Gyro Valve Centering

Vacuum differential may result from he Rate Gyro Valve being off center while the aircraft is stationary on the ground. Yawing the aircraft will precess the Rate Gyro. In this manner it may be determined whether the pneumatic null is permanently offset. If there appears to be a permanent offset to the right or left, greater than .2" Hg. differential, the Rate Gyro Valve should be repositioned. Only minute movements of the valve stub are required.

4. **ROLL/YAW SYSTEM (CONTINUED)**

4.1 Rate Gyro Valve Centering (Continued)



(Make certain aircraft is in a wings level attitude for this check)

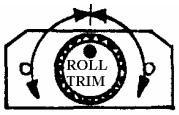
Adjust valve to center 10-0-10" Hg. Differential gauge installed across red and green Gyro bibs. It will be necessary to temporarily remove the red and green servo tubing for this test.

FIGURE 5

NOTE: Unlock allen setscrew only if necessary to allow "stub" movement.

4.2 Roll Trim Valve Centering

Roll Trim Valve stops are factory adjusted and should not be moved. Knob (dot at top) should be centered with same degree of rotation right and left.



5. **OPERATING INSTRUCTIONS AND FLIGHT TEST**

5.1 Climb to a safe altitude in smooth air and trim airplane for straight and level flight at cruise configuration. If it is apparent that aircraft is not properly rigged, re-rigging will be necessary before continuing with the flight test.

5.2 Depress the control wheel mounted Cut-Off Valve. The "PC" system should instantly become inoperative. Upon release of this Cut-Off Valve the system should instantly re-engage. Depress the Cut-Off Valve and command a standard rate turn. Release the Cut-Off Valve and the aircraft should recover smoothly.

5.3 The roll trim will normally handle asymmetrical fuel and passenger loading in cruise configuration. Fully deflected roll trim generally will not exceed 2° or 3° of bank.

5.4 The "PC" system may be easily overpowered at any time. The absence of clutches or electric motors makes it possible to override the system indefinitely with no resulting harm.

6. EMERGENCY PROCEDURES

6.1 If a malfunction should occur in the "PC" unit, it can be overridden merely with pressure on the normal flight controls, and the entire system may be disengaged by depressing the On-Off push button.

6.2 If a loss of vacuum supply occurs, (indicated by a low vacuum warning light) the "PC" system will become decreasingly inoperative. No adverse effect upon the airworthiness of the aircraft is encountered. A check for leaks in the entire vacuum system should be conducted as soon as possible. If no leaks are found, check the vacuum source (pump) and the aircraft vacuum relief valve.

7. MAINTENANCE

7.1 Once the system has been initially adjusted, it should require no further maintenance other than inspection of the various units for security and general condition.

7.2 The gyro filter should be replaced only as required. A partially clogged filter will produce a sluggish gyro sense element.

7.3 If high or low vacuum indicator illuminates, inspect the entire aircraft vacuum system for leaks, stoppages, etc.. Refer to the aircraft manufacturer’s specifications for maintenance of the vacuum pump, relief valve and instrument vacuum system.

8. TROUBLE SHOOTING

8.1 Table "A" below, list the most likely to be reported Flight Control malfunctions, their probable causes and what steps are to be taken to isolate and correct them. In the event that a reported malfunction is not covered by table "A" refer to paragraph 9.

TABLE A

REPORTED TROUBLE	PROBABLE CAUSE	REMEDY
1. INSUFFICIENT OR EXCESSIVE VACUUM	FAULTY VACUUM PUMP OR RELIEF VALVE	PERFORM TEST #1 AND ADJUST VACUUM IF NECESSARY.
2. AIRCRAFT HUNTS	1. PARTIAL CLOSURE OR LEAK IN SERVO VACUUM LINE	PERFORM TEST #2
	2. IMPROPER GYRO SPEED.	PERFORM TEST #3
	3. IMPROPER VACUUM TO VALVES AND INSTRUMENTS	PERFORM TEST #1 AND ADJUST VACUUM IF NECESSARY.
	4. FAULTY SERVO	PERFORM TEST #2
3. AIRCRAFT DOES NOT HOLD DIRECTIONAL HEADING	1. INCORRECT TRIM OF AIRCRAFT.	ADJUST AIRCRAFT TRIM TABS AND "PC" ROLL TRIM KNOB (REFER TO OPERATION INSTRUCTIONS)
	2. EXCESSIVE FRICTION IN SYSTEM	EXAMINE THE AIRCRAFT'S PRIMARY CONTROL SYSTEM TO DETERMINE THAT NO EXCESSIVE FRICTION EXISTS. LUBRICATE ALL HINGE POINTS PER AIRCRAFT MANUFACTURER'S SPECIFICATIONS.
	3. IMPROPER VACUUM TO VALVES AND INSTRUMENTS.	PERFORM TEST #1 AND #2 AND ADJUST VACUUM.
	4. FAULTY RATE GYRO	PERFORM TEST #4
4. AIRCRAFT RECOVERS ONE DIRECTION BUT NOT THE OTHER	1. PARTIAL CLOSURE OR LEAK IN SERVO VACUUM LINE	PERFORM TEST #2
	2. LOOSE OR DISCONNECTED SERVO CABLE	PERFORM TEST #2
	3. FAULTY SERVO	PERFORM TEST #2
	4. FAULTY RATE GYRO	PERFORM TEST #4
5. AIRCRAFT TENDS TO ROLL TO ONE SIDE	1. LEAK OR PARTIAL RESTRICTION IN SERVO VACUUM LINE	PERFORM TEST #2
	2. IMPROPER GYRO ROTOR SPEED	PERFORM TEST #3
	3. FAULTY SERVO	PERFORM TEST #2
	4. RATE GYRO VALVE OFF CENTER	PERFORM TEST #4
6. CONTINUOUS WHEEL OSCILLATION IN SMOOTH AIR	1. GYRO ROTOR SPEED IMPROPER.	PERFORM TEST #3
	2. TOO HIGH VACUUM SETTING	PERFORM TEST #1
	3. FAULTY RATE GYRO	PERFORM TEST #4
7. SLOW RECOVERY FROM TURN IN ONE DIRECTION	1. EXCESSIVE FRICTION IN PRIMARY CONTROL SYSTEM	EXAMINE THE AIRCRAFT'S PRIMARY CONTROL SYSTEM TO DETERMINE THAT NO EXCESSIVE FRICTION EXISTS. LUBRICATE ALL HINGE POINTS PER AIRCRAFT MANUFACTURER'S SPECIFICATIONS
	2. LEAK OR PARTIAL RESTRICTION IN SERVO VACUUM LINE	PERFORM TEST #2
	3. LOOSE OR DISCONNECTED SERVO CABLE	PERFORM TEST #4
	4. FAULTY SERVO	PERFORM TEST #2
	5. FAULTY RATE GYRO	PERFORM TEST #4

9. TROUBLESHOOTING TESTS

9.1 The following test referred to in Table "A" are to be conducted as required by the "Remedy" column of Table "A". As each of the following test are conducted, the reading or indication should be noted. If, in any test, the reading or indication differs from the correct indication, follow the corrective measures as indicated.

In the event that reported "PC" malfunctions are not covered specifically by Table "A", the following test should be used as a step by step procedure for thorough system analysis.

9.2 TEST #1 Vacuum Settings

Start the aircraft's engine and increase the RPM to 1700. If desired an external vacuum pump may be utilized if the vacuum source is attached to the engine side of the aircraft vacuum relief valve.

Adjust the aircraft vacuum relief valve to produce 4.75 +- .25" Hg. output as read at the inlet to either the gyro horizon or Directional Gyro case (See Figure 3). If this vacuum reading is un-obtainable, refer to the aircraft manufacturer's vacuum system specifications and maintenance instructions.

9.3 TEST #2 Vacuum Line and Servo Leak Test

9.3.1 **Important -** All servo lines and servos must be free from any leaks to insure proper autopilot operation. While making an initial installation, and before upholstery or side panels are replaced, leak check the installed servo lines and servos. This should be done before lines are connected to the Gyro Sense Element.

Vacuum leak check may be accomplished by inserting a test suction gauge in a closed servo line - servo system and extending the piston by moving the aircraft control surfaces (See Figure 6). Move the control column to fully extend the piston of the servo being tested. This will provide a vacuum in the system which will be indicated on the test suction gauge. Hold the control column firmly against the stops, making certain that the servo piston is stationary. If no leak exists in the system, the test suction gauge reading will remain constant. Test the other servos and tubing in the same manner.

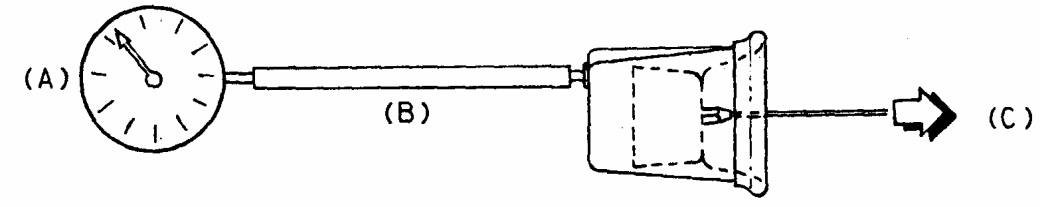


FIGURE 6

9. TROUBLESHOOTING TEST (CONTINUED)

9.3 TEST #2 Vacuum Line and Servo Leak Test (Continued)

Pressure leak check should be accomplished following vacuum leak check by inserting a tee in the servo line - servo system and pressurizing the line with 2" Hg. positive pressure (See Figure 7).

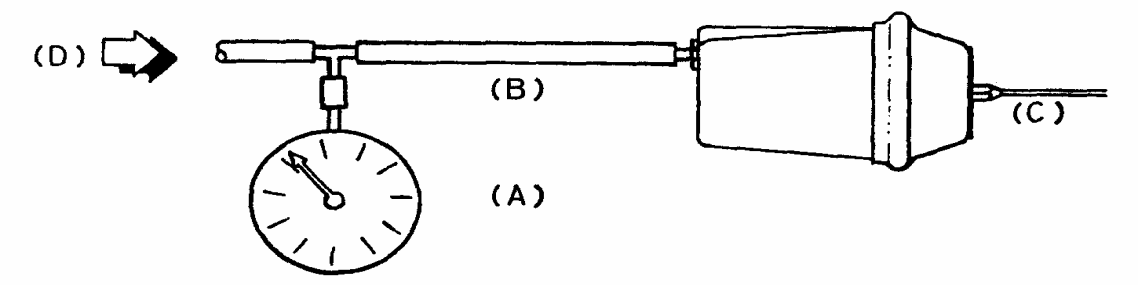


FIGURE 7

(A)	10-0-10 Test suction gauge	(C)	Free piston
(B)	Installed tubing	(D)	Apply 2" Hg. pressure

9. TROUBLSHOOTING TEST (CONTINUED)

9.3 TEST #2 Vacuum Line and Servo Leak Test (Continued)

NOTE: Examine all servos for compliance with Figure 8. The servos must be taped to preclude leaks around the piston seals. If they have not been taped, the following procedure must be accomplished:

Step 1 Remove the servo from its mounting bracket. If the servo has a rubber collar around the seal perimeter, the collar must be carefully removed and discarded. Do not remove any existing tape from the servo seal.

Step 2 Apply sufficient vacuum to the servo to bottom the piston. Using 1/2" wide Scotch #33 electrical tape, or equivalent, wrap the perimeter of the servo seal on the crown centerline a minimum of one and one-half turns as shown in Figure #1. Do not wrap the tape too tightly or the seal will crawl or tear.

Step 3 Using 3/4" wide Scotch #33 electrical tape, or equivalent, wrap the perimeter of the servo from the centerline of the crown onto the servo body a minimum of one and one half turns as shown in Figure #2. Continue wrapping while moving the tape diagonally on to the centerline of the crown for an additional one and one half turns as shown in Figure #3. Leak check and re-install the servo.

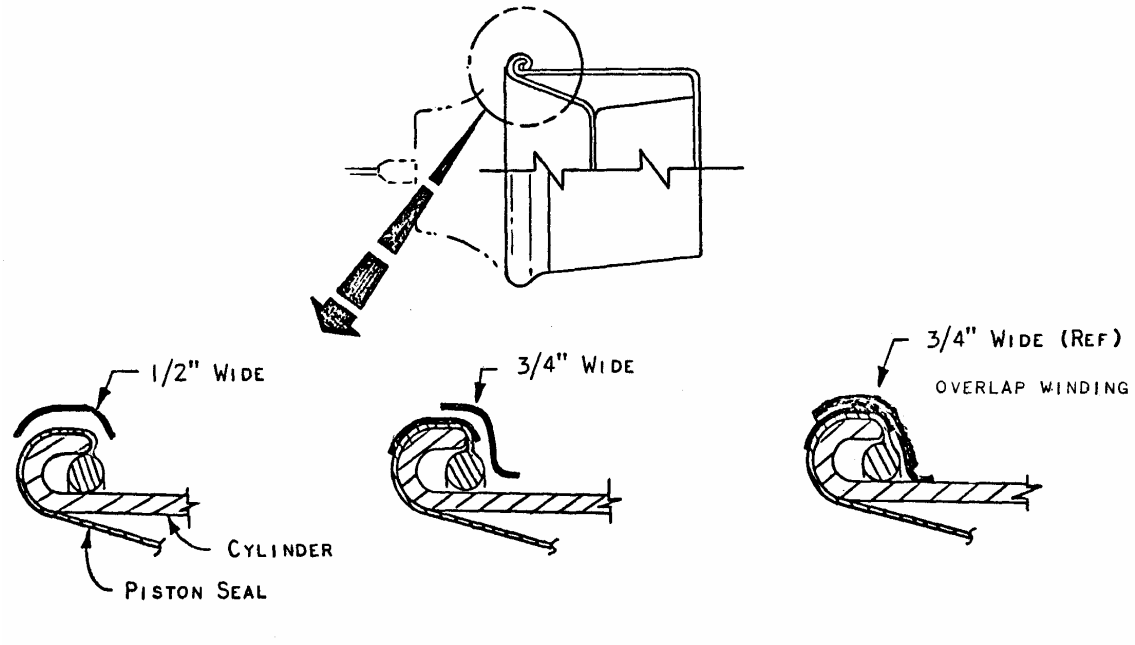


FIGURE 8

9. TROUBLE SHOOTING TESTS (CONTINUED)

9.4 TEST #3 Gyro Rotor Speed

Refer to Figure #3. Attach a 0-10" Hg. vacuum gauge to test bib #1. With the vacuum relief valve set as described in paragraph 3.3, a reading of approximately 4.25" Hg. should be obtained at this point. This reading will vary depending upon the tolerance of .25" Hg. outlined in paragraph 3.3. Note the actual vacuum reading at this time.

Uncap test bib #2 as shown on Figure #4. Plumb a line from the vent side of suction gauge to test bib #2. Adjust the set screw called out on Figure 4 to a reading of 3" Hg. + .5" - 0" Hg. (use 4" Hg. + .1" - 0" Hg. if autopilot is installed).

9.5 TEST #4 Rate Gyro Valve Centering

Refer to figure #5. Disconnect red and green Poly-Flo tubing from back of Rate Gyro. Plumb a differential gauge across the two bibs and rotate valve until 0" differential is obtained.

Yaw aircraft. Note needle deflection on differential gauge indicating Rate Gyro deflection. When aircraft stops yawing gyro should come back to center within ± .2" Hg.. Rate Gyro should be replaced if it does not center properly.

9.6 TEST #5 Installation Inspection

Rotate the aircraft control wheel. The attachment to the respective servos must be tight and the servo piston extended, with rubber seal not stretched.

Examine the aircraft's primary control system to determine that no excessive friction exists. Lubricate all hinge points per aircraft manufacturer's specifications.

10. EMERGENCY PROCEDURES

10.1 If a malfunction should occur in any of the flight control units, the system can be overpowered merely with pressure on the manual controls. the entire autopilot may be disengaged by depressing the Cut-Off Valve on the control wheel.

11. RETURNING AIRCRAFT TO SERVICE

11.1 Upon completing the flight test, entry should be made in the aircraft log that the autopilot system has been test flown and evaluated for proper function by an appropriately rated pilot (REF: FAR Part 91.167 A.)