MOONEY PITCH CONTROL

OPERATION & SERVICE INSTRUCTIONS MANUAL

No. 11968-2

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TULSA, OKLAHOMA

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1. INTRODUCTION

The purpose of this manual is to assist service and maintenance personnel in testing and calibration of the Dynertial Pitch Control System. This manual is concerned primarily with the Dynertial Pitch Control System. Reference is made throughout this manual to the basic 11968 manual to assure proper performance of the "Positive Control" system.

It is imperative that the "Positive Control" System is functioning properly before the Ground and Flight Test procedures outlined in this manual are completed. Refer to manual 11968 for basic system operation.

This manual was automated on April 30, 2001, content was not changed.

2. THEORY OF OPERATION

2.1 Pitch axis stabilization is obtained through the same basic data which the human pilot used in controlling the aircraft about its longitudinal axis. Rather than referencing the pitch axis to an artificial space reference horizon for all types of loading, stick force changes and weather conditions, the M-6 system takes into consideration the following in its sensing: (1) forward air speed, (2) vertical speed as related to rate of climb or descent, (3) "G" loads.

2.2 The Dynertial Pitch Control and Altitude Hold System consist of a Pneumatic Computer-Amplifier, a miniaturized Pitch Trim Indicator, and two simplified pneumatic servos attached to the primary elevator control system. Pilot command features include a master valve for engaging the Pitch Control and a separate Altitude Hold engaging valve. The Pitch Control must be functioning before the Altitude Hold will operate.

2.3 The Dynertial Pitch Control is designed to control the aircraft about its pitch axis by sensing dynamic forces from forward and vertical motion, inertial forces from "G" loads and changes in the attitude of the aircraft. More specifically, the data is derived from the ram air pressure of the pitot system, the changes of air density as related to rate of climb, and the gust loads by the displacement of an internal inertial mass. Abrupt changes in the attitude of the aircraft also effect the inertial mass. The combination of all of these forces results in an output signal from the Computer/Amplifier which causes the pneumatic servos to effect a correcting movement of the elevator surfaces. The corrections are almost instantaneous, smooth and air cushioned

2.4 The Pitch Control system is designed to be capable of maintaining the aircraft's attitude through its operational speed range under conditions that would otherwise cause rapid pitch axis changes. The device is also intended to control longitudinal stability, preventing excessive changes in attitude and air speed in turbulent air, without pilot control, and without placing excessive loads on the elevator surfaces or the aircraft structure. The system may be engaged for climb-out, when reaching cruise altitude or in making let-downs.

2. THEORY OF OPERATION (CONTINUED)

2.5 The attitude of the aircraft is basically determined by the positioning of the aircraft's elevator trim tab. If the aircraft is trimmed for climb attitude, the miniaturized Pitch Trim Indicator will be displaced above the mid reference point, conversely, if the aircraft is trimmed nose down for descent, the Pitch Trim Indicator will be displaced below the mid reference point. In sustained level flight (altitude hold off), the Pitch Trim Indicator will move about the mid reference point. A momentary displacement of the indicator signifies changes to the elevator servo pressure required to make minute corrections to maintain the commanded attitude.

2.6 Response of the Pitch Control System to air speed changes is determined by the adjustment of the "Decay Rate" located on the Pitch Control Sensor Assembly. This is one of the two in-flight adjustments that may be required. For proper setting, refer to the procedure section on in-flight adjustments and the appropriate diagrams.

2.7 Secondary adjustments marked "V" and "Centering" are presented on the Pitch Control Assembly. Adjustment at these points is rarely required and should be made only after following an autopilot installation survey "Check List" - never before the servos and lines have been leak checked.

2.8 Altitude Hold capabilities are provided by a mechanically simplified approach of referencing density pressure when the pilot wishes to maintain a particular altitude. This simplified approach provides economic benefits with a high degree of reliability.

2.9 When it is desired to maintain a given altitude, the Altitude Hold Knob "Pull-On" is engaged. In effect, this closes a valve which seals a pressure chamber remotely mounted away from effects of changes in cabin temperatures. The valve, Altitude Hold Assembly and Pressure Chamber are all interconnected by orange tubing to form a closed system, when the valve is closed, "Pull-On". The pressure chamber provides for a reference to air pressure at a given altitude. If the aircraft is displaced vertically, as in an up-draft or down-draft, changes in attitude required to return the aircraft to the initial altitude will be limited by the pitch stabilizing device. Thus excessive changes in attitude or air speed are avoided in an attempt to maintain altitude...

3. SURVEY OF AUTOPILOT INSTALLATION AND BASIC REQUIREMENTS

The intended purpose of this section is to furnish the installer and maintenance personnel with a procedure to be followed to verify proper installation and function of the Autopilot components and system. Accompanying each Autopilot is an inspection report which parallels the following procedure. Experience has shown that needless man hours and flight test hours will be saved by following the survey and methodically checking off the inspection record. Once the installer or service personnel is familiar with he equipment and the survey, a complete checkout of the entire system may be accomplished within a thirty minute period.

3.1 AIRFRAME REQUIREMENTS

3.1.1 Prior to installing any automatic flight control equipment, the aircraft should be flown to determine whether or not the basic "Positive Control" system is properly operating. An aircraft which is out of rig should be corrected in order to avoid improper Pitch Control operation. refer to manual 11968 for proper operation of the basic system.

3.1.2 The following items must be verified for proper operation before proceeding with the ground adjustment procedures:

(A) PRIMARY VACUUM SETTING

1. Refer to Paragraph 3.2, manual 11968.

2. Cut-Off Valve operation, refer to Paragraph 3.3, manual 11968.

3. Pilot Valve operation, refer to Paragraph 3.4, manual 11968.

4. PITCH SYSTEM OUTPUT ADJUSTMENTS

4.1 There are three adjustments accessible on the Pitch Control Assembly. These are factory set and flight tested: If re-adjustments are necessary they should be made in small increments.

4. **PITCH SYSTEM OUTPUT ADJUSTMENTS (CONTINUED)**

(1) Centering adjustment which balances the pneumatic output of the assembly in relation to "Up-Down" for a static condition.

(2) Decay rate which is an in-flight adjustment. Rotating the decay rate clockwise makes the system more responsive to air speed changes, while rotation counter-clockwise renders the system less responsive. The aircraft should be flight tested prior to changing the decay rate setting.

(3) The "V" adjustment appearing above the hose bibs on the assembly, varies the amount of vacuum available to the elevator servos. Rotation counter-clockwise increases the vacuum output to the servos.

NOTE: Do not attempt any adjustment of the above without following the recommended procedures.

4.2 In a static condition - zero pitot pressure and no motion, there should be zero (± .2" Hg.) differential between the blue and yellow output ports of the Pitch Control Assembly (See Figure #1). the centering adjustment, accessible through the top of the assembly, is a slotted mechanism which, when rotate clockwise, will increase the vacuum output to the blue port.

NOTE: Under no circumstances should the centering adjustment be moved with the elevator servos or servo lines connected to the Pitch Control Assembly. Rotation of the centering adjustment must be made in 1/8 turn increments until the differential gauge is zeroed. Tap the Pitch Control lightly during adjustment. Rotation in excess of 1/2 turn in either direction may permanently damage the sensor.

Make certain that the rubber cap plug is secure in the centering hold after completing centering adjustment.

4.3 Vacuum output to the servos should be determined with servo lines disconnected from the blue and yellow 1/4" ports. Cap these bibs and gently apply positive and negative pressure, not to exceed 1" of Hg., to the pitot input line (See Figure #1). While the Pitch Sensing mechanism is under pressure, read the vacuum differential between the up and down lines. Differential may be increased by rotating adjustment "V" counter-clockwise and decreased by rotation clockwise.

4. **PITCH SYSTEM OUTPUT ADJUSTMENTS (CONTINUED)**

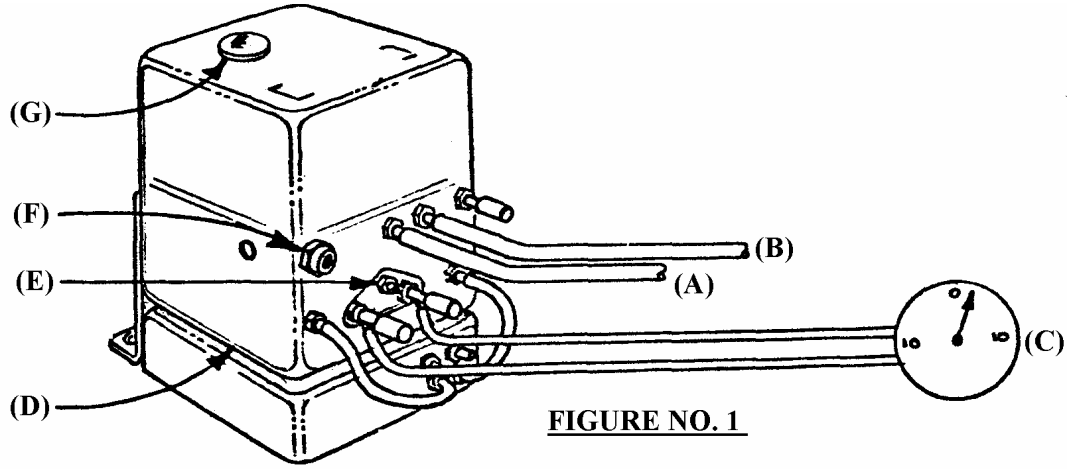

FIGURE NO. 1

(A)	TO VACUUM SOURCE	(E)	V ADJUSTMENT
(B)	PITOT INPUT	(F)	DECAY RATE (FLIGHT TEST ONLY)
(C)	DIFFERENTIAL GAUGE		
(D)	PITCH CONTROL ASSEMBLY	(G)	CENTERING ADJUSTMENT DUST CAP

4.4 Make certain pitot system will hold pressure with Pitch Control disconnected from the system. It is normal to have a small leakage of line air when the pitot system is connected to the Pitch Control device. (If, subsequent to completing the autopilot installation, it is desired to check the pitot system, make certain that the Pitch Control Assembly has been isolated from the pitot system.)

4.5 Verify proper phasing of the blue and yellow servo lines which supply the elevator servos, as follows:

(A) Opening the brown 1/8" Altitude Hold bib on the Pitch Control Assembly will supply vacuum to the blue line (up servo) when the green 1/8" tube is closed.

(B) Conversely, opening the green 1/8" tube connection to the Pitch Control Assembly will supply vacuum to the yellow line, (down servo) when the brown tube connection is closed.

4.6 Leak check the Pitch Trim Indicator. remove the blue and yellow 3/16" tubing from the 11300 Assembly and apply gentle suction to the blue and yellow tubing. Displacing the indicator bar half scale, hold suction thirty seconds. The bar should remain in half scale position. If leak is present, replace indicator.

4. **PITCH SYSTEM OUTPUT ADJUSTMENTS (CONTINUED)**

4.7 ALTITUDE HOLD SYSTEM

4.7.1 The Altitude Hold mechanism is actuated by pressure differential as related to the captured density pressure of the air contained in the chamber, part number 11353. It is imperative for proper function that the tube connections to the chamber, the Altitude Hold Assembly, and the "Pull-On" engage valve be absolutely air tight. Any leak in the orange tubing connections, or the related components, will prevent the aircraft from returning to the captured altitude once it is displaced (See Flight test section, Pitch/Altitude Hold response).

4.7.2 The Altitude Hold System may readily be pressure check in the following manner: (Reference Figure 2).

(1) Disconnect the 1/4" O.D. orange tube from the Altitude Hold Assembly at test point #1. Insert a test suction gage and tee in this end of the tubing. Cap the filter assembly and, with the Altitude Hold valve in the "On" position, apply 5" Hg. to the line. There should be no drop in vacuum.

(2) Uncap the filter and observe the gauge. The 5" Hg. as applied to the line should not be relieved.

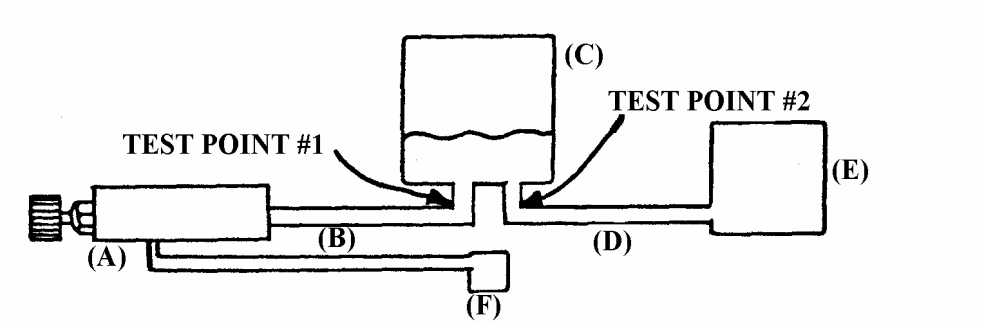

FIGURE NO. 2

(A) ENGAGING VALVE "PULL-ON"
(B) ORANGE TUBE
(C) ALTITUDE HOLD ASSEMBLY
(D) ORANGE TUBE
(E) PRESSURE CHAMBER
(F) FILTER

5. OPERATIONAL FLIGHT CHECK AND ADJUSTMENTS

5.l PRE-FLIGHT CHECKS

5.1.1 Review the Ground Check Inspection record and make certain that all items have been covered.

5.1.2 Complete the aircraft logs for the installation and have the appropriately rated pilot, who is to flight test the installation, familiarize themselves with the "Owners Operating Manual."

5.1.3 Install an Allen wrench in the Pitch Control "Decay Rate" adjustment, but do not rotate unless required.

5.1.4 Adjustments to the Pitch Control may be made during flight or on the ground.

5.1.5 Place the function knob and the Pitch Master Valve in "Off" position until airborne at a safe altitude.

5.2 FUNCTIONAL OPERATION

5.2.1 Climb to a safe altitude above the terrain. Attempt to find smooth air in which to conduct flight test. Trim the airplane for straight and level flight at cruise configuration.

5.2.2 Prior to engaging the Pitch Control System, make certain that the Altitude Hold is disengaged, ("Off" position). Engage the Pitch "On-Off" master with turn controller function knob in the "Off" position. Engage and disengage the Pitch Master Valve repeatedly, and observe the aircraft for any displacement on the Pitch or Roll axis. If abrupt displacement is apparent, abort the flight test. Troubleshoot and re-check ground and test calibrations. If when the autopilot is engaged in a climb attitude, a slight pitch down is noticed, this is normal and you should retrim the aircraft for the rate of climb desired with the autopilot engaged. Use the same procedure during descent.

5.2.3 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 Cutoff Valve in control wheel.

5. OPERATIONAL FLIGHT CHECK AND ADJUSTMENTS (CONTINUED)

5.3 PITCH CONTROL DECAY RATE ADJUSTMENT

5.3.1 The Decay Rate adjustment has been pre-set by the manufacturer for an average installation. Before any attempt is made at repositioning the adjustment, check the Pitch and Altitude Hold response. Evaluation should be made in smooth air.

5.3.2 Normal response of the Pitch-Altitude system is observed in the following manner:

1. With the flight control system engaged, Altitude Hold "Off", command various attitudes of the aircraft by slowly changing the trim tab position. Verify the response of the Pitch system at different angles of attack.

2. With the aircraft trimmed for level flight, (Pitch Trim Indicator moving near the mid reference point) at cruising speed, engage the Altitude Hold "Pull-On" and note the "Captured" altitude.

   Override the autopilot system displacing the aircraft 500 feet above the "Captured" altitude. Hold the aircraft at this level until the rate of climb indicator reads zero.

3. Release the control column and observe the characteristics of the descent. Initially the aircraft will descend rapidly. As the indicated air speed increases, the angle of descent will gradually lessen with the aircraft finally reaching zero rate of descent at or slightly above the pre-selected altitude (See Figure A).

   NOTE: If the aircraft does not ultimately return within 50 feet of the originally "Captured" altitude, there is indicated either a leak in the altitude pressure reference system, (See Paragraph 4.7.2) or a change in temperature within the pressure chamber. Temperature effect may be due to the rate chamber not stabilizing with the outside air, or due to a change in outside temperature.

5. OPERATIONAL FLIGHT CHECK AND ADJUSTMENTS (CONTINUED

5.3.3 Abnormal response of the Pitch-Altitude system as related to the Decay ate adjustment, may be verified as follows:

1. Duplicate the conditions above under Paragraph 5.3.2

2. If the Decay Rate has been set open too far, (counter-clockwise) the curve depicting the descent described in Paragraph 5.3.2 will be represented by the dotted line of Figure "B". The initial rapid rate of descent will continue being only slightly decreased by the increasing air speed. The aircraft will pass through the level of the initially "Captured" altitude and then return above and below in diminishing cycles.

3. If the Decay Rate has been set closed beyond the optimum point, (clockwise) the rate of descent will be represented by the solid line of Figure "B". In the latter instance it will be noted that the aircraft is responding more positively to air speed changes than to altitude hold, which is commanding a lower altitude. Increase in airspeed as the craft is descending will reduce the rate of descent to zero when the craft is as mush as 100 to 150 feet above the "Captured" altitude.

5.3.4 In-flight adjustment of the Decay Rate should be made only if it has been determined that the setting is improper, and no leaks or pinched tubing exists.

If the condition described in Paragraph 5.3.3 occurs. slowly rotate the Decay Rate adjustment clockwise in increments of less than 1/16 of a turn. If the condition described in Paragraph 5.3.3, Section 3 occurs, make the necessary adjustment counter-clockwise in the same 1/16 or less increments.

6. EMERGENCY PROCEDURES

6.1 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.

7. RETURNING AIRCRAFT TO SERVICE

7.1 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).

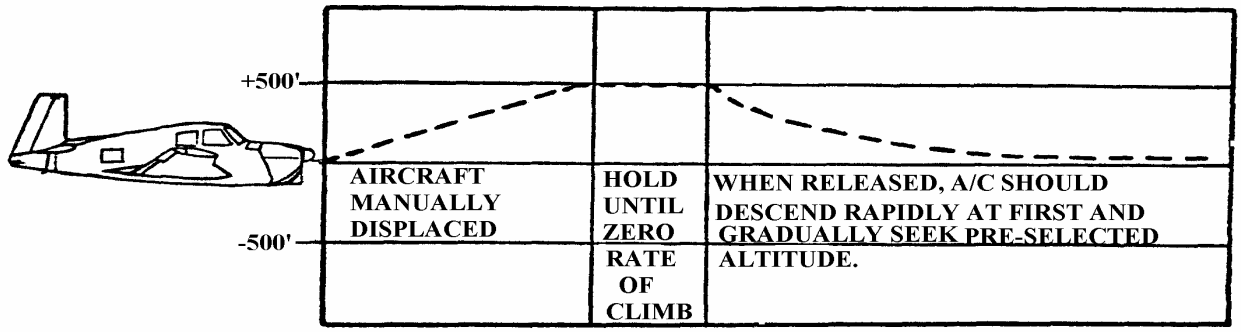

FIGURE A

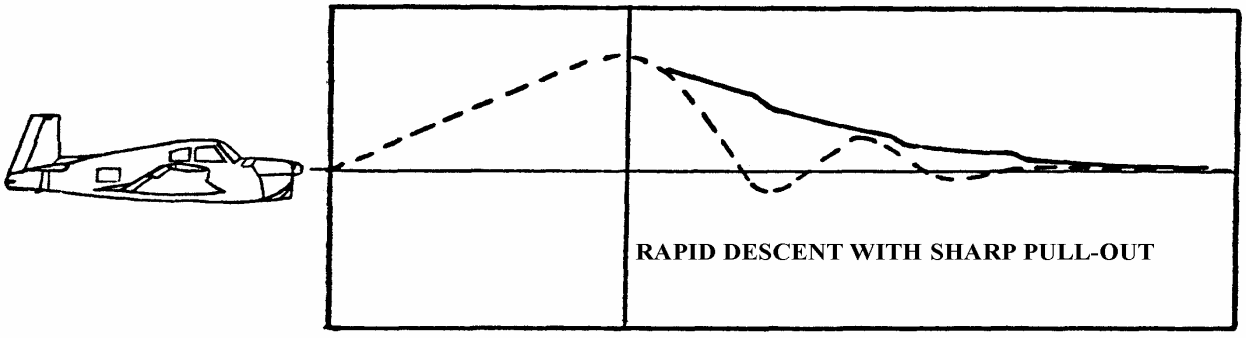

FIGURE B

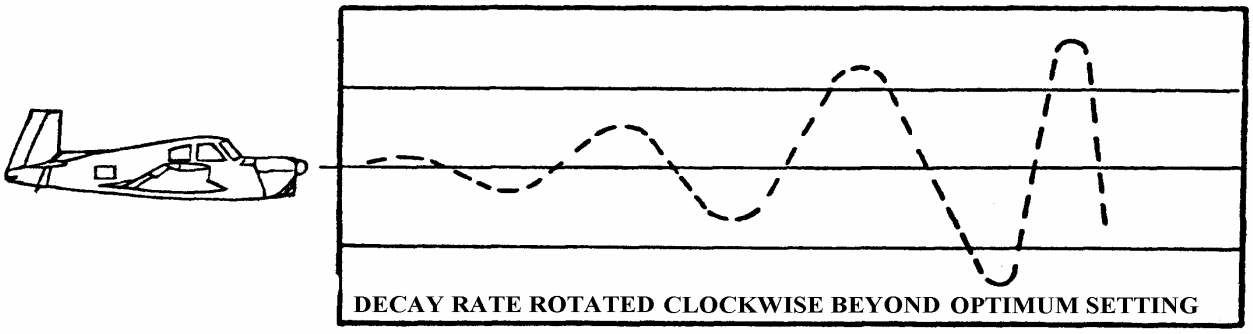

FIGURE C

FIGURE 3