B-4 and B-4A

INSTALLATION, OPERATION, MAINTENANCE

and SERVICE MANUAL

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INTRODUCTION

The purpose of this manual is to familiarize service and maintenance personnel with the principles and methods of the operation of the B-4 Automatic Flight Control System. In addition, a survey is presented, which is to be used upon completion of an installation, to verify proper function and phasing of the components. The procedure presented in the survey is also recommended for system evaluation and verification of proper function after the unit has been in service in the field.

Upon completion of the installation, there are only three ground adjustments and two in-flight adjustments required to optimize the performance of the Flight Control System. Although theses adjustments are seemingly very straight forward and simple, it is strongly urged that the service personnel familiarize themselves thoroughly with the principles and method of operation and conduct a "check list" survey of the installation before attempting any adjustment of the components. For the understanding of the operation of the complete system, one should refer to the "Owners Operation Manual".

Manual 3951, added March, 1968 Section V, Pages 1 through 7.

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SECTION I

PRINCIPLES AND METHOD OF OPERATION

1. GENERAL

1.1 The B-4 Flight Control System is an electro-pneumatic device which provides stabilization of the aircraft on its three axes, as well as, secondary functions. The secondary functions are altitude hold capabilities and directional control by means of a coupler which utilizes magnetic heading and VHF navigational radio information.

1.2 One of the principal design features of the system is the fact that there is no inter-dependence upon the aircraft's Directional Gyro or Artificial Horizon. Three axes stabilization is obtained by utilizing but a single ruggedized rate gyro and an air speed sensing device. Heading control is by means of an advanced design, solid state, electronic coupler which utilizes the latest developments in the present stage of the art. The electronic portion of the system is low in power drain (100 milliamps at 12 volts) and designed for reliability. The basic system provides for basic stabilization of the aircraft on all three axes, even in the event of electrical failure.

2. ROLL/YAW CONTROL

2.1 Primary or basic stabilization on the roll/yaw axis is obtained by means of a single angularly mounted rate gyro which senses both roll and yaw motion in varying proportions, depending upon the pre-determined angle at which the gyro is mounted. Disturbance of the gyro sense element, meters vacuum to cylinder-piston servo assemblies. On all aircraft on which the system is installed, the servos are attached to the aileron controls. On some models of aircraft, additional servos attached to the rudder are provided. Rolling and yawing rates of the airplane caused by wind gusts, out-of-trim conditions or air speed changes, displace the rate gyro. The displacement moves a patented spool-sleeve type rotary valve. The spool is rotated inside the sleeve in proportion to the roll/yaw rates of the airplane, moving to a location between the vacuum supply port and one of the servo output ports. The opposite output port is opened to atmosphere. The resulting vacuum differential is directed to the proper pneumatically operated servo so as to correct the original roll/yaw error. In straight and level flight, the vacuum differential is zero and the servos are balanced with respect to left and right. (A simple ON-OFF function valve supplies vacuum to the system to engage the device). The rotor of the gyro element is energized when the aircraft engine is running. Upon engaging the system the aircraft will immediately be controlled in a manner that will reduce apparent turning or roll rates to zero.

2. ROLL/YAW CONTROL (Continued)

2.2 Directional control of the aircraft in the basic system is accomplished by means of rotating the above mentioned sleeve of the spool-sleeve combination to command right and left turns. In the B-4 and Nav-Flite Systems however, directional control of the aircraft is obtained by means of an electro-pneumatic shunt valve which is located in the amplifier assembly. This shunt valve provides vacuum to the right and left servos to command aileron and rudder control. The variations in the voltage which operate the shunt valve are produced in the amplifier assembly. This is accomplished by means of amplifying and integrating information obtained from a magnetic heading sensor and radio navigation equipment. In addition, a command turn knob, located on the controller, operates the shunt valve for maneuvering of the aircraft.

2.3 Rate-of-turn (bank angle) depends upon the rate gyro's capability of matching the pneumatic imbalance produced by the shunt valve. For this reason, it is essential for proper operation of the directional control system, that the roll/yaw stabilizing gyro be correctly adjusted in respect to rotor speed. If the rotor is turning too rapidly, a shallow bank angle with less than standard rate-of-turn will result. Conversely, if the gyro rotor is turning too slowly, a steep bank angle with an increase in rate-of-turn will result. Variations in the speed of the gyro rotor may be obtained by adjusting a variable restrictor or throttle in the line which allows air to enter the top of the gyro case, passing over the gyro bucket-wheel. Adjustment of this restrictor, P/N *11304*, is one of the two in-flight adjustments required upon completing the installation to obtain optimum performance.

3. MAGNETIC HEADING CONTROL

3.1 Magnetic heading information is obtained by means of the heading sensor which resolves the earth's magnetic flux. When the heading azimuth on the controller is set to 90° and the aircraft is on a heading of 90°, the electrical heading circuit is balanced and zero voltage appears at the shunt valve in the amplifier assembly. When the controller heading azimuth is rotated to 180°, an electrical imbalance is generated. This imbalance produces an error signal which is amplified in the transistorized amplifier. The amplified signal generates voltage on the right side of the shunt valve, causing the valve to open. With the right side of the shunt valve open, the aircraft turns to the right until an opposite error signal is developed by the heading sensor as it rotates with the aircraft in respect to the earth's' magnetic filed. When the aircraft takes up a heading of 180°, the magnetic sensor and the heading azimuth are in phase and the voltage at the shunt valve drops to zero, closing the electro pneumatic valve.

When the heading azimuth and the electrical output of the magnetic sensor are in phase, any change in the heading of the aircraft to right or left will produce an error signal from the sensor. The error signal will cause the shunt valve to be rotated to the right or left, as required, to bring the heading of the craft back to a point where there is no error generated at the sensor.

3. MAGNETIC HEADING CONTROL (Continued)

3.2 The magnetic heading sensor is remotely mounted in the aircraft in manner similar to a remote indicating compass. The sensor contains no moving parts and therefore requires no servicing. When installed the unit is not adversely affected by vibration. However, prior to installation, a sharp blow to one of the poles may damage the solid state sensor and therefore caution must be exercised during installation.

3.3 The mounting of the sensor unit is designed to permit the sensing unit to move freely as a pendulum on the longitudinal axis of the aircraft. Acceleration and deceleration of the aircraft may displace the sensor on its pivots and may produce momentary changes in magnetic headings on East and West. Improper dressing of the harness leading from the sensor causing a restriction of the pendulous motion will exaggerate the heading error on East and West with changes in the attitude of the aircraft.

3.4 There is a definite relationship between the rate-of-turn (bank angle) and program magnetic headings. The transistorized circuitry which provides magnetic heading information is designed for certain "roll out" characteristics which pre-suppose a given rate-of-turn (bank angle). If the rate-of-turn is faster than 3° per second, there will be a tendency for the aircraft to over-shoot programmed magnetic turns to East, North and West. If, by virtue of too fast a gyro rotor, a shallow turn is produced, programmed magnetic headings to North will be slow in approaching the final heading and nearly deadbeat on east and west. Turns to South with a shallow bank angle may over-shoot the final Southerly programmed heading. Proper rate-of-turn, slightly less than standard rate, should allow for approximately 5° over-shoot on East and West, with less than 5° over-shoot on North and South.

3.5 Proper gyro speed will provide for optimum rate-of-turn. However, unequal turns in relation to left and right, may only be corrected by proper trimming or rigging of the aircraft. If an aircraft is rigged or trimmed to fly with one wing down, or with the ball of the turn and bank off center, turns will be steeper in one direction than the other. In addition, final heading accuracy between 280° and 080° may be adversely affected.

3.6 As in all magnetic airborne devices, there are certain inherent errors caused by the vertical component of the earth's magnetic field. To minimize the undesirable effect of the vertical component, particularly while programming magnetic heading changes, there are compensating transistorized networks in the amplifier assembly. The amount of compensation produced may be varied by positioning the "latitude selector" on the amplifier assembly. For optimum performance, make certain that the latitude switch is set to correspond with the positions indicated on the map showing the latitude selector zones.

3. **MAGNETIC HEADING CONTROL (Continued)**

3.7 It may be necessary to compensate the sensor for a particular installation. Adjustments are provided for N-S and E-W errors. These adjustments are to be made in a similar manner to adjusting a magnetic compass (See Pre-Flight Adjustments).

4. **RADIO NAVIGATION COUPLING**

4.1 Radio VOR coupling is obtained by means of additional circuits in the amplifier. These circuits are connected to the left/right meter output of the VOR navigational equipment of the aircraft. Phasing of the connection to the VOR meter is such, that when the VOR deviation is to the right (in yellow zone); the electro pneumatic shunt valve is rotated to the right, commanding the aircraft to turn to the right. When the VOR deviation is to the left (in the blue zone), a left turn is commanded. The voltage that is generated in the VOR system to produce left and right meter movements also modulates the Nav-Coupler.

4.2 Omni Heading intercept and hold is accomplished by selecting the desired VOR radial with the OBS selector of the navigational equipment. The indicated Omni radial is matched by selecting the same heading on the rotatable heading azimuth. When the aircraft is not on the selected VOR radial, the VOR deviation meter will be displaced from the center position. The displacement of the left/right needle represents a bi-polar meter voltage which modulates the navigation portion of the coupler, causing the shunt valve to open and remain open until the bi-polar VOR meter voltage is zero. When the meter voltage becomes zero, the aircraft will continue to fly on the magnetic heading that has been selected on the heading azimuth.

4.3 The relationship of the heading information to navigation information varies in the Capture and Track modes. In the Capture mode, a full scale left/right meter deviation will produce a change in the heading as great as 60° from a selected magnetic heading. As the desired VOR radial is approached and the left/right meter displacement decreases, the aircraft will gradually turn toward the selected magnetic heading. In the Capture position, a VOR error signal equal to 10° off course will result in a change in selected heading of 4°. Maximum bank angle in the Capture mode is approximately a standard rate turn.

In the Track mode, the system is more sensitive to the VOR meter displacement. This optimizes the tracking of a captured Omni radial. The track circuits provide for a ratio of 1° VOR error to 10° magnetic heading error. The bank angle of the Track mode is limited to approximately one third of the maximum bank angle obtained in the Capture mode.

4.4 An added provision is provided in the Track circuit to optimize station crossing where the navigation signal shifts phase. While in Track mode, the effectiveness of the VOR signal is limited to a maximum of 5° displacement. When the left/right deviation needle exceeds a 5° off course level, magnetic heading data automatically supersedes radio navigation information. This precludes rapid and excessive heading excursions while passing over a VOR station.

5. NAVIGATIONAL RADIO REQUIREMENTS FOR AUTOPILOT COUPLING

5.1 The coupler has been designed to a low impedance load of 10,000 Ohms. The intercept circuitry of the Nav-Coupler is floating in respect to ground. Optimum response may be obtained with as little as 35 millivolts across the left/right VOR meter circuit for 10° off course. (Bi-polar voltage up to 500 millivolts is acceptable and may be attenuated by the Nav-Coupler/Amplifier Nav-Sense adjustment). By reason of these characteristics, the Nav-Coupler will be found to be compatible with a great many different makes and models of navigational radio equipment.

5.2 There are considerable differences in the electrical characteristics and performance level of radio navigation equipment of various models and makes. They may be divided into two categories: ARINC standard, and Non-ARINC standard equipment.

A. Radio navigation equipment meeting ARINC standards has provisions for three or more 1,000 Ohm loads. The coupling may be connected across the left/right VOR meter output without changing existing loads. All of the ARINC standard equipment will provide adequate signals for optimum operation of the autopilot Nav-Coupler.

B. Radio navigation equipment that is not designed to ARINC standards may be used, in most instances, with the Coupler System. Some of the equipment in this category requires no circuit modification other than connecting the Nav-Coupler parallel to the VOR left/right meter. There is in common usage, considerable radio navigation equipment, however, which does not provide sufficient signal output for optimum operation of the Coupler. Prior to ground check procedure, it may be determined whether or not the existing radio equipment is compatible with the Nav-Coupler by determining whether or not there is available a bi-polar voltage across the VOR left/right meter of 35 millivolts, minimum, for 10° off course. The compatibility of radio equipment in this group may also be determined by means of a ground check procedure wherein navigation error information is balanced against magnetic heading information (See section covering Pre-Flight adjustment). In the event that there is any question in regard to radio compatibility, the information in item 5.1 should be transmitted to the respective radio equipment manufacturer for recommendations.

5.3 Some VOR equipment have a floating ground in the VOR indicator circuit. Coupling to the autopilot, which is also floating in respect to ground, may result in a loading of the amplifier circuits. This loading may result in an onset of the shunt valve in the amplifier with a voltage differential across the red and orange test jacks when the VOR equipment is energized. This loading of the amplifier may be corrected by placing a ground connection or jumper between lead #3 of the BI-500 cable assembly and the chassis of the VOR converter.

5. **NAVIGATIONAL RADIO REQUIREMENTS FOR AUTOPILOT COUPLING (Cont.)**

5.4 The Nav-Coupler is capable of responding to minute deviations of the left/right VOR indicator. This sensitivity level is necessary to obtain optimum Omni capture and track performance. Make certain the radio navigation equipment is functioning properly, and that the left/right needle is steady. The use of an Omni simulator or Omni station capable of producing a full scale left/right meter deflection is recommended. With left/right needle centered, check for radio interference causing erratic needle movement, this must be at a minimum. Check generator and voltage regulator. Make certain they are filtered sufficiently as not to produce electrical interference. Check Omni course width and sensitivity to equipment manufacturer's specifications.

NOTE: The equipment must respond to the electrical information appearing across the left/right VOR meter. If this information is inaccurate undesirable autopilot coupling will result.

5.5 The Nav-Coupler amplifier and controller assemblies are available in both 12 and 24 volt models. Before proceeding with ground check of the Nav-Coupler system, make certain that the controller and amplifier are the same voltage as the aircraft's electrical system.

NOTE: If required to be compatible with the aircraft voltage, a modification kit, with instructions and necessary components, is available, upon request, which enables the conversion, in the field, of a 12-volt component to a 24-volt component and vice versa.

5.6 Verify that the aircraft's voltage regulator is producing the proper voltage. This check should be made with a maximum electrical load applied and a fully charged battery (low voltage will result in sub-standard operation of the navigation coupler. Low voltage may also result in a decreased rate of turn). After installation of the Nav-Coupler, it must be determined that the operation of the radio navigation equipment meets the radio manufacturer's minimum performance specifications, using specifications and procedures specified in the radio manufacturer's service and maintenance manual.

5.7 Wires #3 and #4 from the controller harness are to be connected in parallel to the left/right meter movement of the VOR/LOC indicator. An optional double-pole, double-throw switch may be installed to enable the pilot to switch the Nav-Coupler from the #1 VOR to #2 VOR if desired.

See installation manual drawing 11280. The output from the two Omni converters must be equal or mismatching will occur.

6. **ELEVATOR CONTROL**

6.1 Pitch axis stabilization is obtained through the same basic data which the human pilot uses 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 B-4 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) changes in attitude about the pitch axis.

6.2 The Dynertial Pitch Control System consist of a pneumatic computer/amplifier; a sensitivity control, which varies the servo reaction time; a miniaturized pitch trim indicator, and two simplified pneumatic servos attached to the primary elevator cables. When equipped with the altitude hold feature, there is also a command function for engaging altitude hold capabilities.

6.3 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 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 attitude of the aircraft also affect 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.

6.4 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 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.

6.5 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 in the elevator servo pressure required to make minute corrections to maintain the commanded attitude.

6.6 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.

6. ELEVATOR CONTROL (Continued)

6.7 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 checklist - NEVER BEFORE THE SERVOS AND LINES HAVE BEEN LEAK CHECKED.

7. ALTITUDE HOLD

7.1 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.

7.2 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 the 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 the 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.

8. B1-400 HI-LO SENSITIVITY ADAPTOR

8.1 The Hi-Lo sensitivity adaptor, model BI-400, may be installed as optional equipment with any Brittain heading lock/navigation coupler installation. Drawing 11122 is included in the back of this manual for verification of proper installation. There are no adjustments required on the Hi-Lo sensitivity adaptor.

8.2 The Hi-Lo sensitivity adaptor optimizes VOR and LOC tracking. During normal operation the Hi-Lo sensitivity adaptor switch should be left in the high position. The only time the selector should be used in the Low position is during excessive turbulence, when the VOR needle is unsteady due to extreme range or during intermittent VOR signal transmission.

SECTION II

SURVEY OF AUTOPILOT INSTALLATION AND BASIC REQUIREMENTS

1. GENERAL

1.1 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 the equipment and the survey, a complete check out of the entire system may be accomplished within a thirty minute period.

2. AIRFRAME REQUIREMENTS

2.1 Prior to installing any Automatic Flight Control Equipment, the aircraft should be flown to determine whether or not the controls are properly rigged. An aircraft which is out of rig should be corrected in order to avoid asymmetrical turns, etc..

2.2 Make certain that control surfaces move freely, that hinge points and pulleys are well lubricated and that the tension of the primary cables is set to the lowest tolerance as specified by the aircraft manufacturer (excessive tension or friction in the control system may result in jerky operation of the autopilot and wandering on heading hold).

3. VACUUM SYSTEM

3.1 Proper vacuum must be obtained for normal operation of both the autopilot and vacuum driven flight instruments. Make certain that the engine driven vacuum pump is capable of delivering the required primary vacuum (vacuum measured between the aircraft's vacuum regulator and the restrictor adjustment located on the 1440 vacuum distributor). Measure primary vacuum with all modes of the autopilot system "ON" and with the aircraft engine's oil temperature in the normal operating range. A vacuum pump which is marginal in capacity may appear to function satisfactorily on the ground when the engine's oil is relatively cool. At altitude and when the oil becomes thinner with increase engine temperatures, the primary vacuum may fall off considerably.

3.1.1 Make certain that the aircraft's vacuum regulator is relieving vacuum <u>only</u> in excess of the maximum primary vacuum required. A good vacuum regulator is essential for the proper operation of any vacuum system.

3.1.2 Before starting engine or conducting any ground or flight test, make certain all pneumatic and electrical phases of the installation have been completed and checked according to the installation data.

3. **VACUUM SYSTEM (Continued)**

3.1.3 Before operating the system, make certain that all vacuum lines are secured and free of kinks and sharp bends. Also make certain that autopilot tubing has been purged or blown free of any foreign particles.

3.2 Vacuum source for accomplishing ground check may be from either the engine driven vacuum pump or from an auxiliary vacuum pump.

3.2.1 If auxiliary vacuum pump is used, connect this source to the engine side of the aircraft's vacuum regulator. Adjust the regulator to relieve at a point that will provide the required amount of vacuum in the form of "primary vacuum" as specified in the autopilot installation manual or drawing number 11086.

3.2.2 If the engine driven vacuum pump is used as a source of vacuum, adjust engine RPM to obtain the required vacuum reading (in green arc) on the instrument panel suction gauge. Check the required primary vacuum for the autopilot system as measured on a test vacuum gauge placed in the system at test point #1 (See Figure 1, section II, page 3).

3.3 The combination aircraft vacuum pump and regulator must be evaluated in the process of setting the regulator to relieve at the proper value. This may be accomplished as follows:

3.3.1 With vacuum gauges in the autopilot system and the gyro flight instrument system, temporarily tape the inlet screen on the aircraft suction relief valve to prevent air from entering the valve. Make certain there are no leaks around the tape or subsequent readings may be inaccurate.

CAUTION Since the relief valve cannot function, engine RPM must be varied to control vacuum output of the pump. If excessive vacuum is developed, it is possible to damage the aircraft air driven gyro units.

3.3.2 With the autopilot system engaged, obtain approximate values for flight instruments and autopilot primary vacuum (see section on adjustment of 1440 vacuum adaptor) by simultaneously varying the RPM of the engine as required to obtain the necessary total vacuum. If an engine speed in excess of 1700 RPM is required to obtain the proper suction gauge readings, check for the following malfunctions:

1. Leaking gyro instruments.
2. Aircraft vacuum relief valve screen not securely taped.
3. Leak in main supply line, servo lines, or servos. Push autopilot master knob to "OFF" position and note change in reading on instrument panel suction gauge. If reading increases more than 0.6" Hg., a leak in the autopilot system is indicated.
4. Defective vacuum pump or leak in aircraft vacuum system
5. Vacuum pump outlet line or oil separator dirty or clogged.

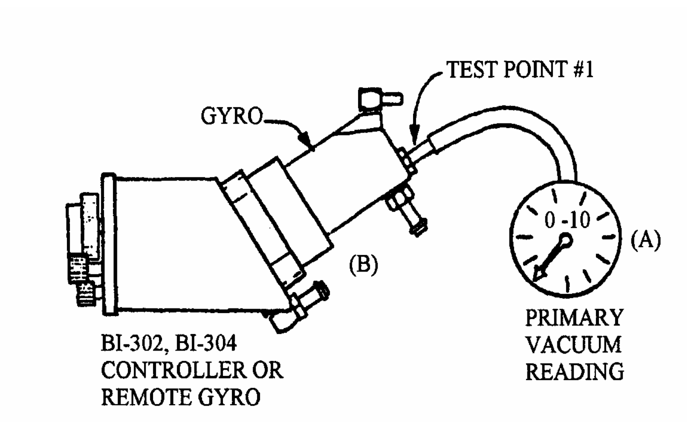
3. **<u>VACUUM SYSTEM (Continued)</u>**

3.3.3 After it has been determined that the aircraft vacuum pump is capable of supplying <u>more</u> than the required total vacuum, remove the tape that was placed over the inlet of the vacuum relief valve and adjust the relief valve so that it will open or relieve vacuum in excess of the required "primary vacuum" (See drawing 11086).

3.4 Adjustment of vacuum distributor, P/N 1440 is necessary to insure proper distribution of vacuum to the autopilot system and to the gyro flight instruments. Readjustment of the airplane's vacuum relief valve and the vacuum distributor will be necessary to obtain the proper balance of vacuum.

3.4.1 All adjustments should be made with autopilot system engaged.

3.4.2 Refer to vacuum suction gauges installed in the gyro instrument vacuum system and the autopilot system test point #1. Values at test point #1 are referred to as "primary vacuum". The amount of "primary vacuum" required is specified in the installation manual or drawing 11086 (See Figure 1).



Remove cap and attach 0-10" vacuum gauge. On some gyros this test bib "1" is not present, in this case remove the gyro plug and install a suitable fitting for this test, or insert a test tee in the primary vacuum line to the gyro.

<u>FIGURE 1</u>

NOTE: <u>On remote gyro with dust covers -</u> It will be necessary to remove the gyro dust cover to expose this test bib.
(A) Test vacuum gauge to read "primary vacuum".
(B) Autopilot gyro-controller

3.5 <u>Gyro Rotor Speed Adjustment</u>

3.5.1 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 4" Hg. - 0 + .5" Hg. is recommended for proper autopilot operation).

3. **VACUUM SYSTEM (Continued)**

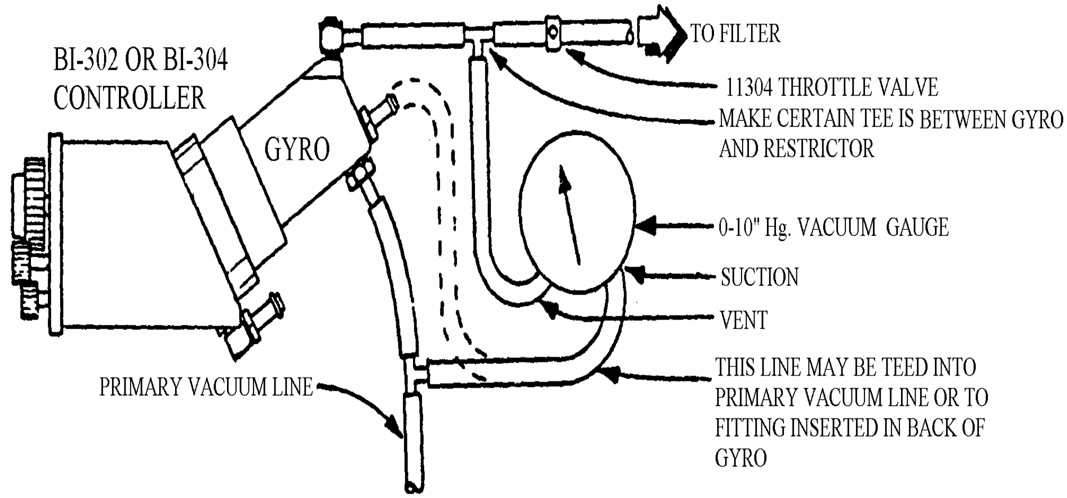


FIGURE 1A

3.5.2 To change the rotor speed: adjust P/N 11304 on Figure 1A to obtain the required 4" ± .5" on vacuum gauge.

Clockwise rotation of adjustment P/N 11304 on Figure 1 will decrease the vacuum reading. Counter clockwise adjustment will increase the vacuum reading. Approximately two minutes should elapse between adjustments.

NOTE: This adjustment is extremely important and care should be taken to make certain this adjustment is completed.

4. **SERVO "B" NUT TORQUE SETTING**

IMPORTANT - Make certain all "B" nuts attaching the servo cables to the servo pistons are torqued to 30" LBS..

5. **SERVOS AND RELATED PLUMBING**

5.1 Make certain that tubing has not been installed adjacent to heater ducts, radio power supply or any source of heat which may melt the tubing. Also, make certain that tubing has been secured so that vibration will not cause abrasion by any sharp object.

5.2 **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 sens element, pitch control assembly and amplifier assembly.

5. **SERVOS AND RELATED PLUMBING (Continued)**

5.2.1 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 2). 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.

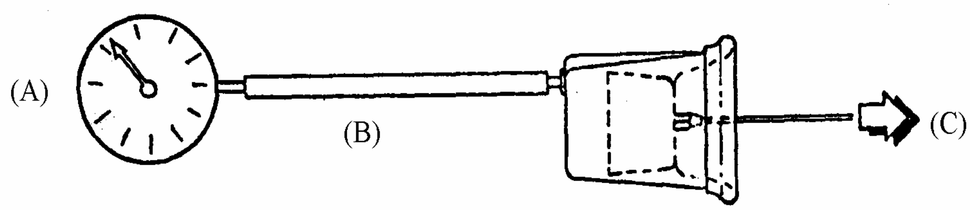


FIGURE 2

(A) Test Suction Gauge
(B) Installed tubing
(C) Extend piston by moving control surface

5.2.2 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 1" Hg. positive pressure (See Figure 3).

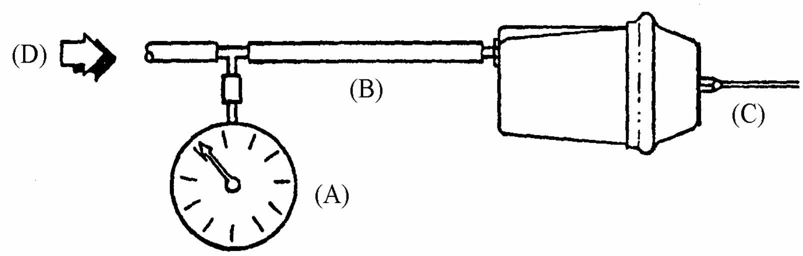


FIGURE 3

(A) 10-0-10 Test Suction Gauge
(B) Installed tubing
(C) Free piston
(D) Apply 1" Hg. Pressure

5.3 Verify that servos and the servo cables are attached so as to provide for full primary cable travel and adequate servo piston travel.

5.3.1 If autopilot servo cable is equipped with a slack eliminator spring assembly, make certain that the assembly is properly installed, eliminating slack from the autopilot cable when the autopilot is disengaged and the primary cables are moved through their full travel.

5. SERVOS AND RELATED PLUMBING (Continued)

5.4 Proper phasing of the servo function in relation to left/right turn, up down elevator must be verified. Servo lines are color coded and with vacuum applied should result in the following servo functions:

Blue - elevator up (climb)
Yellow - elevator down (descend)
Red- Right aileron (right turn)
Green - Left aileron up (left turn)

NOTE: If rudders are installed servo function should produce right and left turns corresponding with the aileron servo color coding.

5.4.1 Proper phasing of the red and green lines to the gyro sense element may be verified by inspecting the installation drawings. Observing the effect of command turns as obtained by operating the shunt valve in the B-4 and Nav-Flite Systems does not verify proper phasing to the gyro sense element. However, both proper phasing and gyro sense element operation may be readily verified by taxiing the aircraft with the autopilot system engaged; turning the aircraft to the right will command a left turn through the control system; turning the aircraft to the left will command a right turn through the control system.

5.4.2 Proper phasing of the blue and yellow servo lines, which supply the elevator servos may be verified 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 connection 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 he brown tube connection is closed.

6. ALTITUDE HOLD SYSTEM

6.1 The altitude hold mechanism is actuated by pressure differential as related to the "captured" density pressure of the air contained in the chamber (P/N 11353). It is imperative for proper function that the tube connections to the chamber, the altitude hold assembly, (12000 series) 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).

6. ALTITUDE HOLD SYSTEM (Continued)

6.2 The altitude hold system may be readily pressure checked in the following manner (Reference Figure 4):

(1) Disconnect 1/8" I.D., orange tube from engaging valve and insert a test suction gauge and a tee in the tube. Apply 1" Hg. vacuum to the altitude hold system and determine that there is no drop in pressure for a period of at least two minutes.

(2) Reinstall 1/8" tube to engaging valve. Remove 1/8" orange tube from the altitude hold assembly and insert the test suction gauge and tee. With the altitude hold valve engaged "PULL-ON", apply suction to the 1/8" line and engaging valve and observe for possible drop in pressure.

(3) By a process of elimination, rule out leaks and tube connections to the components. If there is evidence of an internal leak in the engaging valve, replace the valve. Leaks in the altitude hold assembly can not be repaired in the field and the 11300 assembly should be returned to the manufacturer for repair or replacement.

NOTE: The Pitch Control and Altitude hold are calibrated as an assembly and should be returned as such.

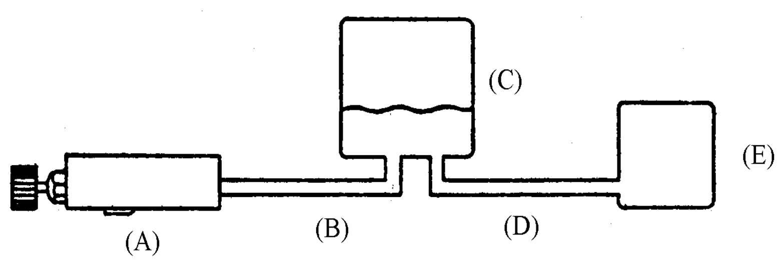


FIGURE 4

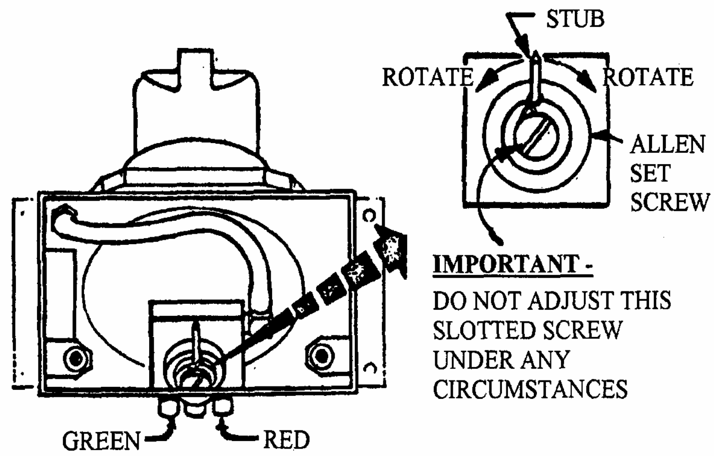
(A) Engaging valve "PULL-ON"
(B) 1/8" I.D. orange tube
(C) Altitude Hold Assembly
(D) 3/16" I.D. orange tube
(E) Pressure chamber

7. ROLL/YAW SYSTEM

7.1 RATE GYRO VALVE CENTERING

Vacuum differential may result from the 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 or not 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.

7. **ROLL/YAW SYSTEM (Continued)**



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

On Model BI-302 Controllers remove electrical faceplate far enough to expose the gyro valve. 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 tubes for this test. On Model BI-304 Controller it is necessary to remove the bottom cover plates to expose the valve.

NOTE: Unlock Allen set screw only if necessary to allow "stub" movement.

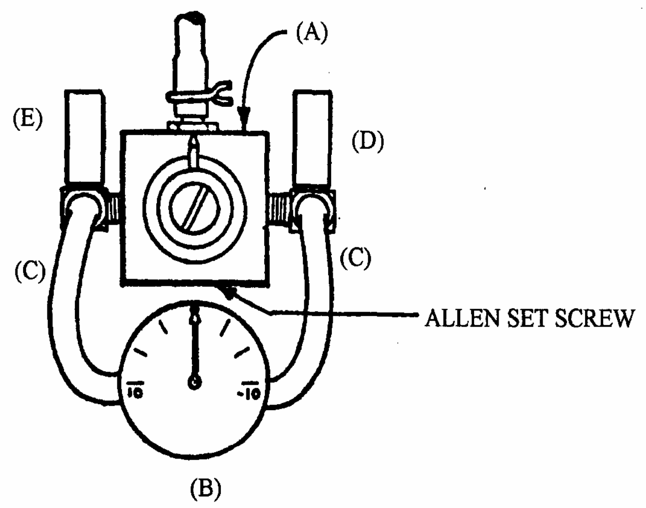
FIGURE 4A

7.2 SHUNT VALVE PNEUMATIC CENTERING

It is important, prior to plumbing the shunt valve of the amplifier Assembly into the roll/yaw system, to determine that the shunt valve is pneumatically centered. No adjustment should be made of the shunt valve however, until it has been definitely determined that there are no leaks in the roll/yaw system and that the pneumatic centering of the gyro sense element's valve is within ± .2" Hg. of zero (See Paragraph 7.1).

7.2.1 Disconnect the red and green servo lines plumbed to the shunt valve. Cap two of the four bibs on the shunt valve with leak proof caps per Figure 5. On the other two bibs plumb a 10"-0"-10" differential gauge. Apply vacuum to the shunt valve through the autopilot master salve or a direct vacuum line with 6-8" Hg.. If differential gauge indicates an off center condition of more than ± .2 " Hg., remove black royalite cap from the shunt valve body, unlock Allen set screw and rotate the slotted brass head right or left as required to obtain zero inches Hg. on the differential gauge. Only minute adjustments, never more that 5° in either direction from its original position will be required. After each adjustment, gently tap or vibrate the valve assembly. Command an electrical displacement of the shunt valve through the manual turn control to determine whether or not the mechanism returns to pneumatic zero ± .2" Hg.. After every deflection, return function knob to "OFF" position; this eliminates any electrical off center condition from interfering with pneumatic centering since the driving mechanism is spring loaded to center. After centering valve, lock Allen set screw. Check again for center.

7. ROLL/YAW SYSTEM (Continued)



NOTE: Unlock set screw only if necessary for valve adjustment.

(A) Shunt Valve
(B) 10"-0"-10" Hg Differential vacuum gauge
(C) Test hose
(D) Airtight cap
(E) Airtight cap

8. PITCH SYSTEM OUTPUT

8.1 There are three adjustments accessible on the Pitch Control Assembly. These are factory set and flight tested; if readjustments are necessary they should be made in small increments.

(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. Rotating the adjusting screw clockwise decreases the vacuum output to the 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.

8. **PITCH SYSTEM OUTPUT (Continued)**

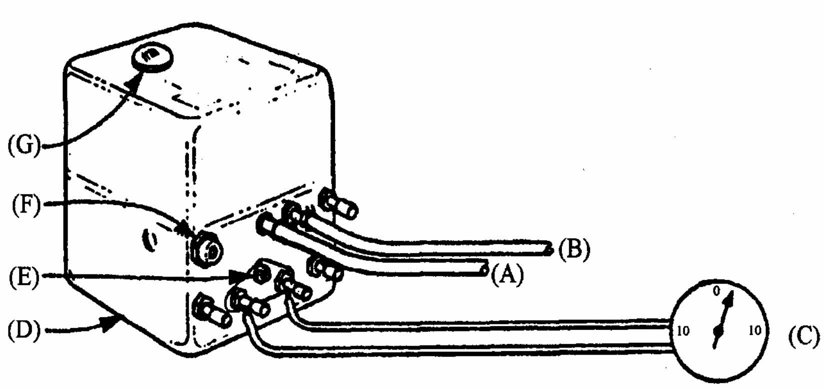
8.2 In a static condition - zero pitot pressure and no motion - there should be zero (± .2" Hg.) differential between the blue and yellow output ports of the Pitch Control Assembly (See Figure 6). The centering adjustment, accessible through the top of the assembly, is a slotted mechanism which, when rotated clockwise, will increase the vacuum output to the blue port.

NOTE; Make certain that the rubber cap plug is secure in the centering hole after completing centering adjustment.

NOTE; Under no circumstances should the centering adjustment be moved with 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.

8.3 Vacuum output to the servos should be determined with servo lines connected to the blue and yellow 1/4" ports. Gently apply positive and negative pressure, not to exceed 1" of Hg., to the pitot input line (See Figure 6). While the pitch sensing mechanism is under pressure, read the vacuum differential between the up and down lines. The differential may be increased by rotating the adjustment "**V**" counter-clockwise and decreased by rotation clockwise. The differential vacuum being read is the output to the elevator servos and should correspond to the value specified in the installation data or drawing 11806.

NOTE; The "Pitch Sens" adjustment should be positioned full clockwise for 8.2 and 8.3 tests.



(A) To vacuum source
(B) Pitot input
(C) Differential gauge
(D) Pitch Control Assembly
(E) "V" adjustment
(F) Decay rate
(G) Centering adjustment dust cap

FIGURE 6

8. **PITCH SYSTEM OUTPUT (Continued)**

8.4 Decay rate adjustment is to be made in flight only (See Flight test procedures, Section IV).

8.5 Make certain pitot system will hold pressure with pitch control disconnected from the system. It is normal to have a small leakage on 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).

8.6 Verify proper phasing of the elevator servos (See paragraph 5.4.2, Section II)

8.7 Autopilot cables must be secured to the primary control cables at a point that will allow for elevator travel both up and down, before the piston becomes bottomed out in the servo.

8.8 Leak check the pitch trim indicator. Remove the blue and yellow 3/16" tubing from the 11300 assembly and apply mouth 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.

9. **MAGNETIC HEADING COUPLER**

9.1 ELECTRICAL SYSTEM

9.1.1 In as much as proper navigation radio operation is essential for proper autopilot functions in the Capture and Track modes, the autopilot installer and service personnel should make certain that the aircraft's electrical system is operating according to the airframe manufacturer specification. Low voltage and/or inadequate filtering of the aircraft's electrical system will adversely affect the VOR electrical signals appearing across the VOR left/right needles.

NOTE; In addition to checking the aircraft's electrical system, refer to Section I for navigational radio requirements.

9.2 The heading sensor should be free to pivot or swing fore and aft. Care must be exercised in securing the harness leading from the sensor so as not to interfere with this motion.

9.3 The sensor should be installed in an area that is magnetically as clean as possible. Proximity to a power supply, remote indicating compass, etc. may result in inconsistent magnetic variations which can not be compensated.

9.4 The amplifier and cables may be adversely affected by RF radiation on certain frequencies. Such interference, although uncommon, may result from locating the autopilot amplifier in the proximity of a VHF antenna (See ground check section). If RF interference produces an offset of the shunt valve, comply with service bulletin #A/P 002.

9. **MAGNETIC HEADING COUPLER (Continued)**

9.5 Connector, P/N P-101 must be carefully assembled to the model BI-500 cable. Pins and wires must be properly oriented; the cable assembly and P/N P-101 connector should be checked for continuity and possible shorts before energizing the electrical system.

9.6 Lead #1 is system ground, make certain this lead is not connected with any other ground leads.

10. **RADIO NAVIGATION COUPLING**

10.1 Determine the capability of the navigational radio equipment according to drawing 11728.

10.2 Temporarily connect leads #3 and #4 of cable assembly, model BI-500, until proper left/right phasing has been established.

SECTION III

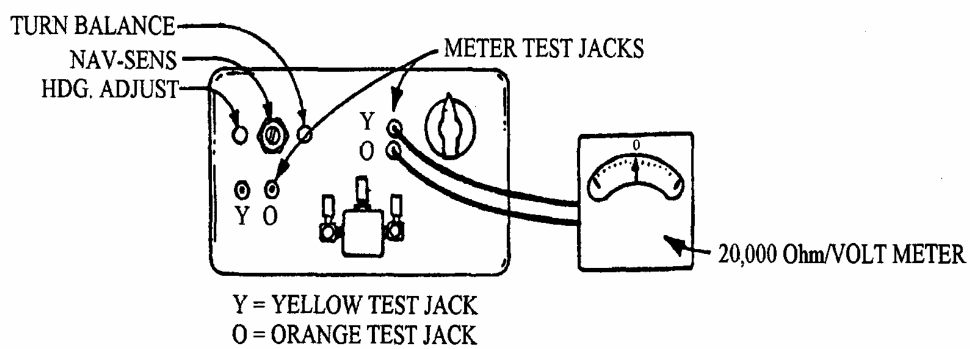
PRE-FLIGHT ADJUSTMENTS

1. RADIO NAVIGATION INPUT LEVEL

1.1 The output of the aircraft's VOR system must be matched to the autopilot coupler by means of the "Nav-Sens" adjustment. This adjustment must be made prior to swinging the aircraft on a compass rose for magnetic heading adjustment.

1.2 Set model BI-100 amplifier latitude switch to zero position before making any adjustments in the amplifier assembly. Return the latitude switch to the appropriate position upon completing ground adjustments.

1.3 Turn on navigation receiver that is connected to the Nav-Coupler, turn mode selector to "HDG" position, select a local Omni station capable of a steady full scale left/right meter deflection or use an Omni simulator. Connect a 20,000 Ohm/Volt meter (12 V.D.C. scale) in the yellow (-) and orange (+) test jacks on the amplifier (See Figure 7). **IMPORTANT -** Do not let the meter leads on the volt meter short out or change voltage scales with test leads inserted in yellow and orange test points on amplifier. This may cause permanent damage to the amplifier.



Zero reading 20,000 Ohm/Volt meter or equivalent. Brittain model TS-100 is recommended.

Two types of BI-100 Amplifier meter connections are shown.

FIGURE 7

1.4 Adjust Nav-Sens input in the following manner:

1.4.1 With the mode selector switch in the "HDG" position, adjust the heading azimuth on the controller until zero voltage appears on the test meters.

1.4.2 Center the VOR left/right needle and carefully note the indicator OBS reading. Omni signal should be a steady "TO" indication on the OBI.

1.4.3 Rotate the OBS knob to obtain exactly 5° off course signal, (Example: rotate from 181° to 186°) and place the mode function switch in the "CAP" position. There will be a voltage differential developed across the test meter.

1. RADIO NAVIGATION INPUT LEVEL (Continued)

1.4.4 Rotate the autopilot heading azimuth until the test meter voltage is canceled out. If the heading azimuth exceeds 20°, decrease the Nav-Sens adjustment on the model BI-100 until the 5° Omni error is canceled out. If the test meter voltage is nulled out by less than a 20° heading change, increase the Nav-Sens adjustment until the test meter voltage is "0" when the heading azimuth has been rotated 20°.

1.5 If zero volts can not be obtained on the test meter with the Nav-Sens adjustment full clockwise, it is likely that the output of the VOR equipment is less than the minimums prescribed in Section II, part 5. Change the displacement of the heading azimuth (Paragraph 1.4) from 20° to 15° and readjust the Nav-Sens level.

1.6 20° magnetic heading change balanced against 5° OBS change, provides for an operating ratio of 4 to 1. Although this appears to be an optimum ratio, satisfactory navigation coupling may be obtained in certain aircraft with various radio equipment providing a ratio of only 3 to 1. If the ratio appears to be marginal, it is suggested that the equipment be flown for evaluation by qualified personnel.

1.7 Before wires #3 and #4 of cable assembly BI-500 are secured permanently, check the phase of the left/right meter. Left needle deflection should produce left turn. Right needle deflection should produce right turn. Vacuum should be applied to the system, and the controller function should be placed in the "CAP" position for this test, with the heading knob azimuth set as close as possible to the aircraft's heading.

2. MANUAL TURN ADJUSTMENT

2.1 With a volt meter in the circuit as described in Section II, paragraph 1.3, (See Figure 7) it may be necessary to balance the voltage that appears across the shunt valve while the turn control is in detent position and the mode function switch placed on "MAN".

2.1.1 Some model BI-100 amplifiers have no provision for balancing the left/right voltage. If there is an electrical offset to the right or to the left, the aircraft will have a tendency to turn toward the offset in flight.

2.1.2 Some model BI-100 amplifiers have a trim adjustment labeled "Turn Balance", (See Figure 7) adjust the turn balance to obtain zero volts at the test meter.

3. MAGNETIC HEADING COMPENSATION (MODEL BI-200)

To compensate the magnetic heading sensor, use the same technique as used in compensating the primary aircraft compass. Rotation of the E-W adjustment clockwise or counter-clockwise will bend East and West headings both towards North and South. EXAMPLE:

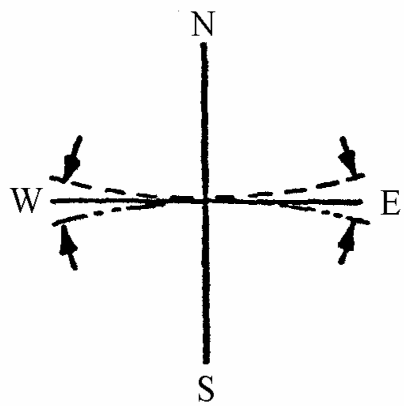


FIGURE 7A

Rotation of the N-S adjustment clockwise or counter-clockwise will bend both North and South towards East and West. EXAMPLE:

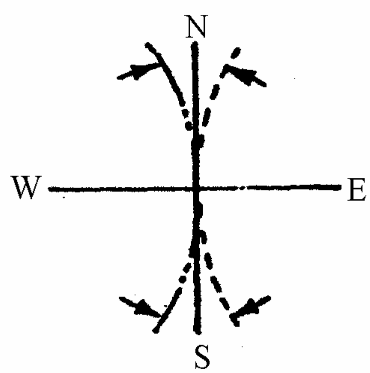


FIGURE 7B

EXAMPLE #1: A reading of 085° east and 275° West would necessitate rotating E-W adjustment to bend both East and West 5° towards South, bringing west to 270° and East to 090°.

EXAMPLE #2: North is 355° and south is 185°. Rotate the N-S adjustment to bend both North and South towards East 5° bringing north to 0° and South to 180°.

3. MAGNETIC HEADING COMPENSATION (MODEL BI-200) (Continued)

3.1 Adjustments for magnetic headings should be made according to the following sequence:

3.1.1 Utilize a compass rose. However, if a compass rose is not available use a master compass. Align aircraft up with North, set function switch to "HDG" and set latitude switch on zero. Connect a volt meter to the amplifier as per Section III, page 1, paragraph 1.3.

3.1.2 Rotate heading azimuth card to obtain "0" volts on the test meter, make certain heading card is approximately on "0" and not 180°. The following readings should be noted and recorded on Diagram 3A; The reading from the azimuth card, the ship's compass and the directional gyro.

Set directional gyro to "0" and uncage. Turn aircraft to 090° on directional gyro. Rotate azimuth card on heading lock to approximately 090° to obtain "0" volts on the volt meter. Write down the heading shown on azimuth card in Diagram 3A, also the reading of the ship's compass. Proceed in exactly the same manner with South and West headings. After all the readings have been recorded, draw an azimuth as per Figure 8 and record the actual error in the headings.

	SHIP'S COMPASS	DIRECTIONAL GYRO	HEADING LOCK
N =	355	0	010
E =	093	090	090
S =	180	180	177
W =	273	270	277

DIAGRAM 3A

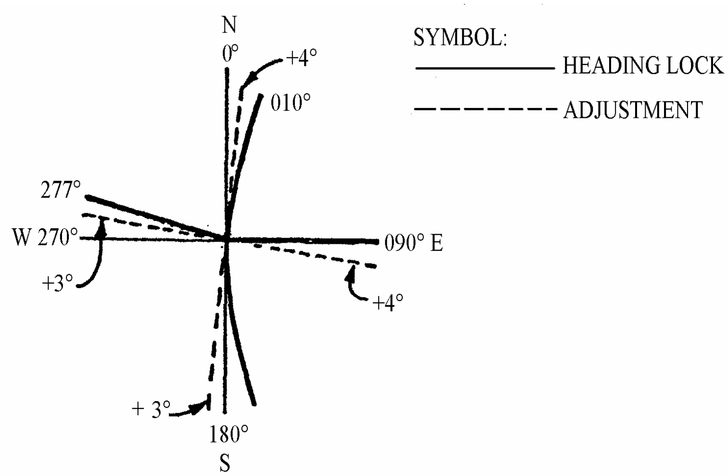


FIGURE 8

3.1.3 From Diagram 3A, as plotted in Figure 8, you can see exactly what has to be done. In this case, you would bend North and South to read, North + 4° and South + 3°. Bend East and West 4° making West equal + 3° and East + 4°. From this we now have + 4° on North, + 4° on East, + 3° on South and + 3° on West (dotted line). The headings are all high and the next adjustment would be accomplished on the model BI-100 amplifier by rotating the "HDG ADJ" pot to obtain the following: North to 0°, East to 090°, South to 179°, and West to 269°. The tolerance on all headings to be within ± 3°.

3. MAGNETIC HEADING COMPENSATION (MODEL BI-200) (Continued)

3.1.4 HEADING ADJUSTMENT (LOCATED ON THE MODEL BI-100)

Rotation of this adjustment clockwise or counter clockwise will linearly increase all headings higher or lower. EXAMPLE: North - 005°, East - 095°, South - 185°, West - 275° would require rotation of the heading adjustment 5° to bring all headings to 000°, 090°, 180° and 270°.

NOTE; Make certain that the latitude switch has been returned to the proper position. See Latitude zone map. (EXAMPLE: N-2 for Continental Untied States, Alaska, Europe, the Caribbean and Mexico. N-3 for Canada, etc.).

3.2 PNEUMATIC TURN BALANCE-ADJUSTING PROCEDURE FOR SHUNT VALVE STOPS

If an in flight unbalance is noted between a left turn and a right turn, it will be necessary to adjust the shunt valve stops to balance the turn. Make certain aircraft is in trim and meets 2.1 flight characteristics. For example: Aircraft turns left at 15° bank angle for full left turn knob deflection and 25° for full right turn knob deflection. A turn of 15° to 18° is standard at cruise speed. See 3.2.1 for proper method of adjustment to correct asymmetrical turns.

3.2.1 Remove the electrical portion from the model BI-100 amplifier dust cover (See Figure 9). Place the controller mode selector in "MAN" position. Rotate the TURN KNOB to command a full right turn. Refer to Figure 9A, adjust the slotted screw (marked red) until the aircraft establishes a 15° to 18° bank at cruise speed. Clockwise rotation of screw (red), decreases the bank angle. Counter clockwise rotation increases the bank angle. Re-check the shunt valve stop setting by rotating the TURN KNOB to full left turn position, then return to full right turn position and re-check the bank angle (15° to 18°). Repeat the above procedure with the TURN KNOB rotated to full left turn position. The bank angle left and right should be within 3° of each other for proper autopilot operation.

NOTE; Make certain the aircraft is in proper manual trim before attempting to adjust the bank angles.

3. **MAGNETIC HEADING COMPENSATION (MODEL BI-200) (Continued)**

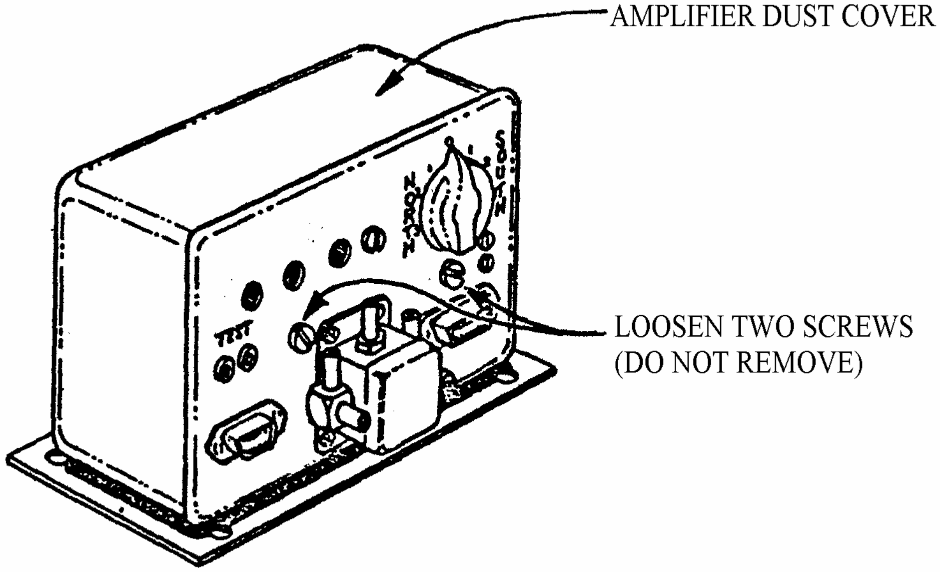


FIGURE 9

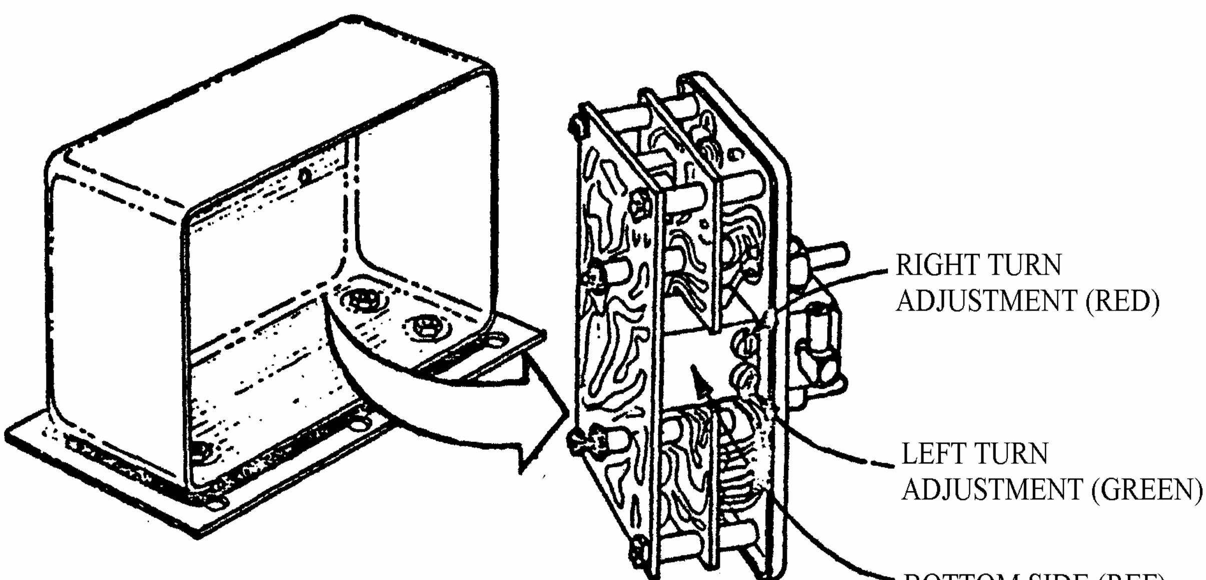
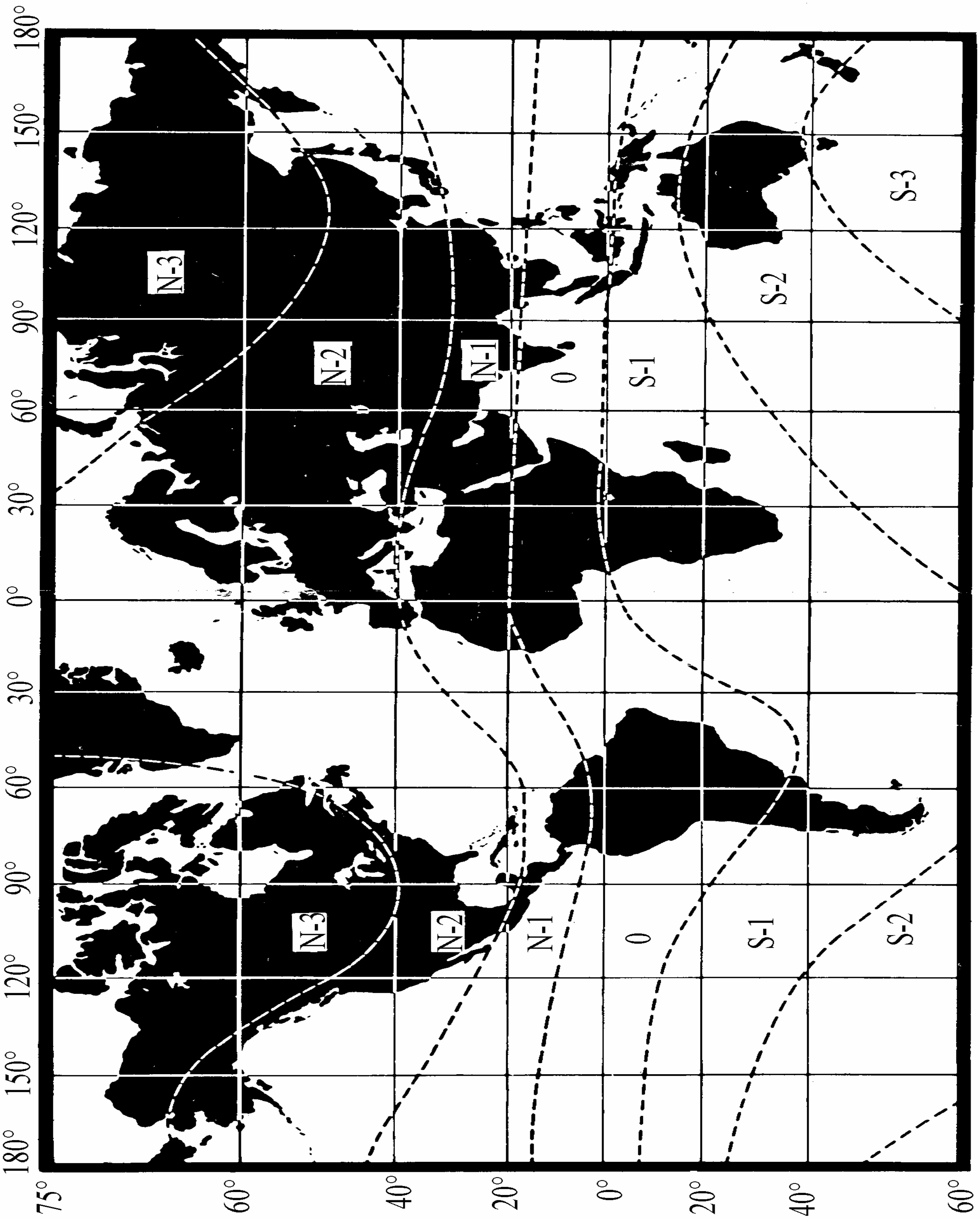


FIGURE 9A

Remove electrical portion and rotate 90° to expose the shunt valve stops.



LATITUDE SELECTOR ZONES

SECTION IV

OPERATIONAL FLIGHT CHECK AND ADJUSTMENTS

1. PRE-FLIGHT CHECKS

1.1 Review the ground check inspection record and make certain that all items have been covered.

1.2 Make certain the latitude switch on the model BI-100 amplifier is on the appropriate number (Check Latitude Selector Zone Map).

1.3 Install an Allen wrench in the "decay rate" adjustment, but do not rotate unless required.

1.4 If so desired, magnetic headings may be verified for accuracy in flight by reference to section lines. For this purpose flight test should be conducted with a volt meter across the yellow and orange test jacks, rather than referencing only the final heading of the aircraft.

1.5 Complete the aircraft logs for the installation and have the appropriately rated pilot, who is to flight test the installation, familiarized themselves with the "Owner's Operating Manual".

1.6 While taxiing the aircraft, engage the autopilot master valve "Pull-On" and observe that when the aircraft is turned to the right, the control wheel will rotate to the left and vice-versa. This verifies proper output and phasing of the gyro in the roll/yaw system.

1.7 With the engine running and nose wheel straight forward, select "MAN" mode and command a turn right and left. Select "HDG" mode and command right and left turns by rotating the "HDG" knob. Rotate the heading azimuth to correspond with the aircraft's heading and select the "CAP" mode. Verify that VOR needle deflection to the right and left turns respectively.

1.8 Place the function knob and the autopilot master valve in "OFF" position until airborne at a safe altitude.

2. ENGAGING THE AUTOPILOT SYSTEM

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. If the aircraft is equipped with aileron and/or rudder trim tabs, adjustment of these tabs should produce "hands-off" stability. If they will not and if it is apparent that the airplane is not properly rigged, re-rigging will be necessary before continuing with the flight adjustment. An out-of-rig aircraft will cause autopilot heading errors and/or wing low condition.

2. ENGAGING THE AUTOPILOT SYSTEM (Continued)

2.2 Prior to engaging the Flight Control System, make certain that the altitude hold is disengaged ("OFF" position). Set turn knob to the center detent position and rotate pitch "SENS" knob full counter-clockwise. Engage the "ON-OFF" master with turn controller function knob in the "OFF" position. Open the pitch "SENS" adjustment full clockwise with the human pilot monitoring the controls. Engage and disengage the autopilot 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. Trouble shoot 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 decent.

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 pushing off the master valve.

3. RATE OF TURN (Bank angle)

3.1 With the aircraft having been laterally trimmed in level flight and at constant cruising speed, select the "MAN" mode.

3.2 Place the controller turn knob in the full left turn position. Note the aircraft bank angle which should be 15° to 18° at cruise speed. Repeat this procedure to the right.

By rotating the slotted screw shown in Section III, Figure 9A, balance the left and right turns within 3° of each other. For example: If you have a noted 17° left bank and a 28° right bank, adjust the right bank slotted screw clockwise until the bank angle matches the left bank angle.

4. DIRECTIONAL CONTROL

4.1 Place mode function knob in "HDG" position and program turns by rotating the heading azimuth. There is a definite relationship between the rate of turn (bank angle) and programmed magnetic headings. The transistorized circuitry which provides magnetic heading information is designed for certain "roll out" characteristics which pre-suppose a given rate-of-turn (bank angle). If the rate-of- turn is faster than 3° per second, there will be a tendency for the aircraft to over-shoot programmed magnetic turns to the East, North, and West. Turns to the south with a shallow bank angle may over-shoot the final to the South with a shallow bank angle may over-shoot the final Southerly programmed heading. Proper rate-of-turn, slightly less than standard rate, should allow for approximately 5° over shoot on East and West, with less than 5° over-shoot on North and South.

4. **DIRECTIONAL CONTROL (Continued)**

4.2 Proper trimming or rigging of the aircraft is essential for precise headings. If an aircraft is rigged or trimmed to fly with one wing down, or with the ball of the Turn and Bank off center, turns will be steeper in one direction than the other. In addition, final heading accuracy between 280° and 080° may be adversely affected.

4.3 While evaluating the accuracy of the autopilot magnetic headings, it must be remembered that reference to a directional gyro should take into consideration precessional errors. Reference to the aircraft's magnetic compass must allow for compass errors.

4.4 Check the radio navigation coupler.

4.4.1 If an airborne VOR test signal is available, one should verify the adjustment of the Nav-Sens. This may be accomplished by allowing the aircraft to stabilize on a random magnetic heading. Center the VOR needle and dial 5° OBS off-course, place the mode function knob on "CAP" and observe on the directional gyro the number of degrees of turn that have been commanded by the 5° VOR needle displacement. (5° Omni error should produce from 17° to 20° heading change.)

4.5 Observe the VOR needle to make certain that there are no erratic movements. (If erratic needle action is noticed, check the Omni converter and navigation receiver for intermittent operation.)

5. **PITCH DECAY RATE ADJUSTMENT**

5.1 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 with "Pitch Sens" full open clockwise.

5.2 Normal response of the Pitch-Altitude System is observed in the following manner:

5.2.1 With the flight control system engage, altitude hold "OFF" and pitch sens full open clockwise, command various attitudes of the aircraft by slowly changing the trim tap position. Verify the response of the pitch system at different angles of attack.

5.2.2 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. Release the control column and observe the characteristics of the descent. Initially the aircraft will descend rapidly. As the indicated air speed increase 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", page 6)

5. **PITCH CONTROL DECAY RATE ADJUSTMENT (Continued)**

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 Section II, Paragraph 6) or a change in temperature within the pressure chamber. Temperature effect may be due to the fact that the rate chamber had not stabilized with the outside air, or due to a change in outside temperature.

5.3 Abnormal response of the Pitch-Altitude system as related to the decay rate adjustment, may be verified as follows:

5.3.1 Duplicate the conditions above under Paragraph 5.2.2

5.3.2 If the decay rate has been set open too far, (counter-clockwise) the curve depicting the descent described in paragraph 5.2 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 "capture" altitude and then return above and below in diminishing cycles.

5.3.3 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 air speed as the craft is descending will reduce the rate of descent to nearly zero when the craft is as much as 100 to 150 feet above the "captured" altitude.

5.4 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.

5.4.1 If the condition described in Paragraph 5.3.2 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 occurs, make the necessary adjustment counter-clockwise in the same 1/16 or less increments.

5.4.2 If the aircraft is not equipped with the altitude hold device or if the pitch stabilizing system is to be evaluated with the altitude hold function disengage, the decay rate should be readjusted if the altitude hold mechanism is subsequently added to the system. The pitch control will have to be returned to the Brittain factory for addition and balancing of the combined pitch and altitude hold (Assembly 11300).

5. **PITCH CONTROL DECAY RATE ADJUSTMENT (Continued)**

5.4.3 Adjustment of the decay rate without the altitude hold device in the system should be made as follows:

(A) With the airplane in level flight, neutral trim and at constant speed, close the decay rate by rotation clockwise until an oscillation develops similar to Figure "C". Note that the amplitude increases and the frequency decreases with each cycle.

(B) Gradually open the decay rate counter-clockwise until the oscillation ceases. Disturb the aircraft on the pitch axis in an attempt to induce further oscillation. If there appears to be a tendency for the craft to oscillate, open the decay rate an additional 1/16 revolution.

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 pushing off the master valve.

6.2 If a drop in suction below 3.5" Hg. is noted on the instrument suction gauge, disengage the flight control. Available suction will then be directed to the flight instruments. Check for leaks in the system at the earliest convenience. If no leaks are found, check the vacuum source (pump) and the aircraft's vacuum relief valve.

7. **RETURNING THE AIRCRAFT TO SERVICE**

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

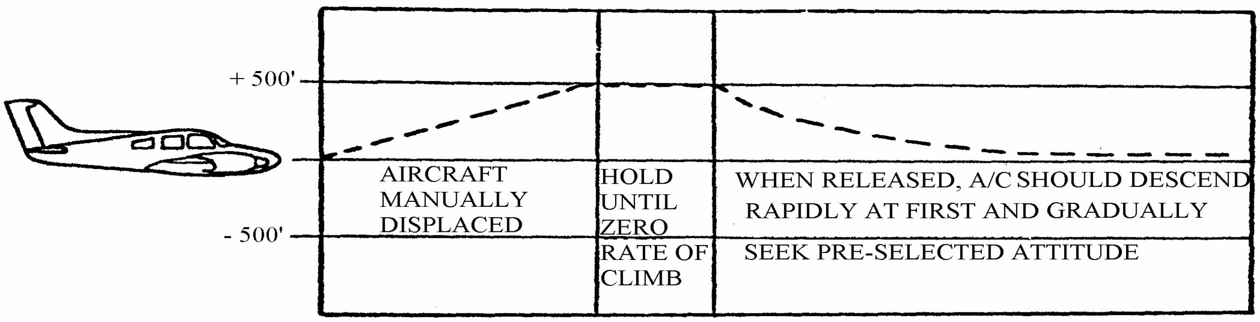


FIGURE A

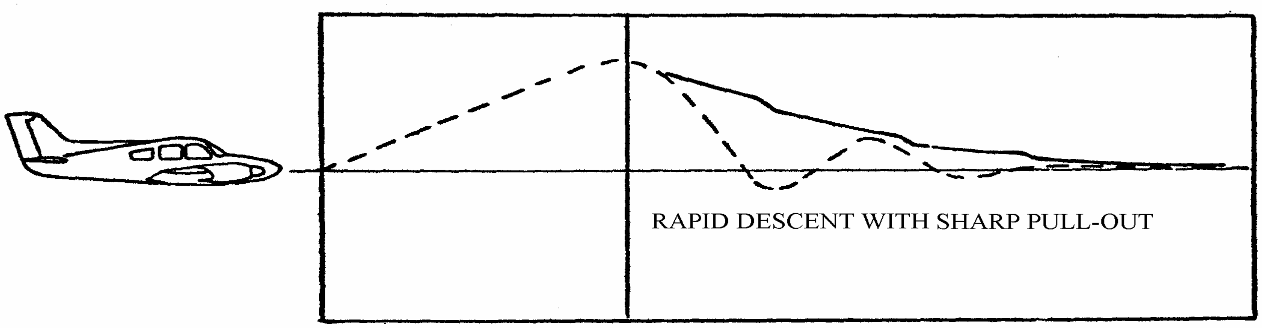


FIGURE B

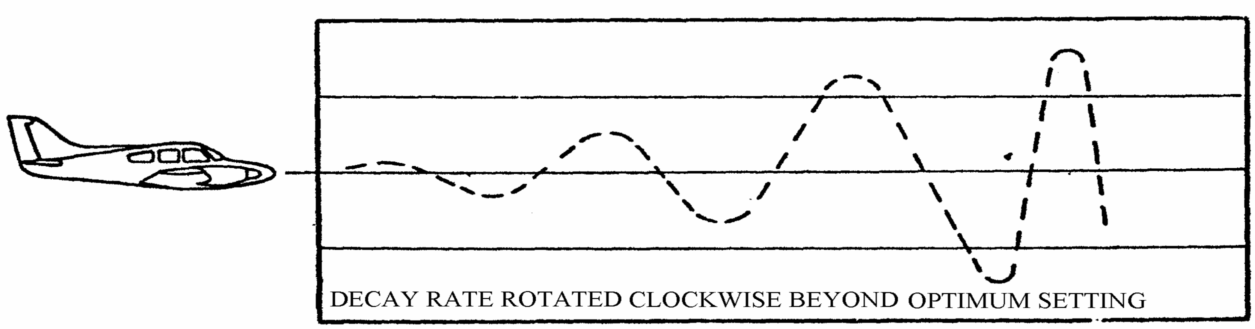


FIGURE C

AIRCRAFT MAKE AND MODEL	PRIMARY VACUUM SETTING BASIC AUTOPILOT	PRIMARY VACUUM SETTING B-4 AND NAV-FLITE CONFIG.	OUTPUT TO ELEVATOR SERVO'S "V"
AERO COMMANDER			
ALL MODELS	9 ± .5" Hg.	9 + .5 - 0" Hg.	4" Hg.
BEECHCRAFT			
*MODEL 23	6 ± .5" Hg.	6.5 ± .5" Hg.	3.5" Hg.
MODEL 35 SERIES	7.5 ± .4" Hg.	8 ± .5" Hg.	3.5" Hg.
MODEL 35-33 SERIES	7.5 ± .4" Hg.	8 ± .5" Hg.	3.5" Hg.
MODEL 95 SERIES	7.5 ± .4" Hg.	8 ± .5" Hg.	4" Hg.
MODEL 50 SERIES	9 ± .5" Hg.	9.5 ± .5" Hg.	4" Hg.
BELLANCA			
ALL MODELS	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
CESSNA			
MODEL 150 SERIES	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
MODEL 170 SERIES	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
MODEL 172 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MODEL 175 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MODEL 180 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MODEL 182 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MODEL 185 SERIES	8 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
MODEL 195 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
*MODEL 210 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MODEL 310 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
HELIO-COURIER			
ALL MODELS	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
MOONEY			
*ALL MODELS	6.5 ± .5" Hg.	6.5 + .5 - 0" Hg.	4" Hg.
NAVION, UNIVERSAL TWIN			
ALL MODELS	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
PIPER			
*MODEL PA20,22 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
*MODEL PA 23 SERIES	8 ± .5" Hg.	8.5 ± .5" Hg.	4" Hg.
*MODEL PA 24 SERIES	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
*MODEL PA 28 SERIES	7.5 ± .5" Hg.	8 ± .5" Hg.	4" Hg.
*MODEL PA 30 SERIES	6 ± .5" Hg.	6.5 ± .5" Hg.	4" Hg.

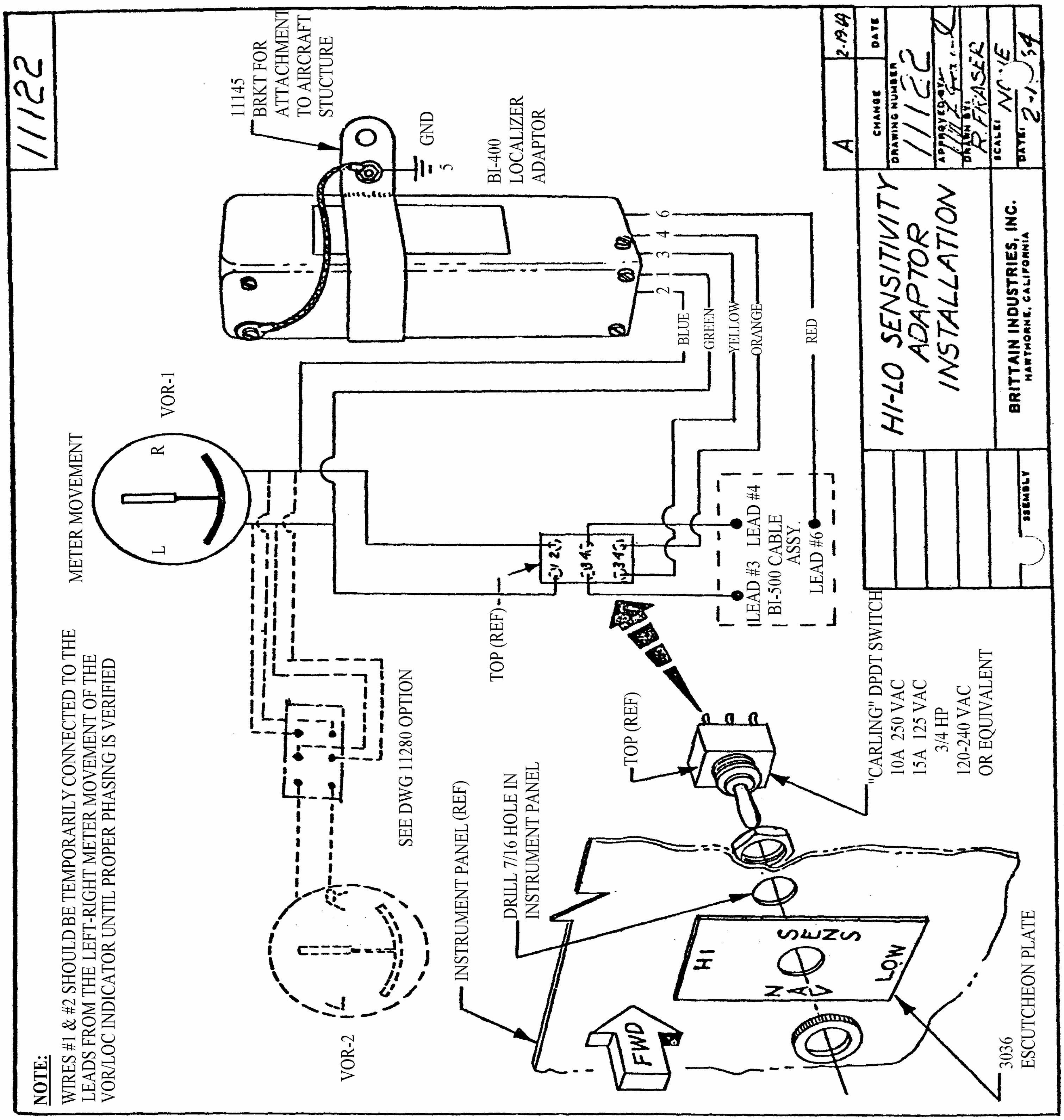
CHANGE | DATE
DRAWING NUMBER: 11086
APPROVED BY:
DRAWN BY: M. FAUL
SCALE: NONE
DATE: 1-3-64

BRITTAIN AUTOPILOT
PRIMARY VACUUM SETTINGS

BRITTAIN INDUSTRIES, INC.
HAWTHORNE, CALIFORNIA

NEXT ASSEMBLY

*NOTE: Aircraft known to be equipped with dry vacuum pumps. Kits suppled with 4" DIA. servos to provide required force. All other aircraft may be equipped with dry vacuum pumps. IF this situation exist, 4" DIA. cylinders must be used and a primary vacuum setting 6 to 6.5" Hg. is required.


11122
NOTE:
WIRES #1 & #2 SHOULD BE TEMPORARILY CONNECTED TO THE LEADS FROM THE LEFT-RIGHT METER MOVEMENT OF THE VOR/LOC INDICATOR UNTIL PROPER PHASING IS VERIFIED
METER MOVEMENT
L
R
VOR-1
11145
BRKT FOR ATTACHMENT TO AIRCRAFT STUCTURE
GND
5
BI-400 LOCALIZER ADAPTOR
6
4
3
1
2
BLUE
GREEN
YELLOW
ORANGE
RED
LEAD #3
LEAD #4
BI-500 CABLE ASSY.
LEAD #6
TOP (REF)
TOP (REF)
"CARLING" DPDT SWITCH
10A 250 VAC
15A 125 VAC
3/4 HP
120-240 VAC
OR EQUIVALENT
SEE DWG 11280 OPTION
VOR-2
INSTRUMENT PANEL (REF)
DRILL 7/16 HOLE IN INSTRUMENT PANEL
HI
SENS
NAV
LOW
FWD
3036
ESCUTCHEON PLATE
HI-LO SENSITIVITY ADAPTOR INSTALLATION
BRITTAIN INDUSTRIES, INC.
HAWTHORNE, CALIFORNIA
A
CHANGE
DATE
DRAWING NUMBER
11122
APPROVED BY
DRAWN BY
R. FRASER
SCALE
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DATE

3951

SUPPLEMENT
FOR
11807 INSTALLATION, OPERATION,
MAINTENANCE AND SERVICE MANUAL

A. Turn coordinator TC-100EVT

B. Amplifier BI-100A
(P/N 1525-1 12 Volt - 1525-3 24 Volt)

This supplement describes the operation and check out procedures for the TC-100 EVT unit and BI-100A Amplifier (ONLY).

All other procedures for ground check of the B-4A System should be referred to the 11807 manual.

This manual was automated on May 31, 2001. Changes were made only to correct typographical errors and to clarify content.

B-4A SYSTEM DESCRIPTION

The new Brittain Flight Control B-4A differs from the B-4 in that the B-4A system uses the TC-100 Turn Coordinator (See Figure A) for sensing roll and yaw disturbances of the aircraft. The gimbal of the TC-l00 drives the spool in spool-sleeve valve mounted on the back of the instrument. Displacement of the spool meters vacuum to the servos.

The TC-100 Turn Coordinator runs on electricity and vacuum providing complete backup if one or the other fails. The TC-100 Turn Coordinator, when used for autopilot purposes, is designated as EVT, meaning it is electric vacuum with a torquer.

Mounted on the manifold and attached to the sleeve is a DC torquing device. When command voltage is applied from the amplifier, the sleeve is displaced by the "Torquer", producing a pressure differential in the servos controlling roll and yaw. (The torquer-sleeve combination replaces a Shunt Valve found in prior Brittain systems for controlling the direction of flight). The B-4A system uses only one valve and it is centered by the use of the roll trim knob mounted on the bottom left corner of the Turn Coordinator. The roll trim mechanism rotates the sleeve of the valve and provides for approximately one quarter (1/4) of a standard rate turn when fully deflected. Roll trim capability is more than adequate to handle asymmetrical loading of the aircraft.

The TC-100 Turn Coordinator also has a potentiometer mounted inside the case with a wiper arm driven directly off the gimbal. The wiper moves back and forth on the pot as the gimbal moves, providing instantaneous voltage output whenever the aircraft is displaced on the roll or yaw axis. This instantaneous voltage energizes the patented magnetic dip compensation circuitry, optimizing the magnetic pre-select and heading hold.

The B-4A system is designed to provide standard rate turns with positive but smooth roll out on all headings.

BI-100 AMPLIFIER

The amplifier used in the B-4A system is physically the same as the B-4 amplifier. The adjustments and location of the amplifier are the same. The unit does differ in that, instead of an electro-pneumatic shunt valve located on the face of the amplifier, there is a plate that contains an amphenol 7 pin connector and two (2) test jacks (red and white) that are used for checking out the potentiometer in the TC-100 EVT Turn Coordinator (See Figure B). There is another adjustment available which is located behind the plate that holds the 7 pin amphenol connector. The adjustment is a pot and is used to vary the amount of current used for dip compensation. The pot adjustment only affects the roll out characteristics on North and South and should be used in the following manner:

The latitude switch on the B-4A system is used and serves the same function as it did in the B-4 system. In other words, it has to be set at the proper latitude whenever the system is being flown. All checks for proper dip compensation should be done at cruise configuration.

By rotating the pot clockwise to the stop, the autopilot system will have maximum dip compensation, meaning that it will roll out early on North and late on South. Upon initial installation, or initial flight, rotate pot clockwise to stop. Fly the system and determine whether or not the autopilot is rolling out satisfactorily on North (South if in the Southern Hemisphere). If the system rolls out early on North and then slowly comes into the final heading, rotate pot counter-clockwise in 1/4 turn increments until a satisfactory roll out is obtained.

TC-100 EVT CHECKOUT PROCEDURE

1. Electrical operation of TC-100 EVT.

    A. Turn master switch of aircraft on.

    B. Listen close to instrument for motor hum.

2. Pneumatic output and centering valve.

    A. Remove servo lines from back of EVT unit (See Figure C).

    B. Plumb left-right vacuum gauge across output bibs.

    C. Turn controller to "OFF" mode.

    D. Center valve by rotating roll trim knob left or right until vacuum gauge centers.

    E. Yaw aircraft back and forth to displace valve.

    F. Stop yawing aircraft and observe centering repeatability of valve tolerance ± .4" Hg.

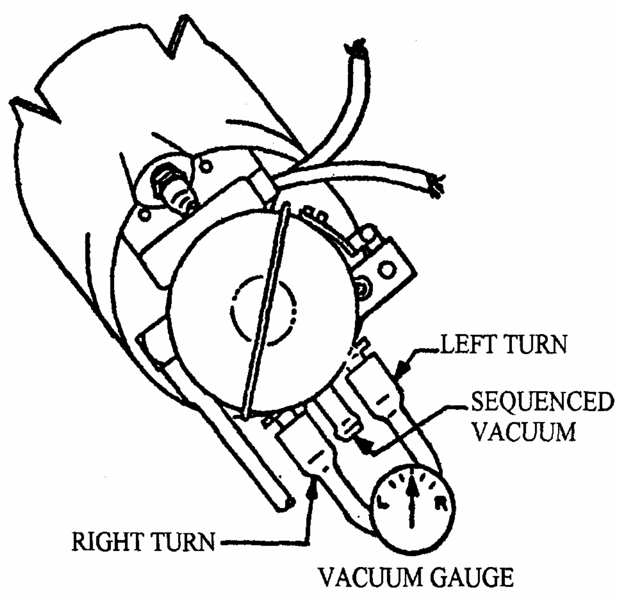

FIGURE C (Picture of back of EVT unit)

* In all following steps through number 3, the vacuum and autopilot master valve must be on.

3. <u>Torquer Operation</u>

   A. Insert voltmeter leads in test jacks of 1525-1 amplifier.

   B. Set latitude switch to 0 latitude.

   C. Turn Controller to "HDG" mode.

   D. Rotate heading azimuth card to 0 volts on voltmeter.

   E. With "HDG" knob apply left and right voltage and observe that vacuum gauge follows voltage smoothly. If dirt or stiction is present in torquer bearings, vacuum gauge will lag behind voltage and will move in steps.

   F. Apply 4 volts to torquer as read on voltmeter. Turn Controller to "OFF" and observe that vacuum gauge returns to center; tolerance ± .4" Hg.

4. <u>TC-100 EVT potentiometer check</u>

   A. Insert voltmeter leads in test jacks on front of 1525-1 amplifier. Orange to white, yellow to red (See Figure A).

   B. Run leads to voltmeter as color coded.

   C. Turn controller to "Man" mode.

   D. Yaw aircraft and observe voltage output.

   E. Stop yawing aircraft and observe voltmeter return to center ± .1 volt.

5. Taxi aircraft to right or left until Turn Coordinator silhouette is displaced to standard rate turn mark. At that point voltage output of pot should be 2- 6 volts (Total output will vary directly with setting of amplifier dip compensation pot, See Figure B).

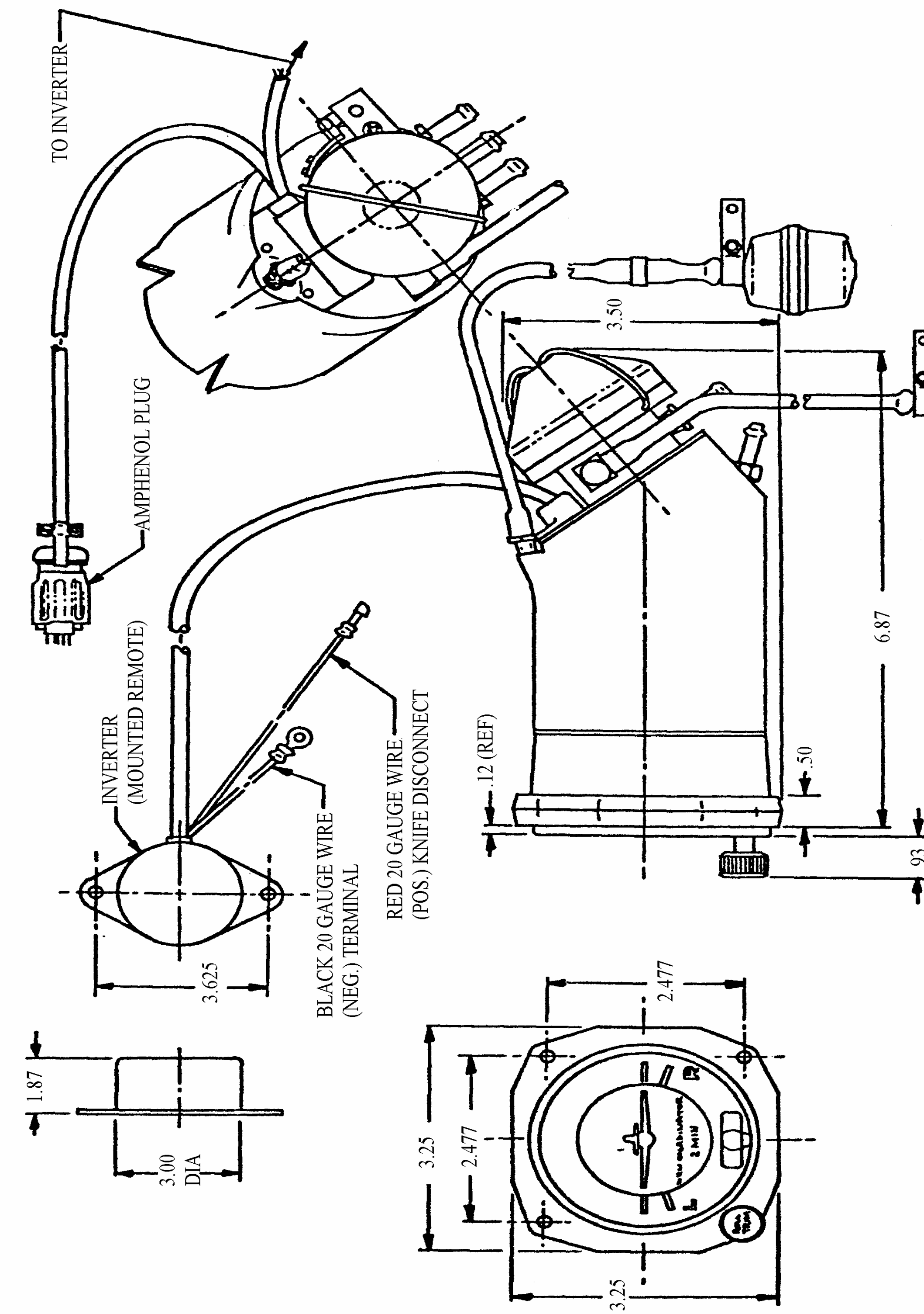
TO INVERTER
AMPHENOL PLUG
INVERTER
(MOUNTED REMOTE)
BLACK 20 GAUGE WIRE
(NEG.) TERMINAL
RED 20 GAUGE WIRE
(POS.) KNIFE DISCONNECT
3.50
6.87
.12 (REF)
.50
.93
3.625
1.87
3.00
DIA
2.477
3.25
2.477
3.25

FIGURE A

Check to make sure that both atmosphere filter lines are not kinked off. This will keep valve from operating and also keep pneumatic rotor from spinning.

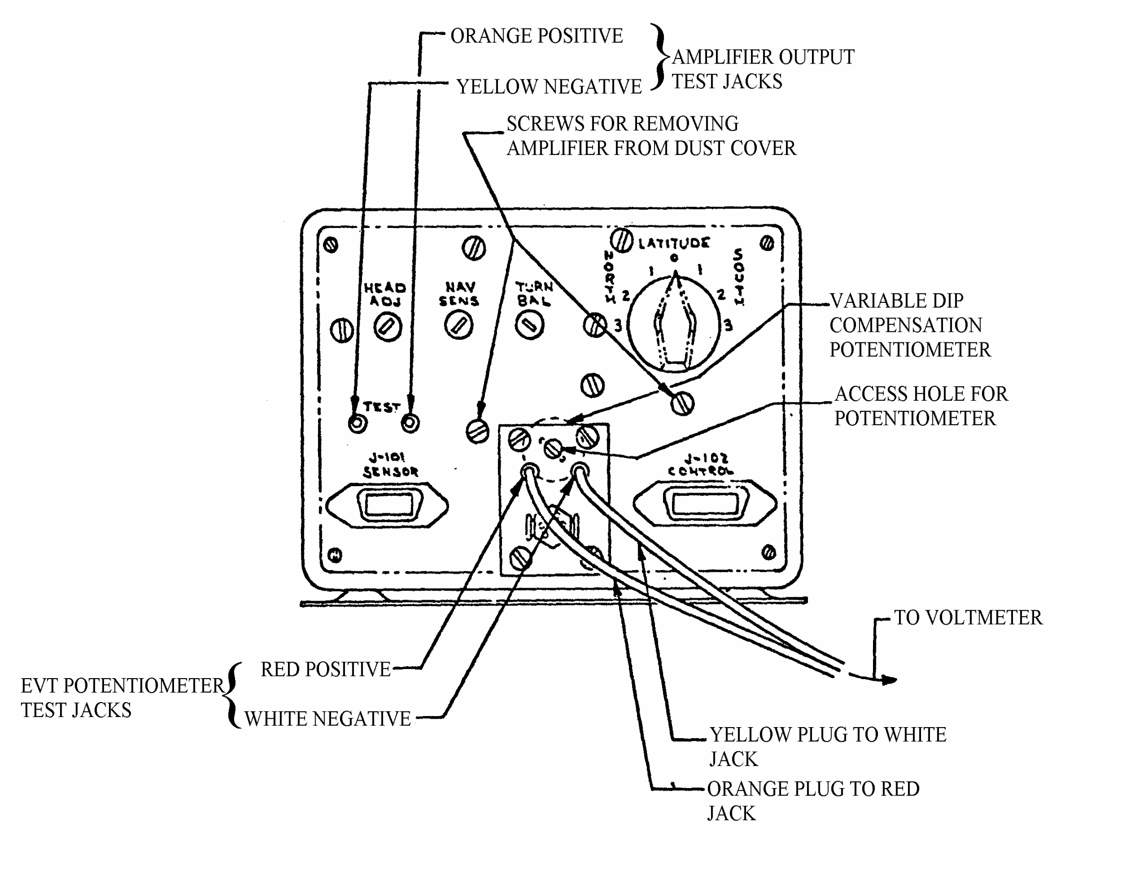

FIGURE B