Chapter 3 AUTOPILOT INSTALLATION

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

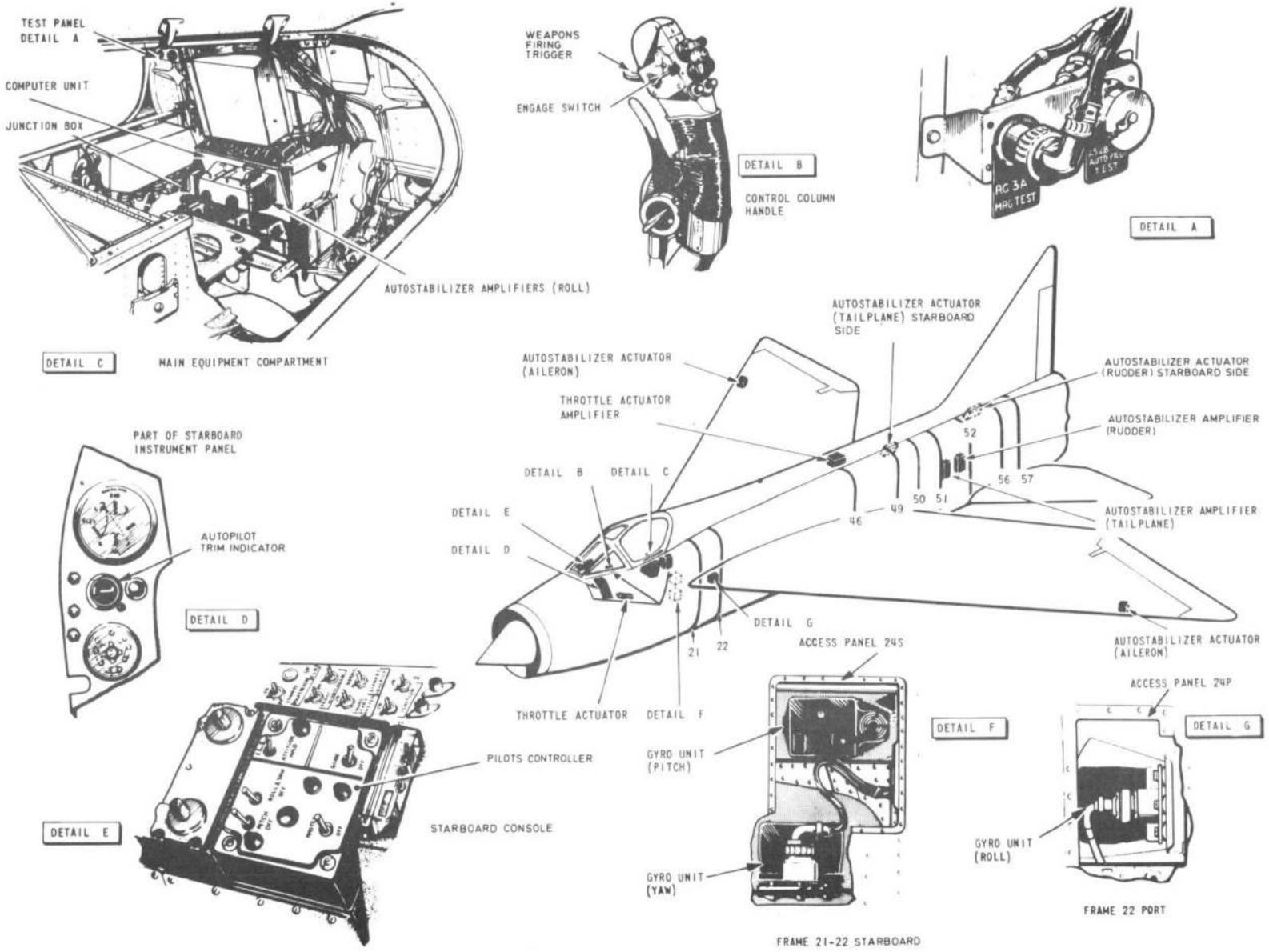

FIG.1. MK.13 AUTOPILOT INSTALLATION

◀ MINOR AMENDMENTS ▶

DESCRIPTION

General

1. The Mk.13 autopilot system provides three-axis autostabilization, attitude holding and auto-I.L.S. coupling, and is used in conjunction with the master reference gyro (M.R.G.) and the Mk.5FT compass *(Sect.7, Chap.5)* and the I.L.S. localizer and glide path receivers *(Sect.8, Chap.3)*. A full description of the Mk.13 autopilot installation in general will be found in A.P.112 series.

Pilots controller

2. This unit is mounted on the starboard console and incorporates all the controls used by the pilot. These are the autopilot master switch, autostabilizer channel selector switches, and the autopilot mode selector switches. The unit also carries three fuses for the a.c. and d.c. supplies to the system, and a magnetic indicator which shows black when the master switch is closed.

Engage switch

3. This is a three-position switch marked A.P. ON-OFF-F.D. ON. The switch controls the pre-selected attitude hold or I.L.S. outputs of the computer to the aileron and tail plane autostabilizer actuator when A.P. ON is selected. The F.D. ON position is inoperative.

Gyro units

4. Three gyro units, Type B, are installed to detect disturbances in each of the aircraft's three axes of roll, pitch, and yaw. The pitch and yaw units are mounted behind access panel 24S in the starboard side of the fuselage, between frames 21 and 22. The roll gyro is positioned on the forward face of frame 22 port side, panel 24P giving access to it.

TABLE 1

Autopilot equipment

Ref. No.	Equipment	Quantity
6TD/4550061	Pilot's controller, Type D	1
6TD/4550006	Gyro unit, Type B (pitch, roll, and yaw)	3
6TD/4550004	Amplifier, autostabilizer	4
6TD/4550005	Mounting tray for amplifiers	1
6TD/4550012	Actuator, autostabilizer, Type 214, Mk.1 (tail plane)	1
6TD/4550003	Actuator, autostabilizer, Type 214, Mk.2 (port aileron)	1
6TD/4550011	Actuator, autostabilizer, Type 214, Mk.3 (rudder)	1
6TD/4550014	Actuator, autostabilizer, Type 214, Mk.4 (starboard aileron)	1
6TD/4550057	Trim indicator, Type C	1
6TD/4550013	Clamp for the trim indicator	1
6TD/610	Actuator, throttle	1
6TD/4550008	Amplifier, throttle actuator	1
6TD/4550005	Mounting tray for amplifier	1
6TD/4550018	Computer unit, Type C	1
6TD/4550007	Mounting tray for the computer	1
6TD/4550060	Junction box, Type B	1

Autostabilizer amplifiers

5. Four autostabilizer amplifiers, each operating in conjunction with one of the autostabilizer actuators, are installed in the aircraft. The two amplifiers serving the port and starboard aileron autostabilizer actuators are mounted together in a container assembly, forward of the M.R.G. in the main equipment compartment; the two amplifiers serving the rudder and tail-plane autostabilizer actuators are secured in mounting trays fitted in the aft port equipment compartment and are accessible after removing access panel 87P.

Autostabilizer actuators

6. An electro-hydraulic autostabilizer actuator, Type 214, is linked into each of the control runs to the port and the

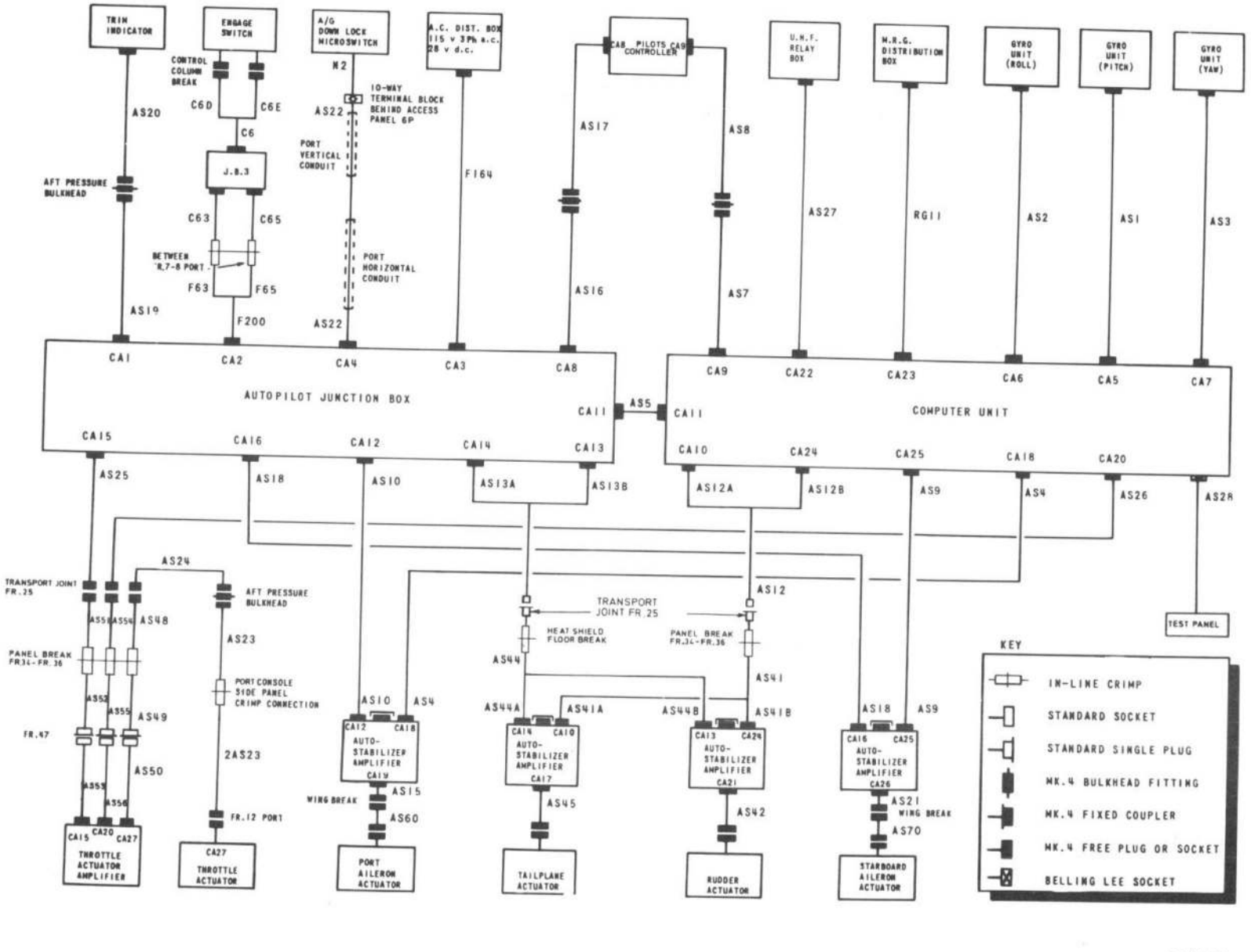

FIG. 2. MK. 13. AUTOPILOT INSTALLATION

◀ MINOR AMENDMENTS ▶

starboard ailerons, to the rudder, and to the tail plane, to move these control surfaces in response to demands made from the autopilot system. Each actuator incorporates a hydraulic pressure operated stroke restrictor controlled by a solenoid and spool-valve mechanism. Full stroke of the actuator is obtained when the solenoid is energized, and the restricted strokes are set to particular values to suit the safety requirements of each channel. The actuator piston is hydraulically operated and is controlled from a relay valve actuated by an electromagnetic torquemotor which is fed with signals from its associated autostabilizer amplifier. The linkages to the control runs are described in A.P. 101B-1001-1A, Sect.3, Chap.4 and the hydraulic services in A.P.101B-1001-1A, Sect.3, Chap.6.

Alighting gear interlock

7. In the I.L.S. mode, the stroke restrictors in the rudder and aileron autostabilizer actuators are controlled by the nose wheel microswitch *(Sect.6, Chap.5)*. When the alighting gear is extended during the landing approach, the microswitch closes and connects an energizing supply to the restrictor solenoids.

Trim indicator

8. This instrument, fitted in a securing clamp, is located on the port instrument panel and gives an aircraft silhouette indication of out-of-trim demands to the pitch servo both in magnitude and direction. A deflection before engagement indicates a lack of synchronisation and probable malfunction of the autopilot, while a sustained deflection of the aircraft silhouette after engagement, indicates that a normal trim change is required.

Throttle actuator amplifier

9. The throttle amplifier, fitted in a mounting tray, is installed in the rear part of the spine, above No.2 engine. It operates in conjunction with the throttle actuator to form a position control relay-servo which is used during auto-I.L.S. approach to actuate the pilots throttle boxes. The amplifier receives from the computer unit, speed error and pitch angle error signals which are amplified to operate a relay, switching power to a motor-tachogenerator in the throttle actuator.

Throttle actuator

10. This unit is operated from the throttle actuator amplifier and is clutch-coupled to the pilot's throttle levers during the I.L.S. mode, maintaining the airspeed at approximately 175 knots. The clutch, positioned below the throttle levers, is manually engaged and disengaged. For details of the clutch and linkages to the throttle levers refer to A.P.101B-1001-1A, Sect. 4, Chap.1.

Computer unit

11. The autopilot computer unit is located in the main equipment compartment and is fitted, in a mounting tray, below the Mk.5FT compass amplifier on the aft pressure bulkhead. It receives signals and processes information obtained from the M.R.G., the Mk.5FT compass system, the I.L.S. receiver, the rate gyros, and the pitot and static system, and demands appropriate aileron, tail plane and rudder control surface angles according to the particular mode of operation of the system.

Junction box

12. The distribution of power supplies to the units of the autopilot system is made from the autopilot junction box which is mounted forward of the M.R.G. junction box, in the main equipment compartment. The junction box also provides the means of interconnecting certain units of the installation.

Test panel

13. A panel mounted on the aft face of the pressure bulkhead at the port side of the main equipment compartment, provides a connecting point for attachment of the test equipment. The panel carries two sockets, one labelled RG3A-M.R.G. TEST, and the other labelled A.S.28-AUTOPILOT TEST. The former test socket is connected to the M.R.G. distribution box, and the latter socket connected to the autopilot computer. When carrying out tests on the installation, the Mk.13 autopilot 1st line test set is coupled into both sockets.

Attitude hold

14. The attitude hold system on the Mk. 13 autopilot installation is used to maintain the aircraft, within limits, in any attitude initially set by the pilot. The system operates by feeding appropriate M.R.G. signals to the control surfaces to correct any variation in the set attitude of the aircraft, and

may be used at any time when the pilot wishes to give his full attention to the operation of other facilities in the aircraft. The system is brought into operation by the pilot selecting 'attitude hold' on the pilot's controller, flying the aircraft into the desired attitude manually, trimming to zero 'stick' force and then engaging the facility by operating the autopilot switch on the control column handle.

I.L.S. auto-coupling

15. The I.L.S. auto-coupler is designed to fly the aircraft automatically from the point of engagement into the approach path defined by the two beams of the instrument landing system *(Sect.8, Chap.3)*. The facility may be used under poor visibility conditions, and is required to bring the aircraft down to a height of about 200 ft where the pilot may complete the approach manually.

Note...

The facilities of 'attitude hold' and 'I.L.S. auto-coupling' as described above, are at the moment non-operational in the autopilot role, but the system will be extended to make them available on later aircraft.

Power supplies

16. The autopilot system requires both a.c. and d.c. power for its operation. The 28-volt d.c. and the 115-volt 3-phase, 400 Hz a.c. power supplies are fed from the d.c. feeder fusebox and the a.c. fuse and relay box respectively, via the a.c. distribution box to the autopilot junction box. These supplies are described in Sect.6, Chap.3.

SERVICING

WARNING

The relevant safety precautions detailed on the LETHAL WARNING marker card must always be observed before entering the cockpit or performing any operations upon the aircraft.

Electrical functioning tests

17. Before testing the Mk.13 autopilot system it is essential to ensure that the checks detailed for the flight instruments *(Sect.7, Chap.5)* have been carried out. It is also important that the instrument master switch is not repeatedly operated. To avoid damage to the M.R.G. a period of 5 min should be allowed between switching OFF and ON again.

Test equipment

18. The following test equipment is required:-

1. A.C. voltmeter (150-volt range)
2. D.C. voltmeter (30-volt range)
3. Frequency meter (range 300/500 Hz at 115 volts)
4. Phase rotation indicator
5. Mk.13 autopilot 1st line test set
6. Mk.13 autopilot actuator simulator
7. Dial test indicator, Mercer Type G71.
8. I.L.S. test set, Type 391
9. Pitot/static test rig
10. Control surface protractors

Note...

Item 6 is only required should it be necessary to diagnose a faulty actuator amplifier or actuator.

Preparation

Power supply check

19. Disconnect cable assembly F164 at the autopilot junction box. With the a.c. and d.c. power connected to the aircraft, operate the INSTRUMENT MASTER switch to its ON position and check the following:-

(1) The 115-volt a.c. supply at F164 cable end, between pins A-B, B-C, C-A, for voltage and frequency.

(2) That the phase rotation is A-B-C.

(3) That 28-volt d.c. exists between pins D and E.

(4) Set the INSTRUMENT MASTER to OFF, check that a.c. and d.c. voltages disappear.

(5) Disconnect the a.c. and d.c. supplies from the aircraft.

(6) Reconnect F164 cable assembly.

(7) Disconnect AS.22 (CA4) at the autopilot junction box and check the continuity between pins A-B at the cable end.

(8) Raise the alighting gear and check

that the continuity is broken when the alighting gear is locked up.

(9) Reconnect AS.22 to the autopilot junction box.

(10) Connect and operate external hydraulic supply rig. Fit control protractors. Ensure that all control surfaces and flags are clear of obstructions and that the flaps are retracted.

(11) Connect the Mk.13 autopilot 1st line test set to the test sockets AS.28 and RG3A at the test panel on the aft face of the sloping bulkhead.

(12) Check the position of the following switches:-

Autopilot master switch - OFF

Autostabilizer channel switch - OFF

Autopilot engage switch - OFF

I.L.S./attitude hold switch - ATTITUDE HOLD

Instrument master switch - ON

◀ (13) Observe that the pilot's controller magnetic indicator remains OFF (white) and, if necessary, manually trim the control surfaces to centre.

Autostabilizer functional test (prior to dither adjustment)

20.

(1) Set the two autostabilizer channel switches to ON.

(2) Set the I.L.S./ATTITUDE HOLD switch to I.L.S.

(3) Set autopilot MASTER switch ON and check that the associated magnetic indicator changes to ON (black).

(4) Check run-up final speed (by observing milli-ammeter on Mk.13 test set) and the direction of rotation of each of the three rate gyros using the Mk.13 1st line test set.

(5) Release each gyro from its mounting in turn, and move it to ensure correct sense of control surface movement. If any gyro produces movement of any other surface than the appropriate one, check the connections at the autopilot junction box.

Note...

Pitch gyro should be moved about the aircraft's athwartships axis; nose up motion should produce a tail plane trailing edge down movement. Roll gyro should be moved about the fore-and-aft axis, starboard side of gyro down should produce starboard aileron trailing edge down and port aileron trailing edge up movements. Yaw gyro should be moved about the vertical axis, turning clockwise should produce movement of rudder to port.

(6) Refit gyros to their mountings.

(7) Check that on pressing the test switch on the Mk.13 test set, the control surfaces move in the correct sense, followed by decay towards neutral.

Port aileron trailing edge - UP

Stbd. aileron trailing edge - DOWN

Tail plane trailing edge - DOWN

Rudder - STARBOARD

Note...

Release of the test switch results in the control surfaces reversing the above movements.

Actuator dither adjustment

21. The dither level of each hydraulic actuator must be checked and carefully adjusted using a dial test indicator. The indicator should be clamped to the actuator output shaft and the relative movement between shaft and actuator case measured. The amount of movement should be 0.001 in. peak to peak. It must be noted that as dither voltage is supplied from one dither oscillator to all four actuator amplifiers, the adjustment of any one actuator channel will effect the dither level in the other channels. Therefore repeated checks and adjustment may be necessary before dither level is balanced throughout the system.

Setting up procedure

22.

(1) With the control column engage switch and the pilot's controller master switch in the ON positions, set up dither in the roll channel to 0.001 in. peak to peak, pitch channel to 0.001 in. peak to peak, and yaw channel 0.003 in. peak to peak, in that order. ▶

(2) Check that vibration is not being transmitted to the control column in pitch and roll. If vibration at dither frequency is present, reduce the dither

level to 0.0008 in. peak to peak. This is most important in the pitch channel.

(3) With the STAB switch ON, recheck the dither level on all actuators. If no dither is present, switch STAB to OFF and increase signal level with the adjustment potentiometer. Repeat procedure until a satisfactory dither level is obtained.

(4) With the STAB switch ON, exercise the actuators by means of the Mk.13 1st line test set. Check that the dither amplitude at the actuators does not exceed 0.002 in. peak to peak.

(5) Switch OFF the pilot's controller MASTER switch and shut down the hydraulic rig. Allow the system to cool for at least 30 min.

(6) With the pilot's controller STAB switch and the control column ENGAGE switch OFF, start up the hydraulic rig and switch ON the pilot's controller MASTER switch.

(7) Recheck the dither amplitudes, they must not exceed 0.002 in. peak to peak and must not be less than 0.0002 in. peak to peak.

(8) If no dither is present repeat (3).

Autostabilizer mode (rate gyros)

23. After satisfactory adjustment of dither level has been obtained, the associated control surface movements must be checked.

(1) Set the two autostabilizer channel switches ON.

(2) Set the I.L.S./ATTITUDE HOLD switch to I.L.S.

(3) Check that autopilot engage switch is OFF.

(4) Select autopilot MASTER switch ON.

(5) Deflect each rate gyro in turn by applying positive volts to the damping coil from the Mk.13 1st line test set. Observe that the initial maximum deflections of the control surface movements are approximately:-

Port aileron trailing edge - UP 0.5 deg

Starboard aileron trailing edge - DOWN 0.5 deg

Tail plane trailing edge - DOWN 0.75 deg

Rudder to starboard - 2.4 deg

(6) Set the I.L.S./ATTITUDE HOLD switch to ATTITUDE HOLD and repeat test (5). The reading should be the same.

Attitude hold (M.R.G. precession)

24.

(1) Set the two autostabilizer channel switches to ON.

(2) Set the I.L.S./ATTITUDE HOLD switch to ATTITUDE HOLD.

(3) Set the autopilot ENGAGE switch to A.P. ON.

(4) Precess the M.R.G. using the Mk.13 line test set until approximately 12 deg of bank to port is indicated on the attitude indicator. Check that the port aileron trailing edge has moved smoothly down 2.4 deg approximately, check that the starboard aileron trailing edge has moved up 2.4 deg approximately, and that both ailerons cease to move after this amount of travel.

(5) Set the autopilot ENGAGE switch to OFF and note that the ailerons revert to their original positions.

(6) Set autopilot ENGAGE switch to A.P. ON.

(7) Precess the M.R.G. to zero bank angle using the fast erection button on the Mk.13 1st line test set. Check that the ailerons move 2.4 deg in the opposite direction to (4).

(8) Turn the desired heading on the Mk.5FT compass heading indicator completely through 360 deg and note that this has no effect on the aileron position.

(9) Set the autopilot ENGAGE switch to OFF.

I.L.S.

25.

(1) Set the two autostabilizer switches ON.

(2) Set the I.L.S./ATTITUDE HOLD switch to I.L.S.

(3) Check that the Mk.5FT compass heading pointer is set to the fixed lubber mark, and that the compass is synchronised.

(4) Set the autopilot ENGAGE switch to ON.

Altitude test

26.

(1) Check that the autopilot engage switch is OFF.

(2) Apply static pressure equivalent to 2000 ft I.C.A.N.

(3) Set autopilot ENGAGE switch to A.P. ON.

(4) Reduce the static pressure to the equivalent of 2200 ft I.C.A.N., and check that the tail plane trailing edge moves approximately 3 deg down from its original position.

(5) Set the autopilot MASTER switch and the ENGAGE switch to OFF.

(6) Disconnect cable assembly AS.22 (CA4) from the autopilot junction box.

(7) Set the autopilot MASTER switch to ON and adjust the static to the equivalent of 2200 ft I.C.A.N. Set autopilot switch ON.

(8) Increase static pressure to equivalent of 2000 ft I.C.A.N. Check that the tail plane trailing edge moves approximately 1 deg up from its original position.

(9) Set both autopilot ENGAGE and autopilot MASTER switches to OFF. Reconnect cable assembly AS.22 (CA4). Operate the master switch to ON, and increase the static pressure to sea level.

Throttle servo

27.

(1) Set the autopilot ENGAGE switch to A.P. ON and apply a pitot pressure of 175 knots.

(2) Set the engine throttle levers to approximately mid-position and engage the throttle servo clutch.

(3) Increase pitot pressure to 200 knots and check that the throttle levers cease to move back at 188 knots ± 2. Reduce pitot pressure to approximately 160 knots and check that throttle levers cease to move forward at 168 knots ± 2.

(4) Set the pitot pressure to 175 knots.

(5) Precess the M.R.G. using the Mk.13 1st line test set, until a small nose down pitch angle is indicated on the attitude indicator. Check that the throttle levers move back and return to their original position within two minutes. Precess the M.R.G. back to zero pitch angle by using fast erection.

(6) Operate the GLIDE switch to GLIDE. Check that the throttle levers move back 0.075 in. and then slowly back a further 0.112 in. and come to rest within two minutes.

(7) Set the autopilot ENGAGE switch to OFF.

(8) Disengage the throttle servo clutch.

M.R.G. precession

28.

(1) Set the autopilot ENGAGE switch to A.P. ON.

(2) Precess the M.R.G. using the 1st line test set, until approximately 8 deg port bank is obtained. Check that the port aileron has moved approximately 2.4 deg down, and the starboard aileron 2.4 deg up. Precess the M.R.G. to bank angle using fast erection and check that the ailerons revert to their original position.

◀ (3) Precess the M.R.G. to zero pitch using the fast erection push-switch. Check that during precession the aircraft silhouette on the autopilot trim indicator moves up or down according to the nose pitch angle. The silhouette should indicate within the white safety zone of the instrument. ▶

(4) Precess the M.R.G. starboard wing low. Check that the tail plane does not move until 8 deg bank angle is indicated, and that at 30 deg bank angle the tail plane trailing edge has moved up approximately 2.1 deg from its original position. Precess to zero bank angle.

(5) Repeat (4) with M.R.G. precessed port wing low.

Mk.5FT compass selected heading

29.

(1) Apply a relative heading by turning the selected heading knob on the compass so that the selected heading pointer reads 3 deg counter-clockwise from the fixed lubber line. Check that the port aileron moves up 2.4 deg and starboard aileron down 2.4 deg. Reset the selected heading pointer to the fixed lubber and

check that the ailerons move back to their original position.

(2) Repeat (1) with the selected heading set to 3 deg clockwise and check that the port aileron moves down 2.4 deg and the starboard aileron up 2.4 deg.

I.L.S. signal checks

30.

(1) Connect I.L.S. test set to supply and switch ON using the test set instructions.

(2) Apply a 'fly right' localiser signal of ½ deg (the needle of the I.L.S. indicator should read 1 dot to starboard). Check that the port aileron moves down approximately 2 deg and the starboard aileron moves up 2 deg.

(3) Apply a 'fly left' localiser signal of ½ deg (indicator 1 dot to port) check that port aileron moves up 2 deg and starboard aileron down 2 deg.

(4) Apply a maximum 'fly right' signal and check that the starboard aileron moves up and port aileron down. Check the heading required to centralise the bead, it should be between 42 deg and 47 deg to port.

(5) Apply a maximum 'fly left' signal and check that the starboard aileron moves down and the port aileron up. Check that the heading required to centralise the bead is between 42 deg and 47 deg to starboard.

(6) Reduce the localiser and heading signals to zero.

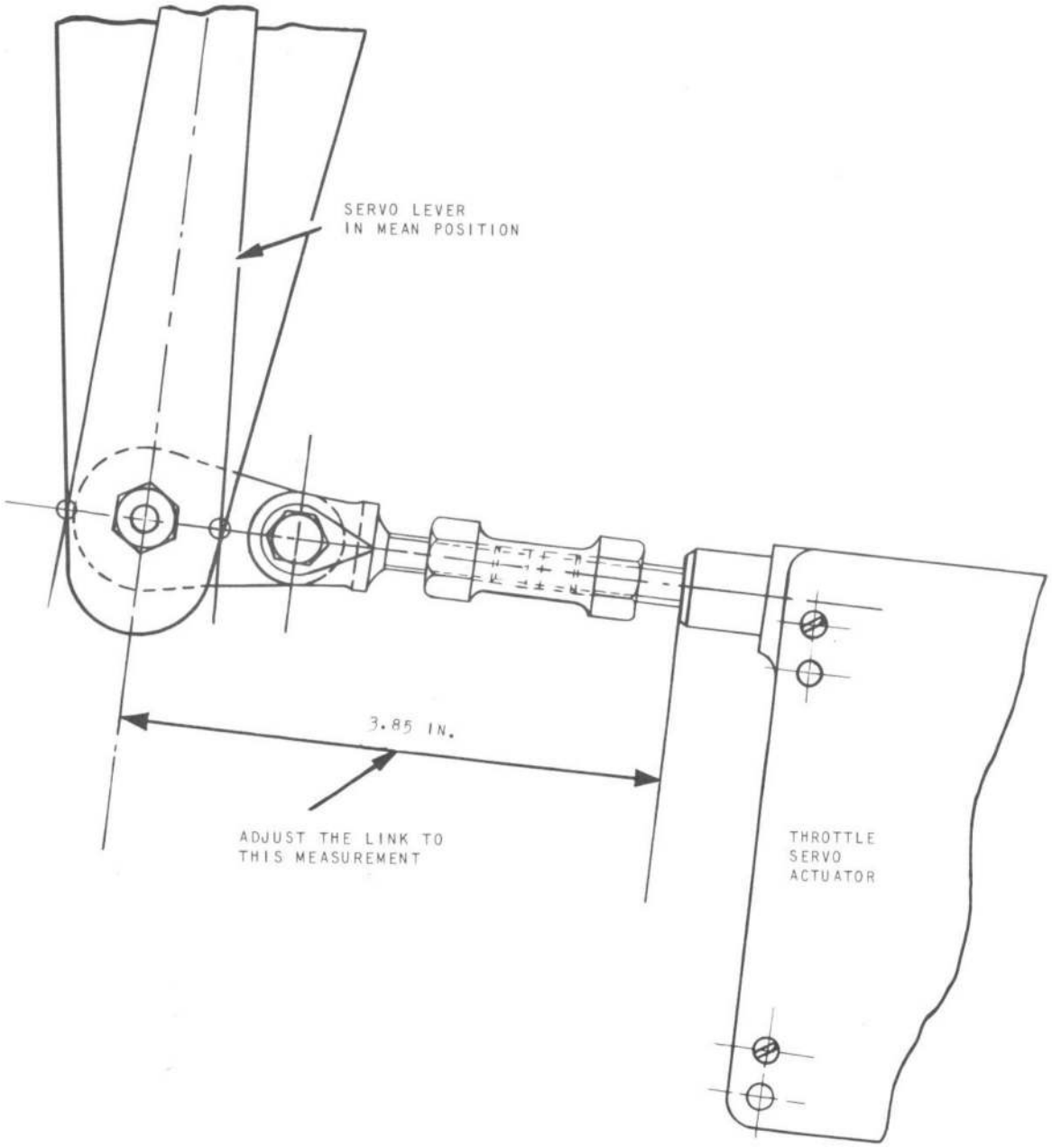

Fig. 3. Throttle servo actuator adjustment

(7) Operate the GLIDE switch momentarily to GLIDE. Check that the tail plane trailing edge moves down approximately 3 deg and returns to its original position within 2 min.

(8) Apply a 'fly right' and then a 'fly left' localiser signal of 1/3 deg, checking that the ailerons move in accordance approximately 2 deg.

(9) Connect the I.L.S. glide path simulator.

(10) Apply a 'fly down' and then a 'fly up' glide path signal of ¼ deg, checking that the tail plane moves in accordance approximately 2.5 deg.

(11) Set the autopilot ENGAGE switch to OFF.

I.L.S./attitude hold interlock

31.

(1) Set the I.L.S./ATTITUDE HOLD switch to I.L.S.

(2) Set the autopilot ENGAGE switch to A.P. ON and check that ATTITUDE HOLD cannot be selected. Set autopilot ENGAGE switch OFF.

(3) Select ATTITUDE HOLD and A.P. ON and check that I.L.S. cannot be selected.

Power failure protection

32.

(1) Set the two autostabilizer channel switches to ON.

(2) Select ATTITUDE HOLD, A.P. ON, and autopilot MASTER ON.

(3) Precess the M.R.G. until 15 deg of port bank is indicated. Check that port aileron moves down and starboard aileron up.

(4) In the a.c. fuse and relay box, remove fuse No.204, which is the supply to the autopilot (115-volt). Check that the autopilot magnetic indicator shows OFF (white) and that the ailerons revert to their original positions.

(5) Replace fuse No.204. The magnetic indicator should show black, the port aileron moves down, starboard aileron up.

(6) Precess M.R.G. until zero bank angle is indicated. Check that ailerons revert to their original positions.

(7) Set autopilot ENGAGE switch to OFF.

Completion of tests

33. Remove all test equipment, set all switches to OFF, with the exception of the I.L.S./ATTITUDE HOLD switch, which should be left in the ATTITUDE HOLD position.

REMOVAL AND ASSEMBLY

Engage switch

34. In the event of the autopilot engage switch in the control column becoming unserviceable, a new control handle of the correct type must be fitted. The procedure for this operation will be found in A.P.101B-1001-1A, Sect.3, Chap.4B.

Autostabilizer actuators

35. Removal and assembly information covering any of the autostabilizer actuators, along with associated rigging and setting of control linkage settings, will be found in the relevant chapters of A.P.101B-1001-1A, Sect.3.

Throttle actuator

36. Removal of the actuator and the consequent breaking down of the mechanical linkage to the throttle servo lever and clutch unit, is achieved through access panel 14P. On replacing the actuator it is essential to have the servo lever in the mean position and the linkage adjusted to the measurement given in fig.3.