

## Chapter 5 FLIGHT INSTRUMENTS

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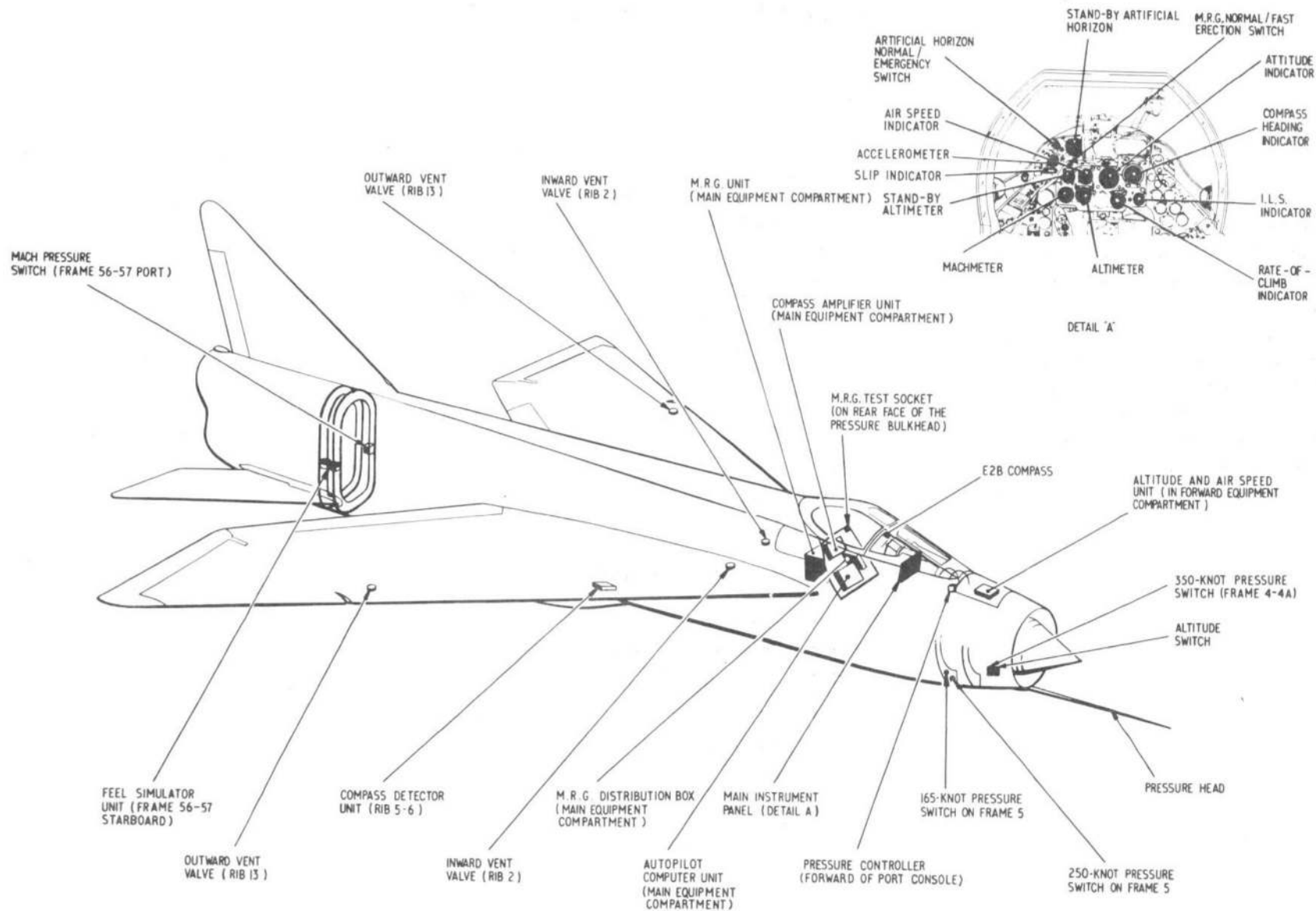


FIG. 1. FLIGHT INSTRUMENT DETAILS

◀ MODS. 456, 4398 EMBODIED ▶

## DESCRIPTION

## General

1. This chapter contains descriptive and servicing information relative to the flight instruments and now includes the following modifications:-

- Mod.456 Introduces stand-by artificial horizon Mk.6G in place of Mk.6A.
- Mod.2531 Introduces stand-by altimeter Mk.26 in lieu of stand-by altimeter Mk.24.
- Mod.4398 Introduces 165-knot pressure switch Pt.No.TP.30187 in lieu of 150-knot pressure switch Pt.No.TP.5694.

## Pitot and static system

## General

2. Pitot and static pressures for operating the instruments and fuel venting system are taken from a Type KPFO 301 pressure head (A.P.112G-0102-1), installed below the engine air intake. Connections to the head are made by three pipelines, a pressure and a static line serving the instruments, and another static line serving the fuel venting system. The pitot and static lines are also connected to a Type PAC-A-12 Mach pressure switch installed between frames 56 and 57 at the port side in the rear fuselage. The switch is used in the air brake system to prevent operation of the brakes above a

predetermined air speed. The pressure head incorporates a heater which is controlled by a switch on the starboard console (Sect.6, Chap.6). Table 1 lists the location of the instruments and their connections into the pitot and static system.

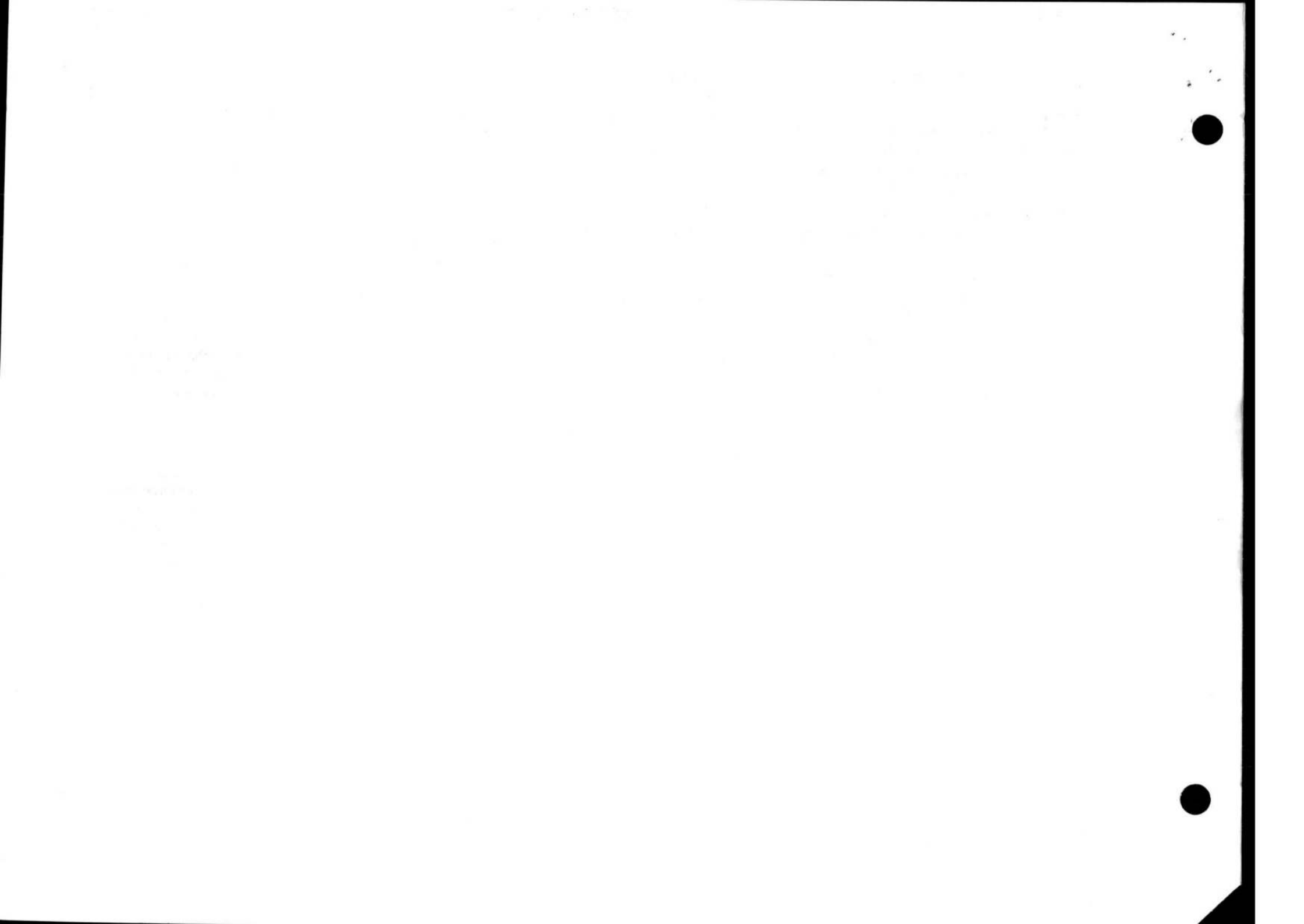
## Drain traps

3. To prevent the accumulation of condensation in the pitot and static pipelines, a total of thirteen drain traps are installed in the system. Each drain trap consists of a short capped tube connected into the appropriate pipeline at the lowest point in its run. Drain trap location is illustrated in fig.2.

TABLE 1

Instruments requiring pitot and/or static pressure

Component	Type	Location	Service required
Pressure head	Mk.9P	Nose	Pitot and static
Pressure switch 350-knots	P.A.D./A/15	Between frames 4-4A starboard	Pitot and static
Pressure switch 165-knots	TP 30187	Forward face of frame 5, starboard	Pitot and static
Pressure switch 250-knots	TP 5080	Forward face of frame 5, starboard	Pitot and static
Altitude switch	P.A.D./A/Q	Between frames 4-4A, starboard	Static
Pressure controller	Type C	Cockpit. Forward of port console	Static
Altitude and air speed unit	Mk.1 or Mk.2	Forward equipment compartment	Pitot and static
Autopilot computer unit	Type C (Sect.7, Chap.3)	Main equipment compartment	Pitot and static
Feel simulator unit	A.P.101B-1001-1A, Sect.3, Chap.6.		Pitot and static
Mach pressure switch	Type P.A.C. -A-12	Between frames 56-57 port	Pitot and static
Fuel vent valves	A.P.101B-1001-1A, Sect.4, Chap.2.	Main plane, port and starboard	Static (separate line)
Altimeter	Mk.22C	Main instrument panel	Static
Altimeter (stand-by)	Mk.24 (pre Mod.2531) } Mk.26 (post Mod.2531) }	Main instrument panel	Static
Rate-of-climb indicator	Type 3P	Main instrument panel	Static
Machmeter	Mk.4	Main instrument panel	Pitot and static
Air speed indicator	Mk.20	Main instrument panel	Pitot and static



**Interim dynamic reference system***General*

4. The installation comprises a master reference gyro (M.R.G.), an attitude indicator, and the Mk.5FT compass system. Indications of the aircraft attitude and heading are presented on the attitude indicator and the Mk.5FT heading indicator, respectively. These two instruments, together with the autopilot computer unit, and the AI 23 equipment, are fed with signals from the M.R.G. unit which senses all movements of the aircraft in roll, pitch, and yaw. A full description of the interim dynamic reference system is contained in A.P. 112C-0012-1.

*Master reference gyro unit*

5. The hermetically-sealed Mk.1, Type D, M.R.G. unit is located in the main equipment compartment and secured by anti-vibrational mountings to a framework held by quick release nuts to a mounting tray fixed to the structure. Connections to the unit are by two Mk.4, 25-pole, miniature plugs. All connections to the M.R.G. unit are made via the M.R.G. distribution box.

*M.R.G. distribution box*

6. This box is located in the main equipment compartment adjacent to the M.R.G. unit. All wiring associated with the interim dynamic reference system is connected through the distribution box, the power supplies being controlled within the box by two d.c.-operated relays and an a.c.-operated torque switch. An internal wiring diagram of the distribution box and a description

of its function will be found in A.P. 112C-0012-1.

*M.R.G. test socket*

7. Facilities for ground testing the system are provided by a test socket labelled RG3A-M.R.G. TEST, mounted on a panel on the aft face of the pressure bulkhead at the port side of the fuselage (fig.1).

*Power supplies*

8. The interim dynamic reference system requires power supplies of 115-volt, 400 Hz, 3-phase, a.c. and 28-volt d.c. for its operation. If the main supplies should fail, there is automatic switching to a Type 100A inverter as described in Sect.6, Chap.13.

**Flight instruments***General*

9. In addition to the instruments used in the interim dynamic reference system, a number of other flight instruments are mounted on the main instrument and port coaming panels. As these instruments are of standard types and described in their associated Air Publications, reference only is given to where the relevant information can be found.

*Altimeter*

10. The main altimeter, Mk.22C, is mounted on the main instrument panel. The instrument operates in conjunction with an amplifier and requires a power supply of 115-volts 400 Hz, single-phase a.c. as described in Sect.6, Chap.4. The altimeter is described in A.P.112G-1023-16.

*Stand-by altimeter*

11. A Mk.24 altimeter (pre Mod.2531) or Mk.26 (post Mod.2531) fitted on the main instrument panel, is provided for use as a stand-by instrument in the event of a failure of the main altimeter. Both types of altimeter are described in A.P.112G series.

*Stand-by artificial horizon*

12. The Mk.6G artificial horizon (A.P. 112G-0306-1) mounted on the port coaming panel, is provided for use in case the M.R.G. or the attitude indicator should fail. It incorporates a fast erection switch which, on operation, increases the erection rate of the gyro. The instrument can be operated from either 115-volt a.c. or 24/28-volt d.c. power supplies. If the normal a.c. supply fails the instrument is automatically transferred to the aircraft generator d.c. supply. If the latter should fail, it will still operate from the aircraft d.c. battery after setting the ART, HORIZON switch to EMERGENCY.

*Rate-of-climb indicator*

13. A Type 3P\* rate of climb indicator (A.P.112G-1007-1) is located on the main instrument panel and connected to the static pipeline.

*Machmeter*

14. The Mk.4 machmeter (A.P.1275A, Vol.1, Sect.21), is installed on the main instrument panel and connected to the pitot and static pipelines.

*Air speed indicator*

15. The air speed indicator Mk.20 (A.P. ▶

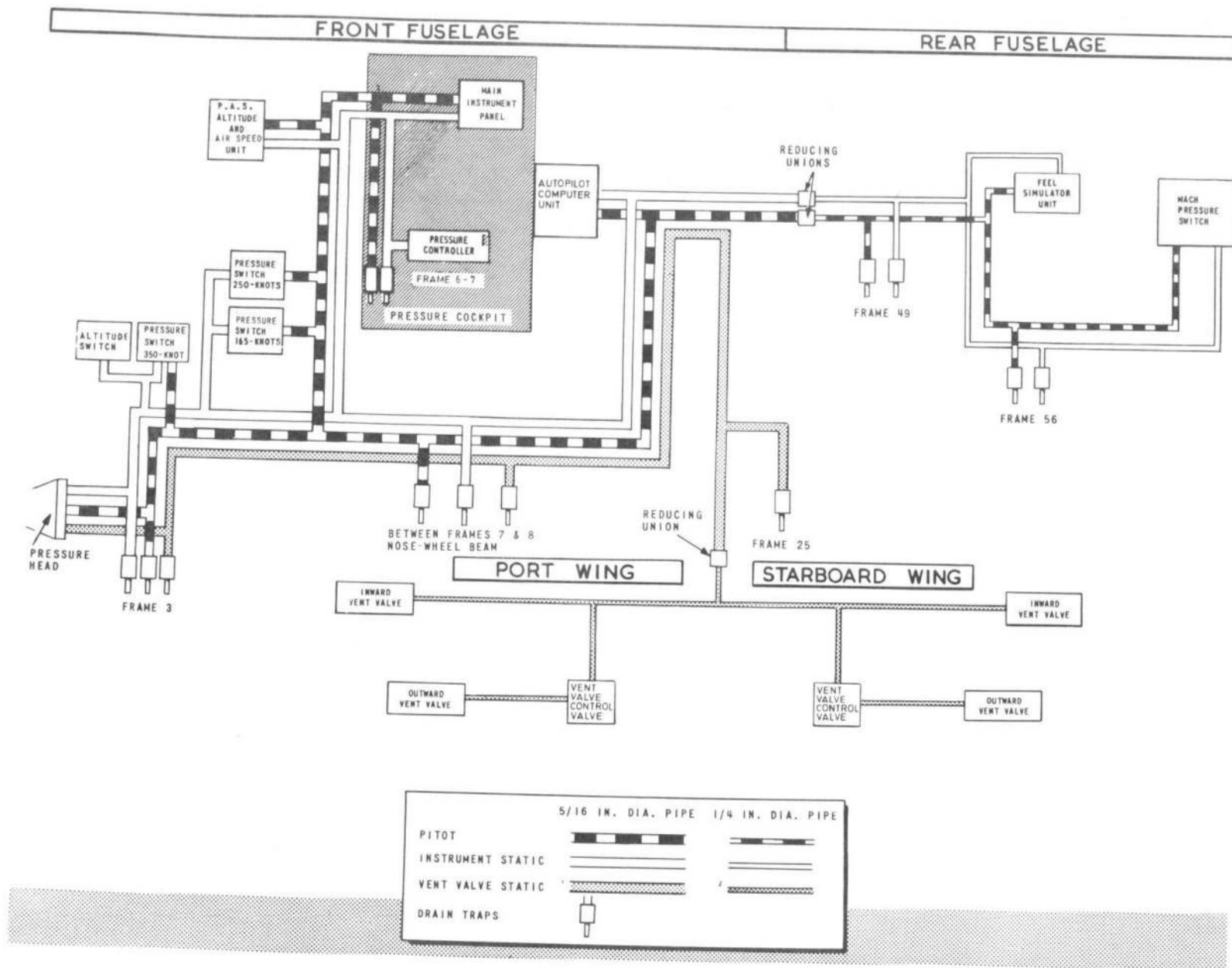


FIG. 3. PITOT AND STATIC SYSTEM

◀ MOD.4398 EMBODIED ▶

◀ 112G-0914-1) is mounted on the main instrument panel and connected to the pitot and static pipelines.

#### Accelerometer

16. The accelerometer Type Mk.3 (A.P. 112G-0208-1) is installed on the port coaming panel.

#### Slip indicator

17. The Type KSL 0301 slip indicator (A.P.112G-0305-1) is mounted on the port coaming panel.

#### Compass E2B

18. An emergency E2B magnetic compass is secured to the starboard frame member of the centre windscreen. The compass card is illuminated by an integral lamp which is controlled by a switch labelled COMPASS DIMMER, fitted adjacent to the starboard instrument panel (Sect.6, Chap.8).

### 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.

#### Pitot and static system

19. The pitot and static pipelines, unions, connections and items associated with the system should be checked periodically for security and freedom from damage. In addition to the normal operational checks, the tests given on fig. 4 are to be made at the intervals stated in A.P.101B-1001-4, or whenever any

major component of the system has been broken down, repaired, or renewed. As all pitot and static pressure operated instruments operate from common pipelines, any fault in the line will normally affect them all. Any single instrument giving suspect readings should be checked in accordance with its relevant Air Publication and renewed if necessary. The drain traps should be removed and drained periodically; after being refitted, the system must be tested for leaks.

#### Bonding

20. The pipelines are bonded to the aircraft structure in accordance with A.P. 113A-0307-1, and should be maintained in this condition.

#### Electrical functioning tests-flight instruments

##### Test equipment required

- 21. A.C. voltmeter reading up to 150 volts
- D.C. voltmeter reading up to 30 volts
- Frequency meter, 300-500 Hz at 115-volts
- Phase rotation indicator
- M.R.G. simulator
- Mk.5FT compass test set
- Mk.13 autopilot 1st line test set
- Pitot/static system test set

##### Voltage check

- 22. Disconnect the following cables:-
- F163 from the M.R.G. distribution box

SA2 from the altimeter amplifier  
SH2 from the stand-by horizon control inverter unit.

Set the artificial horizon NORMAL/EMERG'Y switch, and the stand-by inverter NORMAL/STANDBY switch to NORMAL, then, with the a.c. and d.c. power supplies on, check the following voltages.

PLUG	BETWEEN PINS	VOLTAGE	REMARKS
F163	A-B	115-volt a.c.	Phase rotation
	B-C		A-B-C
	C-A		
	D-E	28-volt d.c.	D positive
	F-E	28-volt d.c.	F positive
SA2	A-B	115-volt a.c.	
SH2	A-B	115-volt a.c.	Phase rotation
	B-C		A-B-C
	C-A		
	D-E	28-volt d.c.	D positive only appears when A.H. switch is set to EMERG'Y
	F-E	28-volt d.c.	F positive. Reset switch to NORMAL after test.

#### Note...

Do not proceed further until all the above checks have been completed satisfactorily.

Switch OFF the instrument master switch and reconnect cable F163 to the M.R.G. distribution box.

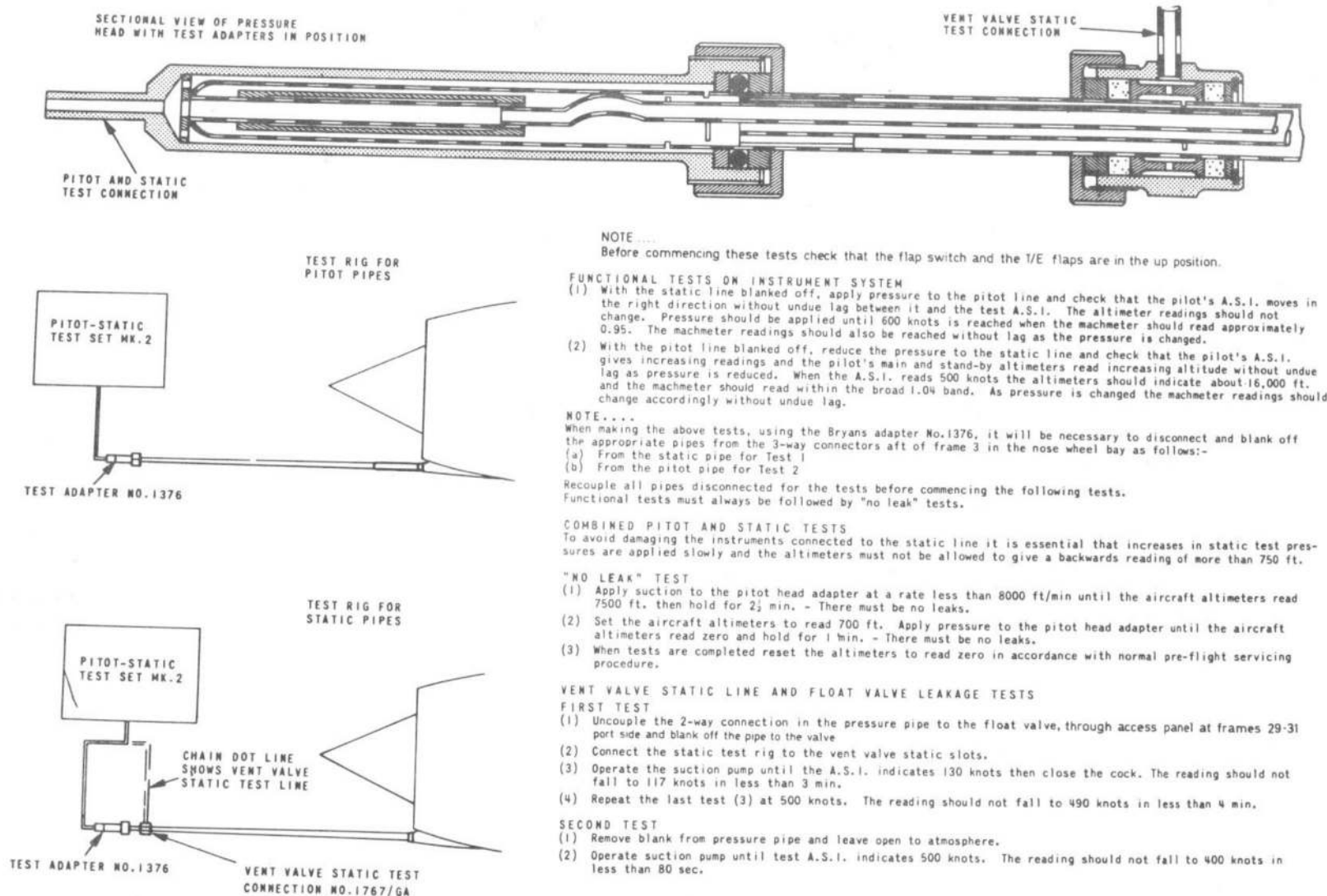


FIG. 4. PITOT AND STATIC SYSTEM TESTS

Throughout the following tests, it is important that the instrument master switch should not be operated repeatedly. To avoid damage to the M.R.G. a period of 5 minutes should be allowed after switching off before an attempt is made to restart the M.R.G. unit.

23. Disconnect cables RG1, RG6, RG7, RG8, RG10, RG11, and AI3A from the M.R.G. distribution box. With the a.c. and d.c. power supplies on, set the instrument master switch to ON, and check the following voltages at the box outlets:-

PLUG	BETWEEN PINS	VOLTAGE	REMARKS
RG1	A-B	115-volt a.c.	Phase rotation A - B - C
	B-C		
	C-A		
RG6	H-J	115-volt a.c.	Phase rotation H - J - K
	J-K		
	K-H		
RG7	V-X	115-volt a.c.	Phase rotation V - X - W
	X-W		
	W-V		
	D-E	115-volt a.c.	Red to white phase
	J-K	115-volt a.c.	Red to white phase
	U-Y	28-volt d.c.	U positive
	T-Y	0-volt	Energized only when M.R.G. monitoring is cut

24. On completion of the above voltage

checks, switch OFF the instrument master switch and proceed to check for continuity between pins on the M.R.G. distribution box as follows:-

FROM	TO	REMARKS
RG7-S	RG1-D	Attitude indicator d.c.
RG7-S	RG6-1	Mk.5FT compass d.c.
RG8-C	A13A-C	A1 transmission
RG8-D	A13A-D	
RG8-E	A13A-E	
RG8-F	A13A-F	
RG8-N	RG8-Q	Autopilot transmission
RG8-N	RG1-C	
RG8-N	RG11-D	
RG8-O	RG11-B	
RG8-P	RG8-S	
RG8-P	RG10-A	
RG8-P	RG11-E	
RG8-R	RG11-A	
RG10-B	RG11-C	
RG8-Y	RG7-Y	Link through test socket RG3A pins A and B

25. Check that the artificial horizon and the stand-by inverter switches are both at NORMAL. Reconnect cable SH2 to the control/inverter unit. With the d.c. only on, switch ON the instrument master switch and check that:-

(1) The artificial horizon flag shows OFF.

(2) The stand-by inverter can be heard running.

(3) The instrument supplies magnetic indicator on the main instrument panel shows WHITE.

Switch OFF the instrument master switch. Do not proceed with any further checks until all the above checks have been completed satisfactorily.

26. Connect the Mk.13 autopilot test set 12-way plug to the M.R.G. test socket RG3A. Reconnect all cables to the M.R.G. distribution box and altimeter amplifier. Before applying the a.c. and d.c. power, check that the following switches are in the correct position viz:-

Stand-by inverter switch - NORMAL

M.R.G. monitor switch - NORMAL

Artificial horizon switch - NORMAL

Mk.5FT compass/DG button - COMPASS  
(D.G. flag not showing)

Mk.13 autopilot test set monitoring - off switch - ON

27. With the a.c. and d.c. on set the instrument master switch ON and observe that the following operations take place:-

(1) The OFF flags disappear immediately from the main altimeter and the artificial horizon, but remain on the attitude and compass indicators.

(2) The attitude indicator blind commences random movement in both bank and elevation.

(3) The artificial horizon commences random movement in both bank and elevation.

(4) The main altimeter commences to move towards zero altimeter.

**Note...**

*If random operation of all instruments has not ceased within 20 sec switch OFF the instrument master switch and investigate the reason.*

28. Providing there are no faults, after the 20 sec period check that:-

(1) The attitude indicator OFF flag clears and the blind has settled to indicate straight and level flight within 1 deg in both bank and elevation.

(2) The Mk.5FT compass indicator OFF flag clears and the compass card swiftly rotates to a random position, and then commences to move steadily towards aircraft magnetic heading at approximately 3 deg per min.

(3) The main altimeter indicates approximately zero height (this is dependent on ground barometric pressure and the setting of the ground pressure knob).

(4) The artificial horizon has settled to indicate straight and level flight within 1 deg in both bank and elevation.

**Note...**

*Tests (1) and (4) depend upon the correct alignment of the M.R.G. unit and the artificial horizon with respect to airframe pitch/roll axes. Airframe axis must be horizontal.*

M.R.G. system functioning check

29.

(1) Release the M.R.G. mounting tray

and move the M.R.G. unit in pitch, roll and yaw. Check that the attitude and compass indicators move in correct sense i.e. tilt the top of the M.R.G. unit to starboard - the attitude indicator blind should rotate counter clockwise, showing starboard bank. Lift the forward end of the M.R.G. unit - the blind should descend showing an aircraft nose-up attitude. Turn the forward end of the M.R.G. unit to starboard - the compass card should rotate counter-clockwise. Ensure that the desired heading pointer remains locked to the compass card, and heading does not slip. Secure the M.R.G. mounting tray and recheck the attitude indicator level.

**Note...**

*A 3 deg error in bank will show if the feet of the M.R.G. unit are not secured under the fittings at one side of the mounting tray.*

(2) Using the Mk.13 autopilot test set, motor-off the M.R.G. unit in bank and elevation to approximately 15 deg in each direction, (i.e. port and starboard bank, nose-up and nose-down in elevation). This should take approximately 1 min for each motoring-off. Reset the motoring-off switch to ON and note the time taken for the attitude indicator to return from 15 deg to 5 deg in each case - the erection rate should be approximately 5 deg per min in bank and 2.5 deg per min in elevation. Check that the compass indicator annunciator centralizes when more than 10 deg of bank is applied.

(3) Synchronize the compass indicator

and check that the card moves only towards the aircraft heading. A ratchet mechanism is incorporated to prevent synchronization on reciprocal headings. Observe the annunciator change-over from CROSS to DOT or vice-versa, and check that the heading is approximately correct by the E2B compass reading. Full scale deflection of the annunciator should occur within 2 deg of the synchronized heading at each side. Select D.G. on the compass indicator and affect the compass card 15 deg from the synchronized heading. Reselect compass mode and note the time taken for the card to move 10 deg towards synchronized heading. The precession rate should be approximately 3 deg per min. Check that the desired heading pointer rotates freely in either direction without causing the compass card to move.

**Note...**

*Fault finding is carried out by using the M.R.G. simulator and the Mk.5FT compass test set. The simulator is normally connected in place of the M.R.G. unit by cables RG7 and RG8. Output transmissions for attitude indicator, compass card, and the Mk.13 autopilot functions can be simulated. Until further notice, outputs for AI should not be used and cable AI3A be disconnected from the M.R.G. distribution box when the M.R.G. simulator is being used. The Mk.5FT compass test set is connected to the miniature 25-way socket connector on the compass amplifier, after removal of the shorting plug. Full instructions for using the test sets are contained in the lids of both units.*

*Check on main altimeter operation*  
30.

(1) Connect the pitot/static test set to the aircraft static slots only. Set the ground pressure knob of the main altimeter to 1013 millibars. Observe that the height reading alters approximately 30 ft per millibar change between 5 and 10 millibars away from datum, i.e. a change from 1018 millibars to 1023 millibars will result in a height decrease of 150 ft. A change from 1008 millibars to 1003 millibars results in a height increase of 150 ft.

(2) Set the ground pressure knob to the applicable ground barometric pressure. Check that the altimeter reads zero height within  $\pm 30$  ft.

(3) Evacuate the static line slowly to show a height of 30,000 ft. Do not exceed 4000 ft per min. The reading should be within  $\pm 500$  ft of that shown on the Mk.19A altimeter in the test set.

(4) Increase static pressure and check that the main altimeter moves slowly back towards zero height. Do not exceed a rate of 4000 ft per min. At zero height, check again that the altimeter reads  $\pm 30$  ft when the ground pressure is set to barometric pressure.

**Note...**

*The test set altimeter should read zero  $\pm 70$  ft at this point.*

(5) Disconnect the pitot/static test set.

*Stand-by inverter system check*  
31.

(1) With all instruments functioning normally, switch OFF the a.c. power at the ground supply truck. Observe that the instrument supply magnetic indicator changes from black to white.

(2) Observe that the main altimeter ceases to operate and the OFF flag appears.

(3) Check that the attitude indicator, compass indicator, and artificial horizon, all continue to operate normally. Note that the OFF flags in both the attitude and compass indicators may flicker momentarily. If the flicker continues for more than 10 seconds switch OFF the instrument master switch and check the output of the Type 100A inverter under full load conditions.

(4) Reduce the d.c. supply to 24 volts, and operate the artificial horizon switch from NORMAL to EMERGENCY. Check that the artificial horizon continues to operate and the OFF flag does not appear. Return the switch to NORMAL.

(5) Return the d.c. supply to 28 volts, switch the a.c. supply on, and check that the instrument supply magnetic indicator changes from white to black, and that the OFF flag in the main altimeter disappears.

(6) Switch OFF the instrument master switch and check that the OFF flags reappear on the attitude and compass indicators, the main altimeter, and the artificial horizon.

(7) Disconnect the Mk.13 autopilot test set and reconnect cable RG3.

**Note...**

*The above tests must be completed satisfactorily before commencing tests on the Mk.13 autopilot, AI23, or the P.A.S. system.*

**Flight instruments**

*General*

32. Apart from periodic checks for security and damage, all servicing of individual flight instruments is included in their Associated Air Publications.

*Machmeter*

33. The Mk.4 Machmeter is serviced in accordance with the instructions in its relevant Air Publication. As this machmeter incorporates pressure error correction for Lightning aircraft only, functional checks on the instrument must be made in accordance with the corrected calibration test figures given in Table 2.

**REMOVAL AND ASSEMBLY**

**Pressure head removal**

34. The sequence of operations for removal of the pressure head is as follows:-

(1) Remove access panel 1, forward of the nose-wheel compartment.

(2) Ensure that the pressure head heater switch on the starboard console is OFF, and remove the relevant circuit fuses.

(3) Disconnect the heater electrical leads at the terminal block on the forward face of frame 3.

(4) Remove the bolts securing the pipeline clamp on the forward face of frame 3, and remove the clamp.

(5) Disconnect the pressure head pitot and static pipelines at the tee unions on the aft face of frame 3. Blank off the tee unions to prevent ingress of dirt and moisture into the systems. Remove the rubber bushes and union nuts from the pressure head pipes.

(6) Through the aperture of access panel 1, remove the locking wire and slacken the 3/8 in. B.S.F. bolt securing the split clamp.

(7) At the nose ring, remove the circlip and grub screw, and slacken the clamping nut. The pressure head is now free to be eased out of its housing. Care must be taken not to damage the pitot and static pipelines at the rear end.

**Pressure head installation**

35. The sequence of operations for the installation of the pressure head is as follows:-

(1) Insert the aft end of the pressure head through the collar at the nose ring until it is held in the split clamp at frame 2 and tighten the clamp securing bolt. Tighten the clamping nut at the nose ring, and fit the grub screw so that it engages in the slot of the split-clamp, then fit the circlip, locking the screw by its screwdriver slot.

(2) Trim the pitot and static pipes if necessary, so that when bent to pass through the pipeline clamp they are the correct length for connection to their

tee unions. From the nose wheel, looking forward, the pitot union is the centre of the three, with the static to starboard and vent valve static to port.

(3) Remove any swarf and thoroughly clean the pipes. Fit the union nuts and new rubber bushes, remove the blanks on the tee unions, and secure the union nuts.

(4) Replace and secure the pipeline clamp to the forward face of frame 3.

(5) Connect the heater electrical leads

to the terminal block, and replace the circuit fuses.

(6) Switch on the heater and check its operation by feel, then set the control switch to OFF.

(7) Wire-lock the bolt securing the split clamp, at frame 2.

(8) Carry out the functional and leakage tests on the pitot/static systems detailed on fig.4.

(9) Replace access panel 1. ▶

**TABLE 2**  
**Machmeter calibration checks**

INDICATED MACH. NO.	RECTIFIED I.A.S. IN KNOTS AT STATIC PRESSURE CORRESPONDING TO HEIGHT I.C.A.N.						
	0	10,000	20,000	30,000	40,000	50,000	60,000
0.7	450	379	314	255	203	160	126
0.8	513	433	360	293	233.5	185	146
0.9	574.5	487	407	332.5	265	210	168
1.0	623.5	532.5	446	365.5	292	231.5	182
1.05	693	595.5	500.5	411	330.5	262	210
1.1	726	625	527	433	349	278	220
1.2		683	578	478	386	308	245
1.3			628	522	423	339	267
1.4			675	564	458	368	294
1.5			721	603	493	397	318
1.6				642	527	424	340
1.7				680	559	452	365
1.8				716	592	480	386
1.9				751.5	621	506	408
2.0					650.5	532	430
2.1					679.5	557	451
2.2					707.5	581	472

The tolerances remain as in A.P.1275A, Vol.1, Sect.21  
i.e. 0-30,000 ft ±0.01 Mach  
above 30,000 ft ±0.015 Mach

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