

PART 2

CHAPTER 15 — NAVIGATION SYSTEMS AND EQUIPMENT

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PART 2

CHAPTER 15 — NAVIGATION SYSTEMS AND EQUIPMENT

Navigation General

Note: Throughout this chapter it is assumed that No 1 equipment is fitted on the left of the aircraft and No 2 on the right; this also applies to the equipment on the radio racks, except where otherwise stated.

AUTOMATIC DIRECTION FINDING EQUIPMENT (ADF)

General Description

1. The ADF system provides facilities for radio navigation and position computing, using ground based transmitters and MF beacons. The navigational information is displayed on three radio magnetic indicators (RMI) and audio identification signals are fed to the intercom system. Radio range flying can be carried out using the equipment and it can be used as a medium frequency radio receiver.

2. Two identical systems are fitted, each consisting of an ADF receiver, a controller and loop and sense aerials. Information from the No 1 system operates the single red ADF-RMI pointers, and the No 2 system operates the double green ADF-RMI pointers.

ADF Receivers

3. The ADF receivers are on the radio racks. The receivers obtain the bearing of the radio station and feed the information to the RMI which display the magnetic bearing of the station on a rotating compass card. The audio output from the receiver is fed to the intercom system. Selection of the crystal controlled frequency is made in steps of 0.5 kHz in the range 100 kHz to 1799.5 kHz by the controller.

ADF Controllers

4. The two controllers are at the navigator's station and are fitted with the following controls:
- Frequency selectors for hundreds, tens and half kHz and a digital display of selected frequency.
 - An OFF/ADF/ANT/LOOP function switch.
 - A LOOP control which rotates the goniometer

search coil, spring-loaded to the centre off position; movement of the knob to left or right moves the coil in the same direction.

d. A two-position SELECTIVITY switch giving a SHARP (1.2 kHz) or BROAD (3.0 kHz) receiver band width.

e. A BFO switch, which mutes the beat frequency oscillator when in the OFF position.

f. A BFO tuning control which adjusts the note of the beat frequency.

g. A GAIN control for use during ANT and LOOP operation; during ADF operation it operates as an audio volume control.

5. *Controls and Indicators—ADF.* (See Table 1.)

Power Supplies

6. The power supplies are obtained as follows:

a. *No 1 ADF*

28-volt DC from No 1 emergency radio supply.
26-volt AC 400 Hz via transformer in No 1 accessory unit A from the 115/200-volt AC emergency supply.

b. *No 2 ADF*

28-volt DC from No 2 normal radio supply.
26-volt AC 400 Hz via transformer in No 2 accessory unit A from the 115/200-volt AC normal supply.

OPERATION

Note 1: Accurate tuning of the ADF is essential for accurate bearings; the receivers are tunable to within 250 Hz of the signal to be received. If the carrier frequency does not lie within the receiver pass band, any modulation will cause the RMI to hunt. When flying a radio range leg, the function switch must not be left at ADF or LOOP, or fading signals (due to the directional properties of the aerials) may be mistaken for zones of silence.

Note 2: Night effect frequently causes unsteadiness in bearings particularly at sunrise and sunset. The operator must average the fluctuations to obtain the

Table 1 — Controls and Indicators — ADF

<i>Item</i>	<i>Location</i>	<i>Marking/Description</i>
ADF-RMI (three)	(1) 1st pilot's panel	ADF
	(1) Co-pilot's panel	ADF
	(1) Navigator's panel	ADF
ADF controllers (three)	(3) Navigator's panel	Frequency selectors (three) Digital frequency indicator Function switch OFF/ADF/ANT/ LOOP LOOP control Selectivity control—SHARP/BROAD BFO switch OFF BFO tuning control GAIN control

correct bearing; an increase in height is often helpful. The lower frequencies are least affected.

Radio Range or Broadcast

7. The ADF is used in the ANT mode mainly for radio range flying or for broadcast reception. The loop is disconnected and only the sense aerial is used.

ADF Operation

8. The ADF position of the function switch connects the loop and sense aerials to the receiver, and the equipment automatically rotates the goniometer loop to a null point, in the correct sense, and transmits the bearing to the RMI.

LOOP Operation

9. The LOOP position of the function switch disconnects the sense aerial and the search drive to the goniometer. Turning the LOOP control to left or right causes the goniometer coil to be driven in the same direction. The null point must be determined audibly and the possible sense ambiguity resolved. The position of the coil will be shown on the RMI.

VOR/ILS SYSTEM

General Description

10. The installation consists of two identical systems, each comprising a VHF receiver, a navigational unit,

a glideslope receiver and a controller; a glideslope aerial in the nose radome and two alternative VOR localiser aerials are shared by both systems.

11. Each system provides indication of aircraft deviation from the radio beam on a course deviation indicator (CDI) and VOR bearing information for display on VOR radio magnetic indicators (RMI). One CDI and one VOR RMI are on each of the pilots' instrument panels and one VOR RMI on the navigator's panel. Either CDI may be supplied with course information from either system; a VOR/LOC changeover switch marked NORMAL/ALTERNATIVE on each sill panel selects the system.

12. The autopilots are fed from the corresponding VOR/ILS equipments. The flight steering computer in the flight director system is fed with VOR/ILS information from the 1st pilot's CDI, which may be fed from the No 1 or No 2 system depending on the position of the VOR/LOC changeover switch.

◀ 13. *Paragraph Not Used.* ▶



◀ 14. A magnetic indicator, below each VOR RMI on the left and right instrument panels, shows:

- a. ILS when an ILS frequency is selected.
- b. VOR when a VOR frequency is selected. ▶

VHF Navigation Controllers

15. VOR/ILS frequencies are selected on the NAV controllers adjacent to each pilot's station on the centre console.

16. Frequency selection is made by a knob, the selected frequency being displayed in digit form adjacent to the knob. The paired glideslope frequency is selected simultaneously with the corresponding LOC frequency. The power supply to the VOR/ILS (NAV) receiver is controlled by the ON/OFF volume control switch which is concentric with the fractional MCS knob.

VOR/ILS Receivers

17. The VOR/ILS receivers are in the radio racks. The frequency ranges are as follows:

<i>Equipment</i>	<i>Frequency Ranges</i>
VHF receiver ...	108.0 MHz to 135.95 MHz in 560 channels at 50 kHz intervals (localiser, VOR communication).
Glideslope receiver ...	329.3 MHz to 335.0 MHz in 40 channels at 0.15 MHz intervals (glide path).
Marker receiver ...	75 MHz fixed frequency.

Navigation Units

18. VOR or ILS localiser signals from the VHF receivers are separated in the navigation units and certain characteristics of the signals are measured to obtain either VOR bearing or ILS localiser information. This information is then fed to the associated CDI and flight director.

19. a. The glideslope receivers are in the radio racks. Signals proportional to the vertical displacement from the centre of the glideslope beam are supplied to the flight director and autopilot systems. The glideslope receiver is switched on when a paired frequency is selected on the VHF NAV controller. The frequency range of 329.3 to 335.0 MHz is covered by 40 crystal-controlled channels at 0.15 MHz spacing.

b. The audio output is filtered through separate rectifier circuits which operate the glideslope

deviation indicators. Duplicate filter/rectifier circuits feed to the autopilot comparison monitor to guard against deviation errors occurring in the filters.

VOR/ILS Changeover Switches

20. Two switches fitted, one on each sill panel, enable the associated CDI to operate from the alternative VOR/ILS system.

Aerials

21. The VOR/ILS receivers can use either of the two localiser aerials; one is in the fin and the other in the bullet. The glideslope aerial, in the nose radome, feeds both receivers.

Operation

22. The system has two modes of operation, depending on the frequency selected on the controller; they are VOR and localiser.

CDI Warning Flags

23. When the received VOR signals are of sufficient level to provide reliable operation of the deviation bar the L-C warning flag in the CDI disappears. The L-C flag appears when the received signals fall below a critical value or if the omni-bearing indicator is more than 8° off-course.

24. During localiser operation the L-C warning flag appears if either the 90 Hz or 150 Hz modulation signals fail, or if the signals fall below a critical level.

25. The GS warning flag appears when the glideslope signals are below a minimum signal level or if the 90 Hz or 150 Hz modulation signals fail. Loss of the supply voltage including the 26-volt reference supply also causes the GS flag to appear.

Emergency Power Condition

26. The No 1 VOR/ILS system and its indications on the CDI are fully operational under emergency power conditions.

27. No heading information is supplied to No 2 CDI but the instrument may be operated as a conventional ILS indicator if the COURSE knob is pulled out and turned until the deviation bar is parallel with the longitudinal axis of the fixed aircraft symbol; the right VOR/LOC changeover switch must be set to ALTERNATIVE No 1.

28. The EMERGENCY flag in the CDI then appears to warn of the abnormal operating conditions.

MARKER SYSTEM

General Description

29. The marker system augments the data from the VOR/ILS and ADF systems by providing positional information during an ILS approach or when passing over an airway beacon having a 75 MHz marker transmitter. Information is displayed by marker lights which come on when the aircraft is over the marker transmitter; coded identification tones are also heard on the intercom system.

30. The installation comprises a receiver, aerial, control switch and two sets of coloured marker lights.

Marker Aerial

31. This aerial is below the fuselage on the centre-line. The aerial has highly directional properties which ensure a sharp marker response.

Marker Receiver

32. The marker receiver is on shelf 3 of the left radio rack. The receiver operates on a frequency of 75 MHz and is powered from the No 1 emergency radio 28-volt DC supply.

Marker Control Switch

33. The receiver sensitivity and on/off switching are controlled from a HIGH/OFF/LOW switch on the forward roof panel. The receiver operates as soon as the switch is moved from the OFF position. LOW sensitivity is used to obtain a sharper light response during an ILS approach.

Marker Identification Lights

34. Three press-to-test lights are fitted, one above each other, on each of the pilots' instrument panels. The indications, visual and aural, are as follows:

<i>Indicator</i>	<i>Aural Identification</i>
OUTER (Blue)	2 dashes per second of 400 Hz tone
MIDDLE (Amber)	Dots and dashes of 1300 Hz tone, continuous morse code.
AIRWAYS (White)	Fan marker, continuous morse code, dot-dash sequence. Z marker, 3000 Hz steady tone.

Operation

35. As the aircraft approaches the marker beacon the received signal, modulated by the identification tone, reaches a sufficient level to operate the receiver squelch circuit. Three separate filters, tuned to 400 Hz, 1300 Hz and 3000 Hz are fed with the audio output and, as each frequency is received, a transistor switch is operated which provides the power for the appropriate coloured light to identify the beacon.

DISTANCE MEASURING EQUIPMENT — TACAN (DMET)

General Description

36. DMET is an airborne secondary radar equipment that measures the range of a surface or airborne transponder, and the bearing of a surface Tacan beacon. The range and bearing are displayed on two indicators, one on the centre instrument panel and the other on the navigator's panel.

37. The equipment consists of a receiver-transmitter, an L band aerial and a control unit, two indicators and a coupling unit.

38. The controls necessary for the operation of the equipment are on the control unit at the navigator's station, except for the AIR to AIR/AIR to GROUND switch which is on the panel above the control unit.

WARNING: When 'air to air' is selected, it is important not to select the channel number of a nearby ground station or the equipment may be burnt out.

Indicator

39. The bearing of the aircraft from the beacon is shown by the tail of the arrow against a fixed azimuth scale, the head of the arrow showing the reciprocal of the bearing or heading to steer to the beacon. The distance from the beacon is shown in digit form in a window set into the instrument face. When signals are unreliable or during a search a yellow bar appears over the distance numerals.

Control Unit

40. Two control knobs on the unit select the operating channel; one selects the units from 0 to 9 and

the other the tens from 0-12, the selected channel number being shown on the channel number indicator between the two controls. 126 channels are available, spaced at 1 MCS intervals in the frequency range 962 to 1,213 MCS; each channel consists of an interrogation and a responder frequency spaced 63 MCS apart.

41. A power control marked T/R-REC-OFF is fitted on the control unit; the OFF position switches the equipment off; in the REC position, bearing information only is available; in the T/R position both bearing and range information are available except in air-to-air mode when only range is available. A VOL control adjusts the level of the audio identification signals fed to the station boxes. ▶

Operation

42. The following information is provided:

- a. Identification of a beacon or transponder in the form of morse code characters.
- b. Distance of the aircraft from a surface beacon or transponder aircraft.
- c. Bearing from a surface beacon.

Identification Information

43. The surface beacons and airborne transponders send out coded identification signals every 37.5 seconds. These signals consist of up to three morse characters; the remainder of the DMET transmission causes a 1,350 HZ tone to be heard in the audio system.

Distance Information

44. The interrogating aircraft initiates a pulse coded signal which is radiated from the airborne aerial. This signal is received by the transponder which transmits a pulse coded distance reply signal after a fixed delay. The receiver reply signals are fed to range circuits which measure the elapsed time between the transmitted and received signals, subtract the fixed delay and convert this time into a distance in nautical miles and display it on the indicator.

45. To avoid confusion when a number of aircraft require to determine their distance from a transponder aircraft the role of interrogator and transponder must be established; they must transmit on two frequencies 63 MHz apart; interrogation and reply signals are then received at the image frequency of each channel. This limits the number of channels available for air-to-air operation to 63.

46. A maximum of five aircraft can interrogate a single transponder aircraft simultaneously.

Bearing Information

47. The surface beacon transmits a pattern consisting of a train of pulses, amplitude-modulated by a continuously rotating pattern. The phase relationship between certain pulses and the modulation is discrete for a particular bearing. The receiver phase shifts the received modulation until it aligns with the reference pulses, the angle of phase shift then equalling the bearing from the beacon.

WEATHER RADAR ^{NOTES TOP OF} _{PAGE 7}

General Description

48. The weather radar installation consists of two indicators, two transmitter/receivers, a scanner unit, a waveguide run, two switches on the centre console, and the junction box forming the backplate of the dual mounting-tray on which the transmitter/receivers are located.

49. The equipment provides en-route weather information and storm detection up to approximately 150 nautical miles. Ground mapping and facilities for the detection of centres of turbulence in storm cloud formations are also provided. The information is displayed on two off-set plan position indicators (PPI's), one to the left of the 1st pilot and one at the navigator's station.

50. Two transmitter-receiver units are fitted, both sharing the same waveguide and scanner unit. A WEATHER RADAR TRANSCEIVER-No. 1/No. 2 switch at the front of the centre console permits selection of either unit for the operation of both indicators.

51. Each indicator incorporates a controller and control of the radar system may be exercised from either crew station by use of the WEATHER RADAR MASTER INDICATOR — No. 1/No. 2 switch adjacent to the TRANSCEIVER switch. Certain controller functions remain independently operative when the system is controlled from the alternative unit, and the area scanned may be simultaneously displayed on both indicators at different ranges.

Scanner Unit

52. The scanner is on the forward pressure bulkhead under the radome. It comprises the beam forming elements necessary to form and propagate a pencil or mapping beam and to receive the returned echoes. Pitch stabilisation is employed and the scanner oscillates to 90 deg. in azimuth either side of the aircraft centre line.

Transmitter-receiver

53. Two units are on the right of the forward equipment bay on a common tray. Each unit consists of a modulator, transmitter, duplexer, mixer frequency control system, IF head amplifier, a blower for cooling purposes and power supplies for the remainder of the system.

Indicator/Controllers

54. The radar display is presented on the face of a cathode ray tube which has an overlay scaled radially in 15 deg. graduations, left and right of the vertical centre line which represents the aircraft heading. The radar system controls below the display consist of:

a. A POWER OFF/ON/STAB OFF switch, which connects the supplies to the selected transmitter/receiver, indicator and scanner. For the system to operate only one of the POWER switches need be at ON; a three-minute delay occurs before the system becomes fully operational. The three-minute delay will also occur when the POWER switch is set OFF and ON again, momentarily. The STAB OFF position is used if the stabilising gyro fails or if a fault develops in the stabilising system.

b. A RANGE SELECTOR switch marked STANDBY/20/50/150. The STANDBY position keeps the equipment ready for immediate operation but cuts the EHT supply to the transmitter and holds the scanner stationary. The numbers on the RANGE SELECTOR refer to the displayed range; the number and intervals of the markers are as follows:

<i>Range in nautical miles</i>	<i>Number of markers</i>	<i>Distance between markers</i>
20	4	5 NM
50	5	10 NM
150	3	50 NM

c. A CONTRAST control, which can be used to adjust the overall brightness of the trace.

d. A continuously variable TILT control scaled 15 deg. UP and 15 deg. DOWN from the horizontal, which controls the degree of tilt of the scanner.

e. A four-position MAP/MAN/WEA/CONTOUR function switch.

f. A MAN GAIN control, which operates in the MAP or MAN setting and adjusts IF sensitivity.

g. A MARKER BRILL control, which adjusts the marker brightness up to the level set by the contrast control.

Transmitter and Controller Selector Switches

55. The selector switches are on a panel in front of the throttle controls on the centre console.

56. The TRANSCEIVER switches select the operational unit for No. 1 and No. 2. A three-minute delay occurs on switching over.

57. The MASTER INDICATOR switch selects the indicator which is to have control of the system; a neon indicator illuminates on the selected indicator.

Power Supplies

58. Two 28-volt DC supplies from the No. 1 and 2 non-essential supplies are used by the radar and connected via rectifiers so that the failure of one supply does not cause the radar to fail.

59. The 115-volt AC 400 HZ supplies for the No. 1 indicator and transmitter-receiver are fed from No. 1 generator and the No. 2 equipment from the No. 4 generator.

60. The 115-volt AC 400 HZ supplies are remotely switched in a junction box which also contains suppressors to prevent interference on other radio equipment.

61. The scanner and waveguide switch motors are supplied from No. 1 or No. 4 generator depending on the position of the master indicator selector switch.

Operation

62. All power supplies are connected when the POWER switch on either indicator/controller is set to ON. A delay of three minutes occurs before the high voltages are applied in the transmitter and this prevents a picture being produced during this period.

63. When the RANGE selector switch is turned to a numbered position corresponding to the maximum displayed range in nautical miles, the trace on the display moves, at a constant velocity from the origin (zero range) radially outward. The velocity of the trace on each range is proportional to twice the maximum displayed range (signals go to and from the target before display). Marker pips are displayed superimposed on the trace at fixed time intervals from the start of the trace and thus calibrate the trace in distance. As the scanner oscillates, the trace moving in synchronism on the screen produces a

sector scan built up in the form of lines radiating from the origin, the markers forming concentric arcs about the origin.

Displayed Information

64. The brightness of target echoes on the screen is, apart from their distance, proportional to their reflective properties. In the case of clouds this varies with the moisture content; the centres of greatest turbulence in storm clouds are normally those with the greatest rain content. These are not always clearly defined as their echoes have a signal value above peak brilliance, whilst surrounding areas return signals approaching peak brilliance. Signals above a certain level are therefore inverted and appear on the screen as dark centres surrounded by the bright areas of lesser turbulence. The sensitivity time control circuit adjusts receiver sensitivity with respect to time so that echoes received from distant targets are registered with a brightness level equivalent to that of nearby targets of similar reflective properties. This circuit operates in the ranges 2 to 24 NM, when the function switch is set to either WEA or CONT.

65. In the MAN or MAP settings, gain is adjusted by the MAN GAIN control. Targets are then displayed at a brilliance level equivalent to their reflective properties and their range.

Beam Shape

66. A conical pencil beam is transmitted in all except the MAP setting. In this setting, the beam-forming plates on the aerial are rotated so as to transmit a fan-shaped beam in the vertical plane while retaining the pencil beam characteristics in the horizontal plane. Ground coverage is adjusted by the TILT control; control of ground mapping operations is from the master indicator.

GROUND POSITION INDICATOR

General Description

67. The ground position indicator (GPI) is an electro-mechanical analogue computer which employs inputs of true heading, true airspeed, drift and groundspeed to compute aircraft position (in latitude/longitude or grid co-ordinate form and as along and across track distances) and most or the vector information required for DR navigation. The GPI forms the centre of a complete navigational system.

68. *Basis of Computation.* The computation is based on the navigational triangle of velocities. Given two

sides and the included angle the computer calculates the third side. Normal operation is the calculation of ground position from true airspeed, heading, ground speed and drift angle. Wind velocity is also presented. The reversionary mode enables the ground position to be maintained after a doppler failure and calculates ground speed and drift from true airspeed and manually-set wind velocity.

69. When the doppler radar is unserviceable or in the memory mode, the wind velocity already set on the instrument is assumed correct and used to correct groundspeed and drift. In the event of a failure in the air data computer the true airspeed can be set manually.

Operation

70. *Heading and Track Indicator.* This indicator labelled TRACK is mounted at the top centre of the GPI front panel and shows track made good against a stationary compass rose; actual heading is also shown by a small marker (bug) which moves round the outer edge of the compass rose. The heading angle is supplied from the aircraft compass system and added to the drift angle from the doppler radar to give the track angle.

71. *Fine Heading.* A two-digit counter to the left of the track dial shows the unit and first decimal place of the heading, the tens and hundreds figures being taken from the track dial.

72. *True Airspeed.* Below and to the left of the track dial, true airspeed (TAS) in the range of 90 to 900 knots is shown on a TAS indicator calibrated from 1 to 9 and is marked KNOTS \times 100. The information is supplied from the true airspeed unit. To the right of the track dial is a switch marked NORMAL/SET TAS which when set in the NORMAL position routes the true airspeed information to the TAS indicator. In the SET TAS position the indicator can be set manually by the knob to the right of the TAS indicator. This knob must not be turned when the switch is in the NORMAL position or an incorrect TAS indication will result.

73. *Groundspeed.* The GROUNDSPPEED indicator is below and to the right of the track indicator and shows groundspeed in the range 90 to 900 knots. the dial is calibrated from 1 to 9 and is marked KNOTS \times 100. Information is normally from the doppler radar but when this is not available it displays GPI-computed groundspeed.

74. *Wind Velocity.* The two components of wind velocity, wind direction and speed, are shown on a

WIND indicator. Wind direction is shown relative to a fixed compass rose and the wind speed on a 3-digit counter reading up to 250 knots. Manual controls marked WIND DIRN and WIND SPEED are provided for use when the memory mode is operating.

75. *Lat/Long or Grid Display.* This display on the right side of the unit front panel consists of two sets of counters and reset controls and a LAT LONG/GRID selector switch. When the switch is set to LAT LONG the aircraft position is shown on the counters in degrees and minutes of latitude and longitude with N/S or E/W being shown on the left of the indication. When the switch is set to the GRID position the counter indications are in nautical miles and work against a 60 NM grid, the capacity being 10,800 NM in each direction. The counter reset controls give a fast, motor-driven, reset when turned. If the control is pushed in before turning, a fine manual reset is provided.

76. *Along/Across Track Display.* The left side of the front panel consists of two similar along track stages designated A and B, and a common cross track display. The along track display shows ALONG TRACK distance on a digital counter; this is the actual distance left to go along the flight leg, the total distance having been set at the start of the leg. The TRACK ANGLE is set manually at the start of the leg and is the desired track angle. The ACROSS TRACK display shows the distance the aircraft is left or right of the selected track. The two stages are set individually with the desired track angle and along track angle distances for the next two legs of the flight plan. Automatic transfer between stages can occur when the along track distance reaches zero. Blue lamps corresponding to the two stages come on when that stage is active. An amber lamp comes on 10 NM before the end of each leg and goes out when the next stage is activated. A three-position switch at the bottom left of the unit selects A, AUTO or B and enables the operator to operate either stage individually or, in AUTO, to have automatic changeover between stages.

Controls and Indicators

77. *Main ON/OFF Switch.* Situated in the bottom right of the unit, this switch controls the supply of power to the GPI.

78. *OPERATE GPI/STANDBY Switch.* Fitted adjacent to the power supply switch, this switch energises the computer in the OPERATE position and keeps it in a warmed-up condition when set to STANDBY.

79. *OPERATE A/A/STANDBY Switch.* Fitted below the along/across display, this switch sets the

along/across computer to operate or standby after GPI/STANDBY switch is set to OPERATE.

80. *OPERATE/STORE Switch and Flag Indicator.* A two-position switch below the longitude window is marked OPERATE/STORE. For normal operation the switch is set to OPERATE. When set to STORE, the co-ordinate and along track displays are frozen and the incoming information is stored. On resetting the switch to OPERATE the displayed information is rapidly up-dated. A flag indicator marked STORE, along-side the switch, shows black and yellow stripes when the switch is set to STORE. The maximum storage capacity is 150 NM; when the switch is reset to OPERATE, the flag shows black and yellow stripes until the whole of the stored information has been released after which the flag shows black.

81. *Doppler Flag Indicator.* A second flag to the right of the OPERATE/STORE switch, marked DOPPLER, shows the mode of operation of the doppler radar. The flag shows black when the doppler is operating normally and a black M on a yellow ground when the doppler and hence the GPI are in the memory mode. When the doppler is switched off the flag shows OFF in black on a red ground.

DOPPLER

General Description

82. The doppler radar system obtains and displays ground speed and drift angle on a combined ground speed and drift indicator and distance-gone information on a veeder counter (both instruments are on the navigator's panel), and also feeds this information to the GPI. The installation comprises two similar systems, each consisting of an aerial, transmitter-receiver, tracker and control units. A change-over switch selects which systems output is to be displayed.

Aerials

83. The aerials are mounted fore and aft, inside the aircraft on the vertical centre line, one just aft of the radome and the other in the tail cone; the latter is limited in pitch movement to avoid fouling the fuselage.

84. RF energy is radiated from each aerial at a frequency of 8800 MHz in 4 lobes, positioned so as to meet the ground at the corners of a rectangle. The lobes are transmitted in the order, left front, right rear, right front, left rear. The front aerial is pitch stabilised within $\pm 15^\circ$, the rear within $+11^\circ$ and minus 4° . They are controlled in azimuth by the servo drift angle system which sets the aerial parallel to the line of flight. Each aerial can turn in azimuth 25° either side of the aircraft centre line. ▶

Transmitter-Receiver Units

85. The transmitter-receiver units are mounted, one in the forward equipment bay and the other aft of the rear pressure bulkhead in the tail cone. A test socket for each unit is provided on a junction box which forms part of the unit.

85A. Each unit consists of a magnetron power oscillator and drive circuit, receiver, AFC and power supply circuits. A three-minute delay occurs each time the transmitter is switched from OFF to ON to allow time for the equipment to warm up. This delay does not occur when the equipment is switched from S/B to ON. The unit is connected to the aerial by a waveguide.

Frequency Tracker

86. The frequency trackers are on the radio racks. They track the frequency spectrum using mechanically-driven phonic wheels to provide the locally generated signals. This makes the system independent of calibration procedures.

Ground Speed and Drift Indicator

87. Ground speed is shown on a three-digit indicator set into the meter scale and indicating from 0 to 999 knots. The actual operating range is from 100 to 1000 knots. Drift angle is shown on a centre zero meter scale, graduated up to 40° either side of zero, but the equipment is limited to 25° of drift either side of zero.

88. An ON/OFF-MEMORY flag in the indicator shows the operating state of the equipment.

89. The accuracy of the displayed information is:

- ◀ Drift angle within $\pm 0.5^\circ$ of true angle. ▶
- Ground speed within 3.5 knots at 100 knots or 6 knots at 600 knots actual ground speed.

Distance Gone Indicator

90. The distance gone is shown on a four-digit indicator reading from 0 to 999.9 nautical miles; the last digit is coloured green. Fast reset is provided by an electric motor, slow reset is carried out manually; the reset knob is on the front of the instrument. Accuracy is within 0.5% of the distance gone.

Control Unit and Changeover Switch

91. The control unit carries an OFF/SB/ON switch, a four-position joy stick switch for ground speed and drift angle correction and a LAND/SEA switch. When the switch is set to SEA the calibration of the equipment is corrected for operation over water.

92. The changeover switch connects No 1 or No 2 equipment to the ground speed and drift indicator and via an on/off switch to the distance gone meter. The switch also connects the selected equipment to the GPI.

93. When the equipment is in use both No 1 and No 2 control unit switches are set to ON and the changeover switch set as necessary. The equipment which is not selected on the changeover switch is held in the standby mode although selected to the ON position. Should a changeover be required, it may be necessary to operate the inching controls to initially set the second doppler within 20% of the correct ground speed so that it will lock on successfully.

LORAN C/A Type ADL 21

General Description

94. The following items of Loran equipment are fitted:

- a. Receiver Unit Type 1831, on shelf 2 on left radio rack.
- b. Amplifier unit Type 1953, inside the fuselage on the left side.
- c. CRT Unit and Read-out Unit at the navigator's station.
- d. Loran aerial, below the fuselage on the left side.

95. Loran A is a pulsed hyperbolic navigational aid operating on frequencies of about 2 Hz. The maximum ground wave coverage is approximately 700 NM over water and 150 NM over land. Sky-waves may be used with reduced accuracy, to about 1500 NM. Fixing accuracy in good ground-wave cover is from 1 to 5 NM deteriorating to 30 to 50 NM when using sky-wave.

95. Loran C is also a pulsed hyperbolic navigation aid, operating on a frequency of 100 kHz. The maximum ground wave is approximately 1200 NM over water and 900 NM over land. Beyond these ranges, sky-wave cover extends to approximately 2800 NM at night; there is usually some sky-wave present in daylight also. Fixing accuracy varies from 200 to 400 yards in good cover to 0.5 to 1 NM at a range of 1000 NM and about 10 to 20 NM when using sky-waves

Controls and Indicators

97. All controls for operation of Loran are either on the Read-Out Unit or the CRT Unit, both panels adjoining. (See Table 2.)

Table 2 — Controls and Indicators — Loran

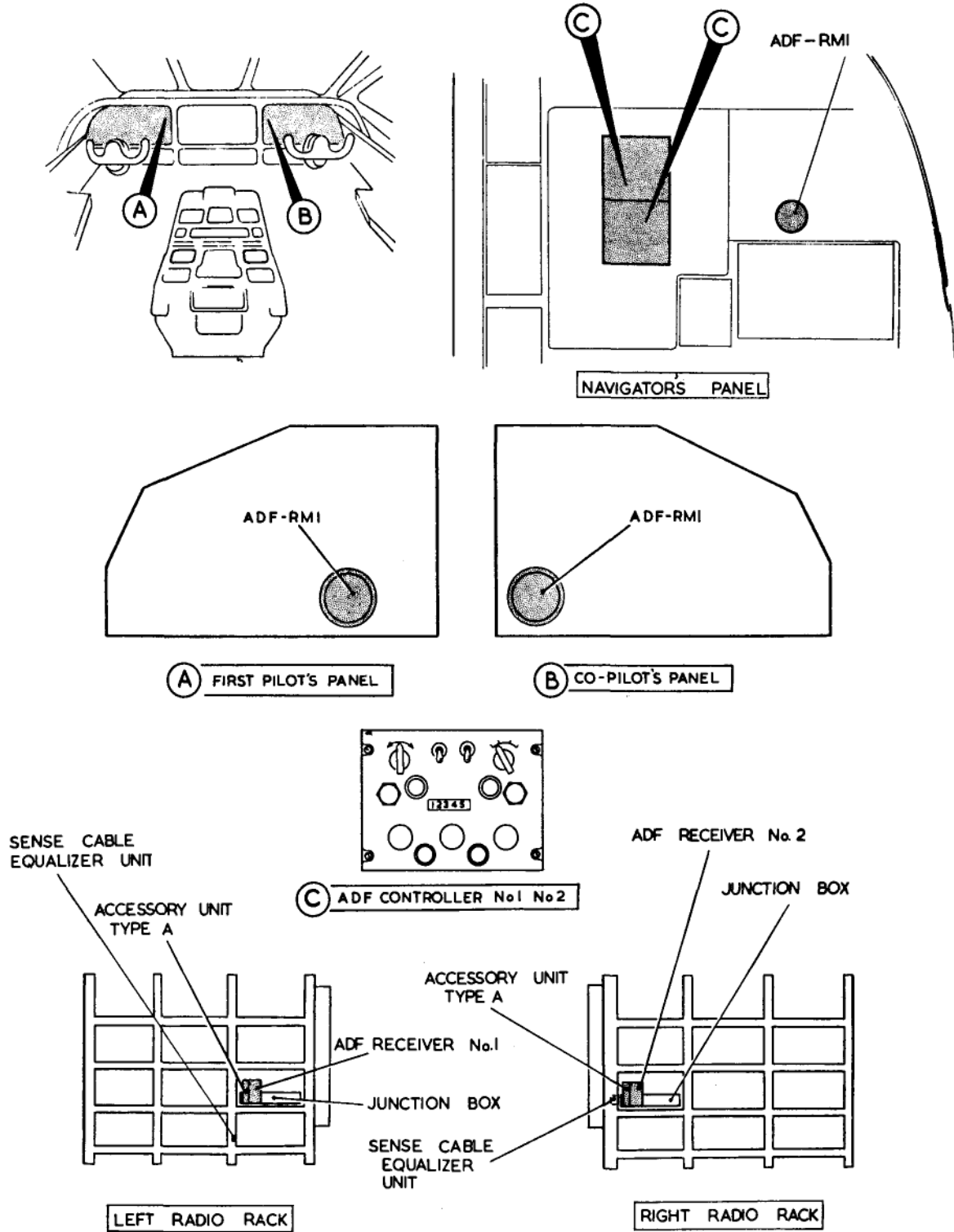
<i>Item</i>	<i>Location</i>	<i>Marking/Description</i>	
<i>Read-Out Unit (Type 1833)</i>			
Main on/off and panel dimmer		OFF/DIM	
Display selector switch		A/A—B/B	
Frequency and band with selector control for Loran C operation		SELECT STATION—1/2/3/C NARROW/B—W/C WIDE	
Basic and specific pulse recurrence rate controls common to both Loran A and Loran C		SELECT STATION—H/L/S/SH/SL/SS SELECT STATION—0 to 7	
M, A or B Channel function warning lights (three)	At Navigator's station	ALARM—AGC ALARM—AFC ALARM—INDEX	
<i>CRT Unit (Type 1832)</i>			
Loran C/A Selector Control		FUNCTION—M/A/B	
Time base control		TIME BASE—1/2/3	
Gain control		DISPLAY GAIN	
RF Controls (three)		RF CONTROLS—LORAN A RF CONTROLS—LORAN C RF CONTROLS—KC	
Meter display selector switch		AGC/INDEX/AFC	
Meter indicator		—	
Store zero/Code jump switch		STORE ZERO / CODE JUMP, spring-loaded to centre off position	
Loran A drift control		LORAN A—DRIFT	
Loran A slave signal drift switch	SLEW—L/R, spring-loaded to centre off position		
Selected signal rapid drift selector switch	COARSE—L/R, spring-loaded to centre off position		
Selected signal slow drift selector switch	MEDIUM—L/R, spring-loaded to centre off position		
Selected signal jump switch	10 μ S JUMP—L/R, spring-loaded to centre position		
All signals jump switch	ALL JUMP—L/R, spring-loaded to centre off position		

Preset Controls CRT Unit

The following preset controls are on the left-hand side of the CRT Unit:

- (1) Brilliance
- (2) Focus
- (3) Astigmatism

Separate controls are provided so that these qualities may be separately set up for TIME BASE 1 and TIME BASE 2/3.



2.15 Fig. 1. ADF Installation

OMEGA

General Description

98. The Litton LTN-211/08 Omega navigation system (ARI 23314/1) is a long range navigation aid operating in the very low frequency (VLF) band of 10 to 14 kHz. Eight ground stations provide global navigation coverage at high and low levels, transmitting phase-locked signals which travel more than half way round the world using the natural waveguide formed between the earth's surface and the ionosphere. Aircraft equipped with an Omega receiver should normally be able to receive signals from at least three stations and obtain a fix to an expected accuracy of 2 NM CEP using an automatic process of signal phase measurement or direct ranging techniques. An Omega receiver can also receive signals from up to four VLF communications transmitters, automatically selected from nine available to the system, in lieu of Omega signals.

99. The Omega receiver tracks and measures accurately the phase of received signals from several ground stations with station selection performed automatically. If the number and quality of received signals are below that required for navigation, a DR mode is automatically initiated. Detected phase changes are fed to a computer to remove propagation anomalies caused by such factors as diurnal variation in the height of the ionosphere and the various land/sea/ice cap surfaces over which the signal may have travelled; propagation anomaly data stored in the computer is correctly applied after the navigator has inserted the known aircraft position, calendar date and GMT during the pre-flight procedures. Detected, corrected phase changes are then converted to distance flown, but due to the format of the Omega transmission system, calculated position can only be updated every 10 seconds.

100. Position ambiguity; caused by temporary loss of signal, is resolved by various signal frequency mixes within the receiver. To further improve position calculations, aircraft magnetic heading (from the No 1 compass system) and TAS (from a TAS computer) are supplied to the computer to improve the dynamic response of the system during aircraft manoeuvre, compensate for the 10-second delay in position updating, and provide a DR capability during periods of signal loss. This Omega equipment has the facility to operate on gyro heading inputs, instead of magnetic heading, whilst continuing to compute and display true geographic positions. This facility is used when the aircraft is required to operate in regions where the accuracy of magnetic head-

ing is unreliable and gyro-grid navigation techniques become essential.

101. As well as showing present position, the control display unit can show data such as track and groundspeed, heading and drift, cross-track distance and track angle error relative to desired track, up to nine waypoints, distance and estimated flying time between any two waypoints or between present position and any waypoint, and wind velocity.

Ground Stations

102. Locations of Omega and VLF stations are shown in **Table 5**. The 10-second Omega pattern for all eight stations is shown in **Fig 1B**. Each station transmits four common frequencies (10.2, 11.05, 11.33 and 13.6 kHz) at a nominal radiated power of 10 kilowatts. The 11.05 kHz frequency is not used in LTN-211/08 equipment.

103. Transmitted signals travel omni-directionally and are synchronised so that only one station is transmitting at a time on any one of the four common frequencies. Thus, at any one instant, only four of the eight stations are transmitting on the common frequencies, the remainder using a unique frequency to fill the quiet time, eg, Liberia 12.0, Hawaii 11.8 kHz etc. Each station has a different signal format to enable station identification and automatic self-synchronisation with the total transmission pattern by the receiving equipment.

104. The signals can be thought of as radiating from each ground station in circular wave fronts. Within each wavelength the phase of the signal undergoes an angular change of 360°. When synchronisation is complete, every common frequency signal received is at a certain phase relative to a reference signal generated by a receiver oscillator. As the aircraft flies towards or away from a ground station, the received signal from that station changes phase in proportion to the distance flown, eg, the 10.2 kHz signal goes through a 360° phase change approximately every 16NM. To resolve position ambiguity, various signals can be mixed, eg, a mixture of the 10.2 and 11.33 kHz signals produces a difference of 1.13 kHz which has a 360° phase change approximately every 144 NM.

Component Location

105. ARI 23314/1 comprises the following major components:

- a. An antenna coupler unit (ACU), fitted on the underside of the port wing adjacent to the

◀ wing tip (zone W2), is an H-plane, bi-directional loop antenna with integral amplifiers.

b. A receiver processor unit (RPU) is on shelf 6 of panel RL.

c. A control display unit (CDU-Fig 1C) is fitted at the navigator's panel R.

d. A true airspeed (TAS) system comprises a TAS computer on shelf 6 of panel RL and an outside air temperature (OAT) probe on the fuselage at station 54 (port).

Receiver Processor Unit

106. The RPU consists of several modules of which the Omega receiver and C-9000 computer/processor are the major components. The receiver module is a printed circuit card containing all the system functions associated with receipt and pre-processing of signals from the ACU, phase measurement using the local precision oscillator, and supply to the C-9000 computer in digital form for further processing. The receiver also uses computer-derived signals to control the antenna loop selection, calibration and self-test functions. The computer, the heart of which is a TMS-9900 microprocessor, is an integrated navigation sub-system containing the central processor and aircraft and CDU interface functions. The computer incorporates extensive built-in-test (BIT) facilities within itself and controls the built-in-test equipment (BITE) of the complete system.

Control Display Unit

107. *Mode Switch.* The mode switch has four settings:

- a. At OFF, all power supplies are disconnected.
- b. At A, automatic (system-initiated) sequential track leg changes are provided.
- c. At M, track leg changes are initiated when the adjacent TK CHG button is pressed.
- d. At R, remote ranging features are provided:
 - (1) Between waypoints.
 - (2) From present position.
 - (3) Along flight plan.

108. *Keyboard.* The keyboard includes 10 buttons labelled 0 to 9 used to insert data, all of which carry additional captions for use in reference to specific data entries. Three additional buttons with integral lights are used to complete the action initiated by pressing the numerical buttons:

- a. *CLR.* The CLR button, when pressed, clears all displayed data to prevent inaccurate data being

fed to the computer and to allow for a re-selection of numerical buttons.

b. *HLD.* The HLD button is a multi-function key which, when pressed, permits position check and update, display of action/malfunction codes and waypoint editing.

c. *ENT.* The ENT button, when pressed, transfers data entered via the numerical buttons into the computer.

109. *WPT Thumbwheel.* The WPT thumbwheel enables up to nine waypoints to be inserted via the keyboard, and allows the lat/long co-ordinates of inserted waypoints to be displayed when WPT is set at the display switch. It also enables various auxiliary functions to be monitored (**Table 4**) when AUX is set at the display switch.

110. *From/To Waypoint Display.* A 2-digit display shows the waypoint numbers between which the track leg is currently being flown; with the display switch at WPT, the setting of the WPT thumbwheel appears as the right-hand 'to' digit.

111. *DIM Control.* The DIM control varies the light intensity of the numerical and waypoint displays.

112. *Display Switch and Numerical Displays.* The 12-position display switch is used in conjunction with the numerical displays as detailed in **Table 3**.

113. Annunciators

a. The alert (ALR) light illuminates, provided that groundspeed exceeds 100 knots, when within two minutes of a selected 'to' waypoint.

(1) *'A' Mode.* The light goes out when a track leg change is made automatically.

(2) *'M' Mode.* The light flashes 30 seconds before reaching the waypoint and until a new track leg is manually inserted.

b. The dead reckoning (DR) light illuminates at switch on following insertion of present position co-ordinates and whenever the Omega/VLF operating mode is unavailable (system status 03), including periods when re-laning is in progress, remaining on until system status 01/02 is achieved or regained. The light remains extinguished during power transfer on the ground if system status 01/02 is attained within two minutes of power transfer.

c. The VLF light illuminates whenever the system is operating predominantly with signals from VLF communications transmitters ie, less than two Omega stations in use.

d. The ambiguity (AMB) light illuminates when-▶

Table 3 — Display Switch Settings and Displayed Data

Switch Setting	Parameter	Coverage		Examples		Remarks																																																						
		Left-hand Display	Right-hand Display	Left-hand Display	Right-hand Display																																																							
GMT/DAT	Greenwich Mean Time and Date	0000 to 2359Z	Month, day, year	2315	12 25 84	Automatically updated after initial manual insertions																																																						
TK/GS	Aircraft track and groundspeed	000-0 to 359-9°T	000 to 999 knots	040-0°	403	Normally both parameters are automatically updated; abnormally, in DR mode, groundspeed must be periodically updated																																																						
HDG/DA	Aircraft true heading and drift	000-0 to 359-9°T	000.0 to 089.9° left or right	050-0°	L010-0°	True heading derived from the No 1 compass system, computer-converted from magnetic to true. In DR mode, drift (like GS) must be manually updated																																																						
XTK/TKE	Cross-track distance and track angle error	000-0 to 999-9 NM left or right	000-0 to 180-0° left or right	L007-5	L 020-0°	Data not displayed until a track leg is initiated																																																						
POS	Present position	Latitude to 0-1' North or South	Longitude to 0-1' East or West	57° 39-3'N	03° 54-6'W	Geographic position is always displayed, even with a gyro heading input																																																						
WPT	Waypoint	Latitude to 0-1' North or South	Longitude to 0-1' East or West	57° 39-3'N	03° 54-6'W	The lat/long co-ordinates of the waypoint number set at the WPT thumbwheel where 0 is reserved for aircraft present position																																																						
DIS/TIME	Distance and time to next waypoint	0000 to 9999 NM	000-0 to 999-9 minutes	0140	016-7	If track leg or remote ranging inserted, time-to-go displayed assumes groundspeed of 480 knots if TAS less than 110 knots; in latter case ETA may be shown																																																						
WIND	Wind direction and speed	000 to 359°T	000 to 399 knots	155°	085	Only displayed when TAS exceeds 100 knots, computer-derived if not in DR mode, abnormally manually inserted																																																						
DTK/STS	Desired track and system status	000-0 to 359-9°T	Action or malfunction codes, and status codes	060-0°	1 01	Desired track readout is blank until track leg/remote ranging inserted. Action code number displayed if fault detected, replaced by malfunction code number on subsequent switching. Final right-hand digits display systems status code as follows:																																																						
				<table border="1"> <thead> <tr> <th>Action Code</th> <th>Malf Code</th> <th>Fault</th> <th>Code Action</th> <th>Malf Code</th> <th>Fault</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>01</td> <td>Check sum</td> <td>2</td> <td>11</td> <td>Loss of heading</td> </tr> <tr> <td>1</td> <td>02</td> <td>Arithmetic check</td> <td>2</td> <td>12</td> <td>Loss of TAS + hdg</td> </tr> <tr> <td>1</td> <td>03</td> <td>Analogue/digital conversion</td> <td>2</td> <td>13</td> <td>Power interrupt more than 7 secs</td> </tr> <tr> <td>1</td> <td>04</td> <td>Memory address</td> <td>2</td> <td>14</td> <td>No synchronisation after 3 minutes</td> </tr> <tr> <td>1</td> <td>05</td> <td>Data check</td> <td>2</td> <td>15</td> <td>Initial data incomplete</td> </tr> <tr> <td>1</td> <td>06</td> <td>Multiple inputs selected</td> <td>2</td> <td>15</td> <td>Initial data incomplete</td> </tr> <tr> <td>1</td> <td>07</td> <td>RF antenna</td> <td>2</td> <td>15</td> <td>Initial data incomplete</td> </tr> <tr> <td>2</td> <td>10</td> <td>Loss of TAS</td> <td>4</td> <td>30</td> <td>VLF self-test</td> </tr> </tbody> </table>	Action Code	Malf Code	Fault	Code Action	Malf Code	Fault	1	01	Check sum	2	11	Loss of heading	1	02	Arithmetic check	2	12	Loss of TAS + hdg	1	03	Analogue/digital conversion	2	13	Power interrupt more than 7 secs	1	04	Memory address	2	14	No synchronisation after 3 minutes	1	05	Data check	2	15	Initial data incomplete	1	06	Multiple inputs selected	2	15	Initial data incomplete	1	07	RF antenna	2	15	Initial data incomplete	2	10	Loss of TAS	4	30	VLF self-test		
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MH/TAS	Magnetic hdg and true airspeed	000-0 to 359-9°M	000 to 999 knots	060-0°	404	Heading as directly supplied by the No 1 compass system; TAS supplied by the TAS computer. Abnormally, both parameters manually inserted																																																						
STA	Station status (see Table 5 for precise station locations)	1, 2, 3 and 4 (or zero in lieu) flashing or steady	5, 6, 7 and 8 (or zero in lieu) flashing or steady	1204	5078	<table border="0"> <tr> <td>1 — Norway</td> <td>5 — La Reunion</td> <td>Digit steady = Presently being used</td> </tr> <tr> <td>2 — Liberia</td> <td>6 — Argentina</td> <td>Digit flash = Available, not used</td> </tr> <tr> <td>3 — Hawaii</td> <td>7 — Australia</td> <td>Zero steady = Auto de-select</td> </tr> <tr> <td>4 — N. Dakota</td> <td>8 — Japan</td> <td>Zero flash = Manual de-select</td> </tr> </table>	1 — Norway	5 — La Reunion	Digit steady = Presently being used	2 — Liberia	6 — Argentina	Digit flash = Available, not used	3 — Hawaii	7 — Australia	Zero steady = Auto de-select	4 — N. Dakota	8 — Japan	Zero flash = Manual de-select																																										
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AUX	Auxiliary functions	See Table 4	See Table 4			Various auxiliary functions are enabled depending on the setting of the 10-position WPT thumbwheel (see Table 4)																																																						

System Status Code	System Operation
90	Self-test
80	Below operating temperature
60	Synchronisation
30	Station selection
04	Grid navigation mode
03	Dead reckoning (DR) mode
02	VLF navigation mode
01	Normal operating mode

ever ambiguous positions are calculated. If ambiguity persists, re-laning can be initiated (DR light on); both AMB and DR lights extinguish when re-laning is complete.

e. The manual (MAN) light illuminates whilst a manual entry of TAS or heading is extant until these entries are reset to zero.

f. The warning (WRN) light illuminates when a fault is detected to prompt the operator to select DTK/STS at the display switch and complete fault analysis. A flashing WRN light occurs following

failure of sub-assembly self-test (action code 1 or 4) or when any fault appropriate to action code 2 is detected (see **Table 3**).

Power Supplies

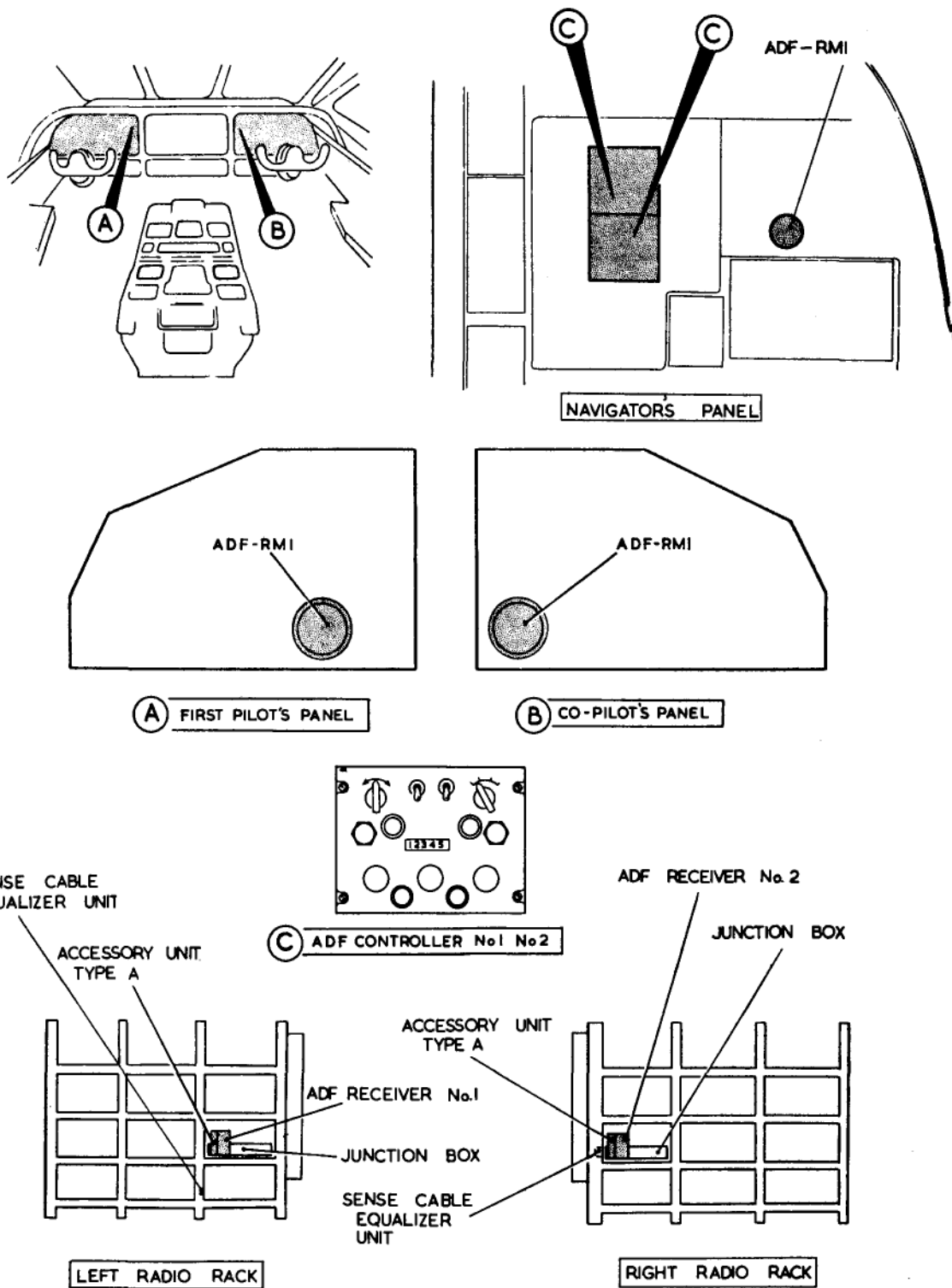
114. A 115V 400 Hz supply is fed via F30 to the TAS computer and via F28 to the RPU; these supplies can be isolated by the RADIO POWER SUPPLIES switch No 1 MAIN. 26V AC synchro reference fed to the RPU is controlled by the RADIO POWER SUPPLIES switch No 1 EMERG.

Table 4 — Auxiliary Functions

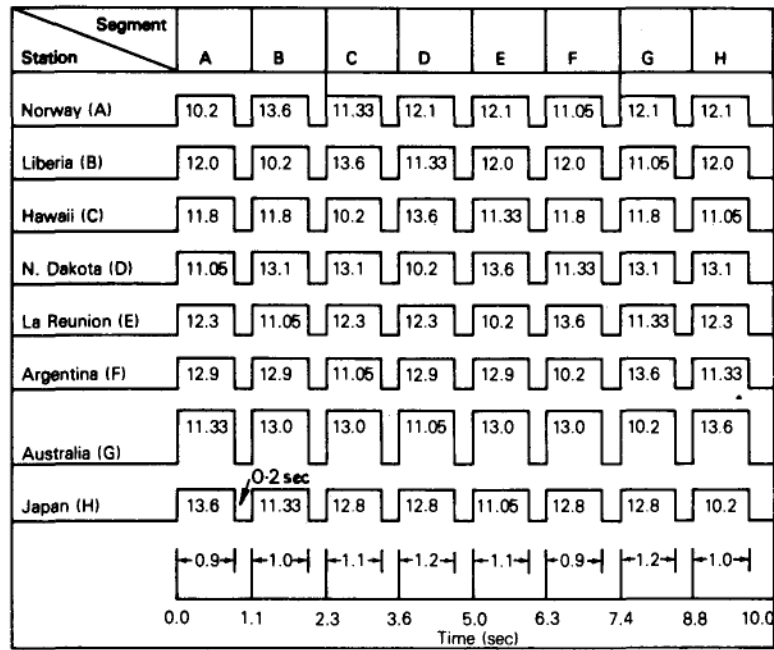
<i>WPT Setting</i>	<i>Function</i>	<i>Remarks</i>		
0	Re-laning			
1	Drift and groundspeed inputs			
2	Memory Display	For groundcrew use		
3	Frequencies being used for each station	<i>Displayed Digit</i>	<i>Frequency</i>	
			10·2	13·6
			11·33	
		0	—	—
		1	—	X
		2	—	X
		3	—	X
		4	X	—
		5	X	—
		6	X	X
		7	X	X
4	Test purposes only	For groundcrew use		
5	VLF station status	See Table 5		
6	Grid offset angle (GOA)	See para 100		
7 to 8	Spare	—		
9	Lamp test	—		

Table 5 — Omega and VLF Station Locations

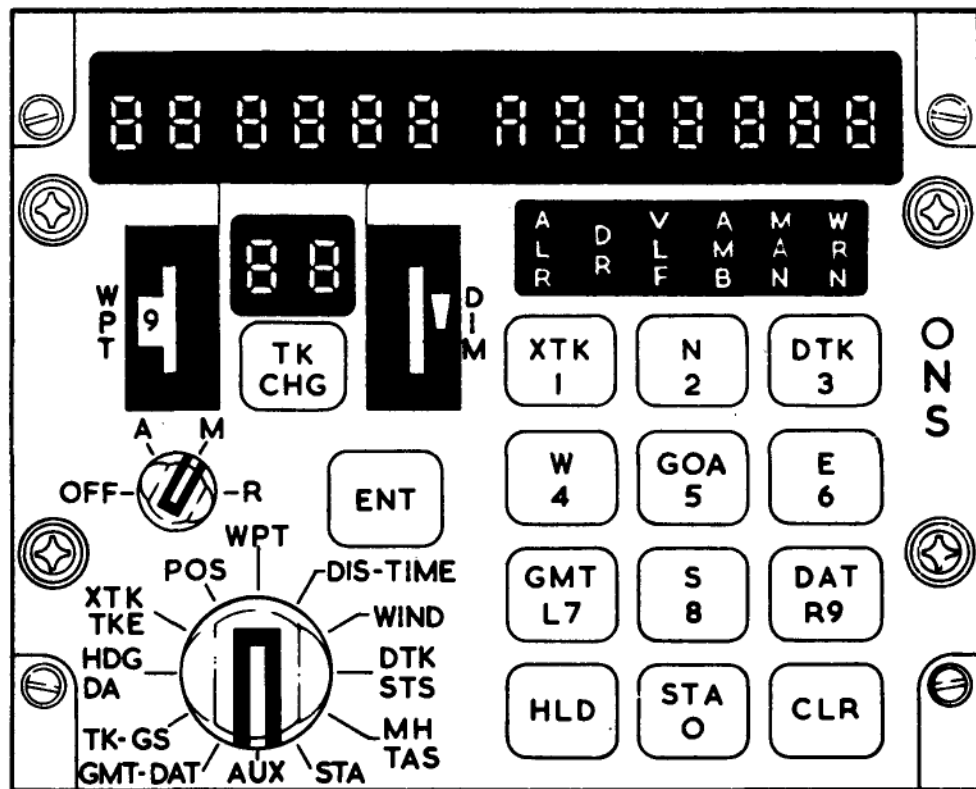
<i>Omega Stations</i>		<i>Station Code</i>	<i>VLF Stations</i>	
<i>Co-ordinates</i>	<i>Location</i>		<i>Location</i>	<i>Co-ordinates</i>
66° 25' 15.00" N 13° 09' 10.00" E	Norway	1	Helgeland, Norway	67° 04' 00" N 14° 04' 00" E
6° 18' 19.39" N 10° 39' 44.21" W	Liberia	2	Rugby, England	52° 22' 10" N 01° 11' 55" W
21° 24' 20.67" N 157° 49' 47.75" W	Hawaii	3	Lulualei, Hawaii	21° 25' 30" N 158° 09' 18" W
46° 21' 57.20" N 98° 20' 08.77" W	North Dakota	4	Jim Creek, Washington	48° 12' 12" N 121° 55' 00" W
20° 58' 26.47" S 55° 17' 24.25" E	La Reunion	5	Annapolis, Maryland	38° 59' 06" N 76° 27' 12" W
43° 13' 12.53" S 65° 11' 27.29" W	Argentina	6	Cutler, Maine	44° 30' 54" N 67° 16' 54" W
38° 29' 00.00" S 146° 56' 00.00" E	Australia	7	NW Cape, Australia	21° 49' 00" S 114° 09' 48" E
34° 36' 53.26" N 129° 27' 12.49" E	Japan	8	Yosami, Japan	34° 58' 15" N 137° 01' 19" E
<p>Note 1: Omega stations are automatically de-selected in the RPU when within 300 NM range.</p> <p>Note 2: Australia is not expected to begin transmission until mid 1981.</p>		9	Anthorne, England	54° 54' 54" N 03° 16' 24" W



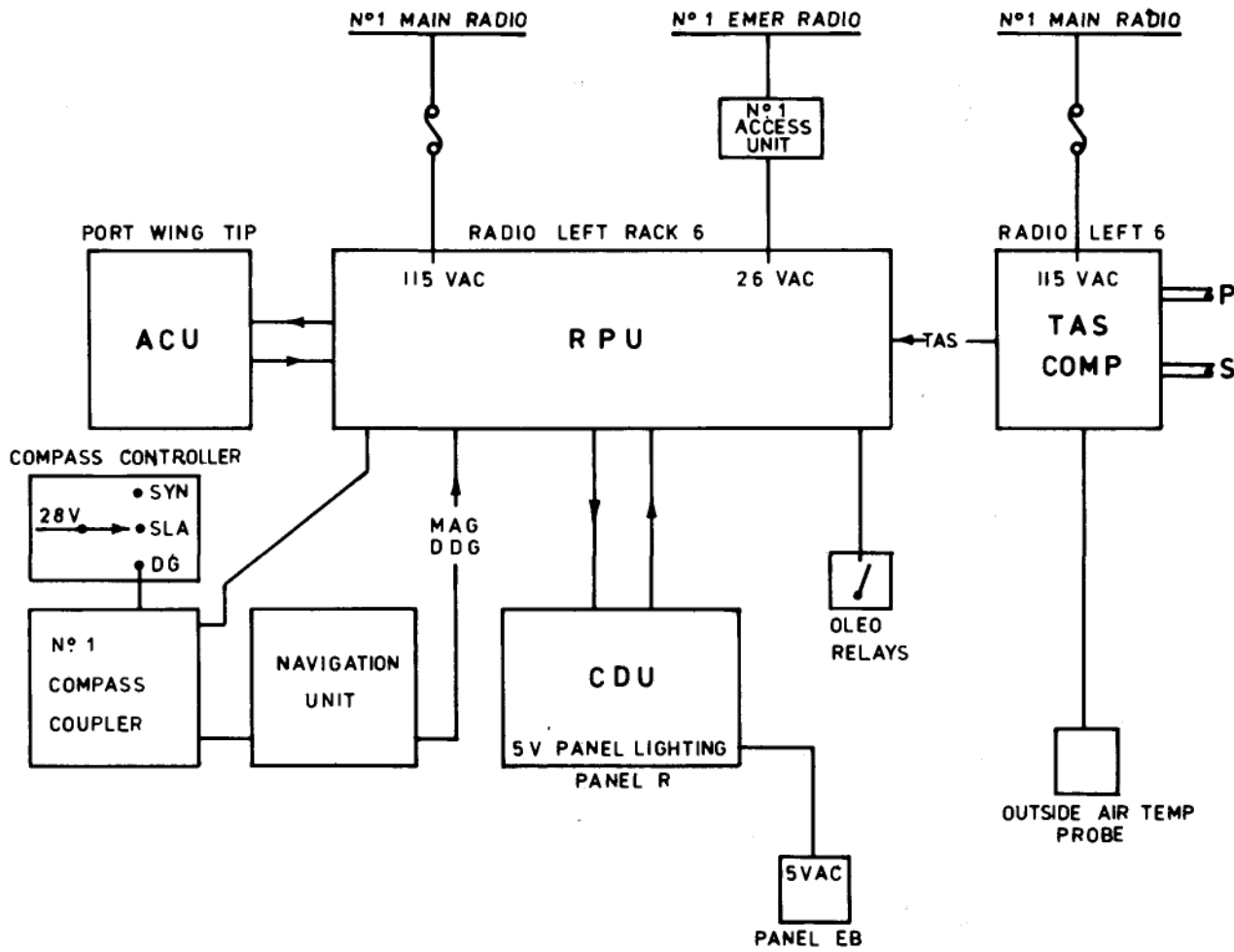
2 - 15 Fig 1A ADF Installation



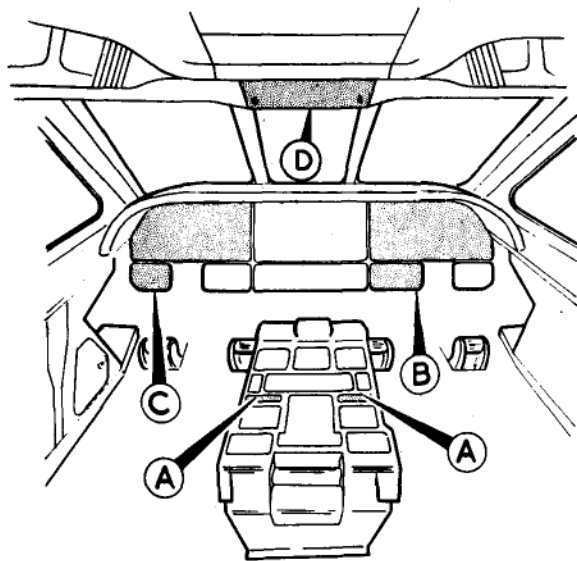
2 - 15 Fig 1B Omega Signal Transmission Format



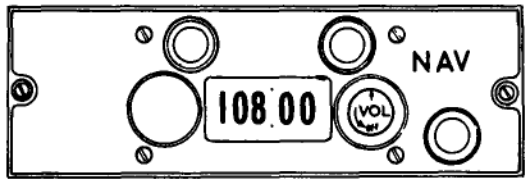
2 - 15 Fig 1C Omega Control Display Unit



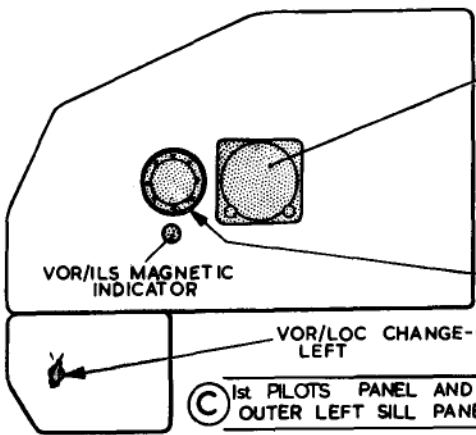
2-15 Fig 1D Omega Block Schematic



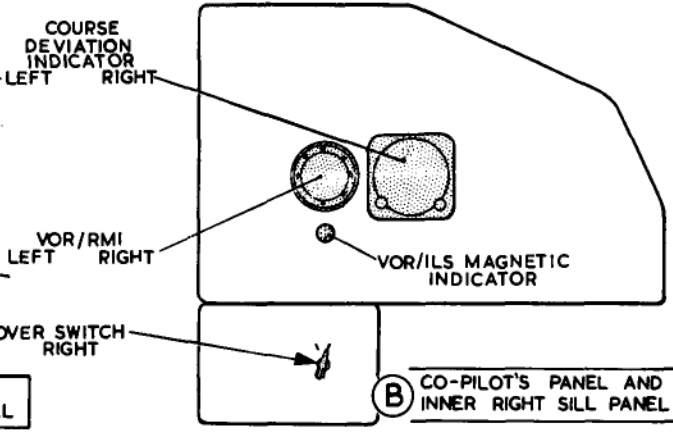
D PILOTS' AUXILIARY ROOF PANEL
No 1 No 2



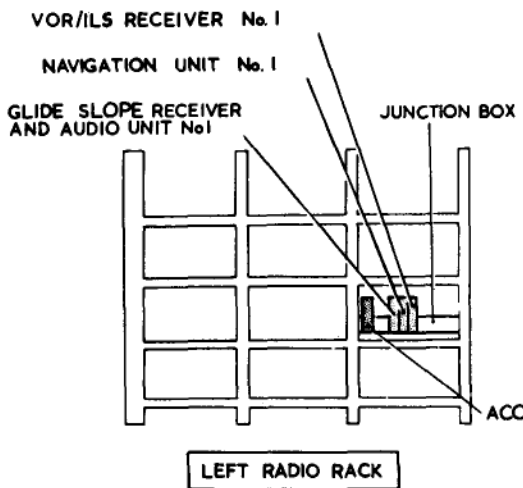
A VHF CONTROL PANEL
LEFT RIGHT



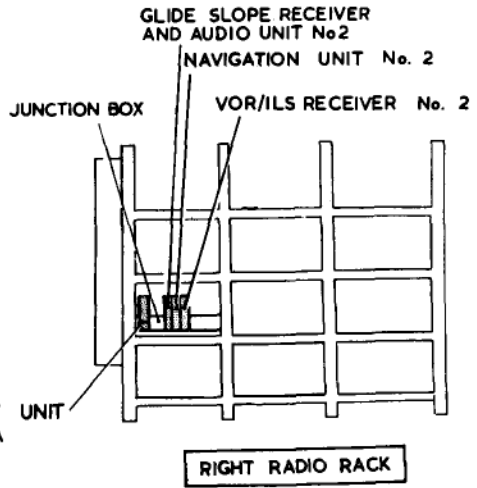
C 1st PILOTS PANEL AND
OUTER LEFT SILL PANEL



B CO-PILOT'S PANEL AND
INNER RIGHT SILL PANEL

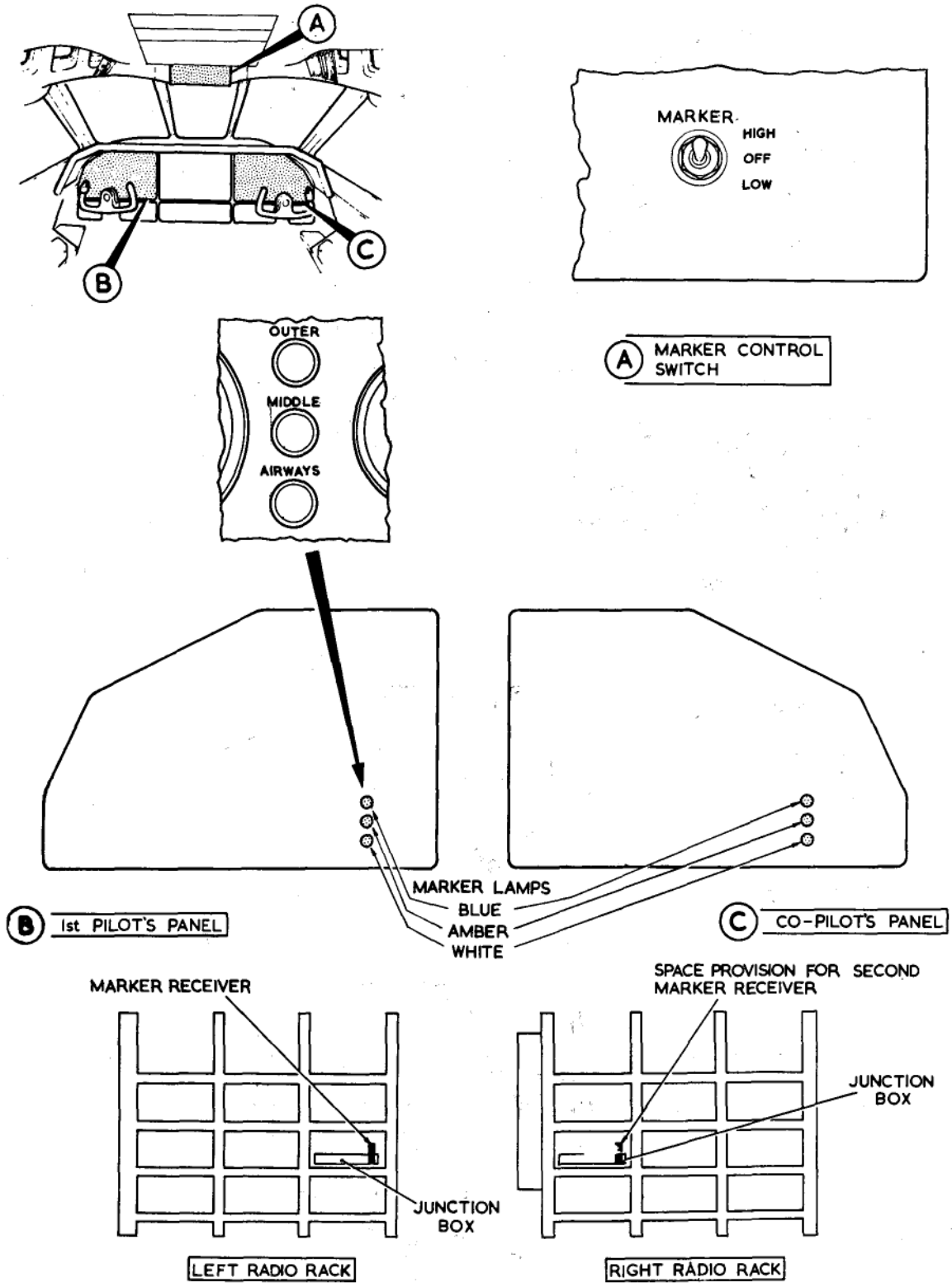


LEFT RADIO RACK

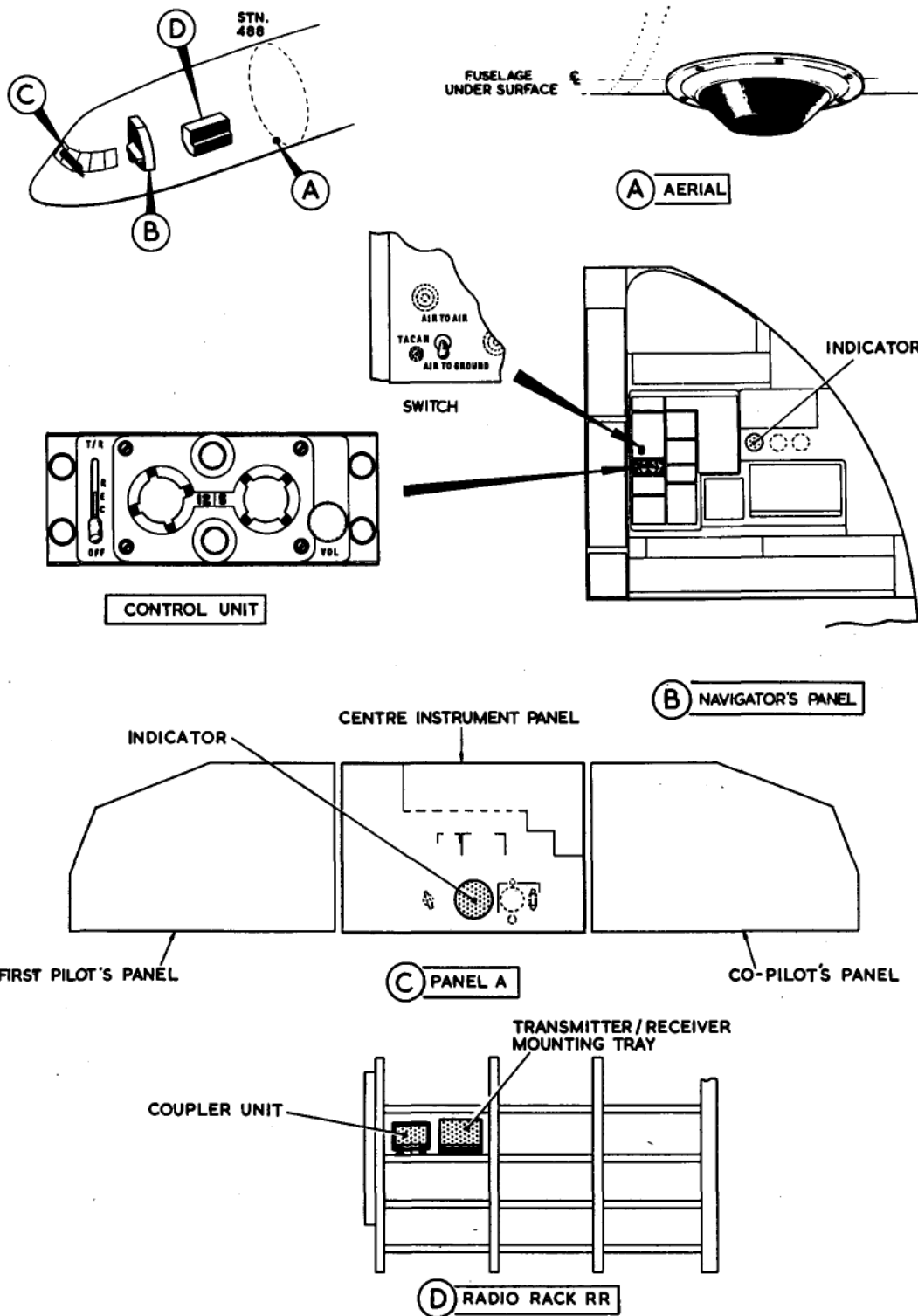


RIGHT RADIO RACK

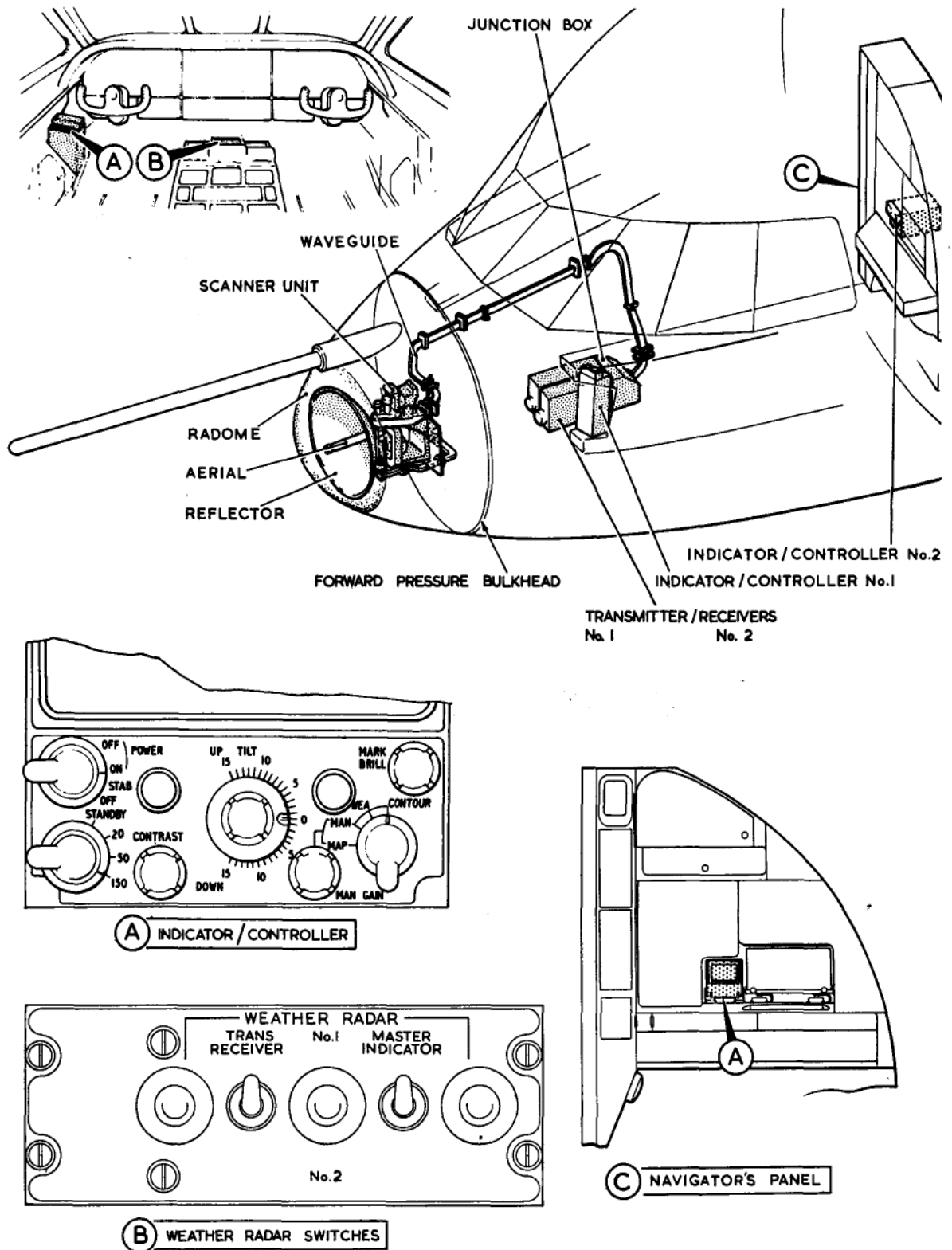
2.15 Fig. 3. VOR/ILS Installation



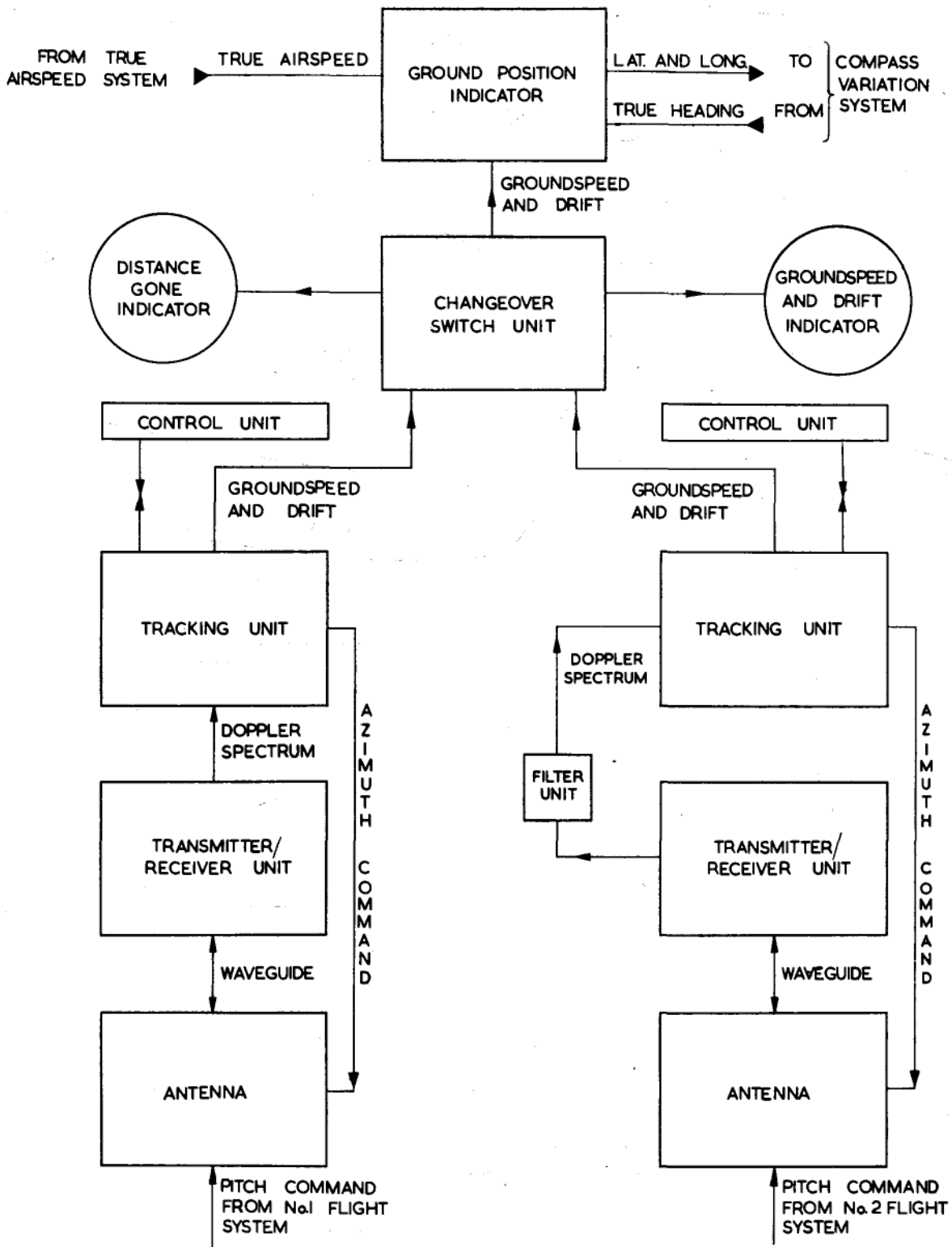
2.15 Fig. 4. Marker System



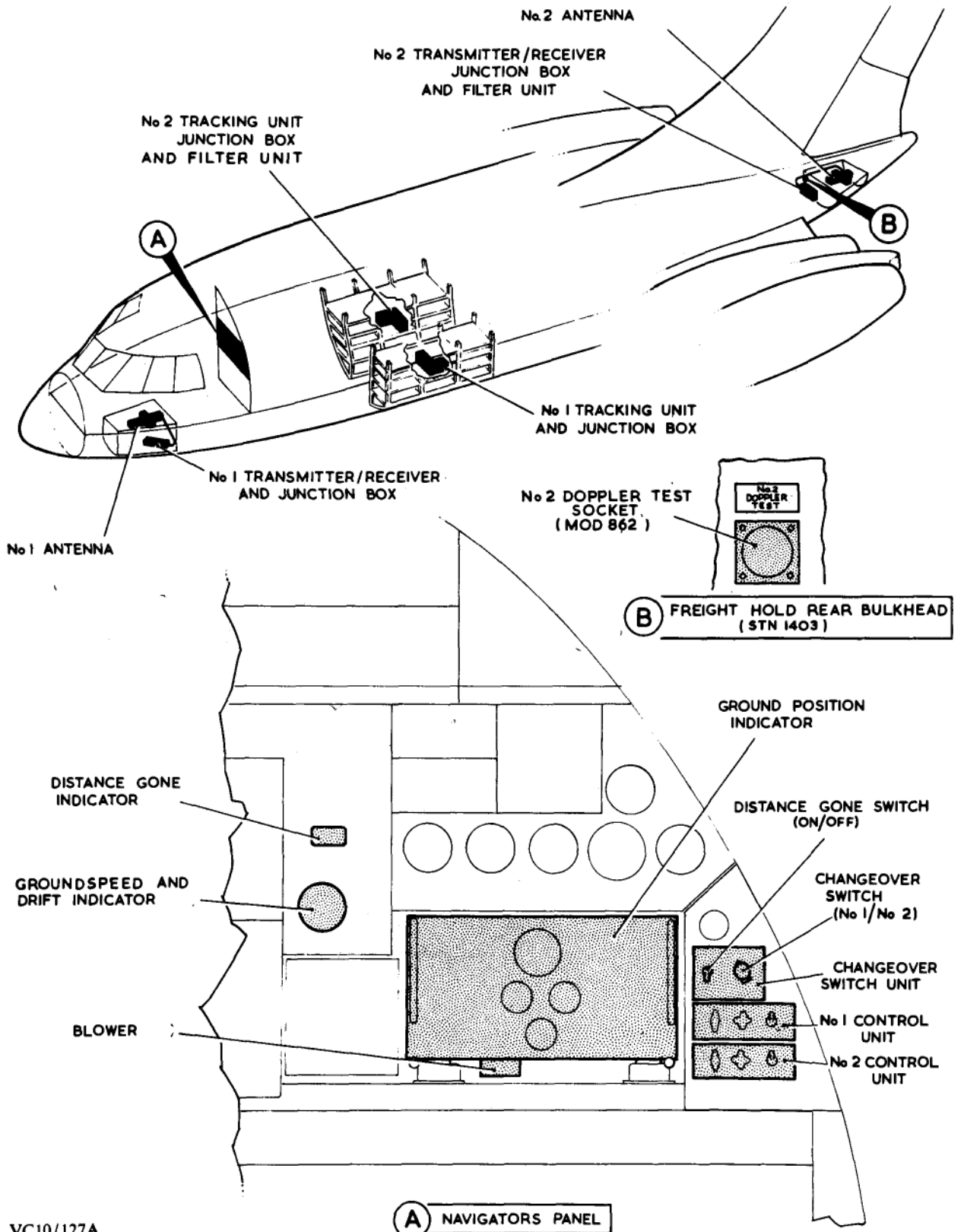
2.15 Fig. 5. Tacan Installation



2.15 Fig. 6. Weather Radar Installation



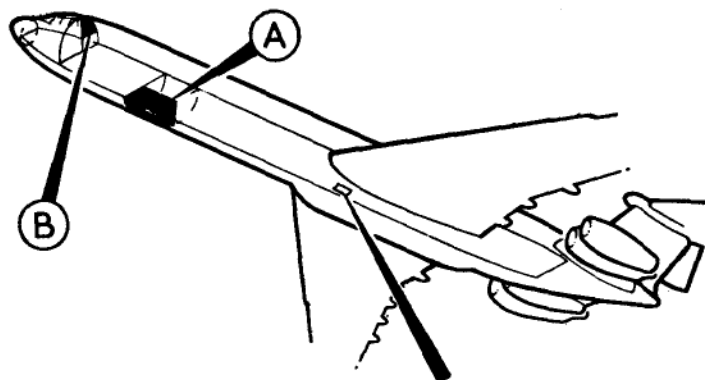
2.15 Fig. 7. Doppler Installation — Block Schematic



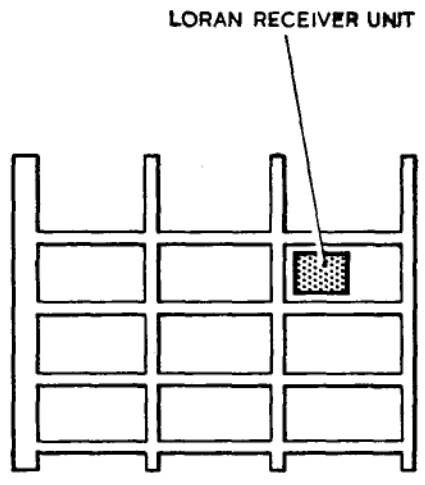
VC10/127A

2.15 Fig. 8. Doppler Installation

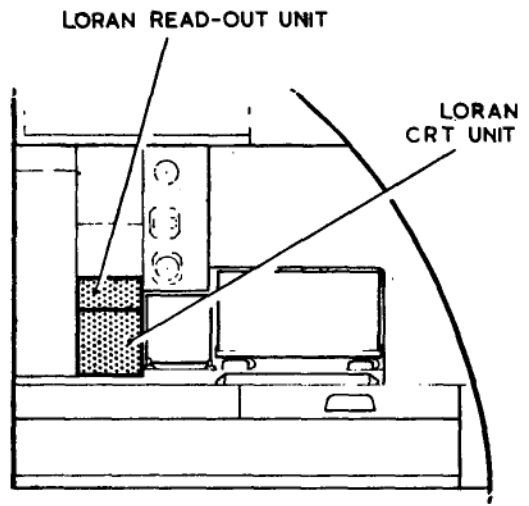
◀ Mod 862 Incorporated ▶



AERIAL AND AERIAL AMPLIFIER UNIT



(A) LEFT RADIO RACK



(B) NAVIGATOR'S PANEL

VC10/128A

2.15 Fig. 9. Loran Installation

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