PART 1

◀ SECTION 3 — AI23D ▶

CHAPTER 2 — MAJOR COMPONENTS OF THE AI

Contents

Introduction

1. The radar system comprises the following major components:

Main power unit
Gyro power unit
Transmitter and transmitter control unit
RF unit and automatic frequency controller
Receiver
Programme selector
Synchro (roll) resolvers
Gyroscope unit
Marker unit
Display selector and control unit
Indicator unit
Altitude and airspeed unit

2. Cross references are made to the scanner, ranging units and computer as appropriate, since these units have some effect on the operation of the major components.

Main Power Unit

3. This unit operates from the aircraft AC supplies and fulfils all the power requirements of the radar units, including that of the gyro power unit.

Gyro Power Unit

4. This power unit provides an exact output of 400 Hz in order to drive the motors of the scanner azimuth and elevation gyros at a constant speed.

Transmitter

5. The transmitter operates in the I-band range, 8500 MHz to 9000 MHz. The energy source is one of three types of magnetron, the type in use determining the actual frequency. The magnetron is fired (ie pulsed) for a duration of one microsecond 991 times a second when *normal* PRF is selected, or 744 times a second when *low* PRF is selected. The pulses of energy are fed to the I-band aerials for propagation (Chapter 3). The transmitter also provides:

a. A narrow-angle signal to the programme selector, for use during the acquisition phase to drive the scanner through ±5° in azimuth.

b. A noise-balancing pulse used by the ranging unit long (Chapter 4) for range-locking purposes.

c. A trigger pulse, synchronised to the firing of the magnetron and used for timing purposes in other components, eg range marker display and timebase sweep.

Transmitter Control Unit

WARNING: The transmitter must not be switched on unless an area enclosed by a ±50° arc extending 80 feet forward from the aircraft's nose is clear of personnel, buildings and other aircraft.

6. a. The AI requires 5 minutes plus 0·25 second to run up to its fully operational state. A motor-driven cam in the transmitter control unit controls the power switching of the transmitter according to a strict timing sequence. The sequence is as follows:

(1) Main on/off switch on. AC and DC power is connected to the control unit. The sequence starts and the azimuth and elevation scales on the B-scope light up.

(2) 4 minutes (heater time). The selected range scale lights up and full heating is applied to the magnetron.

(3) 4·5 minutes (HT time). The B-scope display appears and the main power unit is switched in.

(4) 5 minutes. The gyro power unit is switched in to supply the scanner gyros.

(5) 5 minutes +0·25 second. With the transmitter on/off switch in its on position, full power is applied to the transmitter and transmission begins. The fault counting circuit becomes effective (see para 6b below).

Note 1: A run-up is normally carried out with ground electrical power connected and switched on: ground air supplies are also necessary, and it is advisable to have the MRG erected to avoid the possibility of damage due to the scanner drifting hard against its roll limit stops.

Note 2: With ground power connected, the full sequence is possible only with the ground test switch on the hand control unit in its up position. The run up sequence stops at (or can be returned to if beyond) the 4 minute point if the ground test switch is set to its down position: this is the AI 'warm-up' condition. The ground test switch is effective only if aircraft power is off-line.

Note 3: The timing cam is spring-loaded to its zero time position to which it returns in the event of AC failure. It should be noted that if the aircraft power supplies are permitted to come off line after the removal of ground power (equivalent to power failure) the cam returns to zero and a further 5 minutes +0·25 second is required for the system to return to the fully operational state.

b. *Fault Counting Circuit.* In the event of certain faults occurring, full power is temporarily removed from the transmitter by this circuit. Power is usually restored after approximately 0·25 second but if the fault persists for 12 successive fault counts, full power is not restored. In this event the transmitter on/off switch should be operated in an attempt to clear the fault; if the fault still persists, no further action can be taken.

c. *Radar Unit Pressurisation Failure.* If a pressure failure occurs in the radar unit, a pressure switch operates to switch off the transmitter. This failure is indicated by a warning on the B-scope chassis; additionally, an AI PRESS — O RIDE/OFF switch, adjacent to the B-scope, when set to O RIDE, allows the pressure switch to be overridden and the AI transmitter to continue to function provided the transmitter switch is set to off and then on again. This procedure must be carried out only if operational necessity demands since damage may occur to the unit.

Radio Frequency (RF) Unit and Auto Frequency Controller (AFC)

7. The receiver operates at a frequency much lower than that of the I-band. The RF unit is used to convert the received I-band to the intermediate frequency (IF).

8. The RF unit comprises a local oscillator (LO) and a control unit that automatically adjusts the LO frequency to 30 MHz above the transmitter magnetron frequency. Received signals are mixed with the controlled oscillations to provide the receiver with signals having a resultant frequency of 30 MHz.

9. The automatic frequency controller (AFC) will maintain the LO frequency at 30 MHz. In the event of a fault the AFC will sweep the LO through its frequency range at a rate of 4 Hz producing intermittent operation of the receiver. The effect of the sweep on the B-scope is to give vertical breaks in the display with echoes and/or parts of the altitude line appearing between the breaks.

Receiver

10. The receiver is fed from the RF unit by three IF signals, viz:

a. The azimuth and elevation sum signals.

b. The azimuth difference signals.

c. The elevation difference signal.

11. The function of the receiver is to process the three signals to provide:

a. The B-scope with returns.

b. The ranging circuits with an ungated range echo (Chapter 4).

c. A DC signal for use in the track phase for automatic gain control, which has the effect of maintaining the brilliance of displayed echoes at a set level.

d. The scanner control circuit with azimuth and elevation error signals for use in track.

12. By means of an IF gating signal, from the ranging unit long, only those echoes from targets within a pre-determined range are processed. The range is selected automatically during track and by the pilots range control in search and acquisition. The effect of this signal discrimination is illustrated at Fig 1. The receiver reacts only to signals received from the target being ranged and not to signals from other sources in the same general direction as the target.

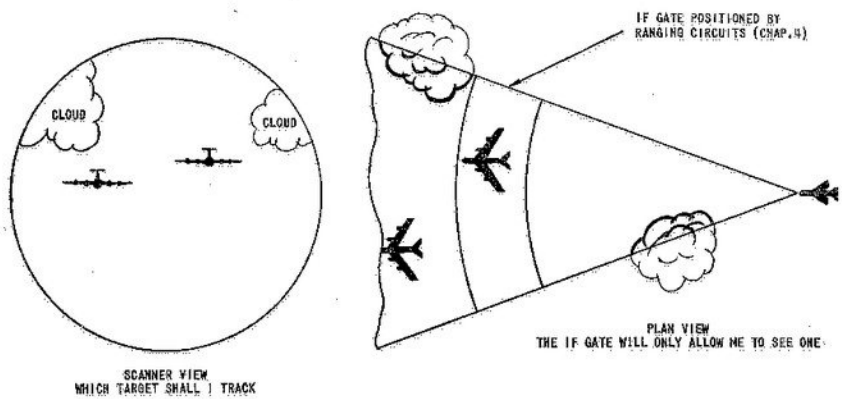
Programme Selector

13. The various operating mode of the AI are selected by the phase change trigger and the LFS/CRT switch, which together control the operation of a rotary (Ledex) switch. The Ledex switch has in effect five positions, one each for the three phases of an automatic attack, one for radar ranging and one for use during ground testing.

14. In an automatic attack the Ledex is controlled by the phase change trigger, which steps the Ledex round until the required position is reached. Each pressure on the switch selects one phase in the sequence search, acquisition and track. The Ledex steps round to the radar ranging position when the LFS/CRT switch is set to LFS. To return to normal operation after radar ranging, CRT must be selected at the LFS/CRT switch; the system then switches to the search phase.

Note: On the ground, the Ledex can be set to a servicing test position. If, in flight, the Ledex malfunctions and steps round to this position, the B-scope shows the track display but with no response from the range timebase or the tracking strobe. Confirmation of the malfunction can be obtained by moving the hand controller laterally and noting that the range timebase moves in sympathy. The phase change trigger should be operated to attempt to clear the malfunction.

15. The majority of the programme selector circuits are used for scanner control and are described



1—3—2 Fig 1 Purpose of the IF Gate

in Chapter 3 of this Section. Other signal voltages produced by this unit are modified, by outputs from the scanner and hand controller respectively, to position the timebase and acquisition circle on the B-scope.

Synchro (Roll) Resolvers

16. The azimuth and elevation misalignment signals received at the scanner are relative to space axes and it is necessary to convert these into pitch and yaw signals relative to the aircraft axes for steering display instructions. This is accomplished by two synchro resolvers which receive the misalignment signals from the scanner, via the computer red. Once resolved into pitch and yaw terms, the signals pass to the gyroscope unit for further modification before being displayed as steering instructions.

17. The output from one resolver, corrected for bank angle, is fed to the marker unit for pilots steering information and to the Firestreak pack as slaving signals. The output from the other resolver is fed direct to the Red Top pack for slaving purposes.

Gyroscope Unit

18. This unit is in the main equipment compartment with its spin axis in line with the aircraft fore and aft axis. The function of the unit is to position the steering dot on the B-scope so that the requisite deflection is displayed, appropriate to the magnitude of the misalignment signals and the rate of turn of the fighter. The unit also passes these resolved signals to the Firestreak missiles for missile slaving purposes.

Marker Unit

19. The marker unit is in the main equipment compartment. Its function is to generate markers on the B-scope at the requisite times for display during the phases of an attack. Each marker output from the unit is a composite signal, which determines the shape of the marker to be displayed and contains the vector components to position the marker on the display.

20. Outputs from the marker unit are fed to the display selector which passes them to the B-scope in a repetitive sequence. The markers displayed in various conditions are tabulated below and are designated 1 to 5.

Table 1 — Markers in Search and Acquisition Phases

Marker No	*Deployment*	*Controlling Inputs*
1	Attitude indicator	Roll and pitch signals from the MRG
2	Scanner elevation angle indicator	Elevation pick-off signal from the scanner, MRG pitch signal and 2° constant signal
3	Acquisition marker	Azimuth marker voltage from the hand control unit via the programme selector. Range voltage from the hand control unit via the ranging unit long
	or	
	Homer marker	Azimuth position signal from the heading selector on the navigation display. Fixed range signal to give marker length during ALIGN and PROP NAV stages of E/F-band homing
4	Breakaway 1 (Normal operation)	Signal from computer red
5	Breakaway 2 (Normal operation) Time circle (New facility only)	Signal from computer red A circle of approximately 2 inches diameter (without a gap)
	or	
	Vis-ident range circle/thermometer (New facility only)	When vis-ident and 10 NM scale are selected, the vis-ident scale will indicate the range of the acquisition circle

Note: The breakaway marker is formed by two separate outputs, one for each diagonal, which are referred to as Breakaway 1 and Breakaway 2.

Table 2 — Markers in Track Phase

Marker No	*Deployment*	*Controlling Inputs*
1	Attitude indicator	Roll and pitch signals from the MRG
2	Scanner elevation angle indicator	Elevation pick-off signal from the scanner, MRG pitch signal and 2° constant signal
3	Acquisition circle	Azimuth marker voltage from the scanner wide angle pick-off via the programme selector. Range voltage from the ranging unit long
4	Steering dot	Yaw and pitch steering signals from the computer red via the gyroscope unit
	or	
	Breakaway 1	Replaces the steering dot when the breakaway signal is given; controlled by the computer red: a. At the inner range limit with Firestreak b. At a computed time with Red Top. c. By the Red Top pack on PAIRS if one of the pair has fired/misfired and the second missile is obscured
5	Time circle	Time circle diameter with gap representing range rate or angle between courses signals from the computer red. This circle is approximately 50 mm in diameter and is positioned in the centre of the B-scope. In a missile attack there are two distinct reductions in the circle size. The first reduction indicates: a. Range Outer with Firestreak b. Automatic firing in 2 seconds (Launch Warning with Red Top) The second reduction indicates: a. Last chance to fire with Firestreak b. The moment of automatic firing (Fire Signal) with Red Top
	or	
	Vis-ident range circle/thermometer	In the vis-ident mode, at ranges above 900 yards the time circle is removed and replaced by the range thermometer which varies in length with range, between 5000 yards and 900 yards. At ranges less than 900 yards the time circle reappears ▶◀ and the circle becomes the range circle, reducing in diameter as the range closes.
	or	
	Breakaway 2	Replaces the time circle when the breakaway signal is given as in Breakaway 1. Not displayed in the vis-ident mode

Note: The computer red produces the breakaway 1 and 2 signals at the appropriate time and the markers are displayed whether the weapons have been fired or not.

21. *Radar Ranging (LFS).* In this mode the markers displayed are as for the track phase, with the exception that the steering dot ▶◀ does not appear.

▶◀

Display Selector and Control Unit

22. The functions of both units are initiated (sequenced) by a timing trigger from the transmitter (see para 5).

23. The display selector fulfils the following requirements:

a. The generation of a range timebase of a length appropriate for the range scale selected.

b. A range timebase voltage for the ranging unit long, for range gate timing (see Chapter 4, this Section).

c. To sweep the range timebase on the B-scope in azimuth.

▶◀

d. To produce the scanner elevation angle marker on the B-scope.

24. The display selector control unit allows only one particular marker to be displayed on the B-scope at any one time. Five counting gates, 1 to 5, effecting the display of markers 1 to 5 respectively are arranged so that when one gate is open the other four are closed. On the occurrence of the timing signal the gate previously open is then closed and the next gate in the sequence is opened; the sequence continuing for successive timing signals.

Indicator Unit

25. The information displayed on the B-scope by this unit is discussed in Chapter 1 of this Section. Only one output is provided by the unit, via the COMPUTER switch. Switch positions numbered 1 to 6 represent various target speeds for computer red calculations in normal and kinematic ranging conditions. The speeds represented by the various switch positions are:

Position	*Programme*	*Target Speed*
1	Firestreak	0·7M
2	Red Top — slow	0·9M
3	Red Top — medium	1·1M
4	Red Top	1·35M
5	Red Top — fast	1·6M
6	Red Top	1·9M

Altitude and Airspeed Unit

26. This unit has two functions:

a. To provide the computer red with altitude information for firing bracket computations and prediction time switching.

b. Altitude information is also used in computer red to provide switching for high and low Radar Ranging GW modes.

c. To provide the external computer with altitude and airspeed information for aircraft incidence computations. (Not used in AI23D).