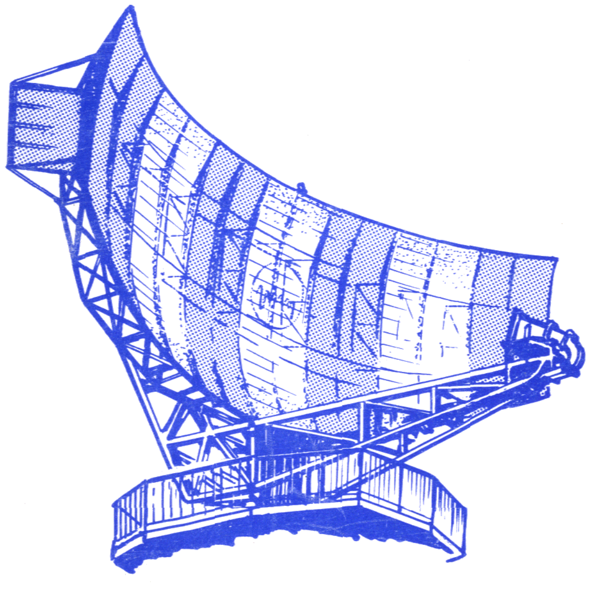
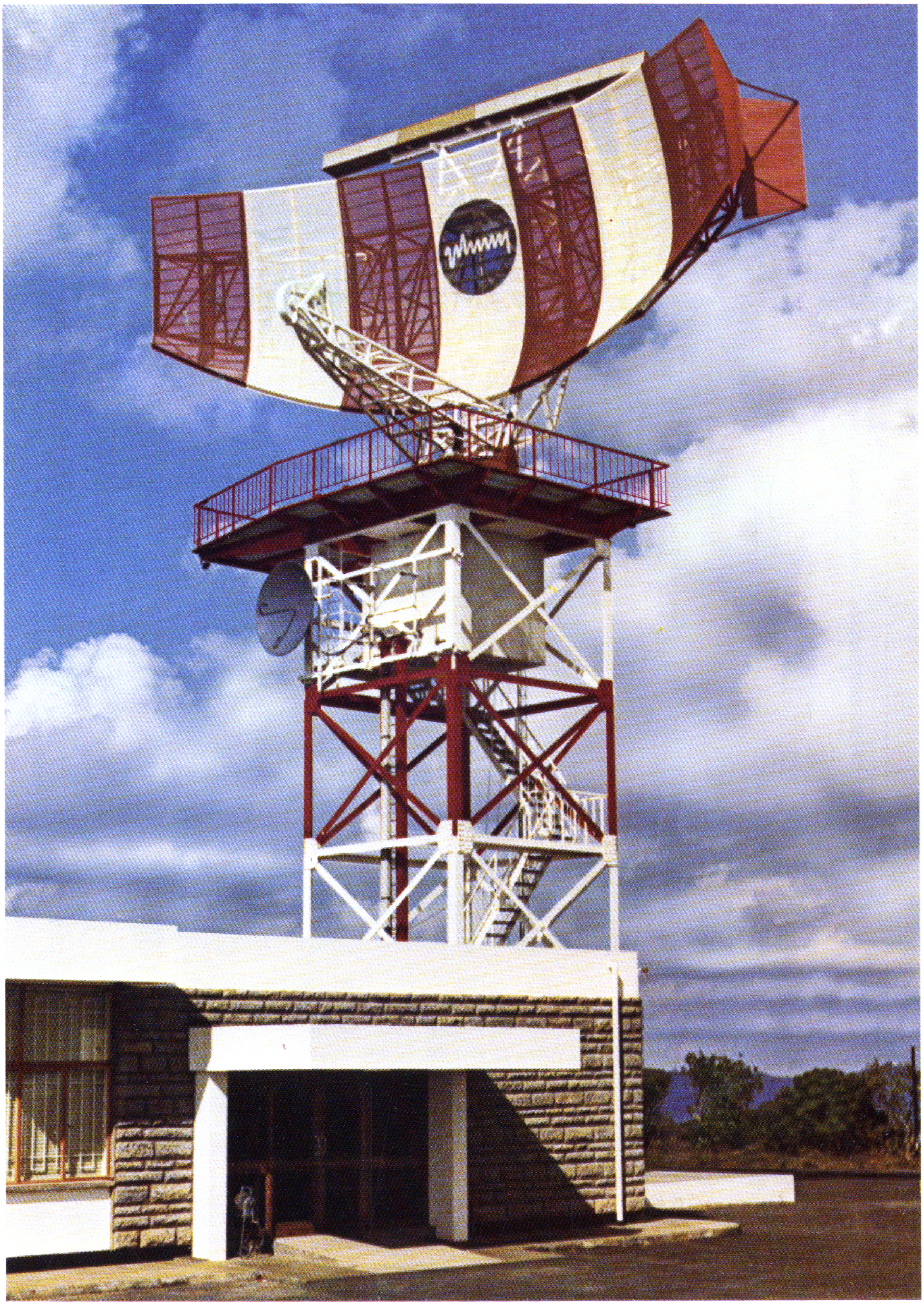
# THE PLESSEY AR5

# AIR SURVEILLANCE RADAR



**PLESSEY**
ELECTRONICS GROUP

**PLESSEY RADAR LIMITED**
**ADDLESTONE WEYBRIDGE SURREY**



PLESSEY RADAR TYPE AR 5
Long range air surveillance

# PLESSEY RADAR

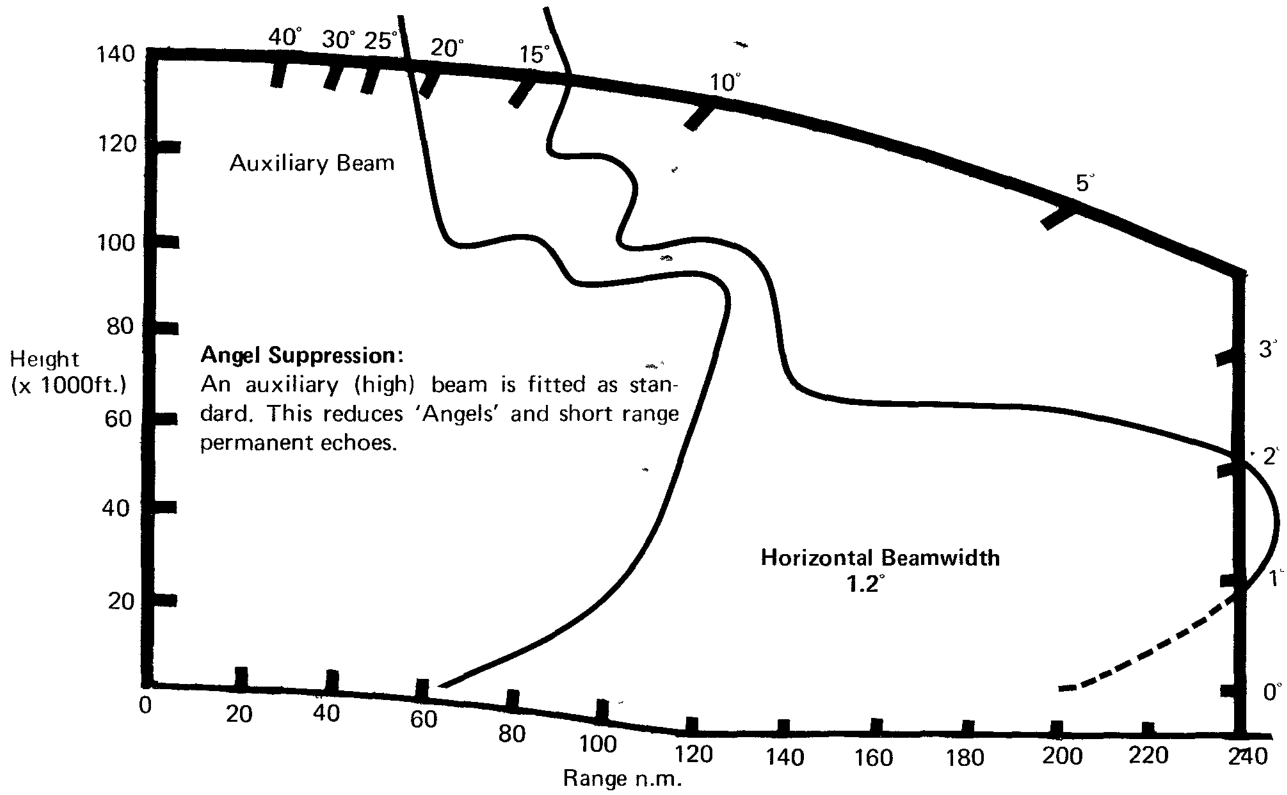
# Plessey Radar Type AR 5

The Type AR 5 is a long-range primary radar used in Air Traffic Control systems for surveillance of en-route and terminal area traffic.

**Frequency:** 'L' band (1250-1365 MHz)
**Maximum range:** 250 nautical miles

**Rain Suppression:** The polarisation is variable by remote control from linear through elliptical to circular.

**Ground Clutter Suppression:** The radar includes a digital moving target indicator (d.m.t.i.) with phase and quadrature detection to reduce phase blindness; staggered p.r.f. and velocity feed-back to reduce blind speeds; video integration and background averaging to remove residual clutter.




The AR 5 may be integrated with on-mounted or remotely sited secondary surveillance radar.

Both primary and secondary radar information may be relayed to one or more remotely sited Air Traffic Control Centres, either by means of plot extractors and narrow-band links or by broad-band (microwave) links.

Plessey Radar can supply all the above items and will be pleased to submit proposals for single equipments or for the design, supply and installation of a complete Air Traffic Control radar and data handling system.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The description and specification contained in this brochure are current at time of publication, but may be subject to variation as a result of later improvements in design or technique. Equipment supplied will be in accordance with the Company's specifications current at the time of manufacture or as otherwise agreed in writing.

# THE PLESSEY AR5

AERIAL ASSEMBLY

## INTRODUCTION

The Plessey 23cm AR-5 Air Surveillance Radar has been designed for world-wide use in modern Air Traffic Control Systems and provides the solid long range, high and low altitude cover needed for en-route, upper air space, and area and airways operations. The AR-5 complies with the ICAO recommendations for radars serving these categories of traffic, and is designed to handle both current and planned aircraft, including super-sonic transport aircraft, from take-off to a range of 200 nautical miles.

## THE AR-5 RADAR OFFERS

**Flexibility** - The AR-5 aerial rotation rate, pulse recurrence frequency and pulse length can be selected from the wide range offered, in order to meet a specific operational requirement.

**Reliability** - The AR-5 is available as a basic system with two stages of non-redundant growth which offer enhanced fail-safe facilities. Extensive use of solid state components and integrated circuits achieves a low failure rate and permits fast repair times.

## STANDARD FEATURES INCLUDE

**A two-feed aerial system** to suppress 'angels' and improve target-to-clutter ratio.

**A digital m.t.i. system** which permits operation over a wide p. r. f. range and which has special video background averaging circuits.

**Video integration** for improved signal levels and for rejection of asynchronous returns.

**Variable polarisation** to reduce precipitation clutter.

**Multi-characteristic receiver** to optimise operations in the radar conditions prevailing.

**Built in performance monitoring** with programmed sequential run-up and fault memory circuits.

## THE PLESSEY AR-5

has been chosen by the British Government for use in its National Air Traffic Control Service.

The Plessey AR-5 meets a wide range of operational requirements and is suitable for integration with:-

**Secondary surveillance radars**

**Computer controlled data handling systems**

**Automatic plot extraction systems**

# SECTION 1

## SYSTEM DESCRIPTION

# CHAPTER 1

## SYSTEM DESCRIPTION



### INTRODUCTION

1. The Plessey AR-5 23cm air surveillance primary radar is designed to meet both present and anticipated future requirements for surveillance of all types of aircraft including supersonic aircraft and aircraft with small reflecting areas.

2. Careful study of the criteria which influence the performance of primary radars in respect of optium coverage, operational utilisation and reliability in the most adverse conditions, led to the choice of the parameters incorporated in the design of the AR-5.

3. Amongst the many factors considered were those quoted at an I. C. A. O. Comm. Session:-

(a) Beamwidth which, in a long range radar, is required to be reasonably narrow.

(b) Coverage which should exclude the effects of nulls in the vertical pattern.

(c) Freedom from precipitation response.

### OPERATIONAL FEATURES

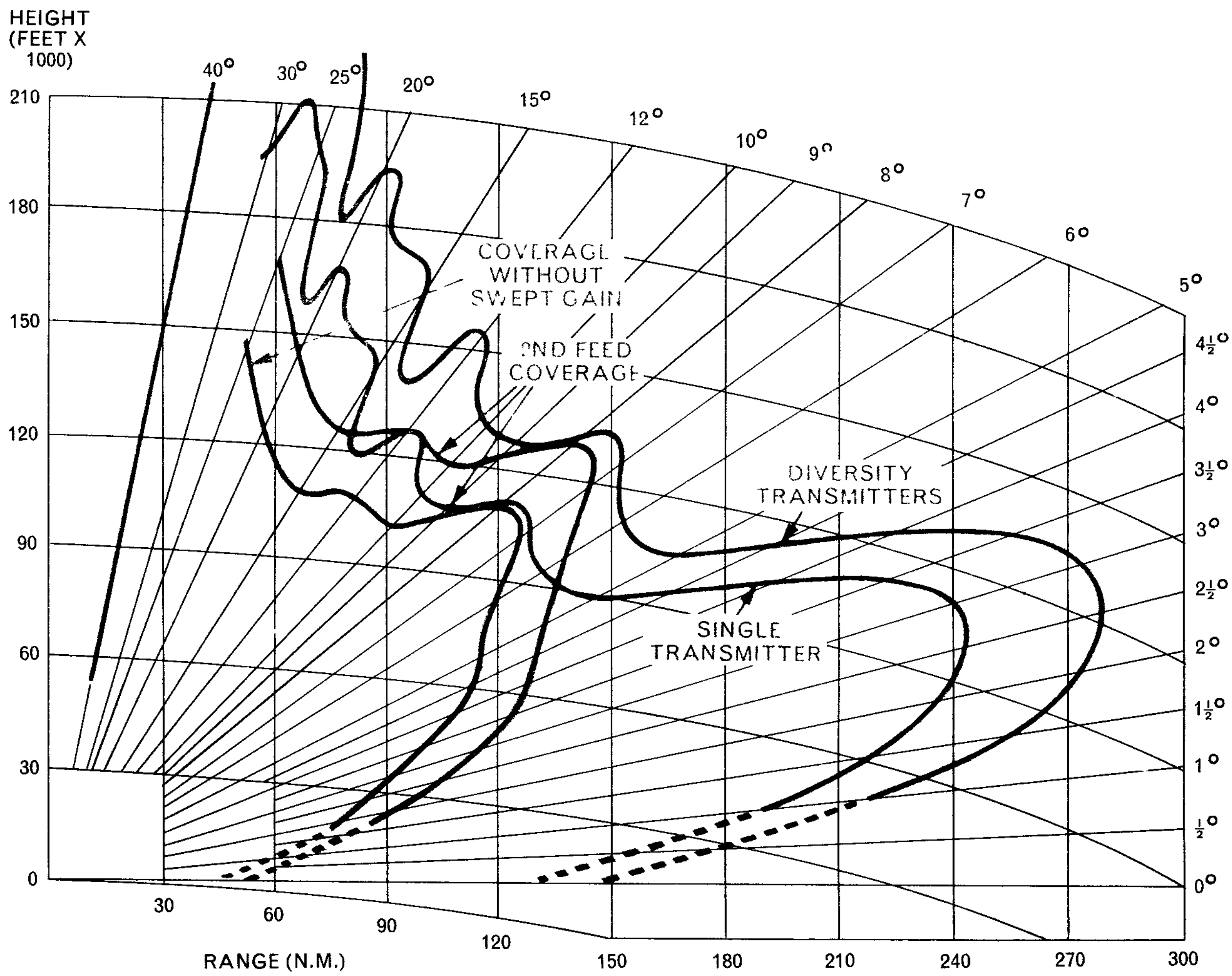
#### Beamwidth

4. The operational beamwidth of a radar is dictated by the need to separate aircraft flying in an airway at the maximum range of the radar. The AR-5, with an aerial beamwidth of $1.2^{o}$, has an azimuth resolution of better than $1^{o}$ which permits lateral target separation of 4 n.m. at 200n. m. with proportional improvement at shorter ranges. This completely satisfies the I. C. A. O. recommendation.

#### Coverage

5. The AR-5 vertical coverage, shown in Figure 1. 1, is typical of

that provided on a small to medium size commercial jet aircraft. The long range high and low level coverage is more than sufficient to fulfil the requirements for surveillance of all types of aircraft.




| | | | | | |
|---|---|---|---|---|---|
| AERIAL GAIN: | 36dB | ROTATION RATE: | 8rev/min | TARGET SIZE: | $8m^2$ |
| PEAK POWER: | 2.0MW | NOISE FACTOR: | 3.5dB | DETECTION PROBABILITY: | 80% |
| PULSE LENGTH: | 3.9μs | RECEIVER TYPE: | Linear | | |
| P.R.F.: | 350p.p.s. | POLARISATION: | Linear | | |

FIGURE 1.1 TYPICAL AR-5 COVERAGE DIAGRAM

6. Excellent close-in coverage is provided, and subject to local siting limitations, it is possible to track aircraft to within 1n.m. of the aerial head. This performance permits the identification of aircraft in accordance with the surveillance radar procedures stated in I.C.A.O. Document 4444 - RAC/501.

Weather clutter suppression

7. Polarisation,variable from linear through elliptical to circular is provided with the AR-5 system and is adjusted by remote control from the operator's position. Thus the optium polarisation for any precipitation can be rapidly obtained; when necessary the polarisation can be changed within a few seconds without the need to switch off the transmitter(s). The integrated cancellation ratio for this system is over 20dB.

8. In addition to variable polarisation, the AR-5 system has a background averaging circuit (digital constant false alarm) in the video output stages of the digital m. t. i. rack, and a logarithmic plus differentiation (f. t. c. ) facility in the normal receiver. These characteristics can be selected as required to suit the prevailing conditions.

9. With the m. t. i. background averaging circuit in use there is no reduction in target-to-noise ratio in areas where there is no residual weather clutter. In areas where residual clutter is present, the video gain is reduced to give a sensibly constant false alarm rate and consequently the signal level to be displayed will depend on the target-to-clutter ratio rather than the normal target-to-noise ratio.

10. With the logarithmic/differentiation facility in use there is a small overall system loss even when no clutter is present. In clutter conditions, the log/diff receiver has an effective constant false alarm rate therefore the signal depends on the target-to-clutter ratio.

Permanent echo suppression

11. Permanent echoes are suppressed by use of a double (cascade) loop digital m. t. i. system which uses solid state logic. The use of solid state logic significantly improves reliability and has reduced the number of setting-up controls. The digital m. t. i. embodies a video integrator, which operates during the beam dwell time, and is available for either m. t. i. or uncancelled video or both.

'Angel' suppression

12. 'Angels' are suppressed by using an aerial system with two feeds. One feed is used in the conventional manner (for transmitting and receiving) to provide the main coverage pattern. The second feed, used for reception only, provides a short range coverage pattern. Electronic range gating, at a range set to suit the operational requirement and site conditions, results in the provision of an optimised coverage pattern derived from the two feeds.

Addition of s. s. r. equipment

13. A secondary surveillance radar aerial can readily be fitted to the AR-5 aerial. The appropriate rotating joint and timing units are provided. Additionally, rotational synchronisation for an off-mounted s. s. r. aerial can be provided.

SYSTEM CONFIGURATION

14. The major units of the AR-5 radar can be arranged in various system configurations to suit the particular requirements of the customer.

Basic system

15. The basic single transmitter/receiver equipment is shown in Figure 1.2. Two stages of growth from the basic system are available.

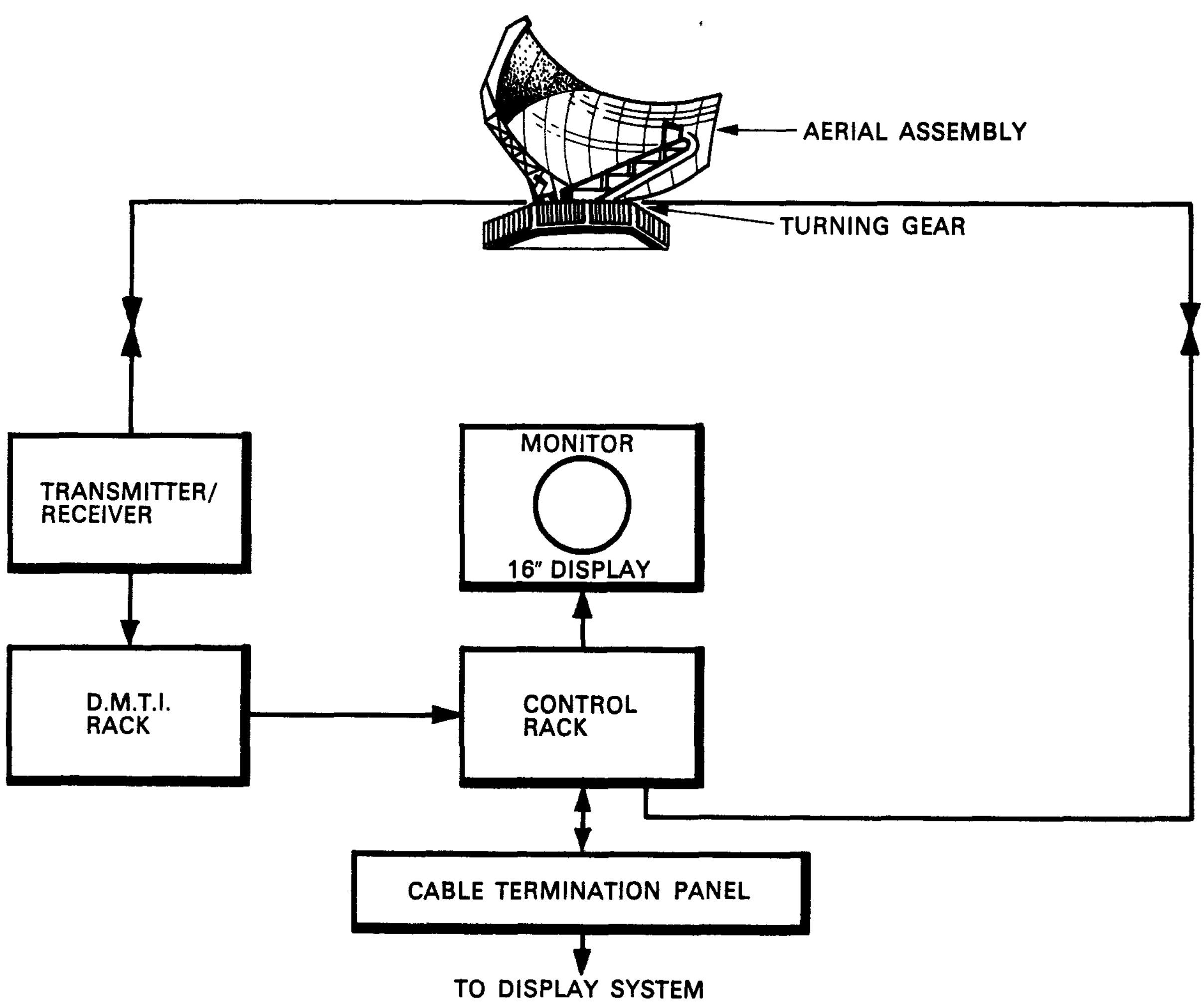



FIGURE 1.2 BASIC AR-5 RADAR SYSTEM

First stage

16. Figure 1.3. depicts the first stage of growth giving additional reliability and increased radar coverage, and shows a second transmitter/ receiver, which may be used simultaneously with the first transmitter/ receiver in frequency diversity or separately as a standby.

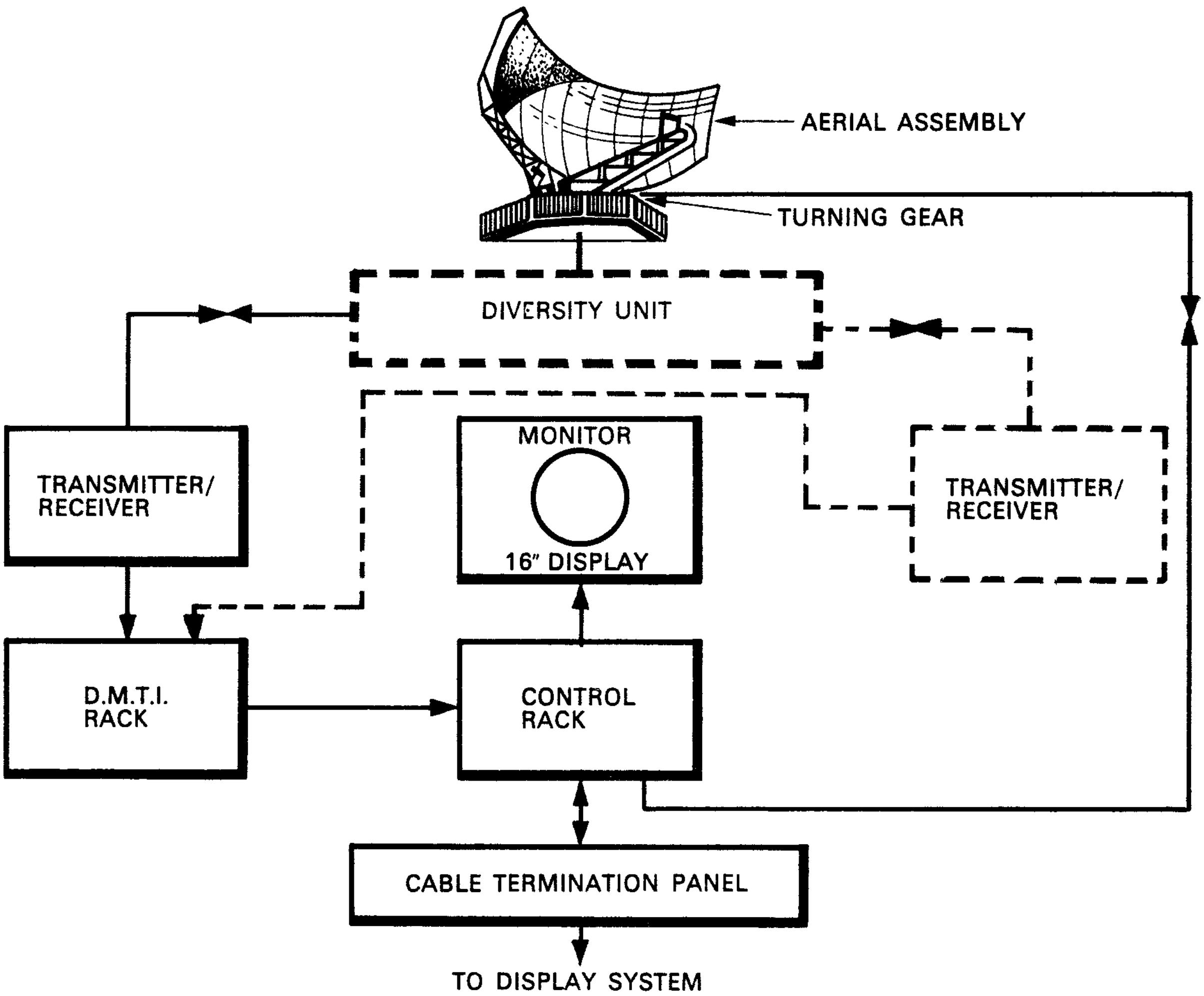



FIGURE 1.3 AR-5 RADAR SYSTEM - STAGE 1 GROWTH

Second stage

17. The second stage of growth, shown at Figure 1.4 is the addition of a digital m.t.i. (d.m.t.i.) rack for use with the dual transmitter/receiver system. In this configuration each transmitter/receiver is associated with its own d.m.t.i. rack, but for even greater reliability, the d.m.t.i. racks may be switched between the transmitter/receivers.

18. Any one of the three configurations may be chosen for the initial installation. Should the basic system be chosen, addition of a second transmitter/receiver and /or second d.m.t.i. may be made retrospectively with the minimum disturbance to the original equipment.

SYSTEM PARAMETERS

19. In addition to the alternative configurations, a number of the parameters of the AR-5 radar may be chosen to optimise the system to meet a particular operational requirement. These are:-

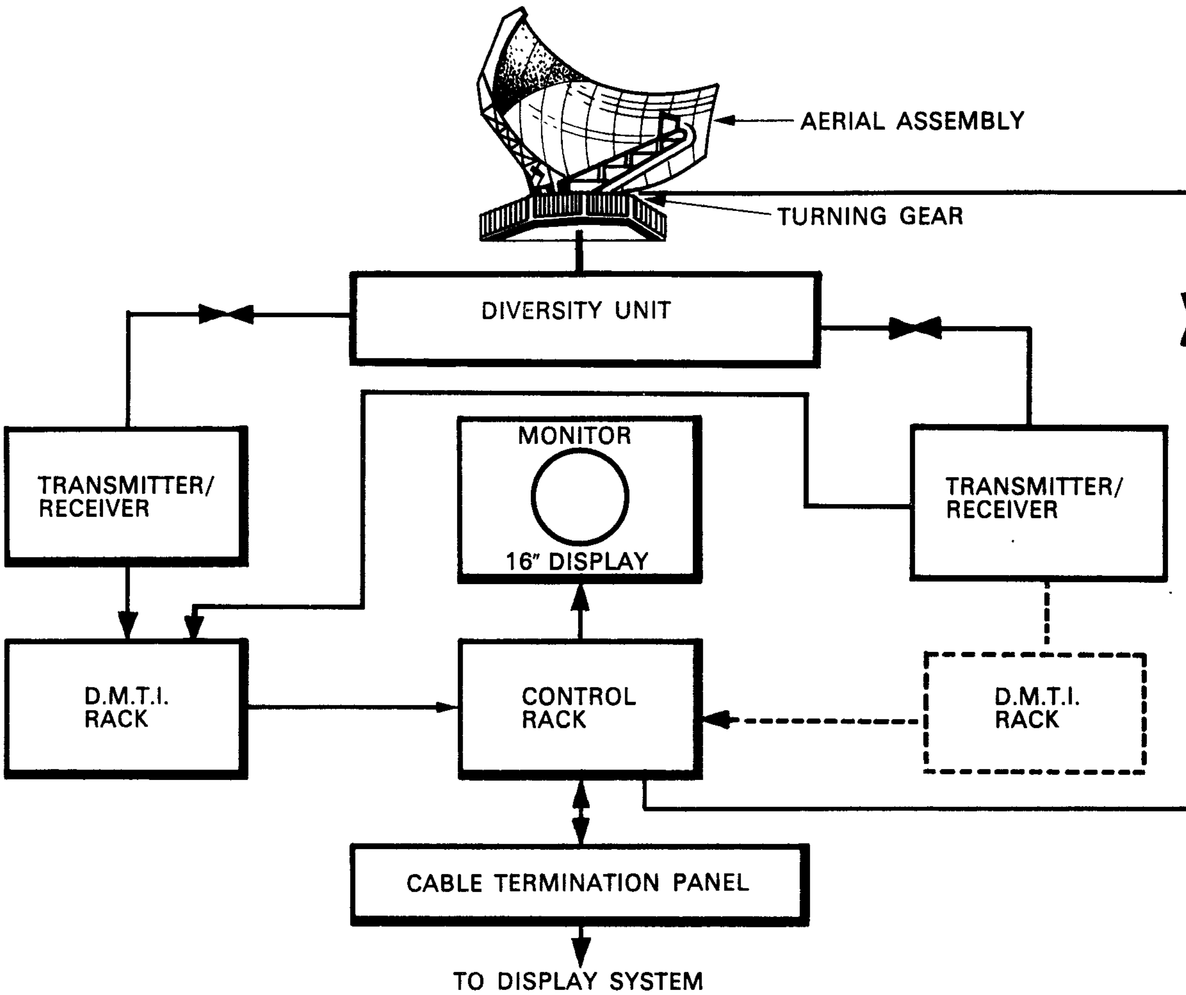



FIGURE 1.4 AR-5 RADAR SYSTEM - STAGE 2 GROWTH

| | |
|---|---|
| Pulse length | 2.0μs to 5.0μs |
| P.R.F. | 680p.p.s. to 270p.p.s. (staggered) |
| Aerial rotation rate | A single speed in the range 6 to 15rev/min. Additionally half-speed switching can be provided to order. |

20. Other parameters of the AR-5 radar are:-

| | |
|---|---|
| Operational frequency | 1 or 2 preselected crystal controlled frequencies in the band 1250 to 1365MHz. |
| Magnetron frequencies | 1250 to 1310MHz) 1305 to 1365MHz) Tunable |
| Diversity guardband | 35MHz (Minimum) |
| Aerial horizontal beam-width | 1.2° (Nominal to -3dB one way) |
| Vertical beamwidth | 3.5° shaped to 40° |

| | |
|---|---|
| Aerial gain | 36dB (at mid frequency) |
| Peak power | 2.0MW (at magnetron of each transmitter) |
| Noise factor | 3.5dB |

# CHAPTER 2

## DATA SUMMARY



1. The main parameters of the Plessey AR-5 radar system are as follows:-

### RADIATION

| | | |
|---|---|---|
| 2. | Frequency: | 1250MHz to 1365 MHz |
| | Polarisation: | Variable from linear through elliptical to circular. |

### AERIAL

| | | |
|---|---|---|
| 3. | Gain: | 36.0dB with respect to isotropic radiator. |
| | Horizontal beamwidth: | 1.2° at half-power points. |
| | Vertical beamwidth: | 3.5° to half-power points with shaping to +40° |
| | Angle of maximum radiation: | Set to suit the site; between 0.5° and 4.5° |
| | Aerial rotation rate: | 6 to 15rev/min single speed with option of a $\frac{1}{2}$-speed switching. |
| | 'Angel' suppression: | A second (receive) r.f. feed is fitted. |

DIVERSITY UNIT

| | | |
|---|---|---|
| 4. | Frequency: | Pre-tuned for two frequencies in the band 1250MHz to 1365MHz |
| | Diversity guard band: | 35MHz (Maximum). |

TRANSMITTER

| | | |
|---|---|---|
| 5. | Output valve: | Tunable magnetron - Temperature stabilised by vapour phase method. |
| | Frequencies: | (a) 1250MHz to 1310MHz |
| | | (b) 1305MHz to 1365MHz |
| | Power output: | 2. 0MW peak per transmitter (duty cycle 0. 00135) |
| | Pulse length: | In the range 2.0μs to 5.0μs |
| | P. R. F.: | In the range 680 p. p. s. to 270 p. p. s. with up to seven period stagger. |

RECEIVER (Parametric r. f. amplifier)

| | | |
|---|---|---|
| 6. | Noise factor: | 3. 5dB |
| | Intermediate frequency: | 30MHz |
| | Local oscillator: | High stability crystal multiplier chain. |
| | A. F. C.: | A. F. C. sensing derived in receiver system to control frequency of tunable magnetron. |
| | Receiver characteristics: | 4 switchable characteristics:- |
| | | (1) Linear |
| | | (2) Logarithmic |
| | | (3) Logarithmic gated by Dicke-fix |
| | | (4) Pulse length discrimination |
| | | In addition f. t. c. (switchable) is available with each output. |

DIGITAL MOVING TARGET INDICATOR

| | | |
|---|---|---|
| 7. | Type: | Double loop cancellation. |
| | Cancellation ratio: | 41.5dB (m.t.i. rack). |
| | Integrator: | Provided as part of m.t.i. system. |
| | Velocity feedback: | Provided. |
| | Sub-clutter visibility: | Depends upon parameters selected. |

POWER SUPPLIES

| | | |
|---|---|---|
| 8. | Voltages: | A voltage in the range 380 to 440V 3-phase ±6% |
| | Frequency: | 50Hz |
| | Power consumption: | Diversity system; 38kVA with wind speed of 10 knots rising to 70kVA with wind speed of 60 knots. (Power factor 0.85). |

ENVIRONMENT

| | | |
|---|---|---|
| 9. | External equipment: | |
| | Temperature: | -40°C to +70°C |
| | Humidity: | 0 to 100% |
| | Radar head equipment: | |
| | Temperature: | -15°C to +55°C |
| | Humidity: | From 0 to 95% depending on temperature. |
| | Typical display equipment: (i.e. Radar head monitor display) | |
| | Temperature: | 0°C to +55°C |
| | Humidity: | from 0 to 95% depending on temperature. |
| | Aerial: | |
| | Rotation (8rev/min) | In wind speeds up to 60 knots when iced to $2lb/ft^2$, and in wind speeds up to 80 knots when not iced. |
| | Survival: | 120 knots. |

# SECTION 2

## EQUIPMENT DESCRIPTION

# CHAPTER 1

## AERIAL EQUIPMENT



### GENERAL

1. The aerial is a horn-fed double curvature reflector of dimensions 45ft (13. 7m) horizontally by 18ft (5. 5m) vertically.

2. The horizontal beamwidth is 1. 2$^{\circ}$ to -3dB one way, the vertical beamwidth is 3. 5$^{\circ}$ to -3dB and shaped to +40$^{\circ}$. The angle of maximum radiation is normally set to +2. 5$^{\circ}$; this setting can be adjusted on site by up to $\pm 2^{\circ}$.

3. Variable polarisation is provided by use of a remotely controlled waveguide phase shifter. The calculated integrated cancellation ratio for circular polarisation is 20dB.

4. A second (receive only) feed is positioned immediately below the main horn to provide 'angel' and ground clutter rejection. The signals from the main feed and second feed are switched at a range which is predetermined to suit local site conditions and the specified operational requirements.

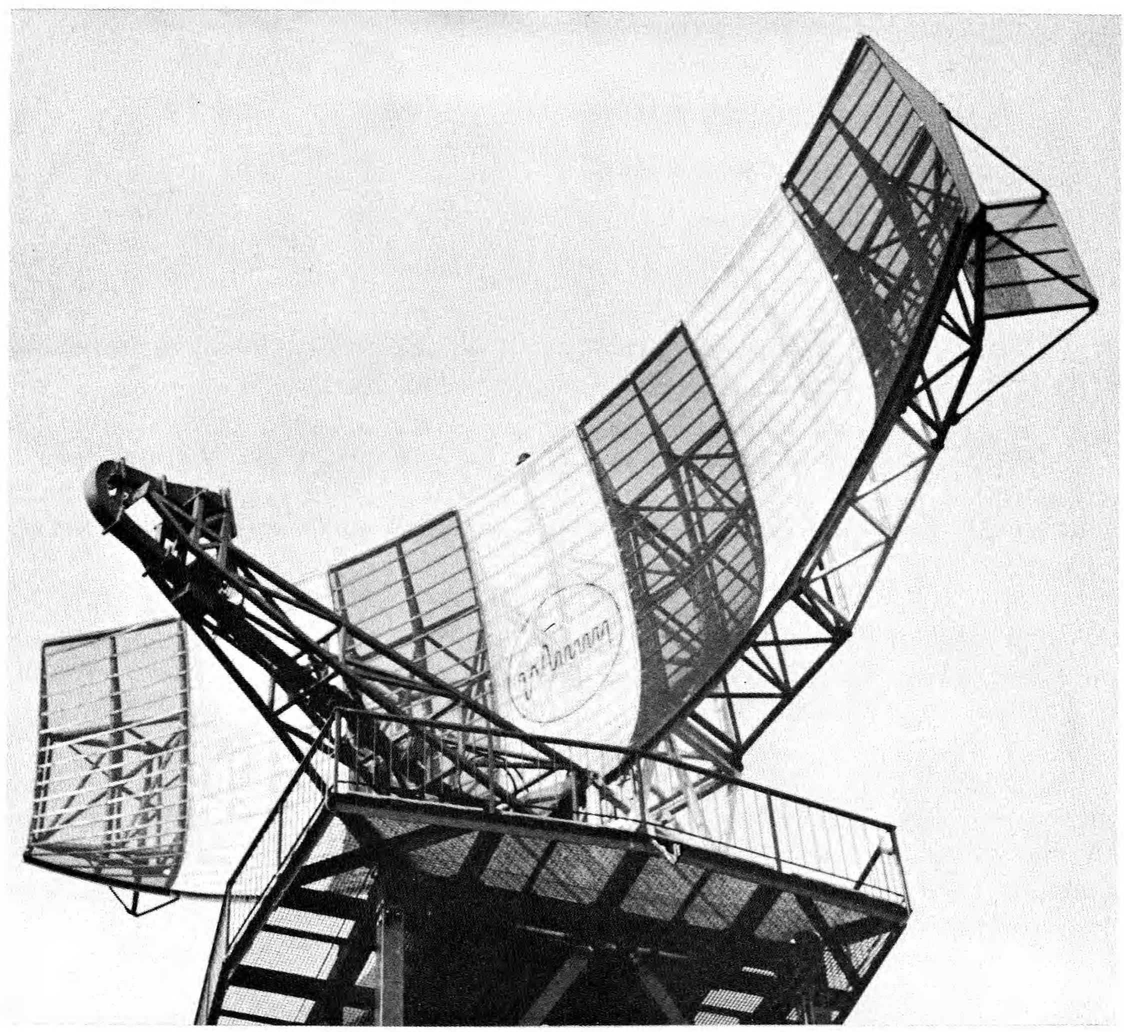
### AERIAL CONSTRUCTION

#### Aerial reflector and back-frame

5. The back-frame of the aerial is constructed from mild steel rectangular tube arranged in a 'T' formation, with all wind loads being carried towards the centre leg of the 'T' to a rotating prefabricated pivot assembly. The pivot assembly carries two bearings which support the whole aerial assembly and about which the aerial system may be tilted vertically by $\pm 2^{\circ}$ from the normal 2. 5$^{\circ}$ angle of radiation. The tilt mechanism is a manual adjustment and is set during the commissioning of the system.

6. The reflecting surface of the aerial is a stainless steel mesh. The aerial is assembled from seven sub-assemblies, each one connected to its neighbour with four self-aligned ball joints. The whole aerial is accurately pre-aligned during manufacture to facilitate easy installation.

7. The aerial back-frame structure is designed to support, above the main reflector, a secondary surveillance radar aerial of dimensions not exceeding 28ft (8. 5m) horizontal aperture and 2000lb (900kg) weight.



AR-5 AERIAL ASSEMBLY

8. A twin bulb obstruction light is mounted on the top of the aerial system. A ladder, built in to the back frame, gives ready access for servicing.

Boom arm assembly.

9. The mild steel tubular boom arm is approximately 13ft (4m) long and supports the waveguide and associated components and the primary and secondary feed horns. All boom arm components are readily accessible from the tower top platform.

## Protective finish

10. Stainless steel is used for all the thin sectioned elements to avoid the effects of corrosion. The mild steel back structure is protected by a 'Walter dip' phosphate etch primer over which is applied an epoxy resin based paint. With this protection the aerial is unlikely to require repainting for a period of five years.

## TURNING GEAR

11. The turning gear (Figure 1. 1) comprises five main units:

(a) The centre module.

(b) Two primary motor gearboxes.

(c) The secondary gearbox.

(d) The aerial bearing assembly.

### Centre module

12. The centre module is designed as an integral part of the turning gear and has three specific functions:-

(a) It provides a mounting and bed plate for the remaining items of the turning gear and the azimuth data take-off unit.

(b) It provides the means of supporting the turning gear on the standard AR-5 tower (or other suitable tower).

(c) It provides the support for the aerial cabin (when fitted).

### Gearboxes (general)

13. The gearboxes are designed to well established standards to carry out the specified duty with maximum reliability. Overall backlash will not exceed 30' of arc in iced-up conditions. In other conditions, torque is always positive and no backlash occurs.

### Primary gearboxes

14. Dual primary gearboxes are fitted to give maximum reliability. One unit will drive the aerial at the designed speed in windspeeds up to 55 knots.

15. Each primary gearbox unit has its own lubrication system. Greasing points are provided which are accessible from below the centre module.

16. The input to each primary gearbox is from a 3 phase, totally enclosed, squirrel cage motor.

Secondary gearbox

17. The secondary gearbox is a single stage reduction unit. The output gear is attached to the main aerial shaft and driven by two input pinions carried in bearings in the casing; overhung loads on the pinion shafts arising from the gear separating forces are thus avoided.

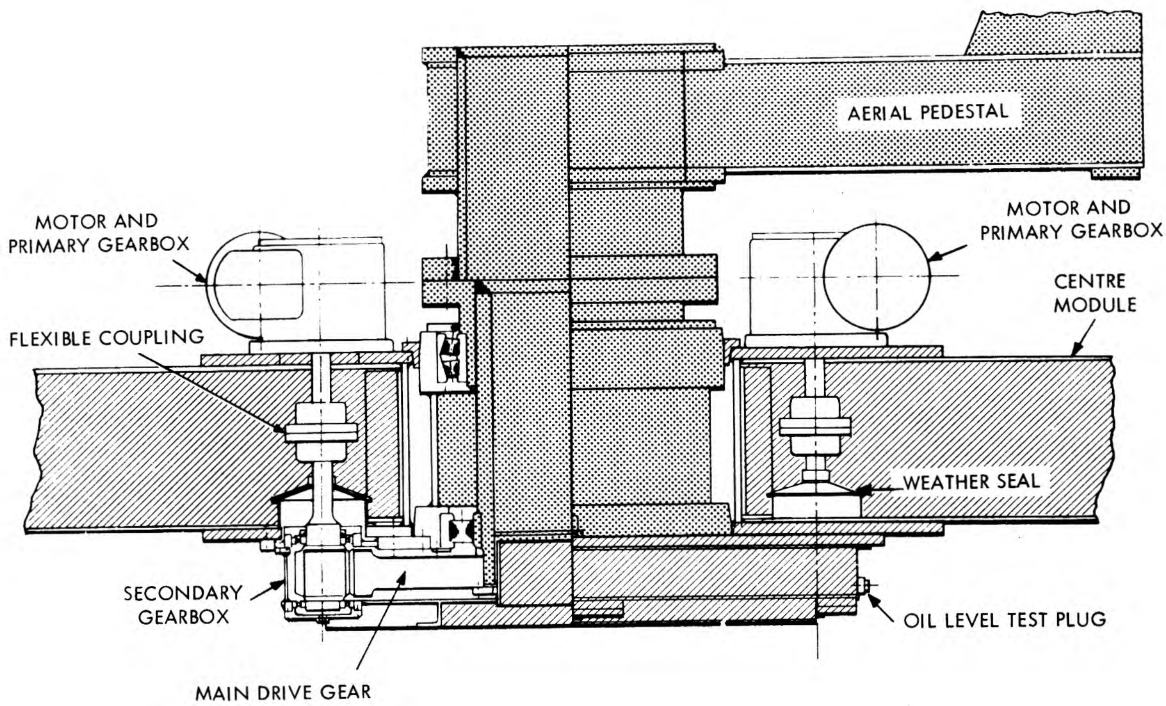



FIGURE 1.1 AR-5 AERIAL TURNING GEAR

18. Particular attention has been paid in the design to preventing oil leakage; static joints are sealed with 'O' rings in machined grooves and shafts are taken out above oil levels and are fitted with dust and oil seals.

19. The load characteristics of the main bearings exceed the design requirements by a substantial margin.

Servicing

20. To reduce off-the-air time to a minimum, major repairs of the turning gear are carried out at ground level after the defective module has been removed. The defective module is uncoupled and lowered to ground level, using a davit attached to the centre module and a hand operated ratchet winch or powered block. The reflector and boom arm assembly are not disturbed during this operation.

## Alignment

21. The turning gear may be 'inched' and locked to permit accurate alignment of the azimuth data transmission system.

## Turning gear control units

22. The starters for the aerial turning motors (including the local/remote selector and the safety switch) and the lubrication unit are housed in two cubicles which may be mounted either on the wall of the Plessey aerial cabin or on the wall of the turning gear room provided by the customer.

# ANCILLARY UNITS

23. Units, such as the azimuth data take-off unit, the slip ring assembly and the rotating joint, are also fitted to the centre module. Each of these units may be separately removed for servicing without disturbing the remaining assemblies.

## Slip ring assembly

24. The slip ring assembly consists of two, concentric, 12-way, silver plated, rotating slip ring grooves and associated static brush assemblies. Each ring is designed to carry a maximum current of 13A at 240V a.c. Both slip ring assemblies face downwards so that dust cannot accumulate on the running tracks.

## Rotating joint.

25. A three-channel rotating joint is used. The third channel is available for use with an on-mounted s.s.r. aerial.

26. The primary radar $TE_{10}$ mode existing in the waveguide runs is transformed for rotation into a coaxial TEM mode within the joint and then transformed once more to the $TE_{10}$ mode in the waveguide. The secondary radar channels consist of one medium power and one low power coaxial system.

## Azimuth data take-off unit

27. The azimuth data take-off provides six output shafts rotating at 1:1 with the aerial system. Synchro transmitters, or digitisers, may be fitted as required by the display system.

OPTIONAL MECHANICAL STRUCTURES

28. To assist the customer to choose the most economical method of mounting and/or housing the aerial and turning gear, Plessey Radar offer a number of additional support and weather protection units. These units are:-

(a) An aerial cabin

(b) A top platform assembly

(c) A modular tower

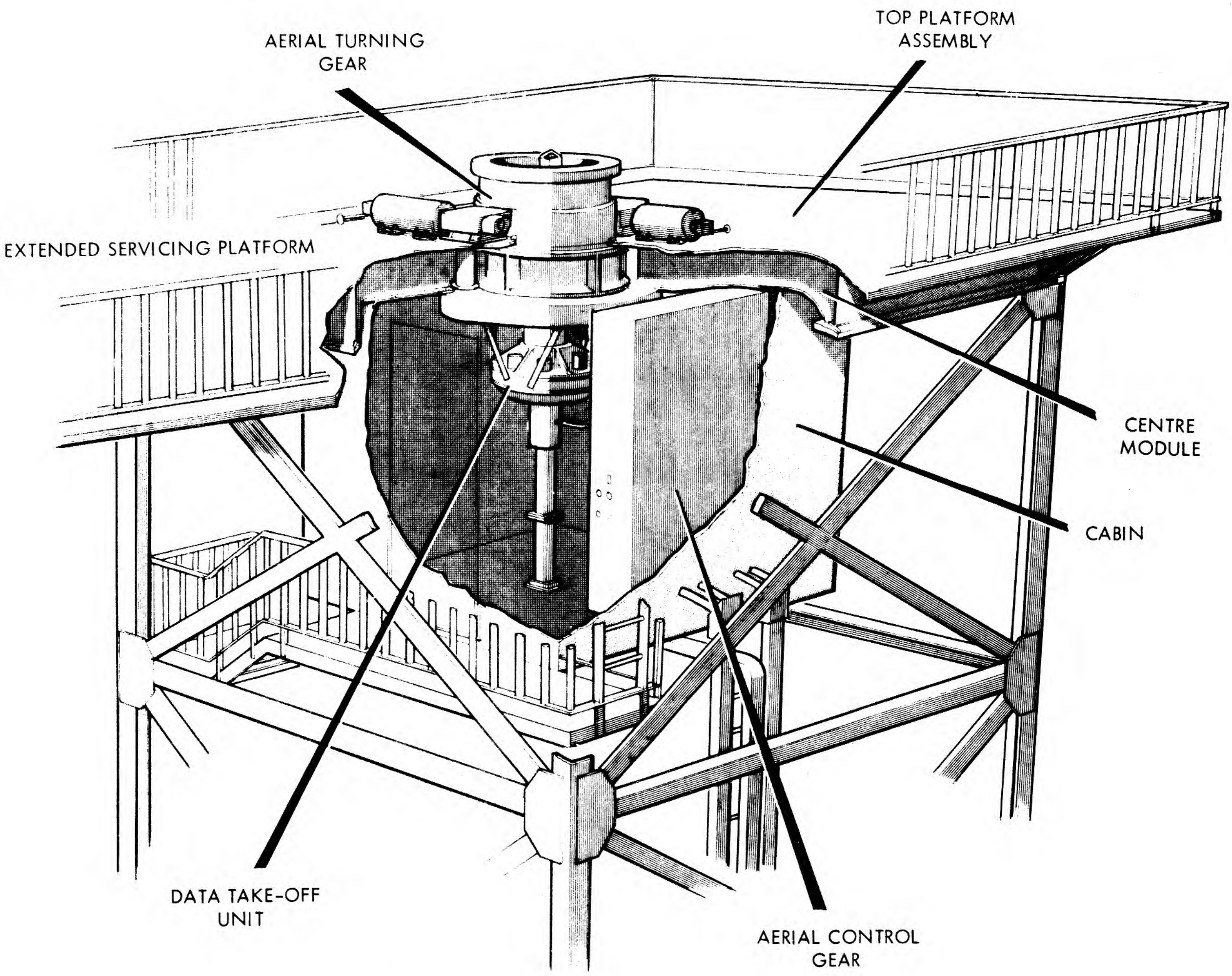



FIGURE 1.2 TOWER, CABIN AND PLATFORM ASSEMBLIES

The aerial cabin

29. The aerial cabin (Figure 1.2) is a braced frame structure which may be suspended from the centre module to provide a weatherproof housing. Access to the cabin is obtained through a door in one wall.

### Top platform assembly

30. The top platform assembly provides walkways and service areas for the upper part of the turning gear and aerial assembly. It also has an extended platform to support a ladder to give access to the boom arm assembly.

31. This top platform assembly surrounds the centre module. The whole assembly may then be mounted on the standard AR-5 tower or any other tower of appropriate dimensions.

## TOWER ASSEMBLIES

### The standard Plessey tower

32. The optimum height of a radar aerial is determined by the operational characteristics required of the radar and by the chosen site. Plessey have designed a four section tower of modular construction which allows tower heights of 10ft (3. 05m), 20ft (6. 1m), 30ft (9. 15m) and 40ft (12. 2m) to be provided to suit the customer's requirements. When the 40ft tower is used, the total aerial height (including on-mounted s. s. r. aerial) is approximately 70ft (21. 5m) and the nominal electrical centre of the aerial is 55ft (16. 7m) above ground level.

### The module

33. Each tower module consists of a braced frame, incorporating cross bracing members. The whole module is bolted together from simple component parts which are readily transportable.

### Stairways

34. The tower incorporates a stairway arranged so as to leave the centre of the tower clear for equipment to be hoisted into the cabin. The upper module of the tower supports the centre module, which in turn supports the aerial turning gear and aerial.

### Waveguide supports

35. The L-band waveguides are firmly attached to specially designed support ladders. Easy access to all flanged joints is provided.

### Tower foundations

36. The foundation for the tower will normally be a concrete raft, the design of which will depend on local soil conditions.

CHAPTER 2

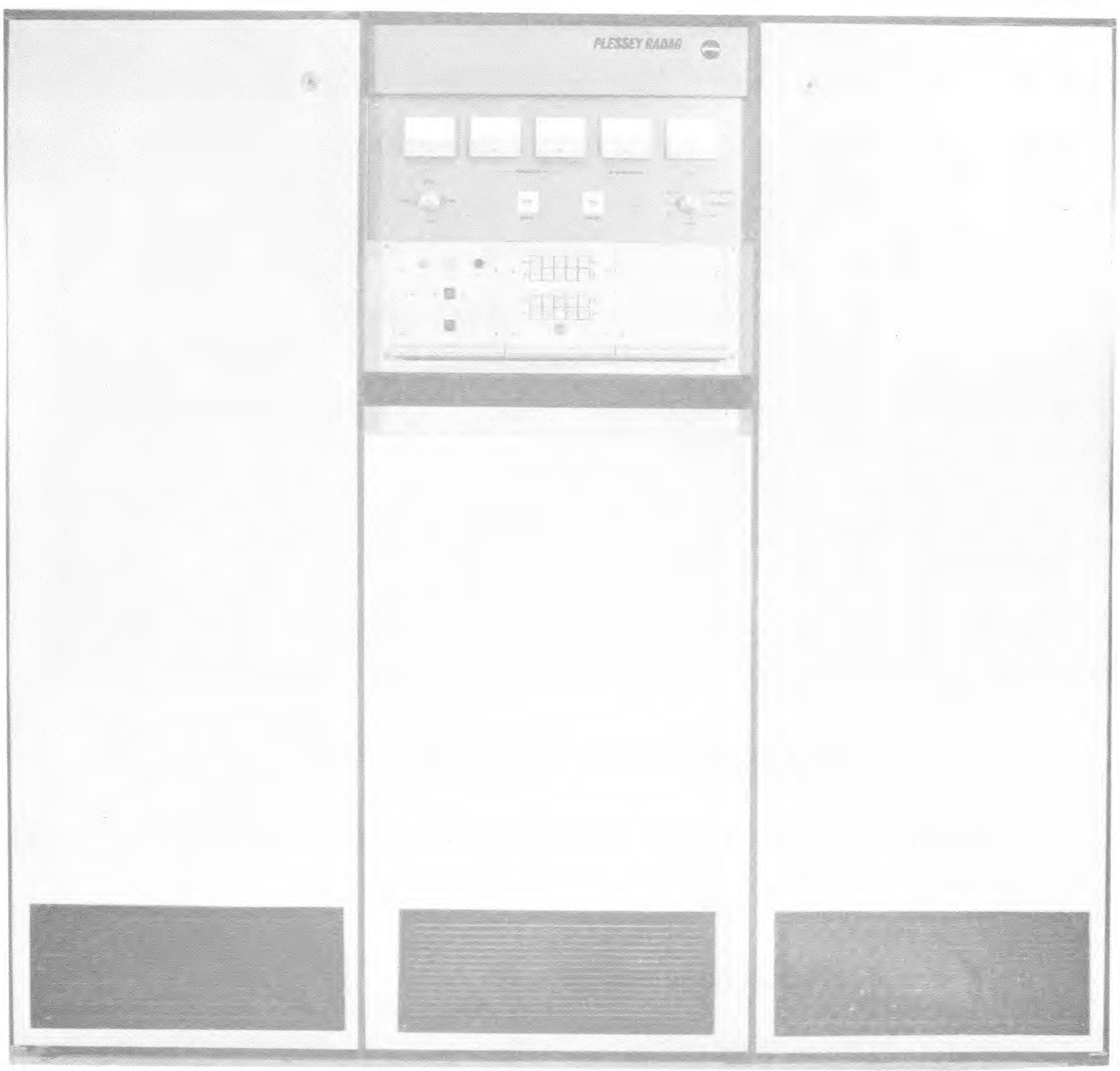
TRANSMITTER/RECEIVER EQUIPMENT



## TRANSMITTER/RECEIVER

### General

1. The transmitter/receiver is an autonomous unit and uses solid state circuits, including integrated circuits. The only electronic tubes used are:-




AR-5 TRANSMITTER/RECEIVER CABINET

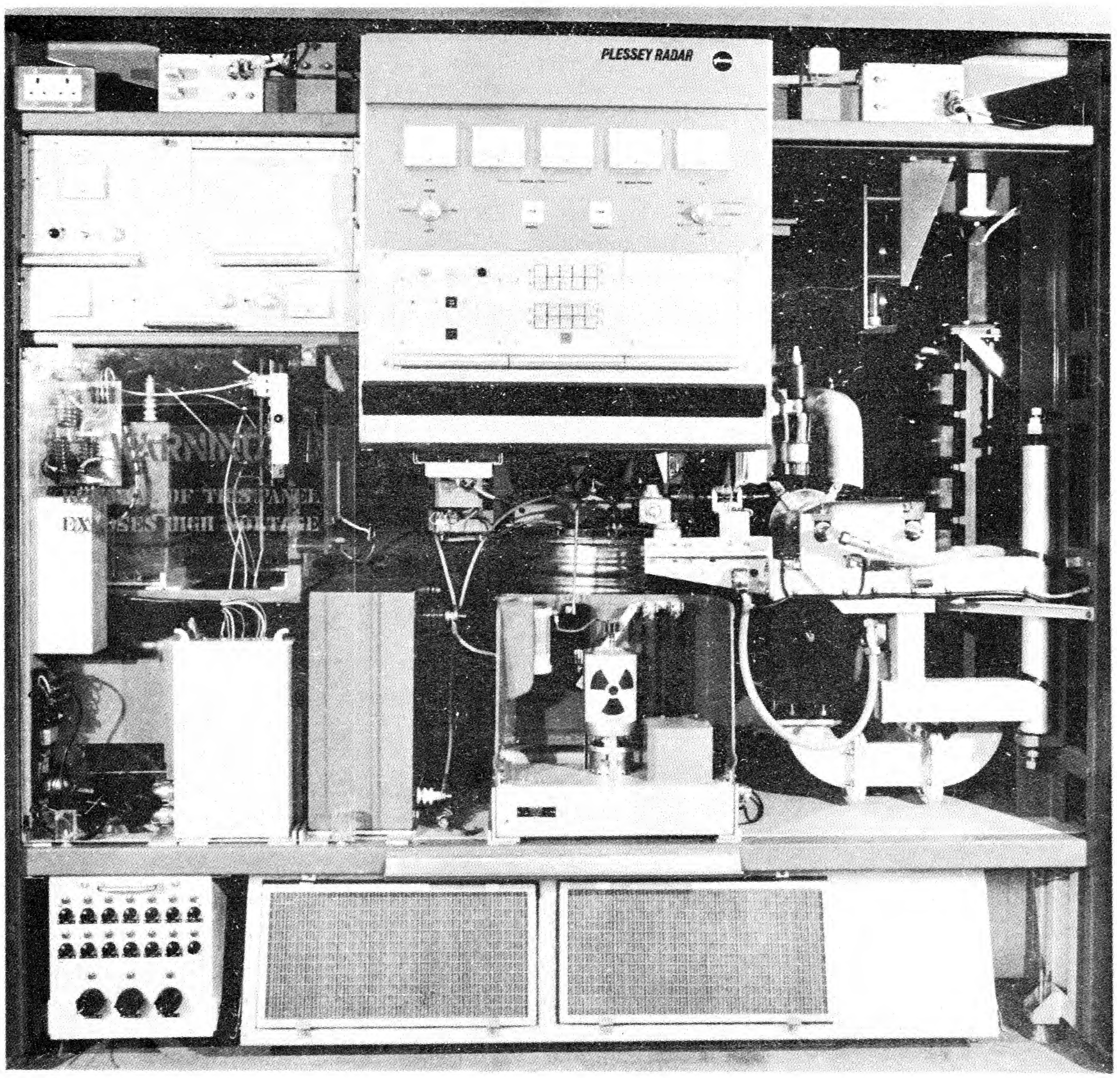
(a) Hydrogen thyratron switch tube

(b) Magnetron

(c) Duplexer tubes

(d) Klystron pump (parametric amplifier)

2. To achieve minimum off-the-air time all sub-units have been made easy to remove. E.H.T. trip and automatic reset circuits reduce the e.h.t. down time.




AR-5 TRANSMITTER/RECEIVER CABINET

3. Figure 2.1 is a basic block diagram of the transmitter/receiver.

E.H.T. unit

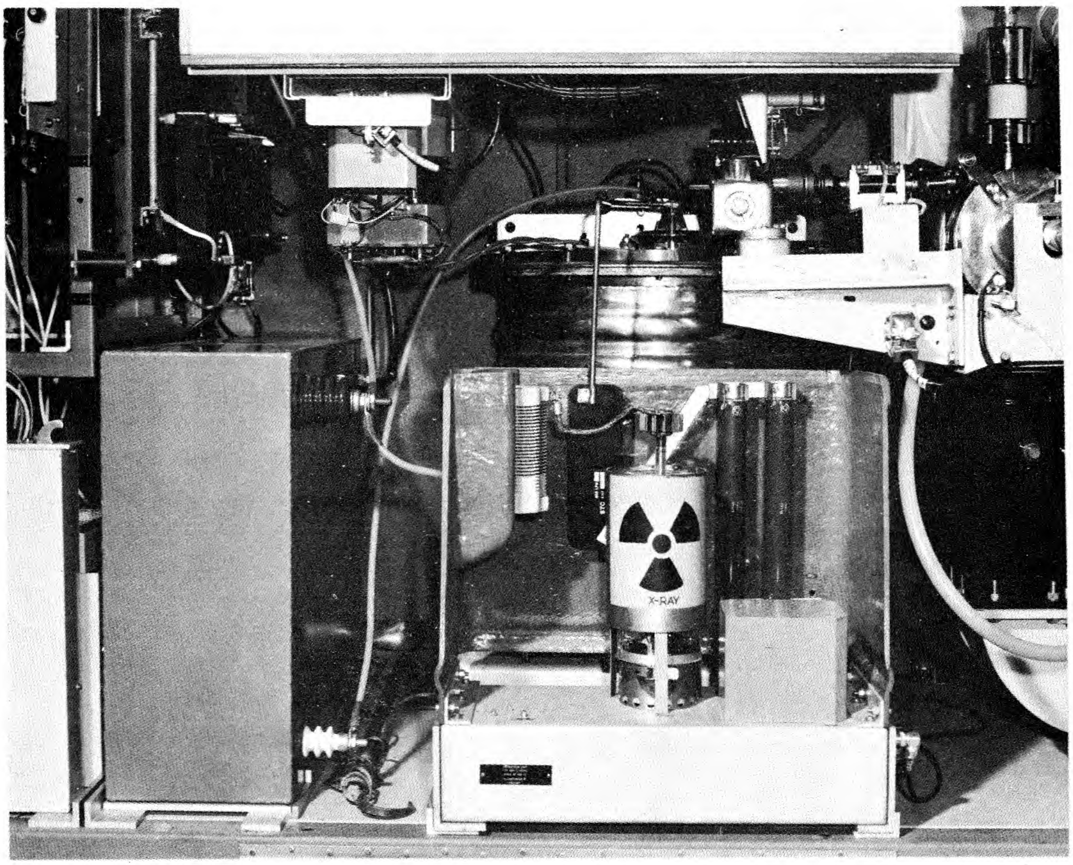
4. The e.h.t. unit consists of:-

(a) Silicon controlled rectifier a.c. controller (in place of traditional motor variac).

(b) E.H.T. transformer

(c) Full-wave rectifier bridge and filter.

5. The controller functions as a high speed contactor in conjunction with the transmitter controls and can apply or re-apply full e.h.t. to the modulator in less than 2 seconds. Feed-back is applied to the controller from the magnetron to stabilise the magnetron mean current during mains fluctuations.




AR-5 MODULATOR SECTION
(SHOWS THYRATRON, P.F.N. AND PULSE TRANSFORMER)

Modulator

6. Resonant charging of the pulse forming network (p.f.n.) is employed and the e.h.t. is routed to the p.f.n. via a charging choke and silicon hold-off diode.

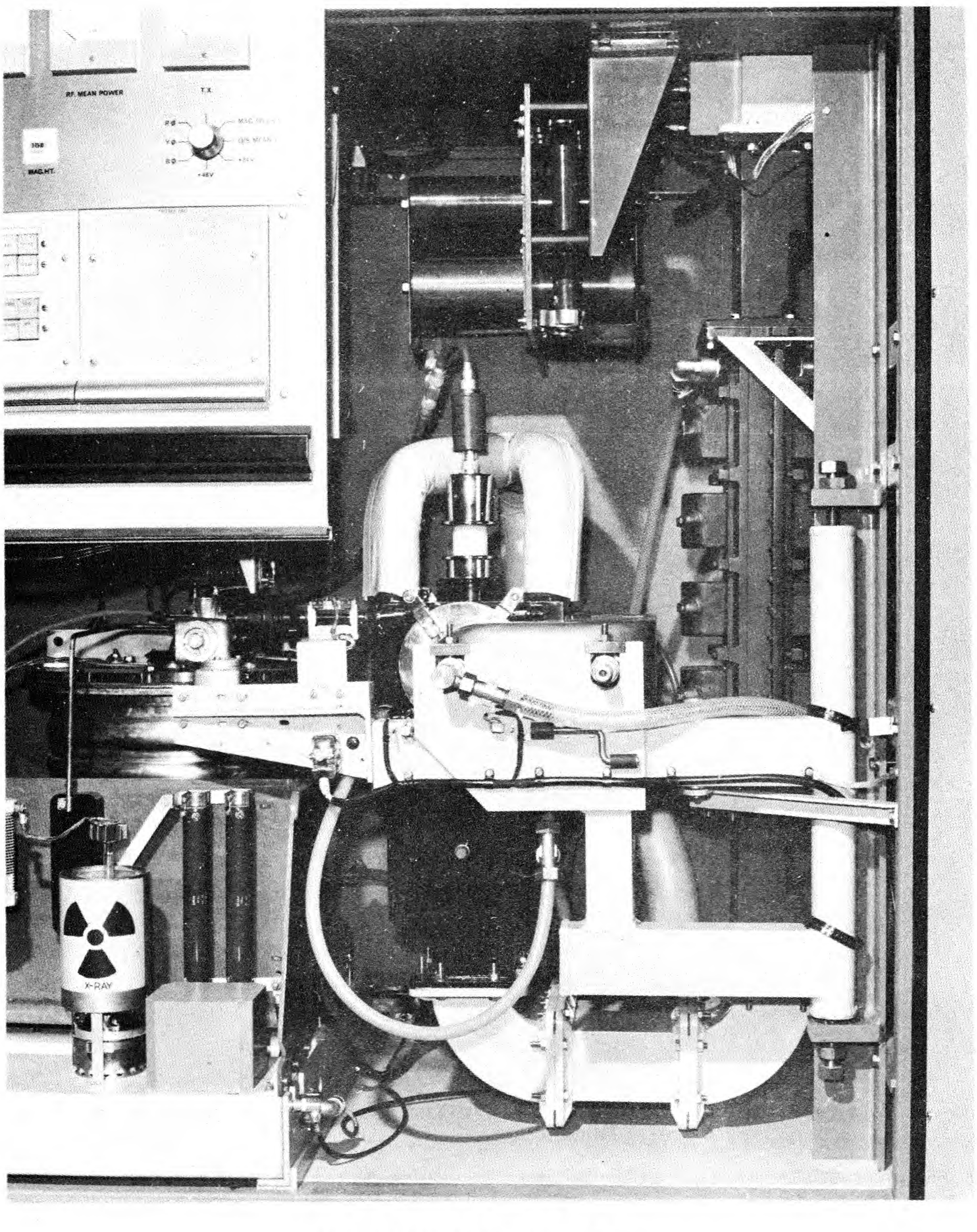
7. The p.f.n. is discharged into the primary of the magnetron pulse transformer by the hydrogen thyratron switch. An over-swing silicon diode stack is incorporated to prevent reverse charging of the p.f.n.

8. The sub-assemblies within the e.h.t. unit and modulator are designed for maximum accessibility and ease of replacement. All major sub-assemblies are secured by quick release catches.

Magnetron

9. The tunable L-band magnetron is of new design and incorporates the latest techniques to ensure maximum stability during operation. Two magnetrons are required to cover the total frequency range.

10. Each magnetron is tunable throughout its specified frequency range and has a peak power output of 2MW and a mean power rating of 3kW. The magnetron frequency ranges are 1250 to 1310MHz and 1305 to 1365MHz.




MAGNETRON SECTION

Ferrite isolator

11. A ferrite isolator is fitted to reduce pulling effects on the magnetron and thus further to improve stability for good m.t.i. performance.

Duplexer

12. A duplexer is housed in the top section of the transmitter/receiver cabinet. A temperature sensor is incorporated in the dummy load arm to warn against malfunction. Mean power is monitored by a pair of thermocouples and the reading displayed on a meter at the transmitter control panel.

Differential power monitor

13. A differential power monitor is fitted between the isolator and the duplexer. This measures forward power delivered from the isolator and reverse power returning to the isolator. When a level of reverse power is being approached which would damage the ferrite isolator, indication is given on the transmitter control panel and the transmitter trip circuits operate.

Trigger unit

14. The trigger unit normally operates from the master trigger pulse derived from the digital m.t.i. equipment and provides trigger pulses for:-

(a) Modulator timing

(b) Dual swept gain attenuators for first and second feed coverage.

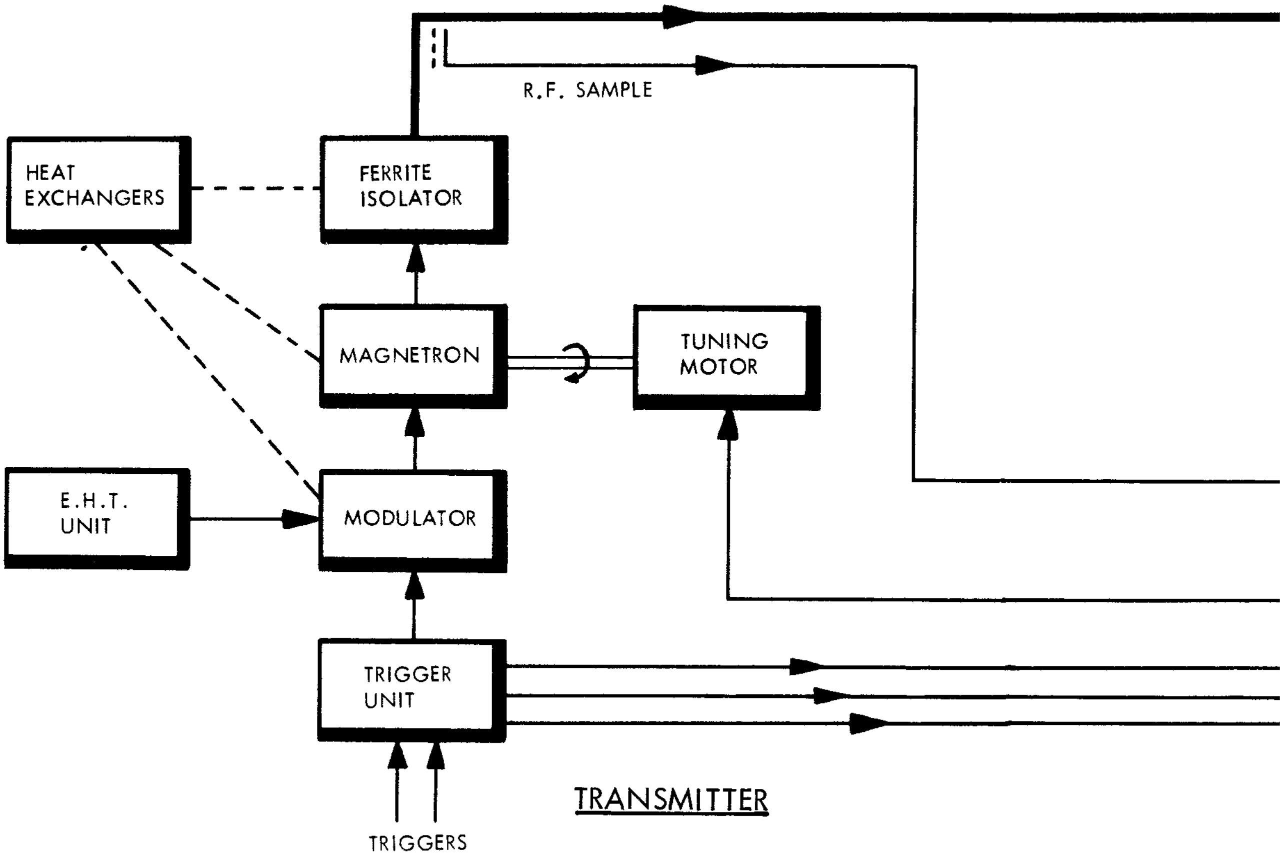
(c) Range gate circuit for the r.f. beam switch (to select first and second feed coverage).

15. The trigger unit contains a p.r.f. generator which permits the transmitter/receiver to be operated independently of the external trigger for servicing.

Receiver and a.f.c. system

16. The received signals from both aerial feeds are input to swept gain attenuator units, the attenuation of which is varied according to preset laws between a maximum of 60dB and 0.3dB.

17. The output of the swept gain attenuators is fed to an electronic range gate unit (r.f. beam switch unit) which selects either first or second feed coverage at a pre-set (technician control) range. The output of this unit is fed to the parametric amplifier.




TRANSMITTER

Parametric amplifier

18. The parametric amplifier is pumped at J-band and has a 20dB gain and a 2dB noise factor. The output of the parametric amplifier is fed to the mixers.

Stalo

19. The conventional stalo is replaced by a high stability v.h.f. crystal oscillator which is multiplied to the L-band frequency required. The v.h.f. crystal provides the reference for the magnetron frequency. Thus magnetron frequency is set by fitting the appropriate v.h.f. crystal. Two tunable magnetrons cover the total frequency range.

A.F.C. system

20. The a.f.c. system is a discontinuous servo which senses any deviation of the signal i.f. from the 30MHz a.f.c. i.f. and causes a motor to drive the magnetron tuning shaft. The rate at which the magnetron tuning is changed is chosen to avoid loss of m.t.i. action during the tuning operation. The a.f.c. system is free from backlash and hysteresis.

Mixer

21. The mixer used is a specially developed single sideband unit

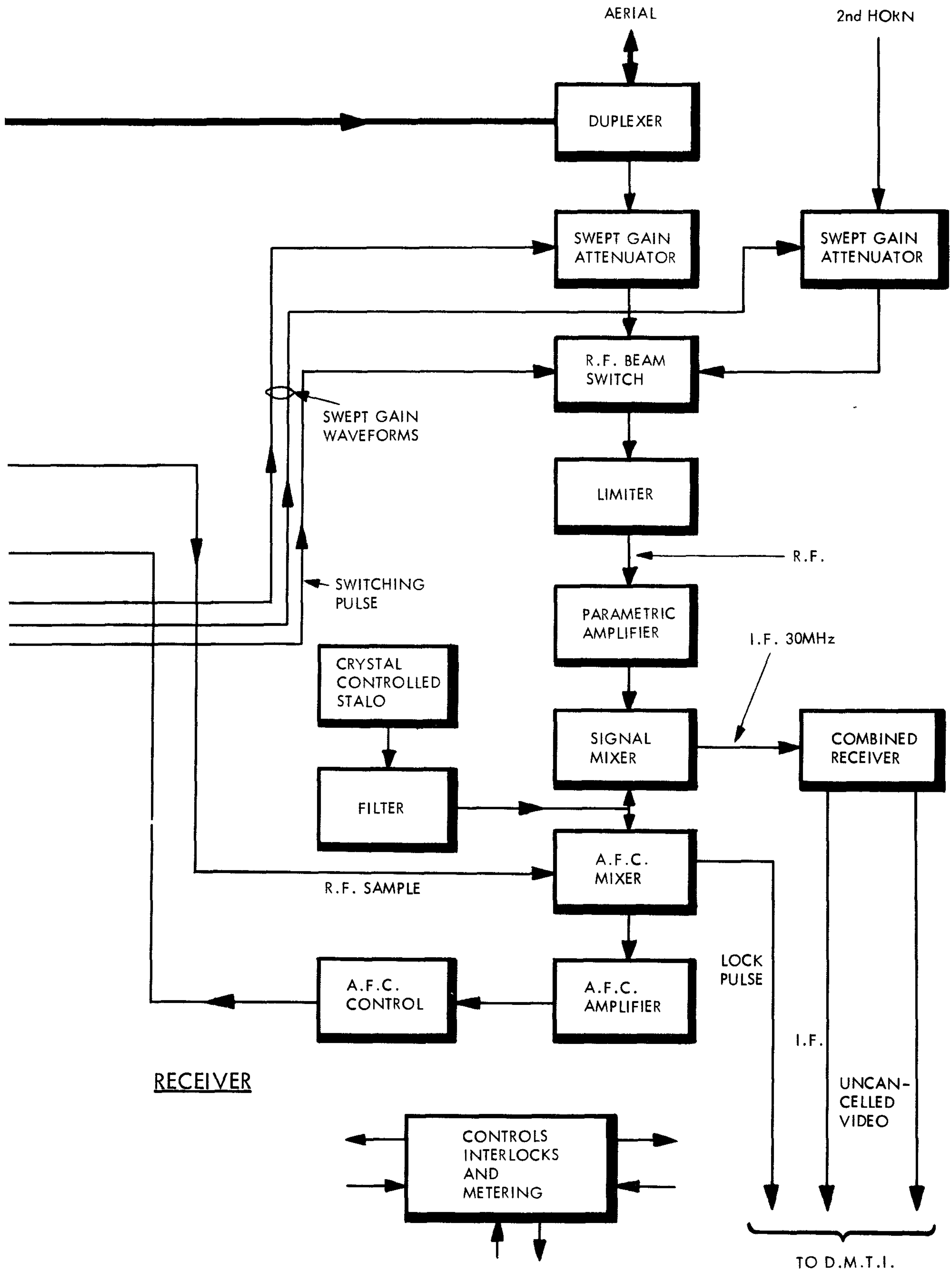



FIGURE 2.1. TRANSMITTER/RECEIVER BASIC BLOCK DIAGRAM

which removes the image noise contribution from the parametric amplifier and prevents the need for manual adjustment if the operating frequency is changed.

Receiver

22. The output of the mixer is fed to a 'combined receiver' which is a single unit containing a split pre-amplifier, the normal (non m.t.i.) i.f. amplifier and video stages. The second output from the split pre-amplifier feeds the d.m.t.i. system. The normal i.f. amplifier has linear and logarithmic sections and a wide-band noise-limited constant false alarm section.

23. A noise level monitoring facility, which gives an indication of relative receiver sensitivity, is provided. The noise level monitor samples the noise in an unsaturated stage of the logarithmic amplifier and presents a reading at the radar control panel.

24. The normal (non m.t.i.) radar receiver has the following switchable characteristics:-

(a) Linear

(b) Logarithmic

(c) Logarithmic gated by Dicke-fix

(d) Pulse length discrimination

Differentiation (f.t.c.) may be applied to any of the output videos.

## MONITORING FACILITIES

25. Monitoring facilities are provided in the transmitter/receiver assembly as follows:-

(a) Multimeter for measuring transmitter auxiliary voltages and currents, together with magnetron mean current and over-swing mean current.

(b) E.H.T. voltmeter

(c) E.H.T. mean current meter

(d) Transmitter mean r.f. output power meter

(e) A multimeter for local receiver voltages.

(f) Magnetron hour meter

(g) Total a.c. hour meter

(h) Receiver drawer multimeter monitoring:-

(i) mixer current
(ii) pump klystron voltage and currents
(iii) a.f.c. action

26. Transmitter waveform test points are provided for the following:-

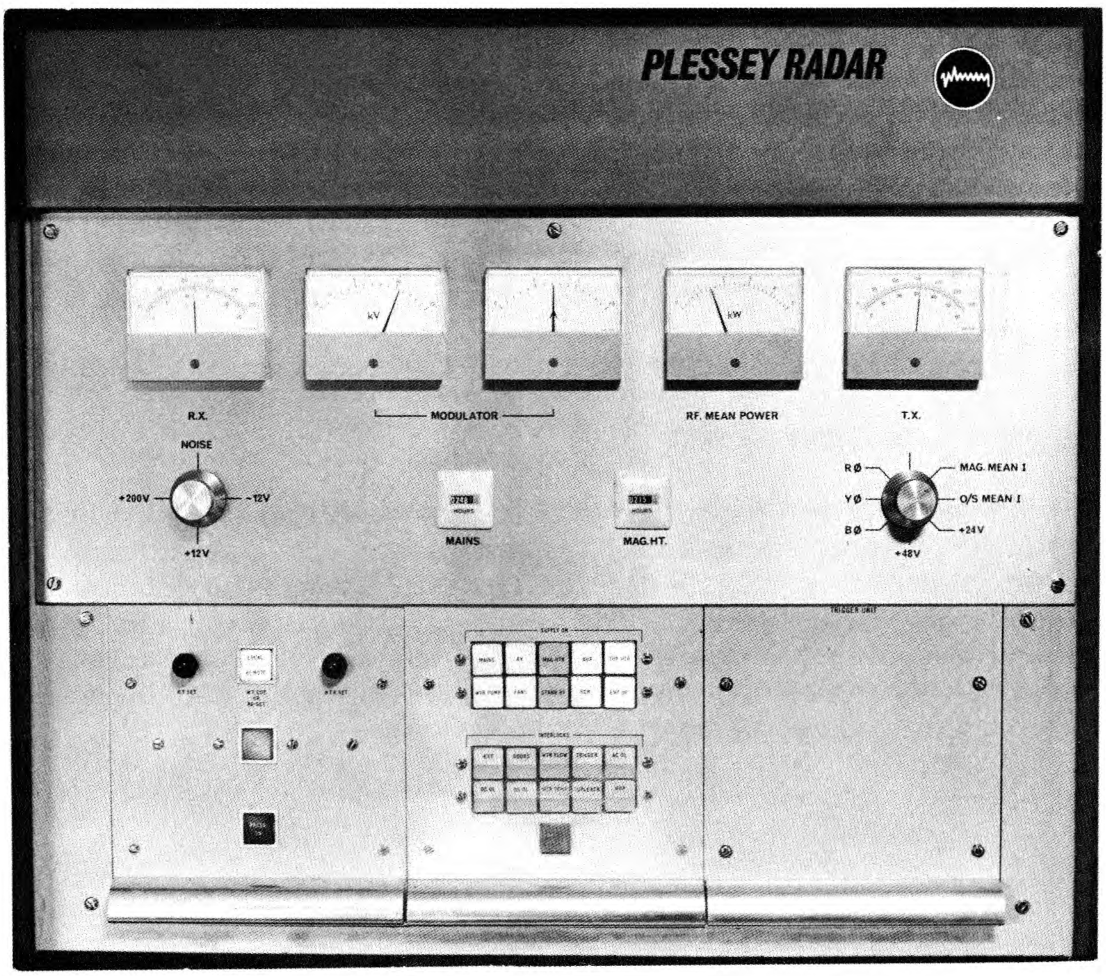
(a) Charging voltage

(b) Magnetron current pulse

(c) Transmitter trigger

(d) Trigger output to thyratron

(e) System trigger




CONTROL AND MONITORING PANEL

Interlocks and indicators

27. The interlocks and indicators are contained with the memory and sequence unit. The interlocks are:-

(a) External

(b) Transmitter doors

(c) Water flow

(d) Trigger failure

(e) A.C. overload

(f) D.C. overload

(g) Over-swing

(h) Water temperature

(j) Duplexer load temperature

(k) Excess reverse power

28. The transmitter run-up sequence is monitored by the sequence and memory unit. White lamps are used to indicate when power is applied to the various units of the transmitters/receivers. The memory section of the unit has a red and a green lamp for each interlock circuit. When an interlock is closed, the green lamp is illuminated. If an interlock is open or a trip has occurred, the appropriate green lamp is extinguished and the red lamp illuminated. If the trip is cleared by automatic reset, the green lamp is re-illuminated; the red lamp remains illuminated until the reset button is pressed. This enables transient faults within the transmitter, which are above the trip threshold level, to be positively indicated at the next routine check.

FREQUENCY DIVERSITY UNIT

29. The frequency diversity unit (waveguide filter) is used when two transmitter/receivers are installed; it permits the r.f. power from, or to, the two transmitter/receivers to be directed through the common waveguide to the aerial system. The frequency diversity unit can be used for radio frequencies at opposite ends of the band or for frequencies separated by only 35MHz anywhere in the band. Frequency tuning of the diversity unit is carried out by pre-plumbed stubs.

# CHAPTER 3

## DIGITAL M. T. I. AND VIDEO PROCESSING SYSTEM



### GENERAL DESCRIPTION

1. For a significant improvement in reliability and ease of setting-up, the AR-5 radar uses a digital moving target indicator system.

2. The m. t. i. system uses solid state techniques throughout and is of the line-by-line coherent type with delay and subtraction, using digital techniques on shift register stores. Double loop cancellation is employed and blind speed effects are minimised by use of multi-period stagger. Static m. o. s. shift registers are used as the storage and delay elements.

3. The video integrator uses a similar store out to the maximum range of the radar and integrates both the m. t. i. and normal radar returns over the beam dwell time, thus providing improvement in target signal-to-noise ratio and rejection of asynchronous interference signals.

4. Three other major improvements benefit the m. t. i. system. They are as follows:-

(a) A 'stalo' of improved performance and reliability.

(b) Phase and quadrature detection to avoid phase blindness.

(c) High stability magnetron.

5. The cancellation ratio of the m. t. i. rack (static test) is 41. 5dB. The AR-5 system sub-clutter visibility depends upon the parameters chosen to suit a specified operational requirement. Typically the system with a p. r. f. of 350 p. p. s. and an 8 rev/min rotation rate will have a 29. 25dB cancellation ratio and a 23. 25dB sub clutter visibility (s. c. v. ) Velocity feedback improves the s. c. v. to 26dB. A further example is that of a system using a p. r. f. of 550 p. p. s. and a 10 rev/min rotation rate providing 33. 5dB cancellation ratio and 29dB sub clutter visibility with feedback.

### DIGITAL M. T. I. SYSTEM

Basic signal flow (See Figure 3. 1)

6. Intermediate frequency signals at 30MHz are fed to the m. t. i. rack from the radar transmitter/receiver. A lock pulse at i. f. carries the phase of the transmitted signals to the coho receiver and thus estab-

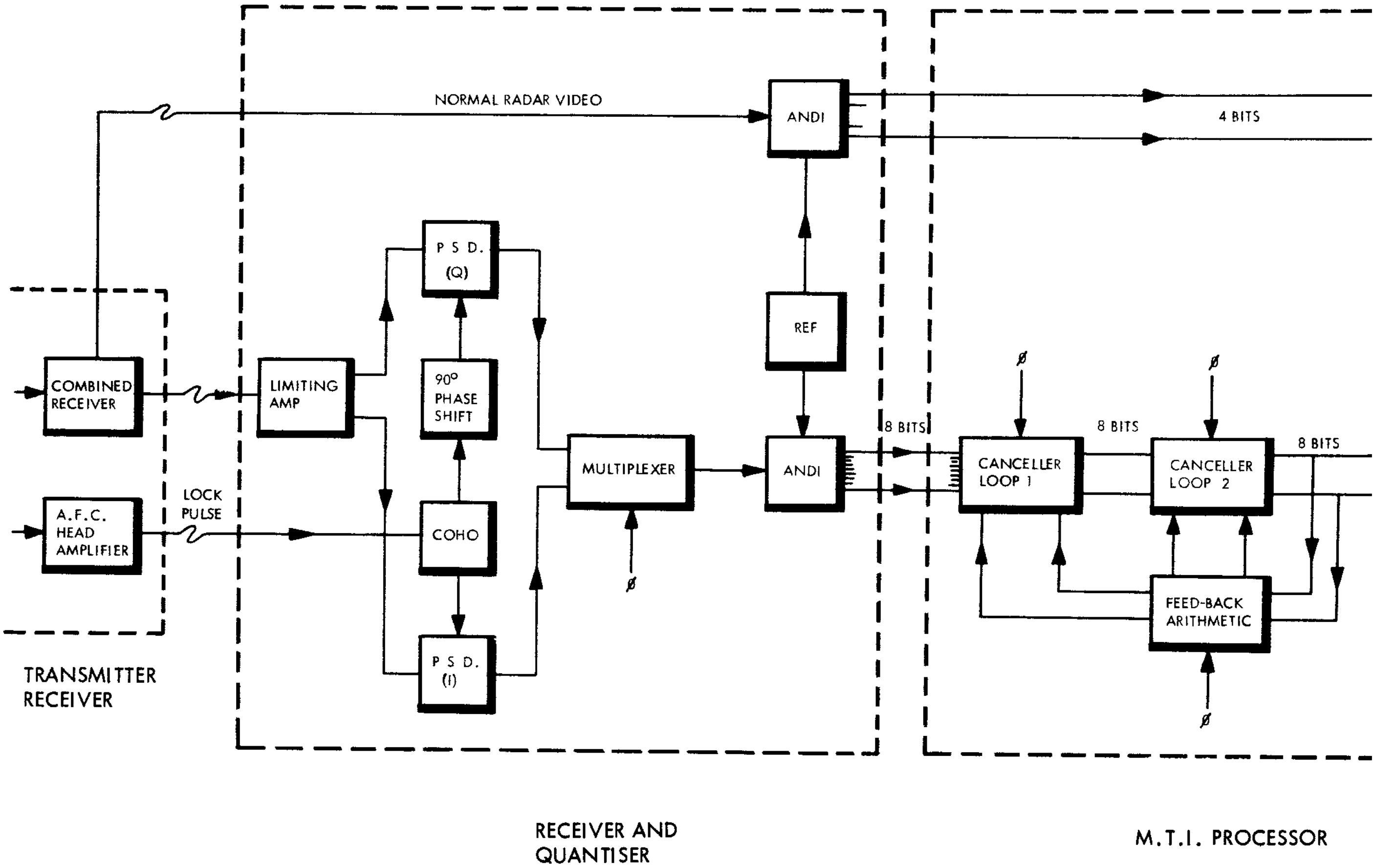



FIGURE 3.1. DIGITAL M.T.I. AND VIDEO PROCESSING

lishes a reference for the phase detection of received signals. The phase detector outputs are converted to 8-bit digital words at the rate of one per sampling interval (1.5 $\mu$s) at the output of the receiver and quantizer block. Normal radar video signals are quantized in this block and output as a 4-bit digital word.

7. Cancellation of fixed echoes takes place in the m.t.i. processor block, the digital signals being stored and subtracted from those received following the next transmitted pulse. The storage and subtraction process is repeated; the resulting double cancellation enables high clutter rejection to be maintained when the radar antenna is scanning. The use of signal feedback enables clutter attenuation to be further improved.

8. The cancelled output of the m.t.i. processor is converted to an all-positive signal, still in digital form, and passed through a digital constant false alarm (c.f.a.r.) circuit which reduces any extended areas of uncancelled clutter to noise level.

9. The whole sequence of timing up to this point has been referred to the transmitter pulse. The transmitter pulse timing is staggered to avoid blind speeds in the m.t.i. response. To enable the display circuits to operate at uniform p.r.f., the signals are 'de-staggered' by switching in blocks of digital storage to introduce a compensating delay. Both normal radar and m.t.i. signals are de-staggered in this way.

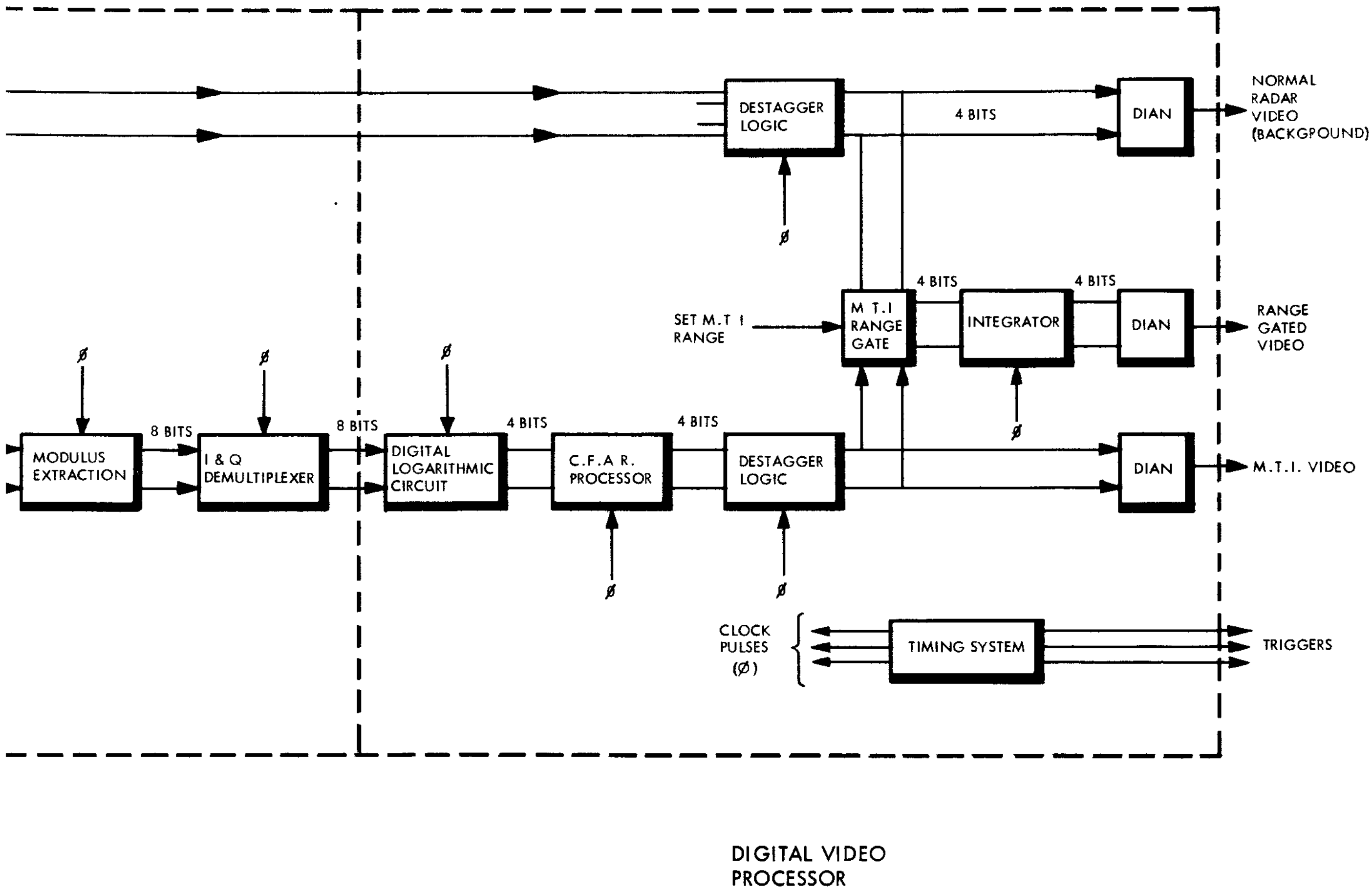



FIGURE 3.1. DIGITAL M.T.I. AND VIDEO PROCESSING

10. The normal radar and m.t.i. signals are switched at an appropriate range by the m.t.i. range gate. The combined signal is passed to a digital integrator which presents the signals at optimum signal to noise ratio at its output.

11. Digital-to-analogue converters deliver the integrated range gated video signals at standard level to the display. Normal radar video and m.t.i. video are available separately where choice of signals is required at the display.

12. The timing system furnishes all clocks and triggers required by the digital processing system, the transmitters and the displays. The timing can be synchronised to an externally supplied lock pulse if required.

13. Both signal processing and timing systems are designed to include a comprehensive self-checking programme enabling faults to be quickly localised.

Coherent receiver, quantizer

14. The 30MHz intermediate frequency signal is fed through a limiting amplifier to the coherent receiver, consisting of two phase detectors in parallel. The reference signals to the phase detectors are in quadrature and are taken from a common coherent oscillator (coho)

which is locked in phase with an intermediate frequency lock pulse supplied from the transmitter/receiver.

15. The coho is of self-gated type requiring no separately generated gate waveform.

16. The multiplexer samples the phase and quadrature detector outputs (I & Q signals) in alternate half length periods. The resulting time-shared signal is fed to the analogue-to-digital converter, which encodes the signals as a series of 8-bit parallel binary words, once per range bit.

17. Similar circuits encode the normal radar video as a 4-bit parallel word.

Canceller

18. The digital m. t. i. signals are clocked into chains of m. o. s. shift registers which form the storage elements of the m. t. i. system. When stores are full, i. e. when the first signals arrive at the end of the shift register chain, the clock is interrupted and the stored information remains static until the next transmitted pulse. The clock waveform is then re-applied and while new signals are put into store, the stored signals are fed to an arithmetic unit where they are subtracted from the incoming signals. The difference is passed on to the second stage of cancellation.

19. Feedback signals are taken from the output of the shift register store of the second canceller. The feedback arithmetic unit multiplies the delayed signals by the required feedback factors and adds the feedback signals to the input data for the first and second cancellers. Correct timing is made possible by using buffer registers in the forward signal path to compensate for the delay in the feedback path.

20. The modulus extraction circuit following the second canceller is the equivalent of the bipolar rectifier in the analogue m. t. i. system. The output consists of 8-bit cancelled signals of uniform positive polarity.

De-multiplexing

21. The phase and quadrature signals have been handled independently up to this point in alternate 1. 5 $\mu$s range bins.

22. Fading due to phase blindness will not occur simultaneously in I and Q channels therefore these channels can be combined after cancellation and rectification. This is done in the I and Q de-multiplexer.

23. The output of the de-multiplexer is an 8-bit digital signal containing clutter residues, noise and moving target responses.

C.F.A.R. circuits

24. The dynamic range of this signal must be restricted before feeding to the display and uncancelled clutter residues reduced to a level at which they will not affect a visual display or automatic plot extractor.

25. Where 'constant false alarm' processing is required the signals are fed into a digital logarithmic converter which compresses the dynamic range from 8-bits to 4-bits.

26. C.F.A.R. processing is effected by storing the digital log signals for 16 pulse lengths in two 8-bit shift registers.

27. The stored signals are averaged and subtracted from the signal taken from the central point of the shift register. This has the effect of maintaining the general level of distributed clutter or noise constant at the output, independent of the input level.

De-stagger

28. Further sets of shift-register stores are used as delay elements to de-stagger the processed signals (both m.t.i. and normal radar). The stores are switched in to circuit to delay signals following an early transmitter pulse and switched out when signals are received following a late transmitter pulse. In this way signals are fed to the display which have a uniform time origin.

M.T.I. range gate

29. The m.t.i. and normal radar signals are combined in the m.t.i. radial range gate, which selects m.t.i. signals out to a pre-selected range, and normal radar signals from that range out to the maximum range of the display.

30. The m.t i. gate range is selected remotely from a supervisor's control panel at the display, or locally at the radar head during maintenance.

Digital integrator

31. The combined signals are fed to the digital integrator where they are first quantized on a 0 or 1 basis.

32. The integrator accumulates a count of '1's for each range bin, up to a maximum of 15, in the form of a 4-bit parallel word. The count is increased by one for each '1' at the input and reduced by one for each '0'.

33. The output of the integrator is either converted to analogue form and fed as video to the display, or thresholded at a certain accumulated count and fed to the display as quantized video.

34. Further digital/analogue converters enable normal radar video signals and m. t. i. video signals to be distributed to displays at standard levels (3V signal into 75ohms).

Timing system.

35. The timing system is referenced to a free running crystal oscillator which is divided down to the clock frequency of the digital processing circuits. The clock frequency is further divided to give the repetition frequency. The p. r. f. counter can be re-set by an external sync pulse where the timing is to be controlled from an external source.

36. Selected outputs from the p. r. f. counter are switched in sequence to form the staggered p. r. f. trigger to the transmitter. A uniform p. r. f. trigger is also derived for the display so as to give the correct time zero for the de-staggered signals.

37. A third counter ensures that the clock sequence for the shift registers in the cancellers is of the correct duration.

Line drive units.

38. Line drive units, which amplify and mix trigger, video and azimuth data, are also housed in the video processing rack. These units prepare the output data for transmission on cables to the display system.

# CHAPTER 4

## CONTROL AND DISTRIBUTION SYSTEM



### CONTROL RACK

1. The control rack provides control facilities and a.c. distribution for the transmitter and receiver system and houses the waveguide drier. All inter-rack connections are taken to the termination panel situated at the top of the rack. Similar termination panels are fitted to the transmitters and digital m.t.i. and video processing rack.
Units contained in the control rack are:-

(a) 50 volt power units

(b) Local radar control unit

(c) Selector panel

(d) A.C. distribution and control panel

(e) Waveguide dehydrator

#### 50 volt power unit

2. Two separate 50 volt power units (one main and the other stand-by) provide power for switching, relay functions and indicators for local and remote control of the AR-5 radar system.

#### Radar control unit

3. The local (radar head) radar control unit contains the controls for operation of the main functions as follows:-

(a) Scanner 'On/off'

(b) Radar 'On/off'

(c) Transmitter 1 control

(d) Transmitter 2 control (in a diversity system)

(e) M.T.I. 'In/out'

(f) Receiver

(i) Linear

(ii) Logarithmic

(iii) Logarithmic gated by Dicke-fix

(g) Integrator 'On/off'

(h) Circular polarisation.

4. A radar control panel identical to that fitted in the control rack can be provided at the display site in which case a local/remote selector unit is incorporated in the control rack.

A. C. distribution and control panel

5. This unit provides a. c. switching and indicators for supplying:-

(a) Transmitter/receivers

(b) S. S. R. (when fitted)

(c) Video processing (m. t. i. ) rack(s)

(d) Video map

(e) 50 volt power units

(f) Waveguide dehydrator

(g) Service sockets

(h) Aerial obstruction light

(j) Tower lighting

6. Each supply is provided with fuses or electro-magnetic circuit breakers as necessary.

DATA PROCESSING RACK

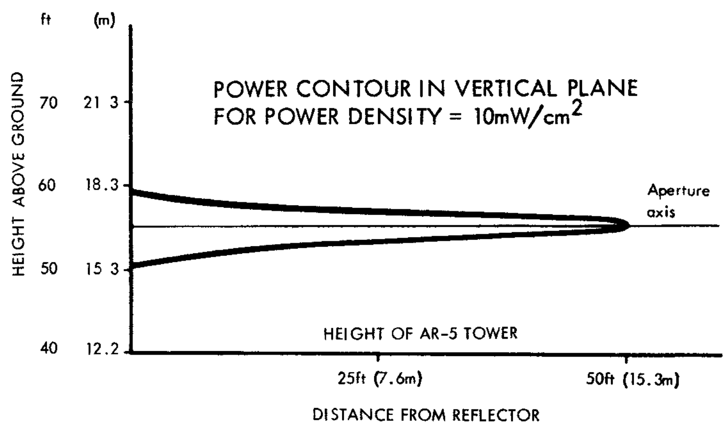
7. The data processing rack is normally situated in the equipment room adjacent to the operations room and contains the essential line amplifiers and video and trigger separation and distribution equipment. The rack also contains, where necessary, the additional equipment to meet particularly long cable runs and special interface problems.

## CHAPTER 5

## SAFETY

### RADIATION HAZARD

1. With the standard AR-5 tower, the centre of the reflector is approximately 55 feet (16.7m) above local ground level. Figure 5.1 shows the power contour for $10mW/cm^2$ power density in both planes from which it can be seen that nowhere does the vertical contour intersect the ground plane. Persons working on the tower platform may be within a region of potential hazard but this danger can be averted by organisational and other safety measures.



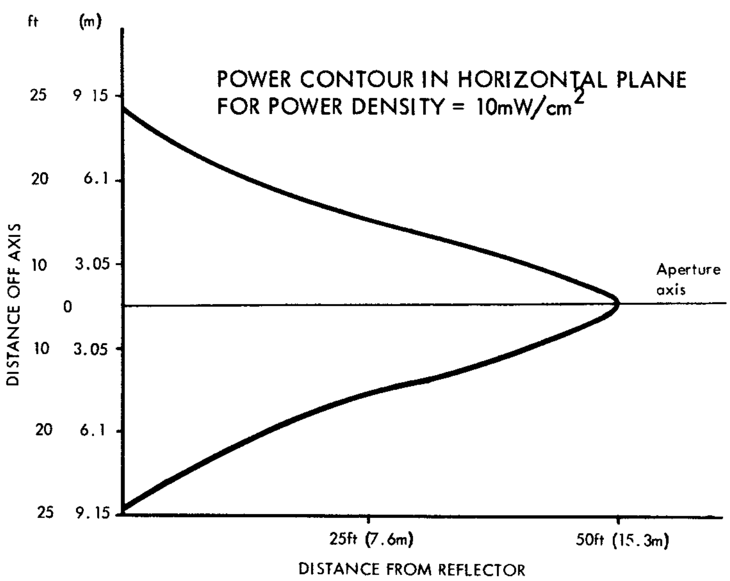




FIGURE 5.1

AR5 RADIATION HAZARD

SINGLE TRANSMITTER

AERIAL STATIONARY

### PROTECTION AGAINST OTHER HAZARDS

2. In accordance with the best established practices for the protection of operational and maintenance personnel against other radiation hazards, high voltages, rotating machinery, antenna movement etc, interlocks, key switches and other appropriate devices are fitted.

## CHAPTER 6

## RELIABILITY



### INTRODUCTION

1. Plessey Radar's policy imposes upon all design engineers the necessity to design for high reliability and system availability with low maintenance costs. To ensure that this aim is achieved, Plessey Radar has established a Standards Organisation, competent to advise in detail on reliability, which controls the type of components used by designers and maintains comprehensive records of equipments in service so that predictions of reliability can be supported by results actually achieved. Careful study in this way assures the user that the Company knows the reliability of its products, and it enables the Company to assess the expected spares consumption costs over a long operating period.

2. The user requires the assurance that the system purchased will function as he requires when he needs it, and he will wish to assess maintenance costs over the life of the system. These two factors, availability and cost, are not entirely within the control of the manufacturer; he is not necessarily aware for example, of the customer's particular facilities (among which stores policy, technician calibre and availability figure largely), but he can give maximum help in the following ways:-

(a) Competent recommendations about equipment servicing policy and spares holdings.

(b) Provision of clear and well-written operating and maintenance handbooks and manuals.

(c) Facilities for training the customer's technicians.

(d) The incorporation of adequate built-in test and monitoring equipment.

3. By paying close attention to all these matters, Plessey Radar Limited has ensured that the Type AR-5 is a well balanced system, with optimum trade-off between mean time between failures and mean time to repair; and in addition that the cost effectiveness in terms of capital costs and support costs is maximum for the present state of the art.

4. In addition to the general considerations of design policy mentioned above, Plessey Radar has calculated two important figures-of-merit:-

Mean time between failures (m.t.b.f.)

Mean time to repair (m.t.t.r.)

## MEAN TIME BETWEEN FAILURES

5. The following assumptions have been made in calculating m.t.b.f.:-

(a) Failure of test and monitoring facilities which do not directly affect the correct operation of the system are given an appropriately low weighting factor in the calculations.

(b) Components, such as the waveguide dehydrator, the failure of which does not immediately disable the system, are given a reduced weighting factor in the calculations.

(c) It is assumed that the recommended regular servicing procedures are followed and that hence the onset of mechanical wear or the deterioration of items known to have limited life will be noticed; and thus that catastrophic random failure from this cause is negligible.

(d) In the dual transmitter/receiver system allowance is made for the probability of repair of one transmitter/receiver should the other fail.

(e) Similarly, in the system with dual transmitters and dual m.t.i. allowance has been made for the probability of the repair of one channel should the other fail.

6. The calculated m.t.b.f. of the major sub-systems is as follows:-

| | |
|---|---|
| Transmitter/receiver | 1724 hours |
| Digital m.t.i. rack | 6670 hours |
| Control and distribution rack | 8330 hours |

7. The calculated m.t.b.f. for a complete system is:-

1720 hours

## MEAN TIME TO REPAIR

8. The time required for fault location and repair has been reduced

to the minimum by imaginative design and careful planning and layout; in particular the maximum use of integrated circuits has immensely increased reliability and has much reduced the time for fault diagnosis.

9. For the AR-5 electronics the mean time to repair is estimated as 1 hour. This includes fault diagnosis, replacement of faulty components, testing and setting up.

REFERENCES:


MIL HDBK 217A - Reliability, Stress and Failure Rate Data for Electronic Equipment.

NAVSHIPS 94234 - Maintainability Design Criteria Handbook for Designers of Electronic Equipment.

# CHAPTER 7

## WEIGHTS AND DIMENSIONS (APPROXIMATELY)

### AERIAL REFLECTOR, BOOM ASSEMBLY AND PEDESTAL

| | | | |
|---|---|---|---|
| 1. | Height | 7.968m | 26ft $1\frac{1}{4}$in |
| | Width | 14.63m | 48ft 0in |
| | Depth | 8.356m | 27ft 6in |
| | Turning Circle (Radius) | 7.46m | 24ft 6in |
| | Weight | 10 520kg | 23 000lb |

### PLATFORM ASSEMBLY
(Includes turning gear support and outer platform structure)

| | | | |
|---|---|---|---|
| 2. | Width | 6.096m | 20ft 0in |
| | Depth | 8.839m | 29ft 1in |
| | Weight | 9 526kg | 21 000lb |

### TURNING GEAR

| | | | |
|---|---|---|---|
| 3. | Weight | 5 988kg | 13 200lb |

### CABIN ASSEMBLY

| | | | |
|---|---|---|---|
| 4. | Weight | 1 524kg | 3 360lb |

### TOWER ASSEMBLY (4 SECTION)

| | | | |
|---|---|---|---|
| 5. | Height | 12.23m | 40ft 0in |
| | Width | 4.28m | 14ft 0in |
| | Depth | 4.28m | 14ft 0in |
| | Weight | 11 455kg | 25 200lb |

### TRANSMITTER/RECEIVER ASSEMBLY

| | | | |
|---|---|---|---|
| 6. | Height (Exc. feet) | 1.93m | 6ft $4\frac{1}{2}$in |
| | Width | 2.03m | 6ft 8in |

| | | | |
|---|---|---|---|
| | Depth | 0.775m | 2ft $5\frac{3}{4}$in |
| | Weight | 1 527kg | 3 360lb |

VIDEO PROCESSING (M.T.I.) RACK

| | | | |
|---|---|---|---|
| 7. | Height | 1.93m | 6ft $4\frac{1}{2}$in |
| | Width | 0.66m | 2ft 2in |
| | Depth | 0.755m | 2ft $5\frac{3}{4}$in |

CONTROL RACK

| | | | |
|---|---|---|---|
| 8. | Height | 1.93m | 6ft $4\frac{1}{2}$in |
| | Width | 0.66m | 2ft 2in |
| | Depth | 0.755m | 2ft $5\frac{3}{4}$in |

# SECTION 3

# TYPICAL SCHEDULE OF EQUIPMENT

SECTION 3

## TYPICAL SCHEDULE OF EQUIPMENT

| Item | Qty | Description |
|---|---|---|
| 1. | 1 | Single transmitter, single d.m.t.i. system comprising items 1.1 to 1.11. |
| 1.1 | 1 | Aerial assembly including reflector, boom arm, two r.f. feeds, variable polariser, waveguide run, tilt and level indicator. |
| 1.2 | 1 | Centre module complete with turning gear and switchgear, rotating joint, data take-off unit, slipring assembly and lubrication unit. |
| 1.3 | 1 | Transmitter/receiver system including duplexer, magnetron, modulator, e.h.t. supply, isolator, parametric amplifier, mixer assemblies, local oscillator, a.f.c. and i.f. amplifiers, meter and indicator panels, power supplies and cooling system. |
| 1.4 | 1 | Moving target indicator and information processing rack, including coherent receiver(s) video processing units, monitor oscilloscope, system control panel. |
| 1.5 | 1 | Control rack providing a.c. distribution and cable termination and including radar control panel and waveguide dehydrator. |
| 1.6 | 1 | Cable termination unit (display location). |
| 1.7 | 1 | Data processing rack, including line termination equipment and power units. |
| 1.8 | 1 set | Waveguide installation (to suit 40ft (12.2m) tower). |
| 1.9 | 1 set | Transmitter room cables and waveguides. |
| 1.10 | 1 set | Aerial to transmitter inter-connecting cables. |
| 1.11 | 1 | Tool kit. |

| Item | Qty. | Description |
|---|---|---|
| ADDITIONAL ITEMS | | |
| 2 | 1 set | Additional equipment to provide the Type AR-5 Radar with dual transmitter and receiver, comprising items 2.1 to 2.3. |
| 2.1 | 1 | Transmitter/receiver system including duplexer, magnetron, modulator, e.h.t. supply, isolator, parametric amplifier, mixer assemblies, local oscillator, a.f.c. and i.f. amplifiers, meter and indicator panels, power supplies and cooling system. |
| 2.2 | 1 | Diversity unit and load. |
| 2.3 | 1 set | Additional installation materials. |
| 3 | 1 set | Additional equipment to provide the Type AR-5 Radar with dual m.t.i. units comprising items 3.1 and 3.2. |
| 3.1 | 1 | Moving target indicator and information processing rack including coherent receiver(s) video integrator, video processing units, control panel and changeover panel. |
| 3.2 | 1 set | Additional installation materials. |
| 4. | 1 set | Test equipment. |
| 5. | 1 set | Recommended spares. |
| 6 | 1 set | Additional equipment, incorporated in item 1 to provide $\frac{1}{2}$ speed aerial turning. |
| 7 | 1 | Aerial Cabin. |
| 8 | 1 | Top platform and extended service platform complete with walkways and guard rails. |
| 9 | 1 | Lattice tower, complete with stairs, walkways and waveguide support ladders. 1-section (3.05m) or 2-section (6.1m) or 3-section (9.15m) or 4-section (12.2m) |
| 10 | 1 | Plessey Mk. 8, 16 inch monitor p.p.i. display, for use at the radar head. |
| 11 | 1 | Radar Remote Control Panel. |
| 12 | 1 set | Intersite cables. |