PLESSEY AR1 AIR SURVEILLANCE RADAR

PLESSEY RADAR
PLESSEY ELECTRONICS GROUP

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TECHNICAL LITERATURE

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INTRODUCTION

1. The Plessey AR-1 is a medium range air surveillance radar capable of fulfilling a number of civil and military air traffic control roles. Among these are terminal air surveillance approach control and the surveillance radar element (SRE) of ground control approach (GCA) radar. It also fulfils the standards and recommended practices stipulated in ICAO Annexe 10 for p.p.i. approaches and departures.

General view of the AR-1 installation at the Company's Training Centre on the Isle of Wight.

2. The equipment, which operates in the 'S'-band offers the advantages of high discrimination and resolution with small antenna dimensions and solid coverage with freedom from lobing effects. A combined transmitter/receiver cabinet is used, the transmitter provides a peak power of 650kW, the receiver utilises a travelling wave tube r.f. amplifier to give improved reliability and a low noise figure. Either a single transmitter/receiver version, or dual transmitter/receiver version with both units operating in frequency diversity may be provided. In this latter form an increase in coverage over the single transmitter version of some 15-20% at 80% blip scan ratio is afforded. The diversity operation also has the advantage of providing instantaneous standby in the case of a single transmitter failure and ensures no break whatsoever in operation.

3. Typical coverage achieved on AR-1 is that shown in Figure 3 Chapter 2 of this brochure. It is emphasised that the coverage shown for a single transmitter system was achieved during very extensive British Air Ministry flight trials with m.t.i. in use. The improved coverage shown for diversity operation has also been carefully checked by flight trials.

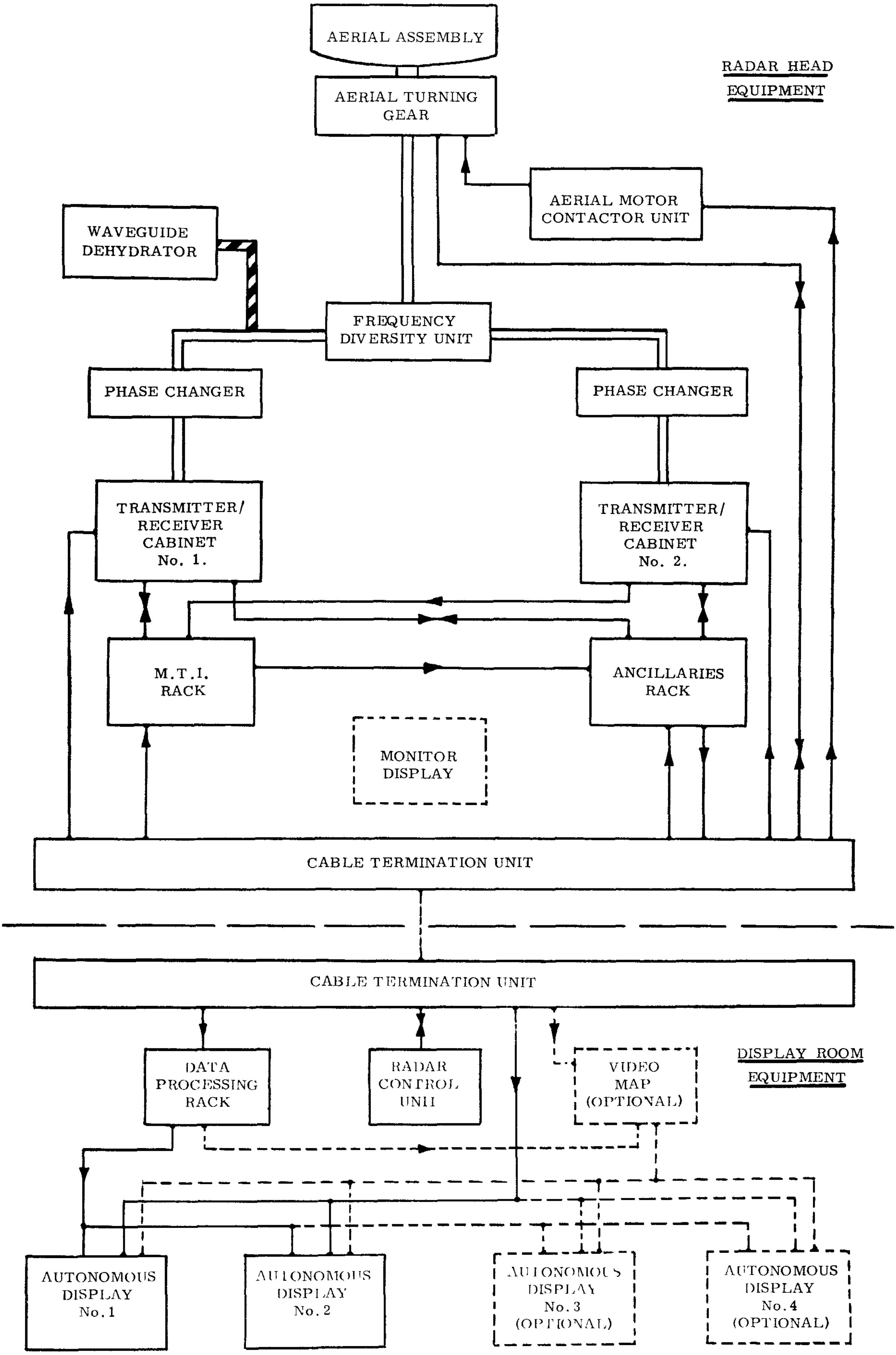
4. The Plessey AR-1 m.t.i. system is fully transistorised and incorporates the latest techniques for improved reliability. Double cancellation techniques are incorporated to provide a cancellation ratio of 27dB, which is equivalent to a sub-clutter visibility of 21dB with the aerial rotating at 15rev/min. Triple p.r.f. staggering is used to reduce the number of blind speeds, the first blind speed is at 560 knots. The m.t.i. range gate control is individually variable at each display between 0-75 nautical miles; the setting at one display in no way affects that of the others. Provision is also made for the introduction of raw radar background video, thus enabling a controller to superimpose a low level of permanent echo background, in the m.t.i. region, whilst retaining the facility for seeing aircraft as clear responses above or relative to the permanent echoes. The intensity of the background video is fully variable and individually selectable at each display and again in no way does the setting at one display affect that of the other displays.

5. Plessey Radar Limited have wide experience in the use of weather suppression techniques for 'S'-band radars. The vast amount of knowledge accumulated over many years of operational experience has been used to incorporate in the AR-1 a most efficient variable polarisation system. Not only are users of the AR-1 able to reduce the effect of precipitation clutter, but they are also able to select a setting such that storm centres or areas of intense precipitation only may be shown in order that aircraft might be vectored around these troublesome areas. As described in detail in this brochure, the system used has broad band characteristics to ensure optimum performance when dual transmitter frequency diversity operation is in use.

6. In addition to adopting the very latest operation and technical features in the design of the AR-1, Plessey Radar Limited have pre-designed a number of AR-1 installation layouts such that provided a customer selects one of many standard variations most suited to his particular requirement, installation design, installtion services, and installation time are kept to a minimum with consequent reduction in overall cost. Furthermore, delivery of equipment is accelerated, and as standard practice, the equipment is system tested prior to despatch to the customer.

7. The AR-1 has been fully evaluated, both operationally and technically, by the British Ministry of Defence (Air), as a result of which they have placed an order for a substantial number of equipments.

8. The high reliability, outstanding performance, and versatility of this latest terminal area approach radar are combined to make the Plessey AR-1 the most advanced radar of its kind in the world.



SYSTEM BLOCK DIAGRAM

FIGURE 1

CHAPTER 1

AR-1 SYSTEM DESCRIPTION

1. The signal flow and video processing stages of the AR-1 are described in this chapter to show how the radar operates as a system; equipment descriptions follow in a later chapter. Only the frequency diversity version is described here as it is the more usual one and the difference between it and a single transmitter/receiver version can be readily deduced. A simplified block diagram is shown in Figure 1.

AERIAL SYSTEM

2. The aerial system consists of a horn-fed double curvature reflector mounted on the turntable of a turning gear which provides an aerial rotation rate of fifteen revolutions per minute. The reflector has a span of 16 ft (488 cm) and is fed from a horn supported by a boom arm which also carries the variable circular polariser.

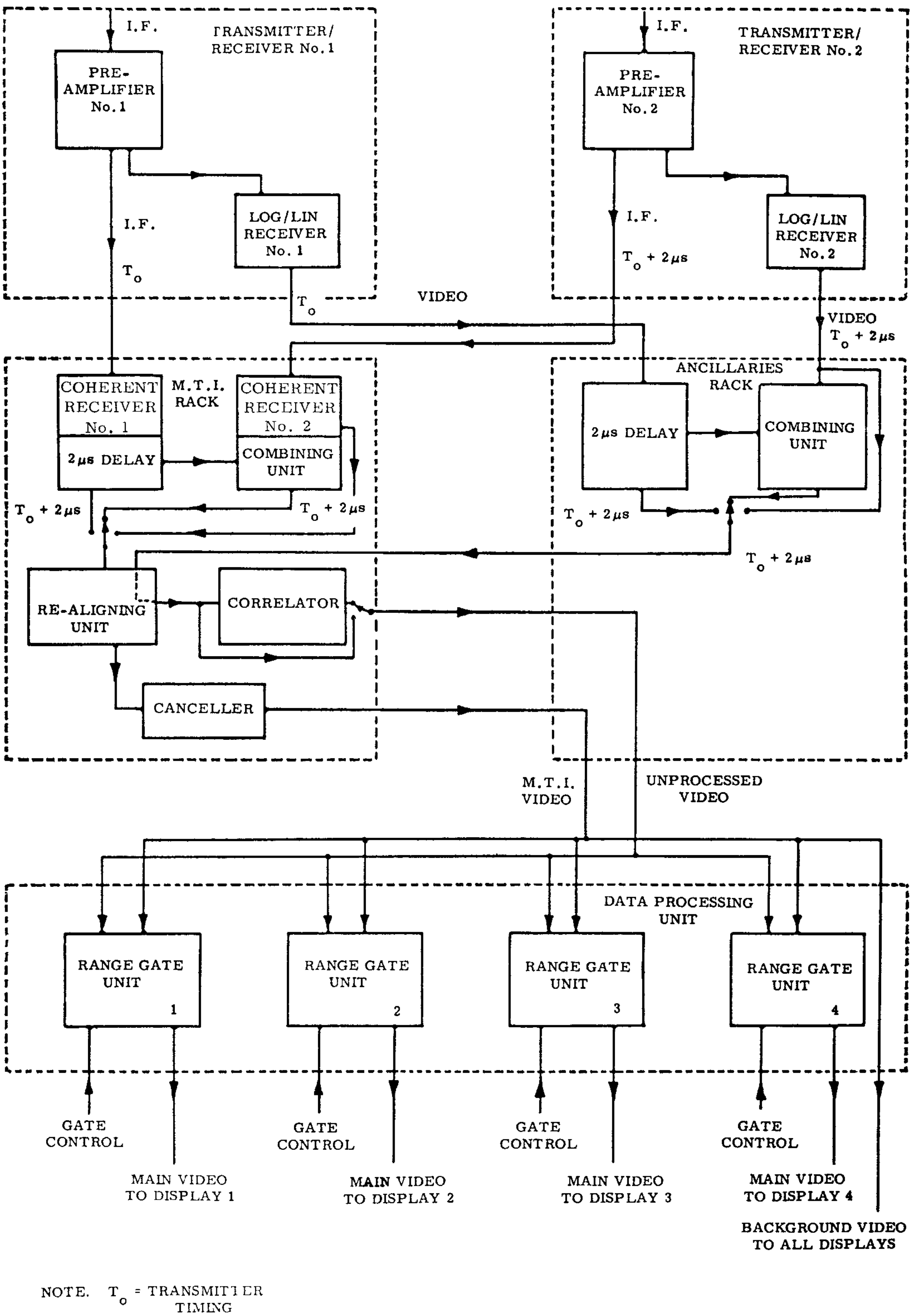
TRANSMITTER ROOM

3. Two transmitter/receivers, each incorporating an S-band 650 kW transmitter and a low noise travelling wave tube receiver, provide two separate transmitter/receiver channels. The transmitters operate on frequencies of 2880 Mc/s and 3020 Mc/s respectively and are connected to the aerial via the frequency diversity unit which is a passive device incorporating an arrangement of couplers and filters, allowing two transmitter/receivers to operate simultaneously with a single feed aerial.

4. The m.t.i. system includes the master timing source for the whole system, and to avoid an undue build-up of power in the waveguide system, a delay of 2 μs is introduced in the trigger line of one transmitter. Because of this delay and because the m.t.i. system uses three pulse stagger to minimise blind speed affects, the receiving system is designed to restore the correct timing relationship. It also combines the video from both channels, though switching is provided to give a choice of either combined video or the video from either channel. These arrangements and their relationship to m.t.i. processing are shown in more detail in Figure 2.

5. Returning signals are routed by the diversity unit to the appropriate transmitter/receiver where they pass via a duplexer, t.r. cell and t.w.t. amplifier to the signal mixer and thence to an i.f. signal pre-amplifier.

6. From each channel the i.f. output from the pre-amplifier is fed to its associated coherent receiver in the m.t.i. rack and also to a transistorised log/lin receiver within the transmitter/receiver cabinet. The log/lin outputs from each channel are fed to the ancillaries rack, where a 2 μs delay is introduced into the undelayed line to bring the signals into time coincidence, and they are then combined to form a single signal. A switch, remotely controlled from the radar control panel, feeds this combined video signal, or the video from either channel, to the m.t.i. rack where it is realigned ('de-staggered') with respect to normal



SIGNAL PROCESSING BLOCK DIAGRAM

p.r.f. At this point a correlation stage may be switched in to reduce unwanted interference from unsynchronised signals and the video is then fed to a data processing rack in the display room.

7. The i.f. signals fed from the pre-amplifier in each transmitter/receiver cabinet to the m.t.i. rack are processed to give cancelled video, and also undergo similar stages of delay correction and combination to those just described for the non-cancelled video. As shown in Figure 2, the cancelled video is then fed via the ancillaries rack to the data processing rack in the display room.

DISPLAY ROOM

8. Normally two 12inch (30cm) p.p.i. fixed coil displays are fitted, along with the radar control panel, at the operating position but up to four displays can be driven.

9. In order that m.t.i. may be presented from zero range to any desired range up to 75n.m., m.t.i. range gating is provided.

10. A separate range gate unit for each display is fitted in the data processing rack and each is fed with cancelled and uncancelled video. A range gate control is fitted at each display and provides a control signal to its associated gate giving a resultant video signal which is composed, in any one p.r.f. interval, of two parts, viz, m.t.i. video out to the selected range, followed by normal (uncancelled) video. This provides the basic p.p.i. picture and is known as 'main' video.

11. As well as being fed to the range gates, the unprocessed video is fed to all displays and can be presented at an intensity controllable from zero to normal viewing level by the operator. This permits the introduction of a light background of 'raw' radar within the m.t.i. region quite independently of m.t.i. performance, this video being referred to as 'background' video.

12. Although several stages are involved in video processing, these are inherent to the system and the operator has a simple task in composing his picture as he manipulates only main video and background video which contain all the constituents for the most effective presentation.

13. The radar control unit which is normally located adjacent to one of the displays provides remote control facilities for the two transmitter/receivers, aerial turning gear, receiver and m.t.i. characteristics and circular polarisation.

14. If fitted, the video map provides two channels of information (e.g. map grid and marker beacons) from transparencies.

EQUIPMENT LAYOUT

15. A number of standard layouts for the aerial and radar head equipment has been designed. These standard layouts enable the purchaser to choose the one most suited to his requirements. Four typical equipment layouts are described in Chapter 6.

16. As local requirements vary greatly, decisions on the display room layout for each separate installation cannot be anticipated. However, sufficient outline information for the customer, when considering a suitable layout, is given in Chapters 6 and 7.

17. The standard equipment is suitable for a maximum separation distance between the display room and the transmitter equipment room of up to 2,000yd (1,800m). Additional equipment can be supplied for greater separation distances.

CHAPTER 2

PERFORMANCE

Coverage

1. Typical vertical coverage diagrams are shown in Figure 3 for diversity and single transmitter working. These diagrams represent the results of field trials on a typical AR-1 installation in normal operation; the single transmitter coverage diagram, was explored in very great detail, and further flight tests were made to establish with confidence the scaling factor for the diversity operation coverage diagram.

Azimuth accuracy and resolution

2. The azimuth accuracy of the AR-1 is better than ±1°. On a typical installation, using targets of similar size, the resolution has been measured at better than 1°.

Range accuracy and range resolution

3. The range accuracy and resolution for AR-1 are both shown in Figure 4 where they are compared with the recommended standards of I.C.A.O. Annex 10 for S.R.E. equipment. The range resolution as measured during official evaluation was considerably better than shown in Figure 4, which is based on the worst performance.

M.T.I. performance

4. The sub-clutter visibility has been measured by conventional laboratory tests to be 21dB, and extensive trials have proved that this is the minimum figure obtainable.

5. When the AR-1 is used with one transmitter operating, the first true blind speed is at 560 knots, thus avoiding the risk that an aircraft will pass into a critical m.t.i. speed during the final stages of an approach. When used with two transmitters in diversity operation, the first true blind speed is in excess of 9,000 knots.

6. A radial speed of zero knots must of course always represent a blind speed in a system designed to differentiate between fixed and moving targets and since aircraft on tangential courses must pass through a point at which their radial speeds will be zero the loss of 1 or 2 paints in the vicinity of the tangential point cannot be avoided; were it not for this point it would perhaps be unnecessary to alter the range over which m.t.i. is applied. However, in order to provide for the best possible conditions at each display the system has been so designed that m.t.i. may be applied to any part of the range scale out to 75n.m. starting from zero range. This control is effected from the display by the range gate control which operates upon the range gate unit in the data processing rack. The main video line carries, during each timebase, moving target video up to the time (and hence the range) dictated by the setting of the range gate control followed for the remainder of the timebase by normal video.

7. The background video control also on the display provides for the insertion of raw video (without m.t.i.) to any desired level without affecting the m.t.i. performance for other displays. This is a notable advance over other radar systems which can achieve the insertion of permanent echo information only by unbalancing the m.t.i. cancellation unit thereby spoiling m.t.i. performance for all displays. The background video control also provides an insurance against the loss of signals from the normal video channel; for these circumstances it can be advanced far enough to paint a normal radar picture although this is of course without m.t.i. The coverage shown in Figure 3 is maintained when m.t.i. is not used.

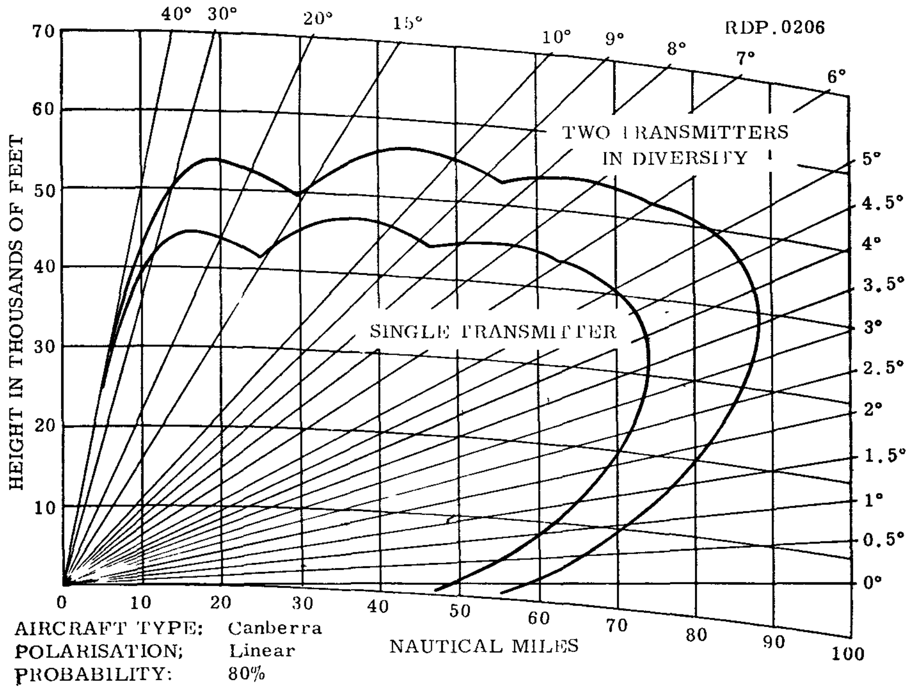


FIGURE 3. COVERAGE DIAGRAM

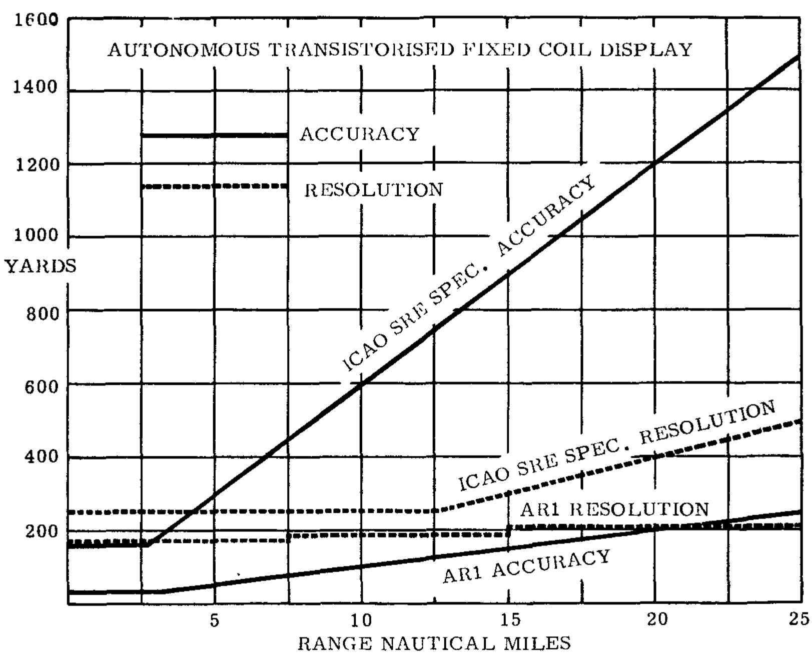


FIGURE 4. RANGE ACCURACY AND RESOLUTION

PLATE 1 P.P.I. PRESENTATION OF M.T.I.

The AR-1 transistorised m.t.i. system enables a choice of main or background video, or a combination of the two, to be made individually at each display position. Double cancellation combined with triple p.r.f. staggering results in a sub-clutter visibility of 21dB with no significant blind speeds below 9 000 knots using the diversity AR-1 system, or 560 knots using the single transmitter system.

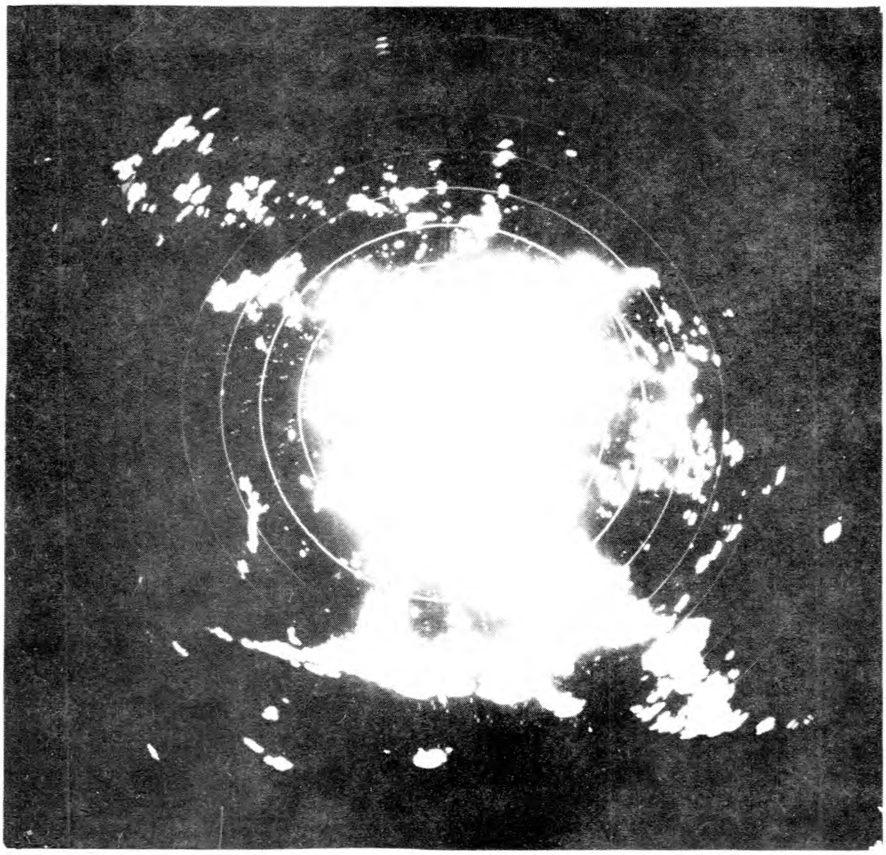
PERMANENT ECHO PATTERN

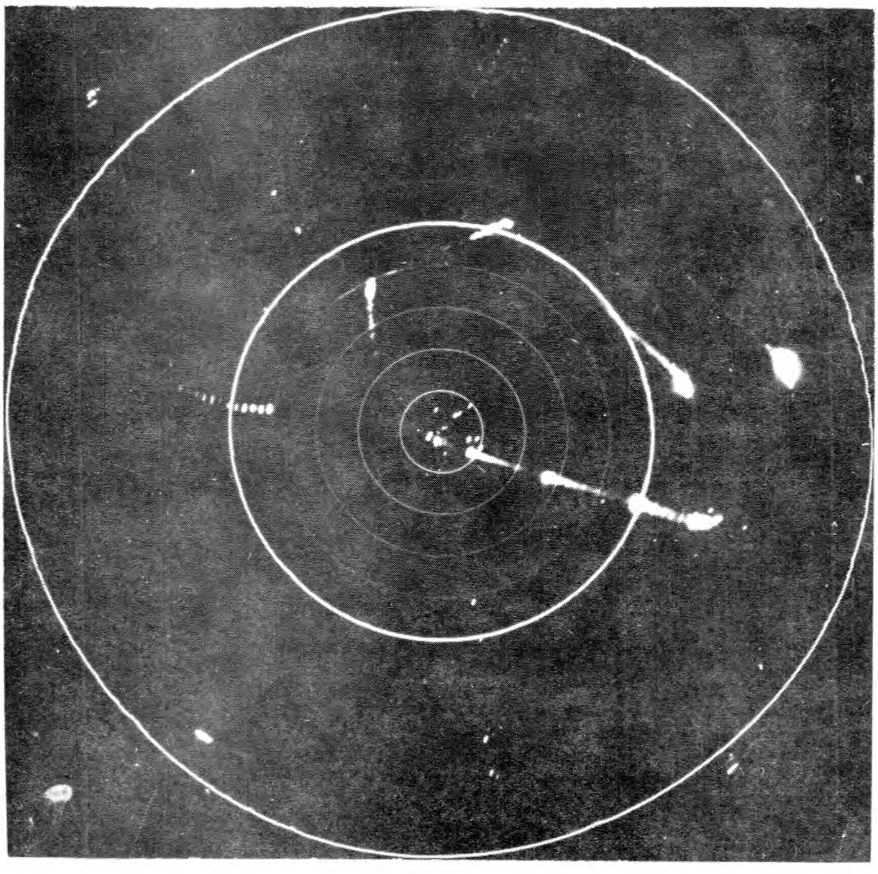
With m.t.i. switched out the full permanent echo pattern is displayed.

Strong permanent echoes are evident to a range of 16 to 20n.m. Maximum intensity measured is in excess of 50dB measured at r.f.

M.T.I. VIDEO

By switching to m.t.i. video, the whole mass of the permanent echoes is suppressed and aircraft targets are clearly seen. This photograph taken at the same location as the previous photograph shows aircraft sequenced at 3n.m. to 4n.m. intervals on approach. It is particularly noteworthy that aircraft can clearly be seen into touchdown.





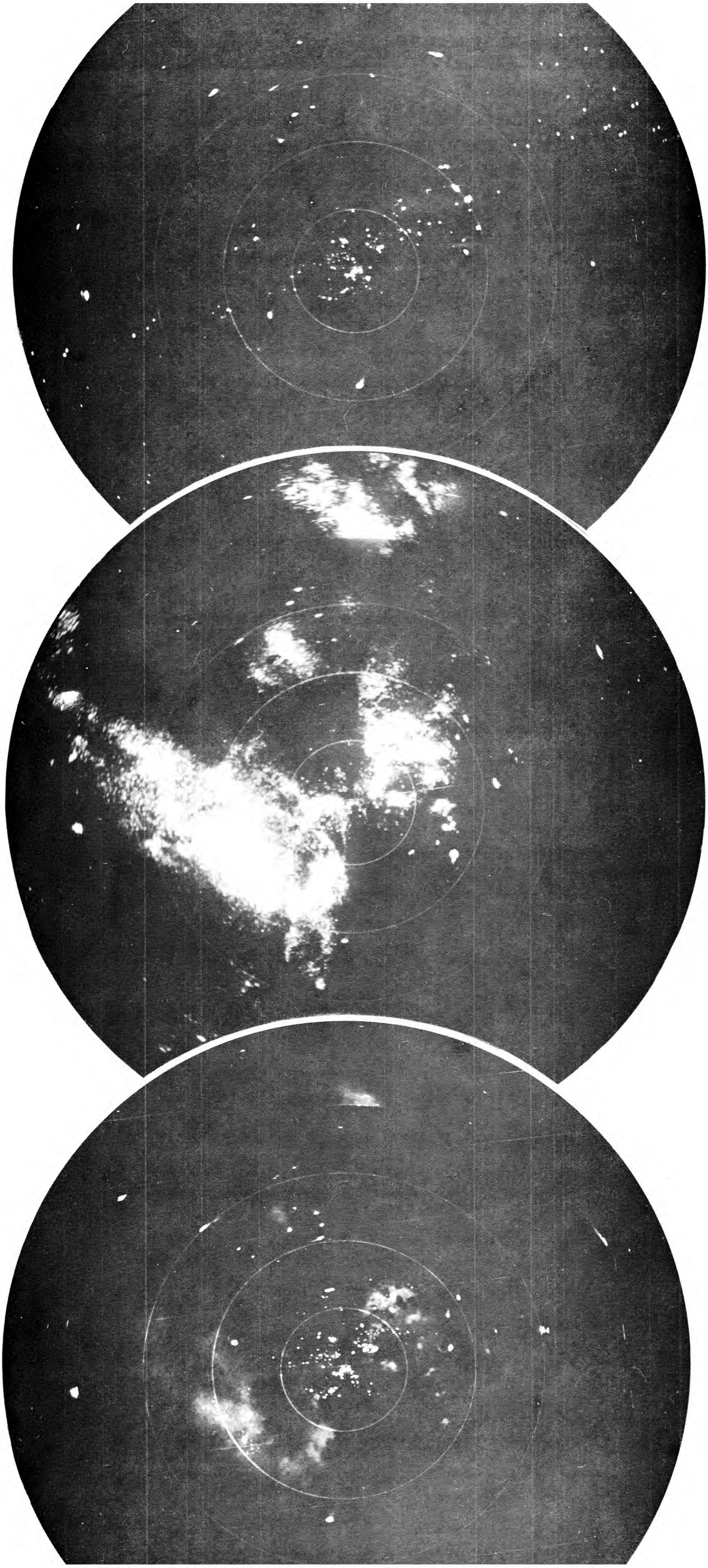


PLATE 2 P.P.I. PRESENTATION OF CIRCULAR POLARISATION

Effectiveness and versatility are the key features of the AR-1 variable polarisation system for the control of precipitation clutter. The series of photographs on the opposite page, taken at minute intervals on a 50 mile range scale at Cowes, Isle of Wight, shows the effect of circular, linear and ellipitical polarisation under the same conditions and indicates how full operational potential can be retained by simple adjustment.

The photographs were taken in the Autumn of 1963 during moderate to heavy rain. The British Isles were experiencing a prolonged period of heavy rain and flooding caused by a stationary occluded front. Cloud extended to 20,000 feet with wind from the south west gusting to 35 knots.

The gain setting is constant throughout the series.

CIRCULAR SETTING

This photograph was taken with the variable polarisation system adjusted to circular to reduce the rain clutter as completely as possible. The aircraft on the bearing of 190° is at 18 miles range and other aircraft within the rain areas can be seen at 250° 15 miles, 050° 20 miles and 060° 20 miles.

The p.p.i. picture is as clear as it would be in fine weather.

LINEAR SETTING

The p.p.i. shows only one aircraft clear of the rain area at at 190°, range 22 miles. The general level of rain makes the radar inoperable.

ELLIPTICAL SETTING

This photograph illustrates the use of fully variable polarisation to show up rain areas without masking aircraft targets. The remotely controlled polarisation has been adjusted to elliptical polarisation to show faintly the general area of rain, yet the aircraft at 250° 15 miles in the top photograph can still be clearly seen and its afterglow trail identified. This important operational facility enables aircraft to be vectored clear of storm centres and areas of heavy turbulence.

Additional operational facilities

8. Additional facilities are included in AR-1 to permit the best possible performance to be obtained from the equipment in various adverse conditions. A selection of receiver modes is provided ranging from linear, the sensitive condition which should be regarded as normal, to logarithmic plus differentiation which adds a powerful weapon against weather clutter in support of the circular polarisation and against ground clutter, if any, outside the range gate.

9. Advantage has been taken of the existence of an otherwise spare channel through the m.t.i. delay line to include in the radar a two pulse correlator. This device, which allows the passage only of pulses arriving at precisely the same time after the beginning of each timebase, offers considerable discrimination against pulse interference from other radars. The threshold control is provided to enable the correlator threshold level to be set to suit the conditions of interference. When no interference is present the correlator may be by-passed.

10. The use of the staggered p.r.f. to improve the m.t.i. performance in respect of blind speeds brings another benefit in that it permits ready identification of second trace echoes. When propagation conditions are such that these occur, they will appear on the display as groups of rather smudgy echoes extended in range because of the staggering of the p.r.f. and the consequent absence of time alignment of the echoes with the transmitted pulses. Their true identity as second trace echoes can be established readily by switching off the p.r.f. stagger at the radar control unit when the smudges will coalesce to take on the appearance of normal permanent echoes.

Diversity working

11. In designing AR-1 it was set as a requirement that zero time should elapse in restoring the equipment to operational service in the event of a transmitter failure.

12. It was thought that the only way to achieve this end was to have two transmitters working simultaneously into the aerial; to make this possible they have to be on different frequencies. As a result of this frequency separation, the blip/scan ratio of targets of any given range is considerably increased. Diversity working therefore offers the two very important advantages of:-

(a) true non-break operation

(b) greatly increased coverage at high blip/scan ratios

13. It is important to note that in clear weather conditions when it is not considered essential to have the no-break facility, either transmitter can be operated by itself into the aerial (the appropriate receiver being selected at the switch on the radar control panel) to yield the performance shown for the single transmitter coverage in Figure 3. Whilst one transmitter is being used in this way, the other may be fully serviced without disconnecting it from the system and without any effect on the display. It is to be expected of course that both transmitters will be running whenever visibility conditions are marginal or deteriorating towards the marginal, since it is in these conditions that the importance of no-break operation becomes paramount.

Circular polarisation

14. AR-1 has the most advanced type of circular polarisation equipment in service anywhere. It may be used to reduce echoes from rain to a level where they are no longer a nuisance to controllers. On the other hand, because the cancellation is continuously variable, it is possible when desired to leave a rain

echo dimly perceptible on the p.p.i. as an indication of the whereabouts and distribution of the bad weather.

Displays

15. AR-1 employs displays from the Plessey autonomous TDS5 Series. These are fully transistorised and self-contained within a single unit. Fixed coil techniques are used, and provision is made for one interscan line; the latter may be used centred or off-centred as a range and bearing line or may be coupled through a special adaptor to present c.r.d.f. bearing lines originating from the position of the c.r.d.f. aerial. Range scales are 7.5, 15, 30 and 75 nautical miles per radius and full off-centring is available. Provision is made for video map and secondary radar inputs through separate on/off switches and gain controls whilst other controls are provided for m.t.i. video, normal radar background, calibration ring intensities etc. The range and bearing shown by the interscan line is read on an optically produced scale. An important advance of this display equipment is indicated by its total heat dissipation of 200W, rendering cooling problems in operations rooms negligible.

16. An alternative version of this display is available, against special order, for area control which differs only in that its range scales are 12.5, 25, 50 and 100 nautical miles per radius.

CHAPTER 3

DATA SUMMARY

1. RADIATION

Frequency	
Diversity operation	2880Mc/s ±20Mc/s and 3020Mc/s ±20Mc/s
Single transmitter station	A frequency in the band 2700-3100Mc/s.
Polarisation	Variable from linear through elliptical to circular. The figures below refer to linear polarisation.

2. AERIAL

Gain	31dB relative to isotropic radiator.
Horizontal aperture	16ft (488cm).
Horizontal beamwidth	1.5° to half power points.
Vertical aperture	6.5ft (198cm).
Horizontal sidelobes	-21dB relative to maximum aerial gain within ±5°, -24dB outside ±5°.
Rotation rate	15rev/min clockwise (at 50c/s supply).

3. TRANSMITTER

Magnetron peak power	650kW nominal at a duty cycle of 0.0007
Pulse length	$1\mu s \pm 0.1\mu s$
Pulse recurrence frequency	700p.p.s. mean.
Stagger p.r.f. ratio	7:8:9

4. RECEIVER (TWT)

Noise factor	Not worse than 6dB
Intermediate frequency	30Mc/s.
Overall bandwidth	1.2Mc/s.

Automatic frequency control	A.F.C. facility is provided.
Receiver characteristics	Linear Logarithmic Linear plus differentiation Logarithmic plus differentiation } Selected at radar control unit.

5. MOVING TARGET INDICATOR

Cancellation	3 pulse
Cancellation ratio	27dB
S.C.V.	21dB
Range gate	Independently variable at each p.p.i. and may be set to any range between 0 and 75n.m.

6. DISPLAYS

Type	Autonomous transistorised fixed coil display.
Quantity	Normally two displays are provided but up to four can be driven.
Cathode ray tube	
Type	12in (30.5cm) diameter, long persistence.
Spot size	0.25mm diameter.
Spot wander	Less than half a spot diameter.
Presentation	Plan position display with one interscan line.
Data presented	
Radar video	Main video. Background video.
Other data	Range markers One interscan line Video map (Channel A or B) S.S.R. video } if inputs available
Range scales	0-7.5n.m. 0-15n.m. 0-30n.m. 0-75n.m. } per tube radius Range scales are pre-set and are selected by push-button.
Range expansion	Registration of mainscan and interscan is maintained. Expansion, when off-centred, is about tube centre.

Off-centring

Up to maximum range in all directions with registration of mainscan and interscan maintained. Off-centring is effected by two slow-motion controls.

Range markers

At 2 and 10n.m. intervals, as selected by push-button. When 2n.m. intervals are selected, every fifth marker is accentuated. A range marker gain control is provided.

Video characteristics

Main video

The displays will provide a separate channel for gated m.t.i. video and raw video signal, with a separate gain control. A m.t.i. range control is mounted on the operator's control panel.

Background video

The displays will provide a separate channel for unprocessed radar video with a separate gain control.

S.S.R. video

One channel is available for s.s.r. video signals (if provided) with an associated video gain control.

Video map

Each display can select by means of push-button switches between two video map inputs (if provided). A single gain control is provided.

Interscan aid

One interscan line is provided which may be used (by push-button selection) as:-

(a) A range and bearing line, or

(b) A c.r.d.f. line.

The origin of this line, when in the range and bearing mode, may be off-centred, selection of centre/off-centre being effected by a push-button.

Range and bearing mode

Range - The range of the line is continuously variable from $1\frac{1}{2}$-75n.m. The accuracy of range measurements made when the interscan line is centred is better than ±0.5% of actual range or ±400yd, whichever is the greater.

Bearing - The bearing of the line is continuously variable throughout 360°. The accuracy of bearing measurements made when the interscan line is centred is ±0.5°.

C.R.D.F. line

Each display will accept c.r.d.f. deflection signals with a modulus of ±6V and a c.r.d.f. on/off gate signal which connects 2 wires when the c.r.d.f. is on bearing.

Note: As an optional extra, a unit can be provided which will change the modulus of the c.r.d.f. equipment outputs to ±6V and provide facilities for off-centring the origin of the line to the site of the c.r.d.f. station. A minimum threshold detection device for setting the on/off gate can also be supplied, if required.
An interscan line brilliance control is provided.

The display control panel contains the following controls:-

Control	
Panel and cursor illumination	Mounted under a flap
C.R.T. focus	Mounted under a flap
X and Y centring	Mounted under a flap
Video channels 1-4 gain (4 separate controls)	Mounted under a flap
2n.m. range marker brightness	Mounted under a flap
10n.m. range marker brightness	Mounted under a flap
Radar trace brightness	Mounted under a flap
Overall video limiter	Mounted under a flap
Off/standby/on switch	Mounted under a flap
Range selector push button (7.5, 15, 30 and 75n.m.)	

The operator's control panel on each viewing unit contains the following controls:-

Control	
Interscan bearing, 0-360°	with illuminated readout graticules
Interscan range, 0-75n.m.	with illuminated readout graticules
Panel illumination	
M.T.I. range	
Line brilliance	
Radar X and Y off-centring	
Line X and Y off-centring	
Line on/off	Push-button on/off switches
Radar shift on/off	Push-button on/off switches
Line shift on/off	Push-button on/off switches
Main video	Push-button on/off switches
Background video	Push-button on/off switches
S.S.R. video	Push-button on/off switches
Video map A	Push-button on/off switches
Video map B	Push-button on/off switches
Range marks 2n.m.	Push-button on/off switches
Range marks 10n.m.	Push-button on/off switches
C.R.D.F. selector	Push-button on/off switches

Display overlay

An amber implosion screen engraved with a 360° compass rose at 1° intervals is fitted over the face of the c.r.t.

Reflection plotter

An anti-parallax screen can be supplied with each p.p.i. for fitting over the face of the cathode ray tube.

7. RADAR CONTROL UNIT

Location	Adjacent to one of the displays.
Controls and indicators (Duplicated as required where two transmitter receiver cabinets are fitted.)	Radar on/off. E.H.T. on/off and indicator lamps. E.H.T. reset button and lamp. Aerial supply on/off. Receiver lin/log switch. Differentiation on/off. Circular polarisation control and meter. M.T.I. on/off. Video correlator on/off. Correlator threshold sensitivity control. Display mainscan generator selector. Stagger on/off.

8. SEPARATION

Aerial-transmitter	The coverage diagram (Figure 3) was obtained with a 12m waveguide run. If additional waveguide is required, an allowance of 0.5% reduction in slant range should be made for every metre of waveguide.
Transmitter-displays	With the standard equipment, the separation between the transmitter/receiver and the display equipment may be 2,000 yards cable run. Additional equipment can be supplied to permit greater separations.

9. POWER SUPPLIES

General	The aerial turning motor and transmitter/receiver and associated equipment are supplied via a common three phase power supply. The aerial motor is a three phase unit whereas the transmitter/receiver and associated equipment power supply requirements are all single phase.	
Aerial	Voltage:	In the range 380-440V (to be stated at time of order) ±6%.
	Frequency:	50 or 60c/s (to be stated at time of order) ±2.5%.
	Phase:	3.
	Power:	Starting surge, 4kVA. Normal running load, 2kVA. Note: Because of windage effects on the reflector there will be a cyclic load variation at 30rev/min. This reaches the worst case for winds of 70 knots when the cyclic load will vary between the limits of 2kVA and 3.3kVA.

Transmitter/receiver and associated equipment	Voltage:	Single phase supply of 220-240V, ±6%, from the three phase supply common to the aerial motor.
	Frequency:	50 or 60c/s ±2.5%.
	Power	

1 transmitter	4.2kVA*
2 transmitters	8 kVA*

*Distributed between the three phases.

Displays and associated equipment	Voltage:	220-240V (to be stated at time of order) ±6%.
	Frequency:	50 or 60c/s (to be stated at time of order) ±2.5%.
	Phase:	1.
	Power	

Display system using 2 autonomous transistorised fixed coil display: 1kVA

CHAPTER 4

EQUIPMENT DESCRIPTION

1. This chapter describes the main units of the AR-1. Only passing reference is made to the circular polariser and to the moving target indicator equipment, as a separate chapter is devoted to these important elements of the AR-1 system.

AERIAL

General

2. The aerial system consists of a horn-fed, double curvature reflector mounted on the turntable of a turning gear which provides an aerial rotation rate of fifteen revolutions per minute. The horn and the circular polariser, which forms an integral part of the r.f. feed, are supported by a boom arm.

Reflector

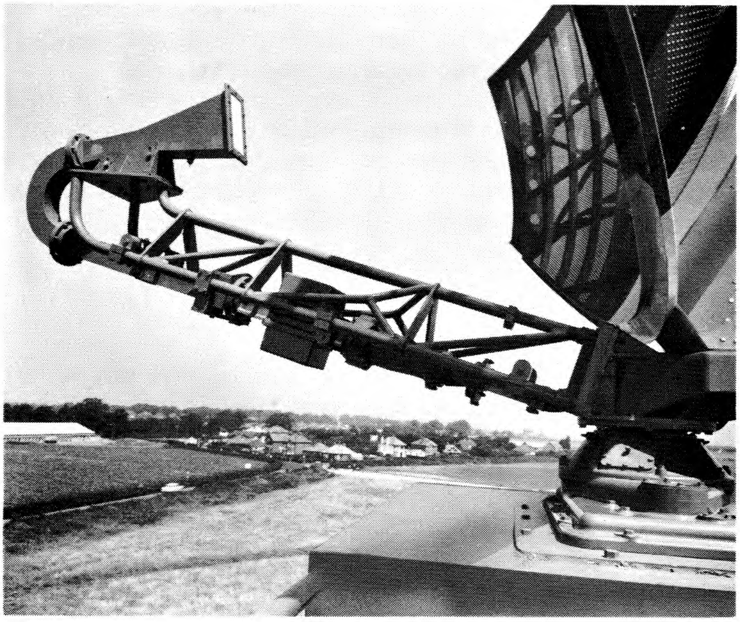
3. The reflector is all metal with a span of 16ft (4.88m) and with an accurately contoured, cosecant squared pattern surface of 100 square feet ($9.3m^2$). It is extremely light and utilises the conventional aircraft wing technique in its construction. A total of twenty one vertical ribs, accurately positioned and accurately contoured spread from a strong central box out to the tips. These ribs are rigidly rivetted to two main cross spars and this frame, when finally cross strutted is both very strong and extremely light. The reflective surface consists of a mesh rivetted to the leading edges of the ribs. This mesh is shaped to follow the rib shapes accurately to give the desired radiation characteristics.

Horn feed

4. The feed horn is fin-loaded to give it certain characteristics which are important for circular polarisation, and which are referred to later. It also facilitates adjustment of (a) the phase centre of the horn and (b) the voltage standing wave ratio, resulting in a good point source feed giving good circular polarisation throughout the beam.

Turning Gear Type 5752

5. The turning gear is driven via a reduction gearbox by a 3 h.p. 3-phase motor.



AERIAL BOOM ARM ASSEMBLY PLATE 3

Transmission of r.f. energy is via a Plessey low loss, low friction, wide band (2700-3100Mc/s) rotating joint driven by a universal coupling. It is suspended immediately below the main turning gear in an accessible position and can be easily removed for servicing. An 8-channel slip ring unit, which splits into two segments for ease of assembly and maintenance, provides connections for the circular polariser and the obstruction light fitted on top of the reflector.

6. A data take-off unit is fitted to the turning gear and drives the necessary synchro elements for providing azimuth information to the displays. This unit gives a maximum output of four take-offs. Three of these are 1:1, the fourth is 36:1. The three 1:1 ports normally take 3inch components but adaptor plates can be supplied to cater for smaller components. The units provide drives for a selection of the following:-

(a) Up to four Plessey fixed coil displays from one synchro at 1:1.

(b) Radar head monitor fixed coil display from one synchro at 1:1.

(c) Video map from one synchro at 1:1.

(d) SSR synchronisation from synchro at 1:1.

(e) A transistorised data retransmission unit (used where the radar head to display separation exceeds 2000yd (1,800m) from two synchros at 1:1 and 36:1 respectively.

Note: The data retransmission will in turn provide suitable outputs for items (a) and (e) above.

7. A locking device is incorporated which allows the reflector to be locked manually on a given bearing to facilitate setting-up of the m.t.i. and circular polariser. Locking can take place in increments of 4° in azimuth, and the device is interlocked with the aerial starter by a microswitch to prevent accidental damage to the turning gear.

8. The aerial is normally fitted either on a tower having a compartment immediately under the turning gear platform, which gives access to the turning gear, or else on top of the transmitter building (see Chapter 6). Spirit levels, pre-set at the factory, are provided for levelling the turning gear turntable.

9. Power to the turning motor is controlled by a 3 h.p. star/delta starter fitted adjacent to the turning gear which can be operated either locally or remotely by switches on the operator's control panel. A manually operated mains isolator is fitted for protection of personnel engaged in servicing work.

TRANSMITTER/RECEIVER

10. The transmitter/receiver circuits are contained in a single cabinet as shown in the accompanying photograph. The S-band transmitter provides r.f. pulses of 1 microsecond duration at a repetition frequency of 700 p.p.s. and of 650 kW peak power. The receiver system incorporates a low noise travelling wave tube r.f. amplifier. For good m.t.i. performance, the local oscillator must remain stable over the p.r.f. interval and a stable local oscillator (stalo) using a triode in a tunable cavity in place of the conventional klystron local oscillator, is incorporated. This unit is shock mounted in a fibre glass acoustic isolation housing, which is itself mounted on shock absorbers within the r.f. head.

Outline of operation

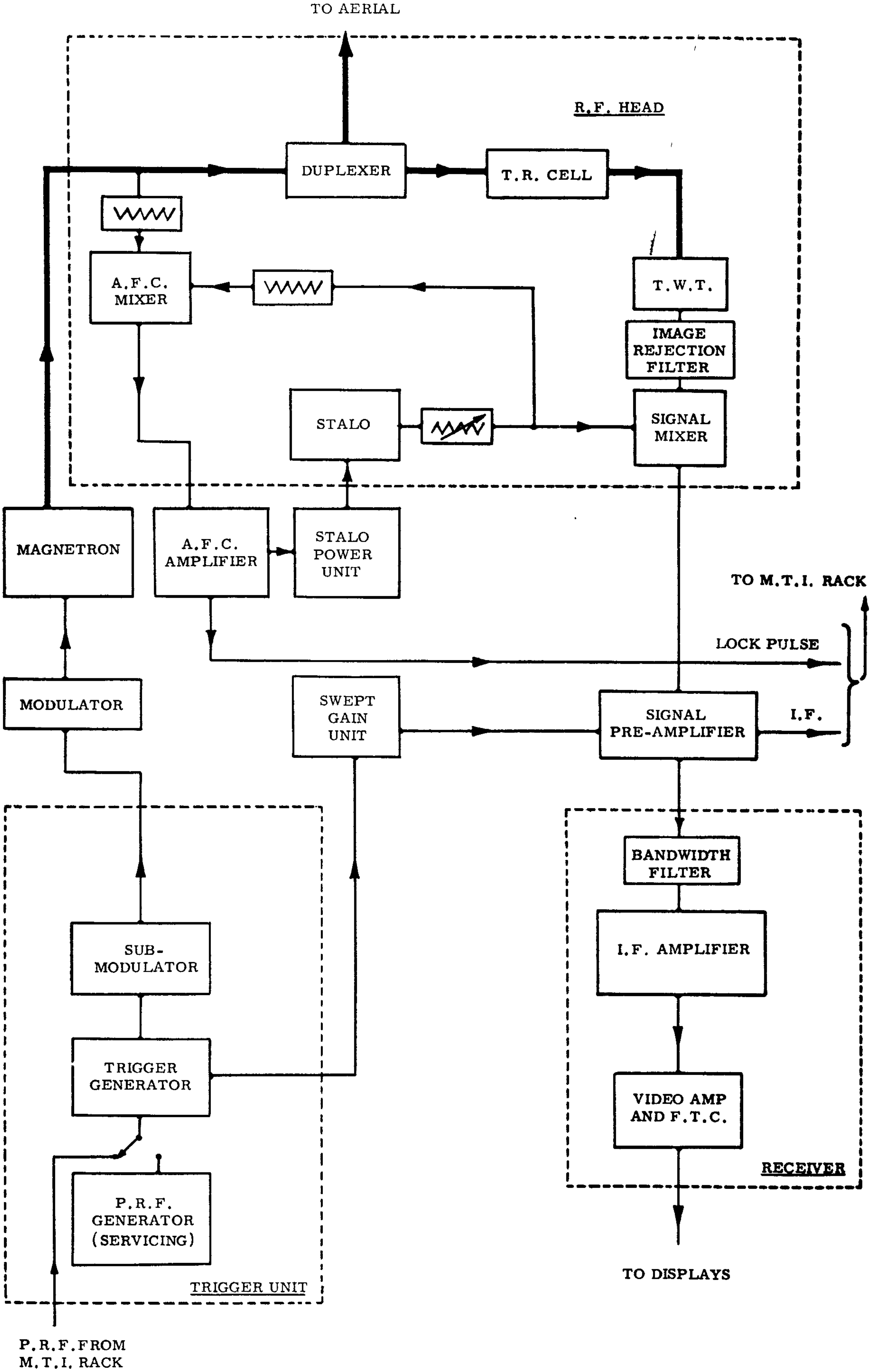
11. The p.r.f. for the AR-1 system is determined by the quartz delay line in the m.t.i. rack (Chapter 5) through which a pilot pulse derived from a stable oscillator is circulated. Automatic means are provided to maintain high accuracy of p.r.f. interval. This p.r.f. train is fed to a trigger unit in the modulator section of the transmitter/receiver which triggers a thyratron pulse-modulator. This causes a pulse forming network, charged between pulses from the e.h.t. unit via a charging choke, to discharge through a pulse transformer for a period determined by the constants of the network. As the network discharges, the pulse developed at the secondary of the pulse transformer is applied to the magnetron. The r.f. energy generated by the magnetron passes via the duplexer and main waveguide run to the aerial system.

12. It should be noted that, although the p.r.f. trigger is supplied from the m.t.i. rack, or the standby p.r.f. generator in the ancillaries rack, an internal trigger unit is incorporated in the modulator section of the transmitter/receiver for servicing it. This unit has a manual 'internal/external' trigger selector switch.

13. Echo signals pass from the aerial system to the receiver arm of the duplexer, through the t-r cell and via a waveguide to coaxial transformer to the travelling wave tube r.f. amplifier. This tube has a noise factor not worse than 4.5 dB at any frequency in the range 2700-3100 Mc/s and its gain is 24 dB $\pm$ 3 dB. The intermodulation characteristic is such that with an intefering signal of -30 dBm at 100 Mc/s from the wanted signal, the small signal gain does not reduce by more than 3 dB.

14. The output of the travelling wave tube is fed to a tunable image rejection filter which has a Q of approximately 250, the signal loss being not greater than 3 dB and the loss at image frequency being approximately 20 dB. The travelling wave tube and its solenoid are fed from solid state power supplies.

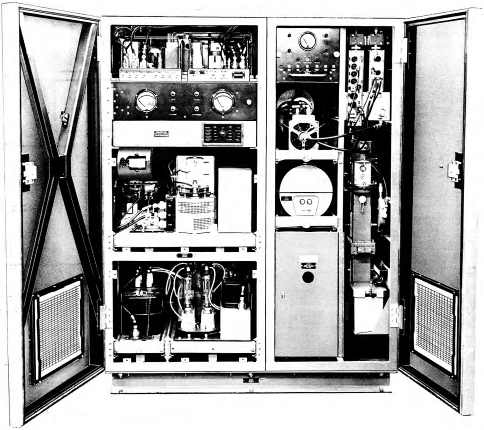
15. From the image rejection filter, the signal is passed to the signal coaxial balanced mixer. The i.f. output (30 Mc/s) is then fed into the signal pre-amplifier which is mounted directly on the crystal current monitoring and mixer assembly.



TRANSMITTER/RECEIVER BLOCK DIAGRAM

FIGURE 5

16. From the pre-amplifier the signal is fed to the main receivers which include a narrow band filter unit, linear/logarithmic channels, and a video amplifier with optional differentiation facilities. The output of the video amplifier is fed to the displays via the m.t.i. rack and the ancillaries rack. An i.f. output is also fed to the m.t.i. rack.



TRANSMITTER/RECEIVER CABINET
Left: Modulator Unit. Right: R.F.Head

PLATE 4

17. A sample of the transmitted r.f. pulse beats with the stalo output in an a.f.c. mixer whose output is fed to an a.f.c. head amplifier. From this, a 30Mc/s output, which contains a reference of the phase of the transmitted pulse, is fed to the coherent receiver in the m.t.i. rack where it acts as a phase lock pulse to the coherent oscillator (coho).

18. The overall noise figure is not worse than 6dB.

ANCILLARIES RACK

19. This rack accommodates several items of equipment essential to the operation of the system but which do not form part of any of the major units. It is 5ft (1.5m) high and can house five 8¾in (22cm) x 19in (48cm) P.O. frames as well as its own distribution panel. The rack is normally unattended. It is enclosed with panels at the back and sides and a door gives access from the front.

20. The upper part of the rack houses a number of modules which perform the following control functions:-

(a) Trigger switching and timing.

(b) Standby p.r.f. source.

(c) P.R.F. main/standby auto-changeover sensing.

(d) Video combining (diversity operation).

(e) Remote switching relays for circular polarisation.

(f) Trigger delay restoring circuits (diversity operation).

(g) M.T.I. video on/off selection circuits.

(h) Trigger and video remoting circuits.

21. Below the modules are two 50V power units, one main and one standby, which provide a control voltage for operating the relays and indicators associated with remote control of the station. The rack also contains two voltage stabilisers for the single phase supply to each transmitter respectively, and also a distribution panel for the rack itself.

22. In the case of single transmitter installation the same rack is used except that certain items such as one voltage stabiliser and those concerned with diversity operation are omitted.

M.T.I. RACK

23. The physical construction and appearance of this rack are the same as the ancillaries rack. It contains all the circuits associated with the m.t.i. system which is described in further detail in the next chapter.

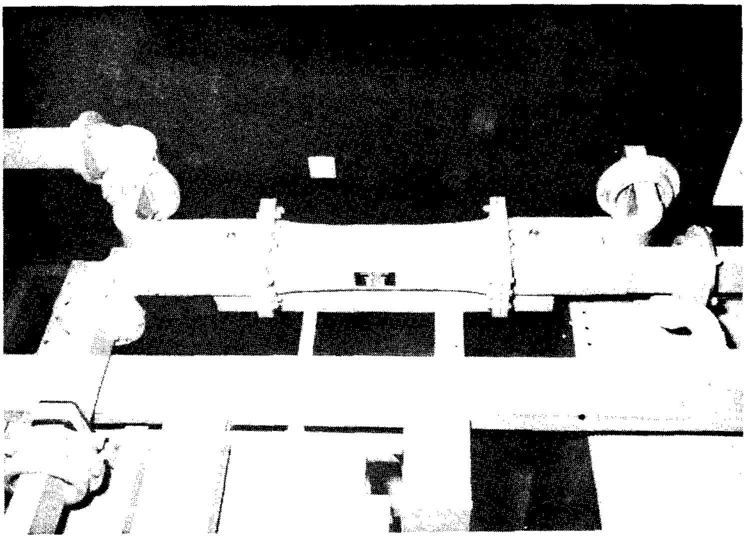
FREQUENCY DIVERSITY

24. Installations with two transmitter/receivers incorporate a Plessey frequency diversity unit which allows two transmitter/receivers whose frequencies are separated by a prescribed guard band (100Mc/s) to be operated simultaneously with a single feed system to offer the following advantages:-

(a) When the received signal videos are combined, the coverage is increased by a significant amount (about 20% at 80% blip/scan ratio) because the effect of target scintillation is reduced in a system using two transmitters of equal power and similar receiver characteristics but on different wavelengths.

(b) Instantaneous stand-by in the event of failure of either transmitter.

(c) Since either or both of two discrete frequencies may be employed, the system provides improved discrimination against external r.f. interference.



PLESSEY DIVERSITY UNIT PLATE 5

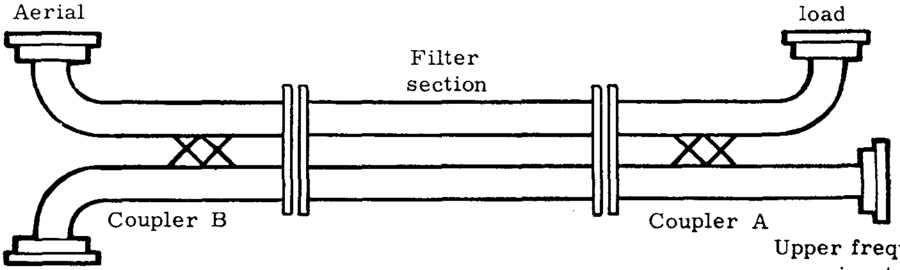


FIGURE 6 COMPONENT ARRANGEMENT OF PLESSEY DIVERSITY UNIT

25. The unit is a passive device and hence gives completely trouble free operation i.e. there is no necessity for tuning nor for external power supplies. Its insertion loss for either frequency is less than 0.3dB.

26. The sketch shows the arrangement of the unit. The higher frequency power is divided by coupler A and fed through two identical filters, and is then recombined by coupler B into the aerial outlet. The lower frequency power is divided by coupler B and rejected by the filters, then recombined by coupler B into the aerial outlet. The reverse action takes place on reception. A medium power matched load is fitted to the fourth arm of the unit to absorb any power which is unavoidably coupled into this arm.

27. The Plessey autonomous display unit uses a 12in (30cm) diameter cathode ray tube of high brightness, resolution and acutance. All circuits use semi-conductors, with the exception of the rectifiers in the e.h.t. supply and the cathode ray tube itself. Wherever practicable, silicon planar transistors are used.

28. Liquid cooling is provided in a controlled manner to maintain an equable ambient temperature for the circuit components. This technique ensures greater stability of operation and improves reliability over uncontrolled systems. Setting-up procedures and adjustments are thereby minimised and mean time between failures considerably extended.

29. The various circuits are mounted either on removable sub-assemblies or on printed wiring boards. The more complex, but relatively low dissipation, circuits are accommodated on up to four plug-in printed wiring boards. The sub-assemblies comprise the relatively simple circuits whose extremely high inherent reliability does not warrant use of plug-in techniques. Each assembly is connected to the main wiring by solderless taper pins. This method of connection gives a reliability at least as high as soldered joints with greater ease, and less risk of damage. It also gives greater reliability and lower cost than plug/socket connection.

30. All cable connections to the unit are made via a quick-release junction pack assembly of connectors which mate with corresponding items on a socket panel at the rear of the unit.

31. The sub-assemblies include the following:-

(a) Power unit

(b) E.H.T. unit

(c) Final main deflection amplifiers

Note: The power transistors and heat sink detach with this sub-assembly from a liquid cooled block, which is left in situ.

(d) Control panel.

(e) Printed wiring connector and socket panel assembly.

32. Four plug in printed wiring boards are provided in three types i.e.:-

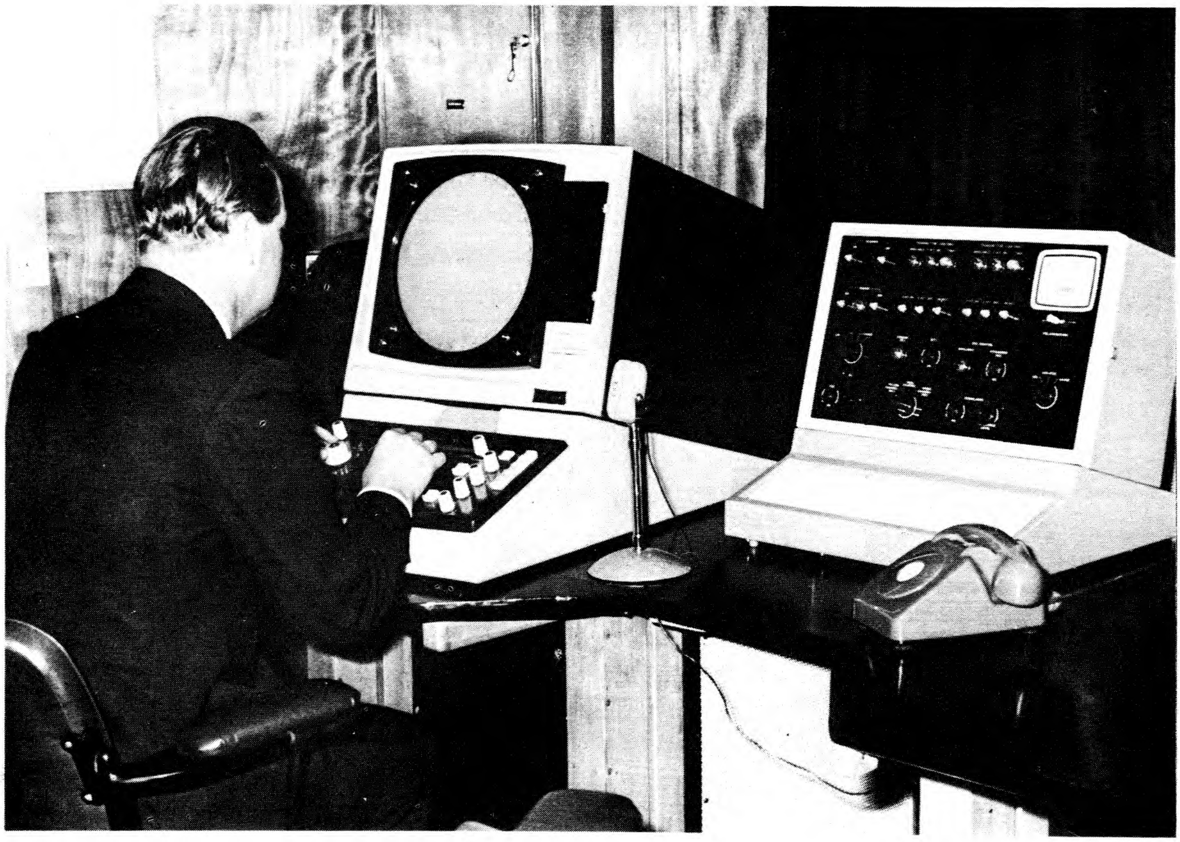
(a) Deflection (X and Y)

(b) Timing

(c) Video

33. Two deflection boards are provided, one for the X and the other for Y deflection circuits. The sine and cosine components of aerial azimuth are fed to these boards from the aerial resolver. Circuits on the board demodulate the resolver signal, and the demodulated signal is then used to control a timebase sweep generator. The timebase waveforms are fed to an electronic scan switch which also accepts the interscan line timebase waveforms, produced on the timing board. The selected output is fed via a range change amplifier to the final main deflection amplifiers.

34. The timing board contains the oscillator which provides the reference waveform to the aerial resolver. The oscillator waveform is also fed to a sample pulse generator which controls the operation of the demodulator circuits on the deflection boards. All the display timing circuits are contained on the timing board and these circuits provide the timebase gating waveforms, the brilliance amplifier gating waveforms and the mainscan/interscan switch waveforms. The interscan line circuits are also contained on this board.



OPERATING POSITION PLATE 6

35. Radar video, and video map inputs to the display unit are mixed in a four-way video mixer contained on the video board. The composite video signal is then mixed in a secondary mixer with the two channels of range markers, which are generated on this board. The mixed video and range marker signal is fed via an overall video limiter circuit to the final video amplifier. This board also contains the display brilliance waveform amplifier which incorporates octagonal blanking circuits.

36. Liquid coolant is pumped around the unit to the final deflection transistor heat sinks and to cold plates for cooling the four printed wiring boards. A small heat exchanger is mounted at the rear of the unit which transfers the waste heat to the external atmosphere.

37. As previously mentioned, each display unit contains an oscillator which provides the reference waveform to the aerial resolver. Also, the display demodulator circuits are controlled by a sample pulse generator which is locked to the oscillator. Therefore, when more than one display unit is provided, it is necessary to select only one display unit oscillator as the master. This operation is carried out in the radar control unit.

RADAR CONTROL UNIT

38. The station controls have been centralised in this unit and have been listed in Chapter 3. The unit itself is fitted alongside the displays.

39. The control functions have been grouped into a number of modules fitted inside a lightproof box whose front is hinged and swings open for servicing. The front panel is opaque with transparent legends and is covered with perspex. It is illuminated from behind by a fluorescent lamp and coloured perspex is used so that all the legends for common controls are white and those for the two transmitter channels are different individual colours. The unit is fitted on a base plinth with a sloping perspex front panel which is also illuminated by the fluorescent lamp to provide a surface on which notes can be made with chinagraph pencil.

40. Cable entry is provided at the rear of the base plinth.

OTHER UNITS

Phase changers

41. A phase changer is fitted in the aerial waveguide run for each transmitter. Each consists of a low loss dielectric vane whose insertion into the waveguide is controlled by an uncalibrated multi-turn knurled knob. Their purpose is to enable the phase of the load impedance presented to the magnetron by the aerial feed waveguide assembly to be adjusted for optimum. This ensures that the magnetron will operate with the necessary frequency stability for good m.t.i. performance.

Waveguide dehydrator

42. Also associated with the waveguide assembly is a dehydrator unit which supplies warm dried air at slightly above atmospheric pressure, so that troublesome condensation cannot occur in the waveguide or aerial feeder system. A small air flow is allowed to escape at the aerial to ensure that adequate circulation occurs.

Power and cable distribution boards

43. An a.c. distribution board is fitted in the transmitter room and provides a.c. supplies as required to the various units fitted there; it also feeds 3-phase a.c. power to the aerial system. A local/remote/isolate key switch in the transmitter room gives the facility for operation in these modes. An a.c. distribution board is also fitted in the display room. A cable termination panel is fitted in both rooms for cables leading between the two.

Data processing rack

44. The data processing rack houses the line termination units, display and video map trigger timing units, and video range gates. The incoming combined trigger and video signals are passed through line compensating circuits, and after amplification, the trigger is separated, reconstituted, and applied via emitter followers to the range gates and display and video map timing units. The m.t.i. and

normal radar videos are routed to the range gates where they are combined as required by each operator before presentation on the displays. In addition, a data servo retransmission unit may be added if the separation distance between the transmitter/receiver exceeds 2,000 yards (1,800m), azimuth turning data to the displays being routed via this unit.

Video Map (optional item)

45. This item generates information which can be displayed in conjunction with the radar video to give the p.p.i. observer additional information on his screen in its correct geographical position. Such information may consist of reference grids, coastlines or airway outlines, or the position of beacons, runways or towers or any combination of such items, for which suitable slides have been prepared.

46. Fuller details are available on request.

Aerial operating conditions

47. The aerial system is designed to operate satisfactorily in windspeeds up to 70 knots and to survive winds gusting up to 120 knots.

Equipment climatic design

48. The external equipment (aerial and turning gear) is designed to operate under the following conditions:-

Ambient temperature	-40°C to +55°C
Relative humidity	0% to 100% at -40°C to +35°C decreasing to 60% at +55°C.

The internal equipment is designed for use in buildings under the following conditions.

Temperature	-10° C to +40°C
Relative humidity	5% to 90% at -10°C to +30°C decreasing to 80% between +30°C and +40°C.

Note: The displays are limited to a maximum temperature of +35°C.

49. It is important that condensation shall not take place when the equipment is switched off. For this reason heaters are included in the equipment for use when not operational. Fans are fitted where necessary, to ensure adequate air circulation within the equipment, and to prevent overheating within the cabinets.

50. Should the internal equipment limits, quoted above, be exceeded, it will be necessary to fit room heating or air conditioning as required.

51. No external air or water supplies will be required within the temperature and humidity ranges stated above.

CHAPTER 5

GROUND AND WEATHER ECHO SUPPRESSION

1. Reference has already been made to the operational value to the user of the moving target indication and circular polarisation facilities which are an integral part of the Plessey AR-1. This chapter deals with the technical aspect of these two important techniques.

MOVING TARGET INDICATION

Basic system

2. The m.t.i. system uses silicon transistors throughout and is of the line-by-line coherent type with a delay and subtraction system using carrier frequency modulation on the delay line. Double cancellation is employed and blind speed limitations are minimised by the use of three pulse stagger.

3. Quartz ultrasonic delay lines are used as the storage and delay elements. The main delay line of the m.t.i. system is also used for one stage video correlation of the normal radar video which considerably reduces the effects of unsynchronised signals.

M.T.I. signal processing

4. The coherent receiver accepts the i.f. signals from the signal pre-amplifier and lock pulse reference signals from the a.f.c. mixer. The lock pulse is fed to a gated coho oscillator thus providing a stable reference i.f. signal. The output from the coho oscillator and the i.f. signal input, after processing, are fed to the phase sensitive detector. The output of the phase sensitive detector is in the form of bipolar video signals corresponding to the received signals and modulated in amplitude according to the phase difference between signal and reference channels. The signals before the phase sensitive detector stage are limited and video amplification after the phase sensitive detector is over the relatively narrow video band, and thus interference signals are minimised.

5. The bipolar video is fed through the stagger and realignment circuits. These circuits stagger the trigger pulses, used to fire the transmitter, by delaying every third pulse and the bipolar m.t.i. video is realigned by delaying the video returns resulting from the undelayed transmitter pulses. Frequency modulation is used to preserve the video amplitude accurately, independently of variation of the carrier level. The trigger and video signals are time-multiplexed on a single carrier frequency channel. The normal radar video is also realigned in a similar manner, but for this amplitude modulation is used since the accurate preservation of amplitude is only important for the m.t.i. video.

6. The realigned bipolar m.t.i. video then passes to the canceller circuits, the main element of which is a quartz ultrasonic delay line whose effective length is equivalent in time to the p.r.f. period. At the input to the canceller the bipolar video modulates a carrier which is fed to two channels; one leads directly to a subtraction circuit and the other is fed to the subtraction circuit via the delay line. The outputs of these two channels are then subtracted to provide successive trains of single cancellation video. To provide more effective cancellation, the above process is repeated, the output from the above canceller again being split and fed directly and via the delay line to a second subtraction circuit. Frequency modulation techniques are used throughout the cancellation system, the same delay line being used with appropriate frequency multiplexing. The output of the second cancellation loop, in the form of bipolar double cancelled m.t.i. video, is passed through a bipolar rectifier to give wholly positive m.t.i. video suitable for combination with normal radar video.

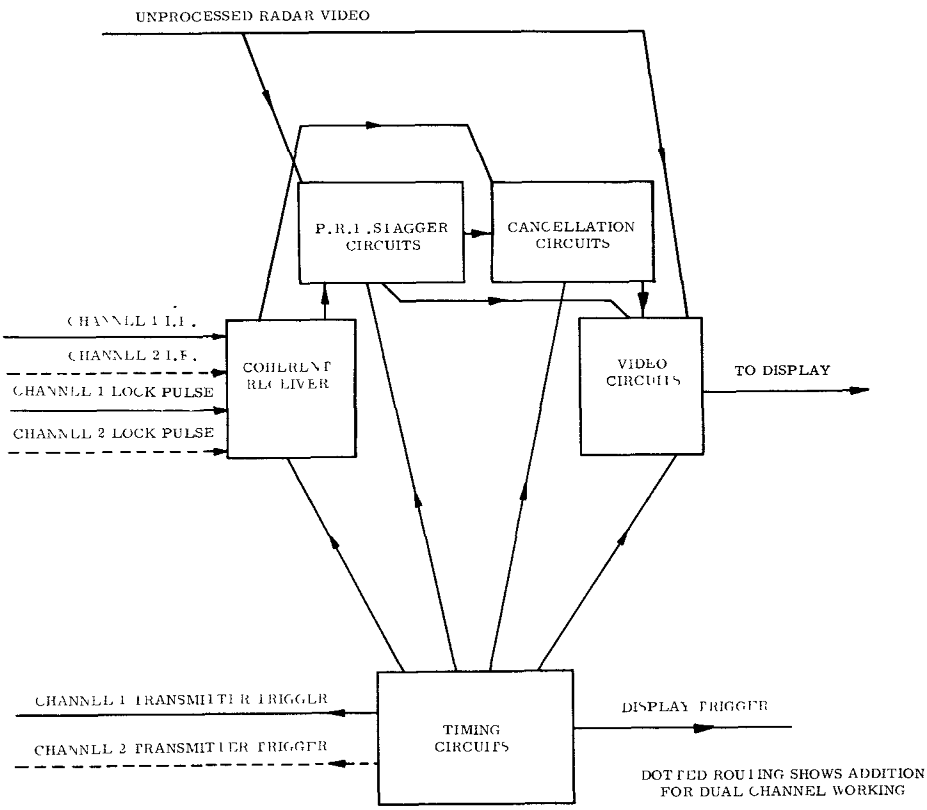


FIGURE 7 M.T.I. SYSTEM BLOCK DIAGRAM

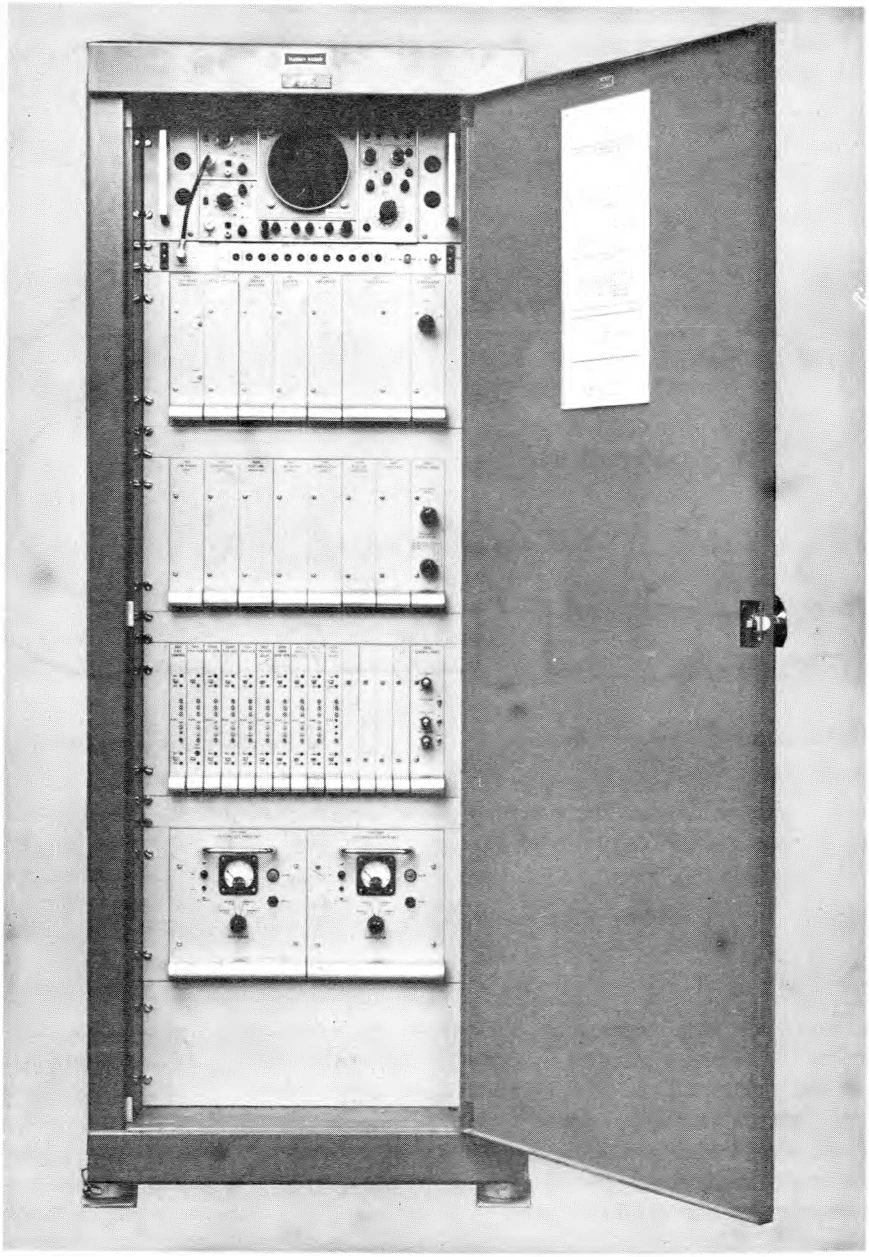
7. The m.t.i. video from the cancellation circuits and normal radar video, which is routed from the realignment circuits through a video correlator, are fed to the m.t.i. range gates. Each display has an associated m.t.i. range gate situated in a data processing unit housed in the equipment room at the operations building. Each range gate selects m.t.i. video from zero n.m. to a range set by a control on the control panel of the relevant display and normal radar video from this range onwards. The m.t.i. video can be set from zero range to 75n.m. by means of the range gate control. Each channel of combined m.t.i./normal radar video is then fed from the data processing unit to its associated display and a second video routing channel allows normal radar video to be fed into each of the displays to provide an independently controllable background video over the whole range. The latter permits the introduction of background permanent echoes within the m.t.i. range gate to be quickly shown should operational conditions warrant it.

Video correlator

8. The main delay line of the m.t.i. system is sufficiently broad band to provide a third frequency channel. This is used for one stage correlation of the normal radar video using amplitude modulation techniques. In this way the effects of unsynchronised signals are considerably reduced.

Station master trigger

9. The master source of timing for the station is the m.t.i. system. The pulse repetition frequency is determined by feeding pilot pulses into the cancellation system and recovering their residue at the output of the first cancellation loop. If the timing is exactly matched to the m.t.i. delay line, no residue will survive, but if incorrect, there will be a residue in the form of positive or negative going spikes. These spikes are integrated and used to control the frequency of a master oscillator. The station master trigger is fed to the ancillaries rack for distribution to the remainder of the system.



M.T.I. RACK PLATE 7

10. In the event of failure of the m.t.i., an auto-selector in the ancillaries rack will effect automatic changeover to a standby 700p.p.s. p.r.f. generator housed in the ancillaries rack, thus preserving the operation of the radar without m.t.i. whilst servicing and maintenance work is carried out on the m.t.i. rack.

11. The performance figures for the m.t.i. system were given in Chapter 3.

CIRCULAR POLARISATION

12. The variable polarisation facility is derived from components included in the aerial feed system as a basic part of the design. They provide a system which ensures good quality circular polarisation such that the ellipticity ratio is always better than one decibel.

13. The precipitation cancellation obtained when operating in the circular polarisation condition is approximately 20dB, with virtually no reduction in performance against wanted targets, other than the normal attenuation introduced through areas of precipitation, which is always present for any polarisation and is in any case low at S-band frequencies.

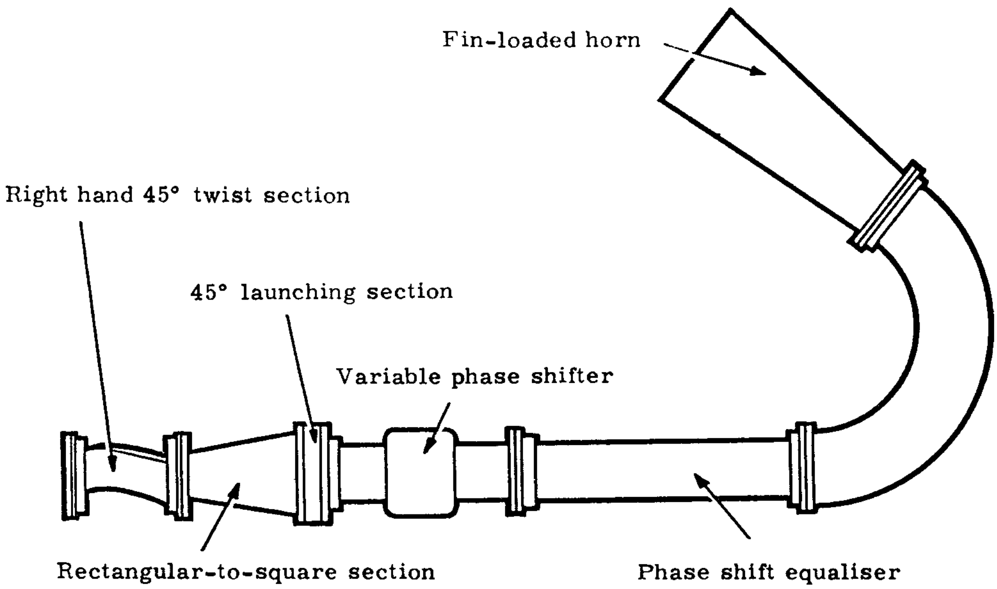


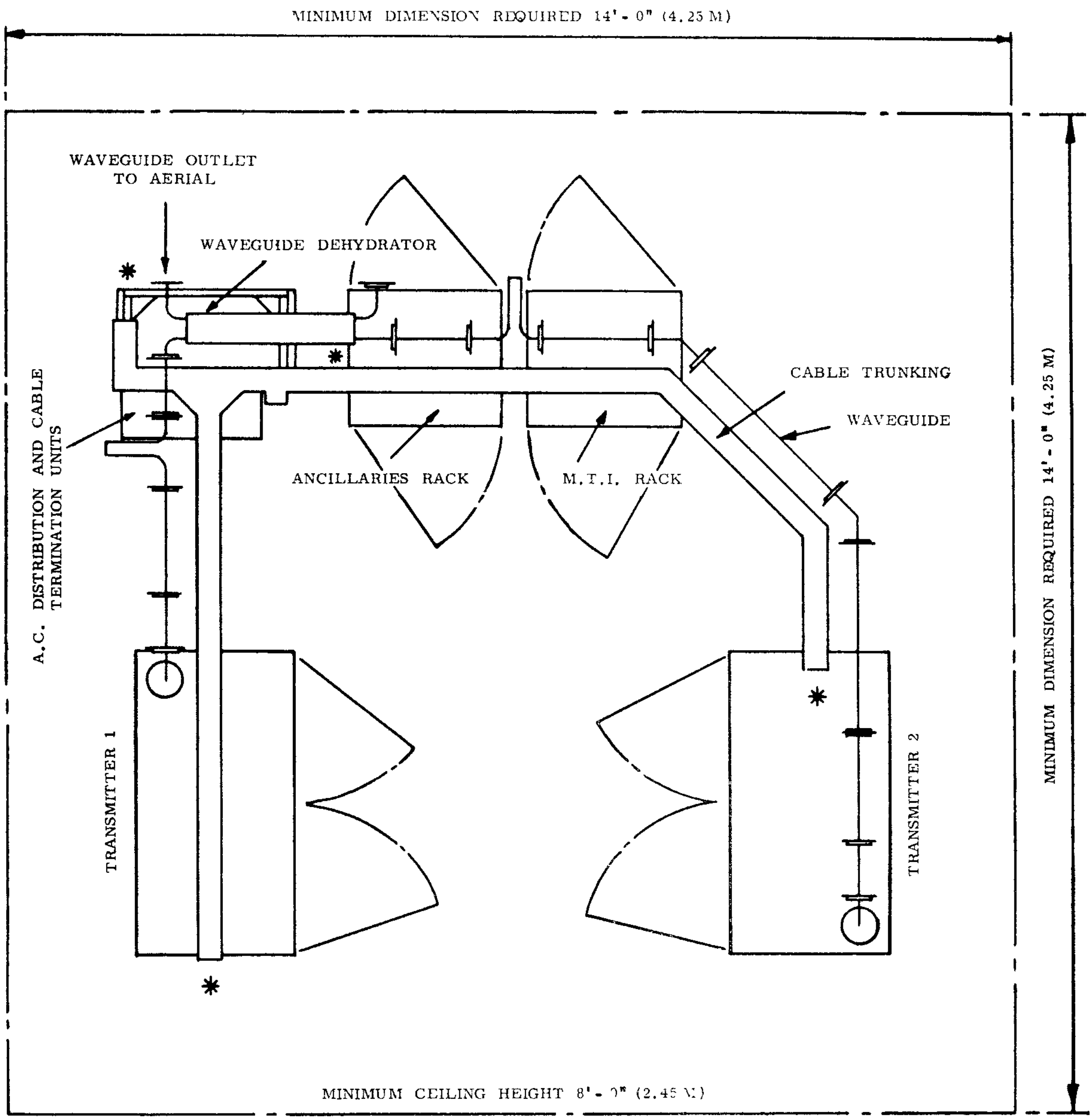
FIGURE 8 COMPONENT ARRANGEMENT OF BOOM ARM ASSEMBLY

14. The input power from the transmitter(s) is split into two equal orthogonal vectors by a 45° launching section. By varying the phase shift between the two orthogonal vectors, it is possible to provide linear polarisation at 45° through elliptical to circular. The phase shifter is a variable twin vane device whose vanes are driven by a small a.c. motor controlled from the radar control panel. A potentiometer operated by the motor shaft feeds a d.c. tell-back voltage to a calibrated meter on the control panel.

15. The circular polarisation components have been designed so that two diverse frequencies feeding the aerial system have the same polarisation at any discrete

setting of the variable phase shifter. This is made possible by introducing a differential phase shift equalising section, which has the effect of correcting any unwanted differential phase shift introduced by the boom arm components, including the r.f. feed horn.

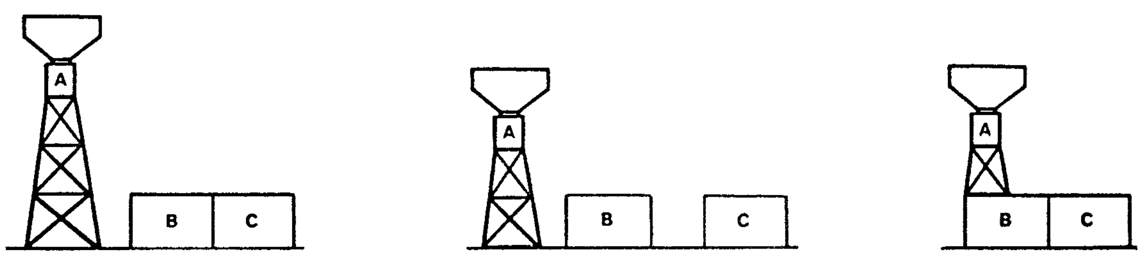
16. Since the degree of circularity achieved by a circularly polarised aerial is dependent on the equality of the aerial's secondary pattern for two orthogonal polarisations, the more equal the primary feed patterns, for different polarisations, the better will be the circularity. Fin loading of the horn is used primarily as a means of achieving equal primary (and hence secondary) radiation patterns which are independent of the polarisation of the radiated energy. Beamwidth equalisation of the primary pattern is achieved as a result of the unequal effect of the fins on the two orthogonal electrical vectors propagating within the r.f. horn.



EXTERNAL CABLES MAY ENTER
AT ANY POINT MARKED *

'U' MODULE INSTALLATION OF TWO TRANSMITTERS

FIGURE 9



SITE LAYOUTS

FIGURE 10

CHAPTER 6

INSTALLATION DESIGN AND SITING

INSTALLATION DESIGN

1. For installation purposes the AR-1 equipment falls logically into three installation groups which offer a wide choice of site layouts.

2. The three installation groups are as follows:-

(a) The aerial equipment (reflector and feed horn assembly, waveguide and turning gear) complete with cabin and support tower (installation group A).

(b) The transmitting and receiving equipment (single or double channel), associated m.t.i. equipment, ancillaries rack, a.c. distribution board, cable termination panel and waveguide dehydrator. (Installation group B).

(c) Display equipment and radar control panels. Normally two displays are fitted but up to four can be driven by the AR-1 (Installation group C).

3. The standard tower, which has been specially designed for the Type AR-1 aerial and cabin, is of a lattice work construction. The tower may be made up of one, two, or three sections, depending only upon the aerial height required. Alternatively, the aerial and cabin may be mounted on top of a suitable building.

4. The transmitter equipment installation is designed to be as little 'room conscious' as possible. This has been achieved by using a floor mounted framework, the top of which supports the waveguide run and cable ducting, the framework enclosing and supporting the equipment as illustrated. Four layouts are designed as standard, these are:-

The 'U' layout using one transmitter; this is suitable for a square room, or a rectangular room.

The 'U' layout using two transmitters; also suitable for a square room as illustrated.

The 'I' layout using one transmitter, with all of the equipment in line, this is suitable for a rectangular room.

The 'I' layout using two transmitters, with all of the equipment in line, this is also suitable for a rectangular room.

SITING

5. The AR-1 radar has been proved to have exceptionally good low cover and a very high angle cut off. In order to minimise the effect of ground reflections, and also to permit good low cover to be achieved, it is recommended that, where possible, the aerial be mounted at a height not less than 30 feet (9 m) above the ground. Greater height is quite acceptable, and could indeed be advantageous, provided that the waveguide run can be kept to less than 50 feet with no extra bends above the number in a standard installation.

6. The precise site selected for the aerial will necessarily depend to a large extent on the role that the radar is required to perform. Wherever low coverage is important the aerial should be mounted in such a position that cut-off from surrounding buildings is as low as possible. A skyline at an angle of elevation of $\frac{1}{2}$° is commonly considered to be acceptable for a terminal radar. This means that radar shadowing would not cut into the base of an airway at, say, 3,000ft, at a range of less than 40 nautical miles from the radar. This angle also represents at 16 nautical miles, a height of 1,000ft, allowing for curvature of the Earth.

7. Where some degree of shadowing cannot be avoided, the site should be chosen so as to place the shadow region in a sector which is unimportant operationally. It is also desirable, so far as is reasonably practicable, to avoid the vicinity of large plane surfaces such as hangar roofs or walls, which could give rise to false echoes by specular reflection.

MAIN UNITS PLATE 8

Typical installation of the main radar units showing from left-to-right one 650kW, S-band transmitter/receiver, rack housing a.c. distribution unit, cable termination unit and (behind) waveguide dehydrator, and the m.t.i. rack. The second transmitter/receiver, which faces the one shown, does not appear in the photograph.

8. For the p.p.i. approach role, consideration must be given to the disposition of the extended centreline and the runway threshold on the final approach display. Whilst the siting of the Type AR-1 in this role is in no way critical, it is evident that the greatest accuracy will be obtained with the aerial position close to the runway centreline and near the mid length of the runway. For all practical purposes the distance between an aircraft and break-off point can then be measured directly on the display, for either approach direction. The minimum distance from the

centreline is determined by the ICAO Recommended Practices for obstacle clearance for instrument runways, 150m (500ft) plus seven times the height of the scanner, which in the case of an AR-1 aerial on a 37ft tower is 660 ft. However, a spacing of up to half a mile is satisfactory, while greater distances can be used if an earlier break-off point is acceptable.

9. When siting at an airfield for p.p.i. approaches in addition to the surveillance function, it is advisable also to find suitable sites for the radar reflectors as centreline and off-set markers etc.

10. In addition to the primary siting requirements which make for good propagation and performance, one must take account of such practical considerations as:-

(a) accessibility of the site for both personnel, vehicles and a suitable unloading area,

(b) the practicability of using a crane for aerial erection,

(c) adequate space to handle the longest packing case,

(d) practicability of running cables to the display position. Spare cable ducts may have to be found for runway, taxiway and apron crossings. Cable runs should preferably be restricted to 2,000yd.

11. Plessey Radar Limited will be pleased to assist in site selection on receipt of plans showing runways, control tower, airport navigation facilities etc., and can, where necessary, quote for a siting specialist to visit the location.

CHAPTER 7

APPROXIMATE WEIGHTS AND DIMENSIONS

AERIAL EQUIPMENT

	Height ft in	Width ft in	Depth ft in	Weight lb
Reflector (with boom arm)	9 $6\frac{1}{2}$ (291cm)	16 7 (488cm) overall		537 (243kg)
Turning gear - Internal depth from cabin ceiling			3 10 (117cm)	800 (363kg)
Aerial cabin	7 2 (218cm)	5 0 (152cm)	5 0 (152cm)	3096 (1407kg)

TRANSMITTER EQUIPMENT

	Height ft in	Width ft in	Depth ft in	Weight lb
650kW transmitter r.f. cabinet	5 4 (163cm)	4 3 (130cm)	2 $6\frac{1}{2}$ (77cm)	1593 (724kg)
Ancillaries rack	5 4 (163cm)	2 $1\frac{1}{2}$ (65cm)	2 $0\frac{1}{2}$ (62cm)	553 (251kg)
M.T.I. rack	5 4 (163cm)	2 $1\frac{1}{2}$ (65cm)	2 $0\frac{1}{2}$ (62cm)	535 (243kg)
A.C. distribution unit	2 0 (61cm)	2 0 (61cm)	0 9 (23cm)	80 (36kg)
Cable termination unit	2 0 (61cm)	2 0 (61cm)	0 9 (23cm)	60 (27kg)
Waveguide dehydrator	2 8 (82cm)	2 5 (73cm)	1 $2\frac{3}{4}$ (37cm)	257 (118kg)

DISPLAY EQUIPMENT

	Height ft in	Width ft in	Depth ft in	Weight lb
Autonomous fixed coil display	1 11 (58cm)	1 $6\frac{3}{4}$ (48cm)	3 4 (101cm)	212 (96kg)
Radar control panel	1 $5\frac{1}{2}$ (44cm)	1 8 (51cm)	1 $6\frac{1}{4}$ (46cm)	50 (23kg)
Data processing unit	5 4 (163cm)	2 $1\frac{1}{2}$ (65cm)	2 $0\frac{1}{2}$ (62cm)	400 (182kg)
A.C. distribution unit	0 9 (23cm)	1 $0\frac{1}{2}$ (32cm)	0 $3\frac{1}{4}$ (8cm)	20 (9kg)
Cable termination panel	2 0 (61cm)	2 0 (61cm)	0 9 (23cm)	60 (27kg)