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PART 3 : SECTION 2

CHAPTER 3

STANDARD BEAM APPROACH

Function

1. The Standard Beam Approach (S.B.A.) system is a pilot-interpreted radio aid by which an aircraft, equipped with an appropriate receiver, may make an accurate approach to the runway on which the system is installed.

Method of Operation

2. The main beacon or transmitter of the system is situated at the upwind end of the instrument approach runway. (An instrument approach runway is generally the one most favoured by the prevailing wind during bad weather, and is therefore chosen for the installation of approach aids.) The S.B.A. main beacon transmits a carrier wave on a frequency between 30.5 and 40.5 mc/s, which is radiated in two slightly overlapping sectors, the bisector of the overlapped sector being aligned with the centre line of the runway (Fig. 1). The carrier wave radiated in the sector

to the left of the runway is modulated with a medium-pitched (1,150 c/s) audible note, keyed as a morse A. The radiation in the sector to the right of the runway is modulated with a similar note keyed as a morse N. The keying of the As and Ns is synchronized so that a continuous note is formed when both letters are heard at equal strength. The zone of equal signal strength is a narrow area midway in the overlapped section of the A and N sectors. This zone is known as the *beam*, and is 1° to 2° in arc.

3. **Twilight Zone.** When the aircraft moves out of the beam into either sector, the A or N of that sector will rise in volume above the continuous "on-beam" note, increasing with distance away from the correct line of approach. The area on each side of the beam in which the sector letter is heard together with a background note is known as the twilight zone.

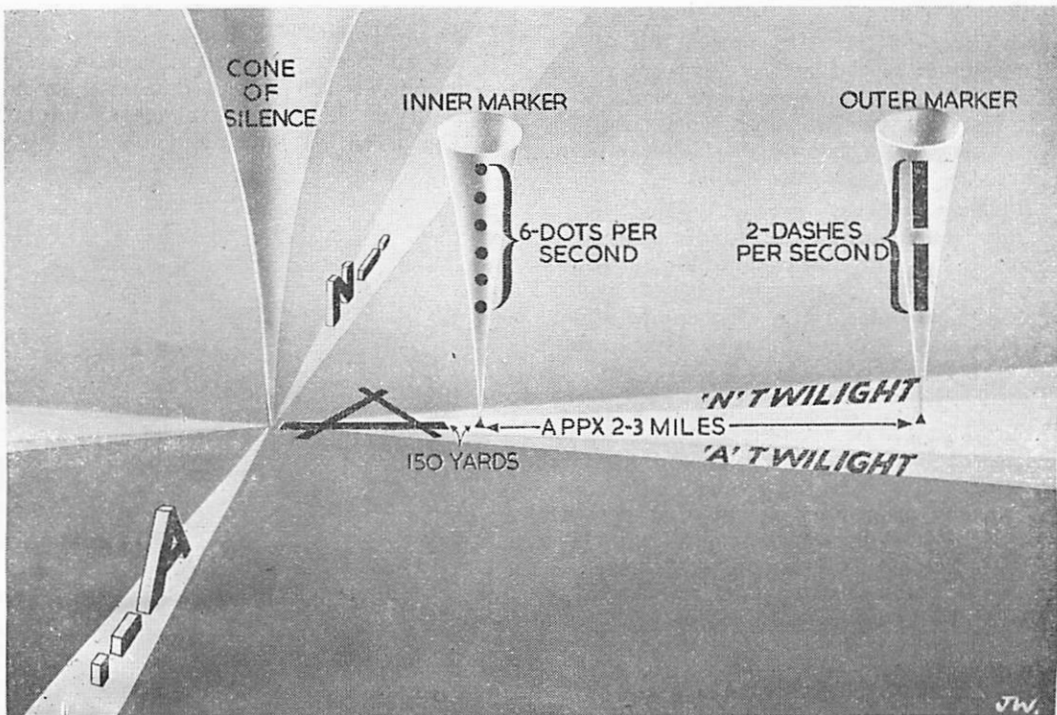


Fig. 1. Signal Radiations of the S.B.A. System.

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**4. Cone of Silence.** Directly above the main transmitter there is an area of no radiation in which no signal is heard. This cone-shaped area is known as the *cone of silence*. It tells the pilot when he is directly above the main beacon.

**5. Back/Front Identification.** There are two beams formed by the overlapping A and N sectors, radiating in opposite directions from the main beacon. An ambiguity arises, therefore, in determining whether the aircraft is flying in the front or the back beam. To overcome this, most of the S.B.A. systems transmit a callsign in two 180° sectors; the front beam bisects one of these sectors, and the back beam bisects the other. The identification is transmitted at approximately 30-second intervals, first in the front-beam sector, then in the back-beam sector. When the aircraft is in the front beam, the identification is heard first, followed by a faint second identification. The reverse occurs in the back beam.

**6. Marker Beacons.** Two marker beacons are placed in the front beam and transmit an identifying signal vertically upward. Their transmissions are received by a separate receiver in the aircraft and converted to audible signals which inform the pilot that he is at a specific point in the front beam of the S.B.A. system.

(a) *Outer Marker Beacon.* This is a transmitter located in the front beam, two to three miles from the inner marker beacon. It radiates a carrier wave of 38 mc/s, which is modulated with a low-pitched (700 c/s) note keyed as two dashes per second.

(b) *Inner Marker Beacon.* This is a transmitter located in the front beam approximately 150 yards downwind of the touchdown point. It radiates a carrier wave of 38 mc/s, which is modulated with a higher-pitched note (1,700 c/s) keyed as six dots per second.

### Tunable Beam Approach (T.B.A.) Receivers

7. Previous S.B.A. receivers employed a stud selector control system, pretuned to six frequencies. To provide more variety in frequency selection, a manual tuning control handle has been provided. The remote control box of the T.B.A. receiver (Fig. 2) is normally located near the pilot, and contains the following switches:—

(a) *ON/OFF Switch.* This switches on the beam and marker receivers.

(b) *Volume Control.* Although the receiver has an automatic volume control incorporated, the sound level to the earphones can be regulated by the pilot using this control.

(c) *Tuning Handle.* By means of this handle, any frequency between 30.5 and 40.5 mc/s can be selected. The indications on the tuning window may be out of alignment; consequently pilots are advised that each S.B.A. station must be identified by its callsign before an orientation or let-down procedure.

(d) *TEST/NORMAL Switch.* This switch is installed on some S.B.A. control boxes. Its purpose is to cut out the automatic volume control when in the TEST position. It is then possible to detect changes in signal strength, and from this the direction of flight along the beam can be determined.

(e) *"Mixer" Switch.* There are two types of equipment in use incorporating mixer switches of differing functions:—

(i) In one type of equipment, a three-position switch (BA, MIX, INTERCOM) is incorporated to provide a degree of flexibility in the use of the equipment. In the MIX position, the beam and communications receivers may be monitored simultaneously. Transmission may be made with the switch in this position. In the BA position, the S.B.A. equipment only is in use. In the INTERCOM position, the inter-communication/receivers may be used simultaneously.

(ii) Another remote control unit in which the mixer switch performs different functions is in use in Flying Training Command. This is also a three-position switch with

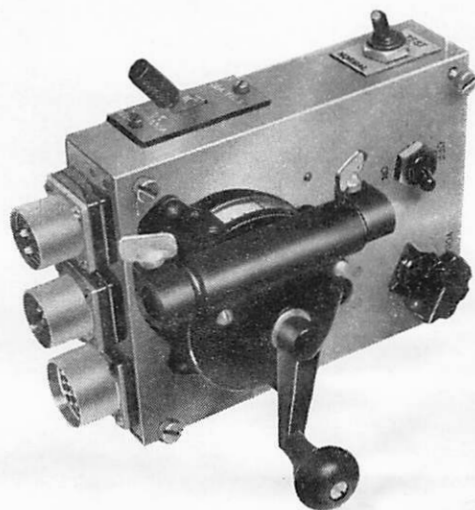


Fig. 2. Remote T.B.A. Control Box.

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SBA - TELS — BLANK — INTERCOM COMM, and SBA-TELS positions. In the SBA-TELS position, the S.B.A. output is fed direct to the pilot's headset and the communication receiver is disconnected. In the central unmarked or BLANK position the S.B.A. is disconnected from the telephones so that R/T can be used without interference from the S.B.A. signal. In the INTERCOM COMM and SBA-TELS positions, all services are available, *i.e.* normal R/T and Intercom. In addition, the output from the S.B.A. receiver is fed through the amplifier portion of the V.H.F. transmitter/receiver so as to produce a greater volume in the telephones.

8. It should be noted that in some installations the control box (Fig. 2) may be divided into several components, *e.g.* the tuning handle may be mounted in front of the pilot, the ON/OFF switch above his head, and the mixer switch beside the throttles.

#### Operational Limitations

9. **Range.** The S.B.A. system operates in the V.H.F. range, and is therefore subject to the limitations of an optical horizon. Systems in use have two different power outputs; consequently maximum ranges may vary from 30 to 50 miles.

10. **Accuracy.** The beam width of  $1^{\circ}$  to  $2^{\circ}$ , and marker beacons providing definite indications of position along the beam, permit an approach to a position from which a visual approach and landing will normally be possible under the minimum permissible conditions.

11. **Traffic Capacity.** Theoretically any number of aircraft can use this system at one time; but in practice the approach control procedures will determine the number of aircraft that can be handled simultaneously.

12. **Mobility.** While the S.B.A. transmitters can be contained in vans, the power and control cables are required to be static. Consequently the S.B.A. system cannot normally be considered as mobile. By dispensing with remote control and supplying auxiliary power, the S.B.A. system could be given slightly more mobility.

13. **Susceptibility to Enemy Interference.** The system can be jammed, and provides a means of homing for enemy aircraft.

### S.B.A. PROCEDURES

#### General

14. The following notes and diagrams are for guidance and explanatory purposes only. Owing to local topographical features or other considerations the beam flying patterns at some airfields vary considerably from those shown here. Pilots should therefore acquaint themselves with the local beam flying orders and pattern before using a beam.

15. The S.B.A. beam will normally be intercepted from a direction that will enable the aircraft to begin a let-down in the shortest possible time. Orientation will not usually be necessary, particularly in S.B.A. systems which have back/front identification.

16. **Homing on Back/Front Identification.** From the back/front identification and the A or N signal being received, the pilot can determine which quadrant he is in (Fig. 1). He then flies the bisector of that quadrant until he reaches the beam or the zone of equal identification signal. With experience it is possible to interpret the relative strengths of the signals heard into an approximate position of the aircraft within the quadrant, and to steer accordingly.

#### Intercepting an Unknown Beam

17. On occasion it may be necessary to carry out an orientation and let-down on S.B.A. without adequate knowledge of the beam headings. In this event the following procedure should be used.

18. It must be assumed that the pilot will have some knowledge of his position and the approximate heading of the beam (north and south versus east and west). Depending upon whether the sector letter heard is A or N, a heading will be selected approximately at right angles to the beam (Fig. 3). The build-up of the twilight signal will indicate to the pilot that he is approaching the beam. As the beam is entered, the time is noted until the opposite sector letter is heard, and a mental note is made of the time of crossing. Simultaneously, a rate one turn to the right is begun. This turn is sustained until the aircraft re-enters the beam, or has turned through  $180^{\circ}$ . In the second instance, the reciprocal heading is flown until the aircraft reaches the beam, and the time of crossing is again noted. As the sector letter of the opposite sector is heard, a rate one turn is started, this time to the left, to bring the aircraft round into the beam. From the point of re-entry the procedure in either case is similar.

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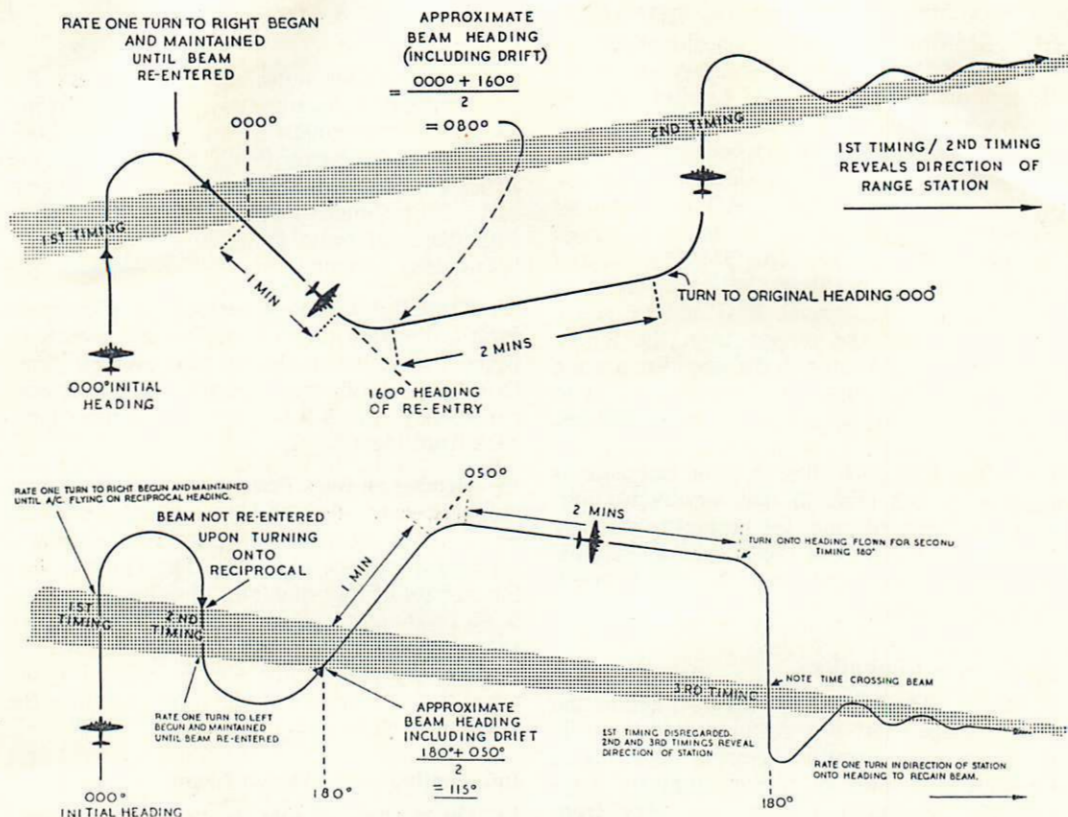


Fig. 3. Intercepting an Unknown Beam.

19. As the aircraft regains the beam the heading is noted, and by averaging this with the previous one flown, the approximate direction of the beam that has been intercepted will be indicated. The heading of re-entry into the beam is maintained into the opposite sector for one minute, then the approximate beam heading is turned onto and flown for two minutes. The original heading is then flown (or the reciprocal, if the aircraft is not in the original sector) to intercept the beam at the same angle and in the same direction as those of the previous timed crossing. A comparison of the times of crossing reveals the direction of the S.B.A. main beacon, as the width of the beam increases with distance away from the beacon.

20. Should the times be approximately equal, it is possible that the crossings were at equal distances on either side of the main beacon. The procedure should be repeated to prove the assumption.

### Beam Bracketing

21. To ascertain the required heading which will keep the aircraft tracking steadily along the beam, a procedure known as *beam bracketing* is flown.

22. On entering the beam for the first time, the aircraft is turned onto the heading of the beam until a signal change reveals the direction of drift as the aircraft leaves the beam. Heading is altered to intercept the beam at 30°. When the aircraft regains the beam, a drift allowance of 15° is applied to the beam heading and the aircraft is flown on the new course.

23. Should the aircraft leave the beam for a second time, the direction will reveal whether the 15° drift allowance was excessive or insufficient. The beam is regained by intercepting at an angle of 30°, then the previous drift allowance is reduced or increased by one half, as the case may be. This procedure must be repeated each

time the aircraft drifts off the beam, until eventually the correct drift allowance is determined. Fig. 4 illustrates one application of beam bracketing.

#### Intercepting a Known Beam

24. Without other radio aids to navigation, the problem for intercepting a known beam is similar to that for an unknown beam, except that the heading for the right-angle interception can be easily calculated. If back/front identification is not available, the procedure for crossing the beam at two separate points, and comparing the times, follows that shown in Fig. 3 and needs no further explanation.

25. When other radio aids are available, a shorter method of approach may be used; in either case, once the beam has been intercepted, beam bracketing follows to establish the amount of drift.

#### Holding Procedure

26. Two circuit patterns may be used for S.B.A. holding procedure, and are illustrated in Fig. 5. These are flown at safety height, or at a height specified by air traffic control

#### Landing Procedure (Front Beam)

27. The let-down and runway approach procedure begins with the aircraft over the main beacon at a minimum height of 1,500 ft. above the aerodrome (Fig. 6). The downwind leg is flown along the front beam to check the functioning of the inner and outer markers, and a descent is made to 1,100 ft. One minute beyond the outer marker, a procedure turn is flown to bring the aircraft onto its final approach. When the aircraft has regained the beam, the descent is resumed to bring the aircraft over the outer marker at 600 ft. and over the inner marker at 100 ft. above aerodrome level. From the inner marker a visual landing is made if the required weather conditions prevail.

#### Landing Procedure (Back Beam)

28. If an outer marker is available in the back beam the procedure conforms to that for the front beam, the main beacon taking the place of the inner marker. If there is no outer marker in the back beam, the procedure detailed in the following paragraphs may be flown as an emergency measure.

29. The procedure begins with the aircraft over the main beacon at 1,500 feet above aerodrome

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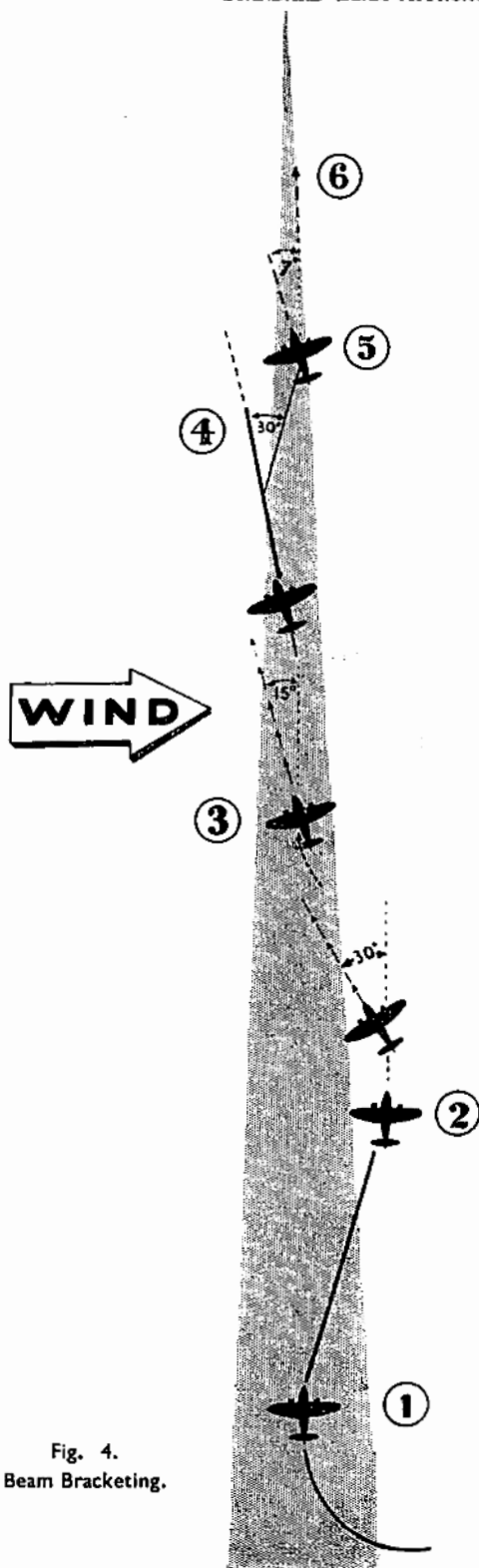


Fig. 4.  
Beam Bracketing.

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level. The aircraft flies outbound along the front beam descending to 1,200 feet (Fig. 7). The time "A" to cover the upwind distance between the inner and outer markers is noted. At the outer marker a procedure turn is flown to bring the aircraft back towards the main beacon.

30. On the inbound heading, the time "B" to cover the downwind distance between the outer and inner markers is noted. The aircraft flies downwind along the back beam for this length of time after passing the main beacon. A procedure turn is then made to bring the aircraft onto its final approach toward the main beacon.

31. On regaining the beam, the descent is resumed to bring the aircraft over the main beacon at 200 feet. The main beacon should be reached in a little over the time "A" taken to fly from the inner to outer marker.

### Overshoot Procedure

32. If a visual landing is not possible, the aircraft is climbed straight ahead to a height of 500 feet and maintains this height until the aerodrome boundary or main beacon has been passed. In

the absence of instructions from air traffic control, heading is maintained and the climb resumed at a rate not exceeding 500 feet/minute to the altitude specified in the Overshoot Procedure for S.B.A. on that aerodrome.

### R/T Check Points

33. There are seven occasions when the aircraft is required to contact air traffic control on R/T:—

- When approximately 10 minutes from the aerodrome, or when instructed by the air traffic control centre to communicate with approach control.
- When the aircraft is told to carry on after having been told to wait.
- When the aircraft first arrives over the main beacon.
- When the aircraft is over the outer marker on an outbound heading along the front beam.
- At the start of the final procedure turn.
- On breaking cloud to visual conditions, when clearance to land has not been previously approved.
- After landing, or when overshooting.

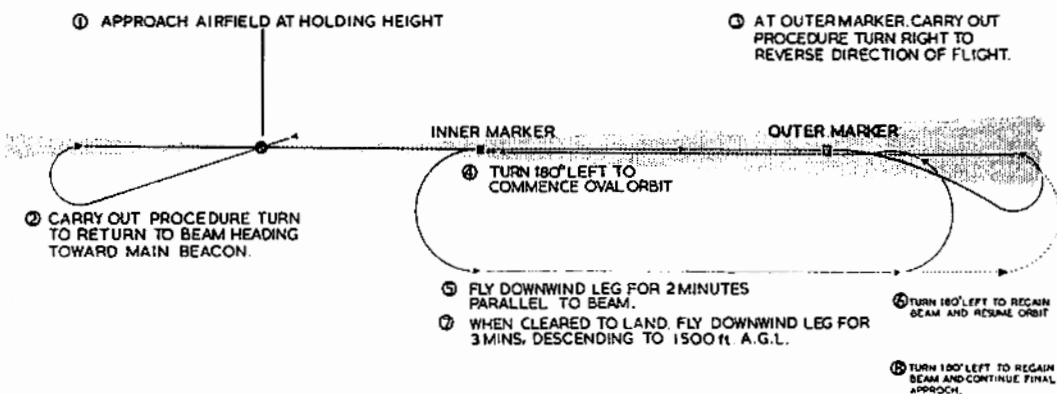


Fig. 5. Holding Procedure—Flight Patterns.

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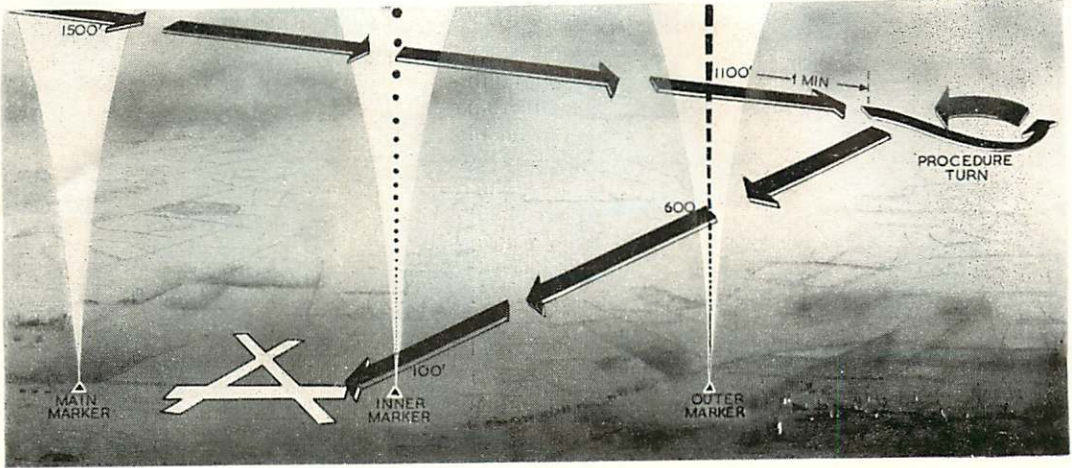


Fig. 6. Landing Procedure—Front Beam.

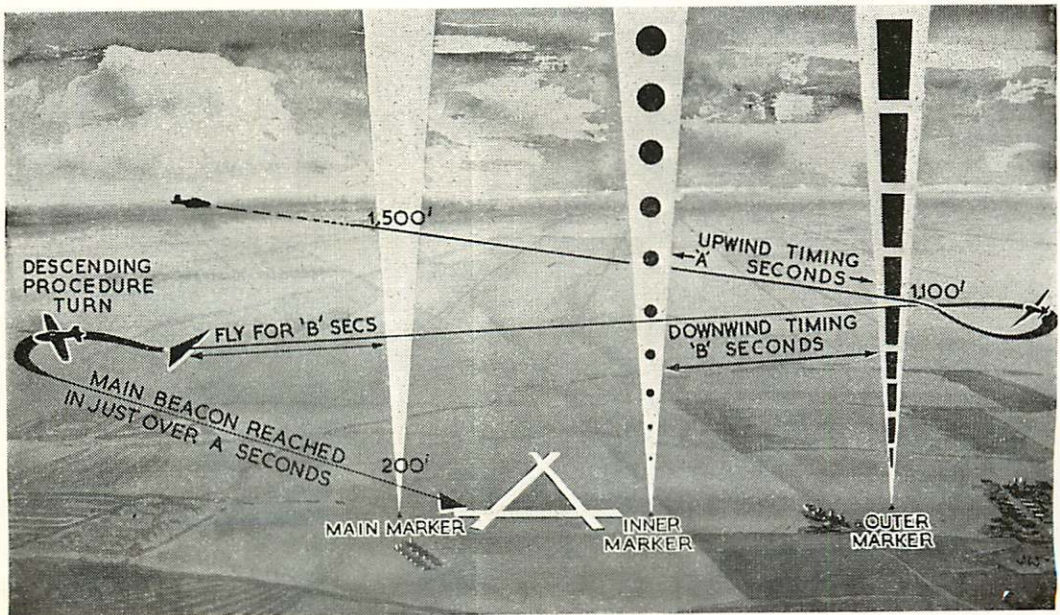


Fig. 7. Landing Procedure—Back Beam.

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CHAPTER 4

RADIO RANGE

Purpose

1. Radio range is a radio beam system which enables an aircraft to orient itself in relation to the range station by means of a receiver which can be tuned to the appropriate frequency.

Method of Operation

2. The radio range transmitter produces a modulated, low-frequency (between 150 to 500 kc/s) carrier wave. The carrier wave is radiated from a directional aerial system in four slightly overlapping sectors (Fig. 1). The radiations in opposing sectors are the same; those in one pair of opposing sectors are keyed with the morse A, while the adjacent transmissions are keyed with a morse N. Where the sectors overlap slightly, a wedge-shaped zone approximately 3° wide is formed in which the signals of the adjacent sectors are heard at equal strength. The four zones so formed are known as *beams* or *range legs*. The keying of the A and N signals is also synchronized so that, when heard over a receiver in the beam, they blend into a steady tone, or "on-beam" signal.

Orientation of A and N Sectors

3. In the United States of America, the N sector is the one containing the true north bearing. If the north leg of the range station coincides with true north, then the northwest is the N sector.

4. Canadian radio range stations transmit N in the northwest sector, or that containing the true bearing of 315° from the station.

5. The position of each radio range station is usually printed on aeronautical maps, or radio aids charts, together with four shaded areas representing its beams, or range legs. The magnetic heading of each range leg, *toward the range station*, is also given. The A and N sectors may be designated in various ways :—

- (a) By the printed letters A and N in their respective sectors.
- (b) By a darkened line on the edge of each range leg bordering the N sector.
- (c) By blacking in the A quadrant for a radius of  $\frac{1}{8}$  in. from the range station (Fig. 2).

Twilight Zones

6. Since adjacent A and N sectors gradually merge, a flight path from the beam into either of the adjacent sectors will be indicated by a gradual build-up of the sector A or N signal over the steady on-beam monotone. As the aircraft travels away from the beam toward the centre of the sector, the sector letter becomes increasingly clear, and the background monotone eventually disappears. The area bordering the beam in which the sector letter can be heard with a background monotone is called the "twilight zone".

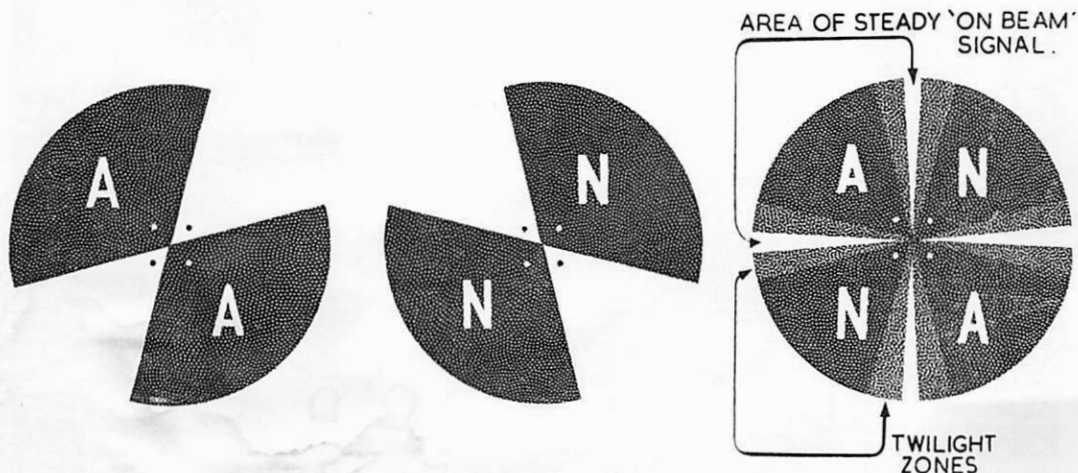


Fig. 1. Radiation Pattern of a Radio Range Station.

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### Station Identification

7. Each radio range station transmits on a different frequency. In addition it is assigned an individual two- or three-letter identification. This identification interrupts the transmission of the A and N signals (approximately every half-minute), being transmitted first in the N sectors, then in the A. On the beam both identification transmissions are heard at equal strength; in the centre of a sector only the transmission of that particular sector can be heard. In the centre of the N sector the identification letters will be heard, followed by a pause; in the centre of the A sector the pause is heard before the station identification letters. The relative signal

strengths of the identification signals is a means of identifying both sector and nearness to the beam when sector or identification letters are unintelligible because of static.

### Cone of Silence

8. Immediately above the aerial system of the range station is a cone-shaped area in which no radiation occurs (Fig. 3). This area is known as the *cone of silence*, and provides a definite indication when the aircraft is directly over the range station. As the range station is approached, the strength of signals gradually becomes stronger and rapidly increases just before the range station. The signals fade completely as the cone

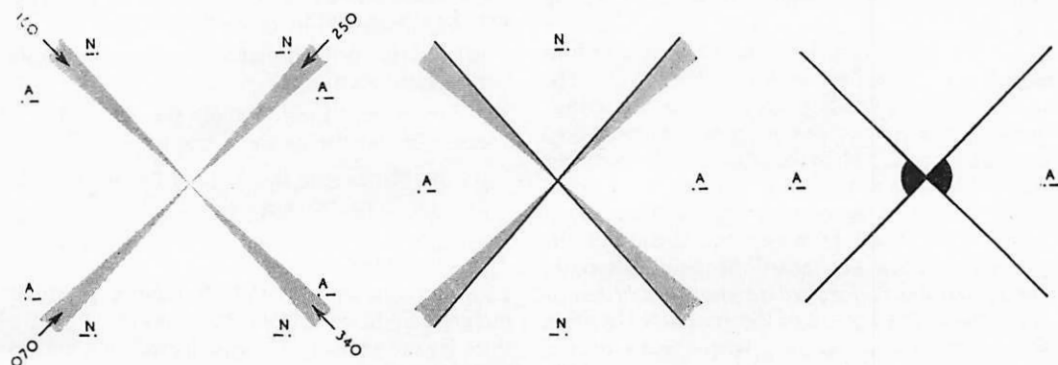


Fig. 2. Designation of "A" and "N" Sectors.

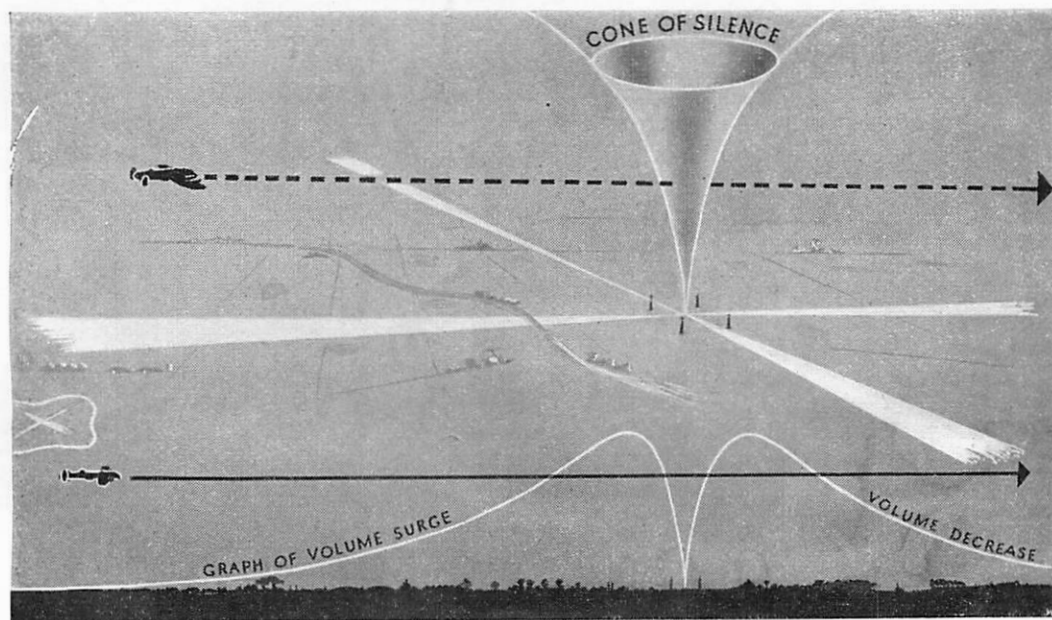


Fig. 3. Cone of Silence.

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of silence is entered and crossed (the duration of the fadeout increases with height), rapidly rising to maximum volume at the far side, after which the signals decrease in volume as the station is left behind.

### Marker Beacons

9. Cones of silence may be marked by radio marker beacons which radiate a field in the form of an inverted cone. Other marker beacons are situated at various points along the main radio range legs as a means of establishing definite fixing points. These fixing points may be used :—

- (a) As check points for reporting to air traffic control.
- (b) As identifiable positions about which holding procedures may be centred.
- (c) To check aircraft groundspeed.

10. The beacons usually transmit on a frequency of 75 mc/s and radiate their signals in a narrow fan-shaped pattern at right angles to the range leg. The carrier wave is modulated with an audible note coded as morse identification letters.

11. An additional beacon receiver is required in the aircraft to feed the audible signal to the pilot's telephones, as well as to cause a light to flash on the instrument panel.

### Irregularities

12. **Bent and Split Beams.** Radio range stations may have their transmissions affected considerably by hills, mountains, or mineral deposits. The resulting beam may be deflected or divided, making it most difficult to follow. In these regions the pilot must be particularly careful to check his navigation by every means, in order to detect any irregular behaviour and avoid taking a wrong course of action seemingly required by the erring beam.

13. **Leaning Cone of Silence.** Variation in transmission intensities may result in a leaning cone of silence. A fadeout may therefore be heard when the aircraft is not directly over the range station, and a false position will be obtained. The error decreases at the lower altitudes and need not affect let-down and approach procedures.

14. **Night Effect.** Reflection of range transmission from the Heaviside layer at night may interfere with the intensity of signal reception, making the beam appear to shift position. This phenomenon decreases in effect as the range station is neared, and within 30 miles it is usually unnoticeable.

15. **Monitoring.** The system of monitoring each radio range station for behaviour of transmission is designed to detect any departure from the normal, and warnings to pilots are issued if necessary.

## RADIO RANGE PROCEDURES

### Radio Range Information

16. **Range Frequency and Callsign.** Usually range data will be known; therefore the tuning in of a radio range station, substantiated by the callsign which interrupts at regular intervals, serves to fix the position of the range station heard.

17. **Signal Interpretation.** By means of the signals heard, the aircraft's position relative to the range station can be established by a methodical elimination of ambiguities. A clear A or N signal indicates that the aircraft may be in either of the two sectors sharing that letter; the absence of the twilight signal further establishes the position of the aircraft within the sector, *i.e.* near the beam or in the centre. The steady on-beam signal locates the aircraft somewhere along a range leg.

18. **Signal Strength.** The change in volume as a straight track is flown indicates whether the aircraft is approaching or leaving the range station. Near the range station the rate of change of volume is great, while at extreme distances a change in volume can be detected only by travelling considerable distances. To solve sector ambiguity at extreme range, time may be saved by tuning in range stations on each side of the one being flown, and comparing their signal strengths. The loudest will usually be the nearest (except where the stations involved differ considerably in power output).

### Volume Control

19. No greater volume should be used than that necessary to make the signals heard without strain. In passing the cone of silence the volume should be kept to a minimum, otherwise a complete fadeout will not be heard unless the aircraft passes directly over the range station.

20. In radio range flying, automatic volume control should never be used. Adjustment of the volume control to maintain a uniform signal level in itself provides useful information. Close to the range station, signal strength builds rapidly. Frequent adjustments of the volume control to maintain a soft signal thus indicate to

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the pilot that he is approaching the range station. A fade of signal without further adjustment, not followed by a build-up, is evidence that the range station has been passed. This allays much of the confusion when a beam is crossed close to the station and the cone of silence is missed. Further out, signal strength varies less rapidly over the same distance, and the volume control will require less attention.

**Orientation Procedures**

21. There are many procedures for orientation on a radio range when the headings of the range legs are known, but only two of these will be described :—

(a) *Combination Method.* This is the procedure most used, as it can be applied in every circumstance.

(b) *90° Method.* This method provides a faster method of orientation when the aircraft is located in the acute-angled sector of what is commonly termed a "scissors" range, i.e. where adjacent range legs form an angle of 60° or less.

22. *Combination Method.* In Fig. 4, an A signal is received with a faint twilight background, indicating that the aircraft is in an A sector, and not far from a beam. Heading is altered parallel to the average bisector of the A sectors (initial direction is optional, or may be based on information of the Most Probable Position). If the aircraft had started from either positions 1 or 2, the twilight signal will build up and volume will increase, indicating that the aircraft is approaching a beam and the range station. Heading is therefore maintained until the beam is crossed, whence a *right* turn will identify the beam intercepted : e.g. in case 1 the aircraft will re-enter the beam shortly after turning 90°; in case 2 the aircraft travels away from the beam, with corresponding change in signals. From positions 3 or 4 the easterly heading used in cases 1 and 2 will cause the twilight signal to fade, and the A signal will decrease in volume, indicating that the aircraft is leaving the range station and getting farther from the beams. A 180° turn, in either direction, is carried out and the aircraft will eventually intercept a beam. When this

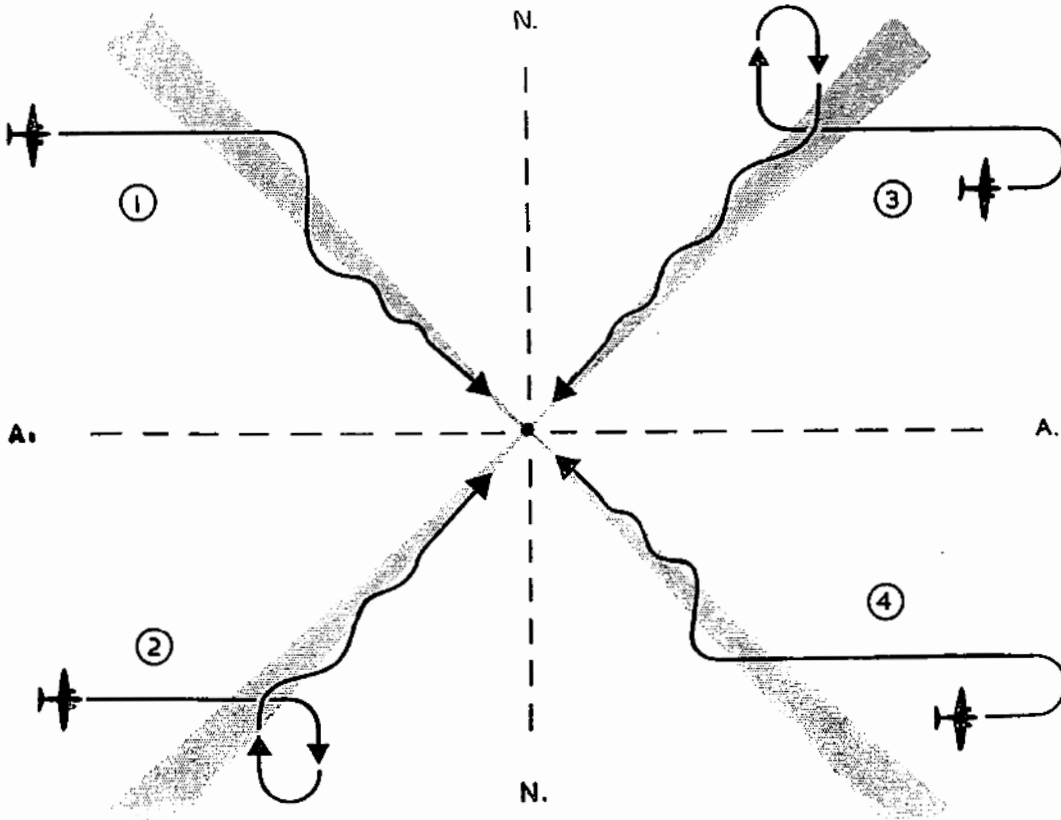


Fig. 4. Combination Method of Orientation.

happens, a 90° turn to the right proves the beam has been intercepted as in cases 1 and 2. In all cases, when the range leg has been regained, beam bracketing is used to establish drift (see S.B.A. Procedures).

required beam the aircraft is on. Heading is then altered to intercept the beam at 30°. When the beam has been regained it is followed for a further two minutes, then a procedure turn is carried out to bring the aircraft back onto the beam on an inbound heading

23. **90° Method.** In Fig. 5, a clear N signal is received, again without background. However, knowledge of this particular range station reveals that the N sectors are very narrow, so a heading is flown at right angles to the average bisector of the N sectors as the shortest distance to a range leg. This heading is maintained until a beam is intersected and crossed. As the opposite A signal is heard, heading is altered 90° to the *right* and, as for the combination method, the beam intersected is proved. In both cases, once the aircraft returns to the beam, bracketing is carried out to determine drift.

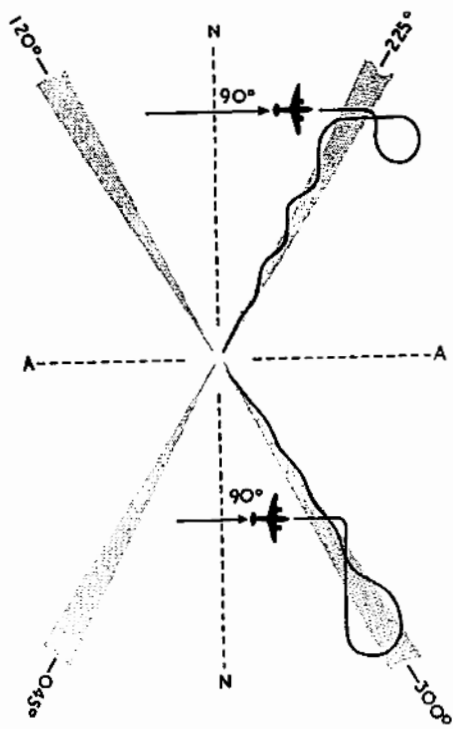


Fig. 5. 90 Method of Orientation.

**Close-In Procedure**

24. When a rapid change of signal strength indicates that the aircraft is close to the station, an attempt to carry out an orientation procedure may lead to confusion as the aircraft may travel through two or more sectors during a single turn (Fig. 6).

25. The aircraft should therefore be turned to an outbound heading parallel to the beam on which the initial approach to the station is to be made. This heading is held and the changing signals ignored until a fading of signal strength is noted. The sector signal indicates which side of the

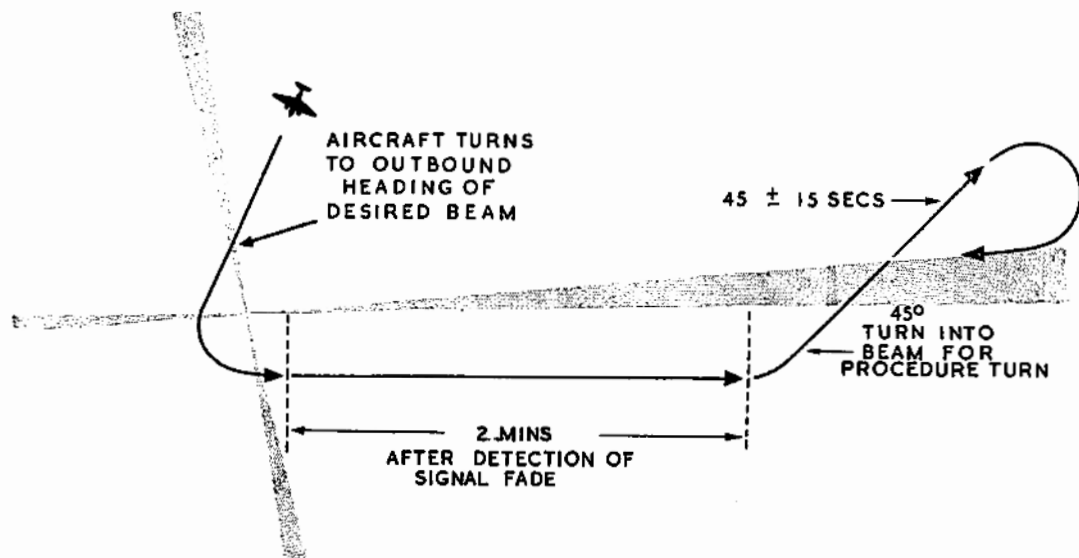


Fig. 6. Close-In Procedure.

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### Instrument Let-Down

26. Fig. 7 illustrates a typical radio range let-down, as given in the Pilot's Handbook.

27. The aircraft approaches the range station and crosses the cone of silence at the required safety height, or assigned altitude. The descent is usually made while flying outbound and returning inbound on the beam opposite to the one aligned over the aerodrome. The let-down is made at reduced speed, proceeding out for about three minutes from the cone of silence before making the procedure turn (to the right, unless otherwise stated). During this time the wheels are lowered and the cockpit check carried out to prepare the aircraft for landing. Flaps may be used if required at slow airspeeds. After the procedure turn the aircraft is flown inbound on the beam, the rate of descent being adjusted to arrive over the cone of silence at the specified altitude. When the cone is crossed, the final descent is made on the beam which crosses the aerodrome. The time from range station to aerodrome, as well as the minimum permissible

altitude over the aerodrome, is given for various airspeeds in the Radio Facilities Handbook. If contact with the aerodrome is not made at the minimum permissible height, overshoot procedure is carried out.

### Overshoot Procedure

28. Overshoot instructions are included in the radio range chart for each aerodrome and must be followed implicitly. The climb is continued to the height specified, and is usually made along the beam which crosses the aerodrome. Particular attention must be paid to the direction of procedure turns, if specified, as these are designed to keep aircraft away from possible obstructions. Control will usually advise whether another approach may be attempted, or will issue diversion instructions.

### Local Procedures

29. The procedures detailed in this chapter are for guidance only. Pilots should refer to the Pilot's Handbook for details of procedures used at individual aerodromes.

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INSTRUMENT  
APPROACH CHART - RNG

SAFE ALTITUDE  
100 N.M. 7600 FT  
25 N.M. 4600 FT

RADIO RANGE  
**REYKJAVIK**  
ICELAND

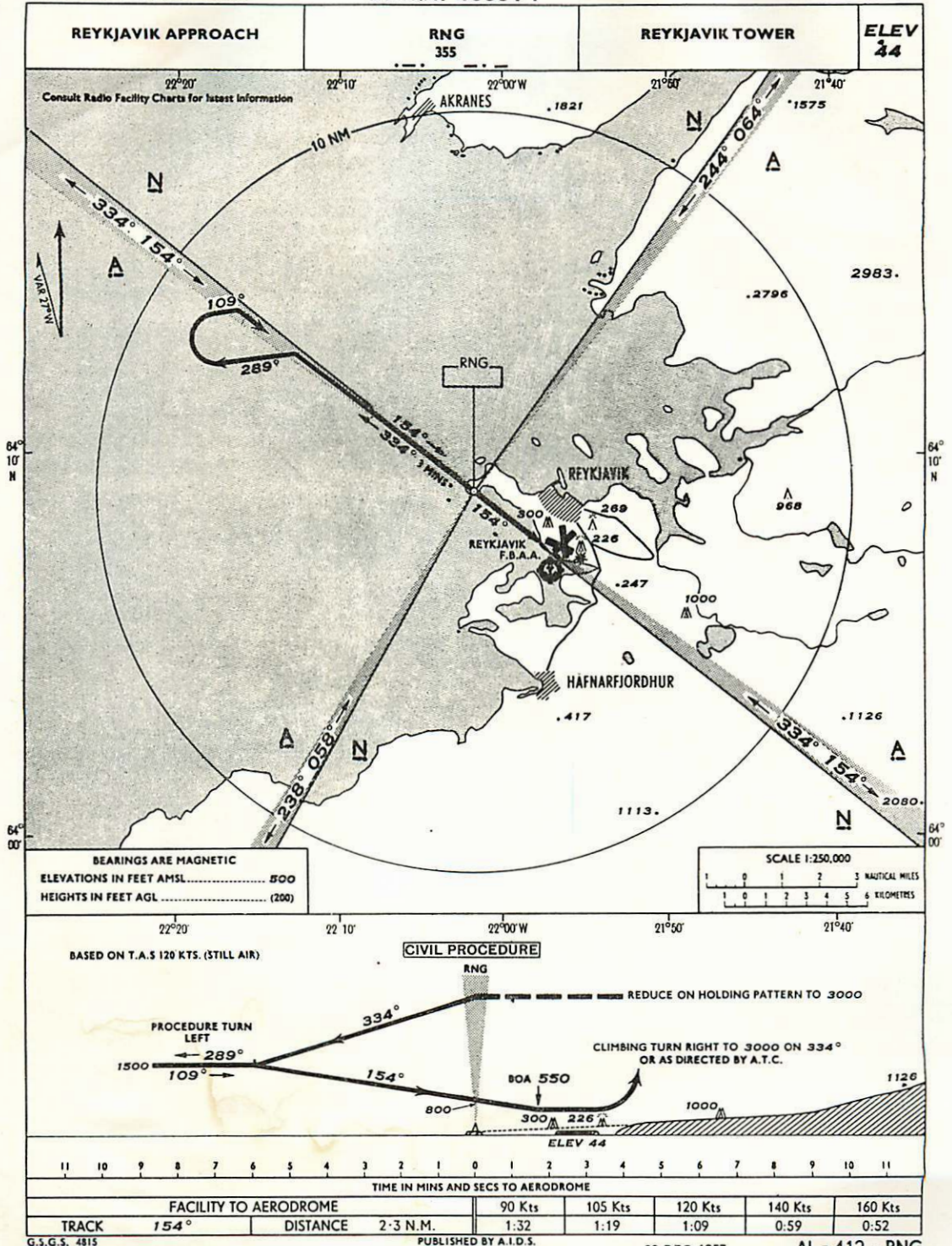


Fig. 7. Radio Range Instrument Let-Down.

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