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B.R. 1634(5) CAFS. 286/46

C.B. 4112 (5) (44)

HANDBOOK

ON THE

USE OF RADAR FOR GUNNERY PURPOSES

G.A. SET–TYPE 285

1944

Admiralty, S.W.1.

Gunnery Branch.

ADMIRALTY, S.W.1.
21st October, 1944.

G. 015801/44.

BR 1634(5)

~~C.B. 4112 (5) (44)~~—*Handbook on the Use of Radar for Gunnery Purposes—G.A. Set, Type 285*, 1944, having been approved by My Lords Commissioners of the Admiralty, is promulgated for information and guidance.

~~C.B. 4112 (5)—*Handbook on the Use of Radar for Gunnery Purposes, Type 285*~~, dated 1941, is hereby superseded and all copies are to be destroyed in accordance with ~~*Article 42 of B.R. Form U.2D (1944) (Restricted)*~~.

~~This book should be inserted in C.B. 4112 (G.B. and I)—*Guardbook for Handbook on the Use of Radar for Gunnery Purposes*~~.

By Command of Their Lordships,

St. V. Markham

To Flag Officers and Commanding Officers of H.M. Ships and Vessels concerned.

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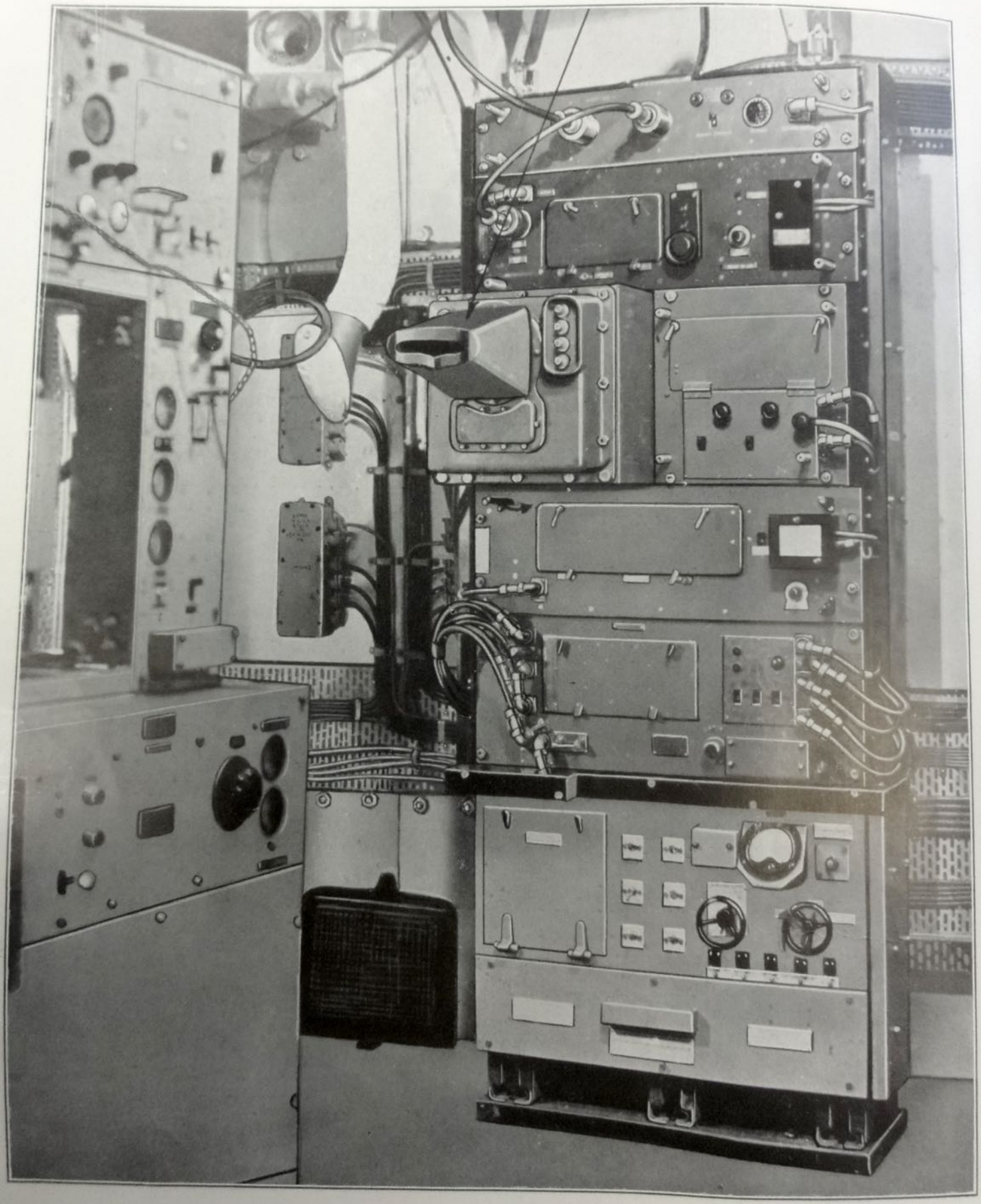


Photograph 1.—TYPE 285P OFFICE.

CHAPTER I

GENERAL

Historical

The early trials of G.C. Radar, Type 282, showed that with a larger aerial array, which narrowed the beam, it was possible to use the set for ranging on aircraft up to the limits of anti-aircraft gun range, and Type 285 was therefore introduced.

2. The Type 285 set, now known as G.A., Type 285, in its first trials showed that ranges were also obtained on surface objects and that the performance of the set in this respect was considerable. This property of the set proved very useful against low flying aircraft or when searching and the set could be employed for low angle warning in certain circumstances, but with the introduction of W.S. sets using P.P.I. displays, these latter uses of the set are not now taken advantage of except in emergencies.

3. Since originally fitted, a number of modifications and improvements have been introduced in order to improve the reliability and performance of the set. The introduction of the beam switch, which enables an unseen target to be followed in bearing by Radar, and of the C.P.U. giving continuous future ranges and used in conjunction with special types of fuze, have now made deterrent fire and particularly barrage fire at unseen targets very much more effective than hitherto.

4. The introduction of the G.R.U.D.O.U. giving accurate deflections will, when used in conjunction with the Radar range and training tubes, enable Radar deflection blind fire to be used.

5. The value of the set as an anti-aircraft rangefinder is enhanced by the evidence of the considerable errors present in optical H.A. rangefinders under certain conditions, and because of this, it should be borne in mind that although the set is useful for searching and low angle warning, these functions are complementary to its value as a rangefinder once the target is sighted.

6. The set is now standard equipment for ranging on aircraft in conjunction with both H.A.C.S. and F.K.C. long range anti-aircraft control systems. An outline of the development of Type 285 is shown schematically in *Plate 7* and briefly described below.

OUTLINE DESCRIPTION

Types 285M (1)/(2)

7. The first major modification to Type 285 was incorporated in these sets which improved the reliability and range discrimination and gave about 100 per cent. greater range. The performance of both sets was approximately the same and both should have now become obsolete. Sets converted by ship's staff were designated M (1) and those supplied incorporating the modifications M (2).

8. The combined range and bearing transmission unit associated with these sets was situated in a separate Radar office and measured rate of change of range and transmitted rate and range to the long range anti-aircraft control positions, also bearing to the H.A.D.T. or R/F director. The fish bone aerial array was mounted on the director.

Types 285M (3)/(4)

9. This second modification included the fitting of a beam switch and a Radar training tube in the H.A.D.T. or R/F director (*see para. 156*) on which was mounted a slightly modified fish bone aerial array. Range, rate and bearing are obtained from an R.T.U. in a separate Radar office as in Types M (1)/(2). The A.B.U. or C.P.U., Mark I, when used with this set for barrage fire is situated in the H.A.C.P. or in destroyers in the T.S.

Types 285P (3)/(4)

10. In this modification, the same aerial array that is used with M (3)/(4) sets is used, but a more accurate and reliable ranging panel is introduced. This is Panel L.24 and used in conjunction with the R.T.U., Mark IV, IV* or V ; it is fitted in the H.A.C.P. or T.S. In cases where there is insufficient room to do this, Panel L.24 may be fitted in the Radar office. A receiver rack and monitor tube are fitted in the Radar office. (*See Photograph 1.*) A spotting tube, Design 4, is being produced for Types 285P (3)/(4), and it will be fitted in the H.A.C.P. or T.S. Panel L.12 will be retained, if sufficient space exists, in the Radar office, pending the introduction of the spotting tube.

Type 285Q

11. The lay-out of the office for this type of set is the same as for Types P (3)/(4). In the H.A.C.P. or T.S., however, an entirely new ranging and control panel, the Tallboy, is fitted, which includes the accurate ranging panel, L.34, which is in effect Panel L.24 laid out horizontally; and a remote training tube, Design 5, while built in below this are the elevation and training control units, for the H.A./L.A. director and aerial array, and the continuous prediction unit, Mark II.

12. The use of the Tallboy eliminates the need for the auto barrage unit, the function of this unit being performed by the continuous prediction unit, Mark II. The Tallboy has been designed for use with Radar, Type 275, but in ships where it is fitted and Type 285Q is used, *i.e.* when "K" D.C.T.s are fitted, the elevation control unit is not used for blind following as Type 285 will not give elevation data. It is only used for power elevation of the sights and aerial array when the director is controlled from below. The Tallboy framework is therefore in place, ready for when Type 275 display panels are fitted. A spotting tube is fitted adjacent to the Tallboy.

PERFORMANCE

Polar Diagram—Shape of Beam. (*See Appendix*)

13. The width of one beam to half amplitude is roughly ± 5 degrees in the horizontal plane and 28 degrees in the vertical plane with the aerials set at zero elevation. When searching, the aerials can be set at a fixed elevation of 10 degrees, thereby increasing the vertical width of the beam, and without undue loss of surface range can pick up distant aircraft as well as surface targets within range.

14. In addition to the main beam of transmission there are subsidiary beams or side lobes which may make targets off the director line of sight visible on the trace. Interference from side lobes on ship targets occurs at ranges below 5,000 yards and on land echoes at greater ranges. Beam switching should assist the operator in distinguishing side echoes.

15. The beam switch will assist in indicating to him the correct target, since the one on which the director and thus the aerials are trained will show its two superimposed echoes the same size.

16. As a result, targets off the director training within these limits are liable to be shown up on the cathode ray tube, and although only one target may be visible in the director telescopes the range operator may be presented with several echoes. The beam split echoes are displayed together and by observing that they are matched the ranging operator can be sure of ranging on the correct target.

Range Performance

17. The greatest reliable and maximum ranges to be expected in ships are given fully in *C.B. 4182/44, Appendix I*, but are given briefly below :—

Cruiser to battleship	22,000 yards
Cruiser to cruiser	17,000 yards
Cruiser to destroyer	13,000 yards
Destroyer to battleship	17,500 yards
Destroyer to destroyer	10,000 yards.

Performance against aircraft depends upon aircraft height and the aerial position in the ship fitted. Maximum range varies between 23,500 yards when the aircraft height is 20,000 ft., to 35,000 yards when the aircraft height is 1,000 ft.

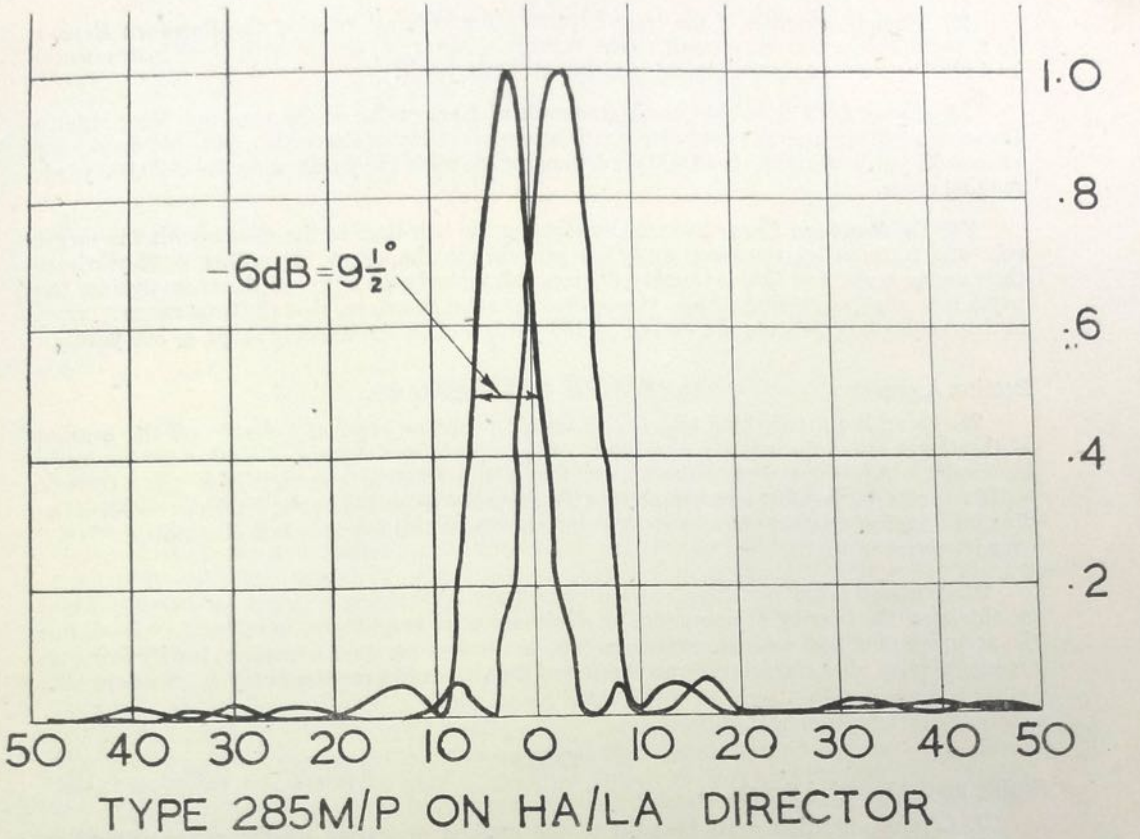
Discrimination

18. Range discrimination is the capability of the set and its operator to distinguish between two targets on the same bearing and at similar ranges. In sets at present fitted, this difference of range is 160 yards.

19. Bearing discrimination is the capability of the set and its operator to distinguish between a target on the line of sight and another target off the line of sight but visible on the trace. The measure of discrimination is the minimum angle off the line of sight which enables a decision to be made as to which is on and which is off. In sets at present fitted this angle is approximately 8 degrees, but it should be accurately determined by test and logged.

Range Accuracy and Consistency

20. ***Index Correction.***—The range given by Type 285 is subject to an index correction. This should be obtained and consistently checked for each ranging panel by range accuracy tests against an object at known range (*see C.B. 4112(1)(45), Chapter VI*). Provided this has been done correctly Radar range should be equal to geographical range, though individual readings will be subject to errors as outlined.



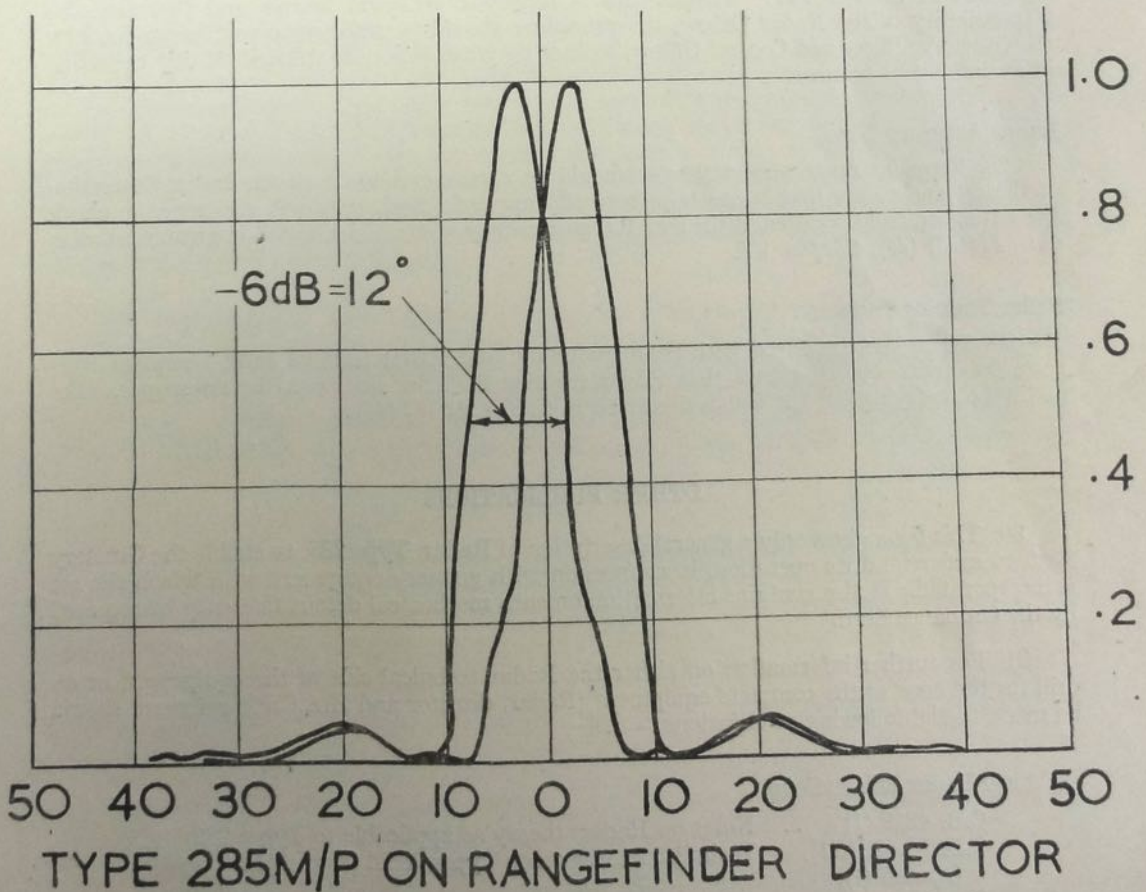


Diagram 1.—PRODUCT FIELD STRENGTH DIAGRAM. TRANSMITTER AND RECEIVING AERIALS.

21. ***Panel L.24*** is subject to a small ***Instrumental Error*** which goes through a consistent cyclic change with every 1,000 yards change of range (*see paras. 73 and 74*).

22. Having a portion of the trace expanded for accurate ranging the ***Random Errors*** in range following are very small. The total ranging errors due to both these instrumental and random errors however should not exceed ± 25 yards.

23. ***Panel L.12*** is subject to ***Instrumental Errors*** due to the scale not being strictly linear, small differences in sweep rate or variation in the Index Correction, but this should not exceed 75 yards using the 0–15,000 yards ranging scope or 150 yards using the 0–30,000 yards ranging scope.

24. The ***Random Error*** incurred by aligning the hair-lines of the cursor with the target echo and transmitting the range away are probably in the nature of another ± 75 yards on the ranging scope and this is roughly doubled when reading ranges off the trace against the paper scale on the warning scope. It may be expected, therefore, that the total ranging errors in the ranging scope should not exceed ± 150 yards and on the warning scope ± 300 yards.

Bearing Accuracy

25. Using beam switching and Radar training tube an error of $\frac{1}{3}$ degree off the bearing of the target alters the relative amplitude of the echoes in the ratio of 5 : 6, which is easily discernible. Against a well defined fixed target the training accuracy is in the nature of ± 15 minutes, but against a moving target the accuracy is limited by the training control of the director. Against a broad target such as a ship the Radar training tube will also indicate " on " over its entire width.

26. Without beam switching various procedures for holding a target for bearing, based on obtaining the bearing of maximum or minimum echo amplitudes, have been evolved, but the accuracy obtained, against surface targets, has only been good enough to justify firing an occasional salvo after careful tracking of a target that has held a constant course. (*See para. 49.*)

TESTS

Setting up the Ranging Panels

27. Careful attention must be paid to the method of setting up the range display as described in *Chapter III*. Though this is largely a technical matter and therefore the responsibility of the Radar Officer, the procedure should be sufficiently well understood by the Gunnery Officer and Control Officer, so that they can supervise the drill of this operation in an intelligent manner.

Range Accuracy Tests

28. Frequent range accuracy tests should be carried out to check the Index Correction of the set and to see that it has been correctly applied. Such tests will also serve to check the setting up and operation of the set. Range accuracy tests are dealt with in greater detail in *C.B. 4112(1) (45), Chapter VI.*

Radar Training Tests

29. When sets are fitted with beam switching and Radar training tubes, frequent tests must be carried out to ensure that Radar training is on for line with the telescopes. The method of carrying out the test is described in *C.B. 4112 (1) (45).*

OTHER PUBLICATIONS

30. This book gives only a general description of Radar, Type 285, to enable the Gunnery Staff to understand its operation, in connection with gunnery equipment with which the set is incorporated. It also contains information on such mechanical details that may be required by the Ordnance Staff.

31. For further information on either the Radar technical side of the equipment, or on drill for the crew of the complete equipment (Radar, director and H.A.C.P.), reference should be made to the following publications :—

Technical Radar Publications

C.B. 4219 (1)	..	Notes on Radar theory as applicable to Types 282/3/4/5.
C.B. R. 4221 (1), (A) and (B)		Technical handbook on Types 285M (3) and (4).
C.B. 3090..	..	Instructions for installation and fitting of Radar equipment.
H.490 ..	..	Technical handbook on Types 285P (3) and (4) and 285Q.
C.B. 4355 (1)	..	Instructional handbook on the H.R.B. teacher.

Drill and Procedure

B.R. 984	..	Radar operating procedure. Drill for Radar gunnery sets. Chapters 2, 3, 5 and 9.
C.B. 3085	..	High angle firing manual.
B.R. 846	..	Drill for H.A.C.S. IV.
B.R. 998	..	Drill for H.A.C.S. III.
B.R. 826	..	Drill for F.K.C. and F.C.B.
B.R. 861	..	Drill for F.K.C. and A.F.C.C. III*.
B.R. 1054	..	Drill for F.K.C. and A.F.C.C.I.

Gunnery Handbooks

B.R. 913	..	Fuzekeeping clock and associated equipment series.
B.R. 901	..	A.F.C. clocks series.
B.R. 919	..	High angle control system and associated equipment series.

TRAINING AND MAINTENANCE

32. As Type 285 has been developed as an adjunct to the H.A. fire control system, the training of its operators as regards the part they play in the fire control team as a whole is the responsibility of the Gunnery Officer. It is equally important that Type 285 should be treated as an integral part of the control system. The instruction of the operators as regards the handling of the set is a matter for the Radar Officer, but the Gunnery Officer should also be conversant with this aspect of their duties so that he can appreciate their capabilities and difficulties.

33. The maintenance of the set is the responsibility of the Radar Officer, but the maintenance of the range transmission unit and associated transmissions is dealt with in the same way as any other fire control instrument in the ship. It must be emphasised that, as in all other branches of gunnery, good results will not be achieved without a considerable amount of practice. It is therefore of value to exercise the Radar operators in the training of the director, and the director trainers in the Radar operators duties, so that each understands the other's difficulties. In this way proper team work and the minimum of cross-talk on the telephone is achieved.

Communications. *Diagrams 2 and 3*

34. *Diagrams 2 and 3* show how Type 285 links up with the fire control arrangements of a ship. *Diagram 2* shows Type 285P in conjunction with a rangefinder director, Mark IIIW with F.K.C. and A.F.C.C. Telephones are shown by the green tubing, and for simplicity are not split up into groups, which normally include the control group, rate group, training group, order group, and warning Radar groups. *Diagram 3* shows Type 285P in conjunction with a H.A./L.A. director, Mark V, with H.A.C.S. IV. Telephones are shown by the green tubing and for simplicity are not split up into groups, which normally include the control group, sweeping group, order group and A.D.O. group.

35. Care should be taken to reduce conversation to an absolute minimum until the enemy is detected so that everyone is able to listen in for the first warning of the enemy's approach. This can be most easily achieved if each member of the fire control team has some idea of the duties of the other members. Full details of Radar gunnery communications for Type 285 are given in Confidential Admiralty Fleet Orders. Changes are constantly being made and the latest C.A.F.O. on the subject should be referred to. (*C.A.F.O. 1566/43* or subsequent orders.)

36–40.

CHAPTER II

RADAR EQUIPMENT ON THE DIRECTOR

THE AERIAL ARRAY

41. The aerial arrays fitted in conjunction with Type 285 on the various directors differ only in detail. Generally the array consists of light "fishbone" aerials with semi-circular reflectors at the rear. The whole array is carefully balanced to avoid any undue strain on the elevating system, and is so disposed as to afford the minimum of wooding to the crew of the director. The array is mounted on a common axis over the director and is lined up with the layer's and trainer's binoculars with which it trains and elevates.

42. As the aerial is mechanically coupled to the layer's sight bracket, in ships which have level stabilisation of the layer's sight, the aerial is thus stabilised in elevation. In ships which have the "P" sight ("L" and "M" class destroyers) there is insufficient power available from the stabilising unit, and a hand-driven follow-up elevation drive stabilises the aerial array.

43. The aerial dipoles and director rods should be kept clean, and any distortion, however slight, must be avoided, as it will adversely affect the performance of the set. Care must be taken to prevent them fouling signal halyards, etc.

44. If damage causes the loss of one or two director rods at the outer end of the "fishbone," the range performance will not noticeably be affected, and any error in bearing introduced can be corrected by means of the adjustment to the beam switch and line unit referred to in *paras. 49 and 50*.

THE BEAM SWITCH

45. This is also referred to as the rotary capacity switch and line unit. It is a mechanical switch driven by an electric motor, which by switching the Radar signals through different aerial feeders, alternately throws the beam slightly to the right and left of the sight line to produce a polar diagram as shown in *Appendix*.

46. Thus by training the aerials until the echo signals obtained from the two beams are of the same amplitude, the bearing of the target can be obtained accurately. On the trace of the Radar training tubes the two echoes can be displaced laterally from each other, and an error of $\frac{1}{2}$ degree off the bearing of the target alters the relative amplitude of the two echoes enough to be easily detected.

47. Beam switching is also of value in assisting the operators at the ranging panel to select the correct target. On this panel the echoes are not separated but are superimposed, so that the target on which the aerials are trained produces two echoes on the trace, merged so that they appear as one. Targets off the line of sight will appear as double echoes, with the smaller inside the larger, while the target well off the sight line will give only one echo; the absence of the other being indicated by the uninterrupted base line of the trace. In *Diagram 5* three target echoes are shown, but the operator should reject the first and third and range on the middle one. *Diagram 1* shows the horizontal product field strength diagram for the transmitting and receiving aerials.

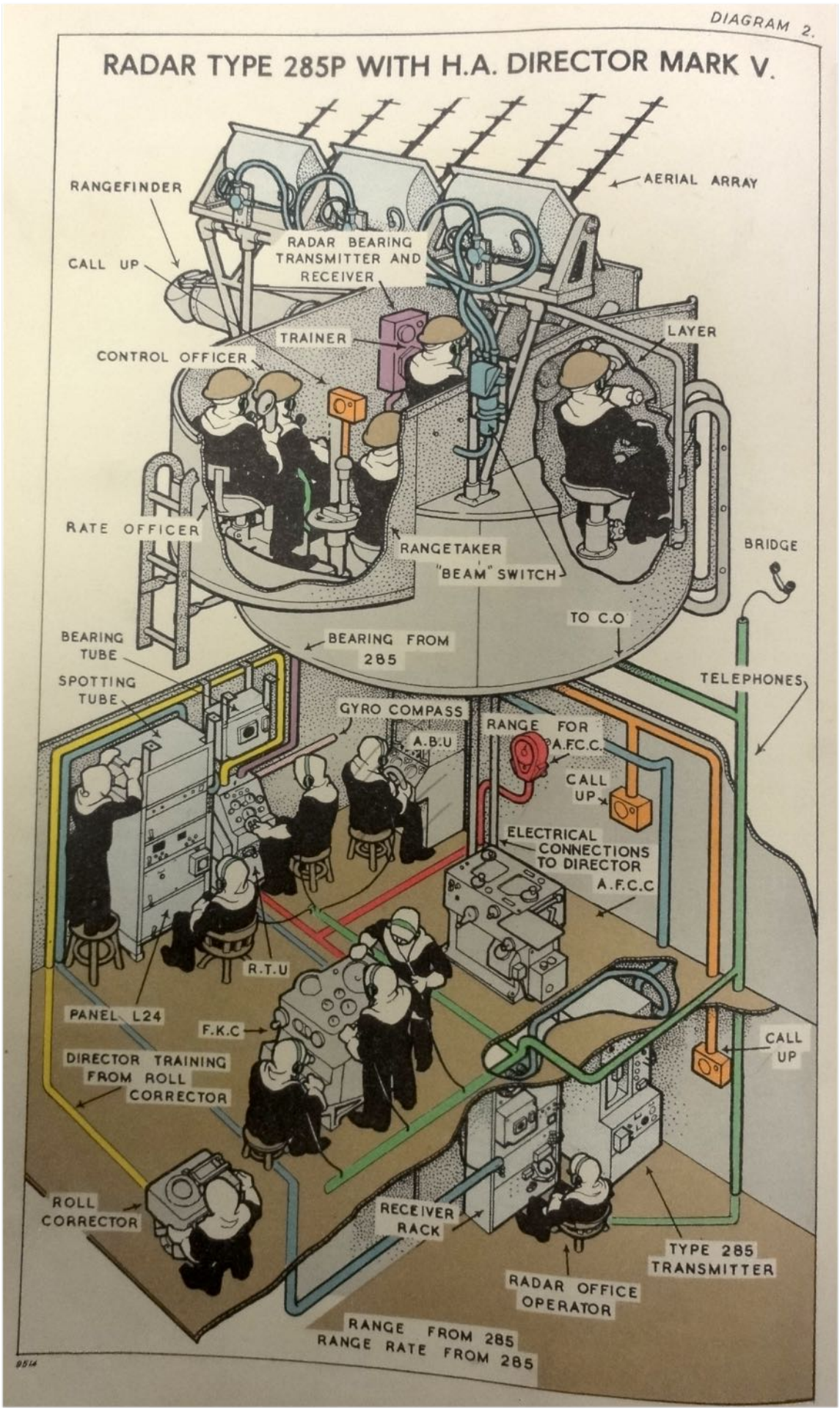
Maintenance of the Beam Switch

48. The beam switch is mounted on the director and its maintenance is the joint responsibility of the electrical and Radar staffs. A full description of the switch is given in the technical handbook (*see para. 31*) of the set and strict compliance with the instructions therein is essential, and as it is a precision made unit, very great care must be taken when making any adjustment to it.

49. If the beam switch breaks down, the beam will lie at an angle of about $2\frac{1}{2}$ degrees left or right to the line of training. This will not affect the range performance to a noticeable extent, but will prevent any indication of training. If blind fire then becomes a definite requirement, a line spotting correction equal to the amount the beam lies off the line of training should be applied by means of the lateral deflection handle. On reverting to visual fire, this correction must of course be immediately removed. Temporary arrangements however, taking about $\frac{1}{2}$ hour to complete, can be made to disconnect the beam switch in such a manner, that a single beam on the line of sight is produced. Approximate bearing can then be obtained by training to maximum amplitude of echo as with Types 285 M(1) and M(2). Instructions for carrying out this repair are given in the books mentioned in *para. 31*.

DIAGRAM 2.

RADAR TYPE 285P WITH H.A. DIRECTOR MARK V.



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Radar Training Test

50. To test or adjust so that Radar training is on for line with the visual line of sight, proceed as follows :—

(*a*) Select a target that gives a suitable echo (an isolated object such as that shown in *Diagram 20* of *C.B. 4112 (1) (45)* is necessary) and train accurately on it by telescope. Then, by means of the telescopic adjustment described in *Chapter 6* of *C.B. 4221 (1) (A)* or *C.B. 4221 (1) (B)* adjust the beam switch until the two echoes showing on the Radar training tube in the director or the office are of the same amplitude.

(*b*) Check by training off in alternate directions and training on again by Radar and note position of the vertical cross wire or its equivalent when the Radar trainer reports " on ". It should be the same amount short of the target when approached from either direction.

(*c*) This test can also be carried out at sea on a suitable surface target preferably at inclinations of 0 degree or 180 degrees.

RADAR ON RANGEFINDER DIRECTORS. *Diagram 2*

51. The aerial array consists of six fish-bone aerials with three semi-cylindrical metal reflectors disposed on a common axis over the director. The axis is mounted in bearings carried on a frame support which is built up from and rotates with the windscreen of the director so that the aerials are kept trained on the line of sight of the director.

52. The aerials are elevated with the director sight by means of a flexible drive or link mechanism connected to a ball or other joint adjacent to the trainer's telescope arm. To avoid interfering with the canvas cover of the director, which spreads over the frame support under the aerials, a harbour stowage is provided for the elevating link, in the shape of a short stanchion bolted to the windscreen and carrying a ball joint to which the elevating link is transferred when in the secured position.

53. Parallelism of the aerials with the director in training is arranged in the fitting of the trunnion bearings, and in elevation it can be adjusted by a bottlescrew in the elevating link or by easing and re-clamping the elevating crank on the aerial axis. More acurate adjustment than can be obtained by sighting along the aerials is not essential.

54. The aerials and reflectors are balanced by counter-balance weights, to avoid an undue additional load in elevation. Rubber buffers are fitted to limit the aerials between 10 degrees depression and about 90 degrees elevation, when disconnected from the director sight. The feeder cables come up through the gland plate with the remainder of the cables.

55. An additional bearing receiver, receiving bearing from the R.T.U., is fitted on the revolving windscreen of the director, visible to the director trainer, with a drive from the main training gear-box. In early directors this receiver was incorporated in the main training gear-box at the trainer's feet. A remote Radar training tube is fitted in the director but in some ships it may be fitted in the Type 285 office or in the T.S.

RADAR ON THREE-MAN RANGEFINDERS

56. In three-man rangefinders which have been converted to control fuze keeping clocks, the arrangement is generally similar to that in the rangefinder directors, the aerials being elevated by a link from a bracket on the layer's telescope arm.

57. In three-man rangefinders not so converted, the aerials have a worm drive incorporated in one bearing and a flexible drive to this from the blank pointer drive to the C-type elevation receiver, keeps the aerials laid at the same elevation as the rangefinder. This method was adopted to avoid interference with the anti-vibration features of the rangefinder mounting.

58. The bearing receiver is similar to that fitted in rangefinder directors, but is has a bearing transmitter added to it which transmits line-of-sight training in 30-minute steps to the R.T.U. This arrangement avoids having to run the A.F.C.C. continuously in order to show the bearing of the director on the R.T.U. when searching. The remote Radar training tube is positioned at the rear of the director, but in modified three-man rangefinders this may be fitted in the T.S, if there is room.

RADAR ON "L" AND "M" CLASS DESTROYER D.C.T.s

59. The aerial array of six fishbones is mounted on the roof of the D.C.T. above the control officer's hood and has a worm drive incorporated in one bearing. A drive is taken off the shafting from the " B " oil unit, which stabilises the rangefinder, to a follow-the-pointer instrument to indicate the angle of sight at which the binocular of the " P " sight is laid. The cross levelling operator works a handle to keep the pointers in line and thus by a flexible shaft elevates the aerial array through the worm drive to the same angle of sight. This arrangement was adopted to avoid overloading the " B " oil unit as the drive is necessarily rather

tortuous. In low-angle fire, when the cross-levelling operator is already employed, the aeria should be left laid on the horizon or, if there is much motion on the ship, at whatever elevati is found necessary to halve the roll. The array has a housing position at 10 degrees elevati

60. An additional bearing receiver, similar to that fitted in rangefinder directors, Marks II and III, is fitted in a position visible to the director trainer on the right side of the D.C.T., with a flexible drive from the 3-speed training unit. Bearing transmission to the R.T.U. is from the resetter transmitter on the A.F.C.C. in 6-minute steps *via* a 3/30 minute step transformer. This necessitates keeping power on the A.F.C.C. continuously in order to transmit the bearing of the director to the R.T.U. when searching.

61. The remote Radar training tube is fitted in a watertight structure outside the tower and the trace can be seen by looking through one of the windows of the tower. Some towers may still have the training tube inside, but these will be converted to the outside type on refitting.

RADAR ON H.A. DIRECTORS, MARKS I TO IV

62. A cab or hood is built up round the rear of the director and the bearings for the axis of the aerial array are mounted on top of this hood. The worm drive is incorporated in one bearing and the flexible drive to this from the elevating worm of the director sight keeps the array laid on the target. The array consists of six fishbone aerials.

63. Great care is necessary that the four bearings are exactly aligned during erection and provision for adjustment has been allowed for in the design. Any misalignment will result in heavy efforts in elevation, and a test should be made to ensure that the gear is quite free before connecting up the elevating drive.

64. On erection, the centre line of the shaft is made parallel to the line of the trunnions of the director sight, and this ensures the aerials being in line with the telescopes for training. Before connecting up the flexible drive, the telescopes should be laid on the horizon or some object and the fish-bones sighted on the same object to ensure parallelism in elevation. Greater accuracy than can be achieved by sighting along the fish-bones by eye is not essential.

65. A remote Radar training tube is fitted in the director but its position will vary according to the Mark of director fitted. In H.A. directors, Marks I, II, III and IV it is fitted adjacent to the trainer but in Marks III and IV with scooter gear, it is fitted at the right rear of the director.

RADAR ON H.A. DIRECTORS, MARKS IV G.B., V AND V*. *Diagram 3*

66. The aerial array is the same as for earlier marks of H.A. directors, the elevating drive being taken off the drive to the control officer's binocular. A remote Radar training tube is fitted at the right rear of the director for the use of an operator, who trains the director by means of aided training unit.

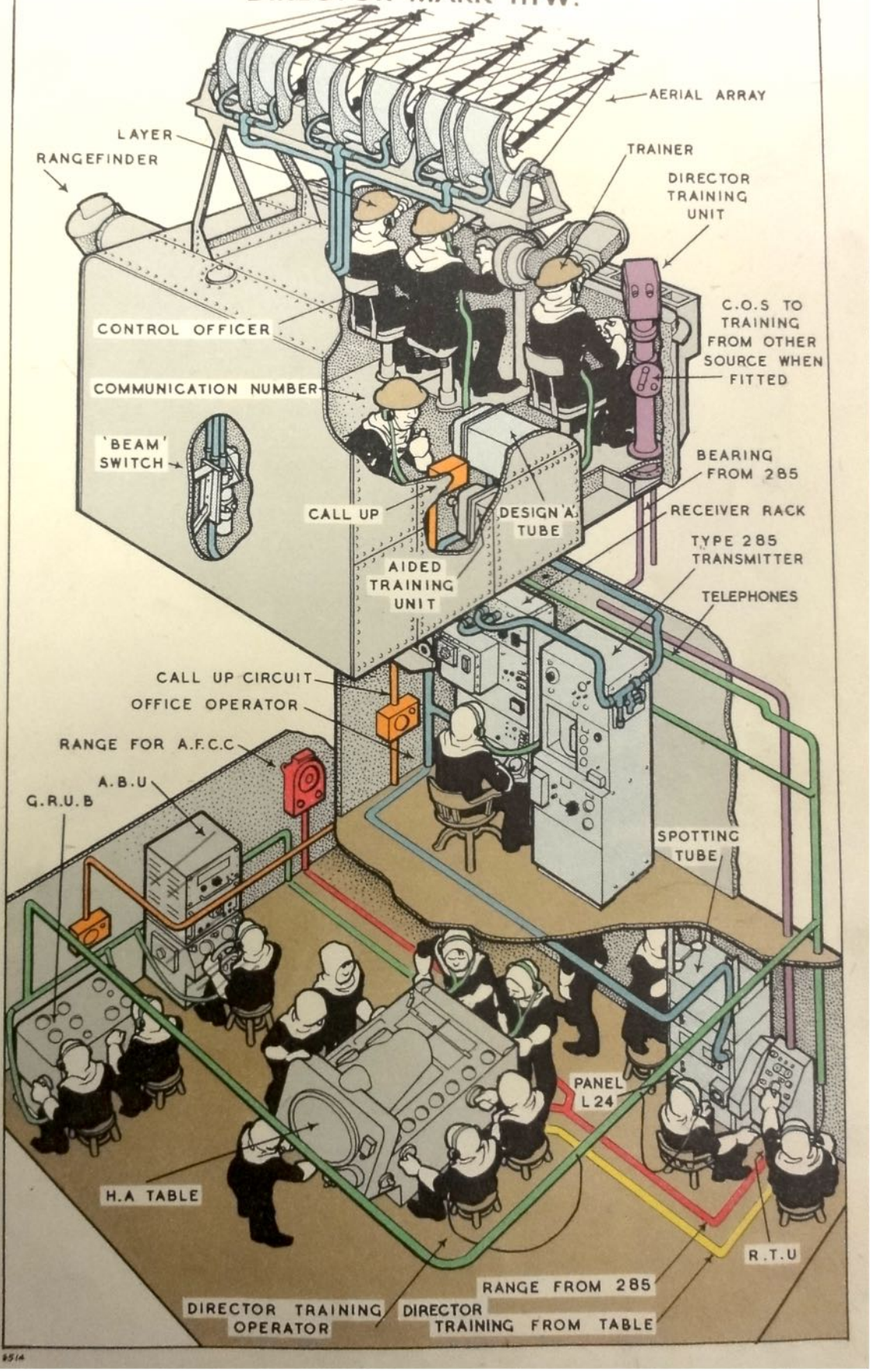
RADAR ON H.A. DIRECTOR, MARK V*M AND "K" D.C.T.s

67. The aerial array used with these directors is the same as for earlier marks of director, the elevating drive being taken off the layers H.A. director elevation handwheel. Type 285Q is fitted with "K" D.C.T.s. H.A. directors, Mark V* M are fitted with Type 285P(4); the training tube is not fitted in the director but in the T.S. This is done because Elevation Control Unit (E.C.U.) and Training Control Unit (T.C.U.) are fitted in the T.S. and Radar training is thus carried out by R.P.C. from below.

(See Correction Slip on Diagram)

DIAGRAM 3.

RADAR TYPE 285P WITH RANGEFINDER DIRECTOR MARK IIIW.



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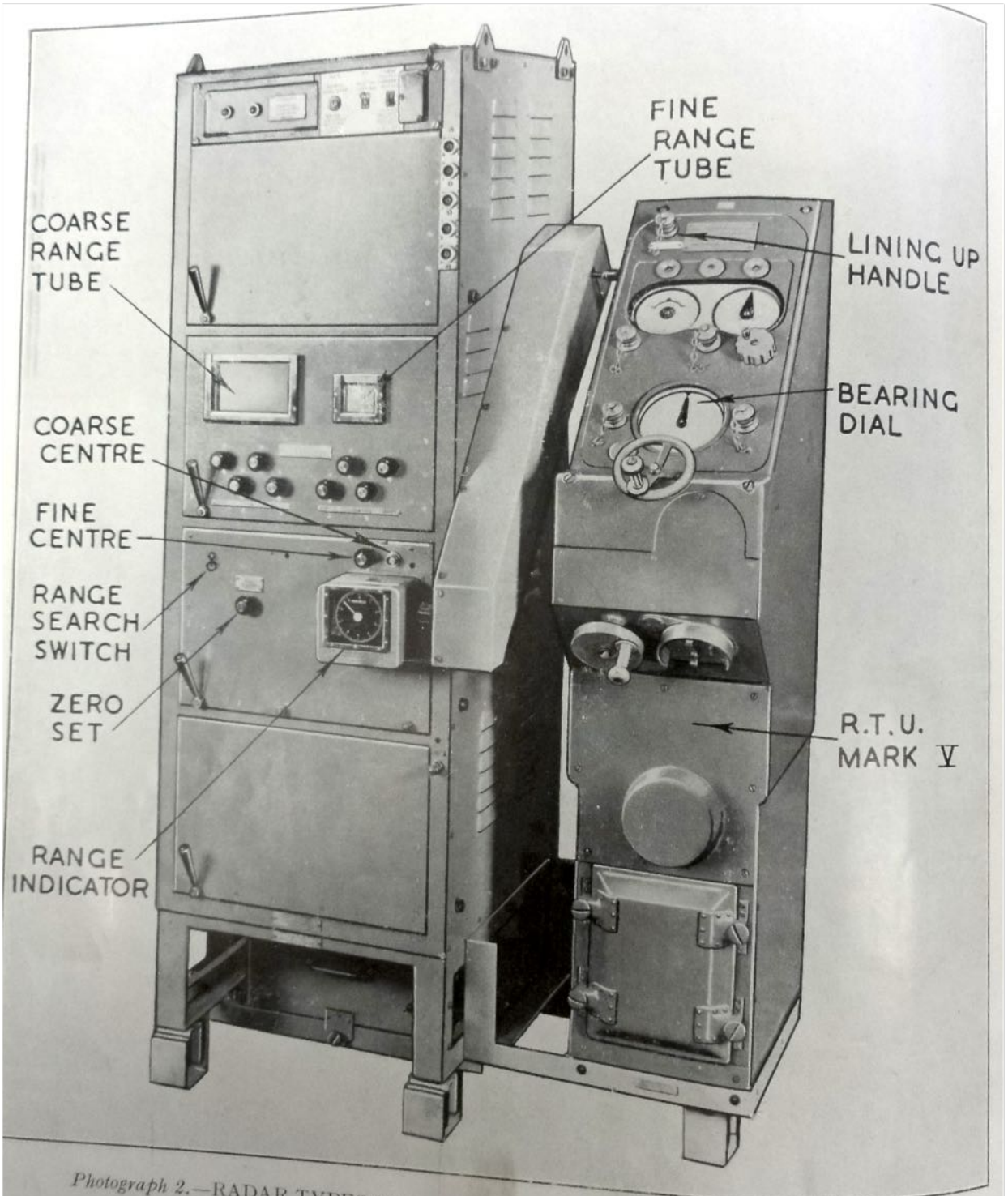


Photograph 2.—RADAR TYPES 285P(3)/(4)—RANGING PANEL L.24 WITH R.T.U. V.

CHAPTER III

TYPES 285P (3)/(4)—RANGING—DESCRIPTION AND OPERATION APPLICABLE TO RADAR OPERATORS

PANEL L.24 (*Photograph 2*) OR PANEL L.34

71. An accurate ranging panel, L.24, has been designed for use with Type 285, and when this is fitted, the G.A. set is known as Type 285P (3) or 285P (4). The advantage of Panel L.24 over the previous display Panel L.12 is, firstly, that it is more technically efficient and produces a more accurate range with greater reliability, but another great advantage from the gunnery point of view is that it can be fitted remote from the Radar transmitter and receiver and can thus be installed in the T.S. or H.A.C.P. where the indication provided is visible to the officer or rating in charge of the T.S. or H.A.C.P. In cases where there is insufficient room in the T.S., H.A.C.P. or suitable annexe, the Panel L.24 and R.T.U. must perforce be fitted in the Type 285 office.

72. The Panel L.24 is thus fitted when space is available in the T.S. or H.A.C.P., and is connected to a range transmission unit, Mark IV, IV* or V, in the same way as the Panel L.12, for transmitting range to the F.K.C. or H.A. table and to the matching receiver (where fitted) over the A.F.C.C. or F.C.B. Panel L.34, which is virtually a Panel L.24 fitted horizontally, is fitted with Type 285Q and although the following description refers to Panel L.24 it applies equally well to Panel L.34.

Accuracy

73. Although various small systematic errors are present, the range accuracy of Panel L.24 is good, the total error, if tests and adjustments in accordance with the Radar handbook have been correctly carried out, being probably within ± 25 yards.

74. These systematic errors in the panel go through a consistent cyclic change with every 1,000 yards change of range ; that is to say, any errors present at ranges between 2,000 and 3,000 yards will be repeated at corresponding ranges every thousand yards. If the range is accurate at 2,000 yards, it will also be accurate at 3,000 yards, 4,000 yards, etc. If there is an error of say + 15 yards at 2,300 yards and — 15 yards at 2,700 yards, there will be corresponding errors at 3,300 yards, 4,300 yards, etc., and at 3,700 yards, 4,700 yards, etc.

Layout and Working Controls

75. The cabinet of Panel L.24 comprises four separate compartments, each of which can be partly withdrawn for servicing. The upper one contains components for producing the traces on the cathode ray tubes, the second contains the cathode ray tubes and adjustments, the third contains the components for measuring range to which the R.T.U. is connected, and the bottom compartment houses the various power supplies. A full description of other technical details is given in *H.490, Handbook for Types 285 P(3)/P(4)*.

76. Two cathode ray tubes are used for the range presentation. One, the coarse range tube, showing the complete trace from 0–40,000 yards, and the other, a smaller tube called the fine range tube, showing any enlarged portion of this trace extending about 500 yards either side of the selected range.

77. The ranging trace on the coarse range tube shows the ground wave and all echoes within the beam of the set. The calibration marks consist of downward pointing pips every 1,000 yards, superimposed upon the range trace. These can be switched on and off by a range/search switch, as required, when the panel has been modified (*see para. 84*). The beam split echoes are superimposed on one another, assisting the range operator in selecting the correct target. By moving the range handwheel on the R.T.U. a bright spot, called the strobe, can be made to move along the range trace and brighten a portion of the trace at any selected echo. The strobe serves to select the portion of the trace to be shown on the fine range tube and it also controls a similar brightening on the remote training and spotting tubes, and positions the correct echo on the trace of the spotting tube. This enables the remote training tube operator to see for himself whether the Radar operator is ranging on the target on which the director is being trained.

78. The fine range tube displays an expanded portion of the ranging trace extending for about 500 yards either side of the centre of the position of the strobe on the coarse range tube. This distance is variable according to the setting of the accurate range sweep length control in the top drawer of the panel. The expanded trace on the fine range tube has a well or

(*v*) Provision is made, in supplying a set of resistors, to alter the range scope of the coarse range tube to suit particular applications of Panel L.24 as follows :—The range scope of all Panels L.24 to be changed to 0–25,000 yards, except those associated with the main armament of battleships and cruisers.

The effect of this is to spread out the coarse range tube display as much as possible consistent with fire control requirements, and so overcome the somewhat cramped trace on existing Panels L.24.

85. The combined effects of these modifications should be to make Panel L.24 easier to use with less strain for the operator. One effect of the modifications is that the bright spot strobe on the remote training tubes is considerably lengthened and therefore may prove more difficult to operate.

RANGE TUNING

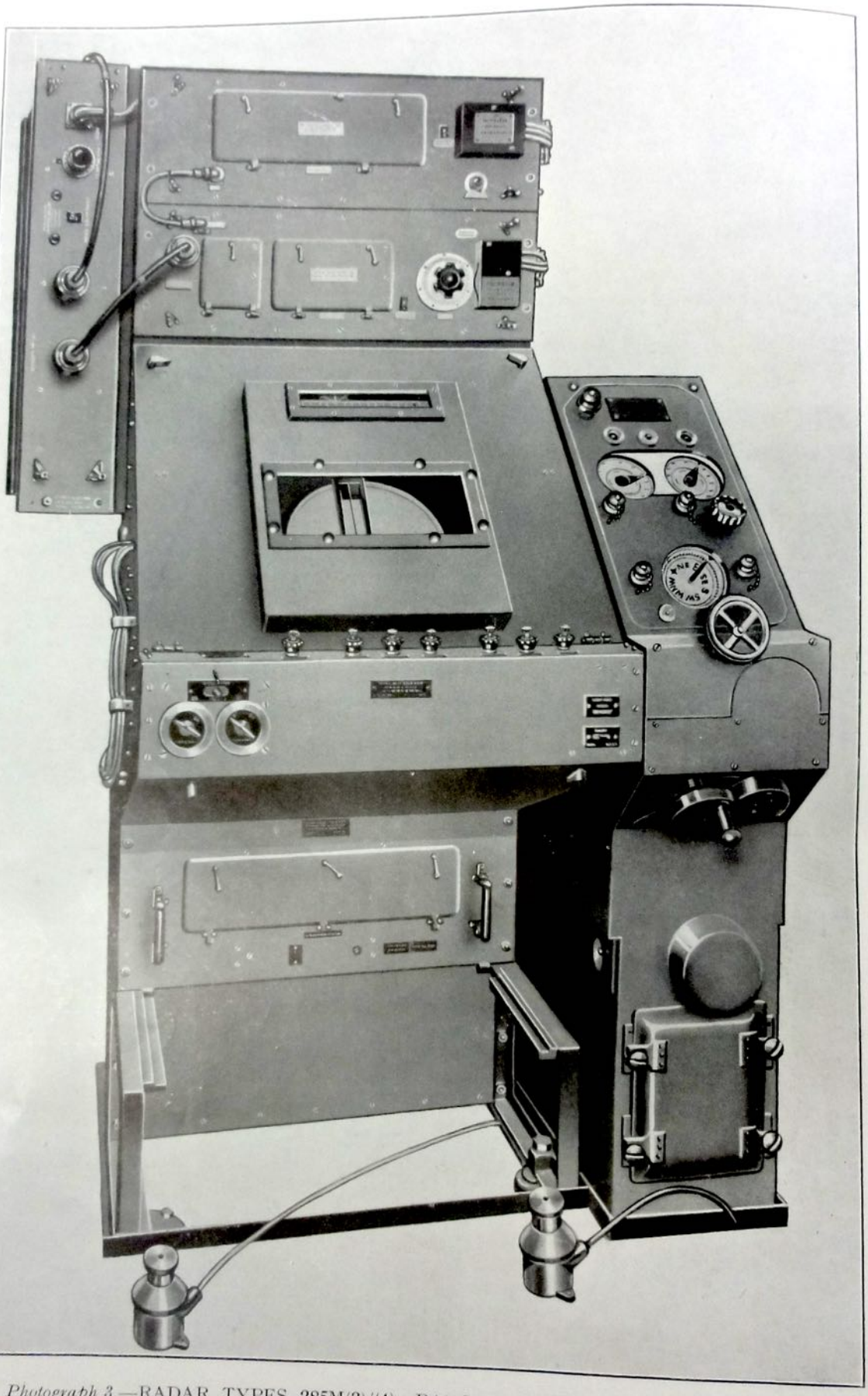
86. When searching, the R.T.U. will be set with the rate motor switched off, the clutch *ON* and the rate set at the expected speed of approach of the target ; this is normally 250 knots for an aircraft and zero for an E-Boat or submarine, but is liable to be changed owing to special circumstances. When the echo of the target has been detected on the coarse range tube, the operator fast tunes to it (handle out) so that the strobe spot is set on to the echo. By so doing he brings the echo into the well on the fine range tube or to the black spot in the trace and by transferring his eye to the fine range tube, sets it accurately as shown in *Diagram 4*. The rate motor is then switched on, the range cut pedal pressed and the echo followed in the fine range tube with the R.T.U. handle *IN*.

87. Subsequent tuning (handle in) serves to correct not only the range but the rate, as explained more fully in *para. 128*. When no further tuning is necessary, *i.e.*, when the correct rate has been achieved, the rate cut push is made. Experience has shown that the range rate cut switch, operated by pushing the handle in further against the spring, is inconvenient. In instances where this type of range rate cut-switch is used (range transmission units, Marks III–V), a push, Pattern 7075, should be fitted instead, convenient to the operator's left foot, the internal switch being disconnected. The operator continues to watch the echo closely, moving the range handle to keep an accurate cut, thereby adjusting the range and the rate. The rate clutch is normally always kept " on " and the rate motor itself switched on or off as required.

Auto-barrage Fire

88. The same Radar ranging information which is fed to the L.24 coarse range tube is fed to the Panel L.22 of the Auto-Barrage Unit when it is intended to use Type 285 for barrage fire. This is fitted in the H.A.C.P. or T.S. for auto-barrage fire as described in *C.B. 4112 (6)*.

89–90.



Photograph 3.—RADAR TYPES 285M(3)/(4)—RANGING PANEL L.12 WITH R.T.U. V.

CHAPTER IV

TYPES 285 M (3)/(4)—RANGING—DESCRIPTION AND OPERATION APPLICABLE TO RADAR OPERATOR

PANEL L.12. *Photograph 3*

91. Panel L.12 is the ranging panel fitted with Types 285M (1) to (4) and is always installed in the Radar office. It has one large cathode ray tube about twice the diameter of the larger of the two tubes fitted in Panel L.24.

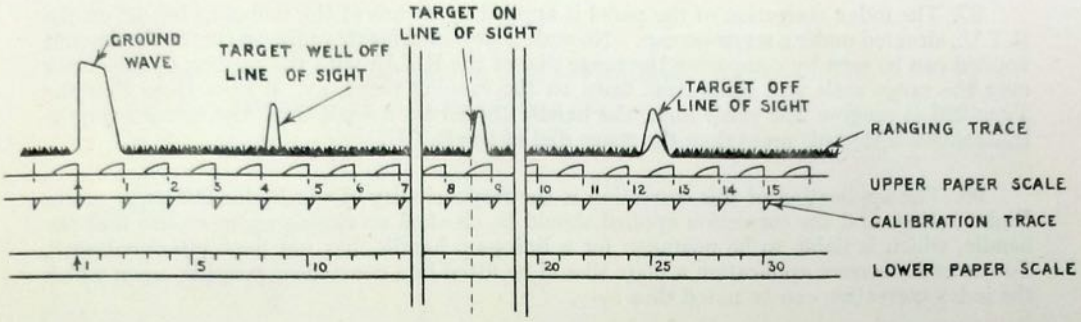


Diagram 5.—Typical Types 285M (3)/(4) Ranging Trace

92. The presentation shows two traces. The upper is the ranging trace on which the ground wave and echoes appear, and below it is the calibration trace which shows a sharp trough every 1,000 yards. Paper scales are stretched across the outside of the face of the cathode ray tube, and give the numerical value of the sharp left-hand stroke of each trough for calibration purposes.

93. A range cursor with two hair lines is fitted so that it can be aligned over the left edge of the target echo. It is driven from the range handwheel of the R.T.U. by a flexible drive and the screwed shaft on which the cursor is mounted. The two hair lines enable the operator to align the cursor accurately without parallax error.

Working Controls

94. The working controls are arranged in the front of the set below the cathode ray tube, and their functions are briefly as follows :—

Gain.—Varies the amplification or magnification of the receiver. Increase in gain brings in its train an increase of electrical disturbance and causes more " dance " on the scan. This electrical disturbance is known as " noise " and the dance of the scan as " grass."

Brilliance.—Varies the brilliance of the signal and calibration traces. Too great a brilliance burns the face of the cathode ray tube and may cause excessive eyestrain.

Focus.—Varies the definition of the traces throughout their length.

Scale Corrector.—Expands or contracts both traces together longitudinally to make the calibration trace agree with a paper scale. A second paper scale below the first is marked with the scale of the long range scope, 0 to 30,000 yards, for reading off the range, as the cursor and range transmission unit cannot be used for the long range scope.

Vertical Shift.—Raises or lowers both traces together.

Horizontal Shift.—Moves both traces together, right or left, to bring the left edge of the " ground wave " opposite the zero of the scale.

Variation in the ship's voltage may cause the ground wave to move and care must be taken to see that its position relative to the zero of the scale is always kept accurately set. Gunfire may cause the trace to swing, and before reading ranges afresh, the trace must be allowed to regain equilibrium.

Scale Shift.—Moves the calibration trace right or left. It should be adjusted to bring one trough opposite the beginning of the ground wave, and this should bring the other troughs opposite their marks on the paper scale. If not so use scale corrector control.

95. It should be noted that the troughs of the calibration trace always represent intervals of 1,000 yards, no matter to what distance apart they are adjusted on the scan. The range scale is not strictly linear throughout its scope and there may be slight variations in the distance apart of various troughs ; but any such variations will be maintained by the set and would not affect its accuracy of ranging, if ranges were read off against the calibration trace and transmitted by hand.

96. Continuous ranging, however, is essential for H.A. fire and the very slight inaccuracy involved by mechanical connection of the cursor to the range transmission unit, which disregards any irregularities in the scale, has been accepted.

Index Correction

97. The index correction of the panel is applied by means of the lining-up handle on the R.T.U., situated under a screw-on cap. No scale is provided for this adjustment, as the amount applied can be seen by comparing the range dial of the R.T.U. with the reading of the cursor over the range scale and calibration trace on the ranging panel, *i.e.*, if tests show that the Type 285 is ranging 200 yards high, the handle should be worked until the cursor over the trace shows 200 yards more than the range dial of the R.T.U.

98. The application of this correction is the responsibility of the Radar Officer or senior Radar rating, and the correction applied should be checked on closing up to ensure that the handle, which is liable to be mistaken for a lining-up handle, has not been interfered with. To ensure its correct application a plate should be fitted in a convenient position, upon which the index correction can be noted thus :—

Index Correction ..... **; set cursor to read** ..... **when R.T.U. reads** .....

Range Scopes

99. The set has been arranged with two range scopes with maximum readings of 15,000 yards and 30,000 yards. The change from one scope to the other is effected instantaneously by a switch, but a few seconds are required after changing, to readjust the traces to the paper scale by resetting the horizontal shift.

Anti-D/F Methods

100. Transmission may be continuous or can be controlled by a push-on switch, if it is desired to limit the duration of transmission on account of the possibility of D/F or interference with other transmissions.

Range Transmission Units

101. Different marks of R.T.U. can be fitted with Panel L.12 according to the control systems served. They will either be Mark IV, IV* or V. The main features of these R.T.U.s are common, but differences in detail are enumerated in *paras. 111 to 115.*

Fall of Shot and Range Spotting

102. Splash echo observation on Panel L.12 is also practicable. A splash observer, over and above the ranging operator, is required. Training of splash observers is a matter of considerable difficulty, as training devices such as the H.R.B. teacher, for this purpose, have not yet been supplied to all ships. Every opportunity for training observers should be taken during practice shoots, and the *Radiolocation Instructional Film, Part VI* (observing fall of shot by Radar) and its complementary film strips will also be of value for primary training.

103. Range spotting on Panel L.12 can be successfully carried out up to ranges of about 10,000 yards, depending on the calibre of the gun, although bursts or splashes between about 50 yards short and 200 yards over are liable to be swamped by the target echo. Own shell can be followed out to about 6,000 yards.

Sequence of Operation

104. The main points of operation are listed briefly below to clarify the description of the equipment. For complete drill procedure, including co-operation with the Director's crew, reference should be made to *B.R. 984, Chapter 5.*

Standing by

105. While standing by, the operator should have his ranging panel and R.T.U. in the following state :—

(*a*) Range trace correctly set up and Index Correction applied.

(*b*) Range tuned to the highest range.

(*c*) Range handwheel pulled out.

(*d*) Rate set to probable rate of enemy.

(*e*) Constant speed motor switch off.

(*f*) Rate clutch *ON*.

Ranging

106. When an echo appears :—

(*a*) Switch on constant-speed motor.

(*b*) Fast tune to echo with handwheel in out position.

(*c*) Follow echo for range with handwheel *IN*.

(*d*) Press range and rate cut pushes when correct range and rate are being transmitted.

107–110.

CHAPTER V

RANGE TRANSMISSION UNITS MARKS IV, IV* and V
(R.T.U.s IV, IV* and V)

111. R.T.U.s IV, IV* and V are fitted in conjunction with Panel L.24 or Panel L.12. R.T.U. IV is fitted when the control system is H.A.C.S. Marks I, II and III, R.T.U. IV* is fitted with the H.A.C.S., Marks IV and IV* and R.T.U. Mark V is fitted with F.K.C. systems. Basically the various marks of R.T.U. are the same, but salient differences and the methods of connection to the control systems are given below.

R.T.U. IV

112. This mark of R.T.U. uses " M " transmissions for log-range, range, range rate and bearing. Log-range is transmitted between limits of 2,000 yards and 15,000 yards to two " M " type motors, which drive the screw of the third pricker fitted under the plot of the H.A. table the other two prickers being observed log-range and generated log-range. The Radar pricker makes a round stab every second to distinguish it from the other plots, and is operated by the range cut pedal at the R.T.U. Range in 25-yard steps is also transmitted to range matching receivers or counterdrum receivers. Bearing is transmitted in 30-minute steps to a Radar bearing receiver in the H.A. director and the R.T.U. receives bearing in 10-minute steps from the emergency director training transmitter in the director. Range rate is also transmitted, in 2½-knot steps, to a counterdrum receiver for use with the H.A.C.S. slide rule.

R.T.U. IV*

113. This mark of R.T.U. only differs from R.T.U. IV in having magslip bearing transmission and reception, as illustrated in *Plate 6*. The bearing transmission goes to the coarse indicator pointer in the L.S.T. unit in the H.A. director via a change-over switch, which can also connect that pointer to the other directors in ships with two or four equipments. The bearing reception is from the director training transmitter in the H.A. or H.A./L.A. director.

R.T.U. V

114. This mark of R.T.U. is used in conjunction with F.K.C. systems and transmits range, range rate and receives bearing transmission by " M " type motors. Range, between the limits 2,000 yards to 15,000 yards, is transmitted in 25-yard steps to blue pointers in the range dial of the F.K.C., which also contains red rangefinder range pointers and black mechanical pointers. In latest deliveries of R.T.U.s, Mark V, the range limits have been altered to — 500 yards to 35,000 yards. Range rate, 0 to 300 knots opening or closing, is transmitted in 2½-knot steps to the blue rim pointer of the rate dial. Included in the rate dial is a battle-axe pointer which shows the rate evolved in the clock by setting speed and angle of presentation, also a black pointer which moves with the battle-axe pointer but which can be offset by the rate spotting handle.

115. The reception of bearing from the director is in 30-minute steps, either from the transmitter geared off the roll corrector, with rangefinder directors, Marks IV, IV*, V, V*, V**, or from a combined bearing transmitter receiver (Barr and Stroud Type, R.B.31) fitted in rangefinder directors, Marks II, III, IIW and IIIW. In " L " and " M " class destroyers D.C.T.s the reception of bearing is from the emergency line of sight transmitter in the D.C.T., in 6-minute steps via a 6–30-minute step transformer.

LOW ANGLE FIRE

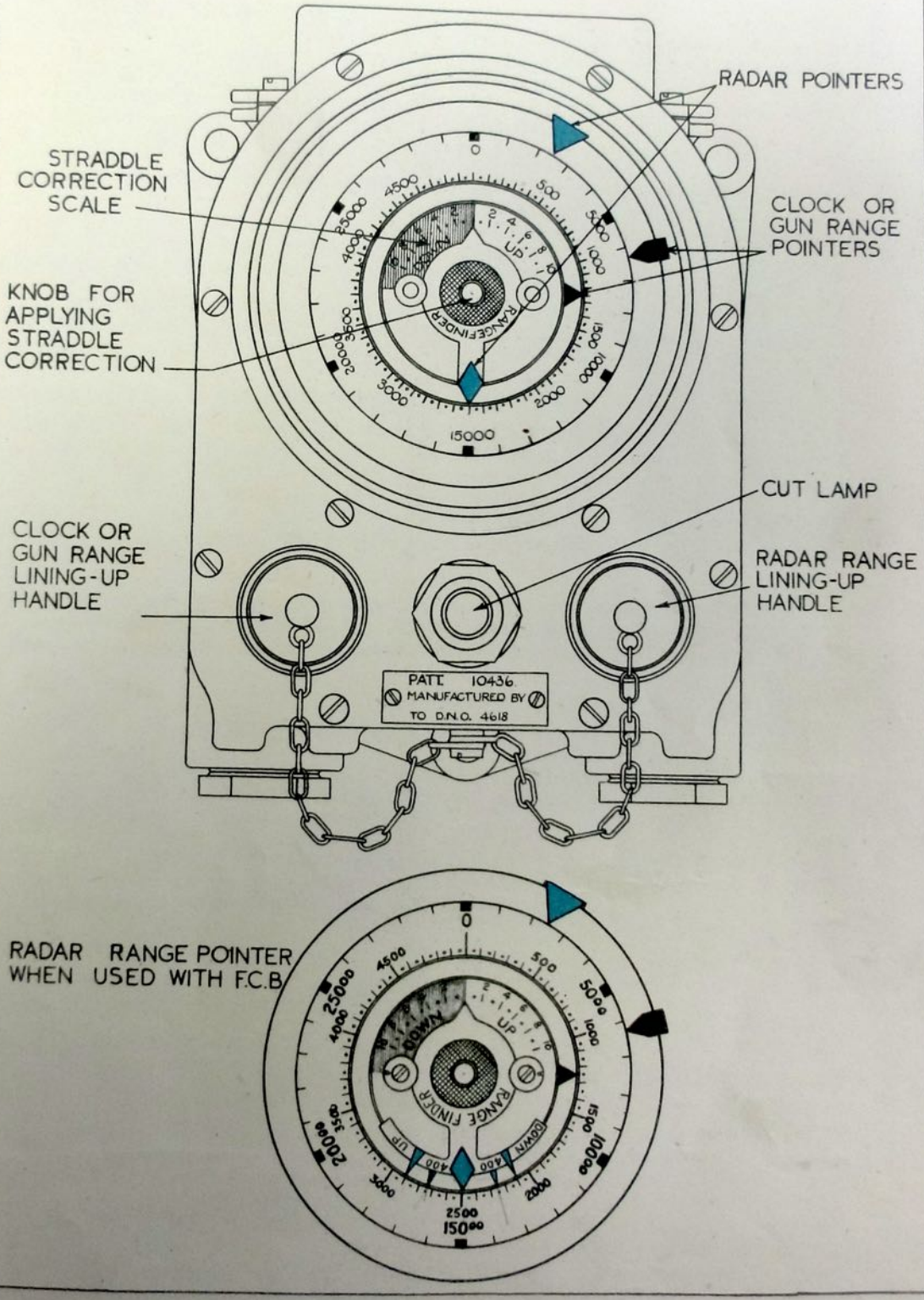
Range Matching Receivers

116. A matching receiver with pointers driven from A.F.C.C. or F.C.B. and R.T.U. of the Radar set is fitted in the T.S. to enable range to be tuned to Radar. In ships for which a matching receiver was not available a counter-drum receiver showing Radar range was fitted in lieu, but will be replaced as matching receivers become available.

117. Apart from simplifying the procedure for tuning to Radar, a matching receiver should also provide a good indication of any rate error.

118. *With the A.F.C.C.*, a matching receiver, Mark V, is fitted. It is illustrated in *Diagram 6*. Two black pointers (fast and slow) are driven by a step-by-step motor, which receives clock range in 25-yard steps from a new transmitter fitted to the clock range shafting in the A.F.C.C. The other two pointers, which are coloured blue, show Radar range, and the clock can be tuned to Radar by bringing the pointers in line when the cut-lamp burns. Subsequent alterations in range correction or spotting corrections will not affect clock range so the clock can be kept tuned to Radar range throughout, if desired.

RECEIVER RANGE MATCHING FOR USE WITH A.F.C.C. & F.C.B.



119. To enable a Radar straddle correction to be applied, the fast Radar pointer is frictionally mounted, and can be displaced relative to its drive by a knob projecting through the glass, any correction applied being shown on a scale at the opposite end of the pointer.

120. *With the F.C.B.*, a matching receiver, Mark VI, is fitted. There is no clock range transmitter so the counter-drum on the F.C.B. and black pointer of the matching receiver show gun range. As this differs from Radar range by range correction and spotting, the matching receiver, Mark VI, though otherwise similar to Mark V has a Radar pointer fitted with a pointer with five prongs or graduations upon it, so that gun range can be tuned above or below Radar to allow for the application of range corrections and spotting corrections. Existing matching receivers have only two prongs on the trident, one 400 yards either side of the centre, but ships are recommended to engrave additional marks 200 yards apart.

Rate Keeping

121. Radar range provides a very good indication of present rate, and valuable suggestions can be obtained by noting any tendency for the pointers on the matching receiver to separate. If No. 1, watching the matching receiver, notes any tendency for the black and blue pointers to separate he can either report **"Rate wants opening (or closing),"** to the Rate Officer, who will order a new inclination and speed; or alternatively, a new inclination and speed can be set in the T.S. and a report to the Rate Officer, **"Inclination . . . . . speed . . . . . set."** The latter procedure ensures less delay and the Rate Officer can veto it if he does not agree.

122. Another procedure has also been recommended. The Radar rate in knots as shown on the receiver at the F.K.C. is reported continually, and compared with the generated rate set on the A.F.C.C. or F.C.B. To enable this to be done a paper strip showing clock rate in knots should be fitted alongside the "rate in yards" strip on the A.F.C.C. or F.C.B. Suggestions of rate error thus obtained are acted on as above.

123. Range and rate receivers must be lined up at 5,000 yards and zero knots. The lining-up switches are in the Radar office. With H.A.C.S. the Radar pricker must be lined up at 5,000 yards.

H.A. Tables Controlled by Either of Two Directors with Type 285M.

124. In some "Fiji" class cruisers, where the forward H.A. Table can be controlled by either of the two forward directors, separate Type 285 receivers are fitted for each director with a common R.T.U. between the two L.12's. The flexible drive from the R.T.U. is duplicated and drives both cursors over the cathode ray tubes of the Panels L.12 simultaneously. The cursor of the L.12 connected to the controlling director is aligned with the echo showing on the appropriate trace. An indicator light is fitted in the Type 285 office to show which director is controlling.

125. This arrangement involves the Type 285 operator working the R.T.U. with his left hand when following the starboard director, but this is acceptable. To have separate R.T.U.s would necessitate re-lining-up the third pricker in the table on each occasion of changing over.

PRINCIPLE OF OPERATION OF R.T.U.s

126. The range handwheel of the R.T.U. operates both the cursor or strobe on the ranging panel and the range transmitters, so that as the former is aligned against the left edge of the echo, the range is transmitted away automatically.

127. Rate mechanism is provided to assist in range following, particularly when the echo fades as it is liable to do. In addition, it provides a measured rate of change of range which can be used for control purposes, particularly in the F.K.C.

Handwheels and Dials

128. The operator is seated so that he can observe the trace on the range panel and operate the following handles and switches, etc., on the R.T.U.

(*a*) *Range Handwheel.*—This has three positions :—

(i) *OUT*—Used for fast tuning to the range of a new target. Movement of the handwheel in this position does not affect the *rate*.

(ii) *IN*—Slow tuning for following an echo for range using rate-aiding. With the handwheel in this position movement of the handwheel, in addition to altering the range, also corrects the *rate*. As the rate, thus corrected, approaches the true setting, there will be less and less need for tuning to keep the hair-line or strobe on the echo, until eventually, when the correct rate is set, there will be no need for such tuning and the rate mechanism will keep the hair-line or strobe on the echo without assistance as long as the rate remains constant.

(iii) *Further in against a spring*—this position is not now used.

(*b*) *Rate Setting Knob.* By means of this knob and a *rate dial* an approximate initial rate can be set so as to save time in having to correct it by the rate-aiding mechanism of the range handwheel.

(*c*) *Range and Rate-cut Pushes* which burn cut lamps at the director and on the R.T.U. are operated by foot pedals.

(*d*) *The Rate Clutch,* which connects or disconnects the rate drive from the constant speed disc, and the *constant speed motor switch* both require to be on if rate is required. The rate clutch is normally left on and the motor switched on or off as required. To guard against the rate back driving to the range handwheel instead of the range cursor the range handwheel should always be held when the motor is running.

RANGE TRANSMISSION UNITS—MECHANICAL DESCRIPTION

129. For manufacture and assembly purposes range transmission units are divided into sections, some of which vary or are omitted according to the mark of R.T.U. The sections are as follows :—

A. Range tuning and rate aiding mechanism (*Plates 1 and 2*).

B. Range and rate dials, transmitters and cut lamps.
R.T.U.s IV and IV* only, pin wheel for converting range to log-range (*Plate 3*).

C. Constant speed motor and mounting.

D. Differential for adding index correction to output drive (*Plate 4*).

E. Main casting and cast cover plate.

F or J. Bearing transmitters and receivers and bearing dial with gyro. (*Section "F"* shown in *Plate 5* and *Section "J"* in *Plate 6.*)

G. Angle iron stand and sheet metal details.

H or K. Bearing handwheel and transmitter known as the bearing transmission unit: B.T.U. (*Section "H"* shown in *Plate 5* and *Section "K"* in *Plate 6.*)

130. Different marks of R.T.U. are used according to the control systems served, but the main features are common to all. The differences in detail are given in *paras. 111 to 115.*

131. The R.T.U. is bolted down on to the same bed-frame as Panel L.24, or L.12, to which it is secured by one bolt at the side to steady it. The only other connection to the display panel is the flexible drive to the mechanism operating the strobe or cursor.

132. The unit as a whole is shown in *Photographs 2 and 3* as fitted in conjunction with Types 285 M and 285 P respectively. The range tuning handwheel is low down on the front convenient to the operator. Beside it is the rate " on and off " clutch. The range dial, rate dial and rate setting head are in the upper part of the sloping front. Electrical repeats (*blue* pointers) of range and range rate are included in each dial. Their lining up handles are below each dial and the cut lamps above. Below these are the bearing dials and bearing handwheel. Internal illumination, with dimming arrangements, is provided for all dials. The constant-speed motor is in the pedestal, and its starting switch is on the left-side plate.

133. In *Plates 1 and 2* range is tuned by the pink gearing and range rate is set by the dark green train. Putting the **rate clutch** to *ON* works the red linkwork to lower the blue housing and with it the range roller on to the balls of the rate mechanism. The rate-setting gear (dark green), determines the position of the balls on the constantly rotating potter's wheel (orange), and an opening or closing rate of the desired proportion is added through the red roller and gearing to the pink range tuning shafting in the **rate differential,** and produces rate-aided generated range on the yellow gearing.

134. This proceeds to *Plate 3,* where it drives a range transmitter and the **mechanical pointers** of the range dial. A drive to a **range rate transmitter** is taken off the dark green gearing, which also drives the pointer of the range rate dial. **Range** and **range rate repeat receivers** drive blue pointers in their respective dials, and *Plate 3* also shows the **log pin-wheel** (red), which converts range from the yellow gearing into log-range. This pin-wheel is only fitted in R.T.U.s, Marks IV and IV*, for use with H.A.C.S. tables.

Index Correction

135. The range drive (yellow) goes to *Plate 4,* where the necessary correction (dark green) for the index error of the set, as determined by calibration, is added in a differential. The resultant (dark blue) is connected to the cursor of the display panel by a **flexible drive.** This differential also enables the cursor to be run back below zero as is necessary if it is desired to replace the cathode ray tube in Panel L.12.

136. *Plate 4* shows the mechanism as supplied in the first 40 sets. In subsequent sets a redesign of some of the parts has taken place, but the principle of the unit is not affected.

Stop Gear. *Plates 1 and 2*

137. Stop gear is fitted to limit the range transmission between 2,000 yards and 15,000 yards. When the yellow nut on the screwed shaft, which is rotated by the outgoing yellow drive of range, reaches either limit it rocks the pale green shaft which engages one or other of the pale green claws in the toothed wheel on the pink shaft. A link from the pale green shaft also operates a **cam** under the blue housing, which carries the **rate roller,** similar to the cam control by the rate clutch, and so raises the housing and prevents rate being applied. In latest deliveries of R.T.U. Mk. V the yellow gearing to the screwed shaft has been altered to give limits of — 500 yards to 35,500 yards.

138. Stop gear on the dark green gearing limits the rate setting to 300 knots opening or closing. If an attempt were made to apply further rate by operation of the range tuning drive the **friction clutch,** if engaged, would slip.

139. To prevent a back drive of range tuning through the differential on to the drive from the rate unit when the rate clutch is to *OFF*, a leaf spring anchored to the fixed structure is arranged to bear on the rate roller which is no longer in contact with the balls. This, in conjunction with friction in the gearing, is sufficient to hold the rate hub of the differential.

RATE-AIDED RANGING

140. The rate mechanism is provided to assist the operator in following fast-moving targets, particularly when the echo fades, as it is liable to do; in addition, it provides a measured rate of change of range which can be used for control purposes, particularly in the F.K.C.

141. The connection of the range-tuning shafting to the rate-setting gear is shown in *Plate 2*, where the pink pinions at the top of the unit are connected to the dark green rate-setting gear by a friction clutch which is engaged when the **rate clutch** is put to *ON*.

ADJUSTMENT OF CONSTANT-SPEED MOTOR GOVERNOR

142. It is essential that the governor of the constant-speed motor be kept adjusted to ensure that the rates generated are as shown on the rate dial. The governor unit is similar to that fitted in the fuze-keeping clock.

143. To test, set 3,000 yards and 297 knots opening rate and with rate clutch *ON* and motor running, time the change of range by a reliable stop watch. It should be 10,000 yards per minute. Repeat for a closing rate, starting at a high range. A check test can be carried out at 149 knots rate, when the change of range would be 5,000 yards per minute.

Note.—It is possible for the rate mechanism to back-drive through the range tuning handle instead of driving the cursor. To guard against this, the range tuning handle should always be held when the rate motor is running.

Page 19. Last line *Delete* "144–150" and *substitute:*—

MODIFICATION TO R.T.Us. IN SHIPS FITTED WITH A FIRE CONTROL BOX OR WITH A RADAR INTERLINKING UNIT.

144. To enable the B.T.U. operator to indicate accurate gyro bearings of a target to the director, the following modification is to be carried out:—

(*a*) Remove the gyro compass dial and accurately etch in, in black, degree marks between the present ten and five degree marks.

(*b*) Lengthen the existing outer pointer by soldering on a fine wire so that the tip of the pointer slightly overlaps the outer edge of the gyro compass dial.

(*c*) Shorten and taper off the inner director repeat pointer so that it is just clear of the new outer pointer.

145–150.

(*G. 07979/50.—A.F.O. P.548/50.*)

CHAPTER VI

SWEEPING AND TRACKING

TARGET INDICATION

151. Ships fitted with the Visual/Radar Target Indication System will be able to use it to indicate targets to the H.A. armament via the T.I.O. This should prove especially useful during the approach phase of a night action or when there are numerous echoes in a small sector. *See C.B.4112(8)* for information on Visual/Radar Target Indication.

152. Target bearing from the T.I.U. sections can be indicated to the H.A. directors via T.I.U/sight C.O.S. at the A.D.O.'s sight, where it appears on the red pointers of the director training unit and the trainer follows. So doing he transmits back to the T.I.U. the bearing on which he is trained and hence enables the T.I.U. operator to see that the director is following his indication. Alternatively the P.C.O. or A.D.O. sight can be power driven on to a bearing by the T.I.U. and the director can then follow P.C.O. or A.D.O. sight.

153. When Type 285Q is used range from an R.T.U. 53 (now called ranging outfit R.T.B.) on Panel L.37 in the target indication room is transmitted to a position convenient to the C.P.U. to assist the C.P.U. operator in picking up the target.

THE RADAR TRAINING TUBE WITH TYPES 285 P/Q

154. This is a cathode ray and rectifier unit, " Design 5," similar to the monitor tube fitted in the receiver rack, and it is fitted in one of the following places : in the director, in the Tallboy (285Q), over the A.F.C.C. or over the R.T.U. It has a range scope on a horizontal trace of 0–30,000 yards approximately, with the twin echoes displayed side by side, and the target whose range is being taken by Panel L.24 or L.34 is denoted by a strobe. In order to follow a target, the director is trained towards the larger echo until the twin echoes are balanced.

155. A rubber face-piece is provided to shut out external light from the tube and the following controls are provided for adjustment by the Radar training tube operator :—

Brilliance.—Varies the light value of the trace. Too great a brilliance will burn the tube face and cause excessive eye-strain.

Focus.—Varies the definition of the trace throughout its length.

Separation.—Moves the right-hand echo laterally with reference to the left-hand one. It should be adjusted so that the echoes are a convenient distance apart for mutual comparison and to avoid interference between the echoes from targets at almost similar ranges.

Shift.—Alters the position of the entire trace horizontally across the face of the tube.

Gain.—This adjustment cannot be controlled by the Radar training tube operator as it is fitted on the receiver rack in the Type 285 Office. Co-operation is therefore needed between the operator in the office and the ranging and training operators so that the echoes are adjusted to a convenient level. They should never be more than three-quarter saturation.

Control of the Director

156. The method of training using the trainer's tube in the various types of directors is as follows :—

(*a*) *H.A. Directors, Marks V and IV G.B.*—These directors are fitted with power training and are stabilised for training as well as elevation. The Radar training tube is situated at the back of director and the communication number carries out the duties of Radar training (*see Diagram 3*). He is provided with an aided training unit which operates the power training of the director in parallel with the director (visual) trainer and Control Officer's joystick. The sum of their movements thus affects the training, and when one of the three is controlling the others should leave their control central.

The Radar trainer's control can be either direct or rate-aided. Thus if the push is pressed, movement of his handwheel trains the director a proportional amount. Otherwise movement of the handwheel not only displaces the director but also applies or adjusts a rate of training.

(*b*) *H.A. Directors, Marks IV, III and I.*—In these directors, which are hand trained and cannot be fitted with an additional training position, the Radar training tube is positioned so that it can be used by the director trainer himself. In order to preserve the trainer's night adaptation the brilliance of the trace should, at night, be adjusted as low as possible and the director layer should be prepared to train as well as lay during change-over periods. (*Note.*—Fitting of an auxiliary trainer's position in Mark III directors will be carried out, if possible, when scooter control is added.)

(*c*) *Rangefinder Directors* (fitted with F.K.C.).—The training tube may be fitted, in certain ships, at the rear of the director, but in the majority of ships it will be fitted below, either in the T.S. or in the Radar office. This will depend on whether Panel L.24 or Panel L.12 is fitted. In destroyers E.s, I.s, O.s, P.s, Hunts and Wairs the training tube will be fitted over the R.T.U., and in J.s, K.s, N.s, Q.s, R.s, S.s, T.s, U.s, V.s, W.s and Tribals it will be fitted over the R.T.U. or over the A.F.C.C.

BEARING CONTROL

157. The bearing dial (*see Plates 5 and 6*) contains relative and gyro compass rings and a blue pointer which shows the bearing of the director.

158. A black pointer is connected to a **bearing transmitter** in the R.T.U. worked by the **bearing handwheel**. This transmits to a bearing receiver visible to the director trainer and enables the Radar operator to indicate the bearing he wants the director to train on, when searching for a target not visible to the director.

159. When *ranging*, *i.e.*, when the director can see the target, there is no need for the bearing operator of the R.T.U. to pay any attention to the bearing dial or to touch the bearing transmitter. The blue pointer will show the bearing of the director, but this is of no interest to the bearing operator.

160. When *searching* for a target not visible to the director, however, close co-operation between the director trainer and the bearing operator at the R.T.U. is necessary. The director trainer trains slowly over the arc ordered. If the arc ordered is between two gyro bearings, the bearing operator keeps the director trainer informed of the corresponding relative bearings, reading off the bearing dial of the R.T.U., which has gyro and relative bearing rings.

161. This method relieves the bearing operator of the necessity of working the bearing handwheel and is also easier for the director trainer. But unless the bearing operator watches the ship's head on the gyro ring, or the director's crew watch for any alteration of course, it is liable to allow the director to be trained over the wrong arc if the ship alters course without it being noticed.

162. Therefore, if the ship is zigzagging or altering course frequently while an arc between two gyro bearings is being searched, it is advisable for the bearing operator to control the training of the director by the bearing handwheel.

163. The speed of training should not exceed two degrees per second or targets are liable to be missed. This speed allows the whole horizon to be covered in three minutes. The speed of training should be slower if a smaller arc is being searched.

164. When searching for a target at long range, the speed of training should be as slow as possible, taking into consideration the time taken to cover the arc required. The echo is very variable even when the aerials are trained directly on the target, and a speed of training slow enough to reveal targets at short or medium ranges may be too fast to be certain of revealing a target at long range.

165. Until an echo appears the bearing operator need not touch the bearing handwheel, as described above, when frequent alterations of course are being made.

166. On a target becoming " visible " to the ranging operator the latter reports **" Echo "** [illegible] The bearing operator aligns the black pointer in

Page 21. *After* paragraph 166 *add* :—

Note.—The B.T.U. operator can indicate accurate gyro bearings when the modification described in *paragraph* ***144*** has been carried out. In ships fitted with F.C.Bs., the B.T.U., when modified, can also be used to indicate target bearing in indirect bombardment.

(*G. 07979/50.—A.F.O. P.548/50.*)

167. All range and rate receivers must be lined up at 5,000 yards and zero [illegible] blue bearing pointer must be lined up to the bearing of the director. The gyro compass ring must be lined up to the ship's head, which can be obtained from the bridge. The gyro compass supply switch and lining up switches are fitted on the bulkhead of the Radar office. With H.A.C.S. IV and IV* the bearing pointer is magslip and requires no lining up.

BEARING TRANSMISSION AND RECEPTION IN H.A. DIRECTORS

168. In H.A. directors, Marks I, II and III, an additional bearing receiver is fitted on the screen, visible to the director trainer, with a drive from the main training gear-box. This receives bearing in 30-minute steps from the R.T.U. The existing emergency line of sight transmitter in the director (10-minute steps) transmits to the blue pointer on the bearing dial of the R.T.U.

169. In H.A. directors, Marks IV and V, reception of bearing is arranged on the coarse pointer only of the existing director training unit by the existing indicator change-over switch in the director. Transmission to the bearing pointer in the R.T.U. is from the existing table training indicator transmitter in the H.A. table.

170. In the Mark V* M, H.A. director reception of bearing is arranged on the director training unit from either the A.D.O.'s sight or R.T.U. *via* the Plot/Sight C.O.S. in the A.D.P. Director training indication, coarse and fine, is received on the director training dial of the T.C.U. All these indications are achieved by magslip.

BEARING TRANSMISSION AND RECEPTION IN "K" D.C.T.s

171. In the "K" D.C.T. reception of bearing is arranged in the tower on a director training unit, Mark V. Reception can be from the T.I.U. or the T.C.U. *via* the Target Indication/Emergency Control C.O.S. in the T.S. Director training is received on the director training dial of the T.C.U.

172–180.

CHAPTER VII

RADAR SPOTTING ARRANGEMENTS

181. One of the outstanding developments of Radar has been its application to spotting, and although it is still in an early stage of development quite good results can be attained on Panel L.12 and to a lesser degree on Panels L.24 and L.34. To take full advantage of the spotting capabilities of Type 285 and to improve the results obtained with Panels L.24 and L.34 a special spotting tube has been designed for fitting with Types 285P and 285Q, *i.e.*, Type 285 sets using Panel L.24 or L.34. Ships with Type 285M will use Panel L.12 for spotting as well as ranging.

RADAR SPOTTING TUBE

182. The Radar spotting tube is similar in appearance to the Radar remote training tubes now in use and it is designated Design 4. It is fitted on top of Panel L.24 and a separate operator watches the trace, when required, by standing on a stool. When a Panel L.34 is part of the equipment the spotting tube is fitted conveniently near and can be watched without the operator standing on a stool. An additional Mark X telephone on the spotting group is used by the spotting operator.

183. A rubber face piece is provided to shut out external light from the tube, and the following controls are provided for adjustment by the operator :—

Brilliance.—Varies the light value of the trace. Too great a brilliancy will burn the face of the tube and cause excessive eyestrain.

Focus.—Varies the definition of the trace throughout its length.

Horizontal Shift.—Alters the position of the entire trace horizontally across the screen of the tube.

Vertical Shift.—Alters the position of the entire trace vertically on the screen of the tube.

184. The trace displayed is Type A with the addition of three " pips," one in the centre of the trace and one on each side, 1,000 yards from the centre " pip." The ranging panel operator by correctly setting the strobe spot on the coarse range tube automatically sets the target echo to the centre " pip " of the spotting tube trace, and the spotting tube operator watches the trace for the appearance of the splash or burst echo. The distance of the splash from the target echo is then measured either by interpolation between the " pips " or by a paper scale. The trace extends for approximately 1,500 yards either side of the centre and all single salvo splash echoes within these distances of the target should be seen up to ranges of roughly 15,000 yards. If shell burst nearer than 100 yards from the target the burst echo is liable to be obscured by the target echo.

185. The splash echoes are not clear enough to enable beam switching to give any indication of line errors, but the beam switching effect is noticeable on echoes from shell up to about half range and may assist in identifying salvos from consorts before they get close to the target.

186. A good deal of experience is necessary before an operator can be considered a reliable spotting operator as the splash echo obtained is very fleeting. Every opportunity therefore should be taken to train the operator initially with the *Radiolocation Instructional Film, Part VI* (observing fall of shot) and when the equipment becomes available, with the H.R.B. Teacher outfit. Further cinematograph fall of shot training devices are under development.

187–190.

CHAPTER VIII

USE OF TEACHER OUTFIT H.R.B. WITH TYPE 285

191. The H.R.B. teacher outfit has been designed to enable operational conditions to be simulated on Radar display panels without the necessity for the appropriate Radar transmitter to be working.

192. The output from the teacher can be fed into the Type 285 display panels and by working the teacher controls, the Radar operators can be given practice in ranging, spotting and tracking. The teacher can be used with a selected forward Type 285 or with the forward 284. It cannot be used with any after set because the separation supply from the line units adjustable is taken to a central point, only from a selected forward Type 285 and the forward Type 284.

193. Instructions in the use of the teacher outfit and its connection to Type 285 will be found in *C.B. 4355 (1)*, and during the ten minutes which must be allowed to elapse between switching on and beginning instructional exercise, the instructor should run through the relevant paragraphs of the book. A stop watch will be useful to the instructor.

194. The training can consist of exercises which will train the ranging, bearing and spotting operators. With this in view it will be possible to carry out range measurements, rate keeping, zero checking and pre-determined runs using all the displays.

CHAPTER VIII

USE OF TEACHER OUTFIT H.R.B. WITH TYPE 285

191. The H.R.B. teacher outfit has been designed to enable operational conditions to be simulated on Radar display panels without the necessity for the appropriate Radar transmitter to be working.

192. The output from the teacher can be fed into the Type 285 display panels and by working the teacher controls, the Radar operators can be given practice in ranging, spotting and tracking. The teacher can be used with a selected forward Type 285 or with the forward 284. It cannot be used with any after set because the separation supply from the line units adjustable is taken to a central point, only from a selected forward Type 285 and the forward Type 284.

193. Instructions in the use of the teacher outfit and its connection to Type 285 will be found in *C.B. 4355 (1)*, and during the ten minutes which must be allowed to elapse between switching on and beginning instructional exercise, the instructor should run through the relevant paragraphs of the book. A stop watch will be useful to the instructor.

194. The training can consist of exercises which will train the ranging, bearing and spotting operators. With this in view it will be possible to carry out range measurements, rate keeping, zero checking and pre-determined runs using all the displays.

Page 24. Chapter VIII. *Add* new paragraphs 195–199 :—

RADAR TEACHER OUTFIT H.R.F.

195. Radar Teacher Outfit H.R.F. is a small compact equipment which is unofficially known as the Suitcase Teacher. It operates with Types 282 and 285, and has been produced in order to provide training facilities in small ships which have insufficient space to accommodate Teacher Outfit H.R.B.

196. The teacher produces on the display panels an echo which can be set by hand at any range from 3,000 yards to 30,000 yards (approximately). This echo can be made to travel along the trace by an electronic system which can be set to give any constant rate between 500 knots opening and 500 knots closing. It must be pointed out, however, that this teacher has been designed to simulate aircraft targets only ; low rate settings are unreliable and for this reason the outfit is unsuitable as a surface target teacher.

197. The bearing of the target is set by means of a manual control ; no automatic continuous change of bearing is available. The target echo is displayed as the director passes through the chosen bearing. When used with Type 282, or with Type 285 in ships fitted with R.F. Director, Mark 6 and F.C.B., Mark 6*, only ranging exercises are possible, since in these cases no " M " type transmission is available to operate the Bearing Conversion Unit.

198. The " M " type motor in Unit B of Teacher outfit H.R.F. operates in 6-minute steps. In ships fitted with Mark 5, 5* or 5** rangefinder director, director training is transmitted mechanically. Bearing transmission should, therefore, be taken from gun training instead of director training. It should be noted that gun training is director training plus deflection and spotting corrections.

199. A full descripton of the teacher, including instructions for setting up and operating, is given in B.R. 1830—Handbook for Teacher Outfit H.R.F.

200.

(G. 0796/49.—A.F.O. P. 219/49.)

(Previous Amendment No. 2—A.F.O. P.331/46.)

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CHAPTER IX

THE RADAR TRAINING SIGHT

Introduction

201. In order to replace the bulky cathode ray and rectifier unit which has been found in practice difficult to maintain and difficult to site adequately in directors, a Radar Training Sight has been developed and will shortly go to sea. There are three designs of the sight and they will be fitted as below :—

Admiralty Pattern 57432 ..	Radar Training Sight, Design I—All Marks of rangefinder directors, to fit Pattern G.352P and series binoculars.
Admiralty Pattern 59108 ..	Radar Training Sight, Design II—Marks III and IV H.A. Directors, to fit Pattern G.350 monocular, not suitable for G.331Y.
Admiralty Pattern 59109 ..	Radar Training Sight, Design III—Mark V H.A. Directors, to fit Pattern G.367 binocular.

202. The Radar Training Sight (*see* photograph 4) consists of two main units : the radar display itself, which fits between the binocular and the colour filter box, and the time base unit. No modification whatever is required to the existing binoculars, but the Aldis tube is removed and re-sited in a special mount attached to the radar sight. The part of the Radar Training Sight which fits on to the trainer's binocular comprises a mirror assembly in a housing and a 1-in. cathode ray tube. The mirror assembly or box is rotatable in its housing so that the display on the cathode ray tube can be reflected at will into the left eyepiece of the trainer's binocular.

203. The Radar Training Sight, Designs I, II and III, will give three operating conditions :—

(i) Radar out—normal use of both eyepieces (one eyepiece in the case of the monocular).

(ii) Radar in—side by side echo presentation received through left eyepiece, target obscured by darkness or smoke, etc.

(iii) Radar in—as for (ii) but with target visible in right eyepiece, thereby giving superimposed visual and radar presentations.

Note.—For this, correct interocular distance are important.

204. The Radar Training Sight, Design II, when fitted in Marks III and IV H.A. directors, takes the place of the right-hand eyepiece. The trainer can look either through his monocular normally with his left eye or through the eyepiece of the Radar Training Sight with his right eye.

205. Trials which have been carried out show that very little preliminary instruction is required to enable the trainer to operate the tube. Once the operator has overcome any tendency to " eye wander " no trouble should be experienced in operating the sight by the trainer. Total weight of the time base is about 40 lb., and the sight itself weighs 25 lb. (with binoculars).

Performance

206. Target echoes should be detected in most instances out to the limits of the display. The smallness of the display does tend to make differentiation slightly more difficult, but this fact is amply counter-balanced by the definition of the display, which is superior to that of a larger tube.

Accuracy

207. The use of the Radar Training Sight will enable the operator to obtain the optimum results from the 285 Radar with a much greater facility than hitherto, i.e. using the remote training tube in the director or the one in the calculating position. Overall bearing accuracy will of course be limited by the performance of the 285 Radar.

GENERAL DESCRIPTION OF THE RADAR TRAINING SIGHT (PLATE 8)

208. The unit as fitted to the existing trainer's sight consists of a mirror assembly with a 1-in. cathode ray tube (Pattern NC.19) mounted fore and aft along the top of the sight. The display faces forward. In Design II the display faces the trainer and therefore no mirror assembly is required.

209. The mirrors and cathode ray tube are fitted into a hermetically sealed housing which is fitted with desiccating unions. A small permanent magnet system, adjustable by means of the external vertical shift control, allows for about $\frac{1}{8}$ in. adjustment of vertical shift on the display. At the front end of the cathode ray tube housing is a glass range graticule calibrated in 5,000 yard steps from 0–20,000 yards and illuminated through its edge. The value of illumination is controlled by a mechanical dimmer situated in the graticule illuminating system and adjustable from the top of the sight.

210. The mirror housing contains a mirror block which is pivoted at the C.R.T. end and is rotated through 90 degrees by means of the operating lever working through a gear train. The operating lever is on the left side and at the rear of the mirror housing.

211. The mirror block contains two front illuminised mirrors set at 45 degrees to the tube axis (i.e. 90 degrees to each other) and a 9·25-in. focal length collimating lens. Adjustment is provided in the mirror for initial setting-up, and a pre-set focussing adjustment allows the lens to be moved $\frac{1}{8}$ in. for correct setting-up at manufacture or in subsequent maintenance. (The setting-up procedure allows the display to be in focus with the binocular focussing lever set at ± 0 for a normal eye.)

212. The presentation shows a normal A display with the ground wave to the left and side by side presentation when on the long range scope. On the short range scope only the side by side presentation will be visible and as the range graticule is now meaningless (because the binocular time base unit is now synchronised with the strobe of the fine display of Panel L.24 instead of the sync. pulse as on long range scope) the graticule illumination is extinguished (*see* paragraph 231).

213. At the beginning of the display on the short range scope will be seen two downward pointing marks called " Cedillas ". These can be used so as to facilitate correct echo separation with the echo separation control without the presence of an echo (*see* para. 223). It is possible that on some tubes the " Cedillas " will not be apparent.

214. So as to preserve the night adaption of the trainer's eyes the screen of the cathode ray tube is coated with a special material which, though appearing green, has sufficient red in the spectrum to enable a red filter to be used at night if desired.

Time Base Unit

215. This unit contains the time base circuits, amplifier and power packs, etc. These components are contained in a resiliently mounted hermetically sealed case approximately 10 in. by 10 in. by 20 in. with a sloping control panel. Desiccating unions are fitted. This is sited convenient to the trainer so that he can adjust the controls. There are four controls mounted on the sloping panel of the unit, and their functions and positions are :—

Brilliance.—Varies the light value of the trace. Too great a value of brilliance will burn the face of the cathode ray tube. (Left-hand control.)

Focus.—Varies the definition of the trace throughout its length. (Middle control.)

Range.—Two-position switch—long range scope (switch lever to the left) and short range scope. (Lower middle control.)

Echo Separation.—Adjustment of this control sets the amount of separation of the side by side presentation, or the cedillas on the short range scope. (Right hand control.)

The control knobs are of a design suitable for operation by a heavily gloved hand and are self-sealing against moisture.

216. Four pre-set screwdriver operated controls, each with an air-tight screw cap, are fitted on top of the time base unit and their functions and positions are :—

Horizontal Shift.—Moves the display laterally in either direction on the cathode ray tube screen. Adjust so that the short range scope centres the display. (Right-hand lower control)—i.e. the ground wave is at zero range when the control is correctly set up.

Stig.—An astigmatic control which varies the uniformity of the focus of the trace throughout its length. (Left-hand lower control.)

Scan Speed.—This control varies the scale of the display and shortens the total range scope slightly. (Left-hand upper control.)

Scan length.—This control varies the total range displayed but not the scale, i.e. X yards per cm. remains constant. It is adjusted in conjunction with scan speed to give a display of 20,000 yards. (Right-hand upper control.)

OPERATING PROCEDURE

Radar Controls

217. The radar controls are of two types, and are all mounted on the time base unit. They are :—

(*a*) Pre-set controls, to be adjusted only by radar officer or radar mechanic.

(*b*) Variable controls which may need adjustment during operation, and the function of which should be clearly understood by layer ratings.

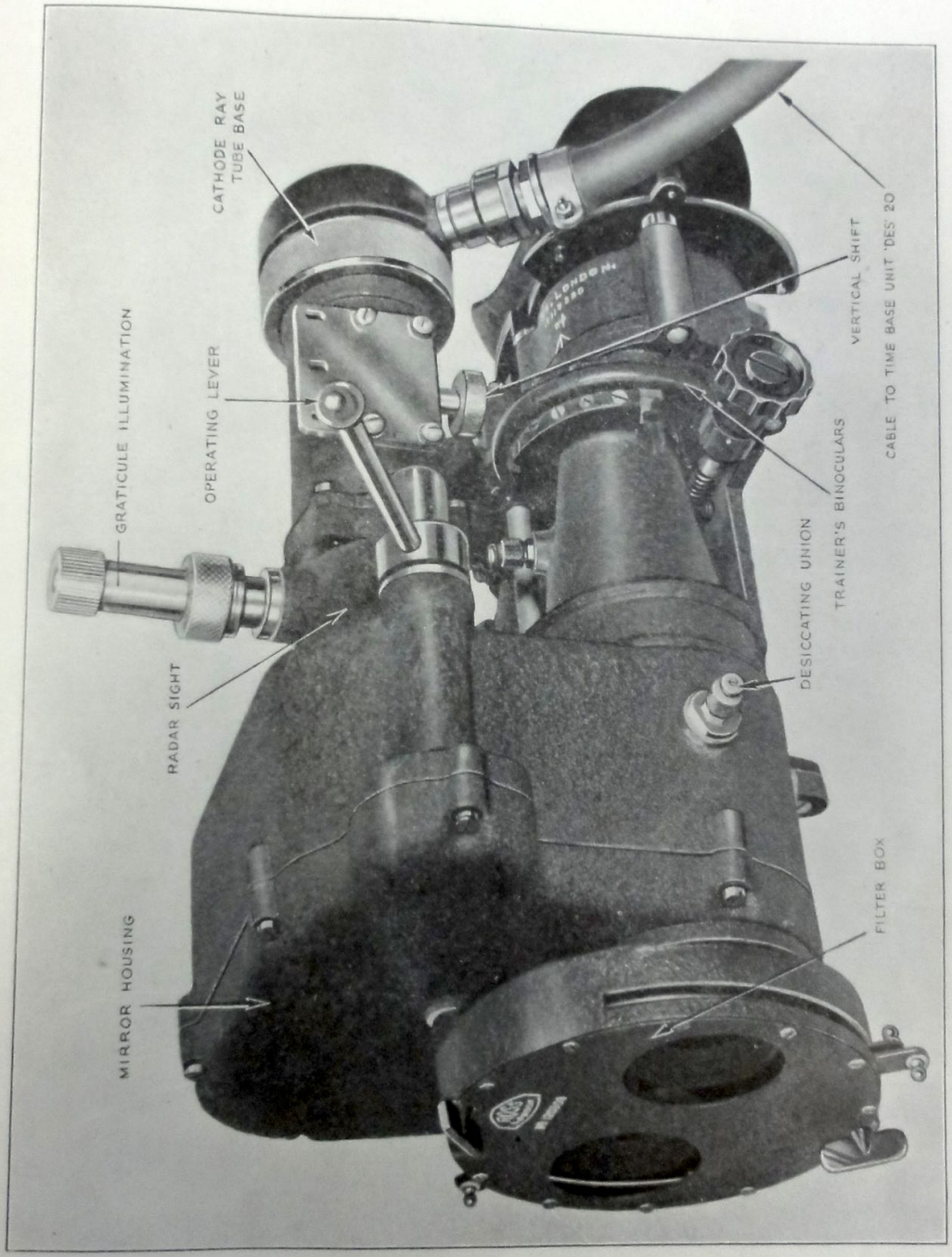
218. There is no on/off switch in the director ; the equipment should function when the appropriate switch is made on the distributing board in the 285 office. About half of one minute will be required for warming up.

219. The **brilliance** control, when rotated (clockwise rotation increases the brilliance) varies the intensity of the " picture " seen by the layer while the **focus** alters the sharpness of this picture. These two controls interact to some extent, and the operators must learn to adjust these controls to find the best picture for their own vision. Attention must be paid to the following points :—

220. *In daylight* the radar image is never comparable in absolute brilliance with that of the target in direct sunlight. This does not matter as each eye can accommodate itself to the different light intensity. It is important, however, in order that the radar display shall be seen as distinctly as possible, that no stray light should reach the eye through gaps between the face and the face mask. This is particularly true when the trainer himself is exposed to direct sunlight.

221. *At night* the brilliance of the display should be kept as low as possible so that both eyes are dark-adapted to the same degree. Then, if visual training only is to be used and the radar presentation is swung out of position, the " radar " eye is already accommodated to the correct focus and degree of dark-adaptation, and there is no lag in the perception of the visual image.

222. It will, however, then be found that when the BRILLIANCE control has been adjusted for minimum usable brilliance on long range, the trace will not be visible on switching to *Short Range.* This is inherent in the use of the much faster scan and is acceptable, as the necessary re-adjustment can be made quickly.



Photograph 4.—RADAR TRAINING SIGHT

Echo Separation

223. The trainer must learn by experience to pre-adjust the ECHO SEPARATION control without the presence of echoes. This can be done on *long range* by setting the control till the two ground waves overlap by 50 per cent. and on *short range* by separating the two little " Cedillas " at the beginning of the scan by the appropriate amount.

224. The range switch control puts into the binocular either :—

(*a*) A long scan covering 0–20 thousand yards range.

(*b*) A short scan centred on the TARGET ECHO and extending 1,500 yards either side.

225. When searching and until the correct echo is identified, the full display should be used. When no ambiguity remains as to which is the correct echo, the trainer should switch to *short range* scope.

Radar In/Out

226. The radar presentation is introduced into the left half of the director trainer's binoculars when the lever on the body of the sight is in the " *Radar in* " position ; it can be swung out of position instantaneously by putting the lever to " *Radar out* ". The trainer has the choice of the following conditions :—

(*a*) " *Radar out* " position. Both eyes using the binoculars in normal fashion for visual training.

(*b*) " *Radar in* " position. Trainer sees the target image only by using the right eye, or the radar display only, by using the left eye.

(*c*) " *Radar in* " position. Trainer using both eyes and seeing the radar display superimposed on the image of the target.

227. When the radar presentation is in position, the trainer can alternate between visual training and radar training, according to the visibility conditions, merely by concentrating on either the optical or radar presentation. There is no break in the continuity of training.

228. The superior optical properties of the Radar Training Sight when in the " *Radar out* " position, which are most marked in conditions of low visibility, and the swiftness and ease with which the change from " *Radar out* " to " *Radar in* " can be carried out, make it a cardinal principle that, unless the target becomes very clearly illuminated (*e.g.* by abundant starshell fire, etc.), the trainer should switch to " *Radar out* " before training visually. He can change at will from visual to radar training should circumstances demand it (*e.g.* on failure of starshell illumination), reporting each time **" Trainer target "** or **" Tube target "** as appropriate. Exception may be made to this rule in conditions where the target is frequently becoming obscured but is clearly defined when visible, *e.g.* in movement in or out of a smoke-screen. In such cases, monocular training would be adequate.

Optical Focussing

229. In order that the trainer may use the sight with the maximum efficiency and without eyestrain, it is important that his correct inter-ocular distance should be set on his instrument and that both halves of the binoculars should be carefully focussed. The correct method of focussing binoculars is as follows :—

230. Screw the eyepiece fully out ; screw it in until the object is most clearly defined. Screw out again as far as possible without loss of definition of the object. Do this with each eye in turn with the other eye closed. Set at — 1 for night.

Graticule Illumination

231. The graticule illumination should normally be kept to the minimum (using knob marked " *Dim* ") when being used at night and turned off completely when switched to SHORT range.

General Procedure

232. It is of the greatest importance, once the trainer has begun radar training, that the bearing operator at the R.T.U. in the calculating position should continue to follow up the director bearing with his bearing handwheel. If the ship swings suddenly, he can, by using his gyro ring, keep the blue pointer in the training receiver in the director on the correct bearing ; the trainer, if he loses the target, can then return at once approximately to the correct bearing. It is the further duty of the bearing operator to call the attention of the trainer to any sudden change of director gyro bearing, e.g. an obviously false bearing.

233. As in any remote training system, the correct manipulations of the receiver gain control by the radar room operator is of first importance. The target echo must at all times be kept at about three-quarter saturation by steady, smooth adjustment of the gain control with range.

234. The danger of the trainer matching two echoes, one from a main lobe and the other from a side lobe, of the other beam is more pronounced with the Radar Training Sight since he has no bearing indicator in view when operating. He must know how to tell when on a true bearing and when on a false one by training quickly to either side of " *Echoes matched* " position. If he is on the correct bearing, training to one side of the matched position will cause one of the echoes to fall, while training to the other side will cause the other echo to fall. When on a false bearing, training to one side of the matched position will cause one of the echoes to fall, while training to the other side will cause BOTH echoes to fall. The danger will be reduced further by following the procedure given in *paragraph 232* above.

235. The trainer must be informed of his own ship's movement to enable him to anticipate training direction, *e.g.* " *Ship turning to Starboard* ".

236–240.

(*G. 02002/46.—C.A.F.O. P.1/46.*)

CHAPTER X

RADAR INTERLINKING UNIT

Introduction

241. The Radar Interlinking Unit (hereinafter referred to as " the Unit ") provides a method of target indication, and has been designed to meet a requirement stated by destroyers, to transmit instrumentally the bearing of a target detected by their Warning Radars to the Rangefinder Director.

242. The Unit is a simple one, designed to work in conjunction with broad beam gunnery Radar. The present policy is to fit the Unit in the following classes of ship :—

(i) Fleet destroyers, W class and earlier, fitted with Radar, Type 285, except in a few cases where individual ships have already been fitted with a T.I.U., Mark II.

(ii) " Hunt " Class destroyers.

(iii) A.A. Sloops and " Bay " Class A.A. Escorts, except in cases where T.I.U., Mark IIs, have already been fitted or in new construction where the fitting of T.I.U., Mark II, has already been progressed.

(iv) Fast minelayers.

243. If and when any of the above ships which are fitted with the Unit are rearmed with modern gunnery Radars or blind firing equipments, the fitting of a T.I.U., Mark II, instead of the Unit will be reconsidered.

DESCRIPTION OF THE UNIT

244. The Unit is designed to transmit relative bearing from Radar warning sets to rangefinder directors fitted with Radar, Type 285, via the R.T.U., Mark V, and thus enable a target detected by Warning Radar to be indicated to the main armament.

245. The Unit, which is fitted adjacent to the R.T.U. and which therefore may be found in either the T.S. or the Type 285 office, was originally intended to receive its bearing from the W.C. (Type 291/286) Radar aerial and re-transmit it, via the R.T.U. to a bearing receiver in the R/F Director. In some cases it was fitted so as to receive bearing from the W.S. (Types 271/272/273) Radar aerial.

246. The progress in fitting W.C. and W.S. Radars with continuously rotating aerials and P.P.I. presentation made it clear that better target indication facilities can be provided by taking the bearing from a hand transmitter fitted close to the P.P.I. in the bridge plot or A.I.C., instead of direct from the aerial. With this arrangement, the relative bearing of the target selected for the main armament can be read off the P.P.I., set on the hand transmitter, and transmitted via the Unit and R.T.U. to the bearing receiver in the R/F Director.

247. The hand transmitter, fitted close to the P.P.I. in the Plot or A.I.C., is a counterdrum transmitter, Pattern 10273, and transmits relative bearing by " M " type transmission in $\frac{1}{2}$ degree steps to the Unit.

248. Owing to initial delay in the supply of these transmitters, certain ships were fitted instead with either—

(i) Inclination Transmitter, Pattern 5830, or

(ii) Transmitter Switch, Pattern 9524, and Datum Angle Receiver, Pattern 6574.

In either case, minor alterations to these instruments were authorised in Admiralty Fleet Orders.

Detailed Description

249. The Unit itself consists essentially of a pair of " M " motors, which, through the medium of a chain of gears, can be made to drive the bearing transmitter in the R.T.U. and thus transmit relative bearing to the R/F Director. The Unit is fitted on the bulkhead adjacent to the R.T.U. and as near to it as is conveniently possible, and is connected to the R.T.U. by means of a flexible shaft coupled to the bearing shaft of the R.T.U. from which the handwheel has been removed. (*Plate 9.*) The handwheel is then fitted on the Unit itself as will be seen later. It is essential to the efficient working of the Unit that the flexible shaft should have as straight a lead as possible from the Unit to the R.T.U.

250. The " M " motors receive transmissions of bearing from the hand transmitter in the Plot in $\frac{1}{2}$ degree steps, and drive the pink chain of gears. (*Plate 10.*) By means of the Main Clutch shown in red, the pink chain can be connected to the green chain of gears and so in turn drive the flexible shaft and bearing transmitter in the R.T.U. This is done when the Main Clutch is put to WARNING SET. When the Main Clutch is put to " 285 ", the green chain of gears is disconnected from the pink and the " M " motors will merely idle if the hand transmitter

251. The reason for the Main Clutch is to enable the transmission of relative bearings to be made to the R/F Director either remotely from the Plot using the hand transmitter by the P.P.I., or locally from the T.S. (or 285 office) using the handwheel on the Unit itself shown in brown (*Plate 10.*) This is the handwheel that was originally mounted on the bearing shaft of the R.T.U. and removed when the flexible shaft is coupled up between the Unit and the R.T.U.

252. This handwheel is now mounted on the yellow coloured shaft (*Plates 10 and 11*) of the Unit. To connect up the handwheel with the green chain of gears and so, via the flexible shaft, with the bearing transmitter in the R.T.U., use is made of a simple push-in-clutch. By pushing in on the handwheel, the yellow shaft moves inwards so engaging the yellow bevel wheel with the green. (*Plate 11.*) Turning the handwheel now will operate the bearing transmitter in the R.T.U. and the relative bearing being so transmitted to the R/F Director is shown by the black mechanical pointer in the bearing dial on the R.T.U.

253. The object of the push-in-clutch on the bearing handwheel is to prevent the operator inadvertently transmitting a false bearing to the R/F Director by turning the handwheel when the Main Clutch on the Unit is to WARNING SET.

With the original design it was still possible to push in the handwheel and over-ride the step-by-step motors when in the WARNING SET position, so transmitting a false bearing. Arrangements have now been made to fit an interlock so that the handwheel can only be depressed when the clutch is to " 285 ".

254. The bearing handwheel is used for sweeping with Type 285 and also for keeping the R/F Director " on " by means of the remote training tube.

255. Connected to the pink chain of gears is the bearing dial of the Unit (shown in dotted lines on *Plate 10*) by means of which there can be read off against the index pointer the relative bearing received by the Unit from the hand transmitter in the Plot. This dial is only mounted frictionally on its blue shaft (*Plate 10*), and by unscrewing the nut on the end of the shaft the dial itself can be rotated independently. This is merely for the purpose of lining up the Unit with the hand transmitter in the Plot.

256. Since the whole system is " M " type, care has to be taken that before putting the Main Clutch to WARNING SET, the system is in line. This is done by first lining up the bearing dial on the Unit to the same bearing as the hand transmitter in the Plot by means of the nut referred to in *para.255* above, and then, using the bearing handwheel on the Unit, lining up the bearing transmitter in the R.T.U. to the same bearing. The handwheel can then be disconnected by means of the push-in-clutch and the Main Clutch put to WARNING SET.

DRILL AND PROCEDURE

Drill at the Unit

257. On closing up at Action Stations, the unit is lined up as follows :—

(i) The training tube operator, who works the Unit, will first see that the Main Clutch is to " 285 " and will then order the Plot or A.I.C. to **Line up the Interlinking Unit.**

(ii) The Plot/A.I.C. operator will line up the hand transmitter to zero (right ahead) and report to the T.S. (or 285 office as the case may be) " Plot/A.I.C. transmitter lined up".

(iii) The training tube operator will then line up the bearing dial on the Unit to zero by means of the nut referred to in *para. 255* and will also line up the bearing transmitter and repeat pointer in the bearing dial on the R.T.U. to zero using the bearing handwheel on the Unit and lining up knob on the R.T.U. respectively.

258. If time permits, receivers should be checked as follows :—

(i) Having lined up the Unit, the training tube operator should put the Main Clutch on the Unit to WARNING SET and then order the Plot/A.I.C. to " *Check receivers, Bearing . .* ". He should also order the R.F. Director to " Follow 285 ".

(ii) The Plot/A.I.C. operator will then run the hand transmitter to the bearing ordered.

(iii) The training tube operator will check that the bearing dial on the Unit and the black mechanical pointer in the bearing dial on the R.T.U. both read the bearing ordered. He should also check that the blue repeat pointer in the bearing dial on the R.T.U. also reads the bearing ordered thus indicating that the R/F Director has correctly followed Type 285.

(iv) If all readings are correct the training tube operator will put the Main Clutch on the Unit to " 285 " and will report " *Interlinking Unit receivers correct* " to the Plot/A.I.C and R/F Director.

(v) Hearing this report the R/F Director will return to its lookout bearing and the Plot/A.I.C. operator will run the hand transmitter back to zero. The training tube operator will then, by means of the bearing handwheel on the Unit, return the black mechanical pointer in the bearing dial on the R.T.U. to zero.

259. When a plot has been developed from either W.S./W.C. reports or from outside reports, and this plot is accepted by the Command as the target to be engaged, the Command will order over the A.I.D. **Indicate Target—to the Director.**

260. The Plot/A.I.C. operator reads off the latest relative bearing of this target from the P.P.I. and sets it on the hand transmitter, passing the range of the target over the A.I.D.

261. The training tube operator, who will have the Main Clutch on the Unit to " 285 ", hearing the order from the Command for the indication of the target, will follow the relative bearing received on the Unit by means of the bearing handwheel and black pointer in the bearing dial on the R.T.U. When he has got the R.T.U. in line with the Unit he will disconnect the bearing handwheel by means of the push-in-clutch put the Main Clutch on the Unit to WARNING SET, and will thereafter watch to see that the bearing dial on the Unit and the black pointer in the bearing dial on the R.T.U. remain in line. He should also check that the R/F Director has followed up correctly.

262. In the meantime the P.C.O. will have ordered the R/F Director to **" Follow 285 ".** The Director trainer will follow up the Radar pointer in the bearing receiver in the R/F Director, thus keeping the Director " on " the bearing transmitted from the Plot/A.I.C.

263. The training tube operator, as soon as he is satisfied that the R/F Director is following up correctly, should watch the remote training tube for the echo of the target. As soon as he and the L.24 operator have identified the echo (and the R/F Director has NOT reported " *Director Target* "), the training tube operator will put the Main Clutch on the Unit back to " 285 ", push in on the push-in clutch, and by means of the bearing handwheel himself transmit relative bearing on to R/F Director as necessary so as to keep the twin-echoes in the training tube balanced. At the same time he will report " *285 Target* " to the Plot/A.I.C. over the A.I.D. and to the R/F Director over the Control Group telephone.

264. The Plot/A.I.C. operator, hearing the report " *285 Target* " will cease transmitting bearing to the Unit, and will return the hand transmitter to zero.

265. If and when the R/F Director sees the target and reports " *Director Target* ", the training tube operator will line up the black pointer in the bearing dial on the R.T.U. to zero and leave the Main Clutch on the Unit to " 285 ".

266–270

(*G. 03218/46—A.F.O. P.331/46.*)

259. When a plot has been developed from either W.S./W.C. reports or from outside reports, and this plot is accepted by the Command as the target to be engaged, the Command will order over the A.I.D. **Indicate Target—to the Director.**

Page 30 (*inserted by A.F.O. P.331/46*). *After* paragraph 261 *add* :—

Note.—In ships where the B.T.U. has been modified (*see paragraph 144*) the following drill is to be carried out.

(*a*) The clutch on the Interlinking Unit is left to " 285 ".

(*b*) The bearing transmitter operator in the Operations Room reads off gyro bearings of the target from the P.P.I. and passes them by 'phone to the B.T.U. operator in the T.S.

(*c*) The B.T.U. operator indicates these bearings to the director by means of the bearing handwheel.

(*G. 07979/50.—A.F.O. P.548/50.*)

(*Previous amendment No. 3—A.F.O. P.219/49.*)

263. The training tube operator, as soon as he is satisfied that the R/F Director is following up correctly, should watch the remote training tube for the echo of the target. As soon as he and the L.24 operator have identified the echo (and the R/F Director has NOT reported " *Director Target* "), the training tube operator will put the Main Clutch on the Unit back to " 285 ", push in on the push-in clutch, and by means of the bearing handwheel himself transmit relative bearing on to R/F Director as necessary so as to keep the twin-echoes in the training tube balanced. At the same time he will report " *285 Target* " to the Plot/A.I.C. over the A.I.D. and to the R/F Director over the Control Group telephone.

264. The Plot/A.I.C. operator, hearing the report " *285 Target* " will cease transmitting bearing to the Unit, and will return the hand transmitter to zero.

265. If and when the R/F Director sees the target and reports " *Director Target* ", the training tube operator will line up the black pointer in the bearing dial on the R.T.U. to zero and leave the Main Clutch on the Unit to " 285 ".

266–270

(*G. 03218/46—A.F.O. P.331/46.*)

APPENDIX I — RANGE HEIGHT DIAGRAMS RADAR TYPES 285M/P/Q

The high frequency pulses generated by the Radar transmitter are radiated from the aerial array in the horizontal and vertical planes in definite directions, dependent upon the type of set and the aerial design. Generally speaking the beam is made narrower by using a higher frequency, i.e., Type 271, or by increasing the number of aerial arrays in parallel, i.e., as in Type 284.

Diagram 7 shews the horizontal polar diagram. This also illustrates the action of the beam switch in moving the main lobe of radiation a small amount to the left and right of the present bearing of the aerials (and of the director).

Diagram 8 shews the vertical polar diagram arranged as a range height diagram. A combination of 7 and 8 produces a total polar diagram which is a solid figure consisting of two (due to the beam switch) cigar shapes, wider vertically than horizontally as the aerials are more directional in the horizontal plane. This ignores the side lobes shewn near the origin in Diagram 7

When the aerials are at low elevations the depth of the vertical beam allows part of the radiation to strike the sea and this is reflected causing a large number of small lobes in the vertical plane. The number of these lobes and the angles at which they occur depends mainly on the height of the aerials above sea level and their angle of sight. These small lobes occur in "bunches" and it is possible to draw around their extremities so enclosing them in one large lobe.

At a certain angle of sight sea reflections will cease to be of import with respect to the main lobe which will not encompass any smaller lobes but become a solid cigar shape. Side lobes however will still be affected by sea reflections. In Diagram 18 a few of the small lobes caused by sea reflections are drawn illustrating how they are enclosed in the main lobes. For clarity it is not possible to draw them all.

Diagram 10 shews a combination of the horizontal and vertical polar diagrams illustrating the type of coverage obtained with Type 285M/P but not technically accurate. The lobes appear as a "bunch" of cigars the spaces in between indicating that no radiation is taking place at that particular angle, *i.e.* a target could not be detected.

It must be remembered that each cigar is composed of a large number of small cigars and that one of the causes of the target echo fluctuating is that it is passing in and out of the small cigars. Diagram 9 shews that if the aerials are elevated with the target it is possible to keep the target, at certain ranges, within a solid cigar shape and so prevent the fluctuation of the target echo.

The true diagrams for any particular ship depend on the type of aerial fitted and on its height above the sea, but intelligent interpretation of these diagrams will enable an estimate to be made of what the set will or will not do. It need hardly be pointed out that to obtain the ranges shown the set must be working at full efficiency and must be correctly set up in accordance with instructions in the RADAR handbook.

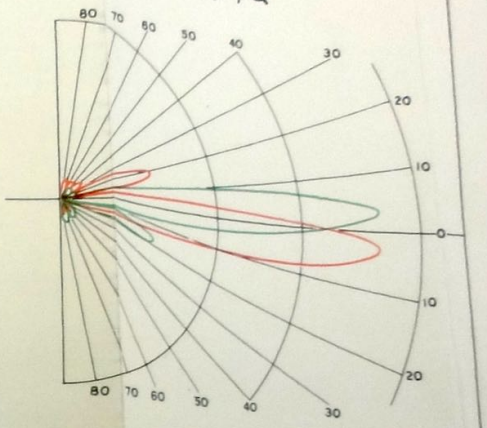


Diagram 7. **Type 285M/P3/4/Q** Horizontal Polar Diagram shewing Action of Beam Switch.

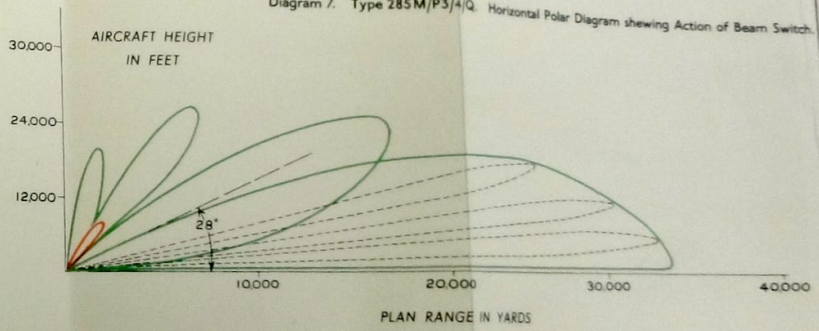


Diagram 8 Range-Height Diagram for Type 285M/P3/4/Q with aerials at a fixed elevation of 10°

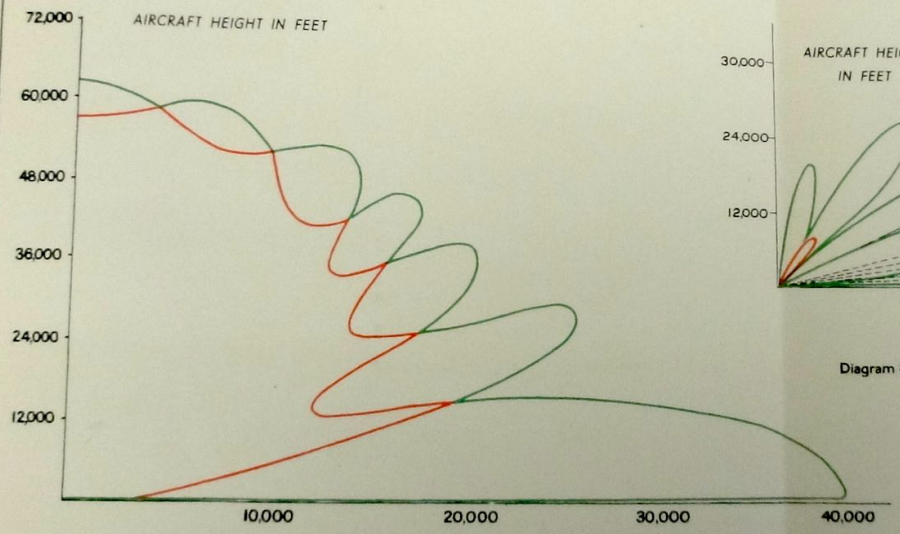


Diagram 9 as for Diagram 8 but aerials elevating with target

Diagrams 8 and 9 only.

Fluctuating signal sometimes vanishing.

Fluctuating signal always greater than twice noise level.

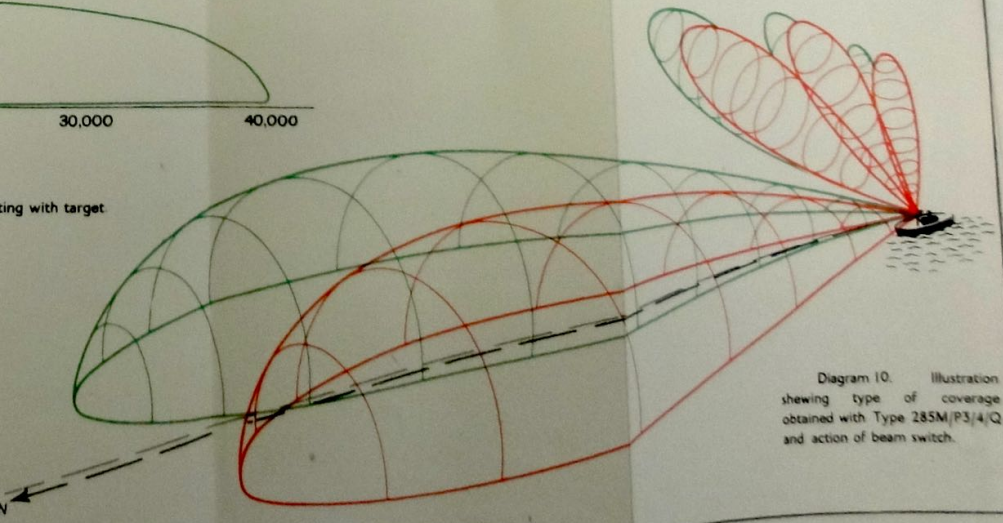
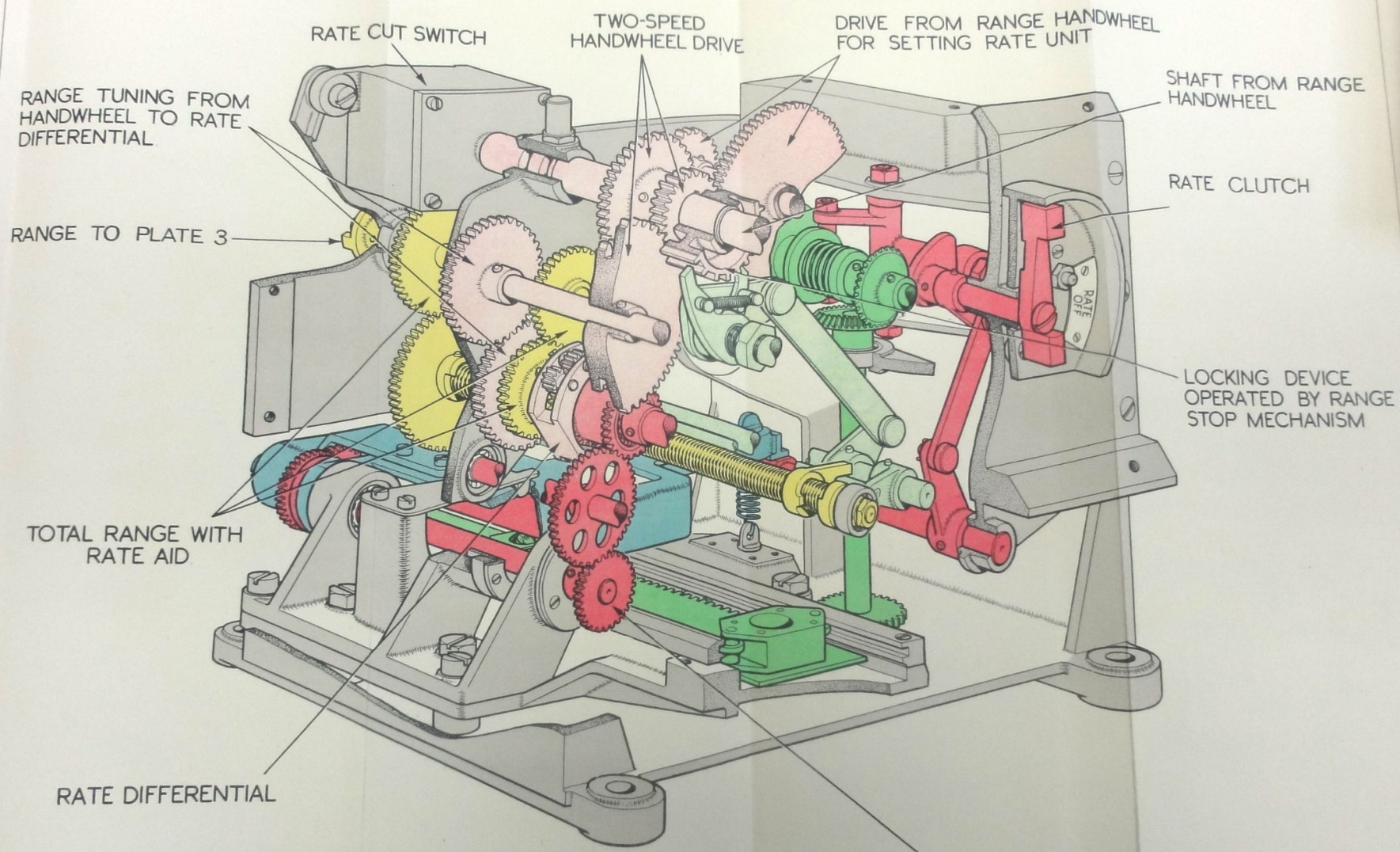


Diagram 10. Illustration shewing type of coverage obtained with Type 285M/P3/4/Q and action of beam switch.

RANGE TRANSMISSION UNIT, MARKS III, III*, IV, IV* AND V RANGE AND RATE MECHANISMS

PLATE 1



RANGE TRANSMISSION UNIT, MARKS III, III*, IV, IV* AND V RANGE AND RATE MECHANISMS, WITH DIFFERENTIAL REMOVED TO SHOW STOP GEAR

PLATE 2

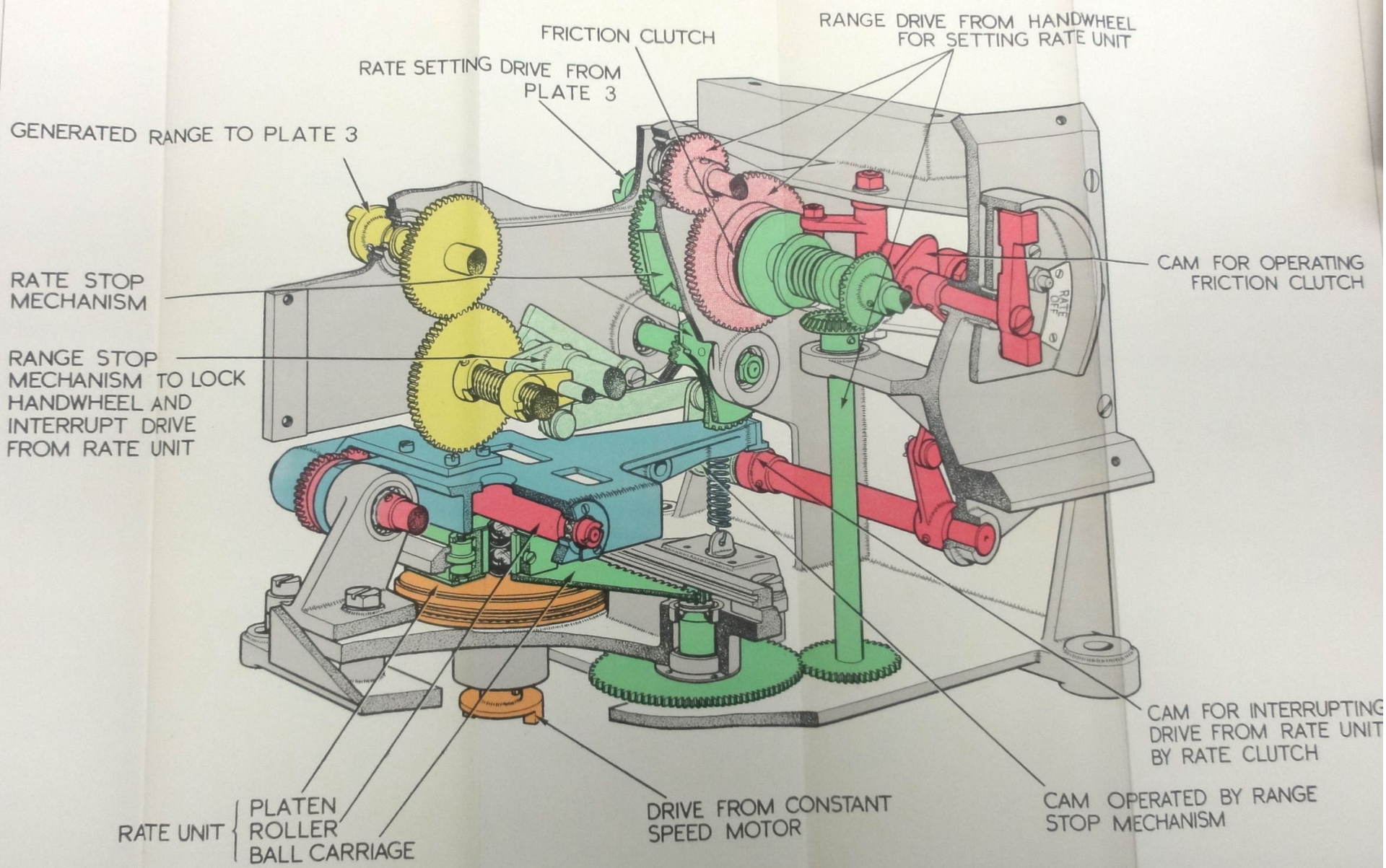
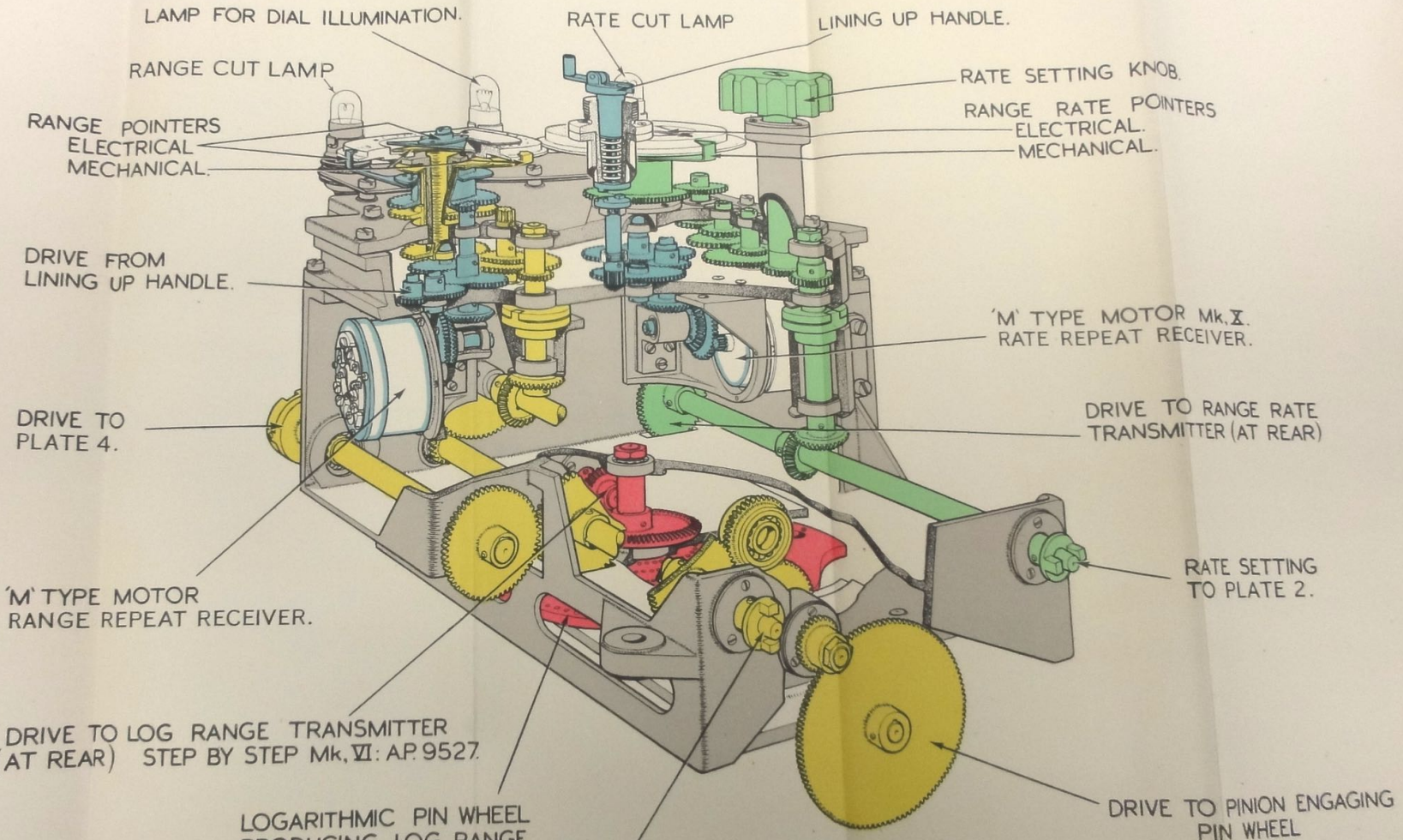


PLATE 3

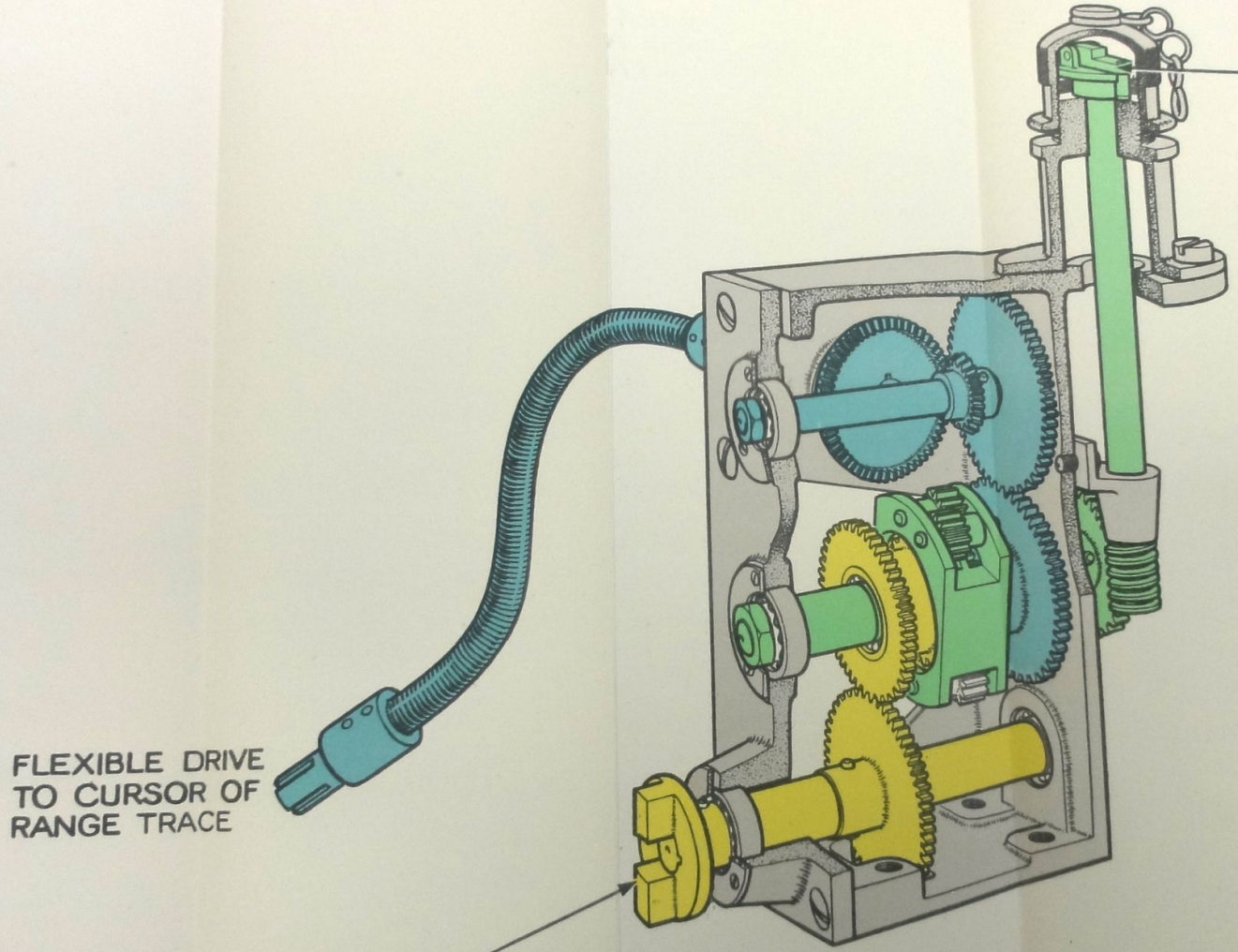
RANGE TRANSMISSION UNIT MARKS IV AND IV* MECHANISM TO DIALS AND CUT LAMPS.



2928. 760.8.41.
2514

RANGE TRANSMISSION UNIT, MARKS III, III*, IV, IV*, AND V DRIVE TO CURSOR RANGE TRACE

PLATE 4



NGE TRANSMISSION UNIT. MARKS IV AND V. BEARING MECHANISM.
(WITH H.A.C.S. I TO III AND F.K.C.)

PLATE 5

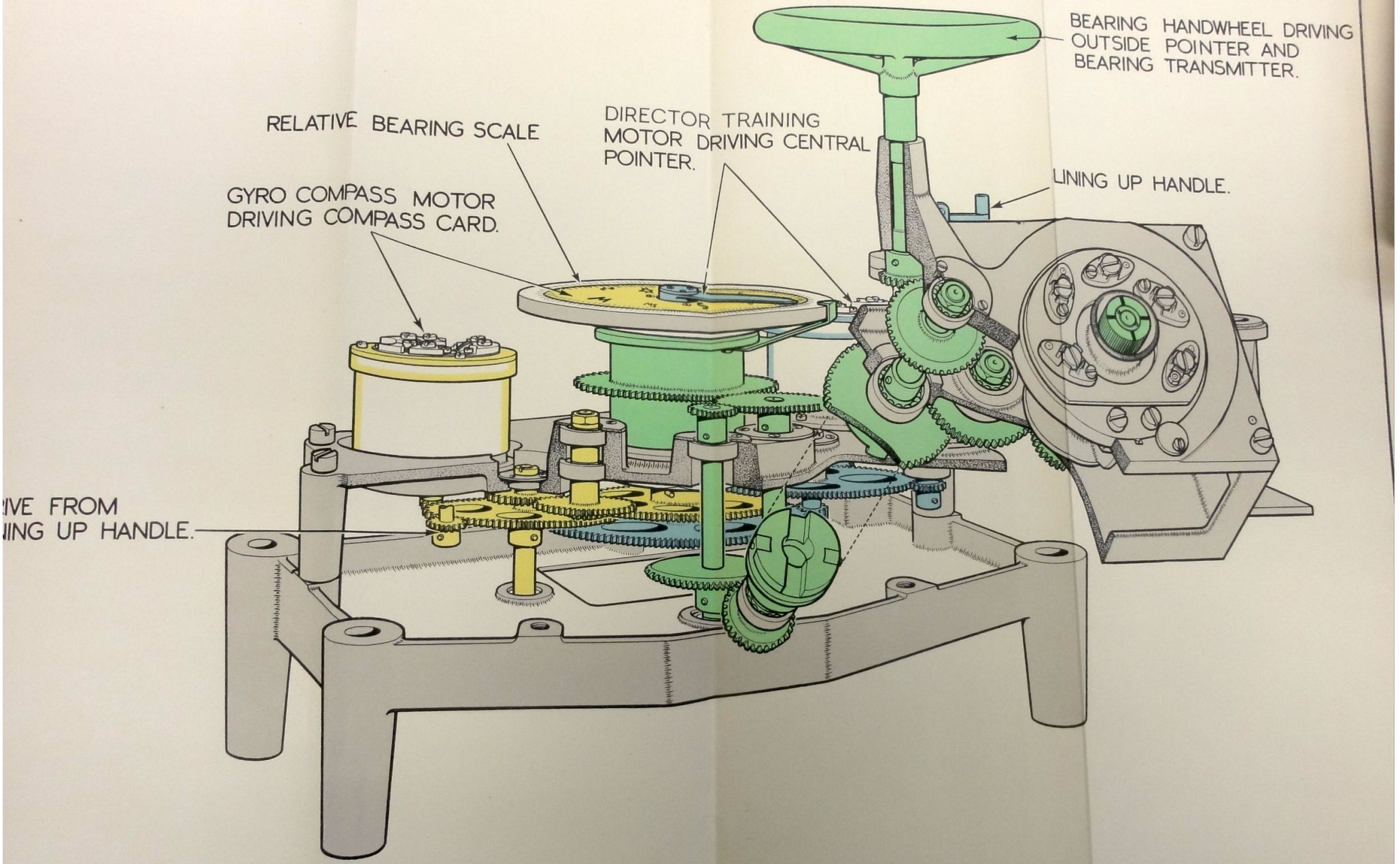
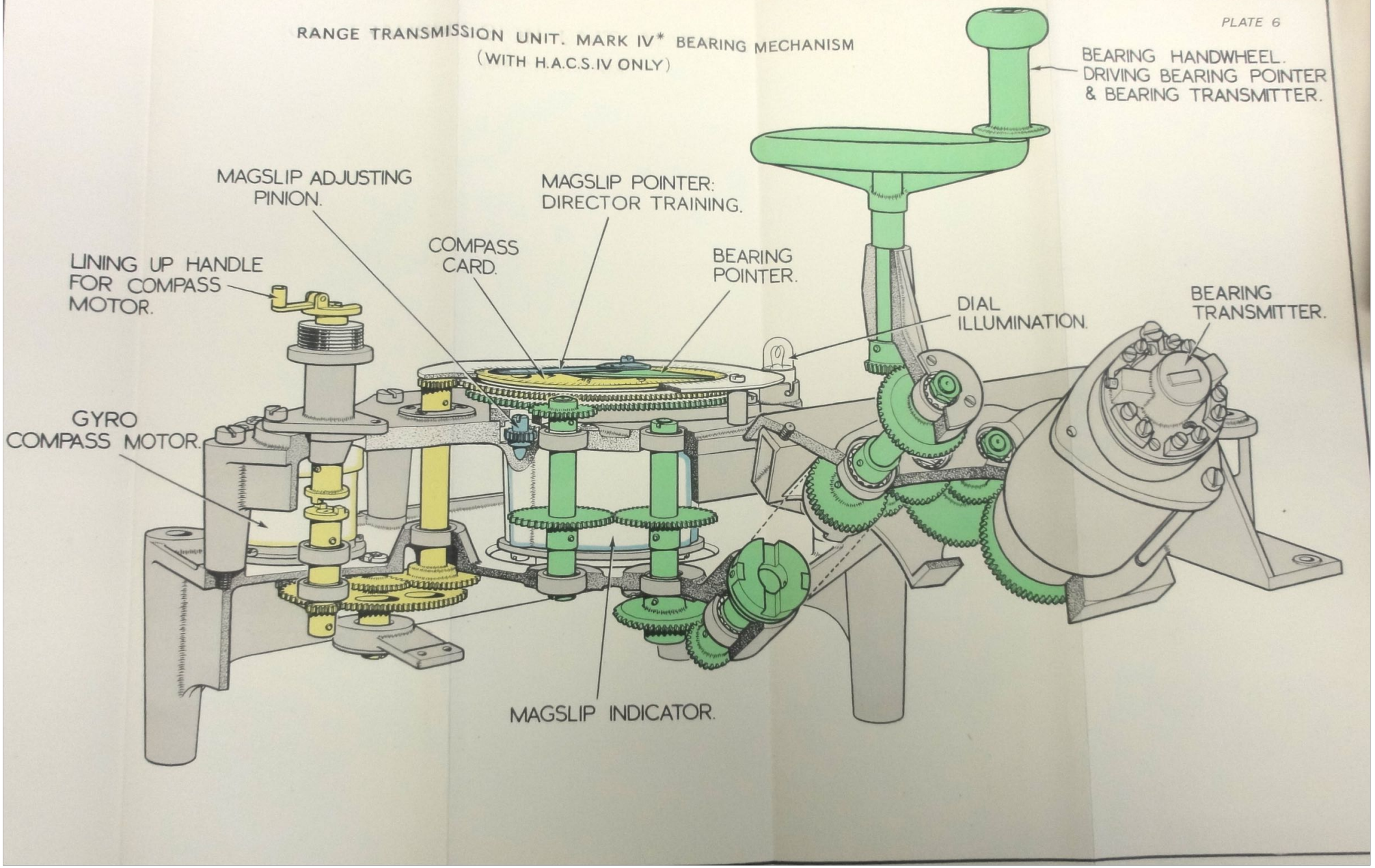


PLATE 6

RANGE TRANSMISSION UNIT. MARK IV* BEARING MECHANISM
(WITH H.A.C.S.IV ONLY)



DEVELOPMENT DIAGRAM OF RADAR TYPE 285.

PLATE 7

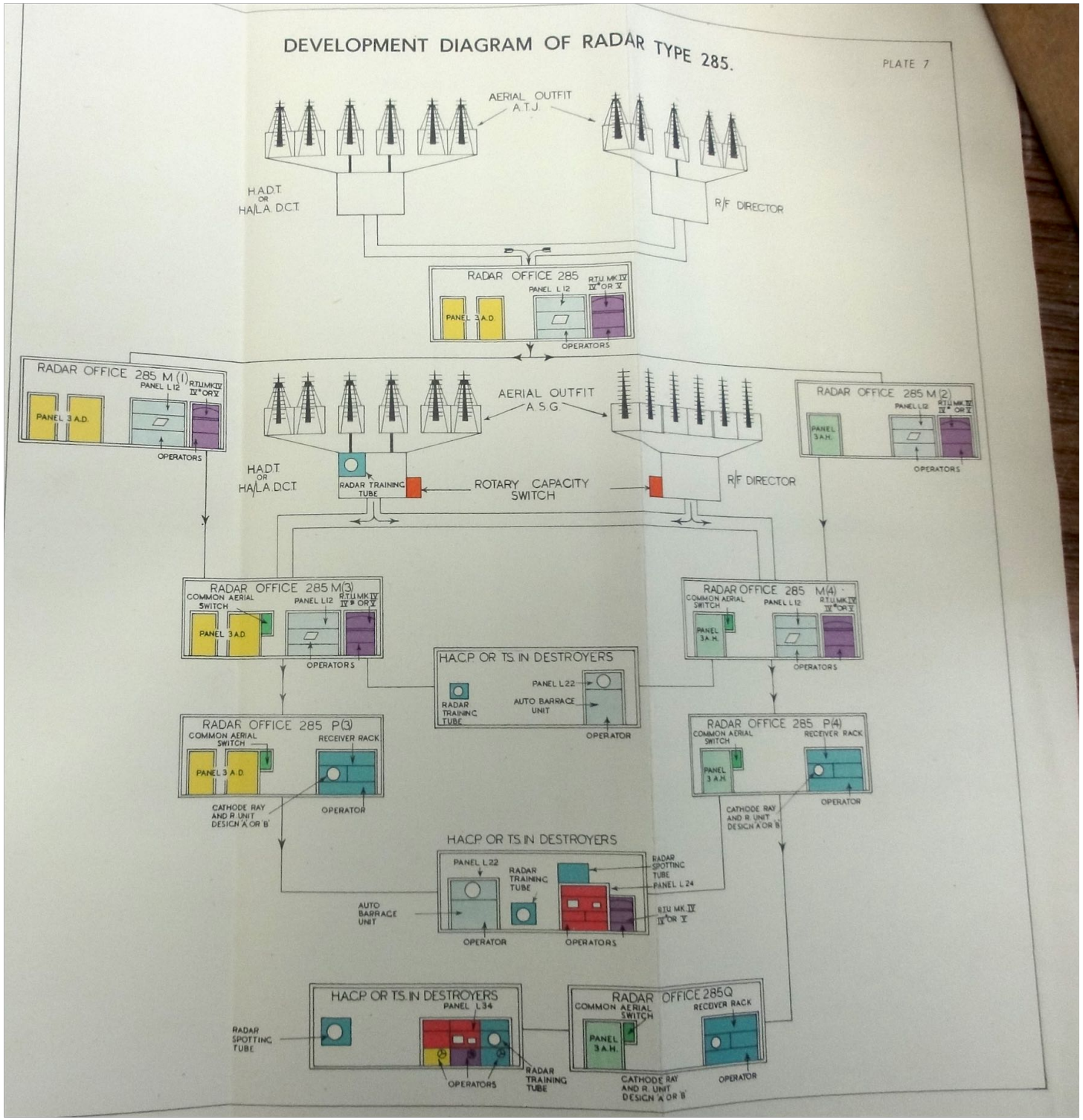


PLATE 8

MECHANISM OF THE RADAR TRAINING SIGHT

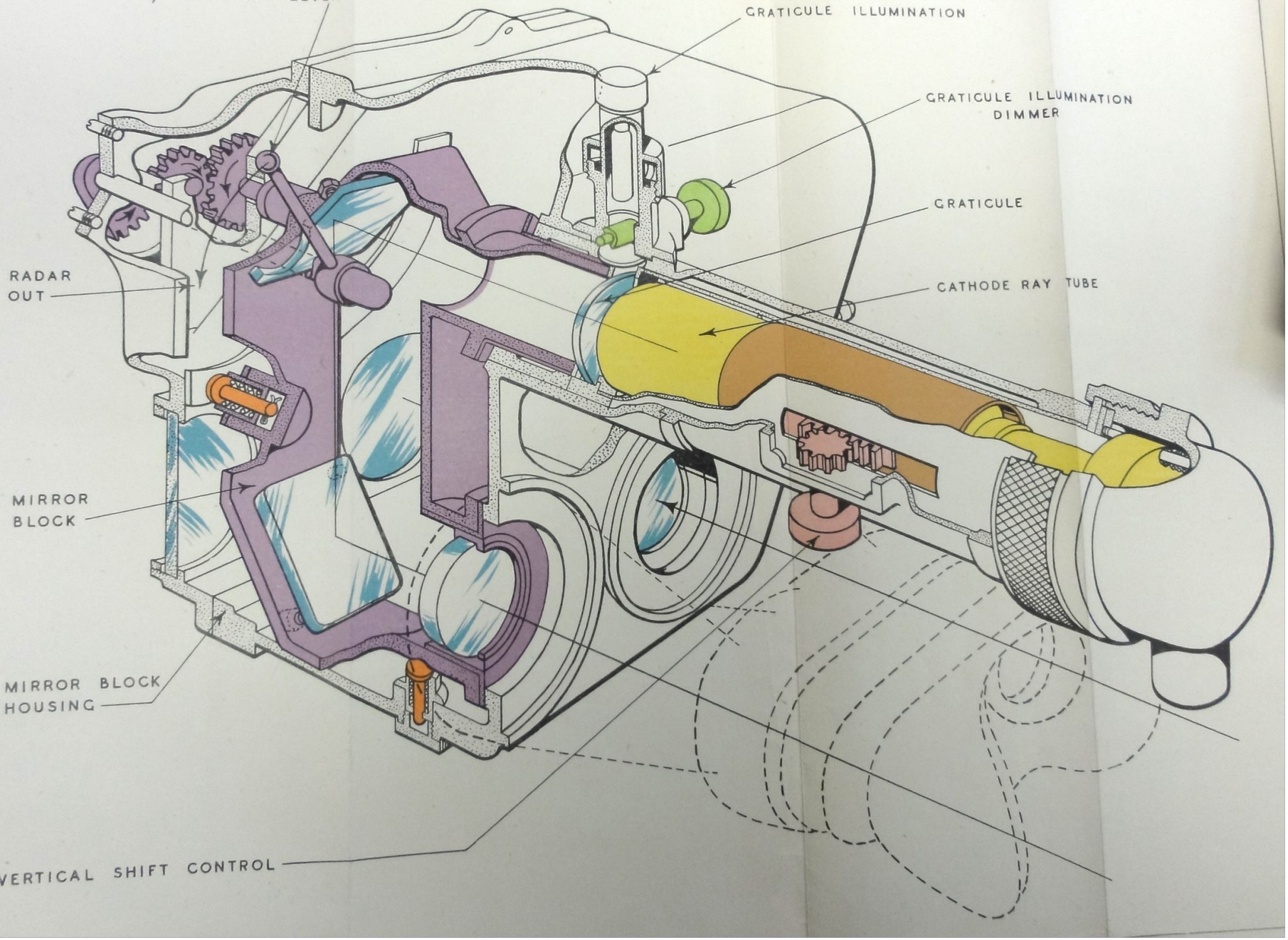
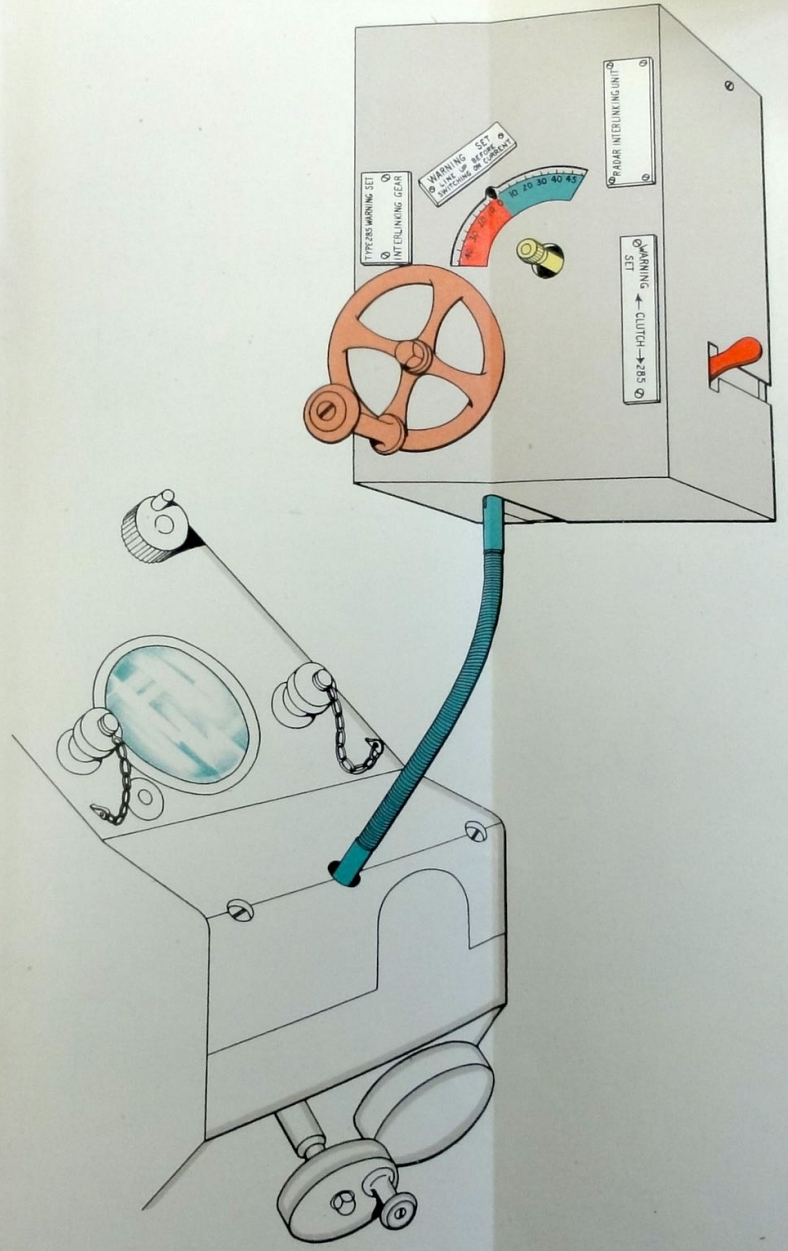


PLATE 9

RADAR INTERLINKING UNIT FITTED TO R.T.U. MARK V.



RADAR INTERLINKING UNIT—INTERIOR DETAILS.

PLATE 10