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# SECTION 6, CHAPTER 10
# AERIAL, SCREENED LOOP, TYPE 3

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# AERIAL, SCREENED LOOP, TYPE 3

(Stores Ref. 10B/10594)

## INTRODUCTION

1. The screened loop aerial, type 3 is designed for installation in aeroplanes. It is used in conjunction with a suitable radio receiver for the purpose of obtaining D/F bearings.

2. The loop consists of a circular former about 10 in. diameter to which is attached a winding forming the loop aerial. The centre point of the winding is connected to earth. The loop aerial is mounted upon a rotatable base. It can be mounted within the aeroplane, or upon the fuselage in a suitable housing, either above or below the aeroplane. In certain instances the loop is mounted within the aeroplane, but outside of its metallic structure, and in such instances it is provided with an electrostatic screen. In whichever manner it is mounted, in either case the ends of the loop aerial are carried through the base by suitable conductors and are connected to the receiver.

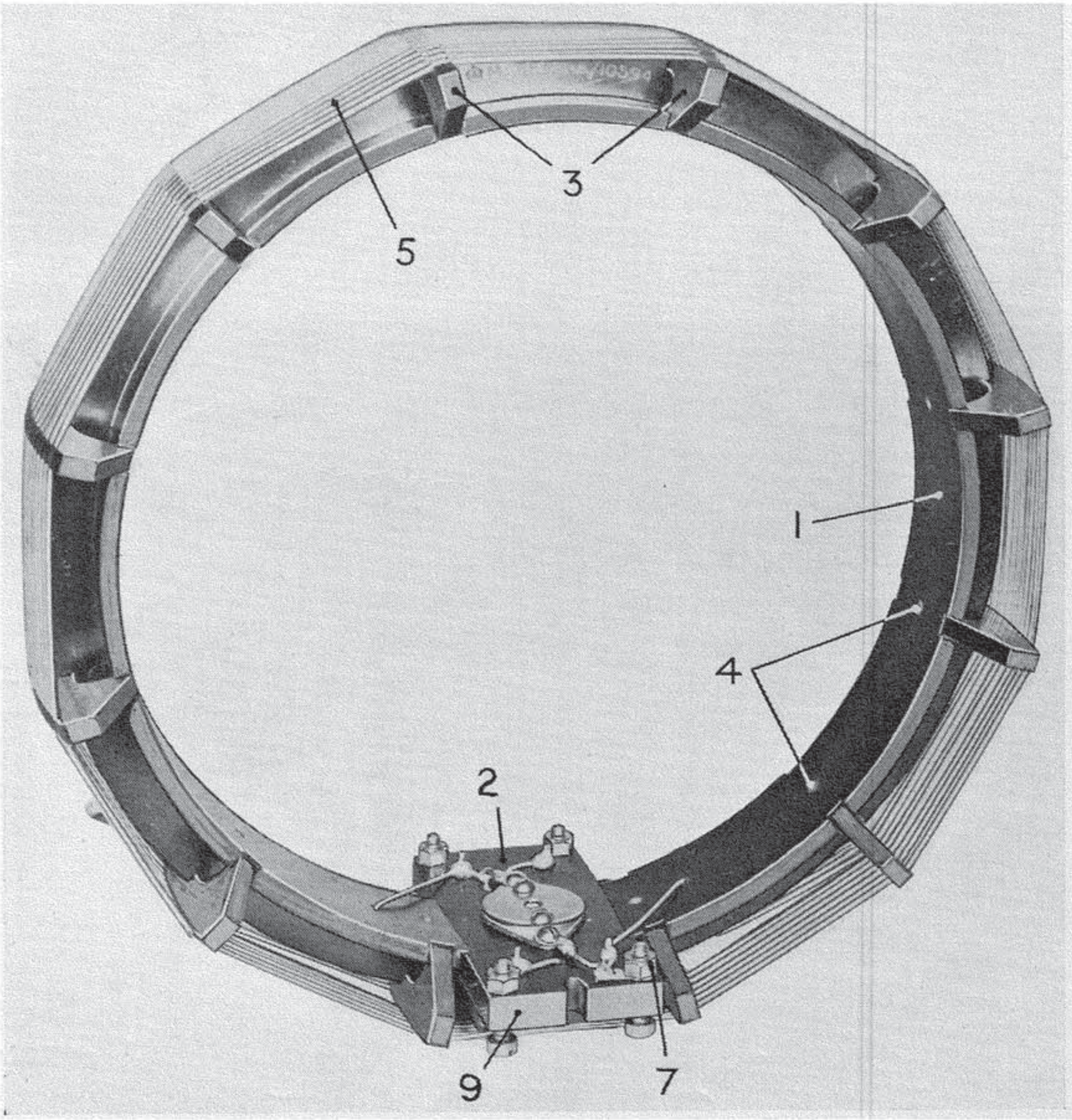


FIG. 1—AERIAL LOOP WINDING ON FORMER

3. The loop may be rotated from within the aeroplane, either through a handwheel directly connected to the rotatable feature of the base, or by means of a remote control device. Where such remote control apparatus is fitted, a bearing indicator is provided at the control position, so that the orientation of the loop at any particular moment is known to the operator.

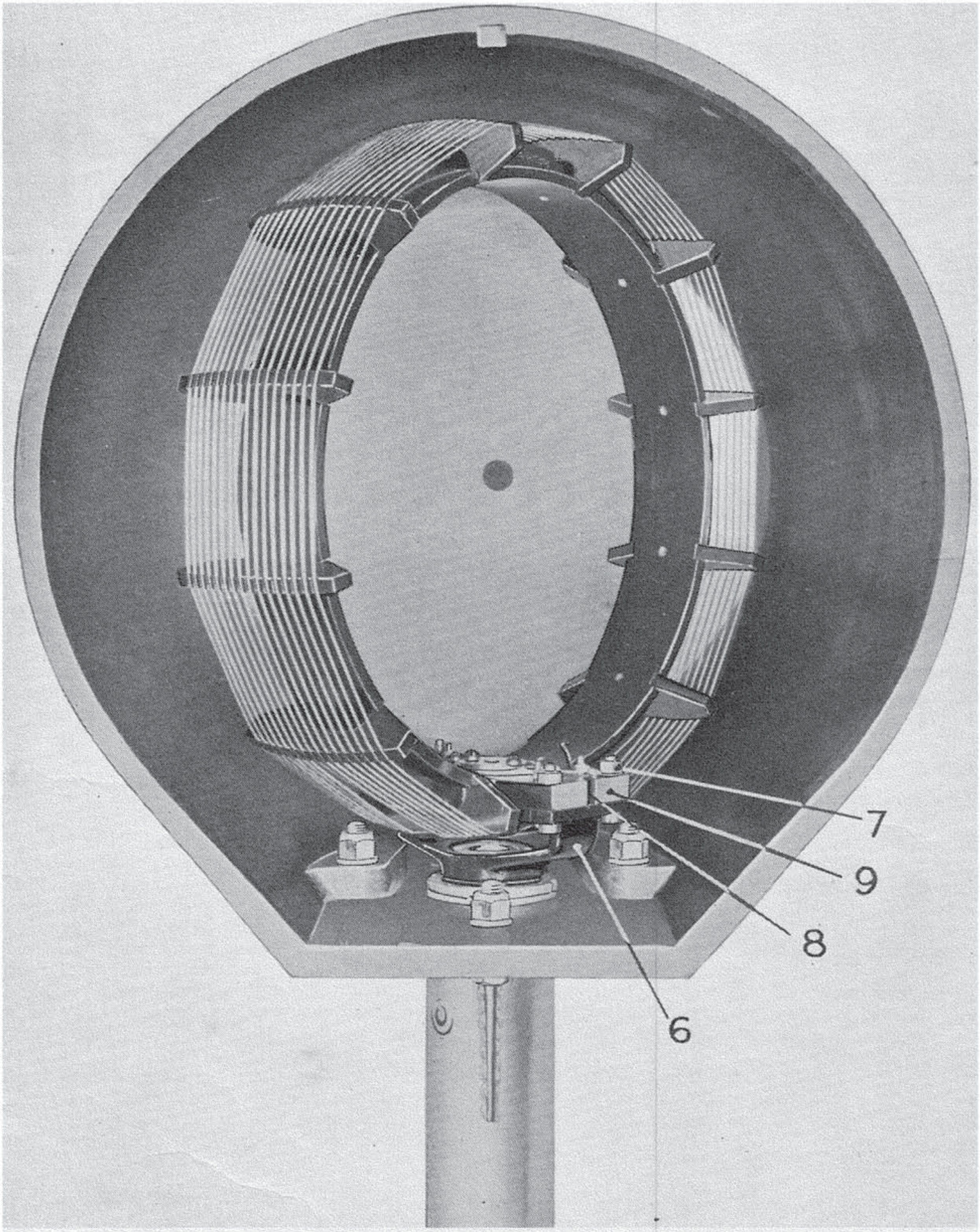


Fig. 2—Aerial Loop in Housing

4. When the loop aerial is connected to the radio receiver, the operator is able to rotate the loop while listening to the signals emanating from a distant radio transmitter. The orientation of the loop giving minimum signal strength is noted. The bearing indicator then gives the apparent relative bearing of the transmitter, with an ambiguity of 180°. After certain corrections have been applied, the bearing of the radio transmitter may be laid off on a chart or map.

## CONSTRUCTIONAL DETAILS

### Aerial loop, type 3

5. The loop, as illustrated in figs. 1 and 2, is mounted upon a former made of moulded composition. This former has a tube section with a supporting base and terminal plate (2) moulded integrally at one point of the circumference. Upon its periphery are mounted twelve slotted segments (3) which carry the loop windings. These segments are held in position temporarily by a single screw (4) at the mid-point of each. These screws are removed when the former has been wound. The former, with segments attached, supports two sets of loop windings (5) which consist of a total of 16 turns of 18 s.w.g. tinned copper wire. These windings are disposed so that 8 turns are held in the slots on each side of the central position. The inductance of the loop windings amounts to about 100 microhenries which gives a natural frequency of about 3·5 Mc/s. The ends of the two sets of windings are brought to the terminal plate (2) at the base of the loop former and attached by soldering to connection spills which are fixed in the terminal plàte. The wound loop has an approximate overall diameter of 11 in. It is 3 in. wide, and is carried on a cradle of cast aluminium (6, fig. 2), to which it is attached by its base with four screws and nuts (7). A slot in the base of the former and a pin on one leg of the cradle, both of which can be seen at (8), locate the loop former with respect to the cradle. The edge (9) of the loop former base in which the slot is provided is painted red.

6. The requirements for mounting the loop are that it should be supported rigidly in position in the aeroplane whilst at the same time it is capable of being rotated about its vertical axis. This is achieved as is shown in fig. 3, by means of a tubular unit comprising an outer support tube assembly (1) which is rigidly fixed to the aeroplane by a suitable clamp, not shown in the illustrations, and an inner drive or torque tube (2) supported in the outer tube assembly by two ball bearings, the lower of which can be seen at (3). These ball bearings are packed with anti-freezing grease and are suitably spaced to give vertical rigidity to the inner tube. The loop is mounted by its cradle on to the end cap (4) which is brazed on to the drive or torque tube (2). To the other end of this tube the driving mechanism is attached with any necessary registering scales or remote control device which may form part of the particular installation. The cradle and tube mountings are fitted with dowel pins, slots and holes to locate them with respect to each other. This is to keep the correct sense of the assembly when orientated with respect to the aeroplane.

7. A short length of Dumet 4 cable (5) connects the loop windings to the cable run which in turn connects them to the radio receiver. This cable is clamped into the terminal plate at the base of the loop and passes down through the cradle and drive or torque tube to a plug connection (6), situated behind the point of emergence of the cable from the drive or torque tube. It is essential that this cable is kept short, a length of 18 in. is allowable from the end of the box drive. The cable is connected to the radio receiver by a suitable socket and plug and a length of Dulocapmet 2·5 cable, this type of cable being used in order to reduce capacitance effects to a minimum. The plug from the loop is connected into the socket and the plug at the other end of this cable connects directly into the receiver. Sockets and plugs have register guides and slots in order to keep the right sense in the electrical connections. The holder of the socket should be bonded to the metal frame of the aeroplane. All cable connections must be made colour for colour throughout the whole cable run, that is the same colours of the cable cores must be connected together at cable joints whether by plugs and sockets or direct connection.

8. The loop is mounted in a streamline housing on the fuselage, or within the skin but outside the metallic structure of the aeroplane. Within specified limits and the requirements set out in this Chapter, contractors are given a certain latitude in the manner in which the loop is mounted on the aeroplane. This includes also the actual mounting of the loop upon the tube assemblies which carry it and allow it to be rotated.

9. When the loop is mounted in a streamline housing on the fuselage of the aeroplane, this housing has to be of special design. Its general outline and design is shown in fig. 3. It is made of moulded composition in three portions, nose, centre and tail, which are fastened together. The centre section is illustrated in fig. 2. The centre and tail sections are coupled by screws round their periphery. The nose is clamped to the centre section by a single moulded composition screw at the nose. The housing is mounted on the aeroplane with its nose facing into the airstream.

### Quadrantal error corrector

10. The quadrantal error correction device is illustrated in fig. 4 and is shown in position in the loop housing in fig. 3. It consists of two metal strips (7 and 8, fig. 4), forming a single turn loop, which are mounted in the streamline housing and surround the D.F. loop in a vertical plane containing the major axis of the loop. A variable inductance (9) is in series with these strips, which are made

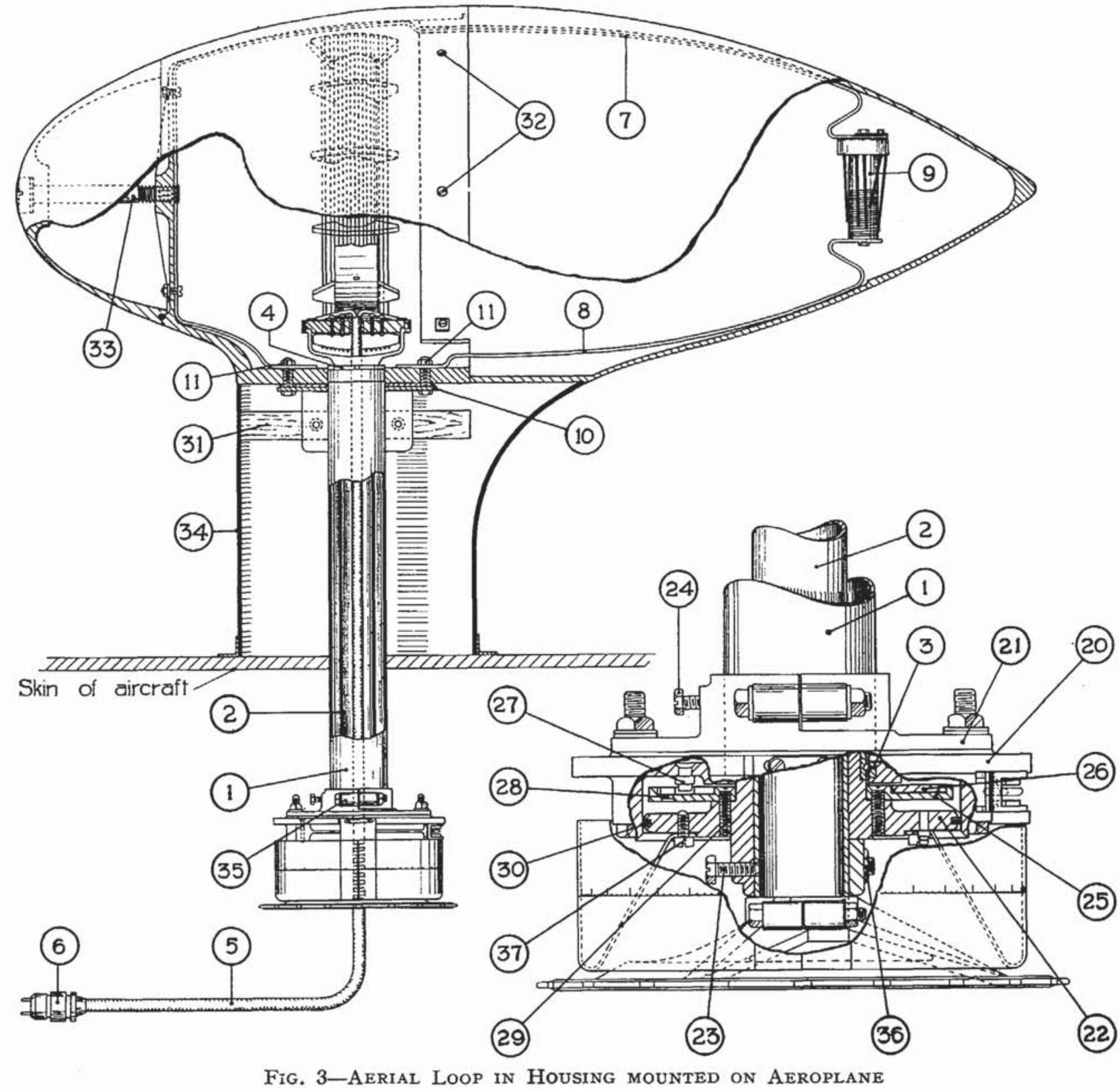


FIG. 3—AERIAL LOOP IN HOUSING MOUNTED ON AEROPLANE

electrically continuous and earthed through the metal plate (10) and bolts (11) which clamp the tube assembly to the housing (see fig. 3). By adjusting the value of the variable inductance, the local field is modified in a manner which corrects, within 2 degrees, the quadrantal error due to the distortion of the field by the metallic structure of the aeroplane.

11. The quadrantal error correction inductance coil (9) fig. 4, consists of an ebonite or moulded insulation former about 1 in. dia. and 3½ in. long. It has a flange at one end about 1¾ in. dia. and ½ in. long. In this are set nine studs at positions (12) each of which is drilled and tapped to take a screw at the remote end. The remote end of the former flange in which these studs are fixed is recessed and has a disc of ebonite or moulded insulation material (13) which is attached in the recess by two screws (14). This disc serves to insulate the tapped studs from external contact, but access is given to them by holes (12) in the disc over each stud through which a screw can be introduced to make electrical contact with the stud. Each hole has engraved above it a number in the following clockwise sequence 0°, 10°, 12°, 4°, 14°, 16°, 6°, 2°, 8°.

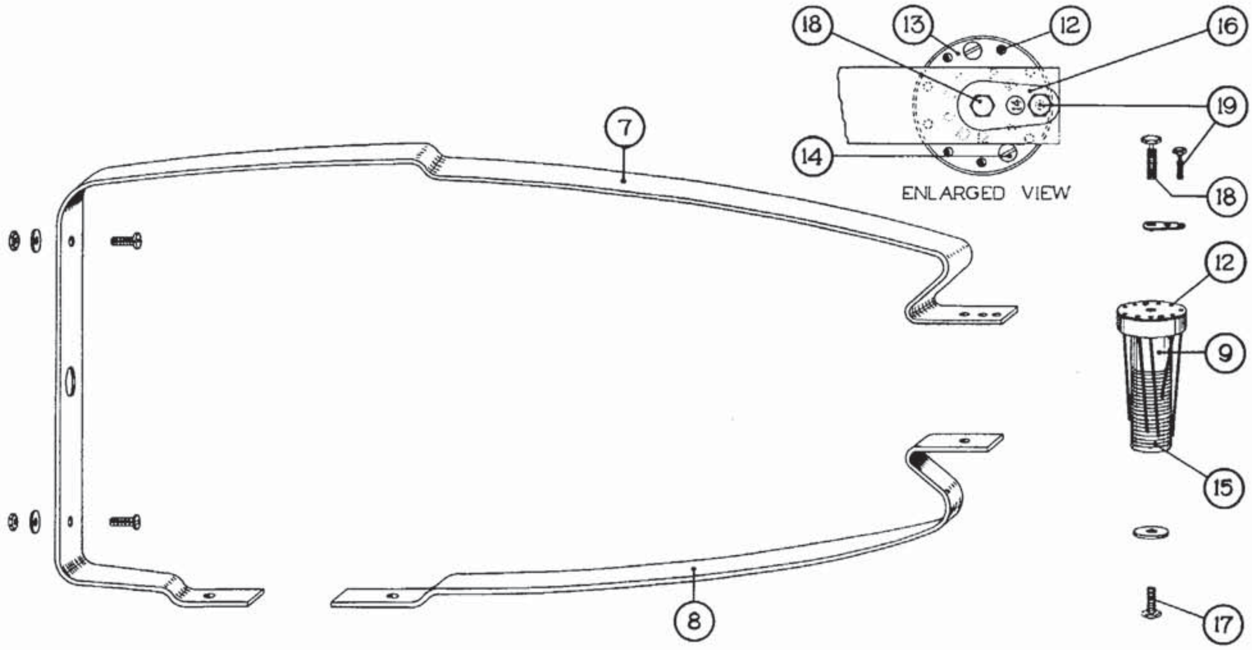


Fig. 4—Quadrantal Error Coil and Loop

12. The stock or cylindrical portion of the former remote from the flange, has a screw thread cut upon it for about 2⅜ in. of its length. In the slots of this thread is wound a coil of tinned copper wire (15) having 9 tappings at slected points. These tappings are connected by insulated wires to the studs in the flange of the former. The first tapping point, at the remote point of the coil is connected into a large brass insert which is screwed into the end of the former at its centre. This insert is tapped to take a screw connection. At the flange end, in a similar position, is another smaller insert similarly tapped. These tapped inserts are provided to make both mechanical and electrical connection with the quadrantal error correction strips which fit into, and are attached to, the loop housing. A shaped brass plate (16) about 1¼ in. long, having in it three holes, is also provided to enable tappings to be connected into the correction loop circuit. This plate is attached, by a hexagon-headed screw (18), to the centre stud on the flange of the former. Its centre hole is positioned so that the engraved numerals on the disc in the recessed portion of the flange can be read through the hole. The third hole is positioned so that a screw (19) entering it can engage the coil connection stud holes, through the disc.

13. The quadrantal error correction strips (7 and 8) which are associated with the quadrantal error correction coil are of brass, about 1 in. by ⅛ in. cross section. They are shaped to fit into the housing to which they are attached at the flat wall portion behind the nose by two sets of screws, washers and nuts (*see* fig. 3). A hole at the centre of this portion of the strip allows the nose fixing bolt (33) to pass through it. The tail end of the strips are shaped into a spring which when they are in position holds the strips rigidly in place by forcing them against the walls of the housing. The strips are clamped by the bolts attaching the loop to the housing. At the spring end of the strips the correction coil (9) is fitted. Details of these strips are illustrated in fig. 4. It is attached to the shorter strip by a hexagon screw (17) and washer fitting into the stud at the end remote from the flange in the former. The screw is locked by turning up the washer against one of its flats and punching the washer into a hole provided in the strip. The larger strip is attached by a hexagon headed screw (18) which when passed through the selection plate (16) enters the central stud in the flange of the former. Selection of the required tapping is explained in para. 29 and para. 58, (X), (c) and a further hexagon-headed screw makes the required connection. The nuts are locked in position by turning up a portion of the washer against a flat of the hexagon-headed screw.

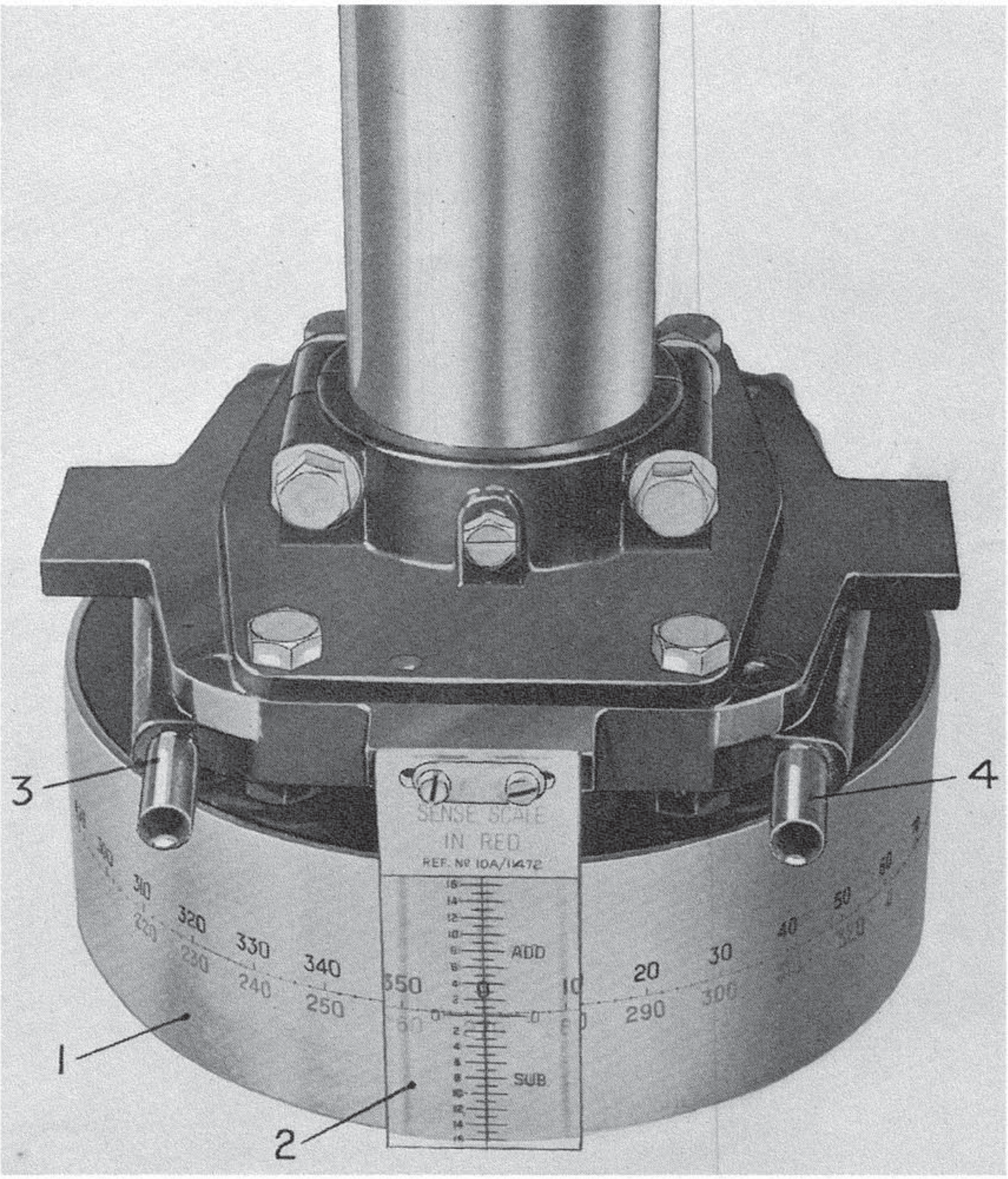


FIG. 5—BOX DRIVE, TYPE 1

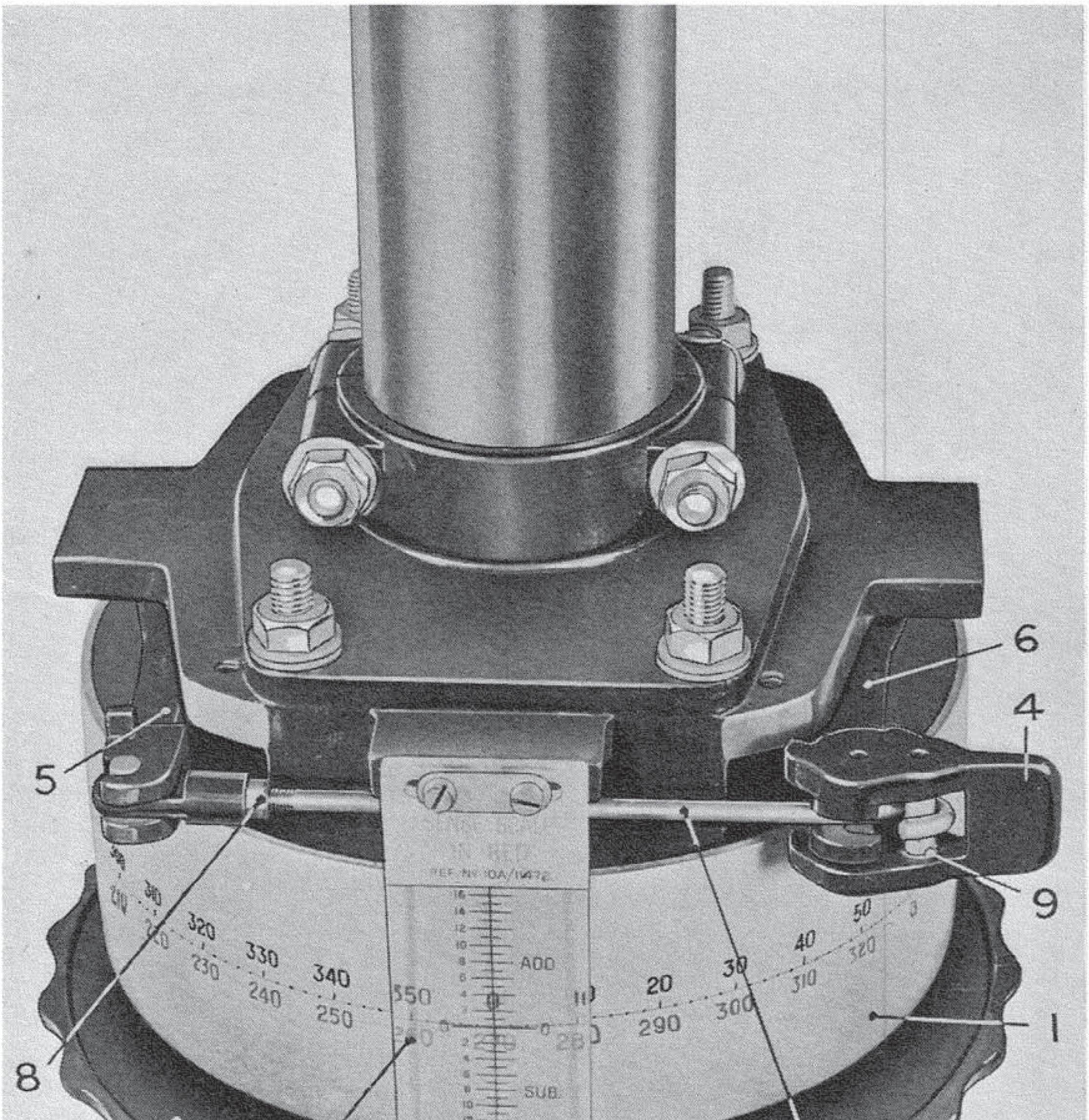


Fig. 6—Box Drive, Type 2

14. The corrector is designed to reduce quadrantal error, which is negative in the first quadrant, as is usual in most types of aeroplane. In cases where the error curve is positive in the first quadrant, as is expected in flying boats where the loop is mounted on the upper plane away from the hull, it is not possible to apply correction by means of this device. In such cases the coil should be locked at 0°, which is an open circuit.

15. A skirt-shaped scale ring, shown at (1) in figs. 5 and 6 is attached to the inner mountings of the box drive which is fixed to the end of the torque tube remote from the loop. The scale ring encloses this mounting. Its position and method of fixing is shown in the enlarged view in fig. 3. Two types of scale ring are provided, one for use when the loop is mounted above, and the other for use when the loop is mounted below the aeroplane, the latter has the engraving reversed for normal visual reading. Scale rings are engraved about their centre with a scale of degrees from 0 degrees to 360 degrees, one above and one below the centre, the latter filled in red and displaced 90 degrees for sense indication. Referring again to figs. 5 and 6 it will be seen that outside of this scale ring is a transparent cursor reading vertically up and down from a central zero, from 0° to 16° up and from 0° to 16° down. The up position is also engraved ADD, and the down position SUB meaning subtract. Its zero coincides with the scale line of the scale ring. The scale ring is finished to enable the quadrantal error correction to be plotted and drawn upon it in pencil. The cursor is attached to the outer or support tube mounting and thus is stationary relative to the scale ring.

## Control

16. The drive, which imparts rotation to the loop, can be for either direct or remote operation. The direct operated drive illustrated in fig. 6 functions by means of a handwheel (3) which is attached to the end of the torque tube and is controlled by hand. A brake (4) which can be used to retard the movement or lock the loop in position is provided on the box drive. A remote control installation is illustrated in fig. 7. A shaft which runs within guide tubes (1), consists of a stranded core of steel wire on which is wound a helical tooth wire making about nine turns to the inch. This shaft is operated by a controller (2). A remote indicator (3) is provided to repeat the indication given on the scale ring which is attached to the torque tube.

## Controller

17. The controller is illustrated in fig. 8. It consists of a handwheel mounted upon an aluminium box which contains a chain of gear wheels giving a reduction of approximately 4½ to 1. This chain of gears drives a wheel which has teeth cut on its periphery and which engages with the shafting connecting the controller with the loop drive. The shafting is led past the toothed wheel by a guide tube (1), which is cut away about its lower centre in order to allow the shafting to mesh with the toothed wheel. This guide tube is detachable, and can also be swung clear to disengage the shafting from the toothed wheel for the purpose of adjustment during assembly, or any necessary subsequent calibration of the drive. Four lugs are provided for fixing the controller to the aeroplane structure.

## Indicator

18. The indicator, which repeats the readings given on the scale ring mounted on the torque tube of the loop, is illustrated in fig. 9. It consists of a circular aluminium container housing a wheel which has teeth cut on its periphery, in a similar manner to that of the controller. A guide tube (1), of the same design and function as that provided for the controller, is attached to the top of the container above the toothed wheel and is similarly removable or can be swung clear for meshing or unmeshing the shafting. The front of the container is protected by a transparent covering of special design, to give clarity to the scale markings. It encloses a circular scale engraved in degrees, from 0 degrees to 360 degrees clockwise The scale is finished to enable the quadrantal error correction curve to be plotted and drawn upon it. A circular transparent cursor is attached to the fixed portion of the hub of the indicator by three screws in slots which are provided to facilitate zero adjustment. This cursor has a scale engraved upon it, up and down from a central zero, 0 degrees to 16 degrees up and 0 degrees to 16 degrees down. These markings are inverted on the other side of the central scale so as to facilitate reading when the cursor is rotated. The up position is also engraved ADD, and the down position SUB meaning subtract. The cursor has also a sense arrow engraved upon it at an angle of 90 degrees counter-clockwise to the cursor scale. It is filled in red and has the word SENSE engraved upon it. The lugs of the casting adjacent to the ends of the guide tubes are painted red and yellow respectively. The left-hand and right-hand lugs are painted at their edges red and yellow respectively. This is provided to facilitate the correct connection of the casing, as is described in para. 34. Three lugs are provided for fixing the indicator to the aeroplane structure.

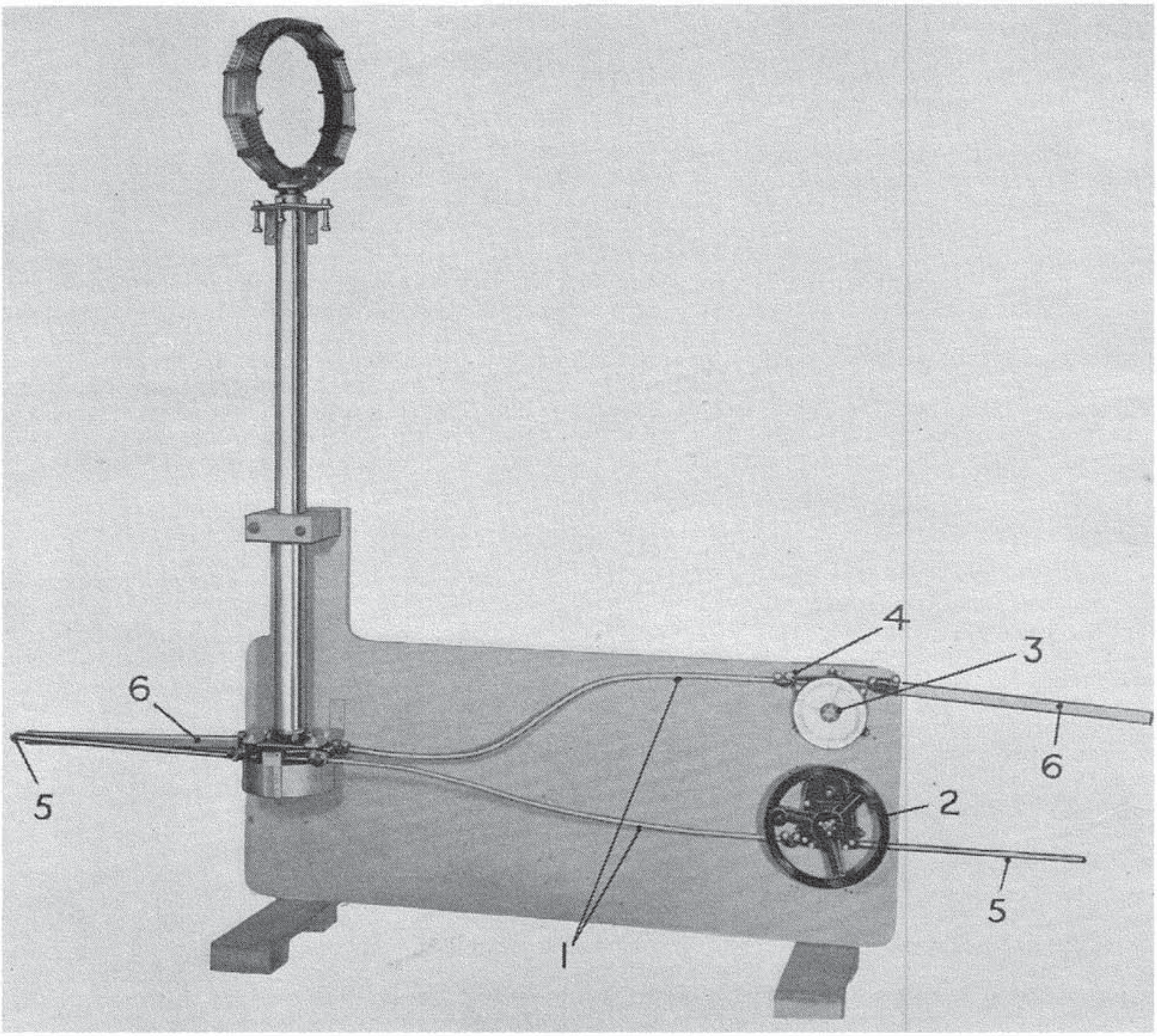


Fig. 7—Remote Control Layout

**Box drive**

19. The box drive forms an integral part of the assembly; two types are provided. Type 1, illustrated in fig. 5, is for remote control and type 2 illustrated in fig. 6 is for direct drive. Reference to fig. 3 will show that in each case the box drive consists of two aluminium castings which fit one within the other. On to the outer casting (20) the outer or support tube (1) of the loop tube assembly is fixed by means of a brass stamping (21) which is bolted to the casting. This casting carries the outer portion of the ball bearing (3) remote from the loop, which is secured in position by a retaining plate fastened with screws. Inside this casting and bearing assembly is another casting (22) which is clamped to the drive or torque tube (2) of the loop tube assembly. This casting carries the inner portion of the remote ball bearing (3) held in position and locked by two circular nuts and a locking washer. Two cone-ended screws are provided, one (23) for the inner and the other (24) for the brass stamping to register them to the inner and outer tubes of the loop tube assembly respectively. They are fixed into position when final adjustments have been made.

20. Between the inner and the outer castings is formed a chamber in which is housed either a brake wheel (25) or a toothed wheel, according to whether the box drive is type 1 or type 2, that is, for remote or direct control respectively. These wheels are of similar design and embody a stop plate (26) which is cut away for about 200 degrees of its circumference. Pins are attached, one (27) to the outer casting and one (28) to its toothed wheel or to the brake wheels. These pins project into the cut-away portion of the stop plate and are mounted so that they clear each other when the loop is rotated. A total rotation of 400 degrees is possible when the inner casting is rotated in

relation to the outer. The gear wheel or the brake wheel is attached by screws (29) to a suitable bearing surface on the inner casting and runs in the chamber which is formed between the inner and the outer castings. This chamber is completely enclosed by a felt washer (30) held in a groove in the edge of the inner casting closing the space between the inner and the outer castings. Type 1 box drive includes a toothed wheel and two guide tubes (3) and (4) which can be seen in fig. 5. These are similar in design and function to those of the controller and indicator. They are attached to the outer casting of the box drive and allow shafting from the controller in one instance and the indicator in the other, to be meshed with the toothed wheel. Similar detachable and meshing features are provided for these guide tubes to those of both controller and indicator. The casting adjacent to the ends of the guide tubes is painted red and yellow respectively. These indication colourings are diametrically opposite each other, the yellow being on the left-hand corner as seen in fig. 5.

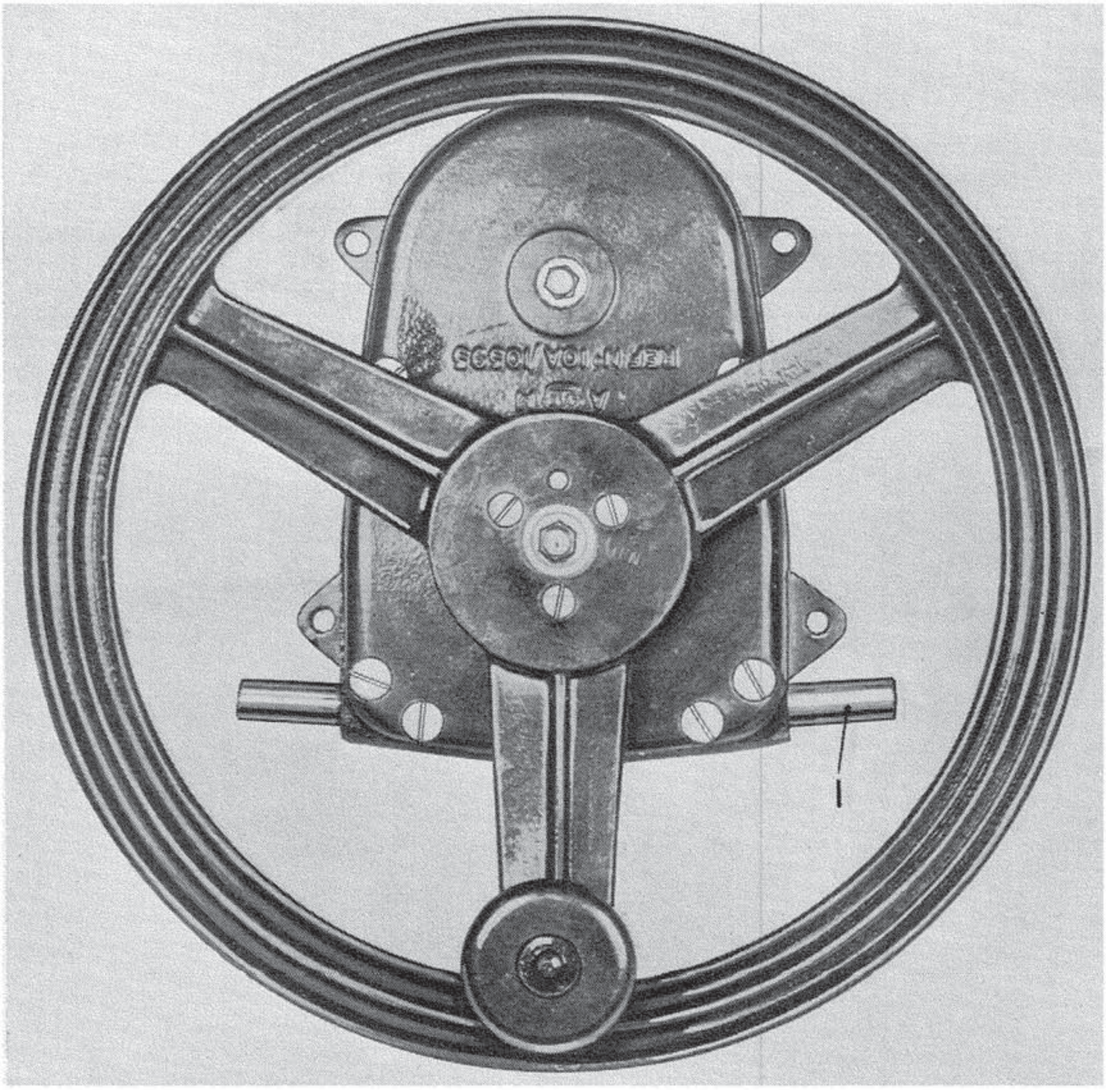

FIG. 8—CONTROLLER

21. Type 2 box drive includes a brake wheel, and referring to fig. 6 it will be seen that instead of the guide tubes which are incorporated in type 1, their place is taken by two brake levers (5) and (6) having cork brake blocks attached to them. These brake blocks press against the brake wheel through the cut-away portions in the casting through which the shafting engages the worm gear wheel in type 1. The brake levers are linked together by a connecting rod (7) and a toggle with a thumb locking lever (4). The connecting rod and toggle draw the levers together and press the brake blocks against the brake wheel. This brake locks the loop aerial in any desired position and can be used while taking a reading to prevent involuntary movement when a minimum has been obtained. Adjustment of the pressure on the cork brake blocks is made by loosening the

nut (8) and removing the rod from the pin (9). The rod may then be adjusted a turn either way, after which it should be locked by the nut (8). Type 2 also carries the skirt scale ring (1) on the inner casting. A cursor (2) is attached to the outer casting on the most convenient of any of the four lugs provided.

**Shafting**

22. The shafting which connects the controller to the box drive, and the indicator to the box drive is flexible and is known as shafting, flexible, Type E1. It carries a continuous helix upon its periphery which engages with the toothed wheel in the controller, indicator and box drive. It runs in tubular casing known as casing, rigid, Type E2. This casing which can be seen at (1) in fig. 7 is attached to the aeroplane structure by suitable cleats, and is bonded to the frame of the aeroplane at frequent intervals. Lengths of the casing are connected together and the casing is connected to the guide tubes of the controller, indicator and box drive by unions (4). Certain of these are lubricating unions, a number of which need to be incorporated in each run of casing depending upon its length. As the shafting does not revolve, but travels forwards and backwards in the casing, provision has to be made to house the overrun portion of the shafting. This is accomplished by attaching extension tubes (5) to each of the open ends of the guide tubes of the controller and the box drive. These extension tubes are formed by a suitable length of casing with the free end pinched.

**Anti-torsional unit**

23. The indicator shafting has an anti-torsional unit which is fitted to each of the free ends of the guide tubes of both the indicator and the box drive. These can be seen at (6) in fig. 7. Their purpose is to prevent any tendency on the part of the indicator shafting to twist in operation, a tendency which if allowed to operate would introduce an appreciable error between the readings of the scale on the box drive and the indicator scale. The anti-torsional unit consists of an extension tube which has an elliptical instead of a circular bore. A metal bead, also of an elliptical cross section, is secured firmly to the shafting and runs smoothly in the elliptical bore of the extension tube. Any tendency on the part of the shafting to twist is prevented by the bead which, whilst allowing free movement of the shafting to and fro in the casing, prevents the twisting action which may be imparted to it by reason of the worm gear wheels with which it is meshed.

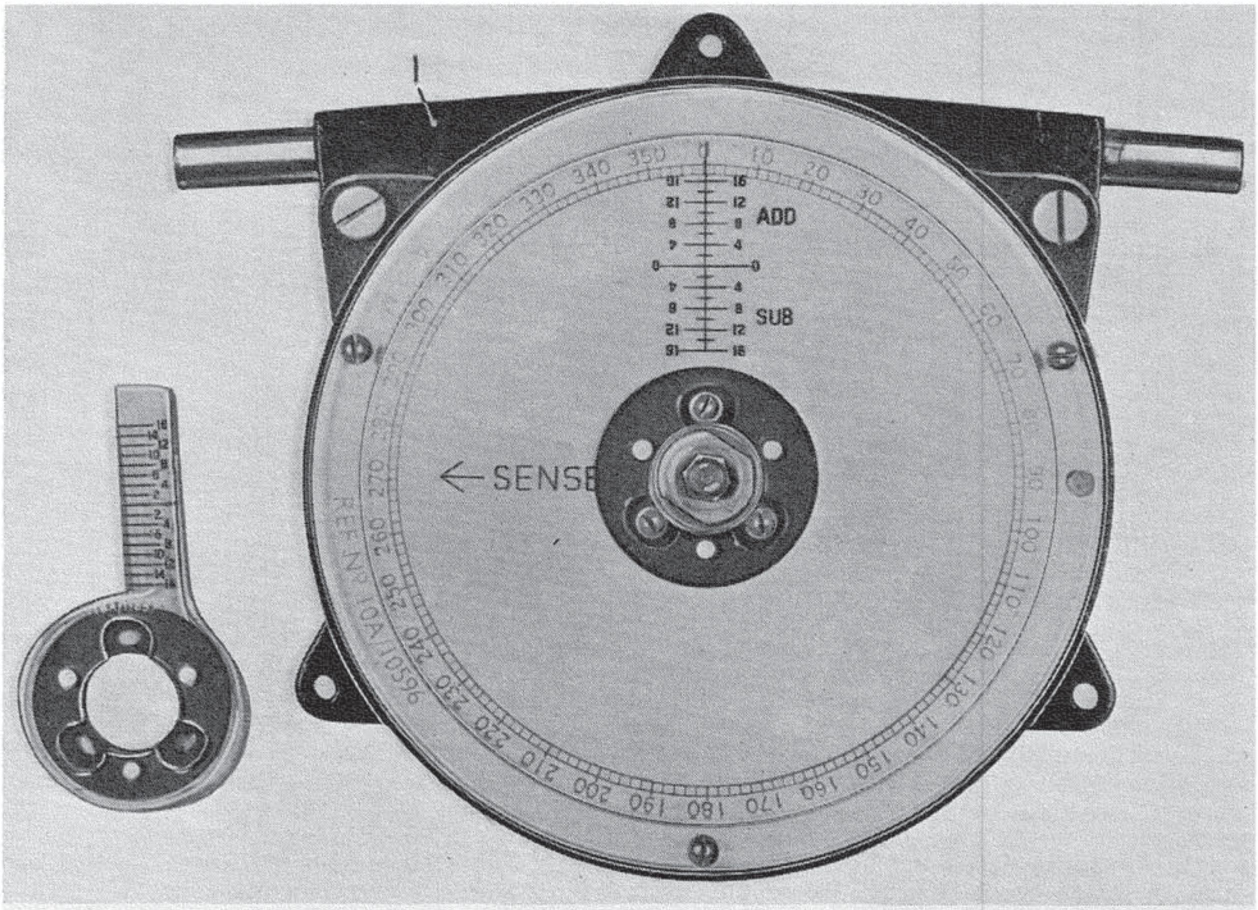


FIG. 9—INDICATOR

## INSTALLATION

### General

24. The exact disposition of the various parts of the loop and its control equipment cannot be given as this varies with each individual type of aeroplane. The method employed to rotate the loop depends on the position of the loop in relation to the W/T operator. The contractors are responsible for the actual fixing details in each aeroplane, within certain limits, but the basic requirements, as set out in this chapter, remain the same and are applicable to all types of aeroplane. In detail the actual fixing of the support tube of the tube assembly may vary in method, both as to how it is fixed to the structure of the aeroplane and to the housing fairing former, but there are certain specified strength requirements for this fixing which have to be fulfilled. This fixing also involves a variation of the actual distance between the loop cradle and the box drive which requires that in some instances the tube assembly shall be lengthened. When this becomes necessary, extension tubes each of the same length, are joined on to the support and torque tubes by muffing. These tubes are of steel 2 in. and 1·25 in. outside diameter respectively. The dumet 4 cable has also in such instances to be longer but the maximum allowable free portion outside the box drive remains 18.

### Loop without housing

25. The box drive should first be fixed to the aeroplane structure, in a convenient position for the operation of the loop, by means of the four screws which project from it. It should be so disposed that when remote control is to be used the guide tubes are in a favourable position for the run of shafting to both controller and indicator, and the cursor so positioned that it can be read accurately. The tube assembly can then be slipped into the box drive and the top clamp tightened. The cradle should next be attached to the tube assembly. A locating dowel pin is provided on the cradle which should enter the hole provided on the tube assembly. The cradle should be locked into position by means of a fixing nut which screws on to the threaded portion at the top of the tube assembly. Two holes are provided in this fixing nut into which fits a pin spanner for tightening the nut, and two further holes are provided, tapped for grub screws which are fixed in position after the fixing nut is tightened.

26. The loop can now be attached to the cradle, but first the dumet 4 cable should be fitted. This cable is connected to the loop windings at the flat base portion of the loop former. This is illustrated in fig. 10. The braiding of the cable should be cut back 1½ in. The circular plate (1)

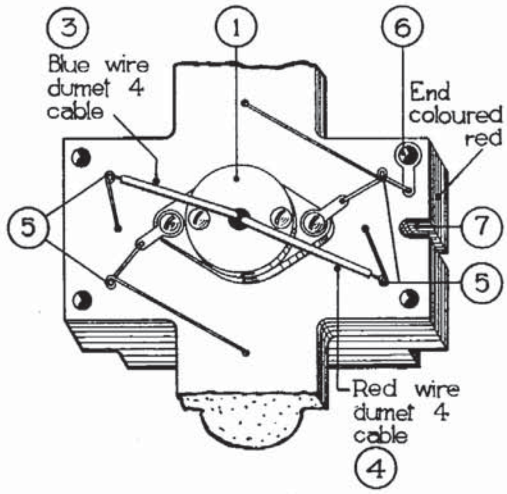


FIG. 10—TERMINAL PLATE OF LOOP

should be removed and the cable screwed up through the central sleeve until sufficient wire and about one inch of braiding has been screwed up past the top of the base. The braiding should be spread over the flat surface of the former base and the circular plate replaced and screwed down, thus clamping the braiding securely between the plate and the flat end of the sleeve. The cable wires (3 and 4) should be soldered to the tags or spills (5) on the inner flat surface of the loop former. The mid-point of the loop is connected to earth, that is the frame of the aeroplane, by a connection from the plate to one of the fixing screws (6) of the cradle, (*see* para. 1). The cable is threaded up through the tube assembly to the loop which is attached to the cradle by four screws with washers and nuts. A pin fixed into the cradle locates the position of the loop by fitting into a slot (7) in the base of the loop former.

### Loop with housing

27. The support tube of the tube assembly is attached to the aeroplane by a suitable clamp at the end of the tube assembly which enters the aeroplane structure. This tube is then also attached to the housing fairing former at the loop end. Reference to fig. 3 will show the general features of this assembly and attachment. The housing fairing former (31) is of spruce and in two portions, split along the centre line. These two portions are clamped together, by two sunken bolts with nuts and washers, and grip the support tube. The cradle fixing nut should be removed from the drive or torque tube which should then be passed up into the support tube until its shoulder is against the ball race of the bearing. The cradle should then be replaced and the fixing nut fitted, tightened up and its grub screws put into position. The loop, with cable fitted, should now be assembled to the cradle, as explained in para. 26, the cable having previously been passed through the drive or torque tube.

### Quadrantal error corrector

28. The quadrantal error correction device can now be fitted. Its general disposition in the housing is shown in fig. 3. The wooden spacing piece which is sometimes in position on delivery should be removed from between the tail ends of the strips of the corrector, and the coil (9) fitted into this space, i.e. between the free ends of the strips. It is fitted, with the engraved end farthest from the skin of the aeroplane, by means of the two larger screws which should be loosely fitted at this stage. Two soft metal washers are placed between the strips and the screw heads.

29. The coil can be rotated between the strips and being so rotated the markings 0, 8, 2, 6, 16, 14, 4, 12 or 10, which are engraved on the top of the coil, appear in turn in the hole in the long strip. These details can be seen in fig. 4. The markings tally with the threaded insert in which the third, or selector screw (19) is located. The coil should be rotated until the marking 0° appears, when the selector screw should be inserted into its socket. In this position the correction device is inoperative. When the selector screw (19) has been tightened it should be locked by turning up the end of the plate (16) against one of the sides of the hexagon head of the screw.

### Housing

30. The housing is illustrated in fig. 3. The centre section is attached to the housing fairing former (31) by a bracket to which it is bolted and the nose and tail sections attached. The tail section is attached by screws (32) round its periphery and the nose section by a single screw (33) at its centre. The fairing (34) which encloses the tube assembly and is about $9\frac{1}{2}$ in. high is of sheet aluminium 22 s.w.g. It is sometimes mounted upon an inner former, to keep its shape, and is fastened to the skin of the aeroplane by a suitable flange and to the housing, at the housing fairing former line. The housing is fixed in position so that the nose points to the front of the aeroplane.

31. When the housing is fixed in position with the fairing attached, the box drive should be clamped to the support tube of the tube assembly, inside the aeroplane. This should be positioned, whenever possible, so that when remote control is to be used, the guide tubes are in a favourable position for the run of shafting to the controller and indicator and the cursor so disposed that it can be read accurately. The tube assembly can now be tightened.

### Adjustment

32. Referring again to fig. 3, the bolts (35) clamping the box drive to the support tube should be slackened and the box drive revolved until the cursor is in the best position for accurate reading. The clamping bolts should then be re-tightened. The loop should be set athwartships, with the red end of the former nearest to the tail of the aeroplane and held there. The portion of the box drive which is attached to the drive or torque tube should then be rotated, its clamping bolts (36) having previously been slackened. Rotation should be made until the cursor reads 0 degrees on the rotating scale ring, when the clamping bolts should be re-tightened. This adjustment is made to the nearest tooth of the toothed wheels and final exact adjustment is completed by loosening the fixing screws on the cursors of the indicator and box drive and setting them exactly. Both should read 0 degrees. The loop rotates approximately 400 degrees and is usually set to rotate 20 degrees on either side of 0 degrees in order to provide ample overlap. Set screws (23) and (24), to be found in each of the clamps, one on the support tube and one on the torque tube, should be removed and a No. 26 drill entered through the tapped holes and drilled through each tube. The scale ring will have to be removed, by unscrewing four screws (37) on the base of the box drive, for this purpose. The set-screws should then be replaced and screwed in firmly, after which the scale ring should be replaced.

### Controller and indicator

33. When the loop and its drive equipment have been fixed into position and adjusted, the indicator and controller should be mounted in the aeroplane in a position that will be convenient for operation. Each is fixed to the aeroplane structure by screws, using the lugs provided. Convenience for fixing the tubing which carries the shafting is a factor of importance when locating the selector and controller.

### Casing

34. The casing is attached to the aeroplane structure by cleats, and is joined to the guide tubes of the controller, box drive and indicator by unions and lubricating unions. It is essential when fixing the casing to give special attention to two points, namely, that no sharp bends are incurred, and that the total of all the bends between the controller and the box drive or between the box drive and the indicator do not exceed exceed 360 degrees. At the points where unions are used to join two pieces of casing together, or where unions join the casing to the guide tubes, the ends of the casing and guide tubes are bell-mouthed to ensure an absolutely free run for the shafting and to obviate any possibility whatsoever of the shafting catching or being subject to friction at any junction. All casing junctions are pinned to prevent disengagement or any extension in the length of the run by partial disengagement at a joint or joints. The connection of each unit to the other is normally by the rule of like colour to like colour, namely, yellow to yellow and red to red, but when the loop is mounted to project *below* the aeroplane, the casing has to be assembled between unlike colours on the box drive and indicator guide tubes.

### Shafting

35. When the equipment has been assembled and the casing runs fixed, one screw should be removed from each of the four guide tubes and each tube, at the freed end, swung out clear of the worm gear wheel. The correct length of shafting is cut with a bolt cropper and the ends ground to a cone. Each length should then be inserted into its respective casing run, through the guide tubes, until an equal amount of shatfing extends from each guide tube. Both the loop and the indicator should then be rotated until they each register 0 degrees and, having made sure that in each case the shafting extends equidistantly from each guide tube, they should be swung back into position and the retaining screws replaced and screwed up. When swinging the guide tubes back into position care should be taken to ensure that the shafting and toothed wheel mesh properly. The protecting casing for the ends of the shafting which project from the guide tubes of the box drive—controller run can now be assembled and fixed.

### Anti-torsional units

36. The drive box—indicator shafting requires anti-torsional units to be fitted to each of the free ends of the guide tubes of the box drive and indicator. These are attached by means of the unions provided which are clamped to the guide tubes. The beads are then assembled by clamping them one to each end of the shafting by the screws provided in each bead, after which the anti-torsional tubes are passed over the beads and clamped by the unions which receive them. Minor adjustments to give exact coincidence between cursor and dial should be made at this stage, after which all clamps and screws should be finally tightened and clamped.

37. All metal parts are zinc-sprayed and enamelled black. Certain metal parts are cadmium or zinc-plated. Care should be taken to ensure that cleanliness and free working conditions are maintained. Lubrication should be made in all cases by anti-freezing oil or grease according to the purpose of the part lubricated.

## OPERATION

### General

38. The loop is connected by means of the plug which is attached to the dumet 4 cable projecting from the box drive. This plug fits into a socket which is attached to the dulocapmet 2·5 cable run and terminates in another plug which is used to make direct plug-in connection with a sense unit in turn connected to the receiver. The *fixed* aerial of the aeroplane is also connected to the sense unit by means of a plug and socket, for sense finding purposes. The trailing aerial of the aeroplane is not to be used for this purpose.

39. The sense unit, which is used in conjunction with the receiver R1082, is illustrated in fig. 11. It comprises two switches (1) and (2) and a variable resistance, suitably housed and provided with a socket (3) to make connection with the loop connection plug, a plug (4) to make connection with the receiver, a socket (5) to take the plug connection from the fixed aerial, and a plug (6) to connect the fixed aerial with the receiver. The switch (1) has three positions engraved D/F, SENSE and TRAFFIC. The other switch (2) has two positions engraved RECIPROCAL and BEARING. This latter switch has SENSE engraved upon its operating handle, and a reminder, SELECT MINIMUM, is engraved on the case immediately above this handle. The resistance operating knob is engraved INCREASE.

40. The switches of the sense unit perform the following functions. When the three-position switch is placed in the D/F position it disconnects the fixed aerial enabling the loop to be used alone. When the switch is placed in the SENSE position the fixed aerial is connected to the receiver through the variable resistance, the loop still being connected. When placed in the TRAFFIC position, the fixed aerial is connected directly to the receiver. The two-position switch enables the connections of the loop to be reversed.

41. The detailed operations for obtaining D/F bearings with any given receiver will be found in the chapter appropriate to that receiver, but the method of using the screened loop aerial, type 3, as given in this chapter is applicable generally.

42. The loop may be used directly or through remote control. When used directly, the position of the receiver will be sufficiently close to enable the operator to make simultaneous adjustments of both receiver and loop. When used with remote control the controller and indicator will be installed near the receiver and the operator will rotate the loop, by means of the controller, and observe the indicator readings, whilst using the receiver.

43. Cursors are provided which are engraved to read above and below a zero line. These markings are universal in the case of indicator cursors, but are of two different types for the box drive scales, depending upon whether the loop is mounted above or below the aeroplane. For calibration purposes, special marking cursors are provided. They are fixed in place of the normal cursor during calibration, and removed and stowed away for future use when the calibration has been completed.

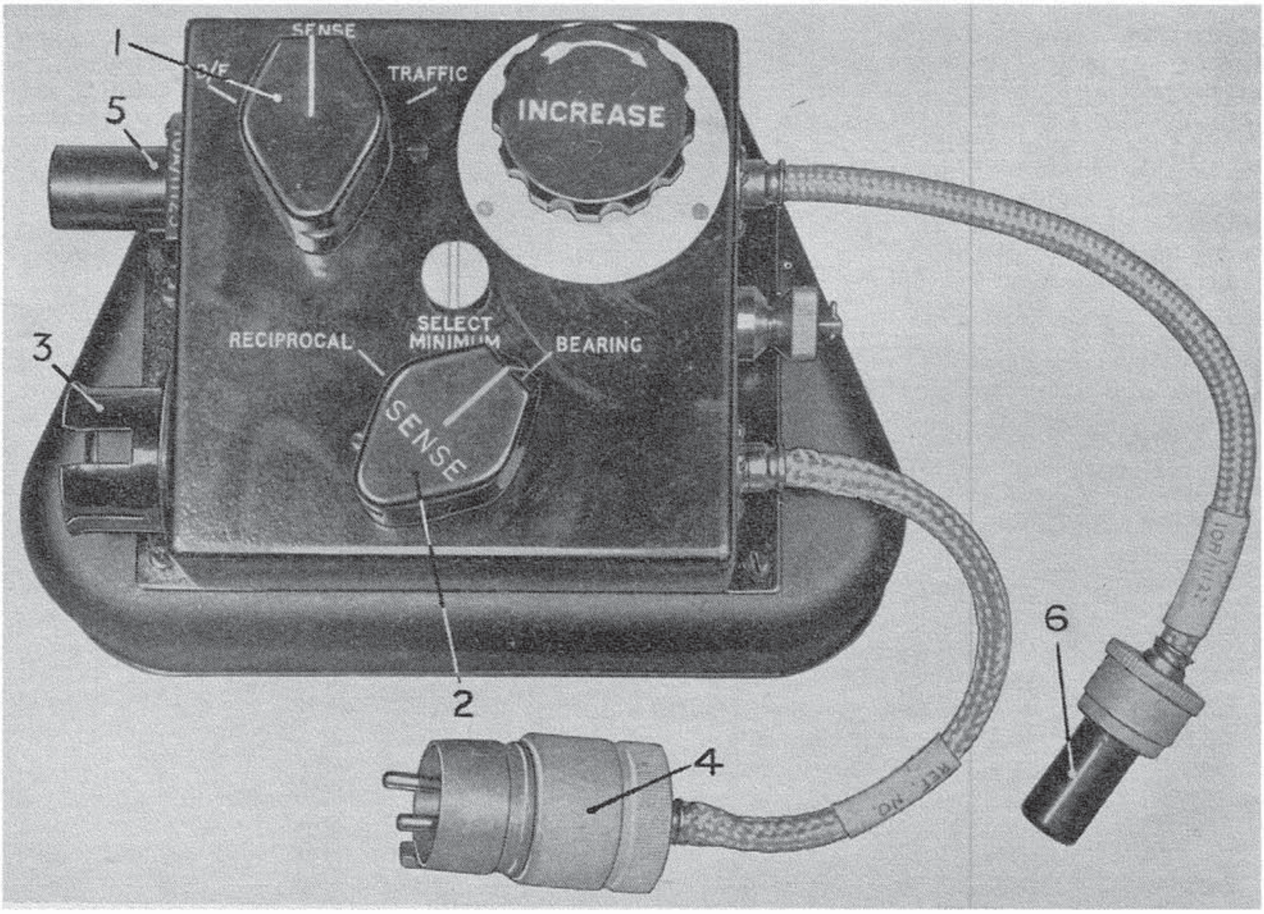


FIG. 11—SENSE UNIT

44. The operation of taking an ordinary D/F bearing resolves itself into the simple process of identifying and tuning the receiver to a suitable transmitter and, with the loop connected to the receiver, rotaing the loop whilst simultaneously listening to the transmitter. The strength of the signal heard in the head receiver telephones will vary as the loop is rotated, and at two points in each revolution of the loop the signal will fall to a minimum. If the scale on the indicator is observed it will be found that the two readings at which these minima occur are separated by 180 degrees. One of these minima is the bearing of the station from the aeroplane heading and the other the reciprocal of the bearing.

45. The ambiguity of 180 degrees can be resolved by dead reckoning. It may also be resolved by obtaining a second bearing on the same transmitter a few minutes later or by obtaining a bearing on another transmitter. In order to resolve this ambiguity at the same time as the bearing is taken, however, sense-finding arrangements are provided.

46. With the loop aerial connected to the receiver, two signal minima are obtained, by rotating the loop, which are 180° apart. To determine which of these minima corresponds to the direction from which the signal has arrived, the sense aerial should also be connected to the receiver through an adjustable resistance. The combination of the signals picked up by the loop and the sense aerial then produces a heart-shaped or cardioid polar diagram in place of the figure-of-eight which is produced by the loop alone. The single minimum of the heart-shaped diagram is displaced by 90° from the two loop minima on the loop scale. By maintaining a series of fixed conventions for the loop aerial and the sense aerial connections and positions, it is possible to arrange that the heart-shaped minimum is always 90° *higher* than the loop bearing minimum and hence 90° *lower* than the reciprocal minimum or vice versa. The screened loop aerial, type 3, is connected so that with the sense switch in the "bearing" position the cardioid minimum is 90° higher than the loop bearing minimum on the loop scale, and the cardioid maximum 90° lower than the loop bearing minimum on the loop scale.

47. In practice, sense determination is facilitated in the following manner. The indicator has an arrow with the word SENSE engraved with it and filled in red. This arrow is at an angle of 90 degrees counter-clockwise to the main pointer. Similarly the scale ring attached to the box drive has two sets of scale markings, one under and one over the central scale. One of these scale markings is engraved in red and is 90 degrees clockwise advanced in phase with the other markings. The application of these scales to the determination of sense in practice is described in the following paragraphs.

**Bearing**

48. With the switch of the sense unit in the TRAFFIC position a suitable transmitting station should be identified and the receiver tuned to receive it. The fixed aerial should then be disconnected at the receiver and the station listened to with only the loop connected. The loop should now be swung through 360 degrees, observing at the same time, the readings of the two minima on the indicator. When using the remote indicator the readings should always be taken on the correction curve at the zero line intersection. Very broad minima should not be used if another suitably located transmitter can be selected which will give better minima. It should be borne in mind that the broader the minima, the less will be the accuracy. Having obtained satisfactory minima the mid-point of one should be carefully noted. This may be either the bearing or its reciprocal.

**Determination of sense**

49. The same procedure should be used as indicated for obtaining a bearing and after noting the reading the loop should be swung so as to bring the sense arrow into the position previously occupied by the main reading of the cursor, or when using the loop without remote control, until the cursor occupies a position which gives a similar reading on the red scale. The fixed aerial should then be re-connected and the switch turned to SENSE. The connection of the loop should now be reversed by means of the switch provided on the sense unit, repeatedly changing over and observing the change in the signal strength from one position to the other. The variable resistance incorporated in the sense unit and connected in series with the fixed aerial, may require adjustment to produce the maximum change.

50. The reversing switch is engraved in white characters, at one position BEARING, and at the other RECIPROCAL. If the minimum occurs at BEARING then the figure noted on the scale is the bearing. If the minimum occurs at RECIPROCAL then the figure is the reciprocal.

51. Whenever any modification is made to an installation, and in the case of a new installation, it is essential to remove any doubts in regard to sense and bearing by making a check as early as possible on a station whose bearing is known. Unless it can be assumed with confidence, by previous exact comparison, that the installation functions correctly, no reliance can be placed upon bearings obtained by this method. It is therefore essential to be able to assume constant installation conditions.

## CALIBRATION

52. After installation, and at certain subsequent periods, the D/F equipment must be calibrated in order to ascertain the magnitude and distribution of the errors due to distortion of the electro-magnetic field of a received wave, by the metallic structure of the aeroplane. These calibrations must also be checked in flight.

53. A re-calibration must be carried out whenever any of the following conditions come into being:—

(i) If a serious discrepancy is revealed between the ground calibration and the results obtained in the air.

(ii) When any major modification is made to the aeroplane structure, for example, the addition of armour plating, a change of engine or fuel tank within the fuselage, the addition or removal of a fixed W/T aerial or aerial mast, or any structure external to the aeroplane.

(iii) When a compass has been re-swung (in accordance with K.R. and A.C.I.762), but this is not essential in time of war.

(iv) In the case of an aeroplane of wooden or composite construction, when any modification or repair is made to the aeroplane bonding system.

(v) Every three months.

54. The errors which can affect D/F readings vary in magnitude, reaching a maximum value in each quadrant of relative bearing, and are therefore usually referred to as quadrantal errors. The maximum errors, however, rarely occur exactly at the quadrantal points. They are usually from about 6 to 12 degrees and have the effect of giving a blurred minima. A complete calibration, that is, a series of readings on more than 24 points, must be performed on either the 150 to 500 kc/s band, or on the 500 to 1,200 kc/s band. If the complete calibration is made on one wave band, it must be checked carefully on not less than 8 points on the other wave band.

55. The calibration must be performed by competent personnel who have a knowledge of navigation. The essential requirements are, a suitable site and suitable sources of radio signals. With regard to site and apparatus required, Chapter 9, Section 6 of this publication should be consulted. As suitable sources of signals, broadcasting stations are usually satisfactory. If possible, stations within 150 miles, but not in the immediate vicinity, should be selected. The sources chosen, with their frequencies, should be noted for future use. In time of war a local oscillator such as a T1083 on low power should be used, provided it is ½ mile or more away and can be accurately sighted.

56. Having chosen the signal source or sources to be employed, the *true* bearing, at the position where calibration is to take place, should be measured accurately by means of a suitable map and protractor. The true bearing, thus found, must be converted into the *magnetic* bearing by applying the magnetic variation, the value of which is usually given on the map from which the bearings are taken. The magnetic bearing must be used for the purpose of calibration.

57. Immediately before the calibration, the aeroplane compass must be swung on 16 points and a deviation card compiled. The following preliminary tests of the D/F equipment should also be made.

(i) The D/F loop should rotate easily in its bearings without play.

(ii) The scale and cursor should be examined for security, and also to verify that they are easily readable without parallax error. Where a remote indicator is also fitted, the readings on the scale on the box drive and on the selector should agree substantially at several points on the scales.

(iii) The connections of the D/F loop to the receiver should be examined carefully and it should be ascertained that the combination of loop aerial and receiver is working normally. In particular, close attention should be paid to the following:—

(*a*) The connections and cleanliness of the plugs and sockets at the loop of the receiver.

(*b*) The electrical contact between the metal earthing flange on both loop and receiver and the metal screening of the cable connecting the two.

(*c*) The earthing of the D/F loop at its point of attachment to the structure.

(*d*) Continuity in both leads of the dumet 4 and the dulocapmet 2·5 cable connecting the loop and the receiver.

(iv) With the aeroplane clear of hangars, etc., and the tail plane at flying level, the receiver should be tuned to one of the signal sources and the quality of the minima on both true and reciprocal readings tested. For this test the aeroplane should be heading approximately toward the signal source. The minima should be sharp enough to read to an accuracy of $\pm \frac{1}{2}$ degree and the reciprocal bearing which should be 180 degrees from that of the true, to an accuracy of the same order. If these conditions are not satisfied, an observation should be made on another signal source, and if this also proves unsatisfactory, the installation should be examined for the following possible defects:—

(*a*) The loop not properly earthed to the structure.

(*b*) A higher resistance (due to faulty connection, etc.) in one side of the loop circuit than in the other.

(*c*) The electrical centre of the loop incorrectly determined.

(v) The fixed aeroplane aerial is connected to the sense unit and all tests should be made with the switch on the sense unit in the D/F position, i.e. with the aeroplane fixed aerial disconnected.

58. When it has been ascertained that the complete installation is satisfactory, calibration may be commenced.

(i) Calibration *must* be undertaken during the period two hours after sunrise to two hours before sunset.

(ii) The aeroplane to be calibrated must be equipped with its full military load.

(iii) The aeroplane, with the tail at flying level, should be wheeled to a level spot on the aerodrome, well clear of metal hangars or other high metallic objects. (The compass swinging base will be suitable only if it satisfies such conditions.)

(iv) The aeroplane should be lined up, by its compass, on the measured bearing of the source, the deviation being taken into account and the D/F reading observed. The accuracy to be desired is 0 degrees to $\pm \frac{1}{2}$ degree. If it differs by more than 1 degree from zero the discrepancy may be due to any one of the following:—

(*a*) Site error.

(*b*) Index incorrectly set.

(*c*) The D/F loop fitted asymmetrically with respect to the framework of the aeroplane.

(v) Where the site is well chosen, the measured bearing may be accepted as the reference bearing and the index set accordingly.

(vi) The aeroplane should then be swung through an angle of 360 degrees in steps of 12 to 15 degrees and the compass and D/F scale readings noted and recorded at each point. The bearing reading of the D/F scale should always be taken and *not* the reciprocal. It will be found helpful if the aeroplane is turned counter-clockwise, which causes the scale readings to increase from zero to 360 degrees.

(vii) If the compass readings are taken from the pilot's compass, care should be taken to see that the control (steering) column is in the normal flying position. The compass should be lightly tapped before taking a reading in case the pivot is sticking. Also, no loose metal objects such as keys, screwdriver, pairs of telephones and so forth may be brought within three feet of the compass when taking readings.

(viii) The readings thus obtained may now be tabulated, in the manner shown in the example given in the table below. It should be noted that the compass reading, corrected for deviation, is added to the *D/F scale reading* to produce the *W/T observed bearing*, (*magnetic*). Where the result of this addition produced a figure of more than 360 degrees the correct figure can be determined by subtracting 360 from the addition. A separate table should be completed for observations on each frequency band.

| Aeroplane: | No.: | Where swung: | Stn. on which calibrated: |
|---|---|---|---|
| | | Frequency: | Date: |

| (*a*) Compass Reading | (*b*) De-viation | (*c*) Aeroplane Head (Magnetic) (a + b) | (*d*) D/F Scale Reading | W/T Bearing (Magnetic) Observed (c + d) | W/T Bearing (Magnetic) Measured | Error | Remarks |
|---|---|---|---|---|---|---|---|
| 12° | +1° | 13° | 47° | 60° | 62° | −2° | Sharp |
| 34° | $+1\frac{1}{2}$° | $35\frac{1}{2}$° | 24° | $59\frac{1}{2}$° | 62° | $-2\frac{1}{2}$° | — |
| 301° | −2° | 229° | 126° | (425° − 360°) | 62° | +3° | — |

(ix) From the table a curve of errors should be drawn on squared paper, the error being plotted against the D/F scale reading. In cases where some of the points (errors) do not lie on a smooth curve it is advisable to check these points, paying particular attention to the compass readings. Observations taken on each frequency band must be checked against the curve, which can be drawn together, to confirm that they agree substantially. In most cases it is advisable also to plot a curve of the compass deviations as errors may arise in interpolation.

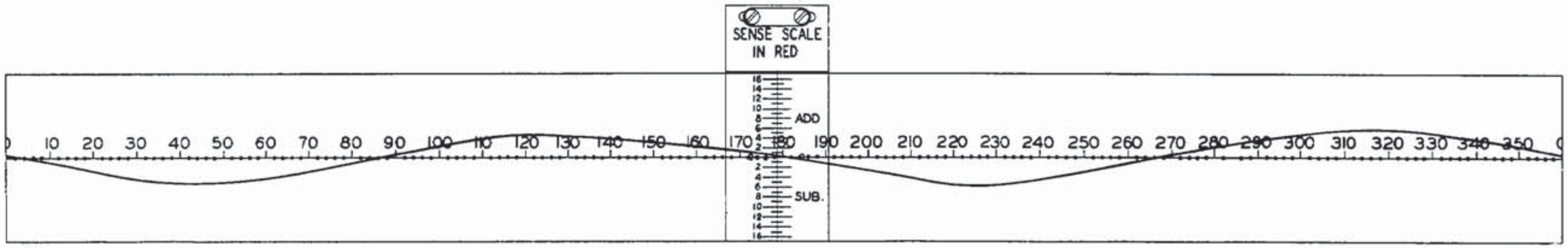


Fig. 12—Scale of Box Drive, with Q.E. Correction Curve

(x) The quadrantal error corrector should now be calibrated and a correction adjustment made in the following manner :—

(*a*) If the curve of errors shows a greater positive than negative degree of error, or vice versa, e.g. +10 degrees and +11 degrees with −5 degrees and −6 degrees, or −10 degrees and −11 degrees with +5 degrees and +6 degrees, the loop and its cursor are not correctly aligned. This fault should be rectified by moving the cursor, $+2\frac{1}{2}$ degrees respectively in the above example, and the calibration repeated.

(*b*) The average degree of error can be found by adding together the maximum error in each quadrant, irrespective of sign, negative or positive, and dividing by 4, e.g. −4 degrees +4 degrees −4 degrees +4 degrees = 16 degrees. The average is therefore 4 degrees.

(*c*) The average error having been found the selector screw (19) in fig. 4 should be removed and the corrector (9) rotated until the marking corresponding most nearly with the average error appears in the hole in the long strip. The selector screw should then be replaced and the three hexagon-headed screws (17, 18 and 19) tightened. After tightening, these screws should be locked by turning up the edges of the soft metal washers.

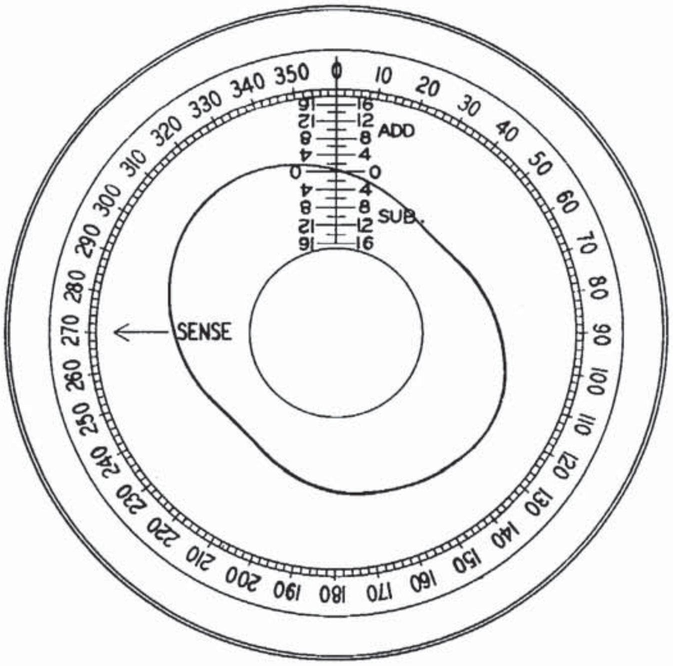


FIG. 13—SCALE OF INDICATOR, WITH Q.E. CORRECTION CURVE

(xi) The aeroplane must be re-calibrated and the residual errors plotted on the squared paper with the original curve.

(xii) From the completed curve the corrections to be applied when using the loop may be tabulated against the scale readings on the card (Form 2026) supplied for the purpose. This card should be placed in such a position in the aeroplane that it can readily be seen when taking D/F bearings. It must be remembered that the *correction* is the inverse of the *error*: e.g. if the error is +3 degrees the correction to appear on Form 2026 will be −3 degrees. The Form 2026 must be filled in completely, that is on both sides.

(xiii) With the normal working cursors removed and the marking cursors fitted in their place on the box drive and the indicator, the quadrantal error correction curve, as tabulated in (xii) above, should be plotted and drawn in pencil on the prepared surface of each of the scales on the box drive and the indicator, using the bevelled edge of the marking cursor as the reference line. This is illustrated in figs. 12 and 13. Fig. 12 shows the scale of the box drive developed to show the full scale with correction curve drawn upon it and fig. 13 that of the indicator also with its correction curve. A marking cursor is illustrated in fig. 9. Having completed the curve the marking cursor should be removed and the normal working cursor replaced in each instance. It is essential before changing cursors to lock the loop rotating drive, and to ensure that the reference lines on the cursors are set at the same figure on the scale in the box drive and the indicator. Bearing and correction can now be read directly on each scale.

# APPENDIX

## NOMENCLATURE OF PARTS

The following list of parts is issued for information only. All the parts of the Loop Aerial or its accessories have not been listed, only those spares for which reference numbers have been allocated. Each installation requires certain groups of parts and accessories which are given in A.M.O. N. 937/39. In ordering spares the appropriate section of AIR PUBLICATION 1086 must be used.

| Ref. No. | Nomenclature | Qty | Remarks |
|---|---|---|---|
| 10B/10594 | Aerial, loop, type 3 | | Wound moulded former only. Including four cradle fixing screws and nuts. |
| | Accessories:— | | |
| | Box | | |
| 10B/10619 | Drive, type 1 | 1 | For remote control. Including two cursor fixing screws. |
| 10B/11523 | Drive, type 2 | 1 | For direct drive, not for remote control. Including two cursor fixing screws. |
| 10B/21 | Coil, Q.E. correction | 1 | |
| 10A/11008 | Cover, type 9 | 1 | For R.A.F. Form No. 2058 |
| 10B/11053 | Cradle, former | 1 | |
| | Cursor | | |
| 10B/11472 | Type 1 | 1 | For loop above aeroplane. |
| 10B/11473 | Type 2 | 1 | For loop below aeroplane. |
| 10B/11474 | Marking, type 1 | | For loop above aeroplane. For initial calibration. |
| 10B/11475 | Marking, type 2 | | For loop below aeroplane. For initial calibration. |
| | Housing | | |
| 10B/10592 | Centre section. | 1 | |
| 10B/10591 | Nose section | 1 | With fixing bolt (10B/84) and spring washer (10B/141). |
| 10B/10593 | Tail section | 1 | With 6 fixing screws. |
| | Plugs | | |
| 10H/9872 | Type 101 | 1 | |
| 10H/10953 | Type 117 | 1 | |
| | Scales | | |
| 10B/11470 | Box drive, type 1 | 1 | For remote control. Including four fixing screws. Screws suitably attached to scale. |
| 10B/11471 | Box drive, type 2 | 1 | For direct drive. Including brake and four fixing screws. Screws suitably attached to scale. |
| 10H/11051 | Sockets, type 63 | 1 | |
| | Strips | | |
| 10B/19 | Q.E. correction, long | 1 | Includes screws, nuts and washers. |
| 10B/20 | Q.E. correction, short | 1 | Includes screw and washer. |
| | Tubes | | |
| 10B/11054 | Driving (torque) | 1 | Complete with cradle fixing nut and grub screw. |
| 10B/11524 | Support | 1 | Complete with top bearing and including four bolts and nuts for fixing flange. |
| 10B/11525 | Wheel, hand | 1 | |
| | Remote controls:— | | |
| 10J/10602 | Casing, rigid, type E2 | | As required. |
| 10J/10595 | Controller, type E2 | 1 | |
| 10J/10601 | Fittings, anti-torsional type, E1 | 2 | |
| 10J/10596 | Indicator, type E2 | 1 | Complete with one cursor marking, type 3. |
| 10J/11657 | Cursor marking, type 3 | | For initial calibration. |
| 10J/8594 | Shafting, type E1 | | As required. |
| 10J/11037 | Union, lubricating type E2 | 8 | |
| 10B/22 | Fitting, alignment | | For aligning loop in housing. |
| | Cable | | |
| 5E/1854 | Dulocapmet 2·5 | | As required. |
| 5E/1328 | Dumet 4 | | As required. |

95109 M06040/191 8/40 4000 C & P **Gp. 1**