

June 30, 1959

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2,893,002

UNIVERSALLY MOVABLE RADAR ANTENNA APPARATUS

Filed April 21, 1954

6 Sheets-Sheet 1

Fig. 1.

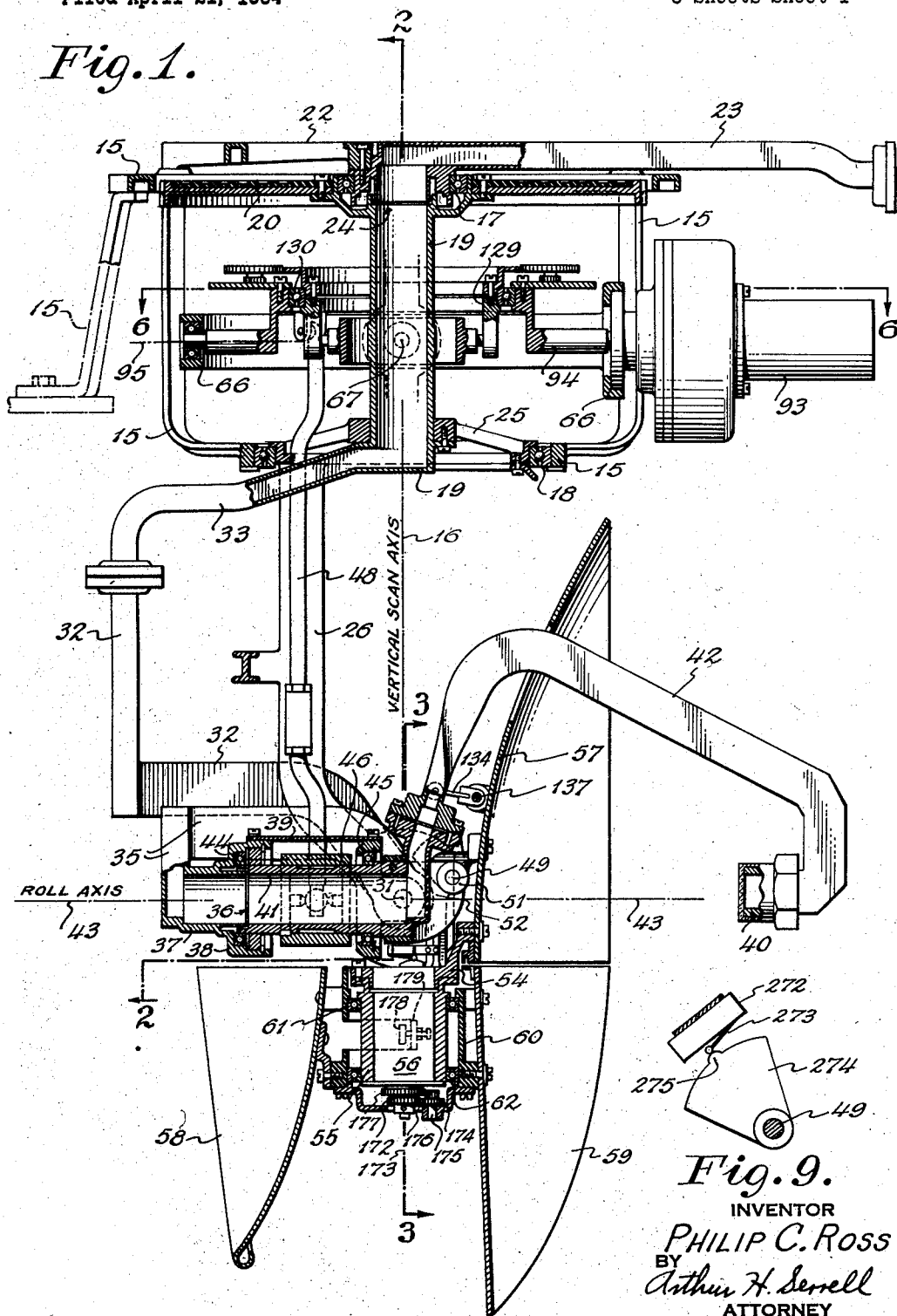


Fig. 9.

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6 Sheets-Sheet 2

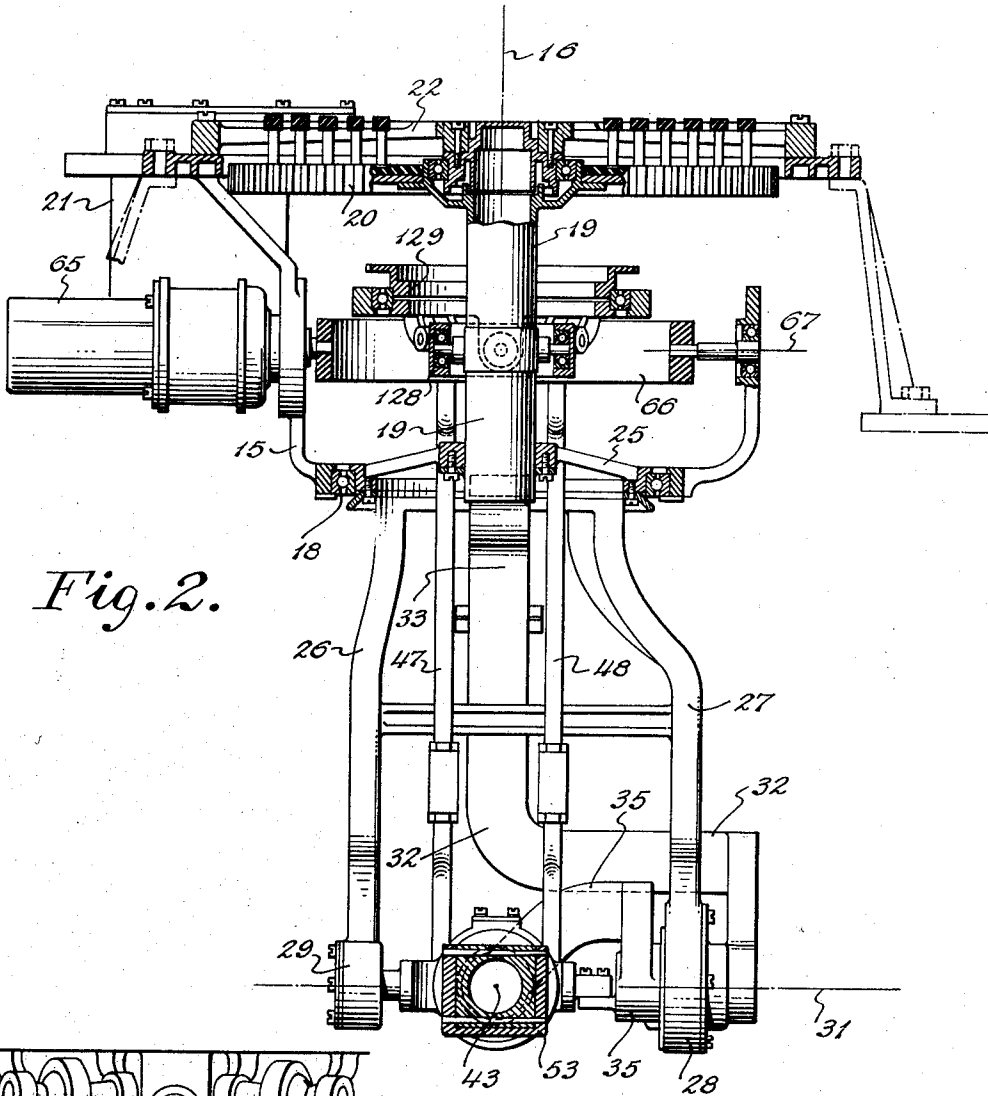


Fig. 2.

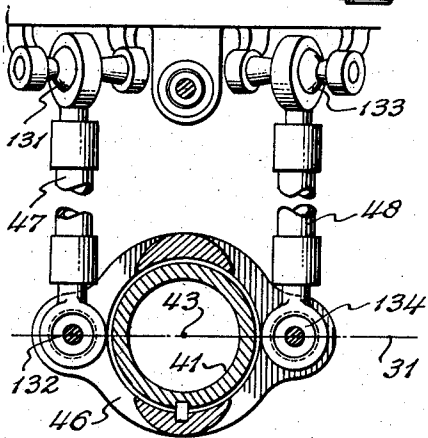


Fig. 2A.

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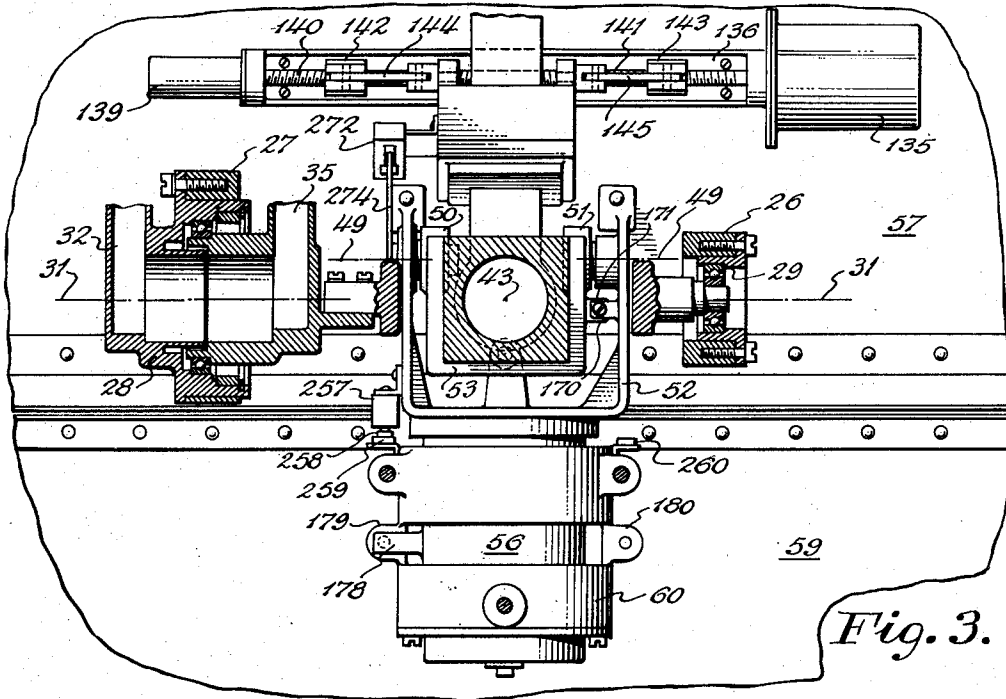
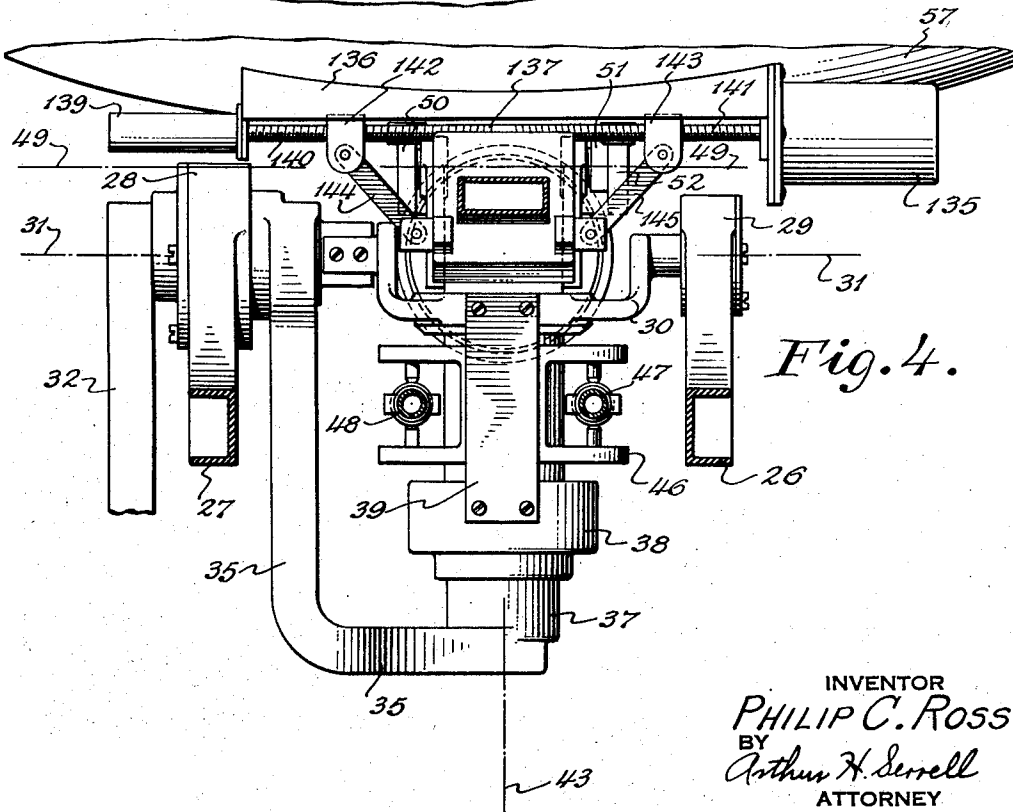
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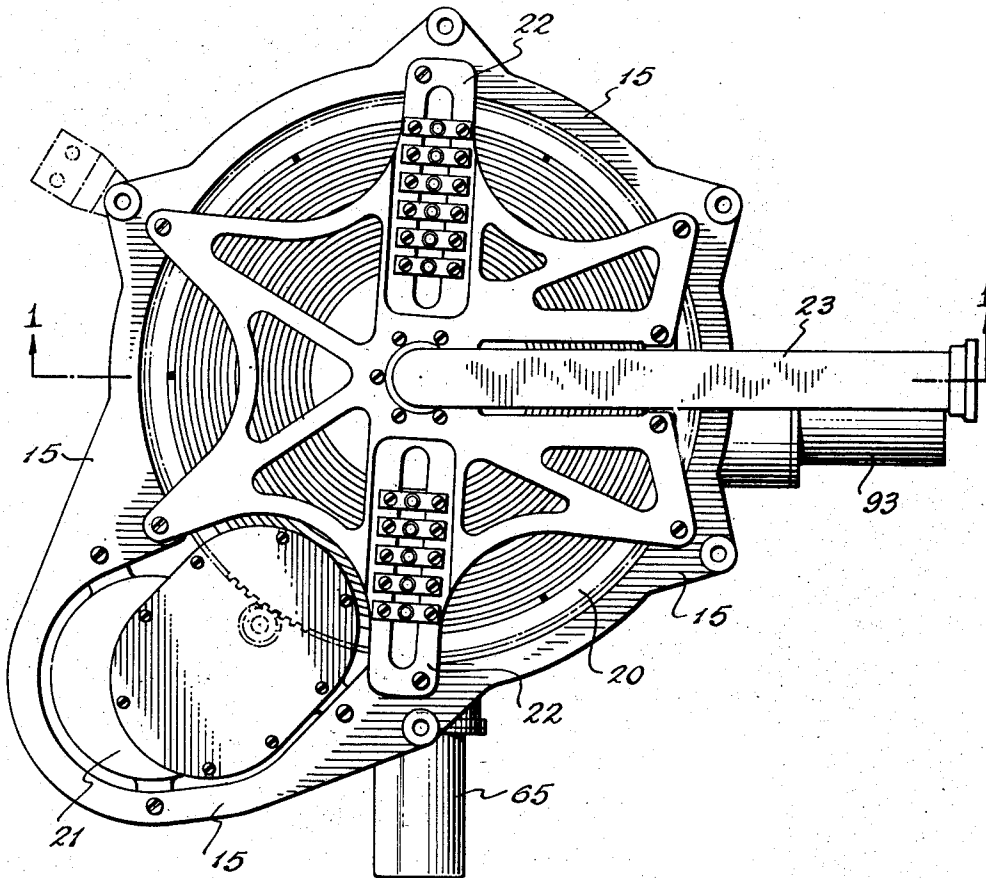
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Fig. 5.



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Fig. 6.

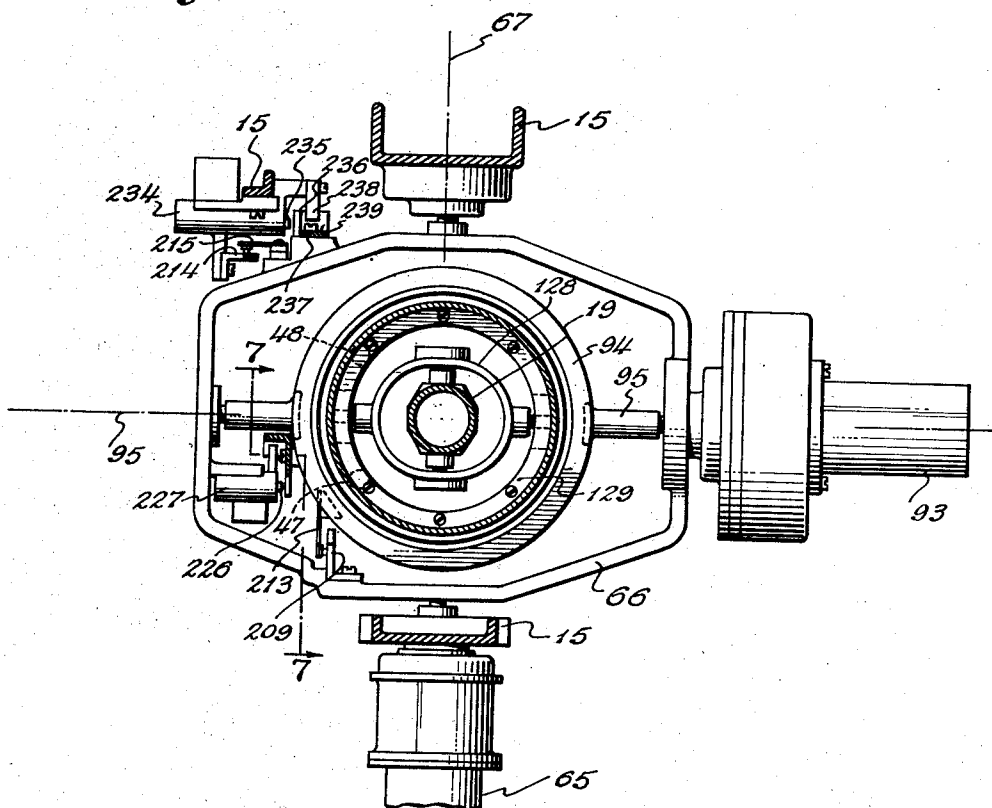
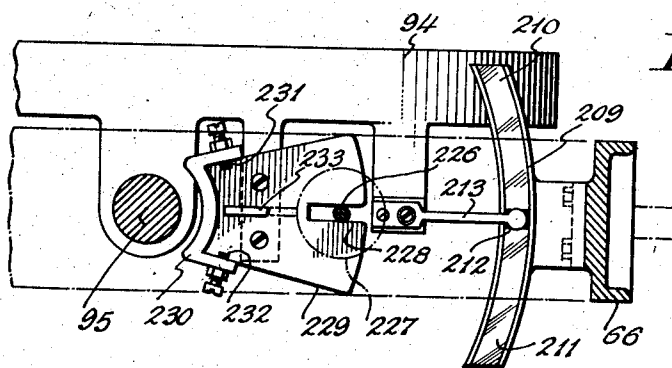


Fig. 7.

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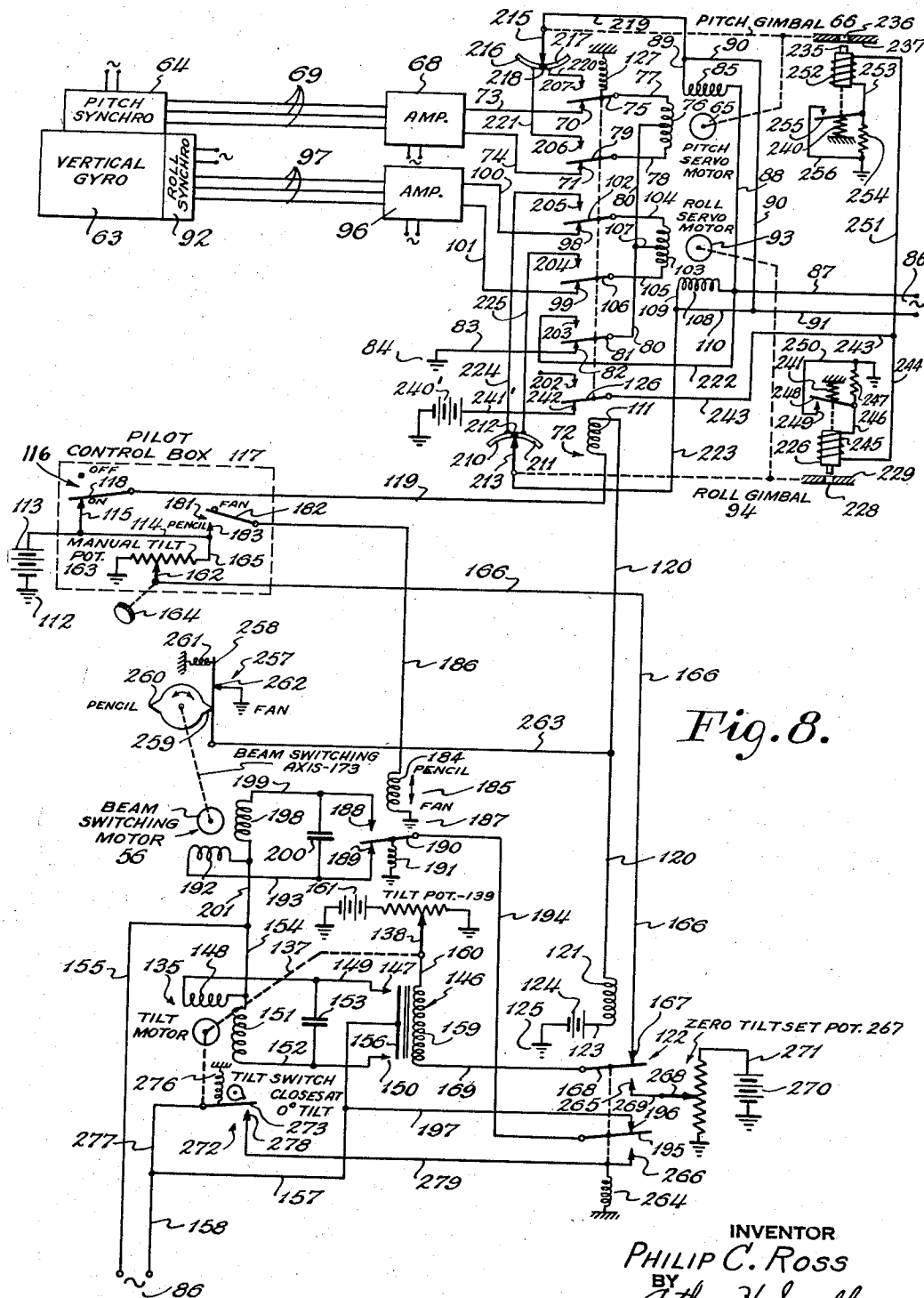


Fig. 8.

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Application April 21, 1954, Serial No. 424,659

16 Claims. (Cl. 343-765)

This invention relates to radar antenna apparatus of the character capable of providing different beam patterns. The improved antenna is particularly adapted for use on dirigible craft such as aircraft in which the same performs the function of a scanning member in a radar search system providing either fan or pencil type beam radiation patterns.

In the embodiment of the invention shown in the drawings, the antenna apparatus includes a suitable radiator of high frequency electromagnetic energy and a dual purpose reflector of the dish shaped type that cooperates with the radiator to provide the different beam patterns. Other types of radiator and reflector elements may be employed in the antenna without departing from the inventive concepts herein disclosed. As shown, the radiator and reflector parts of the antenna are supported on a member movable about a normally vertical axis in relation to the craft so that the parts move together about the axis. This motion may be either rotation or oscillation within the scope of the present inventive concepts. A mounting is also provided on the member on which the respective antenna parts are supported with freedom in relation to the craft about two normally horizontal, mutually perpendicular axes. Means are provided to normally stabilize the reflector and radiator parts of the antenna about the noted mutually perpendicular horizontal axes. Such means, when effective, separates the antenna from the craft so that the antenna position is not influenced by motions of the craft about its vertical, pitch or roll axes. In accordance with the teaching of the present invention, the structure includes an additional mounting for the reflector on the member that supports the reflector independently of the radiator to tilt about a further normally horizontal axis and thereby change the directivity of the antenna. The reflector is positioned about this additional tilt axis by a motor responsive to an adjusting means settable by the operator to control the tilt angle of the stabilized reflector. This adjustment is independent of the attitude of the craft and of the provided stabilization means. By adjustment about the noted tilt axis, the relation between the radiator and reflector parts of the antenna is modified to control the directivity of the respective radiated beams as desired.

The reflector of the improved apparatus may be of a generally paraboloidal concave dish type that is formed of a half dish fixedly mounted on the member and a pair of back to back arranged half dishes of different concave shapes that are movably mounted on the member in interchangeable relation with the fixed half dish to provide different beam patterns. The interchangeable dishes in the present specific structure are shaped to provide fan and pencil type beam radiation patterns with the fixed dish. The fan or cosecant squared type of radiation pattern is generally employed in the search system to initially locate the object to be detected. After the object is located, the dishes are interchanged to provide a narrow sharply defined or pencil beam radiation pattern from the antenna so the object can be observed more accurately.

In order to assure that the movable reflector dishes do not strike any of the relatively close fixed parts of the antenna during a beam interchanging operation, the improved apparatus includes a means for monitoring the beam interchanging motor to prevent the operation from

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occurring until possible without interference. In accordance with the present inventive concepts, the antenna apparatus includes a means for conditioning the reflector and radiator free of tilt about their normally stabilized horizontal axes in relation to the craft. With this means effective the antenna is freed from the stabilizing means and the parts are driven about their axes into correspondence with the pitch and roll axes of the craft, the same then being tilt free in relation to craft regardless of its pitch and roll attitude.

The monitoring means of the present invention also includes a means for conditioning the reflector element of the antenna in a tilt free condition relative to the radiator about its heretofore mentioned normally horizontal tilt axes.

Other features and structural details of the invention will be apparent from the following description when read in connection with the accompanying drawings, wherein:

Fig. 1 is a vertical section of an apparatus embodying the present inventive concepts taken on lines 1-1, Fig. 5;

Fig. 2 is a sectional view of the apparatus taken on lines 2-2, Fig. 1;

Fig. 2a is a detail sectional view looking in the same direction as depicted in Fig. 2 showing the links of the stabilizing means included in the apparatus;

Fig. 3 is a partial section taken on lines 3-3, Fig. 1;

Fig. 4 is a sectional plan view of the parts illustrated in Fig. 3;

Fig. 5 is a top plan view showing the frame, the brush assembly, slip rings and azimuth drive motor parts of the apparatus;

Fig. 6 is a horizontal section taken on lines 6-6, Fig. 1 showing a portion of the means for conditioning the antenna free of tilt in relation to the craft about the stabilization axes thereof;

Fig. 7 is a detail section taken on lines 7-7, Fig. 6;

Fig. 8 is a wiring diagram for the components of the improved apparatus, and

Fig. 9 is a detail view of the tilt switch component as shown in Fig. 1.

Assembly structure

The base assembly or fixed frame 15 of the improved radar antenna structure shown in Figs. 1, 2 and 5, is suitably attached by bolts or otherwise to the framework of a dirigible craft such as an aircraft. The radiator and reflector components of the apparatus are shown in the drawing as being below the base or fixed frame 15. These parts extend exteriorly of the fuselage (not shown) of the craft and are protected by a suitable radome included on the craft. The noted antenna components are mounted on the fixed frame 15 to move together about a normally vertical axis 16 by means of an upper roller bearing unit 17 and a lower roller bearing unit 18. As particularly shown in Figs. 1 and 2, the rotatable member supporting the antenna elements for rotation or oscillation about the axis is provided by a tubular wave guide 19 that is constructed to include at its top end a slip ring carrying disc 20. An azimuth drive motor 21, Fig. 5, fixed to frame 15 is gear connected to a pinion on the periphery of the disc 20 to effect the required rotation or oscillation of the tubular wave guide 19 with corresponding movement of the radiator and reflector parts. A brush assembly 22 cooperating with the slip rings on the disc 20 is fixed to the frame 15 as particularly shown in Fig. 5. The motor 21 may be controlled through suitable circuitry not herein shown of a known arrangement so that the antenna may be rotated in clockwise or counterclockwise directions in a slow sweep mode, may be rotated clockwise in a slow sweep mode for long range operation, may be rotated clockwise in a

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fast sweep mode for short range operation, and may be oscillated about the heading of the craft in a slow speed sector scan mode. Various hereinafter described electrical components of the apparatus are supplied with suitable electrical energy by way of the described slip rings and brush parts. Energy for the radiator of the antenna is provided from a suitable high frequency electromagnetic source (not shown) that is fed to wave guide 19 by way of a fixed guide 23 secured to the frame 15 and a suitable rotating joint and wave trap 24 between the parts 23 and 19 at the bearing unit 17.

A mounting is also provided for the reflector and radiator parts of the antenna on the member or wave guide 19 for supporting the parts with freedom about two normally horizontal, mutually perpendicular axes in relation to the craft. As shown in Figs. 1 and 2, a wheel element 25 is connected at its hub portion to the lower part of the wave guide 19. The rim of wheel 25 carries the inner race of the roller bearing unit 18 at the lower portion of the wave guide 19. The outer race of the bearing unit 18 is carried by the frame 15. The wheel 25 oscillates or rotates in the same manner as wave guide 19 under control of the drive motor 21. A bifurcated frame is fastened at one end to the bottom of the wheel 25, the frame having two downwardly extending arms indicated at 26 and 27. A combined rotating joint and bearing unit 28, Figs. 2 and 3, similar to the corresponding parts designated at 24 and 17 is situated at the end of the arm 27 of the bifurcated frame. A bearing unit 29 is located at the end of the arm 26 of the frame structure. A U-shaped supporting element 30, Fig. 4, includes horizontally extending opposite arm parts for each of the internal races of the respective spaced elements 28 and 29. The axis 31, Figs. 2 and 4, for part 30 provided by the bearing units 29, 28 provides one of the horizontal axes about which the antenna parts are supported with freedom to move together. The high frequency electromagnetic energy fed to the compound joint and bearing 28, includes a fixed wave guide 32 which is coupled to a wave guide 33 extending from the bottom of guide 19 by a coupling joint 34. The guides 19, 33 and 32 move about axis 16 along with wheel member 25, the arms 26, 27 of the bifurcated frame and the supporting element 30. As shown in Figs. 3 and 4, the internal race for the unit 28 is carried by a wave guide piece 35 that is fixed to one of the arm parts of the supporting element 30. Element 30 and wave guide 35 move together about the horizontal axis 31. The wave guide 35 is bent to extend parallel to the axis 31 as viewed in Fig. 4.

The supporting structure of the antenna that moves relative to axis 31 further includes the fixed end of a third rotating joint 36, Fig. 1, that is connected to wave guide 35 by way of wave guide 37. A bearing housing 38 formed as a part of the fixed end of the joint 36 is connected to the U-shaped supporting element 30 by a spacing plate member 39 that is suitably secured to the respective parts. The radiator of the antenna indicated at 40 is connected to one end of a rotary wave guide 41, Fig. 1, by way of the bent wave guide 42. Wave guide 41 is situated at the movable end of the rotary joint 36 and is mounted with freedom about a second normally horizontal axis 43 that is perpendicular to the axis 31 of the apparatus. As shown, the wave guide 41 is mounted on the relatively fixed supporting element 30 and wave guide 35, 37 related structure by the spaced bearing units indicated at 44 and 45. Bearing unit 44 is contained within the bearing housing 38. The bearing unit 45 is formed as a part of the bracket shaped supporting element 30. The wave guide 41 has a collar 46 keyed thereto with two oppositely projecting arms that respectively include universal connections for the lower ends of two control links 47 and 48, Figs. 1 and 2a. Collar 46 is situated to the left of the pivot axis 31 of the structure as viewed in Fig. 1 so that the links are operable

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to position the antenna about both normally horizontal axes 31 and 43. The means for operating the links 47 and 48 includes the stabilizing and conditioning means of the apparatus as hereinafter particularly described in detail.

A further mounting is provided for the antenna structure on the supporting and driving member 19 that supports the reflector of the antenna with freedom in relation to the radiator 40 about a third normally horizontal axis 49, Fig. 4. The axis is provided by a pair of spacing bearing units 50, 51 in the arms of a yoke 52 that is fixedly connected to the wave guide 41 by a bracket 53, Fig. 2. Axis 49 as viewed in Fig. 1 is situated perpendicularly to axis 43 and to the right of as well as above the axis 31 with which it is located in parallel relation. A mounting piece 54, Fig. 1, connected to the reflector element 57 is situated between the spaced bearing units 50, 51 and extends below the axis 31 to provide support for the housing 55 of a beam switching motor indicated at 56. The axis of the motor 56 corresponds with the vertical scan axis 16 of the antenna in a non-tilt condition of the reflector relative to the radiator. The reflector of the antenna is of the dish type having an upper half dish 57 that is fixedly secured to the ends of the arms of the yoke 52 as shown in Figs. 1 and 3. Dish 57 has an opening therein through which the wave guide 42 of the radiator structure extends. The half dishes of the reflector as indicated at 58 and 59 are situated below the dish part 57. Dishes 58 and 59 are of different concave shapes and are movably mounted on mounting piece 54 in interchangeable relation with the dish part 57. As shown in Fig. 1, the dishes 58 and 59 are fixedly secured in back to back relation on a common rotatable element 60 located on the mounting piece 54 by the vertically spaced bearing units 61 and 62 between the element 60 and the stationary housing 55 of the beam switching motor 56. Dishes 57 and 59 are indicated in an aligned condition in Fig. 1. When so conditioned, the dishes 57 and 59 provide a reflector with a cosecant squared or fan type of beam radiation pattern. When dishes 57 and 58 are aligned, a paraboloidal reflector is obtained which provides a pencil type beam radiation pattern. The motor 56 operates to locate the dishes 58 and 59 so that the desired type of beam radiation pattern is provided.

Stabilizing means

As described, the radiator and reflector components of the improved antenna apparatus are supported with freedom about the noted pitch axis 31, roll axis 43 and vertical axis 16. The antenna parts move together about the three noted axes. The axes 31 and 43 are normally horizontal and are mutually perpendicular. In the structural arrangement shown, the point of intersection of the horizontal axes 31 and 43 is situated on the vertical axis 16. In accordance with the invention, the reflector and radiator parts of the apparatus may be stabilized about the pitch and roll axes 31 and 43 respectively, the stabilizing means functioning to maintain the noted axes horizontal and unaffected by changes in the attitude of the craft carrying the apparatus about its pitch axis, and/or its roll axis.

As shown in the drawings, the stabilization means includes a suitable vertical reference device such as a conventional gyro vertical indicated at 63 in Fig. 8. This instrument is carried by the craft and may be mounted in a position on the base frame 15 above the brush assembly 22 shown in Fig. 5. The details of such an instrument are well known so the same are not added to the present drawings to unnecessarily complicate the detail assembly views of the improved antenna structure. The reference instrument or gyro vertical 63 includes a pitch pick-off or synchro 64 that provides an electrical signal output for operating the pitch servomotor 65, Fig. 6, so that the pitch gimbal 66 carried by the frame 15

is stabilized thereby. Servomotor 65 is suitably mounted on the frame 15 and is operatively connected through suitable reduction gearing to drive the trunnion of the ring 66 about axis 67 in the stabilization mode. As shown in Fig. 8, the synchro 64 is connected to a suitable amplifier 68 by way of leads 69. Amplifier 68 is connected to the contacts 70, 71 of a relay 72 by the respective leads 73, 74. An armature element 75 of relay 72 shown engaging contact 70 in Fig. 8 supplies electrical energy to one end of the split phase control winding 76 of servomotor 65 through lead 77. The other end of winding 76 is connected through lead 78 to the armature 79 shown engaging the contact 71. Lead 80 is connected at a center tap location on the control winding 76 and is grounded in the stabilization mode through the relay armature 81, contact 82, and lead 83, to ground 84. The constantly excited winding 85 of the servomotor 65 is energized from a suitable source of alternating current electrical energy 86 by way of leads 87, 88 and leads 89, 90 and 91. The direction of operation of the servomotor 65 depends on the output of the synchro 64 and amplifier 68 which supplies energy through either armature 75 or 79 to the control winding 76 and to ground 84. The gimbal ring 66 is consequently prevented from tilting about its axis 67 in relation to the reference provided for it by the gyro vertical 63.

The reference instrument also includes a roll pick-off or synchro 92 that provides an electrical signal output for operating the roll servomotor 93 of the stabilization means herein provided. As shown in Figs. 1 and 6, the roll servomotor is carried by the gimbal ring 66 and is operatively connected to drive a second gimbal ring 94 whose axis 95 is perpendicular to the axis 67 of ring 66. As shown in Fig. 8, the output of synchro 92 is fed to an amplifier 96, like amplifier 68, by way of leads 97. The amplifier 96 is connected to the contacts 98, 99 of relay 72 through leads 100 and 101, respectively. An armature element 102 of relay 72 shown engaging contact 98 in Fig. 8 applies electrical energy to one end of the split phase control winding 103 of servomotor 93 through lead 104. The other end of winding 103 is connected through lead 105 to the armature 106 engaging the contact 99. Lead 107 is connected at a center tap location on the control winding 103 and is grounded as heretofore described in the stabilization mode through a second connection to lead 80. The constantly excited winding 108 of the servomotor 93 is energized from source 86 by way of lead 87, lead 109, lead 110 and lead 91. The direction of operation of roll servomotor 93 depends on the output of the synchro 92 and amplifier 96 which supplies energy through either armature 102 or 106 to the control winding 103 and to ground 84. The gimbal ring 94 is consequently prevented from tilting about its axis 95 in relation to the reference provided for it by the gyro vertical 63. Both servomotors 65 and 93 operate in the stabilization mode as follow ups to the reference instrumentation so that the axes 67 and 95 define a horizontal reference plane for the apparatus that is perpendicular to the vertical scan axis 16.

As shown in Fig. 8, the relay 72 is energized to condition the same in the stabilization mode, the winding 111 of the relay being included in a closed circuit having a ground connection 112, a battery 113, lead 114, lead 115 to the on contact for a stabilization control switch 116 located in the pilot control box 117, the blade 118 of switch 116 set in the on position, lead 119 to winding 111 and lead 120 from winding 111 to the winding 121 of a relay 122 adapted to control the operation of the beam switching motor circuit hereafter described in detail, lead 123 and battery 124 to ground 125. The relay 72 includes a further armature 126. The armatures 126, 81, 106, 102, 79 and 75 of relay 72 are ganged and are normally held in an up position as viewed in Fig. 8 by spring 127. With the stabilization switch 116 on as depicted in Fig. 8, the relay 72 is energized and the

armature elements are situated as illustrated in the full line down position to interconnect the pitch and roll servomotors 65, 93 with the vertical reference instrument or vertical gyro 63. The stabilization means is disabled or rendered ineffective by setting the blade 118 of the switch 116 in the off position.

With particular reference to Figs. 1, 2, 2a and 6, the stabilization means provided further includes a rotatable universal connection between the rotating or oscillating wave guide member 19 and the frame 15 of the structure. As shown in Fig. 6, this connection includes a gimbal ring 128 that encircles the guide 19 and is pivotally connected thereto by suitable bearings and a pair of oppositely arranged stub shafts that are fixedly connected to the guide and extend therefrom radially of the vertical axis 16 of the antenna. The trunnions of ring 128 perpendicular to the stub shaft defined axis engage a rotatable gimbal ring 129. In the described structure rings 128 and 129 rotate or oscillate with the antenna and the rings 66 and 94 are pivotally connected to the relatively fixed frame 15 of the antenna and do not move with motion of the antenna about its vertical axis 16. The rings 94 and 129 as particularly shown in Figs. 1 and 2 are interconnected by a roller bearing structure 130 whose respective circular races are connected to the juxtaposed noted rings. In the stabilization mode the gimbal 94 is stabilized in pitch and roll relative to the craft carrying the antenna to define a horizontal plane. The gimbal 129 through the bearing connection 130 is maintained in the stabilized plane by the gimbal 94 although the gimbal 129 partakes in the motion of the antenna about axis 16. The hereto described links or push rods 47 and 48 interconnect the collar element 46 and the ring 129 for the purpose of transmitting the provided stabilization to the reflector and radiator parts of the antenna. As shown in Fig. 2a, the respective ends of link or rod 47 are connected to the noted elements by the universal joints 131 and 132. The similar joints 133 and 134 connect the same parts for the push rod or link 48. In operation, the links 47 and 48 move together under the influence of servomotor 65 to position the antenna about the pitch axis 31 in accordance with the horizontal plane defined by the vertical reference means as reflected in the location of the gimbal rings 66 and 129. The links 47 and 48 move differentially under the influence of servomotor 93 to position the antenna about the roll axis 43 in accordance with the horizontal plane defined by the vertical reference means as reflected in the location of the gimbal rings 94 and 129. The reflector and radiator parts of the antenna are thusly stabilized about their normally horizontal axes 31 and 43 about which the same move together. The lengths of the links 47, 48 are made adjustable to make the level and cross level axes 31 and 43, respectively, parallel to the corresponding universal axes between the gimbal 129 and the rotating member 19.

The motor structure and control circuits for tilting the reflector in relation to the radiator about axis 49

The reflector parts of the antenna provided by the relatively fixed dish 57 and the interchangeable dishes 58 and 59 move as a unit about the noted tilt axis 49. The described mounting arrangement on the rotating or oscillating wave guide member 19 supports the reflector with freedom in relation to the radiator about the tilt axis 49. The means for positioning the reflector part of the antenna about axis 49 includes a suitable motor indicated at 135 in Figs. 3, 4 and 8. As shown in Figs. 3 and 4, the housing of the motor 135 is fixedly mounted on the rear of the reflector dish 57 to one side of a yoke piece 136. A threaded shaft 137 journaled between the arms of the yoke piece 136 is directly driven by the tilt motor 135. The slider element 138 of a tilt potentiometer 139 is positioned by the shaft 137 and motor 135. As shown

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in Figs. 3 and 4, the potentiometer 139 is fixedly mounted on one of the arms of the yoke piece 136 opposite to the motor 135. The slider 138 of the potentiometer is shown in Fig. 8. The reflector is moved relatively to the radiator 40 by operation of the motor 135 through a toggle mechanism that includes the right and left hand threaded portions of shaft 137 indicated at 140 and 141, a travelling nut 142 fitting on the threaded portion 140 of the shaft 137, a travelling nut 143 fitting on the threaded portion 141 of the shaft 137, a link 144 between the nut 142 and a bracket on the side of wave guide 42, and a link 145 between the nut 143 and a bracket on the opposite side of wave guide 42. With this arrangement operation of the motor 135 causes rotation of the shaft 137 and translatory motion of the nuts 142, 143 either toward or away from each other depending on the direction of rotation of the motor 135. With movement of the nuts 142 and 143 towards one another, the effective length of the toggle links 144 and 145 is increased resulting in a clockwise movement as viewed in Fig. 1 of the reflector relative to the radiator about axis 49. Movement of the nuts 142 and 143 away from one another, results in effectively decreasing the length of the toggle links 144 and 145 to cause the reflector to move in a counterclockwise direction about axis 49 as viewed in Fig. 1 in relation to the radiator.

The circuitry providing the means for adjusting the operation of the tilt motor 135 to determine the angular relation or position of the reflector and radiator parts of the antenna is clearly shown in Fig. 8. As illustrated in this figure, the windings of the motor 135 are shown interconnected with an alternating current source 86 by way of a polarized relay indicated at 146. A contact 147 of the relay 146 is connected to one end of the winding 148 of motor 135 through lead 149. A second contact 150 of the relay 146 is connected to one end of the winding 151 of motor 135 through lead 152. A phase shifting condenser 153 is connected across the leads 149 and 152. The motor windings 148 and 151 have a common connection to the source 86 by way of leads 154 and 155. The polarized armature 156 of the relay 146 is connected to the source 86 through leads 157 and 158. As shown, one end of the coil 159 of the relay 146 is connected to the slider 138 of the tilt potentiometer 139 by way of lead 160. One end of the potentiometer 139 is directly connected to a suitable ground. The other end of the potentiometer 139 is connected to a battery 161 that is grounded. The opposite end of the relay coil 159 is connected to the slider 162 of a manually settable tilt potentiometer 163 located in the control box 117. The knob element 164 connected to the slider 162 is positioned by the pilot in accordance with the angular relation between the reflector and radiator part that is desired. One end of the potentiometer 163 is grounded. The opposite end of the potentiometer 163 is connected to lead 114 through lead 165. Lead 114 is energized by battery 113. The slider 162 of the potentiometer 163 is connected to the coil 159 by way of lead 166, the engaged contact 167 and armature 168 of relay 122, and lead 169. With this arrangement, the relay coil 159 receives signals from both the motor operated tilt potentiometer 139 and the manual tilt potentiometer 163. When these signals are equal and opposite, the amount of tilt of the reflector corresponds with the setting of the knob 164 at the control box 117 and the tilt motor is stalled. When the amount of the tilt setting of the knob 164 is changed, the signals at the relay 146 are unbalanced and the armature 156 engages either contact 147 or contact 150. This closes the circuit between the motor windings 148, 151 and the source 86 so that the motor 135 operates in accordance with the change in setting of knob 164 to reposition slider 138 of potentiometer 139 to restore the signal balance at the relay 146 and remove the operating signal from the motor. The direction of operation of the motor 135 is necessarily depend-

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ent on which of the contacts 147, 150 that the armature 156 of the relay 146 engages. Furthermore, the motor 135 always operates in the sense required to restore the balance condition at the relay 146 and stops when this condition is attained. As shown in Fig. 3, the movement of the reflector unit about axis 49 is limited by a fixed lug 170 extending from the bracket 53 around wave guide 41 and a pair of spaced stops on the yoke 52 one of which is indicated at 171.

The beam switching motor structure and control circuits

The interchangeable half dishes 58 and 59 of the reflector unit are mounted on the piece 54 for movement through an angular range of approximately 180 degrees. The dishes 58 and 59 are of different concave shapes to provide with the fixed dish 57 both fan and pencil type beam radiation patterns. As shown in Fig. 1, the rotatable element 60 to which the dishes 58 and 59 are fixed is moved about the axis defined by the spaced bearings 61 and 62 by a drive mechanism including a gear 172 on the shaft of the beam switching motor 56. The axis 173 about which the switching operation occurs is coincident with the vertical scan axis 16 of the antenna in a zero tilt condition of the reflector as depicted in Fig. 1. Drive gear 172 meshes with a gear 174 carried on a stub shaft 175 rotatably mounted on the element 60 in an eccentric position to the axis 173. A third gear 176 fixed to shaft 175 meshes with a gear 177 fixedly mounted on the bottom of the motor housing 55 in a location coincident with the axis 173. Operation of the motor 56 moves the pair of dishes 58, 59 within the permitted range to change the beam pattern of the antenna. In operation, the rotation of driving gear 172 causes the stub shaft 175 to move and the gear 176 to walk along the fixed gear 177. This causes the element 60 on which the stub shaft 175 is mounted to move about the axis 173.

With reference to Figs. 1 and 3, the structure shown includes a plurality of stop elements situated between a relatively fixed member in the form of the housing of the motor 56 and the rotatable element carrying the pair of dishes 58, 59. One of the elements of the stop limit structure is provided by the arm 178, Fig. 3, extending from the housing of the motor 56. The parts cooperating with the stop arm 178 are illustrated in Fig. 3 as two lugs 179 and 180 that are fixedly secured to the rotatable element 60 of the structure. Lug 179 and arm 178 are illustrated in an engaged position in which the dish 59 is located in aligned relation with the fixed dish 57. The stop elements are so arranged as to align each of the pair of half dishes 58 and 59 with the fixed dish 57 at the respective limits determined thereby. The stop elements described facilitate movement of the interchangeable dishes 58, 59 through an angular range of approximately 180 degrees. As shown in Fig. 1, the lug stop parts 179 and 180 may include adjustable screw pieces.

In addition to interchanging the dishes 58 and 59, the motor 56 is effective to maintain one of the two lugs engaged against the arm 178 and thusly assure alignment of the desired interchangeable dish with the fixed dish 57. In this connection, the control circuit for the beam switching motor is clearly shown in Fig. 8. As illustrated, the means for selecting the desired beam pattern, is provided by a switch indicated at 181 at the pilot control box 117. With the switch 181 in an open condition, a fan type beam radiation pattern is obtained. When the switch 181 is in a closed condition, the dish 58 is aligned with fixed dish 57 and the antenna provides a pencil type beam radiation pattern. As shown, the contact 183 for blade 182 is energized from battery 113 through lead 114. The switch blade 182 is connected to the winding 184 of a relay 185 by way of lead 186. The opposite end of the winding 184 is connected to ground 187. Relay 185 includes a pair of spaced contacts 188, 189 and an armature 190. With blade 182 in the fan position, relay 185 is unenergized and the spring 191 connection to the arma-

ture 190 urges the armature against contact 189. One end of the winding 192 of the motor 56 is connected to source 86 by way of lead 193, contact 189, armature 190, lead 194 to the armature 195 and engaged contact 196 of relay 122, lead 197 from contact 196, lead 157 and lead 158. One end of the winding 198 is connected to the contact 188 of relay 185 through lead 199. A phase adjusting condenser 200, like condenser 153, is connected across the leads 193 and 199. The common end of the windings 192, 198 is connected to source 86 by way of lead 201 to lead 155. Motor 56 is consequently energized in the fan radiation pattern mode to urge the lug 179 against stop arm 178 with the dishes 57 and 59 aligned. In the pencil radiation pattern mode, the switch blade 182 is situated against contact 183 and relay 185 is energized, the armature 190 then being positioned against contact 188. When this condition exists, after the beam switching operation is completed, the motor 56 urges the lug 180 against stop arm 178 with the dishes 57 and 58 aligned. The operation of the apparatus in beam switching as monitored in accordance with the present inventive concepts will hereinafter be described in detail.

The means for conditioning the antenna free of tilt about the axes 43, 31 in relation to the craft

The means for conditioning the antenna free of tilt about the axes 43, 31 in relation to the craft are rendered normally ineffective by the closure of the stabilization switch 116 at the pilot control box 117. With switch 116 in the closed position, the antenna is under control of the heretofore described stabilization means. Switch 116 consequently provides the means for rendering the conditioning means effective, the same being accomplished by moving the switch blade 118 to the off position, Fig. 8. The conditioning means includes the heretofore described pair of interconnected gimbal rings 66 and 94 mounted in the frame 15 with their respective horizontal axes corresponding to the pitch and roll axes of the craft as indicated at 67 and 95, respectively. The arrangement also includes the pitch servomotor 65 operatively connected to the gimbal ring 66 and the roll servomotor 93 operatively connected to the gimbal ring 94. The switch 116 further functions as a changeover means facilitating conversion from the stabilization mode to the tilt free conditioning mode. In going from the stabilization mode to the conditioning mode, the stabilization is disabled by the relay 72 and the reverse function occurs when restoring the apparatus to the stabilization mode. When the switch blade 118 is set in the off stabilization position, the relay 72 is deenergized as the circuit to the battery 113 is opened. The armature elements 126, 81, 196, 102, 79 and 75 of the relay are then urged by the influence of spring 127 against the respective contacts 202, 203, 204, 205, 206 and 207. The circuits to the motors 65 and 93 from the vertical gyro by way of contacts 70, 71, 98 and 99 is thus broken and the stabilization control disabled.

The conditioning means further includes a means providing an output with tilt of the roll gimbal ring 94 about its axis 95 relative to the roll axis of the craft. As shown in Figs. 6, 7 and 8, this means is provided by a segment part 209 fixed to the gimbal ring 66 having two conducting portions 210 and 211 with a central insulating portion 212 therebetween at a position of zero tilt between the rings 94 and 66. A brush 213 rides on the segment part 209, the brush being fixed to the gimbal ring 94 and extending radially of the roll axis of the ring 94 in ring 66. A similar arrangement of parts provide an output with tilt of the pitch gimbal ring 66 relative to the frame 15 of the craft about the pitch axis 67. In Fig. 6, these elements are indicated as the segment 214 which is fixed to frame 15 and the brush 215 fixed to gimbal ring 66 and extending radially of the pitch axis 67. The conducting parts of the segment 214 are indicated in Fig. 8 at 216 and 217 and the zero tilt insulating part is indicated at 218.

As shown in Fig. 8, the pitch tilt detecting means is operatively connected to the servomotor 65 to cause the same to operate in a direction that moves the brush 215 on gimbal ring 66 to a tilt free condition relative to the craft where the same comes to rest on the insulating portion 218 of the segment 214. In Fig. 8, lead 219 connects the brush 215 and the leads 90, 91 to source 86. Lead 220 connects the conducting portion 217 of the segment 214 to contact 207. Lead 221 connects the conducting portion 216 of the segment 214 to the contact 206. With tilt between the frame 15 and ring 66, the brush 215 engages either segment part 216 or 217 and a circuit is closed from source 86 through the brush and contacted conducting portion of the segment 214 by way of either lead 220 or 221, contact 207 or 206, armature 75 or 79 and lead 77 or 78 to the control winding 76 or motor 65. The circuit from the winding 76 is completed to the source 86 by way of lead 80, armature 81, contact 203 and leads 222 and 87.

The roll tilt detecting means is operatively connected to the servomotor 93 to cause the same to operate in a direction that moves the brush 213 on ring 94 to a tilt free condition relative to ring 66 where the same comes to rest on the insulating portion 212 of the segment 209. As shown in Fig. 8, the brush 213 is connected to source 86 by way of lead 223, lead 110 and lead 91. The conducting portion 210 of segment 209 is connected to contact 205 through lead 224. Also, lead 225 connects the conducting portion 211 of segment 209 to the contact 204 of the relay 72. With tilt between the rings 66 and 94, the brush 213 engages either segment part 210 or 211 and a circuit is closed from source 86 through the brush and contacted conducting portion of the segment 209 by way of either lead 224 or 225, contact 205 or 204, armature 102 or 106 and lead 104 or 105 to the control winding 103 of the motor 93. The circuit from the winding 103 is completed to the source by way of lead 107, lead 80, armature 81, contact 203, lead 222 and lead 87.

The interconnected gimbal rings 94 and 66 provide a mounting for the antenna with freedom about two normally horizontal, mutually perpendicular axes 95, 65 which correspond to the pitch and roll axes of the craft when conditioned free of tilt in relation to the craft. The provided mounting or rings include a locking means for engaging the same to the frame 15 when the apparatus is conditioned free of tilt relative to the craft. As shown in Figs. 6, 7 and 8, the lock structure for the rings 94 and 66 is effective to engage the rings 94 and 66 in a tilt free condition about axis 95 and to engage the ring 66 to frame 15 in a like condition about axis 67. When the locks are effective the plane defined by the axes 95, 67 of the antenna mounting corresponds with the plane defined by the pitch and roll axes of the craft, the mounting then reflecting changes in the attitude of the craft about both its pitch and roll axes. This contrasts with the stabilization mode of controlling the antenna in which the plane defined by the axes 95, 67 is level and does not change with the change in the attitude of the craft about its pitch and roll axes. Fig. 7 shows the lock structure between the gimbal rings 94 and 66 as including the plunger element 226 of a solenoid 227 mounted on ring 66. The plunger 226 engages a slot 228 in a plate 229 fixed to the gimbal ring 94. Relative movement between the rings 94 and 66 is limited by a yoke piece 230 fixed to the ring 66 with spaced stop parts 231, 232 and a cooperating stop element 233 extending from the plate 229 fixed to the ring 94. The lock and motion limiting structure between the ring 66 and frame 15 is similar in form, the solenoid 234 being mounted on frame 15. As shown in Fig. 6, the plunger 235 of solenoid 234 engages the slot 236 in a two armed bracket 237 fixed to the ring 66. The motion limiting means for axis 67 is constituted by the stop piece 238 fixed to frame 15 and

the respective spaced arms of the bracket 237 on ring 66, one of which is indicated at 239.

As shown in Fig. 8, springs 240 and 241 normally urge the respective plungers 235 and 226 to a locked condition in the slots of the respective plate 229 and bracket 237 parts. In the stabilization mode, the solenoids 227 and 234 are energized so that the plungers 226 and 235 are withdrawn from locking engagement in the plate 229 and bracket 237 so that the servomotors 93 and 65 are free to operate as required by the vertical gyro 63. The means for rendering the locking means ineffective about axis 95 includes battery 240', lead 241', the contact 242 of relay 72, armature 126, lead 243, lead 244, the winding 245, and lead 246 through resistor 247 to ground. To assure quick release of the plunger 226 from a locking condition, the resistor 247 is shorted by a switch whose blade 248 engages contact 249 when plunger 226 is engaged in slot 228. The shorting circuit is completed by the lead 250 between the contact 249 and ground. Consequently, when switch 116 is moved to the on position, restoring the stabilization mode, the full voltage of battery 240' at the winding 245 obtains quick release of the plunger 226. Upon release, the switch blade 248 opens the short circuit and the solenoid 227 remains energized at a decreased holding voltage. The solenoid 234 controlling the plunger 235 is operated as described for solenoid 227, lead 251 supplying voltage from battery 240' to the winding 252 thereof. Winding 252 is grounded by way of lead 253 and resistor 254. The switch arm and shorting lead for solenoid 234 are respectively indicated at 255 and 256.

In conditioning the antenna free of tilt relative to the craft, the operation is started by moving the stabilizer switch 116 from an on to an off position. The motors 65 and 93 then operate until the gimbal ring 66 is locked to the frame 15 and the gimbal ring 94 is locked to the ring 66 thusly arriving at the desired condition.

The means for monitoring the beam switching operation

To change beam patterns, the switch 181 at the control box 117 in Fig. 8 is moved from the fan position to the pencil position or vice versa. The means for monitoring the operations of the motor 56 include a circuit having a switch 257 with a moving element or switch blade 258 positioned by the motor 56. As shown in Fig. 3 the switch 257 is illustrated as mounted on the relatively fixed yoke piece 52 in a position so that its moving element or blade 258 is urged to a closed condition by engagement with two actuator parts 259 and 260 that are located on the rotatable element 60 driven by the motor 56. The actuator parts are shown diagrammatically in Fig. 8 as a cam having two 180 degree opposed rise portions that correspond to the respective fan and pencil dish arrangements, the cam being indicated as directly driven by the motor 56. The switch may be a micro-switch of the character employing a spring such as indicated at 261 to normally maintain the same in an open condition. With either dish 57 and 59 or dish 57 and dish 58 aligned the actuator part for the switch 257 overcomes the influence of spring 261 to close the switch as depicted in Fig. 8 of the drawing. As shown, the contact 262 engaged by the blade 258 is grounded. The blade 258 is connected to lead 120 by way of lead 263. Opening of the switch 257 therefore opens the circuit including the relay 72 and the relay 122. The opening of the circuit with the relay 72 is equivalent to changing the switch 116 to the off position so that the stabilization means is rendered ineffective and the effective conditioning means operates the motors 65 and 93 to lock the gimbal rings 94 and 66 in a position free of tilt relative to the craft. The relay 122 also situated in an open circuit by the opening of switch 257 functions to disable the manual tilt potentiometer 163.

In initiating the beam switching operation, for example, switch blade 182 is moved from the fan position to

the pencil position. This closes the circuit to battery 113 and energizes the relay 185 so that the armature 190 is moved from contact 189 to contact 188. This reverses the sense of operation of the motor 56 which starts to rotate to move the dish 58 into alignment with the dish 57. With initiation of the movement, actuator 259 moves away from the switch blade 262 of switch 257 and opens circuit including relay 72 and relay 122 as hereinbefore noted.

The spring 264 of relay 122 is then effective to move the armatures 168 and 195 against the respective contacts 265 and 266. With movement of the armature 168, the control of the manual tilt potentiometer 163 over the tilt motor is disabled. The relay 122 of the monitoring means conditions the circuit to disable the manually settable means for positioning the reflector about its tilt axis 49 during a beam switching operation.

With movement of armature 195 to contact 266 in relay 122, the circuit between source 86 and the armature 190 supplying energy to the beam switching motor 56 is opened, this break occurring between the armature 195 and contact 196. Consequently, as soon as the motor 56 has moved the actuator 259, in this instance, away from the switch blade 258 its operation is interrupted automatically by the monitoring means.

The monitoring means further includes a means for conditioning the reflector free of tilt about axis 49 in relation to the radiator. Such means is operable through the hereinbefore described means for positioning the reflector about its axis 49 including the tilt motor 135 and the polarized relay 146. As shown in Fig. 8, during a beam switching operation, the control of the relay 146 is transferred from the manual tilt potentiometer 163 through armature 168 and contact 265 to a zero tilt set potentiometer 267 whose centrally located slider 268 is connected to contact 265 by way of lead 269. One end of the potentiometer 267 is grounded and the other end is supplied with energy from a battery 270 through lead 271. The motor 135 is consequently operated under control of the polarized relay 146 until the slider 138 of the tilt potentiometer 139 is driven to a control position to match that of the slider of the zero tilt set potentiometer 267. The reflector is then conditioned with zero tilt relative to the radiator. Furthermore, the tilt motor 135 has stopped operating due to the restoration of the required balanced condition of the inputs to the polarized relay 146.

The monitoring means further includes a circuit for controlling the operation of the dish interchanging motor 56 having a switch with a moving element positioned by the motor 135 for positioning the reflector about axis 49. The switch shown in Fig. 9 to perform this function may be a microswitch 272 similar in character to switch 257 that is fixedly mounted on the radiator of the antenna. The switch blade 273 or movable element is actuated or positioned in a closed condition by a cam 274 with a rise portion 275 that urges the element against the action of spring 276 at the zero tilt location of the reflector. Cam 274 is shown as mounted for movement about axis 49 and is driven by the motor 135 through the toggle mechanism hereinbefore described in detail.

After operation of the tilt motor 135 to drive the reflector to a zero tilt condition and closure of the tilt switch 272, the supply of energy to the beam switching motor 56 is restored through relay 122 by way of source 86, lead 158, lead 277, blade 273, the contact 278 of switch 272 with which blade 273 is engaged, lead 279 to contact 266, armature 195 engaged with contact 266, and lead 194 to the armature 190 of relay 185. As heretofore described, the relay 185 is now in an energized condition with the armature 190 thereof engaged with contact 188. The interrupted operation of motor 56 is then resumed and the operation continues until stop 180 engages the stop 179 with the reflector parts 58 and 57 aligned for pencil mode radiation. Upon

completion of the operation, the cam rise 260 closes the switch 257 so that the relay 122 is again energized and the initial circuit described between the supply source 86 and armature 190 is restored. The zero tilt set potentiometer 267 is also shorted and the control of the tilt of the reflector about the axis 49 restored to the tilt of the reflector about the axis 49 restored to the manual tilt potentiometer 173. Through relay 72 the zero tilt conditioning means for the antenna is also rendered ineffective and the action of the stabilization means restored. Operation of the motor 56 in a reverse sense is similar to that described except that the armature 190 of relay 185 is initially moved from contact 188 instead of contact 189.

As described, the beam switching motor 56 of the apparatus is monitored to prevent its operation until the reflector is conditioned free of tilt about axis 49 relative to the radiator 40. The monitoring means provided includes such conditioning means which is operable through the tilt motor 135. The beam pattern selecting means consisting of switch 181 is operatively connected to such conditioning means through the relay 122. The monitoring means of the apparatus is furthermore effective to disable the stabilizing means and render the means for conditioning the radiator and reflector free of tilt about axes 43 and 31 in relation to the craft effective during the beam switching operation.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In radar antenna apparatus for use on aircraft, the combination of, a frame fixed to the craft, a radiator, a reflector, a member supporting said radiator and reflector on said frame to move together about a normally vertical axis, means for moving said member, a mounting for said reflector and radiator on said member supporting the reflector and radiator with freedom about two normally horizontal, mutually perpendicular axes in relation to the craft, means for stabilizing said reflector and radiator about said normally horizontal axes, a second mounting carried by said first mounting supporting the stabilized reflector in tiltable relation to the stabilized radiator about a third normally horizontal axis, means including a motor carried by said second mounting operable to change the tilt angle between the reflector and radiator about the third horizontal axis, and means connected to operate said tilt angle changing motor means to control the directivity of the apparatus.

2. A radar antenna having a fixed frame, a radiator, a reflector, a member supporting said radiator and reflector on said frame to move together about a normally vertical axis, means for moving said member, a mounting for said reflector and radiator on said member supporting the reflector and radiator with freedom about two normally horizontal, mutually perpendicular axes, means for stabilizing said reflector and radiator about their respective horizontal axes including a rotatable universal connection between the member and frame, a second mounting for said reflector on said first mounting supporting the stabilized reflector in tiltable relation to the stabilized radiator about a third normally horizontal axis, means including a motor interconnecting the second mounting and reflector operable to change the tilt angle between the reflector and radiator about the third horizontal axis, and means for controlling the directivity of the apparatus operatively connected to said tilt angle changing motor means.

3. In a radar antenna apparatus for use on aircraft, the combination of, a frame fixed to the craft, a member movably mounted on said frame, a radiator support-

ed on said member, a dish type reflector supported on said member to move with the radiator about a normally vertical axis formed of a half dish and a pair of back to back arranged half dishes of different concave shapes movably mounted on the member in interchangeable relation with the first half dish to provide fan and pencil type beam patterns, means for moving said member, means for interchanging said pair of half dishes, a mounting carried by said member supporting the reflector in tiltable relation to the radiator about a normally horizontal axis to change the directivity of the apparatus for both fan and pencil type beam patterns, means including a motor carried by said member operable to change the tilt angle between the reflector and radiator about the normally horizontal axis, means for monitoring the operation of said dish interchanging means including means for operating said tilt motor to condition the reflector free of tilt about its normally horizontal axis relative to the radiator, and beam pattern selecting means operatively connected to said dish interchanging means through said monitoring means.

4. The combination claimed in claim 3, in which said monitoring means is a circuit for controlling the operation of said dish interchanging means having a switch with a moving element operated by said tilt motor.

5. The combination claimed in claim 3, in which said reflector tilt changing means includes manually settable means, and said monitoring means is a circuit having a relay conditioned to disable said manually settable means during the beam switching operation.

6. The combination claimed in claim 3, in which said monitoring means further includes a circuit having a switch with a moving element positioned by said dish interchanging means.

7. In a radar antenna, the combination of, a movable member, a radiator supported on said member, a dish type reflector supported on said member to move with the radiator about a normally vertical axis formed of a half dish and a pair of back to back arranged half dishes of different concave shapes movably mounted on the member in interchangeable relation with the first half dish to provide different beam patterns, means for moving said member, a motor operable to interchange said pair of half dishes, a mounting for said reflector on said member supporting the reflector independently of said radiator for movement about an axis perpendicular to the axis of said member to change the directivity of the antenna for the respective beam patterns, means for positioning said reflector about its second axis including a motor, means for monitoring the operation of said dish interchanging motor including means operable through said positioning means for conditioning the reflector free of tilt about its second axis with the radiator at the focal point thereof, and beam pattern selecting means operatively connected to dish interchanging motor through said monitoring means.

8. In a radar antenna apparatus for use on aircraft, the combination of, a frame fixed to the craft, a radiator, a reflector, a member supporting said radiator and reflector on said frame to move together about a normally vertical axis, means for moving said member, a mounting for said reflector and radiator on said member supporting the reflector and radiator with freedom relative to the craft about two normally horizontal, mutually perpendicular axes, normally ineffective means for conditioning said reflector and radiator free of tilt about their respective horizontal axes in relation to the craft including a pair of interconnected gimbal rings mounted on the frame with their respective horizontal axes corresponding to the pitch and roll axes of the craft, means providing an output with tilt of the pitch gimbal ring about its axis relative to the pitch axis of the craft, a motor operatively connected to said pitch ring responsive to said pitch output means, means providing an output with tilt of the roll gimbal ring about its axis relative to the roll axis of the

craft, a motor operatively connected to said roll ring responsive to said roll output means, and settable means for rendering said conditioning means effective.

9. The combination claimed in claim 8, in which said gimbal rings include respective locking means for engaging the same to the frame when conditioned free of tilt in relation to the craft.

10. In a radar antenna apparatus for use on dirigible craft, a radiator and reflector mounted with freedom in relation to the craft about two normally horizontal, mutually perpendicular axes, means for stabilizing said radiator and reflector about their respective horizontal axes independently of the craft, alternatively effective means for conditioning said radiator and reflector free of tilt about their respective axes in relation to the craft, and changeover means operable to disable said stabilizing means and render said conditioning means effective.

11. In a radar antenna apparatus for use on dirigible craft, the combination of, a frame fixed to the craft, a member movably mounted on said frame, a radiator supported on said member, a dish type reflector supported on said member to move with the radiator about a normally vertical axis formed of a half dish and a pair of back to back arranged half dishes of different concave shapes movably mounted on the member in interchangeable relation with the first half dish to provide different beam patterns, a motor for interchanging said pair of half dishes, a mounting for said reflector and radiator on said member supporting the reflector and radiator with freedom about two normally horizontal, mutually perpendicular axes, means for stabilizing said radiator and reflector about their respective horizontal axes, normally ineffective means for conditioning said radiator and reflector free of tilt about their respective horizontal axes in relation to the craft, means for monitoring the operation of said dish interchanging motor including means operable to disable said stabilizing means and render said conditioning means effective, and beam pattern selecting means operatively connected to said interchanging motor through said monitoring means.

12. The combination claimed in claim 11, in which said disabling means includes a circuit having a switch with a moving element positioned by said beam pattern interchanging motor.

13. A radar antenna apparatus for use on aircraft including a frame fixed to the craft, a member movably mounted on said frame, a radiator supported on said member, a dish type reflector supported on said member to move with the radiator about a normally vertical axis formed of a half dish and a pair of back to back arranged half dishes of different concave shapes movably mounted on the member in interchangeable relation with the first half dish to provide different beam patterns, means for moving said member, a motor for interchanging said pair of half dishes, a mounting for said reflector and radiator on said member supporting the reflector and radiator with freedom about two normally horizontal, mutually perpendicular axes in relation to the craft, means for stabilizing said reflector and radiator about their respective mutually perpendicular horizontal axes, normally ineffective means for conditioning said radiator and reflector free of tilt about their respective horizontal axes in relation to the craft, a second mounting for said reflector on said member supporting the reflector independently of said radiator to tilt about a third normally horizontal axis to change the directivity of the apparatus for the respective beam patterns, a motor for positioning said reflector about its third horizontal axis, adjusting means for controlling the tilt angle of the reflector about its third horizontal axis, means for monitoring the operation of said interchanging motor including means for conditioning the reflector free of tilt about its third horizontal axis, means for disabling said stabilization means and rendering said normally ineffective conditioning means effective, and beam pattern selecting means operatively

connected to said interchanging motor by way of said monitoring means.

14. The combination in an apparatus of the class described of, a radar antenna for use on a dirigible craft, a mounting for said antenna supporting the same on a movable member with freedom about two normally horizontal, mutually perpendicular axes, means for conditioning said member with the antenna free of tilt about said mounting axes in relation to the craft, alternatively effective means for stabilizing said antenna about said mounting axes independently of the craft, and changeover means operable to disable said conditioning means and render said stabilizing means effective.

15. A radar antenna for dirigible craft having a member movable about an axis, a radiator fixed to the member, a dish-type reflector formed of a half dish fixedly mounted on said member and a pair of back to back arranged half dishes of dishes of different concave shapes movably mounted on said member in interchangeable relation with the fixed half dish to provide different beam patterns, means for aligning each of the pair of dishes with the fixed half dish comprising a plurality of stop elements on the member and pair of dishes, a mounting for said radiator member and reflector member supporting the same on the craft with freedom about two normally horizontal, mutually perpendicular axes, normally effective means for stabilizing said radiator and reflector about said normally horizontal axes, normally ineffective means for conditioning said radiator and reflector free of tilt about said normally horizontal axes in relation to the craft, motive means on said member operable to move said pair of dishes within the range determined by said stop elements to change the beam pattern of the antenna, means for monitoring the operation of said beam pattern changing motive means including means for disabling said stabilizing means and means for rendering said conditioning means effective, and beam pattern selecting means connected to said pattern changing motive means through said monitoring means.

16. A radar antenna for dirigible craft having a member movable about an axis, a radiator fixed to the member, a dish-type reflector formed of a half dish fixedly mounted on said member and a pair of back to back arranged differently shaped half dishes movably mounted on said member in interchangeable relation with the fixed half dish, stop elements between said member and pair of dishes facilitating movement of the pair of dishes through an angular range of 180°, said elements being arranged to align each of the pair of dishes with the fixed half dish at the limits determined thereby, a mounting for said antenna member supporting the radiator and reflector on the craft with freedom about two normally horizontal, mutually perpendicular axes, normally effective means for stabilizing said radiator and reflector about said normally horizontal axes, normally ineffective means for conditioning said radiator and reflector free of tilt about said normally horizontal axes in relation to the craft, motive means on said member for moving said pair of dishes to change the beam pattern of the antenna, means for monitoring said pattern changing motive means including means for disabling said stabilizing means and means for rendering said conditioning means effective, and beam pattern selecting means operatively connected to said motive means through said monitoring means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,475,746	Kenyon	July 12, 1949
2,501,479	Sproule	Mar. 12, 1950
2,543,188	Moseley	Feb. 27, 1951
2,585,579	Norden	Feb. 12, 1952
2,625,678	Allison	Jan. 13, 1953
2,681,991	Marco	June 22, 1954
2,706,781	Goss	Apr. 19, 1955