Nov. 19, 1968 E. A. BERGLING 3,412,404

SCANNING DISH REFLECTOR HAVING A STOWED POSITION

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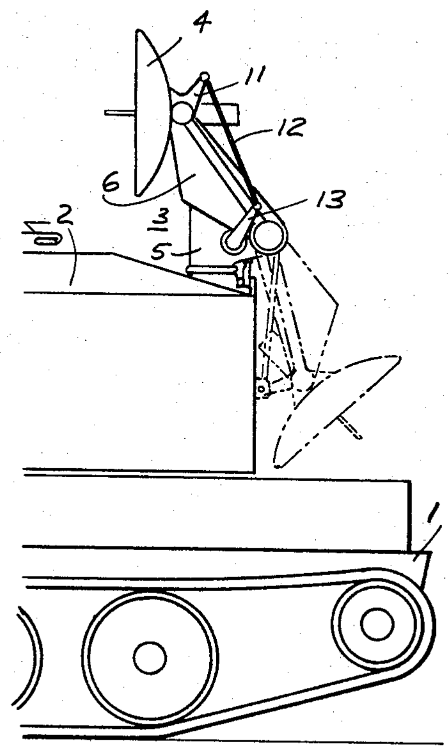

FIG. 1

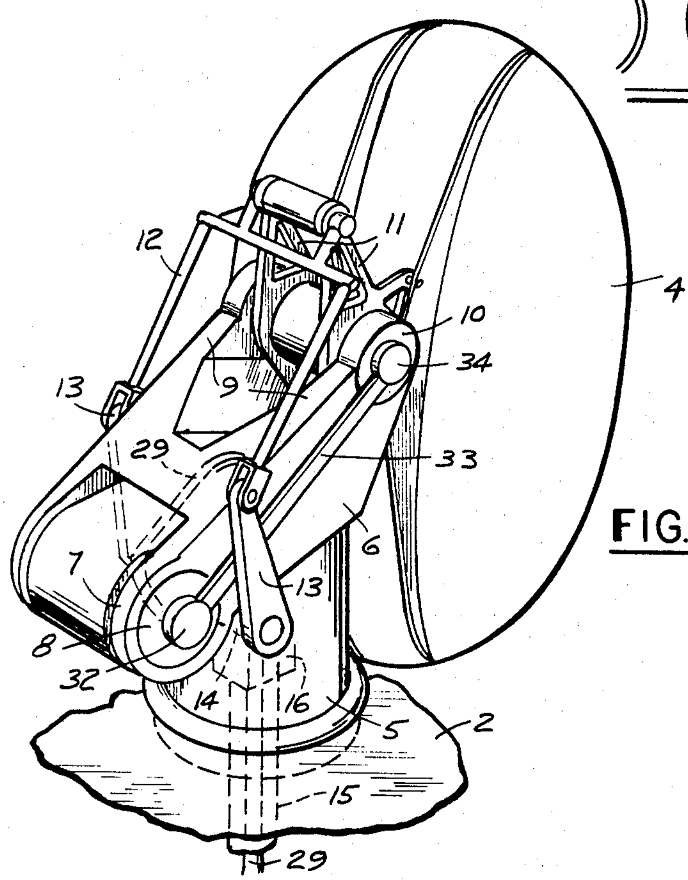

FIG. 2

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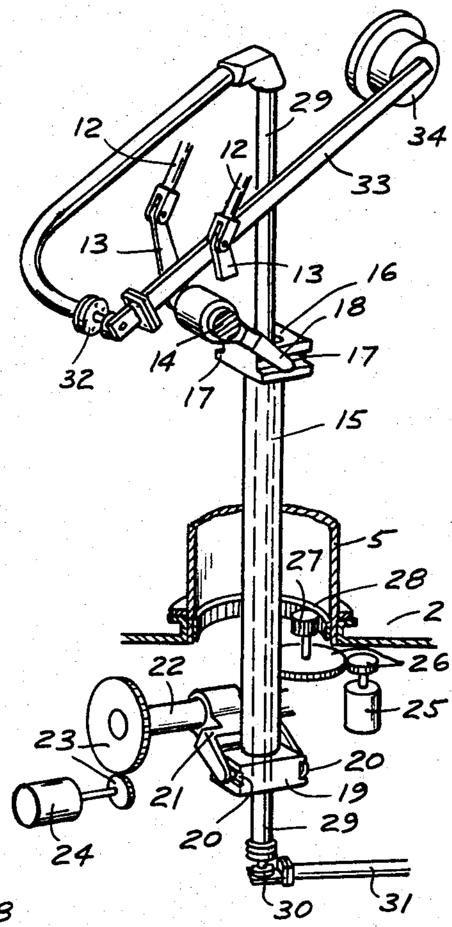

FIG. 3

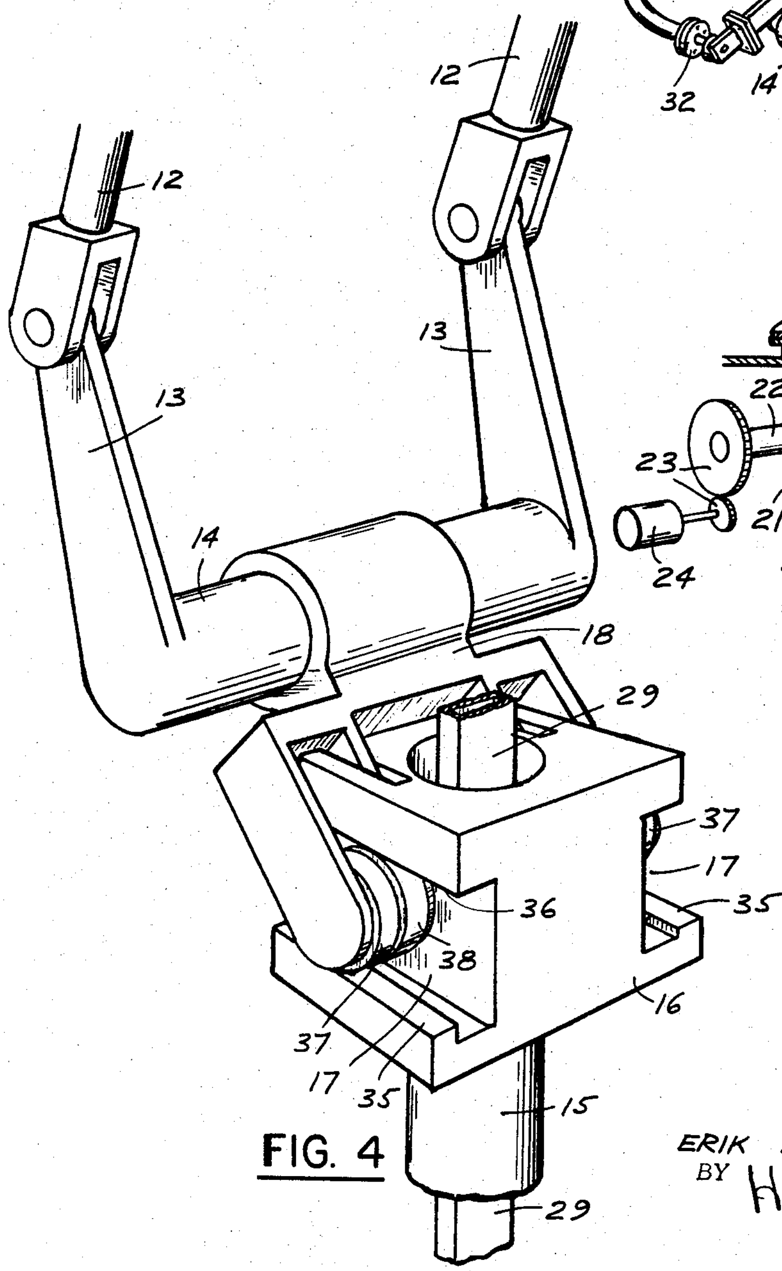

FIG. 4

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SCANNING DISH REFLECTOR HAVING A STOWED POSITION

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7 Claims. (Cl. 343—762)

The present invention is related to a radar antenna system of the type, in which the reflector and associated radiation transmitting and receiving members can be vertically elevated as well as rotated in azimuth by drive motors and which with this object comprises a reflector stand mounted on a supporting base for rotation about a vertical axis relative to the base, the reflector being mounted on this reflector stand so as to be rotatable relative to the stand about a horizontal axis. Radar antenna systems of this type are primarily used in fire control radar stations for air targets, in which case it is a primary requirement that the reflector can be displaced or directed with a high speed, great accuracy and a small time lag. If this is to be achieved, it is necessary that the rotating and elevating masses of the antenna system have smallest possible inertias about their axes of rotation and that the mechanical motion transferring mechanisms include very small error sources, as for instance dead plays. As radar stations of this type are often mobile, for instance mounted on a gun carriage, it is also desired that the radar antenna system can be folded, so that its height above the ground can be reduced, as this will make it easier to move the vehicle for instance in woods, under bridges, etc., and also easier to hide the vehicle from the enemy, when the radar station is not operating.

With a radar antenna system according to the present invention the above requirements are satisfied in that the drive motor for the rotation of the reflector in azimuth as well as the drive motor for the elevation of the reflector are mounted in the supporting base, the azimuth rotation drive motor being coupled to the reflector stand for rotation thereof about its vertical rotation axis relative to the supporting base, whereas the elevation drive motor is coupled to the lower end of an axially displaceable tubular rod extending vertically upwards from the supporting base through the reflector stand coaxially to the vertical rotation axis of the stand so that this tubular rod will be axially displaced in dependence of the rotation of the elevation drive motor. The upper end of this tubular rod located in the reflector stand is coupled to the reflector for rotation thereof about its horizontal elevation axis relative to the reflector stand in dependence of the axially displacement of the rod. The wave guide between the radar station located in the supporting base and the radiation transmitting and receiving members associated with the antenna reflector comprises a first wave guide member extending vertically upwards from the supporting base through the tubular rod into the reflector stand, in which it is coupled through a rotating wave guide joint coaxial with the horizontal elevation axis of the reflector to a wave guide member rigidly mounted on the reflector and leading to the radiation transmitting and receiving members associated with the reflector.

As in the radar antenna system according to the invention the azimuth rotation drive motor as well as the elevation drive motor are mounted in the supporting base and consequently are not included in the rotating and elevating masses respectively of the antenna system, the inertias of this masses are considerably reduced. In spite of the fact that the elevation drive motor is mounted in

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the supporting base, the radar antenna system according to the invention will in a very simple way provide an accurate transmission of the movements of the elevation drive motor to the reflector through the tubular, axially displaceable rod, which extends vertically upwards coaxially relative to the vertical rotation axis of the reflector stand and which encloses the wave guide member extending from the supporting base upwards into the reflector stand and to the reflector.

In order to make the antenna system collapsible the reflector stand consists according to the invention preferably of a lower reflector stand member mounted for rotation on the supporting base and an upper reflector stand member, which is supported by the lower reflector stand member and is pivoted in this about a horizontal folding axis so that it can be folded downwards beside the lower reflector stand member. The reflector is mounted at the upper end of this upper reflector stand member for elevation about its horizontal elevation axis, which is parallel with the folding axis between the upper and the lower reflector stand members. In this way the upper reflector stand member together with the reflector can be folded downwards beside the lower reflector stand member so that the maximum height of the antenna system in this folded position is determined by the height of the lower reflector stand member above the supporting base. When the radar antenna system according to the invention is designed in this way, the upper end of the tubular rod for the elevation of the reflector is coupled to a first lever arm attached to a horizontal shaft mounted for rotation in the lower reflector stand member parallel to the horizontal elevation axis of the reflector, and this shaft is provided with a second lever arm, which is coupled through a connecting rod to the reflector. The wave guide member disposed inside the tubular rod is then in the lower reflector stand member coupled through a rotating wave guide joint coaxial to the folding axis between the two reflector stand members to the one end of a wave guide member rigidly mounted on the upper reflector stand member, the opposite end of the last mentioned wave guide member being coupled through the rotating wave guide joint coaxial with the horizontal elevation axis of the reflector to the wave guide member rigidly mounted on the reflector.

The horizontal shaft in the lower reflector stand member for the lever arms coupled to the upper end of the tubular rod and to the connecting rod respectively and the folding axis between the two reflector stand members are preferably so disposed as to be spaced from each other and to be located on the same side of the vertical rotation axis of the reflector stand, with the folding axis between the two reflector stand members located furthest away from the vertical rotation axis of the reflector stand. If the lever arm coupled to the connecting rod is then given an effective length substantially corresponding to the radial distance between the rotation axis of this lever arm and the folding axis between the two reflector stand members it will be possible to fold the reflector stand without any axial displacement of the tubular rod; that is it will be possible to fold the reflector stand without disengaging the elevation drive motor from the tubular rod. Furthermore, the reflector will not during the folding movement be rotated about its horizontal elevation axis to any substantial degree.

In the following the invention will be further described with reference to the accompanying drawing, in which by way of example a radar antenna system according to the invention mounted on a gun carriage is shown.

FIG. 1 shows schematically the rear portion of the gun carriage seen from the side with the radar antenna system mounted upon a gun turret of the carriage.

FIG. 2 is a perspective and more detailed illustration of the radar antenna system, in which some parts of the system are shown transparent.

FIG. 3 shows the wave guide arrangement and the motion transferring mechanisms for the azimuth rotation and the elevation of the reflector; the reflector stand and the reflector and certain other members being omitted for the larger part.

FIG. 4 shows on a larger scale and in detail the coupling between the upper end of the tubular rod and the lever arm coupled to this end of the rod.

FIG. 1 shows schematically a gun carriage having a chassis **1** and a rotatable gun turret **2** mounted on the chassis. On top of the gun turret **2** a radar antenna system **3** having a parabolic reflector **4** is mounted. As most readily seen in FIG. 2, the radar antenna system comprises a reflector stand consisting of a lower reflector stand member **5**, which is mounted on the upper side of the gun turret **2** for rotation about a vertical axis relative to the gun turret, and an upper reflector stand member **6**, which is supported by the lower reflector stand member **5** and is shaped as a double-forked arm. In the operating position of the antenna system, shown in full lines in FIGS. 1 and 2, the reflector stand arm **6** is resting upon the lower reflector stand member **5** and can by suitable means be locked in this position relative to the lower reflector stand member. The two arms **7** of the lower fork-shaped end of the reflector stand arm **6** are, however, pivoted about a horizontal shaft **8** in the lower reflector stand member **5**, whereby after the locking means between the reflector stand arm **6** and the lower reflector stand member **5** having been released the reflector stand arm **6** can be swung about the shaft **8** to a folded transport position, shown with dotted lines in FIG. 1, beside the lower reflector stand member **5** and behind the gun turret **2**. The antenna reflector **4** is pivoted about a horizontal shaft **10** in the outer ends of the arms **9** of the upper fork-shaped end of the reflector stand arm **6**. The reflector **4** is provided with two lever arms **11**, which are coupled to a fork-shaped connecting rod **12**, having its two arms pivoted to two lever arms **13**, which are disposed on opposite sides of the lower reflector stand member **5** outside the reflector stand arm **6** and are attached to each one of the ends of a horizontal shaft **14** journalled in the lower reflector stand member **5**. As can be seen in FIG. 3, a vertical tubular rod **15** is extending from the interior of the gun turret **2** upwards into the lower reflector stand member **5**. The tubular rod **15** is axially displaceable and its upper end is provided with a grooved head **16** having two external, horizontal, straight grooves **17**, into which the ends of a fork-shaped lever arm **18** attached to the shaft **14** are projecting, as can be seen in FIG. 4. Through the cooperation between the grooves **17** in the head **16** and the lever arm **18** it is consequently possible by axial displacement of the rod **15** to rotate the shaft **14** and thus the two lever arms **13** about an angle corresponding to the axial displacement of the rod **15**. This rotation is transferred through the connecting rod **12** and the lever arms **11** attached to the reflector **4** to a corresponding rotation of the reflector **4** about its horizontal elevation shaft **10** relative to the reflector stand arm **6**. It is consequently possible to elevate the reflector **4** by displacing the rod **15** axially. The lower end of the tubular rod **15**, which is located inside the gun turret, **2**, is provided with a corresponding grooved head **19**, similar to the grooved head at the upper end of the rod. Also this head **19** is provided with two external, horizontal, straight grooves **20**, into which the ends of a fork-shaped lever arm **21** are projecting. The lever arm **21** is attached to horizontal shaft **22**, which is stationarily journalled in the gun turret and through suitable gearing means **23** coupled to the elevation drive motor **24** for the antenna reflector, which is mounted inside the gun turret **2**. The tubular rod **15** is coaxial relative to the vertical axis of rotation of the lower reflector stand member **5** relative to the gun turret **2**, whereby the tubular rod **15** will not prevent the rotation of the reflector stand about its vertical axis and thus the azimuth rotation of the reflector. In order to permit the rotation of the reflector stand there is a rotational joint between the tubular rod and one of the two grooved heads **16** and **19**, preferably between the lower head **19** and the rod. The reflector stand and thus the reflector **4** are rotated about the vertical axis by an azimuth rotation drive motor **25**, which is mounted inside the gun turret **2** and through suitable gearing means **26** coupled to a gear wheel **27** engaging a gear rim **28** attached to the lower reflector stand member **5** mounted for rotation in the gun turret **2**.

The radar station is located inside the gun carriage, preferably in the gun turret **2**, and is connected to the radiation transmitting and receiving means (not shown in the drawing) associated with the reflector **4** through a wave guide **29**, which is stationarily mounted in the lower reflector stand member **5** and is extending from the inside of the gun turret **2** vertically upwards through the tubular rod **15** into the lower reflector stand member **5**. The lower end of the wave guide **29** in the gun turret **2** is coupled through a rotating wave guide joint **30** coaxial with the vertical axis of rotation of the lower reflector stand member **5** to a fixed wave guide **31** in the gun turret **2**, which wave guide **31** leads to the radar station arranged in the gun turret. The upper end of the wave guide **29** in the lower reflector stand member **5** is bent and inserted into the pivot shaft **8** of the reflector stand arm **6**. At the one end of the shaft **8** there is a rotating wave guide joint **32** coaxial with the shaft **8**, which joint connects the wave guide **29** rigidly mounted in the lower reflector stand member **5** to a wave guide **33** rigidly mounted on the outside of the foldable reflector stand arm **6**. The other end of the wave guide **33** is coupled through a rotating wave guide joint **34** at the one end of the horizontal elevation shaft **10** of the reflector **4** to a wave guide (not shown in the drawing) stationarily mounted on the reflector **4**, which leads to the radiation transmitting and receiving members (not shown in the drawing) associated with the reflector. This arrangement of the wave guide makes it possible to rotate the reflector **4** in azimuth as well as to elevate the reflector by means of the drive motors **24** and **25** respectively mounted in the gun turret **2** and also to lower the reflector stand arm **6** together with the reflector **4** to the transport position shown with dotted lines in FIG. 1.

As in the radar antenna system according to the invention the elevation drive motor as well as the azimuth drive motor for the antenna reflector are mounted in the supporting base for the reflector stand and consequently are not included in the elevating and rotating masses of the antenna system, these masses will have a smaller weight and inertia. Due to this the antenna reflector can be moved at a higher speed and with smaller time lags and by means of smaller drive motors. Furthermore it is achieved that no slip-ring connections are necessary for the electric control signals to the drive motors and this is advantageous, as in such slip-ring connections uncontrolled voltage drops easily appear, which can give cause to an erroneous displacement of the antenna reflector. Furthermore, the measuring devices that are generally necessary for determining the elevation angle and the azimuth angle of the antenna reflector and often also for determining the elevation angular velocity and the azimuth angular velocity of the reflector can be mounted in the gun turret, wherefore also for the metering signals generated by these measuring devices no slip-ring connections are necessary. In spite of the fact that the azimuth rotation drive motor as well as the elevation drive motor are mounted in the gun turret **2**, a very accurate displacement of the reflector **2** in azimuth as well as in elevation in agreement with the rotation of the azimuth drive motor and the elevation drive motor respectively is obtained in a very simple and reliable way.

In order to eliminate dead plays in the elevation mechanism the connections between the tubular rod **15** and the lever arms **18** and **21** are designed in a special way, as shown in detail in FIG. 4. FIG 4 shows the upper end of the tubular rod **15** with the grooved head **16** and the associated lever arm **18** on the shaft **14**. As can be seen in the drawing, each one of the two external horizontal grooves **17** in the head **16** is formed to have two horizontal, exactly parallel roller tracks **35** and **36**. Furthermore the end of the arms of the fork-shaped lever arm **18** cooperating with each groove **17** is provided with two rollers **37** and **38**, which are individually rotatable in the arm of the lever arm **18** in such a way that the one roller **37** is running on the lower roller track **35** in the groove **17**, whereas the other roller **38** is running on the upper roller track **37** in the groove **17**. In this way any friction and dead play is eliminated in the connection between the lever arm **18** and the tubular rod **15**. The lower grooved head **19** at the lower end of the tubular rod **15** and the fork-shaped lever arm **21** cooperating with this head are designed in the same way.

It is preferred, if the reflector stand arm **6** with the reflector **4** can be folded to the transport position without any axial displacement of the tubular rod **15** during the folding movements, whereby it will not be necessary to disconnect the rod **15** from the elevation drive motor and from the servo circuits controlling the elevation of the reflector. In order to achieve this the shaft **14** and the folding shaft **8** between the lower reflector stand member **5** and the reflector stand arm **6** are according to the invention disposed spaced from each other and the lever arm **13** mounted on the shaft **14** is designed to have an effective length corresponding to the radial distance between said two shafts. Before the reflector stand arm **6** with the reflector **4** is being folded, the rod **15** can then by means of the elevation drive motor **27** be displaced and thus the lever arms **13** on the shaft **14** be swung to such a position that the pivot joints between the two lever arms **13** and the two arms of the connecting rod **12** are disposed on or close to the folding axis between the lower reflector stand member **5** and the reflector stand arm **6**. Thereafter the reflector stand arm **6** can obviously be folded from its operating position to its transport position without any simultaneous axial displacement of the tubular rod **15** and without any substantial rotation of the reflector **4** about its horizontal elevation axis **10** relative to the reflector stand arm **6**. A minor rotation of the reflector **4** about its axis **10** relative to the reflector stand arm **6** during the folding movement can of course be permitted and in certain cases even be desired. It is consequently not necessary that the pivot joints between the two lever arms **13** and the connecting rod **12** are disposed exactly on the folding axis between the lower reflector stand member **5** and the folding reflector stand arm **6** during the folding process, but it is only necessary that they are disposed close to said folding axis.

In addition to the wave guide **29** from the interior of the gun turret **2** to the antenna reflector also other electric conductors, as for instance from a radiation meter mounted in the reflector or a drive motor mounted on the reflector for rotation of the radiation beam, can be located inside the tubular rod **15**. These additional electric conductors can be connected to associated parts on the reflector through rotating joints at those ends of the folding shaft **8** of the reflector stand arm **6** and the horizontal elevation shaft **10** of the reflector **4**, respectively, which are not occupied by the rotating wave guide joints **32** and **34**.

What is claimed is:

1. A radar antenna system comprising a reflector, a collapsible supporting stand for said reflector including a lower reflector stand member mounted upon a supporting base member for rotation about a vertical axis and an upper reflector stand member pivoted to said lower reflector stand member about a horizontal folding axis so as to be swingable between an operating position above said lower reflector stand member and a folded position beside said lower reflector stand member, said reflector being pivoted in said upper reflector stand member about a horizontal elevation axis parallel to said folding axis, a rotation drive motor mounted in said supporting base member and coupled to said lower reflector stand member for rotation thereof about said vertical rotation axis, an elevation drive motor mounted in said supporting base member, a tubular, axially displaceable rod extending from said base member vertically upwards inside said lower reflector stand member coaxially to said vertical rotation axis so as to have its lower end in said base member and its upper end in said lower reflector stand member, said elevation drive motor being coupled to said lower end of said tubular rod for axially displacing said rod, said upper end of said tubular rod being coupled to a first lever attached to a horizontal shaft mounted for rotation in said lower reflector stand member parallel to said folding axis, a second lever attached to said shaft being coupled to one end of a connecting rod, the opposite end of said connecting rod being connected to said reflector in a point located eccentrically with respect to said horizontal elevation axis.

2. A radar antenna system as claimed in claim **1**, wherein said horizontal shaft mounted in said lower reflector stand member and said folding axis between said lower and upper reflector stand members are spaced from each other and located on the same side of said vertical rotation axis of said lower reflector stand member, said horizontal shaft being closer to said vertical rotation axis than said folding axis.

3. A radar antenna system as claimed in claim **2**, wherein said second lever coupled to said connecting rod has an effective length substantially corresponding to the radial distance between said shaft and said folding axis.

4. A radar antenna system as claimed in claim **1**, wherein said upper end of said tubular rod is provided with a grooved head having an external horizontal straight groove, into which a pin on said first lever arm is projecting.

5. A radar antenna system as claimed in claim **4**, wherein the side walls of said groove are forming two horizontal roller tracks and said pin on said first lever arm carries two individually rotatable rollers running on said roller tracks.

6. A radar antenna system as claimed in claim **4**, wherein said lower end of said tubular rod is provided with a grooved head having an external horizontal straight groove, a horizontal shaft mounted for rotation in said base member and coupled to said elevation drive motor, a lever arm attached to said shaft having a pin projecting into said groove in said grooved head on said lower end of said tubular rod, a rotational joint between said tubular rod and the grooved head at one end of said tubular rod.

7. A radar antenna system as claimed in claim **1**, comprising a first wave guide member extending from said base member vertically upwards through said tubular rod into said lower reflector stand member, the upper end of said first wave guide member being coupled through a first rotating wave guide joint coaxial to said folding axis to the one end of a second wave guide member rigidly mounted on said upper reflector stand member, the opposite end of said second wave guide member being coupled through a second rotating wave guide joint coaxial to the horizontal elevation axis of said reflector to a third wave guide member rigidly mounted on said reflector.

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