May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 1

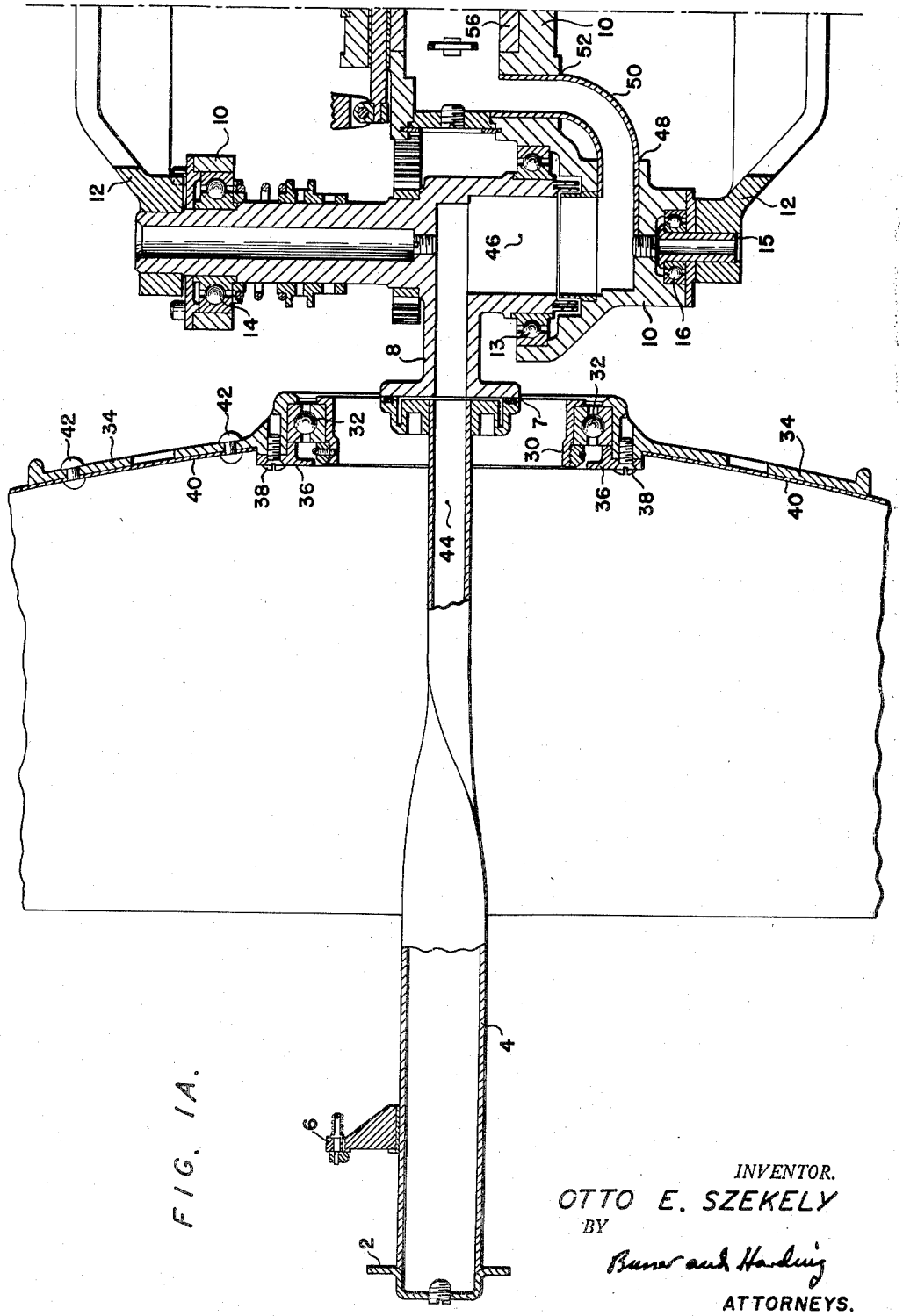


FIG. 1A.

INVENTOR.
OTTO E. SZEKELY
BY
Burner and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 2

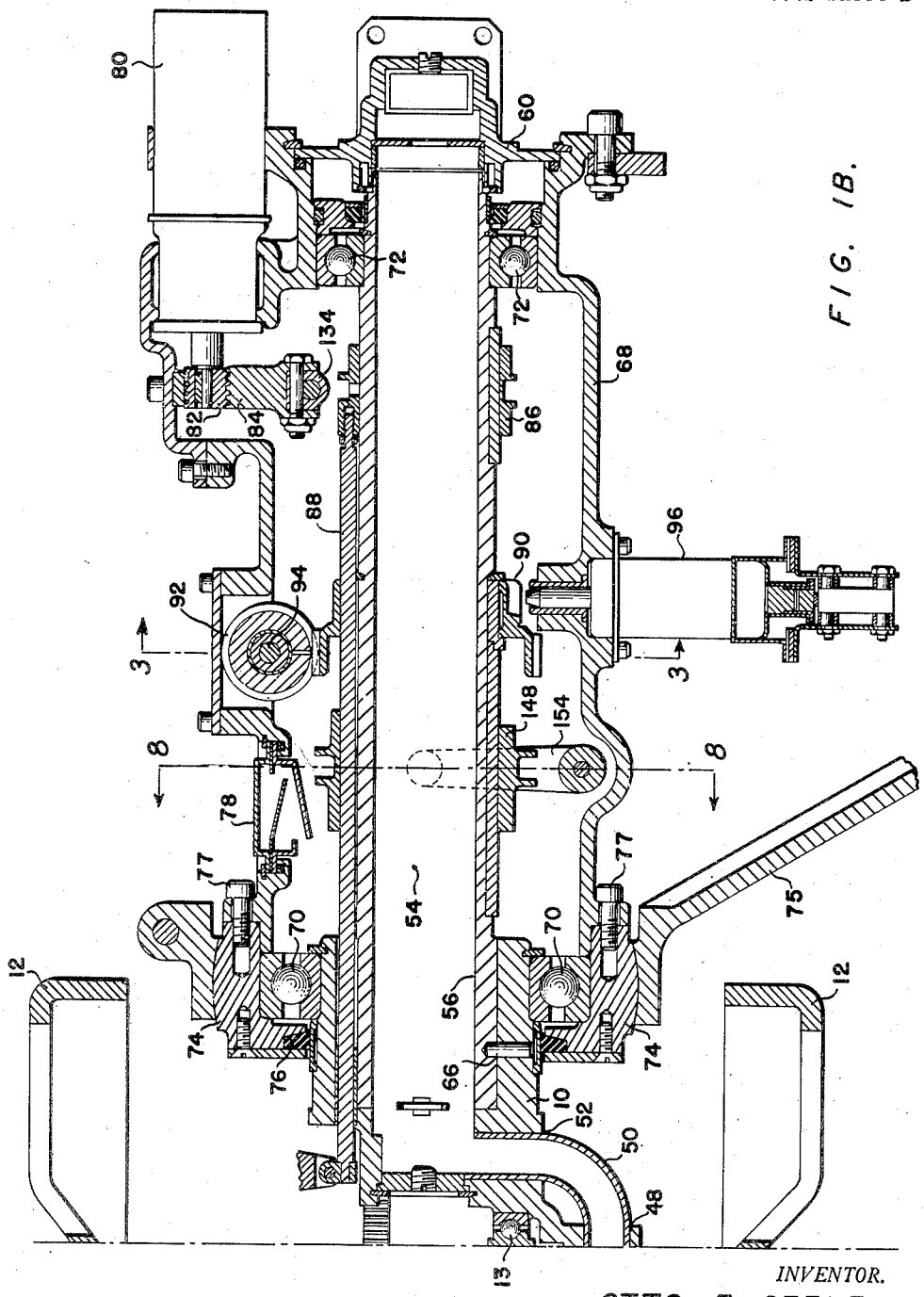


FIG. 1B.

INVENTOR.
OTTO E. SZEKELY
BY
Burner and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 3

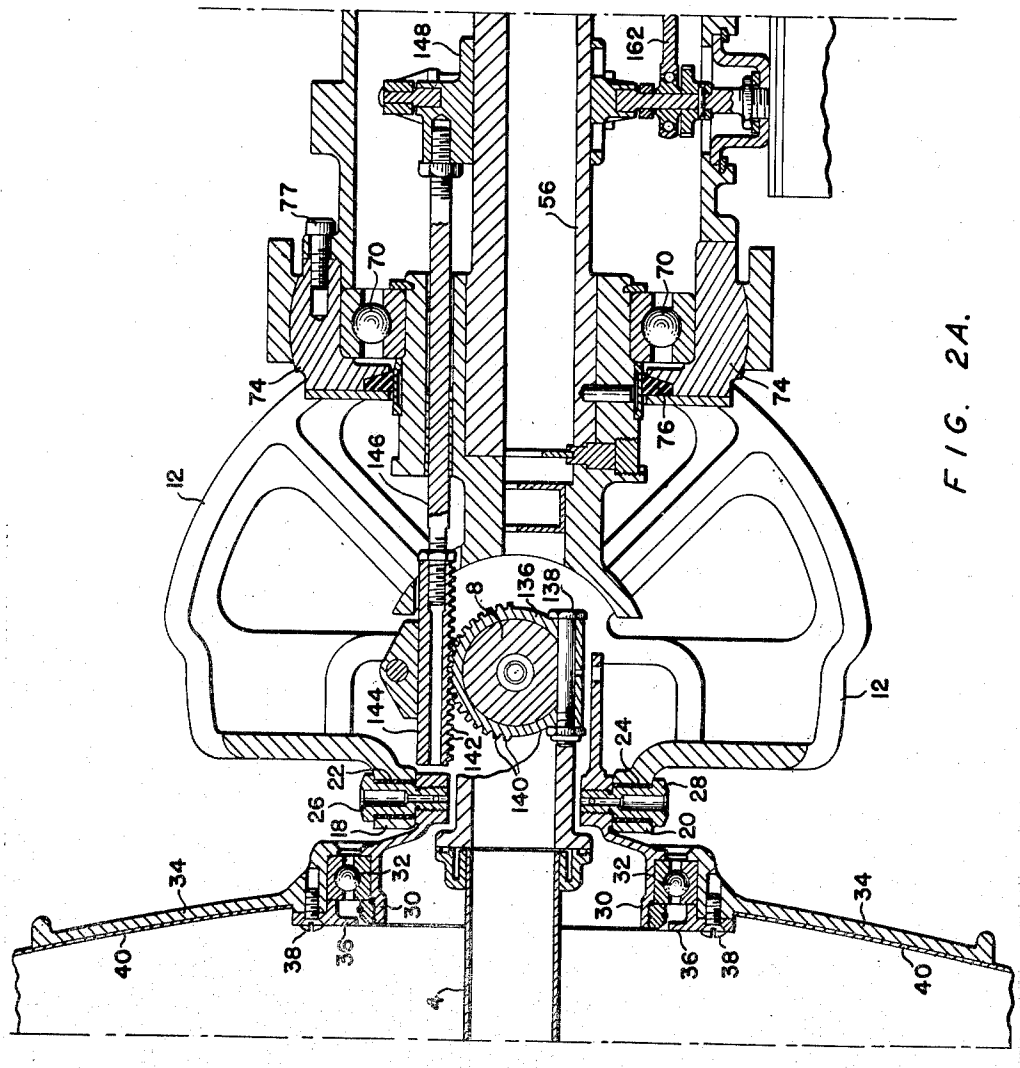


FIG. 2A.

INVENTOR.
OTTO E. SZEKELY
BY
Burns and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 4

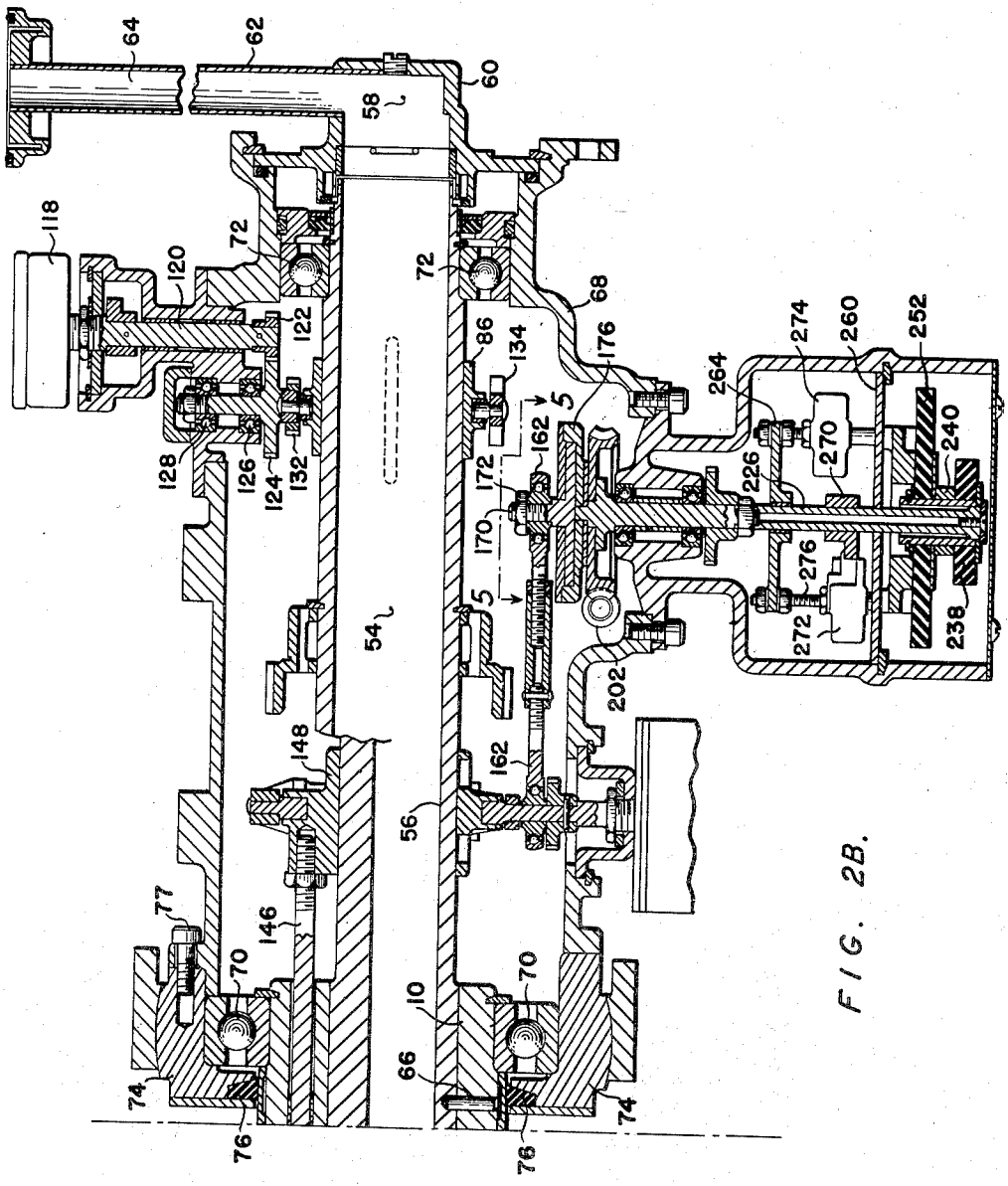


FIG. 2B.

INVENTOR.
OTTO E. SZEKELY
BY
Burns and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 5

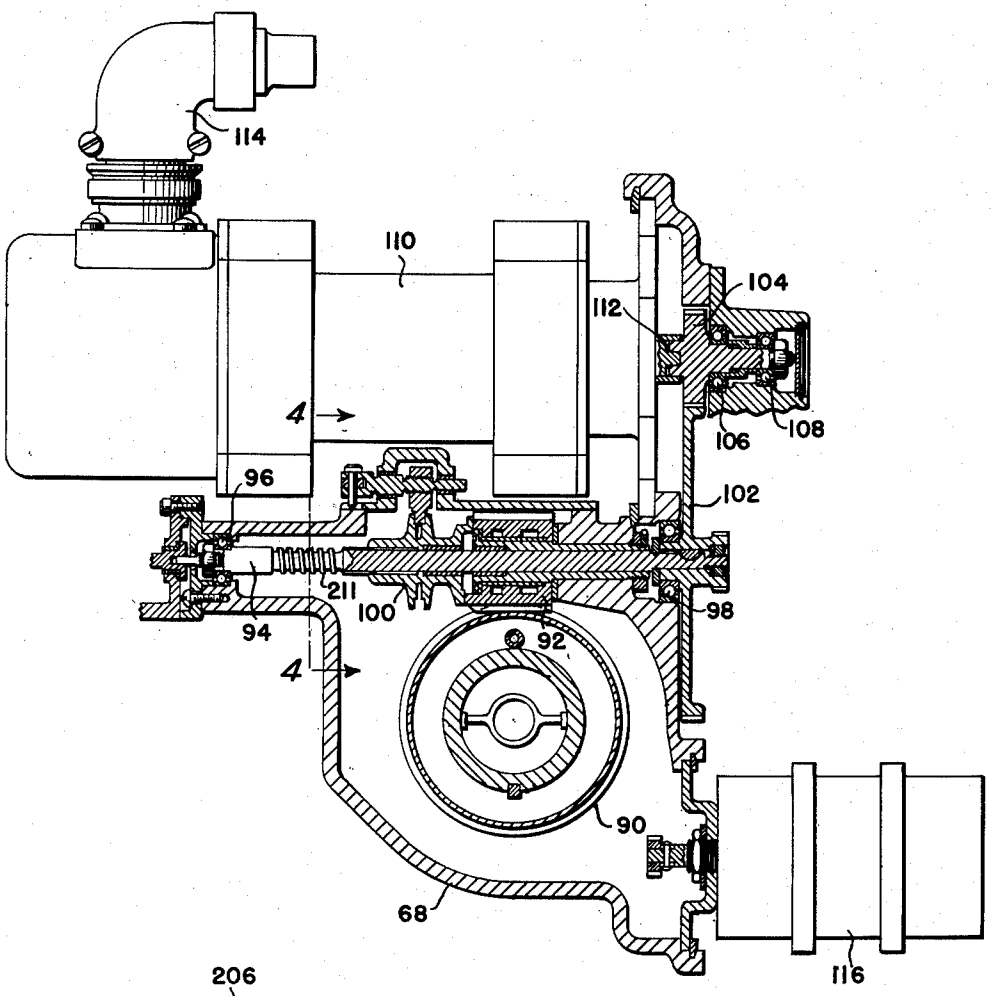


FIG. 3.

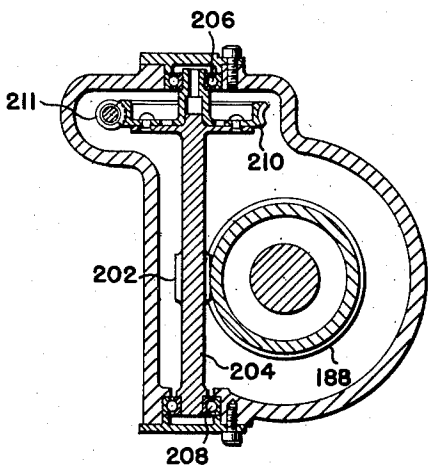


FIG. 4.

INVENTOR.
OTTO E. SZEKELY
BY
Bacon and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 6

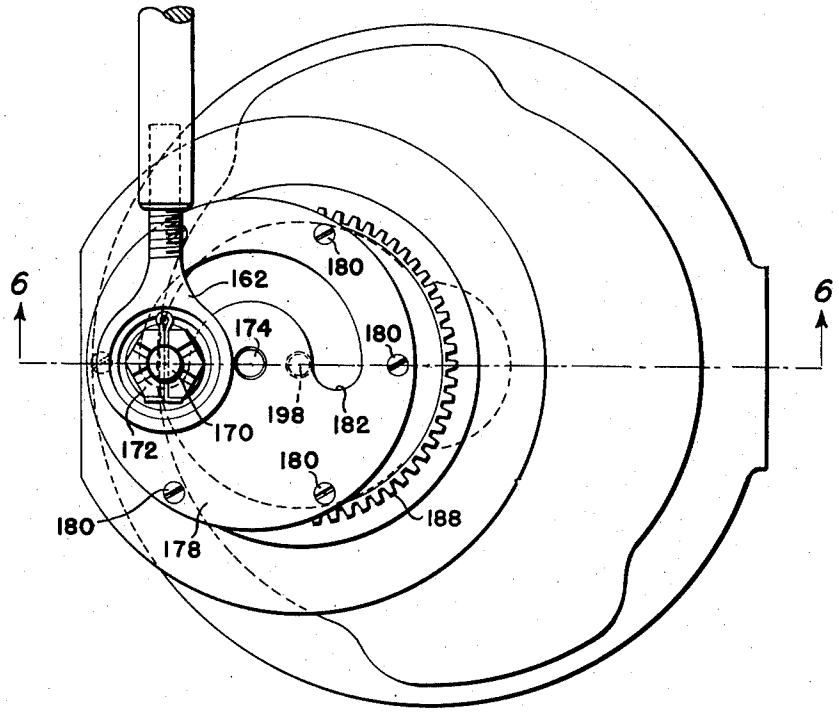


FIG. 5.

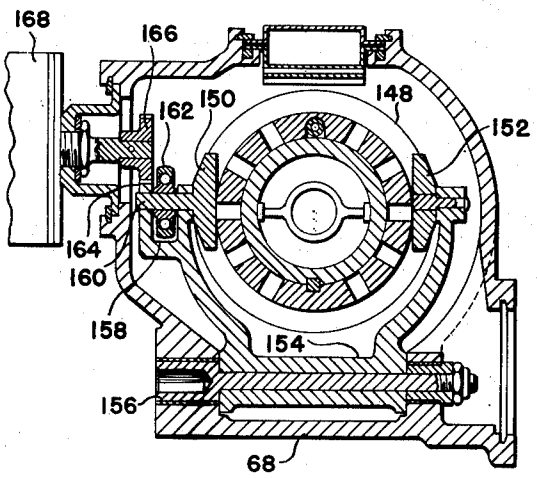


FIG 8

INVENTOR.
OTTO E. SZEKELY
BY
Russell and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 7

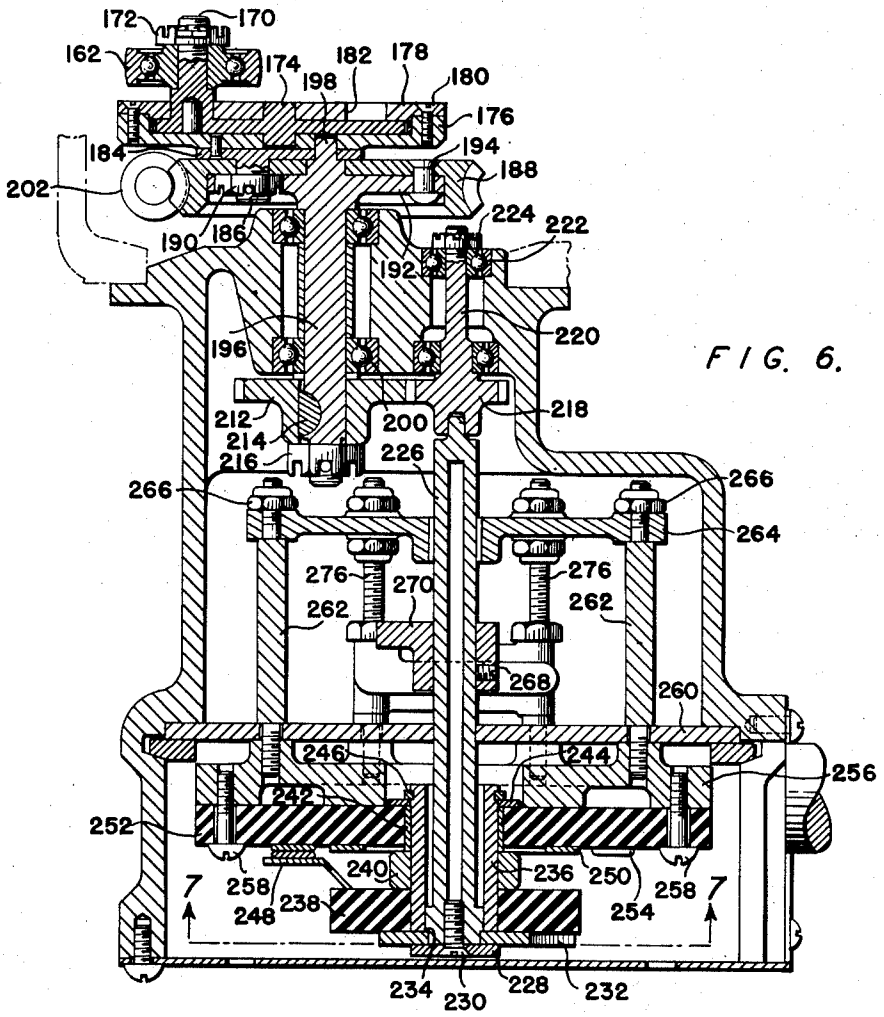


FIG. 6.

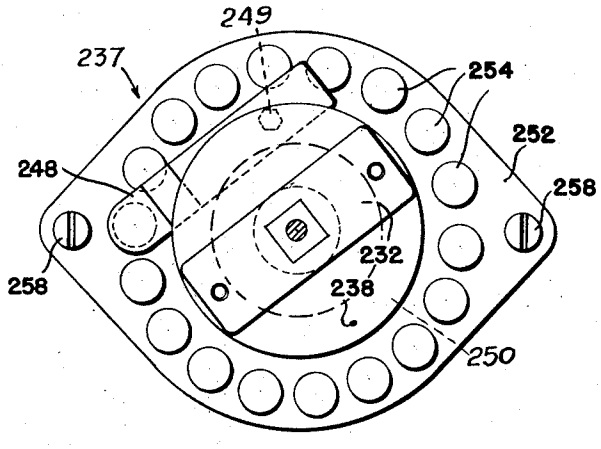


FIG 7

INVENTOR.
OTTO E. SZEKELY
BY
Brumer and Hardwig
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 8

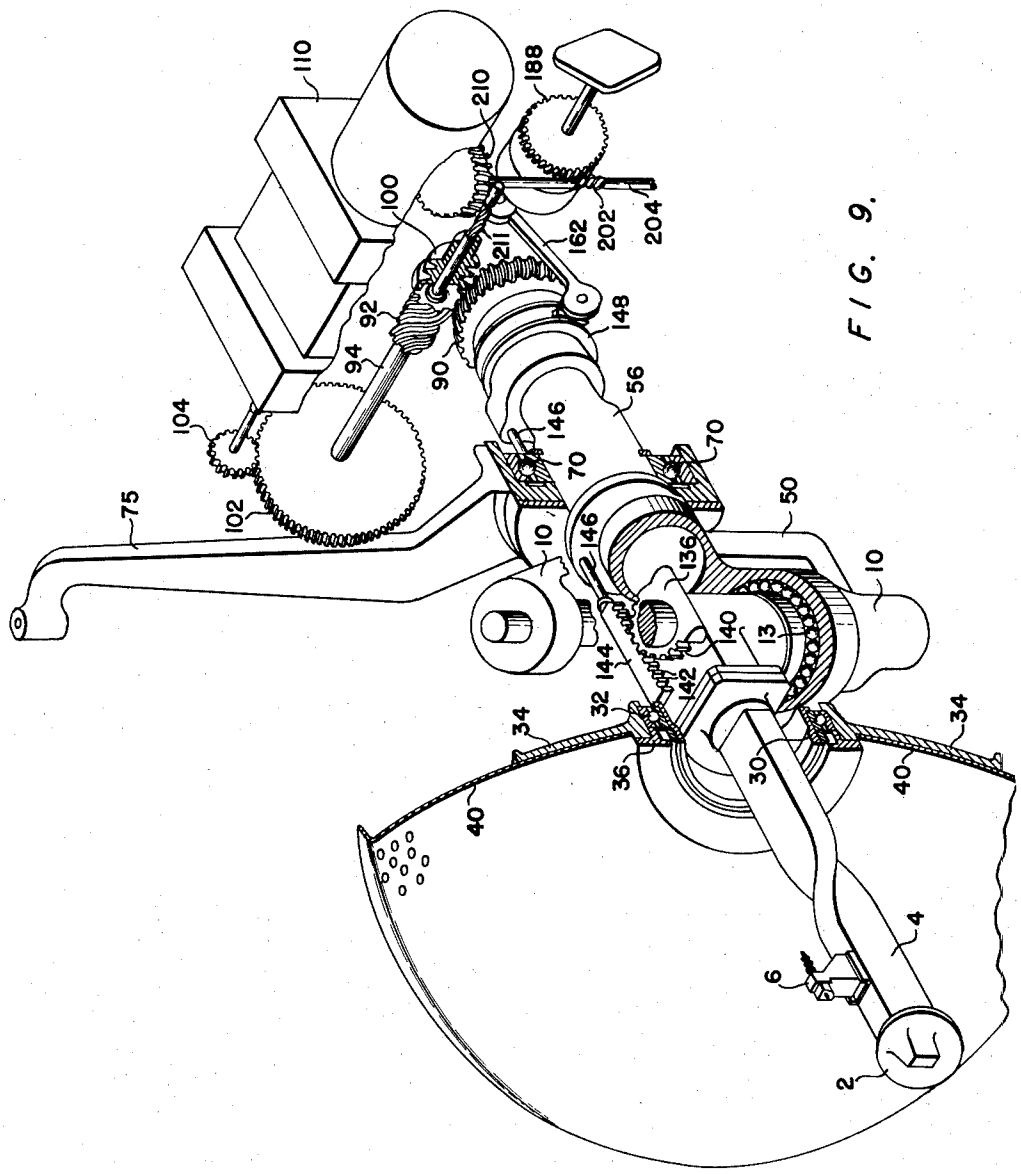


FIG. 9.

INVENTOR.
OTTO E. SZEKELY
BY
Bruesser and Harding
ATTORNEYS.

May 20, 1958 O. E. SZEKELY 2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Filed May 29, 1951 9 Sheets-Sheet 9

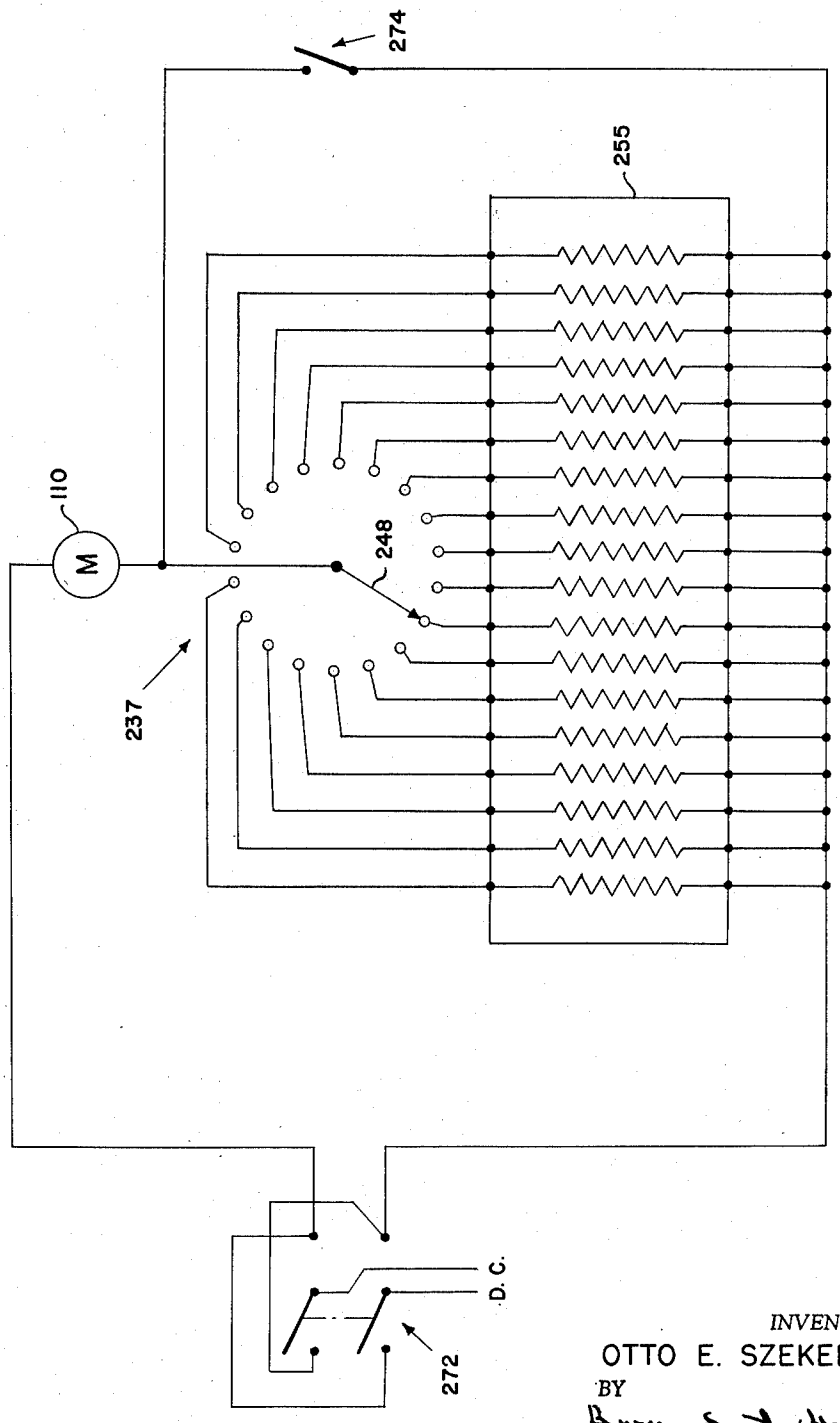


FIG. 10.

INVENTOR.
OTTO E. SZEKELY
BY
Brumm, Smith & Henderson
ATTORNEYS

United States Patent Office

2,835,892

Patented May 20, 1958

2,835,892

ANTENNA USING SINGLE MOTOR FOR ROTATION AND NOD

Otto E. Szekely, Philadelphia, Pa., assignor to O. E. Szekely & Associates, Inc., Philadelphia, Pa., a corporation of Pennsylvania

Application May 29, 1951, Serial No. 228,951

4 Claims. (Cl. 343—766)

This invention relates to an improved radar antenna for use in aircraft.

The essential features of an aircraft radar antenna consist of a spindle which carries a wave guide on which is mounted a source of primary feed, such as a cutler type primary feed that emits electronic rays and a parabolic reflector that directs the rays out and receives the returning reflected rays. The returning rays which impinge on the reflector are carried to a screen and thus present a picture of the objects from which the rays have been reflected.

In order that the maximum area may be covered, the spindle, the wave guide, the cutler feed and the reflector are driven by a mechanism which causes them to rotate and to have azimuth angular deflection. Azimuth angular deflection is frequently called nod or scan.

The spindle may rotate and nod or scan at the same time. When this occurs, the wave guide, the cutler feed and the reflector move through a spiral configuration. Thus they scan a cone of volume directly forward of the airplane. This motion is continuous and rapid since the spindle, wave guide and reflector may rotate at speeds up to 1200 R. P. M.

A reduction in the power required to drive this mechanism results in a reduction in the weight and cost of the driving mechanism. The power is required to drive electric generators to provide current for electric motors. These motors, in turn, drive mechanical mechanisms such as gears, shafts, racks and pinions to carry out the functions as described above. Therefore, it is evident that any reduction in the power required will result in substantial savings in cost, weight and size of the mechanism since all items such as generators, motors and mechanical mechanisms are reduced in proportion to the reduced power requirement. Reduction in weight and size is of utmost importance in all airborne equipment.

Heretofore, it has been considered necessary to drive the spindle in rotation by one motor and drive the nod by another motor. In addition to the weight, cost and complications of two motors, this dual motor arrangement has the even more serious disadvantage that, due to line voltage fluctuations, these drive motors vary in speed. Thus, the drive motor for rotation may speed up while the drive motor for nod may slow down or vice versa. Hence, the spiral configuration due to rotation and nod is unpredictable. With a single motor producing both rotation and nod, the configuration of the spiral, through which the spindle and reflector proceed, is uniform, and the overlap between the successive sweeps of scanning mechanism is always the same. This overlap insures that all of the volume contained in the field of view is investigated during a cycle of operation.

On wide scan, that is when the unit is noding as much at 130° (plus 65° and minus 65° from the straight ahead center line of the unit) and rotating for example at 1200 R. P. M., the motion of the spindle, the wave guide, the cutler feed and the reflector is extremely rapid near the point of extreme angular deflection. This motion is so rapid that even with electronic pulses at the rate of 570–4000 per second, so few returning pulses may be received that the electronic signal may decay before the following signal is received. When this occurs, no image appears on the screen and the target will not be seen at all.

It is, therefore, an object of this invention to provide an improved radar antenna in which the spindle, wave guide, cutler feed and reflector are driven in both rotation and nod by a single drive motor.

It is a further object of this invention to provide an improved radar antenna, having a single drive motor for both rotation and nod, which can be shifted from wide to narrow scan by reversing the direction of rotation of the drive motor.

It is a further object of this invention to provide an improved radar antenna, having a single drive motor for both rotation and nod, in which a novel shifting mechanism is employed for shifting from wide to narrow scan.

It is a further object of this invention to provide an improved radar antenna, having a single drive motor for both rotation and nod, in which a speed control device is employed which reduces the speed of the drive motor in proportion to the cosecant of the nod angle. This reduces the speed of the motion of the unit at the point of extreme angular deflection in wide scan to such an extent that a minimum of three successive hits are obtained on a target. This insures the production of an image of the target on the screen when the target is viewed near the point of extreme angular deflection of the unit.

The accompanying drawings are illustrative of one embodiment of this invention, in which:

Figure 1A is a side view of the left-hand portion of the improved radar antenna showing the parts broken away.

Figure 1B is a side view of the right-hand portion of the improved radar antenna showing the parts broken away.

Figure 2A is a top view of the left-hand portion of the improved radar antenna showing the parts broken away.

Figure 2B is a top view of the right-hand portion of the improved radar antenna showing the parts broken away.

Figure 3 is a sectional view taken on line 3—3 of Figure 1B.

Figure 4 is a sectional view taken on line 4—4 of Figure 3.

Figure 5 is an end view of the shifting mechanism taken on line 5—5 of Figure 2B.

Figure 6 is a sectional view taken on line 6—6 of Figure 5.

Figure 7 is an end view of the speed control unit taken on line 7—7 of Figure 6.

Figure 8 is a sectional view taken on line 8—8 of Figure 1B.

Figure 9 is a schematic perspective view of the complete improved radar antenna.

Figure 10 is a wiring diagram showing electrical connections between elements of the speed control apparatus.

Referring specifically to Figure 1A, cutler feed **2** is mounted on the end of wave guide **4**. Wave guide **4** has dipole **6** mounted thereon and is joined at its right-hand end to azimuth pinion **8**, as shown at **7**. Azimuth pinion **8** is journalled in supporting bracket **10** on bearings **13** and **14**. Secured to the top of azimuth pinion **8** as by press fitting, welding or other convenient means, is weight frame **12**. Weight frame **12** is rotatably mounted on supporting bracket **10** at the bottom thereof, as

viewed in Figure 1A, by pin **15** which engages bearings **16**.

As best seen in Figure 2A, weight frame **12** has two ears **18** and **20** projecting from the front thereof, having two holes therein for the reception of bearing sleeves **22** and **24**, respectively. Journalled in bearing sleeves **22** and **24** are headed machine bolts **26** and **28** respectively, each of said bolts being threaded into reflector supporting bracket **30**. Mounted on reflector supporting bracket **30** are bearings **32** which support reflector backing plate **34**. Reflector backing plate **34** is secured to bearings **32** by cap member **36** and bolts **38**. Secured to reflector backing plate **34** is perforated parabolic reflector **40** which may be secured to the backing plate as by rivets **42** or other convenient means.

Details of the rotatable mounting of the parabolic reflector are disclosed and claimed in my copending application, Serial No. 223,216, filed April 27, 1951, now issued as Patent No. 2,653,240, dated September 22, 1953.

Referring again to Figure 1A, wave guide **4** has a passage **44** therein which connects with passage **46** through azimuth pinion **8**. Supporting bracket **10** has an aperture **48** for the reception of one end of elbow **50** which connects with passage **46** in azimuth pinion **8**. Elbow **50** at its other end is received in aperture **52** formed in supporting bracket **10** and connects with passage **54** in hollow spindle **56**.

As best seen in Figure 2B, passage **54** in hollow spindle **56** connects with passage **58** in stationary housing end plate **60**. End plate **60** has a tube **62** received in an aperture therein having passageway **64** therethrough.

Referring specifically to Figure 1B, azimuth pinion supporting bracket **10** is fixedly secured to hollow spindle **56** as by pin **66**. Hollow spindle **56** is journalled in housing **68** on bearings **70** and **72**. Bearings **70** are supported by housing end plate **74** having sealing gasket **76** mounted therein. Housing end plate **74** is supported by bracket **75**. Bracket **75** may be affixed to an aircraft by any desired means. Housing **68** may be secured to end plate **74** as by machine bolts **77**. Mounted adjacent end plate **74** is breather **78**.

Mounted on the upper right-hand end of housing **68**, as viewed in Figure 1B, is tilt motor **80**. Tilt motor **80** has a pinion **82** mounted thereon which engages rack **84**, the purpose of which is to shift collar **86** on hollow spindle **56**. Shifting collar **86** is rotatably mounted on spindle **56** and has a rod **88** attached thereto which engages a tilting fork, not shown, which is mounted in azimuth pinion **8**. The purpose of tilt motor **80** is to tilt the reflector in a vertical plane when the mechanism is nodding only.

Fixedly secured to spindle **56** is spindle drive gear **90** which meshes with worm gear **92**, said worm gear being rotatably mounted on cross-shaft **94**. Mounted below spindle drive gear **90** is indexing solenoid **96**, the purpose of which is to index spindle **56** so that dipole **6** is in the vertical position when the spindle is stationary.

Referring specifically to Figure 3, worm gear **92** is rotatably mounted on shaft **94**, said shaft being journalled in housing **68** on bearings **96** and **98**. Splined to shaft **94** is clutch **100**, which is actuated by a solenoid, not shown. The purpose of clutch **100** is to engage worm gear **92** for rotation with shaft **94**. Shaft **94** has gear **102** mounted at the right-hand end thereof as viewed in Figure 3, said gear meshing with gear **104**. Gear **104** is supported by bearings **106** and **108**. Gear **104** is slotted at its left-hand end and is engaged by a tongue on the drive shaft of main drive motor **110**, as shown at **112**. Main drive motor **110** is a direct current compound wound reversible motor. Mounted at the top left-hand end of the main drive motor **110**, as shown in Figure 3, is conduit fitting **114** which carries wires which may be joined to a source of current. Affixed to housing **68** at its lower right-hand side thereof, as viewed in Figure 3, is azimuth potentiometer **116**, the purpose of which is to determine the magnitude of the sweep on the oscilloscope. The gearing arrangement for driving potentiometer **116** is not shown.

Referring specifically to Figure 2B, tilt potentiometer **118** is mounted adjacent the top right-hand end of housing **68**. Potentiometer **118** is actuated by shaft **120**, having gear **122** thereon. Gear **122** meshes with gear **124**, which is journalled in bearings **126** and **128**. Gear **124** has a gear **132** affixed thereto which is rotated by a rack mounted on shifting fork **134**.

Referring specifically to Figure 2A, azimuth pinion **8** has a collar **136** mounted thereon, said collar being secured to pinion **8** by machine bolt **138**. Collar **136** has teeth **140** cut therein, said teeth engaging with corresponding teeth **142** on rack **144**. Rack **144** has rod **146** threadedly received in the end thereof, the other end of rod **146** being threaded into shifting collar **148**. Shifting collar **148** is rotatably mounted on hollow spindle **56**.

As best seen in Figure 8, shifting collar **148** is engaged by two bearing members **150** and **152**, respectively, which are supported by shifting fork **154**. Shifting fork **154** is rotatably secured to housing **68** by headed machine bolt **156**. Shifting fork **154** is provided with a slot **158** in the left arm thereof, as viewed in Figure 8. The left arm of the fork is provided with a pair of apertures on either side of the slot **158**, for the reception of stem **160** of bearing member **150**. Mounted on stem **160** by means of bearings is one end of a connecting rod **162**. On the top left-hand side of the slotted left fork arm are provided rack teeth **164** which mesh with corresponding teeth on gear **166**. Gear **166** is mounted on the shaft of generator potentiometer **168**, the purpose of which is to maintain the generator output constant, irrespective of changes in the speed of the drive motor.

As will be seen from Figure 2B, connecting rod **162** is made in three parts and a sleeve is provided intermediate the ends thereof so that the length of the connecting rod may be varied by threading one end into the sleeve.

Connecting rod **162** is driven by stud **170**, as best shown in Figures 5 and 6. Connecting rod **162** is supported on stud **170** by bearings, and is secured thereto by castellated nut **172**. Threaded stud **170** is formed integral with a slidable plate **174**, which is interposed between plates **176** and **178**. Plates **176** and **178** may be joined together as by screws **180**. Plate **178** has a U-shaped opening **182** formed therein and it will be seen from Figure 5 that stud **170**, made integral with slidable member **174**, is driven from one end of slot **182** to the other as the direction of rotation of plate **178** is reversed. Secured to plate **176** is plate **184**, having threaded stud **186** formed integral therewith, said plate **184** being secured to gear **188** by a castellated nut **190**. Gear **188** is secured to member **192** as by pins **194**, said member **192** being formed integral with shaft **196**. Shaft **196** has a pilot **198** at the end thereof which projects through gear **188**, plate **184** and into plate **176**, thus helping to secure these members together.

Thus, it will be seen from the foregoing description that plates **176** and **178**, having slidable member **174** interposed therebetween, are mounted eccentrically with respect to shaft **196**. Thus it will be seen that as the direction of rotation of member **176** and **178** is reversed, stud **170** will be caused to shift to the opposite end of slot **182**. For example, if the device is turned clockwise, as viewed in Figure 5, the length of the crank arm driving the connecting rod **162** will be from the center of shaft **196** to the center of threaded stud **170**. If the direction of rotation is reversed so that the plate **178** rotates in a counter-clockwise direction, as viewed in Figure 5, threaded stud **170** will shift to the opposite end of slot **182**, as viewed in Figure 5, and the length

of the crank arm from the center of shaft **196** to the center of stud **170** will be reduced as a result of the eccentric mounting of plates **176** and **178** with respect to shaft **196**. Due to the fact that connecting rod **162** actuates shifting collar **148**, rod **146** and rack **144**, which turns azimuth pinion **8** about its vertical axis as viewed in Figure 1A, it will be appreciated that the azimuth angular deflection of the wave guide and reflector will be reduced.

Shaft **196** is journalled in bearings **200**. Meshing with gear **188** is worm gear **202**, cut on shaft **204**, as best shown in Figure 4. Shaft **204** is journalled at its upper and lower ends in bearings **206** and **208**, respectively. Mounted on the top of shaft **204** is gear **210** which meshes with worm gear teeth **211** cut on shaft **94**.

Thus it will be seen that the rotation of shaft **94** serves to rotate spindle **56**, when clutch **100** is engaged, and also drives wave guide **4** and reflector **40** through azimuth angular deflection or nod due to the drive through shaft **204**, gear **188**, stud **170**, connecting rod **162**, shifting collar **148**, rack **144** and collar **136**, mounted on azimuth pinion **8**.

Shaft **196**, at the lower end thereof, as viewed in Figure 6, has a gear **212** secured thereto by key **214**. Shaft **196** is threaded at its lower end and has castellated nut **216** mounted thereon. Gear **212** meshes with gear **218** formed integral with shaft **220**. Shaft **220** is journalled in bearings **222** and is threaded at its upper end to receive castellated nut **224**. Gear **218** has a slot at the lower end thereof, as viewed in Figure 6, to receive a tongue portion of drive shaft **226** to the speed control unit. Shaft **226** at its lower end, as viewed in Figure 6, has a cap plate **228** secured thereto by machine bolt **230**. Cap plate **228** holds backing plate **232** in engagement with shoulder **234** formed on shaft **226**. Shaft **226** has a collar **236** mounted thereon which supports insulating ring **238** and spacer member **240**. Collar **236** is supported at its upper end, as viewed in Figure 6, by bearing sleeve **242**, and is secured at its upper end by bearing plate **244** and spring collar **246**.

A rotating switch indicated generally at **237** in Figures 7 and 10 includes, as best shown in Figures 6 and 7, a contact arm **248** secured to an insulating ring **238**. The contact arm **248** mounts a member **249** engaging a slip ring **250** mounted on insulating ring **252**, said ring **252** also supporting a plurality of contact buttons **254** which are engaged by the other end of arm **248**. Contact buttons **254** and slip ring **250** are connected by means of wires to a resistor box **255** shown in Figure **10** having a plurality of resistors therein for a purpose to be hereinafter described. Insulating ring **252** is secured to supporting member **256** by bolts **258**. Member **256** is secured to plate **260** by a plurality of threaded studs **262**, said threaded studs being secured to plate **264** by nuts **266**. Secured to shaft **226** by screw **268** is cam **270**. As shaft **226** rotates, cam **270** trips two micro-switches **272** and **274**, as best shown in Figure 2B. Micro-switches **272** and **274** are supported by threaded studs **276**. The purpose of these micro-switches will be hereinafter described.

The operation of the device is as follows:

Assuming that it is desired to drive the radar antenna in rotation and nod at wide scan, impulses are transmitted through passageway **64** and member **62**, passageway **54** in hollow spindle **56**, through hollow elbow **50** through passageway **46** in azimuth pinion **8** and through passageway **44** in wave guide **4** and through cutler feed **2** against reflector **40**, from which they are directed forward of the antenna. It will be appreciated by those skilled in the art that received as well as transmitted impulses pass through this same channel. Drive motor **110** is energized and due to the driving connection between gear **104** and gear **102**, shaft **94** will be rotated. Clutch **100** will be engaged and worm gear **92** will drive main spindle drive gear **90** which will rotate spindle **56**, azimuth pinion **8**, wave guide **4** and cutler feed **2**. The rotation of shaft **94** will also rotate gear **210** affixed to shaft **204**, and worm gear **202** on shaft **204** will rotate gear **188**. Gear **188** will rotate plates **176** and **178** having slidable member **174** interposed therebetween and since stud **170** is formed integral with slidable plate **174**, it will also rotate and will reciprocate connecting rod **162**. It will be appreciated that in order to drive the mechanism in wide scan, stud **170** must be positioned in slot **182** as it is shown in Figure 5, since this arrangement provides a long crank arm from the center of rotation of shaft **196** to the center of stud **170**.

As connecting rod **162** reciprocates, it in turn, reciprocates shifting collar **148** rotatably mounted on spindle **56**. This results from the fact that connecting rod **162** is secured to shifting fork **154**, which has bearings engaging shifting collar **148**. Attached to shifting collar **148** is rod **146** having rack **144** secured thereto at its left-hand end, as viewed in Figure 2A. Rack **144** has teeth **142** thereon which engage with teeth **140** on collar **136** and since collar **136** is fixedly secured to azimuth pinion **8**, it will be appreciated that the reciprocation of shifting collar **148**, rod **146** and rack **144** will cause azimuth pinion **8** to rotate about its vertical axis, as viewed in Figure 1A. The reciprocating motion of rack **144** will cause the wave guide, cutler feed and reflector to move through an azimuth angular deflection or nod. Since spindle **56**, having azimuth pinion **8** and wave guide **4** affixed thereto, is rotated, it will be appreciated that the wave guide **4**, cutler feed **2** and reflector **40** will move through a spiral configuration. As gear **188** rotates, it, in turn, will rotate shaft **226** of the speed control unit, due to the driving connection between gears **212** and **218**. As shaft **226** rotates, arm **248**, mounted on insulating ring **238**, is caused to travel around button contacts **254** of switch **237**. Button contacts **254** are connected to a plurality of resistors and the resistor box **255** as shown in Figure 10 in such a manner that when the spindle, wave guide, cutler feed and reflector are near the point of extreme angular deflection, resistance is put in series with the drive motor, which serves to decrease the speed of the drive motor at the point of extreme angular deflection, thus insuring a sufficient decrease in speed of the drive motor so that a minimum of three successive hits are obtained on the target by the transmitted pulses. Also at the point of extreme angular deflection, micro-switch **272** is actuated by cam **270** to reverse the current to the motor for a short period in order to rapidly decrease the motor speed. The function of micro-switch **274** is to prevent the speed control unit from becoming operative until the device is rotating at the desired speed. These functions of the switches **272** and **274** are made evident by the wiring diagram of Figure 10.

Resistance is added in series with the drive motor by the rotation of shaft **226** having arm **248** affixed thereto so that the speed of the drive motor is reduced in proportion to the cosecant of the nod angle of the spindle, wave guide and reflector.

When it is desired to operate the antenna on narrow scan, drive motor **110** is reversed and it will be appreciated that this reversal causes a similar reversal in the direction of rotation of shaft **94** and spindle **56**. Also, gear **188** will be driven in the opposite direction, which will cause stud **170** to travel to the opposite end of slot **182**, from the position shown in Figure 5. This will shorten the crank arm from the center of rotation of shaft **196** to the center of stud **170**, which will, in turn, decrease the travel of shifting collar **148** and rack **144**. Hence, rack **144** will drive azimuth pinion **8** through a smaller angular deflection than is the case when stud **170** is positioned in slot **182**, as shown in Figure 5.

It will be appreciated that when operating on narrow scan, the nod angle may be reduced as much as desired

by the proper positioning of slot **182**, relative to shaft **196**. If the nod angle is sufficiently reduced, the speed of the spindle, wave guide, cutler feed and reflector may be reduced sufficiently so that it is not necessary to add resistance in series to the drive motor at the point of extreme angular deflection. Thus, when operating on narrow scan, the speed control unit may not be used if the nod angle is sufficiently reduced.

From the foregoing description it will be appreciated that the improved radar antenna provides for the elimination of one of the motors commonly used in radar antennae which perform a similar function. By the device of the present invention, a radar antenna may be driven in both rotation and nod by a single drive motor, thus eliminating the weight of the additional motor and, at the same time, insuring that the configuration of the spiral through which the spindle and the reflector proceed is uniform and that the overlap between the successive sweeps of the scanning mechanism is always the same. This results from the fact that the speed differences between the two motors formerly used, due to line voltage fluctuations, have been completely eliminated due to the fact that only a single motor is employed.

Further, the device of the present invention provides for driving a radar antenna in both rotation and nod, and also for shifting from wide to narrow scan, using only a single drive motor. The device is shifted from wide to narrow scan by the simple expedient of reversing the drive motor, which decreases the nod angle as a result of the shortening of the crank arm, which actuates the rack in engagement with the azimuth pinion.

The radar antenna of the present invention also provides for a better picture due to the action of the speed control unit, which serves to decrease the speed of the drive motor when a target is viewed near the point of extreme angular deflection of the unit.

It will be appreciated by those skilled in the art that various modifications may be made within the scope of this invention without departing from the spirit thereof and the scope of the invention is to be restricted only in accordance with the appended claims.

What is claimed is:

1. A radar antenna comprising a rotatable spindle, means mounting a wave guide and reflector on said rotatable spindle, said mounting means being pivotable on an axis substantially perpendicular to the axis of said spindle, a reversible motor, drive means connecting said motor to said spindle to rotate said spindle, means connecting said motor to said mounting means to oscillate said mounting means and nod the wave guide and reflector and including means actuated by reversing the drive motor for varying the angle of said oscillation.

2. A radar antenna comprising a rotatable spindle, means mounting a wave guide and reflector on said rotatable spindle, said mounting means being pivotable on an axis substantially perpendicular to the axis of said spindle, a reversible motor, drive means connecting said motor to said spindle to rotate said spindle, means including a crank connecting said motor to said mounting means to oscillate said mounting means and nod the wave guide and reflector and including means actuated by reversing the drive motor for varying the angle of said oscillation.

3. A radar antenna comprising a rotatable spindle, means mounting a wave guide and reflector on said rotatable spindle, said mounting means being pivotable on an axis substantially perpendicular to the axis of said spindle, a reversible motor, drive means connecting said motor to said spindle to rotate said spindle, means connecting said motor to said mounting means to oscillate said mounting means and nod the wave guide and reflector and means to reverse the current to said motor to rapidly decrease the speed of the motor in the range of maximum nod.

4. A radar antenna comprising a rotatable spindle, means mounting a wave guide and reflector on said rotatable spindle, said mounting means being pivotable on an axis substantially perpendicular to the axis of said spindle, a reversible motor, drive means connecting said motor to said spindle to rotate said spindle, means connecting said motor to said mounting means to oscillate said mounting means and nod the wave guide and reflector and speed control means for decreasing the speed of said motor in proportion to the cosecant of the nod angle by adding successive resistances in series with the motor as the nod angle increases.

References Cited in the file of this patent

UNITED STATES PATENTS

312,709	De Valin	Feb. 24, 1885
1,779,981	Nickerson	Oct. 28, 1930
2,407,305	Langstroth	Sept. 10, 1946
2,452,916	Fleischmann	Nov. 2, 1948
2,518,511	White	Aug. 15, 1950
2,543,188	Moseley	Feb. 27, 1951
2,552,566	Levine	May 15, 1951
2,566,843	Lappin et al.	Sept. 4, 1951
2,576,836	Hilsinger	Nov. 27, 1951
2,590,540	Jackson	Mar. 25, 1952