

Aug. 15, 1950

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SCANNER

2,518,511

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Fig. 2.

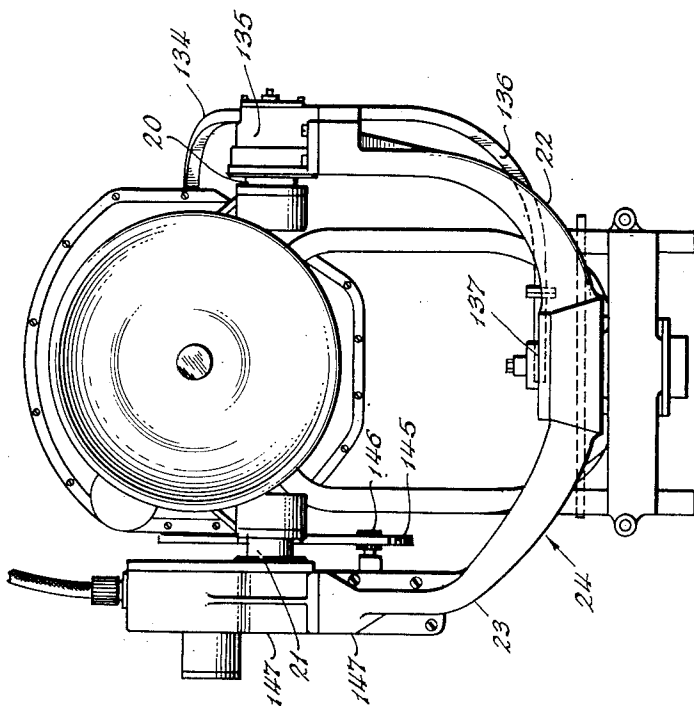
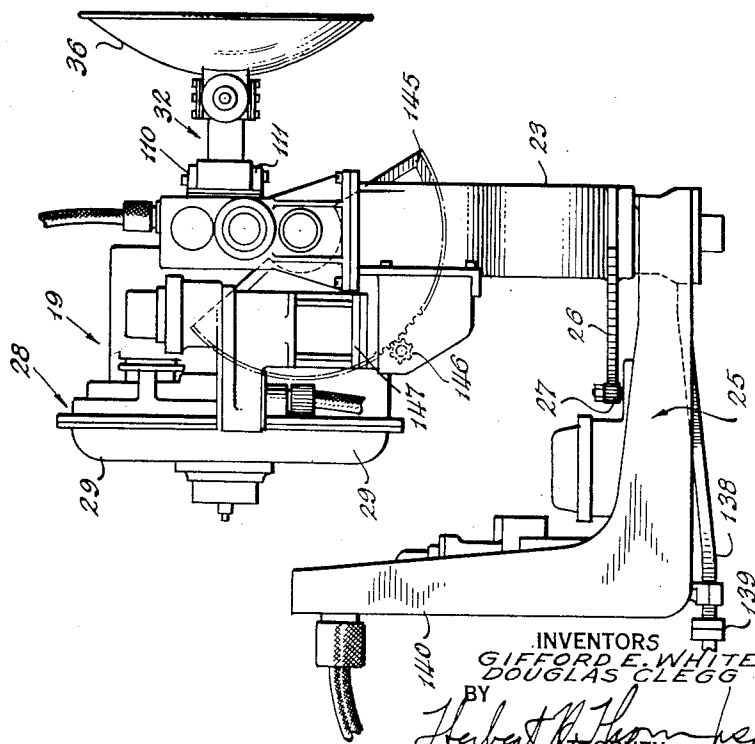


Fig. 1.



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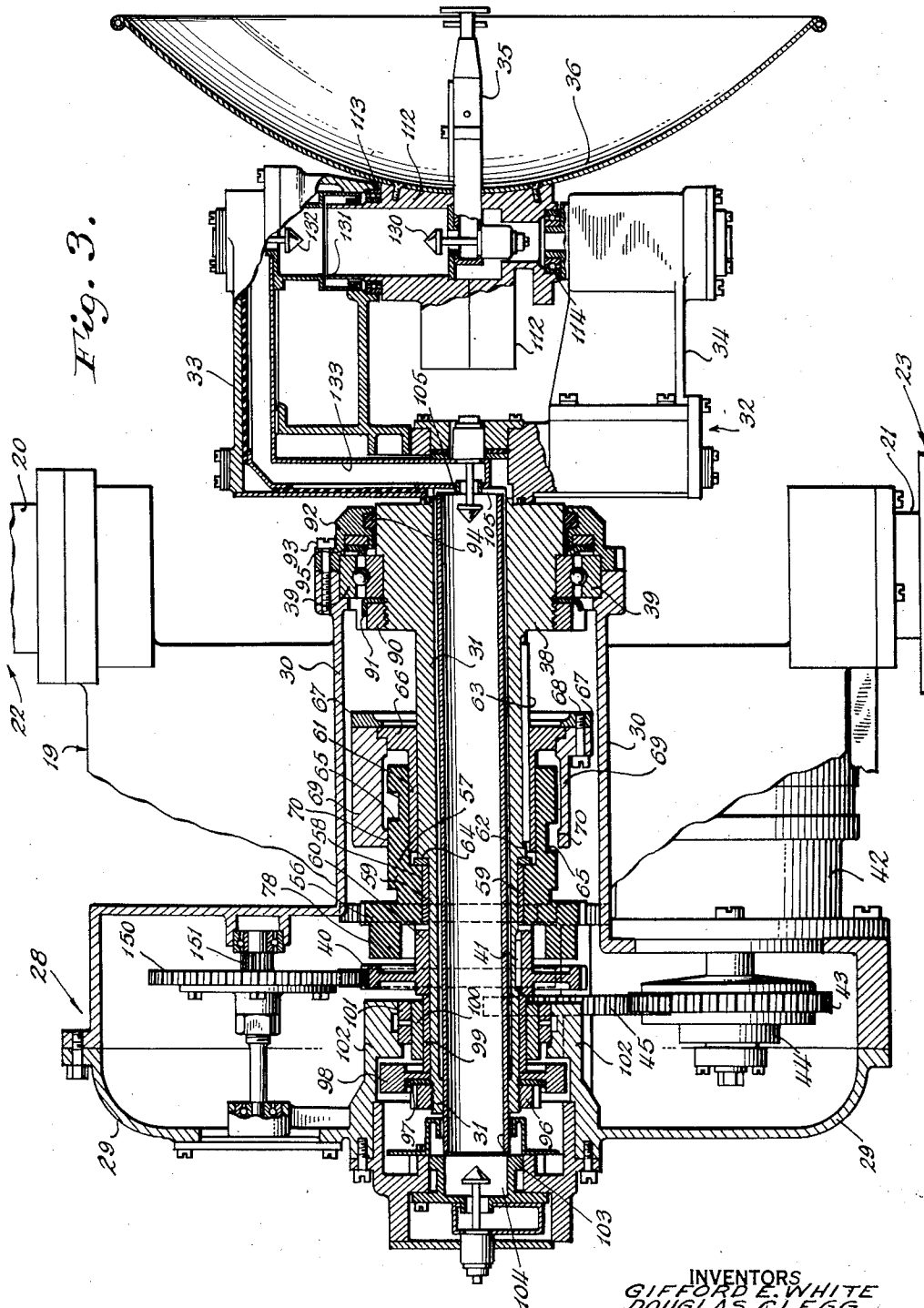
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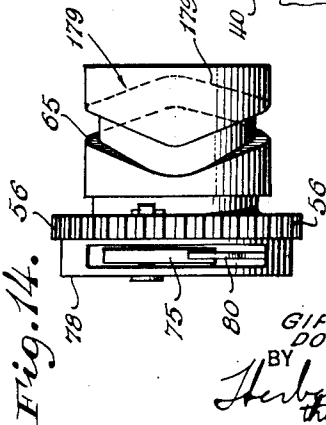
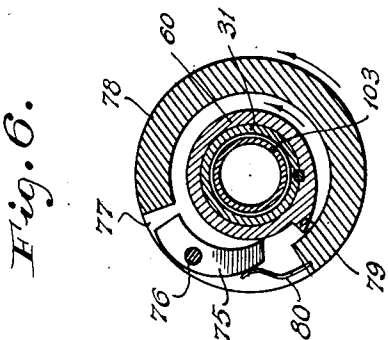
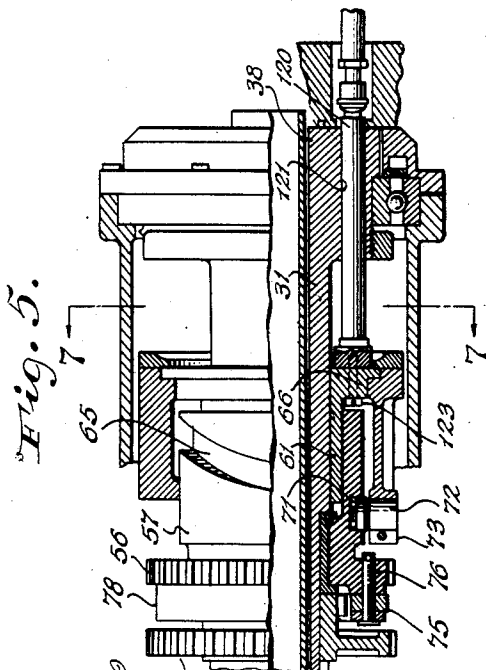
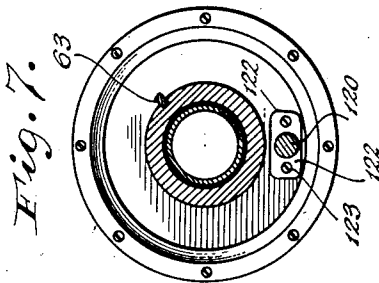
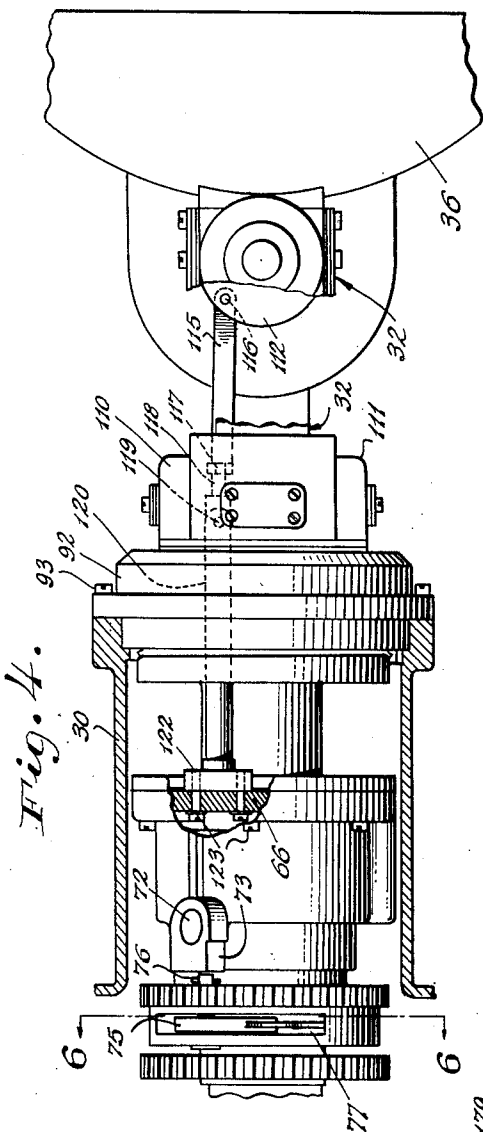
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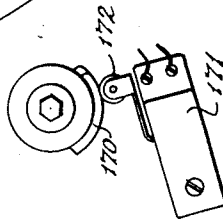
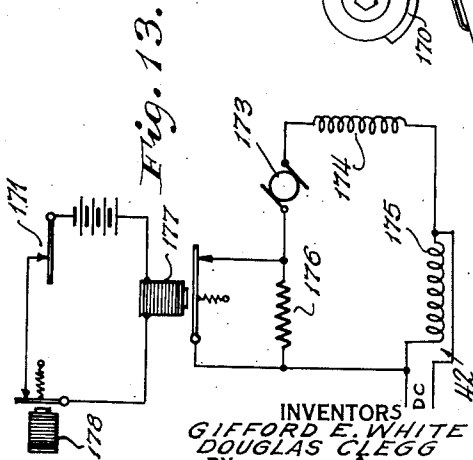
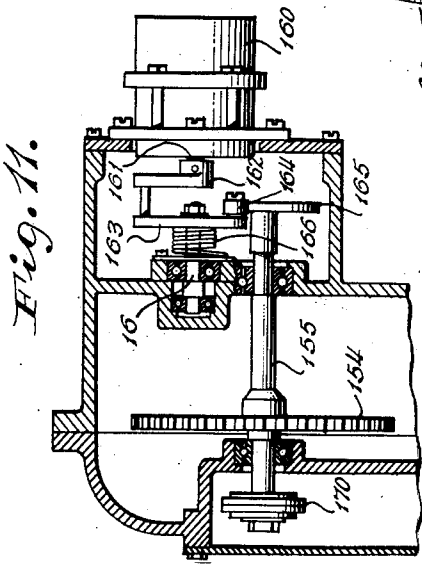
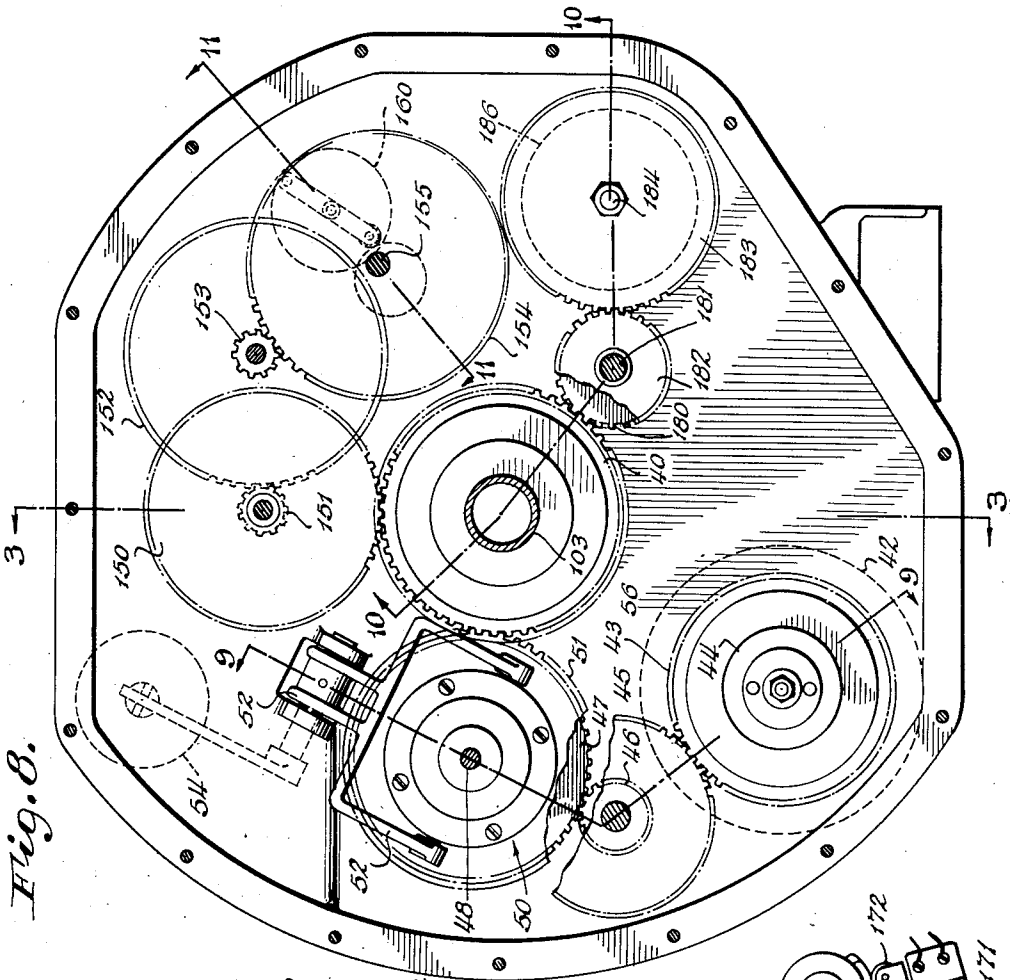
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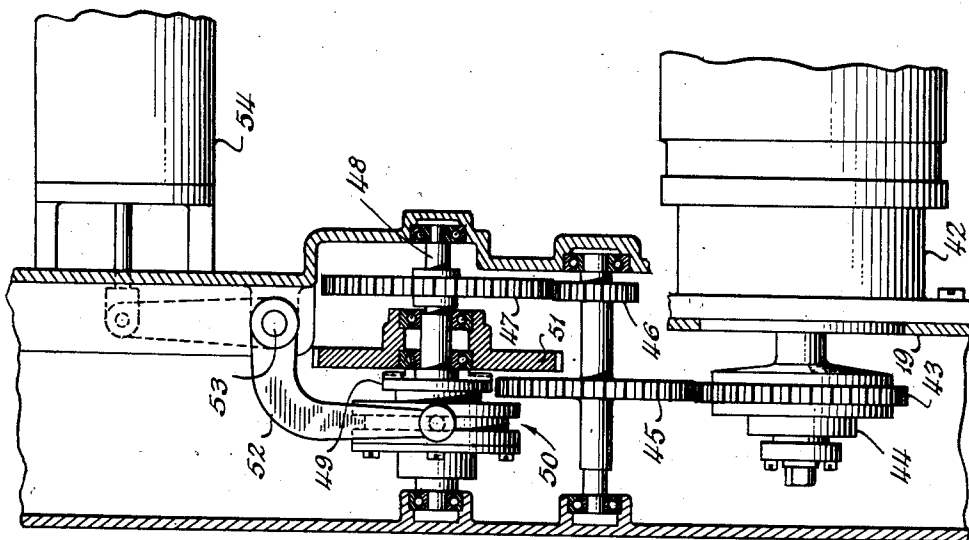


Fig. 9.

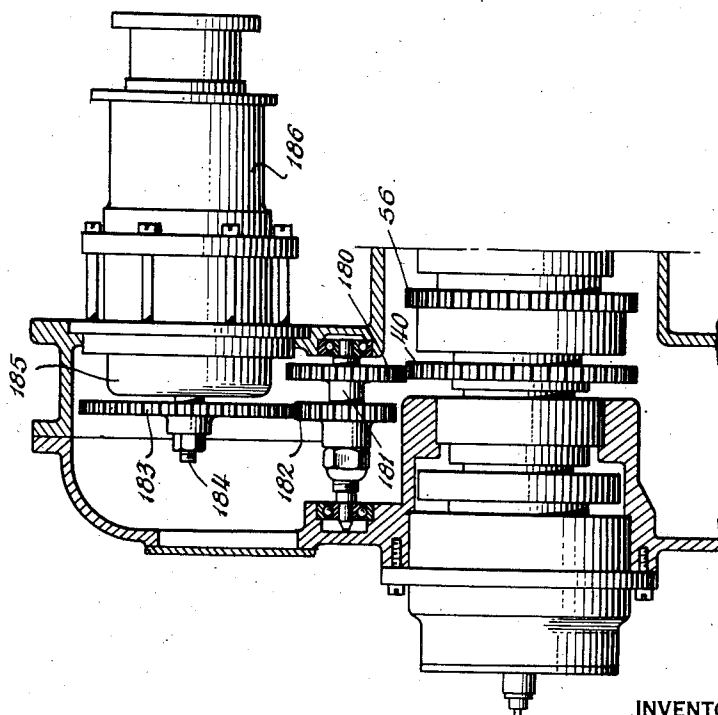


Fig. 10.

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UNITED STATES PATENT OFFICE

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14 Claims. (Cl. 250—33.65)

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This invention relates to a scanning device and more particularly to a scanning device for projecting and scanning radiant energy beams.

An object of the invention is to provide a scanning device of simplified construction having greater efficiency than former scanning devices of the kind.

The invention contemplates an arrangement for projecting a sharply directed beam from a suitable antenna or other projecting device which is rotated about a spin axis for what is generally described as a tracking operation, a further nodding motion being imparted to the projecting device for searching operations. The nodding motion causes a solid angle of radiant energy to be transmitted in a series of spiral paths usually of a substantially conical shape whereby with suitable auxiliary apparatus an object within the area of the cone may be located and thereafter tracked by the apparatus. These operations are described in the copending application Serial No. 438,388 of Leon A. Maybarduk, et al., filed April 10, 1942, now Patent No. 2,410,831 granted November 12, 1946. The present invention is directed particularly to an improved mechanism for spinning and imparting a nod motion to an antenna arrangement.

Another object of the invention is to provide a scanning device in which the number of moving parts of the spinning mechanism has been considerably reduced as compared with former devices of the kind and which can be made of small size and light weight for use on aircraft.

Still another object is the provision of an improved nod mechanism which allows a much faster and more positive return from any position in spiral scan to tracking than did previous mechanisms of the kind.

A further object is the provision of a novel and simplified mechanism for aligning the antenna automatically with respect to the spin axis on changing from spiral scan to track.

A still further object is the provision of an automatic speed regulating arrangement by which the rotary speed of the antenna is retarded at the larger nod angles to provide closer scanning in the outer areas of the spiral path of the antenna.

Other objects will appear in the following description given with the aid of the accompanying drawings, of which

Fig. 1 is a side view of the scanning mechanism and its support;

Fig. 2 is an elevational view of the scanning mechanism and support;

Fig. 3 is a plan view, partly in sections, the section being taken through 3—3 of Fig. 8;

Figs. 4 and 5 are views showing details of the nod mechanism;

Fig. 6 is a view of the overrunning clutch, partly in section, the section being through 6—6 of Fig. 4;

Fig. 7 is a view in section of the nod mechanism, the section being taken through 7—7 of Fig. 5;

Fig. 8 is a view of the gear assembly for rotating the antenna, and also of the clutch mechanism for selectively controlling spin and nod motions thereof, as well as other pick off gears driven from the antenna drive assembly;

Fig. 9 is a sectional view taken through 9—9 of Fig. 8 showing details of the clutch mechanism for selectively controlling spin and nod movements, and also the gearing connecting the drive motor therewith;

Fig. 10 is a sectional view taken through 10—10 of Fig. 8 showing the gear arrangement by which reference current generators are driven from the spin mechanism;

Fig. 11 is a sectional view through 11—11 of Fig. 8 which shows the cam drive for a nod reference generator;

Fig. 12 shows a cam operated switch for controlling the speed of the driving motor;

Fig. 13 is a circuit diagram for the motor speed control; and

Fig. 14 shows the nod cam.

Referring to Figs. 1 and 2, casing 19 encloses and supports the rotary members of the scanning mechanism. The casing is supported substantially in balance by trunnions 20 and 21 between the arms 22 and 23 of yoke 24 mounted for rotary azimuth movement in suitable bearings on a base 25. The yoke may be turned in azimuth by any suitable means, a gear sector 26 secured to the yoke and driven by gear 27 of a suitable servo motor being shown for the purpose in the drawings.

Casing 19, Fig. 3, is an irregularly shaped casting preferably of a light metal having a head portion 28 provided with a cover 29, the head comprising an approximately flat circular cavity. A tubular section 30 of the casing projects from the midsection of the head and encloses a rotary sleeve 31 driven by gearing disposed within the head near one end of the sleeve. An enlarged end portion 32 of the sleeve, arranged to turn in bearings 39 suitably sealed against dust and moisture, supports, beyond the end of tubular section 30, a yoke 32 provided with arms 33 and

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34 having near their ends aligned bearings in which a support for an antenna 35 and a reflector therefor are free to nod, under control of mechanism to be described, while the yoke and sleeve 31 are rotating.

The driving gear 40 for the sleeve 31 is secured thereto by key 41, Fig. 3. The gear is turned by the following mechanism. A driving motor 42, Fig. 9, supported by casing 19 has a shaft carrying a gear 43, which is connected thereto by a friction clutch 44. Gear 43 drives gears 45, 46 and 47, the latter being fastened to shaft 48 to which is keyed the driving member 49 of a clutch 50, the driven member being formed on the side of gear 51 which is free to turn on the shaft when the clutch members are disengaged. Gear 51 is in mesh with gear 40 on the sleeve and turns the sleeve only when the clutch is engaged. The clutch is controlled by solenoid 54 supported by the casing. The solenoid controls a throw-off arm 52 attached to shaft 53 pivoted to the casing. With the arrangement shown, when the solenoid is energized, the throw-off arm slides the driving member 49 along shaft 48 disengaging it from the driven member. Suitable spring means, not shown, tends to hold the clutch in engagement.

Gear 47, as described, is driven constantly by motor 42 independently of the clutch. Gear 47 is in mesh with gear 56 secured to a cam sleeve 57 having a ring 58 formed on its inner surface which rides on a bushing 59 disposed on sleeve 31 spaced by a washer from a tubular extension 60 of gear 40. Gear 56 and the integrally formed sleeve 57 are free to turn with respect to gear 40 and sleeve 31 which are keyed together, but are restrained from axial movement by the ring 58, the edge of which engages a spacing washer which rests against a shoulder 64 on sleeve 31. A portion of cam sleeve 57 adjacent to inner ring 58 is formed with an enlarged bore and on the surface of sleeve 31 and extending into the bore is a flanged ring 61 provided with a longitudinal groove 62 formed on its inner surface which rides on a spline 63 on the outer surface of sleeve 31. The flanged ring, due to the spline arrangement turns with sleeve 31 but may move axially thereon under control of a cam mechanism about to be described.

A cam groove 65, Figs. 3 and 5, is formed in the outer surface of cam sleeve 57. Attached to the flange 66 of ring 61 by means of a clamping ring 67 and screws 68 is an annular member 69 having an inwardly extending ridge or ring 70 which rides on the surface of cam sleeve 57. A cam roller 71, Fig. 5, which rides in cam groove 65 is supported for rotation on a stud 72 secured by clamp 73 to annular member 69.

If gears 40 and 56 are driven at different relative speeds, then the cam sleeve and the cam roller will be rotating at different speeds about a common axis, referred to herein as the spin axis, thereby causing flanged ring 61 to reciprocate on spline 63. This axial movement of ring 61 is used to impart a nodding motion to the antenna by means of a reciprocating shaft, to be described further on. The mechanism for selectively controlling the nodding motion will now be described.

In a preferred embodiment of the invention, driving gears 40 and 56 are coupled together for tracking operations by means of an overrunning clutch. The clutch comprises a pawl 75, Figs. 4 to 6, pivoted on a stud 76 in a slot 77 formed in a ring 78 on the side of gear 56. The pawl cooperates with a single tooth 79 formed on sleeve

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60 attached to gear 40. A spring 80 urges pawl 77 into engagement with tooth 79.

The overrunning clutch operates as follows: Assuming that the gear ratios are such that gear 40 is turned more rapidly than gear 56 and that clutch 50, Fig. 9 is engaged so that both gears 40 and 56 are driven by motor 42, then, as indicated by the arrows of Fig. 6, both the pawl of gear 56 and the cooperating single tooth ratchet are turning in the same direction, but the gear carrying the tooth is turning at the greater rate, and the tooth passes under the pawl periodically, the overrunning clutch, under the circumstances being ineffective. As already described, due to the relative movement of gears 40 and 56, the cam mechanism will cause the flanged ring 61 to reciprocate to provide a nodding motion to the antenna.

When clutch 50 is disengaged, the nodding movement is eliminated as follows: Gear 51 no longer drives gear 40 to which clutch tooth 79 is attached, but gear 56 is still driven from the motor. Pawl 75 carried by gear 56 will engage tooth 79 and will cause sleeve 31 and the associated parts to turn therewith at the same rate, and since there is no relative motion of the cam groove and its roller, the nodding movement stops. Due to the single tooth arrangement of the clutch, sleeve 31 is always engaged in the same angular position, and in this position, the relation of the roller and cam groove is such that the antenna is maintained in alignment with the common spin axis of the members driven by gear 56 or at some desired angle with respect to this axis. Under these conditions the scanner may be used for so-called tracking operations.

When the solenoid 54 is deenergized, clutch 50 engages, and the nodding motion resumes as already described.

The novel nod and spin mechanism of the present invention is much simpler than former mechanisms of the kind. All spinning and nod movements are transmitted to the antenna support by but two gears, 40 and 56. No gears, racks, or rotary shafts are employed in the spinning portion of the mechanism, which, consequently, is greatly simplified and readily balanced. The clutch mechanism for selectively controlling gear 40 and the nod movement is stationary with respect to the spin mechanism and the operation of the clutch imposes no external load on the spinning mechanism. The antenna is automatically aligned with respect to the spin axis when the overrunning clutch is effective which simplifies the device by eliminating special means, such as detents and the like for holding the antenna in alignment with the spin axis when tracking takes place. The change from search to track and vice versa occurs immediately after the solenoid is operated one way or the other, the time required for the change from search to track being unaffected by the extent of the spiral movement of the antenna.

Sleeve 31 turns in bearing 39 held in position against a shoulder formed on the enlarged portion 38 of the sleeve by nut 90 which is threaded thereon. Between the nut and bearing is a soft washer 91. A cap 92 secured to the tubular extension 30 by screws 93 retains the bearing and sleeve against endwise movement. A soft washer 94 is inserted in the cap and other soft washers 95 are held by the cap against the side of the bearings to keep out dust and moisture and prevent oil leakage.

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The opposite end of sleeve 31 is threaded, and assembled thereon and held in place by nut 96 is a soft washer 97, a flange 98 and a bushing 99 separating the flange from the extension 60 of gear 40. Assembled on bushing 99 are a pair of rings 100 and 101 supported by a reentrant portion 102 of cover 29 which forms a support bearing for sleeve 31.

A tube 103, extending through sleeve 31 is associated with joints 104 and 105 at opposite ends thereof are a part of the high frequency plumbing. The following applications describe high frequency plumbing systems and elements thereof which might be used with the present scanning mechanism: Serial No. 441,188, of Holschuh, et al., filed April 30, 1942; Serial No. 471,780 of G. E. White, filed Jan. 8, 1943, now Patent No. 2,419,239 granted April 22, 1947; Serial No. 481,640, of Mallett, et al., filed April 2, 1943; Serial No. 447,524, filed June 18, 1942, now Patent No. 2,407,318 granted September 10, 1946; and Serial No. 462,434, filed Oct. 17, 1942, now Patent No. 2,429,640 granted October 28, 1947, both of Mieher, et al.

Yoke 32, which supports the antenna, is a hollow casting secured between spaced arms 110 and 111 fastened to the part 38 of sleeve 31, Fig. 4. A member 112, Fig. 3, which supports antenna 35 and reflector 36 is supported in bearing 113 and 114 held respectively by arms 33 and 34 of yoke 32.

As shown in Fig. 4, a rod 115 is pivoted at 116 to member 112, the pivot being eccentrically disposed with respect to bearings 113 so that endwise movement of the rod will cause a rocking of the antenna assembly in its bearings. Rod 115 is adjustable in length, a nut 117 on an extension 118 threaded into the rod being provided for adjustment purposes. Extension 118 is pivoted by pivot 119 to a shaft 120, Fig. 5, guided for reciprocation by a bearing 121 formed in the end portion 38 of sleeve 31. The end of rod 120 is coupled as shown in Figs. 4, 5 and 8 by cross piece 122 and screws 123 to the flange 66 of ring 61. By means of the reciprocating shaft arrangement just described connecting the ring 61 and the antenna assembly, the axial movement of the ring imparts a nodding movement to the antenna assembly, and when the axial movement of the ring ceases, the antenna assembly is held in a fixed position corresponding to that of the ring by the rod arrangement, and this, as already described is where the antenna is aligned with or substantially aligned with the spin axis, such position being adapted to be used for tracking purposes.

The joint 105 of the wave guide plumbing is connected to the antenna input member 130 through joint 131, member 132 and a bent tubular member 133. Rotary joint 104 at the opposite end of tube 103 is connected by a tubular conducting member 134, Fig. 2, through a rotary joint 135 associated with trunnion member 20 of the elevation axis to a tubular member 136 through a rotary joint 137 associated with the azimuth axis to a horizontal portion 138 of the plumbing to which at 139 suitable external circuits may be connected. The upwardly extending portion 140 of the base 25, Fig. 1 may be used to support control switches for the device, or a control panel.

In Fig. 2, an elevation gear sector 145 is shown attached to casing 19. The sector is positioned by gear 146 of a suitable servomotor arrangement 147 mounted on arm 23 of yoke 24 for turning the scanner in elevation.

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A rotary transformer 160 for furnishing a nod reference current is shown in Fig. 11 supported in a seat formed in the wall of casing 28 with the shaft 161 of its rotary member extending into the interior of the casing. The transformer may be rotated in its seat for phase adjustment purposes. A crank 162, mounted on shaft 161, enters an opening in one end of a lever 163 mounted on shaft 16. At the opposite end of lever 163, a roller 164 is mounted that acts as a cam follower for a cam 165 secured to shaft 155. Spring 166 holds the follower against the cam. Cam 165 is shaped to rock lever 163 in accordance with the variation of the nod angle of the antenna, and the lever effects a corresponding movement of the rotary member of the transformer with a resulting change in the transformer ratio. The nod cam is driven from gear 40, so consequently the operation of the cam depends on clutch 50 which controls the operation of gear 40. The cam and its shaft 144 are driven from gear 40 by a train of gears which mesh in the following order, best shown in Fig. 8. Gear 40 meshes with gear 150 and drives gears 151, 152, 153, 154 the latter being secured on shaft 155, Fig. 11.

The present invention provides for increased range and accuracy by scanning the outer areas of the cone more closely for a given normal spin rate than was possible with former scanners. This may be accomplished by decreasing the motor speed at the greater nod angles. Various means may be used for the purpose and an effective arrangement is shown in Figs. 11 and 12 where a cam 170 mounted on shaft 155 operates a switch 171 during a portion of its rotary cycle. In a preferred arrangement, the cam is designed to actuate the switch during the time the nod angle is greater than some predetermined angle, for example 45°.

Cam 170 operates switch 171 by means of a roller 172 that rides on the cam. One type of circuit arrangement for controlling the motor speed is shown in Fig. 13 where the contacts of the cam switch 171 are closed for the purpose of decreasing the speed of a conventional shunt wound motor having an armature 173, a series field 174, and a shunt field 175, operated from a source of direct current. Resistance 176 in the armature circuit is bridged by the tongue and back contact of a relay 177 controlled by a circuit including the contacts of switch 171 and the tongue and back contact of a relay 178 which is interconnected by circuits, not shown, with the clutch solenoid 54, relay 178 being energized during tracking operations thereby disabling the control of switch 171 over the motor circuit. With the circuit shown, the switch contacts will be closed at a predetermined nod angle operating relay 177 and breaking the shunt circuit around resistance 176, thereby reducing the speed of the motor and thus providing closer scanning in the outer area of the cone scanned by the antenna in its spiral path.

The load on the motor increases as the nod angle increases due to the antenna assembly becoming increasingly offset from the spin axis and since the speed of a shunt wound motor having resistance in the armature circuit is sensitive to load, the speed of the motor will further vary with the changing load as the nod angle changes, the speed being slowest at the maximum nod angle. Alternatively, if the motor speed is constant at all nod angles the cam may be shaped to provide closer scanning at the greater nod angles by shaping the part of the

cam in the areas indicated by reference characters 179 in Fig. 14, so as to more closely space the spirals in the outer area of the cone. For the optimum scanning pattern, however, the variable speed motor arrangement is employed together with a cam formed to provide decreased spacing between the spirals at the greater nod angles.

Gear 40 is in mesh with a gear 180, Figs. 8 and 10, on shaft 181 that carries a second gear 182 which meshes with gear 183 on the shaft 184 of a generator 185 whose shaft is in alignment with and drives that of a second generator 186, or rotary transformer, mounted thereon. Members 185 and 186 are supported by a seat formed in casing 28 in which they may be rotated for phasing. Their driving gear ratio is such that they turn at the same rate as the spin axis. Generator 185 may be of any desired type but preferably is a two-phase generator to supply a two-phase reference current. The member 186 may be of the "Teletorque" type of rotary transformer, the output of which is fed into a demodulator during search for controlling the spiral pattern of a cathode ray tube.

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 a scanning device comprising an antenna, a pair of coaxially disposed sleeves, means for rotating the sleeves at different rates, a support for the antenna coupled with one of the sleeves whereby the antenna rotates therewith, a bearing turning with one of the sleeves, a shaft supported for reciprocation in the bearing, means controlled by the relative movement of the sleeves for imparting a reciprocatory movement to the shaft, means controlled by said movement of the shaft for imparting a nodding movement to the antenna in its support, and means for coupling the sleeves in predetermined angular relation to maintain the antenna in a fixed angular position with respect to the axis of the sleeves.

2. In a scanning device comprising an antenna, a pair of coaxially disposed sleeves, means for rotating the sleeves at different rates, a support for the antenna coupled with one of the sleeves whereby the antenna rotates therewith, a bearing turning with one of the sleeves, a shaft supported for reciprocation in the bearing, cam means turning with the other of the sleeves for imparting a reciprocatory movement to the shaft, means controlled by the shaft for imparting a nodding movement to the antenna in its support, and means for coupling the sleeves in predetermined angular relation to maintain the antenna in a fixed angular position with respect to the axis of the sleeves.

3. A scanning device comprising a rotary antenna, means to rotate and nod the antenna comprising a pair of members, means for rotating the members at different rates about a common axis, means controlled by the relative movement of the members for imparting a nodding movement to the antenna for search scanning, means for disconnecting the driving means from the more rapidly rotating member to eliminate the nod movement of the antenna, means comprising

an overrunning clutch effective after a disconnecting operation of said means to couple the members in predetermined angular relation whereby the members turn together for track scanning.

4. A mechanism for projecting a beam of radiant energy comprising a pair of coaxially disposed sleeves, driving means for each sleeve effective to drive the sleeves at different rates, a shaft supported for endwise movement by one of the sleeves, a cam groove formed in the other sleeve, a roller in the groove coupled to the shaft whereby relative movement of the sleeves causes reciprocation of the shaft, a yoke supported for rotation by the more rapidly turning sleeve, a scanning device pivoted between the arms of the yoke, a coupling between the device and the shaft whereby the endwise movement thereof imparts a nodding movement to the scanning device, an overrunning clutch having driving and driven members connected to the respective sleeves, a second clutch effective when operated to disconnect the driving means from the more rapidly turning sleeve whereupon the overrunning clutch becomes effective to couple the sleeves, causing both to turn at the same rate and thereby interrupt the nodding motion of the scanning device.

5. In a scanning device wherein an antenna is spun about an axis for track scanning and nodded as well as spun about the axis for search scanning, a pair of members rotatable about said axis, a support for the antenna coupled to one of the members so that the antenna rotates therewith, a gear attached to each member, a driving arrangement for said gears comprising a shaft, a driven gear secured to the shaft meshing with one of said gears, a second gear free to turn on the shaft meshed with the other of said gears, a clutch for coupling the second gear to the shaft whereby both members are driven, the gear ratios being such as to turn the members at different rates, means controlled by the relative movement of the members for imparting a nodding movement to the antenna, a second clutch disposed between the members operable after the uncoupling of the second gear from its shaft by the first mentioned clutch to couple the members so that they turn at the same rate in predetermined angular relation whereby the nodding movement is eliminated.

6. In a scanning device wherein an antenna is spun about an axis for track scanning and nodded as well as spun about the axis for search scanning, a pair of members rotatable about the axis, a support for the antenna coupled with one of the members so that the antenna rotates therewith, a gear attached to each member, a driving arrangement for said gears comprising a shaft, a driven gear secured to the shaft meshing with one of said gears, a second gear free to turn on the shaft meshed with the other of said gears, a clutch for coupling the second gear to the shaft thereby causing both members to be driven, the gear ratios being such that the members turn at different rates, means controlled by the relative movement of the members for imparting a nodding motion to the antenna, an overrunning clutch effective to couple said members in predetermined angular relation when the first mentioned clutch is operated to disconnect the second gear from the shaft, the antenna being maintained positioned for track scanning when the overrunning clutch is effective due to the angular relation in which the members are coupled.

7. A scanning device according to claim 3, in which reference current generator means are driven from the driving means for the more rapidly turning sleeve, whereby after the operation of the disconnecting means the generator means are turned at the rate of the slower sleeve. 5

8. A scanning device according to claim 3, in which a two-phase reference current generator is driven from the driving means for the more rapidly turning sleeve, whereby after the operation of the disconnecting means the generator is turned at the rate of the other sleeve. 10

9. A scanning device according to claim 3, in which means for periodically changing the speed of said rotating means is turned by said rotating means. 15

10. A scanning device according to claim 3, in which said rotating means comprises a motor and gears driven thereby, a cam disposed to be turned by the gearing, and switch means controlled by the cam for changing the speed of the motor in predetermined angular positions of the sleeves. 20

11. A scanning device according to claim 3, in which said rotating means comprises a motor and gear means driven thereby, a cam disposed to be turned by the gear means, switch means controlled by the cam for changing the speed of the motor in predetermined relative angular positions of the sleeves, and means effective when the sleeves are coupled for rendering the switch means ineffective. 25

12. A scanning device according to claim 3, in which said means for rotating the members comprises a motor and gear means driven thereby, a 30

cam adapted to be rotated by the gear means, switch means controlled by the cam, and circuits controlled by the switch means for reducing the speed of the motor to provide closer scanning at the greater nod angles.

13. A scanning device according to claim 3, in which said means for rotating the members comprises a motor and gear means driven thereby, a cam adapted to be rotated by the gear means, means controlled by the cam for reducing the speed of the motor at the greater nod angles to provide closer scanning, and means controlled by the disconnecting means for rendering the speed reducing means ineffective.

14. A scanning device according to claim 3, in which said means for rotating the members comprises a motor and gear means driven thereby, means driven by the gear means for changing the motor speed periodically, and means controlled by the disconnecting means for rendering the speed changing means ineffective.

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