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PARABOLIC ANTENNA WITH HIGH SPEED SPINNER NEAR FOCUS FOR SCANNING

Filed July 31, 1959 2 Sheets-Sheet 1

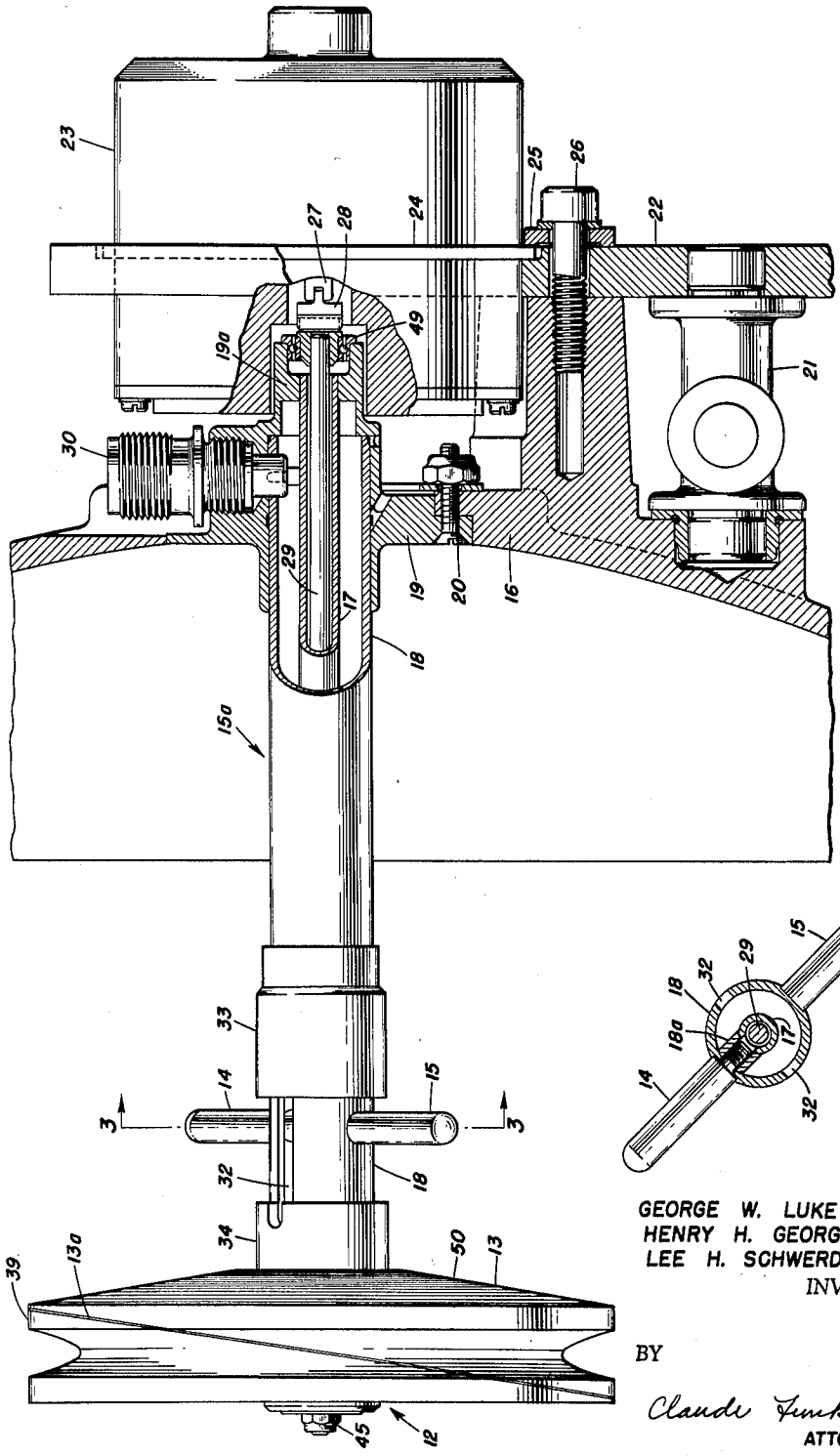


FIG. 1.

FIG. 3.

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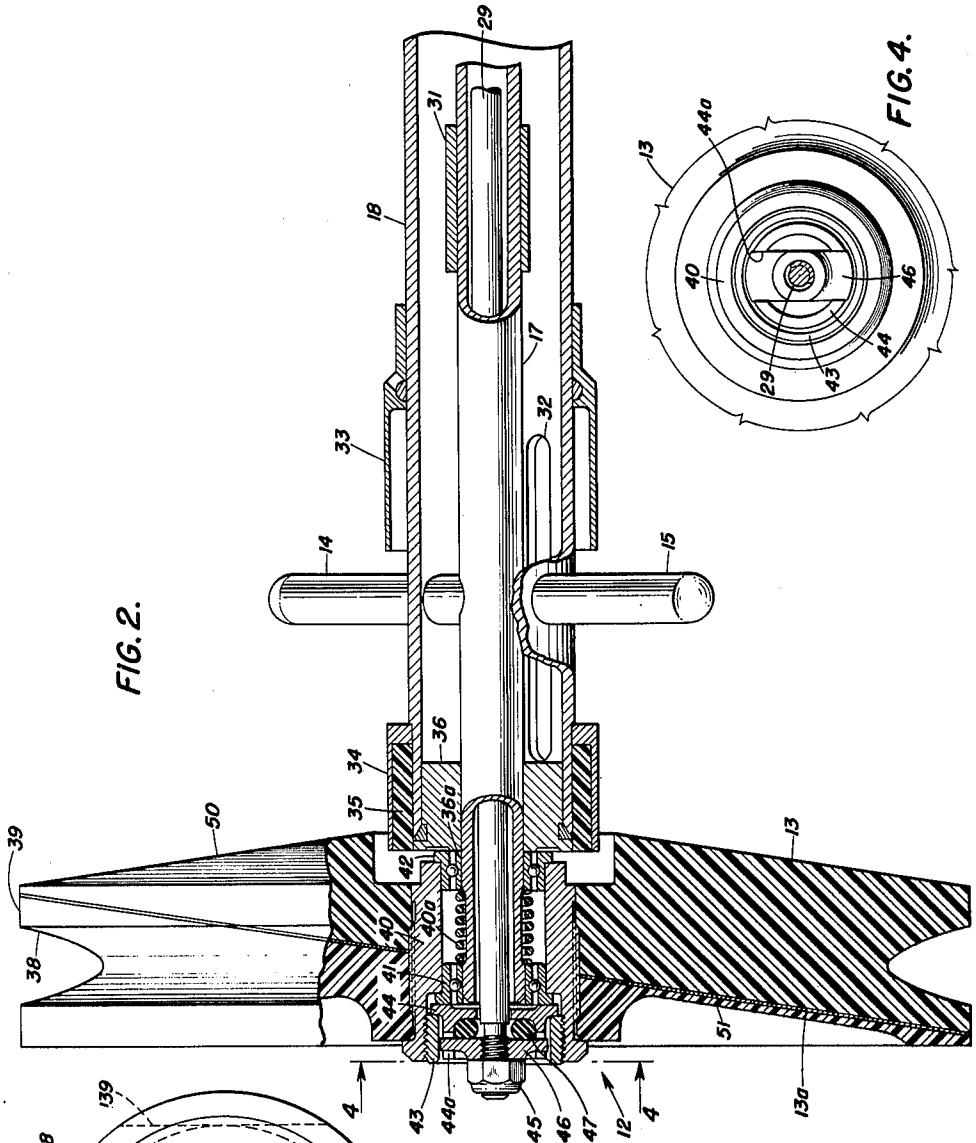


FIG. 2.

FIG. 4.

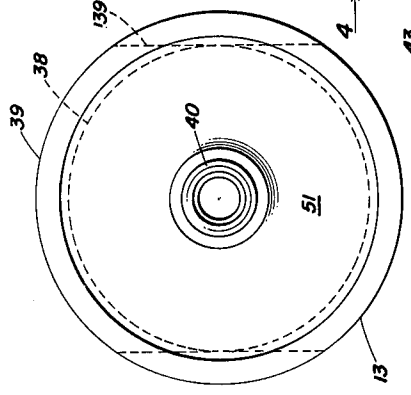


FIG. 5.

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3,230,534

PARABOLIC ANTENNA WITH HIGH SPEED SPINNER NEAR FOCUS FOR SCANNING

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The present invention relates generally to a seeker head for a guided missile and more particularly to a high-speed conical scanning beam antenna assembly.

An object of the present invention is to provide an antenna assembly with a precision double bearing spinner to permit high nutation frequency and long life during missile flight.

Another object of the invention resides in the provision of an antenna that will produce a symmetrical transmitted beam in both planes of radiation, said antenna utilizing the combination of a dipole and an excited slot with a reflector of precise design.

An additional object of the present invention is to provide, in an antenna assembly, a noise free spinner assembly utilizing means for keeping radio frequency energy out of the spinner bearings employed.

Still another object of the invention is to provide a double bearing spinner which will overcome any gyroscopic effects on the drive shaft employed.

A further object of the invention is to provide in an antenna assembly a reflector having a precise shape so designed that it will not disturb the dynamic balance of said assembly during operation thereof.

An additional object of the invention resides in the provision of an antenna that will maintain constant vertical polarization.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a side elevation, partly in section, of the antenna assembly embodying the principles of the present invention;

FIG. 2 is an enlarged longitudinal sectional view of the antenna element and its associated spinner assembly;

FIG. 3 is a cross section of the antenna element on line 3—3 of FIG. 1;

FIG. 4 is a front view of the spinner assembly, on line 4—4 of FIG. 2; and

FIG. 5 is a front view of the spinner assembly and reflector.

The antenna assembly of the present invention is used in a guided missile for velocity tracking of a target by the Doppler principle and for scanning for directional information of the target.

Referring to FIG. 1 of the drawings, there is shown an antenna assembly comprising a spinner assembly **12** having a spinner **13** and embedded reflector disc **13***a*, a dipole having half-wave elements **14** and **15** slot-excited from a coaxial feed **15***a* and a paraboloidal reflector dish **16**. Hollow inner and outer conductors **17**, **18** of a concentric coaxial feed for the dipole extend through the center of the paraboloidal dish concentric to the axis of said dish. The outer conductor **18** is provided with a hub **19** to which the paraboloidal dish is secured by a plurality of fasteners **20**.

The entire antenna assembly is turned and pivoted by a linkage mechanism not shown. However, one of the

front linkage members **21** is shown secured to the back of the paraboloidal dish **16** and to a mounting bracket **22**. A motor reference generator **23** having an external flange **24** is mounted within the bracket **22** and secured thereto by a clamp **25** bearing against the flange **24** and held rigidly to the back of the dish **16** by bolt **26**. The shaft **27** of the motor is connected by a nylon coupling **28** to a drive shaft **29** extending along the axis of the dish **16** through the hollow inner conductor **17** for turning the spinner **13** at a high nutation frequency, say 200 c.p.s.

The ratio of the diameters of the inner and outer conductors **17** and **18** of the coaxial feed match the impedance of a coaxial cable, not shown, adapted to be attached to a connector **30**.

In FIG. 2 of the drawing, a sleeve **31** on the inner conductor constitutes an impedance matching transformer placed at the correct location along said conductor to permit an impedance match to the half-wave dipole elements.

The collinear half-elements are oppositely directed normal to the axis of the paraboloidal dish, located slightly aft of the focal point thereof and are slot-excited from the coaxial feed. As shown in detail in FIG. 3, the slot-exciter utilizes two resonant half-wave slots **32** extending along the outer conductor ninety degrees from the axis of the dipole elements **14** and **15** to feed said elements. Half-wave element **14** is connected to the outer conductor **18** of the coaxial feed and, by a sleeve **18***a*, to the inner conductor **17**. The other half-wave element **15** has its inner end secured to the outer conductor **18**. The portions of the outer conductor above and below the slots and the elements **14** and **15** are excited by energy supplied to the coaxial feed. Consequently, surface currents would exist on the outer conductor and the elements. This arrangement provides an abrupt discontinuity for the electrostatic wave in the vicinity of the slot and establishes an electric field normal to the slot edges and the dipole element axis. It is to be noted that radiation occurs from the slot as well as from half-wave elements.

Radiation from the elements tends to narrow the beamwidth in the E plane, a plane containing the half-wave elements, and widen the beamwidth in the H plane, a plane perpendicular to the axis of said elements. However, the radiation from the slots **32** tends to be the reverse, i.e., widen the beamwidth in the E plane and narrow the beamwidth in the H plane. This type of feed leads to a radiation pattern having comparative low side lobes and a nearly symmetrical radiation pattern in the subtended solid angle.

The decrease of the side lobes insures minimum radio frequency interference with the radome retaining ring (not shown) behind the seeker and the pressure probe (not shown) in the nose of the radome when the paraboloidal dish has a large look angle from the axis of the missile.

A choke **33** aft of the dipole elements **14** and **15** prevents current flow along the outer surface of the outer conductor **18** aft of slots **32**. A forward choke **34**, filled with a dielectric material **35**, provides a noise free antenna assembly by keeping electro-magnetic energy out of the spinner mounting bearings, to be described in more detail hereinafter.

The inner conductor **17** of the coaxial feed is extended inwardly beyond the outer conductor, the aft end of the inner conductor being rigidly connected to a web **19***a* in the hub **19**. The forward end of the inner conductor extends beyond the outer conductor and supports the spinner assembly **12** mounted normal to the axis of dish **16**. An end plug **36** closes the outer end of the outer conductor and electrically shorts energy flowing between the

inner and outer conductors at the forward edges of the slots **32**. The spinner assembly **12** comprises the spinner **13** of dielectric material having a hyperbolic groove **38** in its peripheral rim **39**, a reflector disc **13***a* embedded therein and canted at 8° to the axis of the half-wave elements **14** and **15**, and a hub **40**.

The hub **40** of the spinner **13** is supported by two spaced radial bearings **41** and **42** on the forward end of the inner conductor to provide mechanical rigidity and alignment of the hub with the axis of the paraboloidal dish. The design of the double bearing for the spinner prevents mechanical deflection of the shaft **29** due to any gyroscopic action during sluing of the antenna assembly. Also deflections caused by acceleration, vibration or other characteristics of missile flight are prevented from affecting the operation of the spinner. A preloaded spring **40***a* pushes against the inner races of the bearings so that the inner race of bearing **42** abuts the forward face **36***a* of the end plug **36**. A lock sleeve **43**, secured to the forward inner surface of the hub, retains a slotted retainer **44** in place against the outer race of the bearing **41**. The drive nut **46** is received in the slot **44***a* of the retainer **44**.

On the forward end of the drive shaft **29**, a locknut **45** retains a screw threaded drive nut **46** pressing against an O ring **47** to urge the retainer **44** against the outer race of the bearing **41**. The combination of the spring **40***a* and the ring **47** eliminates any axial play between the inner and outer races of bearings **41** and **42**.

The aft end of the drive shaft **29** is supported in a radial bearing **49** having an outer race fitted on the aft end of hub **19**.

In operation, the spinner assembly **12** is revolved at, say, 12,000 r.p.m. by the motor reference generator **23** coupled to the drive shaft **29** to provide the desired nutation of the microwave beam. The turning of the drive shaft rotates the retainer **44** which rotates the outer races of the radial bearings **41** and **42** to turn the hub of the spinner. By revolving the spinner and not the dipoles, the microwave beam is constantly plane polarized.

The position of the motor reference generator **23** can be adjusted on the mounting bracket **22** so that an aligned phased relationship can be established between a reference generator signal from **23** and the conical scanning beam produced by the embedded reflector disc.

Referring now to FIG. 5, the spinner **13** is shown in frontal view with the embedded reflector disc **13***a* having a configuration of a flat sided ellipse. The elliptical disc is to provide symmetry of the microwave beam in both the E plane and H plane deflection. If a full ellipse shaped disc is used, a dissymmetry of the beam shape between E plane and H plane deflection arises due to the reflector being equidistant from the upper and lower elements **14**, **15** when deflecting in the H plane but non-equidistant when deflecting in the E plane and also because the outer conductor **18** of the coaxial feed **15***a* "shadows" one-half of the dipole assembly for the E plane deflection. Any difference in the signal level at boresight zero between the E and H plane deflections would appear as an undesired signal modulation, being a second harmonic of the nutation frequency.

This modulation is overcome by having the same signal level in both E and H planes. If the reflector disc is considered as a dipole, then a disc shorter in diameter would broaden the beam when deflecting in the H plane. Thus the H plane beam would be wider and give the same forward gain as the E plane beam. This is accomplished by cutting off the edge of the disc to flatten the minor elliptical axis thereof.

The provision of a circumferential groove **38** of hyperbolic section in the spinner rim **39** establishes a precision control of the shape of the disc which is accomplished by a lathe-turning operation. The act of cutting the rim of the spinner by a tool having a hyperbolic edge determines the shape of the disc to be a flat-sided ellipse. The removal of the plastic material of the groove **38** there-

from lowers the moment of inertia of the spinner without disturbing its dynamic balance. This also eliminates any air friction which would result if the rim of the spinner were cut to form a flattened cylinder in order to provide straight edges for the embedded disc.

In addition, the aft face **50** of the spinner **13** can have a different configuration which would influence the beam pattern by changing the nutation angle caused by the refractive properties of the dielectric material of the spinner. The removal of dielectric material from the forward face **51** of the spinner reduces the moment of inertia of the spinner without affecting its function.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A high speed scanning beam antenna system comprising: a pivotal paraboloidal reflector dish, a coaxial feed attached to said dish, said feed having inner and outer concentrically disposed hollow conductors extending concentrically with the axis of said dish, means for securing said outer conductor to said dish, stationary radiating elements having axes normal to the axis of said dish and supported by said feed substantially at the focal point of said dish, the forward end of said inner conductor extending beyond that of said outer conductor, a spinner assembly supported by said forward end of said inner conductor, said spinner assembly comprising a spinner of dielectric material mounted in a plane parallel to the axes of said radiating elements and normal to the axis of said dish, and a reflector disc embedded in said spinner and canted at an angle to the faces thereof, a shaft extending through said inner hollow conductor along the axis of said dish, the forward end of said shaft being coupled to said spinner assembly and the aft end of said shaft being journaled by said securing means, and shaft rotating means secured to said dish and coupled to said shaft for revolving the spinner to effect high nutation frequency of a beam of electromagnetic energy with constant vertical polarization of said beam.

2. A high speed scanning beam antenna system comprising: a paraboloidal reflector dish, a coaxial feed attached to said dish, stationary radiating elements having axes normal to the axis of said dish and supported by said feed substantially at the focal point of said dish, a spinner assembly mounted on the forward end of said coaxial feed, said spinner assembly comprising a spinner of dielectric material mounted in a plane parallel to the axes of said radiating elements and normal to the axis of said dish, and a flat-sided elliptical reflector disc embedded in said spinner and canted at an angle to the faces thereof, a shaft extending through said coaxial feed along the axis of said dish, the forward end of said shaft being coupled to said spinner assembly, and rotating means coupled to the aft end of said shaft for rotating said shaft to revolve the spinner to effect high nutation frequency of a beam of electromagnetic energy with constant vertical polarization of said beam, whereby the shape of the disc establishes a symmetrical scanning beam pattern in both planes of radiation.

3. In a high speed scanning beam antenna assembly, a coaxial feed having inner and outer concentrically disposed hollow conductors, the forward end of said inner conductor extending beyond that of said outer conductor, a spinner assembly supported by said forward end of said inner conductor, said spinner assembly comprising a flat circular spinner of dielectric material mounted in a plane normal to the axis of said feed, a reflector disc embedded in said spinner and canted at an angle to the faces thereof, a hub within said spinner, a shaft extending through said inner conductor, a pair of spaced bearings secured on the forward end of said inner conductor, said hub being supported on said bearings, means for coupling the forward

end of said shaft to said hub, and rotating means coupled to the aft end of said shaft for revolving the spinner, said spaced bearings preventing the introduction of gyroscopic effect on said shaft by the revolving of said spinner.

4. In a high speed scanning beam antenna assembly, a spinner assembly comprising a flat circular spinner of dielectric material and a reflector disc embedded in said spinner and canted at an angle to the faces thereof, the rim of said spinner having a groove whereby the configuration of the embedded disc is precisely determined and the moment of inertia of said spinner is reduced without disturbing its dynamic balance.

5. In a high speed scanning beam antenna assembly, a coaxial feed having stationary inner and outer concentrically disposed hollow conductors, the forward end of said inner conductor extending beyond that of said outer conductor, a circular spinner of dielectric material mounted in a plane normal to the axis of said feed, a reflector disc embedded in said spinner and canted at an angle to the faces thereof, a hub mounted axially within said spinner, a pair of spaced bearings secured on the forward end of said inner conductor, said spinner hub secured axially on

said bearings to support said spinner on the forward end of said inner conductor, a shaft extending through said inner conductor, means for coupling the forward end of said shaft to said bearings, and rotating means coupled to the aft end of said shaft for turning said shaft and rotating said bearings thereby revolving the spinner whereby gyroscopic action on said spinner and shaft is prevented during the sluing of the antenna assembly.

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