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**BUOY ANTENNA**

**STATEMENT OF GOVERNMENT INTEREST**

[0001] The invention described herein was made in the performance of official duties by employees of the U.S. Department of the Navy and may be manufactured, used, or licensed by or for the Government of the United States for any governmental purpose without payment of any royalties thereon.

**CROSS REFERENCE TO OTHER PATENTS APPLICATIONS**

[0002] None.

**BACKGROUND OF THE INVENTION**

**(1) Field of the Invention**

[0003] The present invention is directed to an antenna for ocean buoys and more particularly to an antenna able to intercept incoming signals having an arbitrarily-oriented electric field vector.

**(2) Description of the Related Art**

[0004] An antenna can be used for transmission of a signal, in which radio-frequency electrical energy from a transmitter converts to electromagnetic energy and radiates into the surrounding environment for reception of a signal.

Electromagnetic energy impinging on the antenna converts into

radio-frequency electrical energy and is fed to a receiver. The frequency bandwidth depends on the size and design for a particular frequency while reception and transmission signal strength depends on the orientation of the antenna with respect to a signal path.

**[0005]** Ocean buoys for collecting and processing ambient radio frequency (RF) emissions use omnidirectional antennas that are capable of receiving signals with random electromagnetic polarization. Use of these antennas is advantageous because the antennas are less sensitive to fading and multipath effects due the scattering of signals by ocean waves, as well as changes in water-line height as the buoy device floats on the sea surface.

**[0006]** Ocean buoy antennas are generally expensive, making the total per-unit cost of the buoy assembly (antenna, associated electronics and signal-processing software/firmware) very high; thereby, limiting production. Because of their high cost, the use of ocean buoy antennas is restricted. In order to improve situational awareness beyond restricted regions of use; it is desirable for ocean buoy antennas to have their per-unit cost considerably reduced.

**SUMMARY OF THE INVENTION**

**[0007]** It is therefore a primary object and general purpose of the present invention to provide an antenna for ocean buoys to intercept incoming signals having an arbitrarily oriented electric field vectors due to scattering by time-varying waves or surface features of the ocean.

**[0008]** It is a further object of the present invention to provide a buoy antenna to receive signals whose electric field is arbitrarily oriented relative to a longitudinal axis of the antenna.

**[0009]** The buoy antenna of the present invention includes a shell that is made from soda-lime-silica glass and has six rectangular vanes with a semicircular cutout. Each vane is tilted and connects to a cylindrical hub. The cylindrical hub section has two conical cavities that are plated with conducting material to form a bi-conical dipole antenna. A transmission line attaches to plated portions of the antenna.

**[0010]** The antenna dimensions are determined by selecting a center design frequency that can be used to calculate a corresponding wavelength in the glass material.

**[0011]** The buoy antenna according to the present invention is very inexpensive to make and provides repeatable unit-to-unit performance due to manufacturing techniques used (i.e., molding).

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0012] Other objects, features and advantages of the present invention will become apparent upon reference to the following description of the preferred embodiments and to the drawings, wherein corresponding reference characters indicate corresponding parts throughout the several views of the drawings and wherein:

[0013] FIG. 1 shows a perspective view of an antenna assembly of the present invention;

[0014] FIG. 2 is a first cross-section view of the antenna assembly of the present invention;

[0015] FIG. 3 is a second cross-section view of the antenna assembly with dimensions shown;

[0016] FIG. 4 is a third cross-section view of the antenna assembly with dimensions shown;

[0017] FIG. 5 is a top view of the antenna assembly with dimensions shown;

[0018] FIG. 6 is a side view of the antenna assembly with dimensions shown; and

[0019] FIG. 7 is a graph of the relative dielectric permittivity ( $\epsilon_r$ ) of soda-lime-silica glass.

**DETAILED DESCRIPTION OF THE INVENTION**

**[0020]** When an antenna is in close proximity to or embedded within a dielectric body of finite dimensions, a standing wave pattern is established within the body that depends on physical shape, material properties, and size relative to the wavelength of operation. The internal standing wave pattern (or modal pattern) influences the resultant external radiation field properties (to transmit or receive) in either a desired or an undesirable way.

**[0021]** According to the present invention, the antenna body shape is capable of omnidirectional reception of signals having random polarization that is facilitated by an internal standing wave pattern characteristic.

**[0022]** FIG. 1 is a perspective view of an antenna assembly 100 of the present invention. The antenna assembly 100 has a shell 102 made from soda-lime-silica glass. The shell 102 includes a body 104 and a plurality of vanes 106 connected to the body. The body 104 can be a solid cylinder, referred herein as a cylindrical hub.

**[0023]** The shell consists of six vanes 106 with each vane having a substantially rectangular shape with a semicircular cutout 108 in each vane. Each vane 106 is tilted with respect to a longitudinal axis of the body 104 in order to form a rosette pattern.

**[0024]** Referring to FIG. 2, the body 104 has a top portion 110 and a bottom portion 112. A first conical cavity 114 is located in the top portion 110 and a second conical cavity 116 is located in the bottom portion 112. The first conical cavity 114 is symmetrical with a second conical cavity 116 and aligns along the longitudinal axis of the body 104.

**[0025]** The first conical cavity 114 has a truncated apex 118 and the second conical cavity 116 has a truncated apex 120 with a space 122 between. The first conical cavity 114 and the second conical cavity 116 are plated with a conducting material to form the antenna assembly 100. In this case, the antenna assembly 100 is a bi-conical dipole type antenna.

**[0026]** A transmission line 126 is attached to plated portions of the first conical cavity 114 and the second conical cavity 116. The transmission line 126 can be a coaxial transmission line feed. In some embodiments, the transmission line 126 can be semi-rigid and soldered to the plated portions of the first conical cavity 114 and the second conical cavity 116.

**[0027]** Referring to FIG. 3, FIG. 4, FIG. 5, and FIG. 6; the physical dimensions of the antenna assembly 100 are determined at a desired center design frequency  $f_0$  (in Hertz, Hz), followed by a calculation of the corresponding wavelength in the glass material  $\lambda_g$  with the use of Equation (1):

$$\lambda_g = \frac{v_o}{f_o \sqrt{\epsilon'}} \quad (1)$$

where

$v_o$  is the speed of light ( $\approx 3 \times 10^8$  meters/sec); and

$\epsilon'$  is the relative dielectric constant of the glass material.

**[0028]** Once the wavelength  $\lambda_g$  is calculated, dimensions for the various sections of the antenna assembly 100 are determined as multiples of the antenna height dimension  $H$ .  $H$  was experimentally determined to have a value of  $H \approx 2.8 \lambda_g$ . That is, the body 104 has a height  $H$  and a diameter  $H$ .

**[0029]** As shown in FIG. 4, the first conical cavity 114 has a sidewall length approximately  $0.51 H$  at approximately  $23^\circ$  from vertical. The second conical cavity 116 has a sidewall length approximately  $0.51 H$  at approximately  $23^\circ$  from vertical. In other words, each of the first conical cavity 114 and the second conical cavity 116 defines a cone of approximately  $46^\circ$  in which the truncated apex 118 and the truncated apex 120 have a diameter of approximately  $0.13 H$ . The space 122 between the truncated apex 118 and the truncated apex 120 is approximately  $H/18$ .

**[0030]** FIG. 5 and FIG. 6 show the dimensions of the vanes 106. Each vane 106 is attached at a  $45^\circ$  angle to the body 104. Each vane 106 has a thickness of approximately  $H/6$ , a width of

approximately  $0.78 H$ , and a length of approximately  $1.22 H$ . The semicircular cutouts 108 have a radius of approximately  $0.22 H$ . The overall diameter of the antenna assembly 100 is approximately  $2H$ .

**[0031]** The antenna assembly 100 is scalable to a desired center design frequency according to the relative dielectric constant ( $\epsilon'$ ) of the glass. The soda-lime-silica glass material is selected through a comparison of various dielectrics and per unit volume prices. Using open-literature sources, the prices and dielectric properties of various insulating materials were plotted to find a material with the largest (relative) dielectric constant and the lowest (per unit volume) price. Large deviations in price exist within three classes of insulating materials (plastics, glasses, and ceramics). Container glass (i.e., soda-lime-silica) has the largest dielectric constant ( $\epsilon' \approx 7.5$  at 10 kHz) and the lowest per unit volume cost. A plot of the complex (relative) dielectric permittivity of soda-lime-silica glass is shown FIG. 7. In the plot, the permittivity ( $\epsilon_r$ ) is defined in Equation (2) as

$$\epsilon_r = \epsilon' - j\epsilon'' \quad (2)$$

where

$\epsilon'$  is the dielectric constant,

$\epsilon''$  is the loss factor, and

the complex number  $j = \sqrt{-1}$  .

The graph of FIG. 7 shows values of  $\epsilon'$  at different frequencies.

**[0032]** A fundamental characteristic of a dipole antenna not embedded in the glass shape is an ability to discriminate an electric field orientation of a signal. When the arriving electric field orientation is perpendicular to the longitudinal axis; reception is very weak. When the electric field is parallel to the longitudinal axis, reception is maximized. The change in signal reception with electric field orientation is substantial, with the perpendicular field pickup being 30 dB or more below that of the parallel field.

**[0033]** When the dipole is in contact with the glass shape (by a plating process), the antenna assembly 100 is sensitive to electric fields that are either parallel or perpendicular to the longitudinal axis. The antenna assembly 100 can receive both orientations somewhat equally at  $0^\circ$  elevation (the horizon) with a variation at other angles. The glass shape permits the antenna assembly 100 to sense other field orientations, where the corresponding beam patterns are bounded between those that are parallel and perpendicular to the longitudinal axis.

**[0034]** The bandwidth or deviation from the center design frequency ( $f_0$ ) where the antenna assembly 100 is able to effectively sense the parallel, perpendicular, and intermediate

electric field orientations is experimentally determined to be by Equation (3)

$$(5/6)f_0 \leq f \leq (6/5)f_0 \quad (3)$$

which translates to approximately twenty percent below and 20% above the design center frequency, the total bandwidth being the sum, or 37%, which is considered broad.

**[0035]** The pattern of the antenna 100 over seawater is able to intercept incoming signals having an arbitrarily-oriented electric field vector due to scattering by the ocean time-varying waves or surface features. That is, the antenna assembly 100 is able to receive signals whose electric field is arbitrarily-oriented relative to the longitudinal axis of the antenna assembly.

**[0036]** A buoy antenna according to the present invention is comparatively very inexpensive to make and provides repeatable unit-to-unit performance due to manufacturing techniques used (i.e., molding).

**[0037]** The invention has been described with references to specific embodiments. While particular values, relationships, materials, and steps have been set forth for purposes of describing concepts of the present disclosure, it will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the disclosed embodiments without departing from the

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spirit or scope of the basic concepts and operating principles  
of the invention as broadly described.

**BUOY ANTENNA**

**ABSTRACT OF THE DISCLOSURE**

A buoy antenna assembly with a hub having a first conical cavity in a top portion and a second conical cavity in a bottom portion is provided. The first conical cavity aligns with the second conical cavity with a space between an apex of the first conical cavity and an apex of the second conical cavity. Each of the first conical cavity and the second conical cavity is plated with a conducting material. A plurality of vanes attaches at an angle to the hub. A transmission line attaches to plated portions of the first conical cavity and the second conical cavity. The dimensions of buoy antenna assembly are determined by selecting a center design frequency followed by a calculation of the corresponding wavelength in the material of the hub and the vanes.

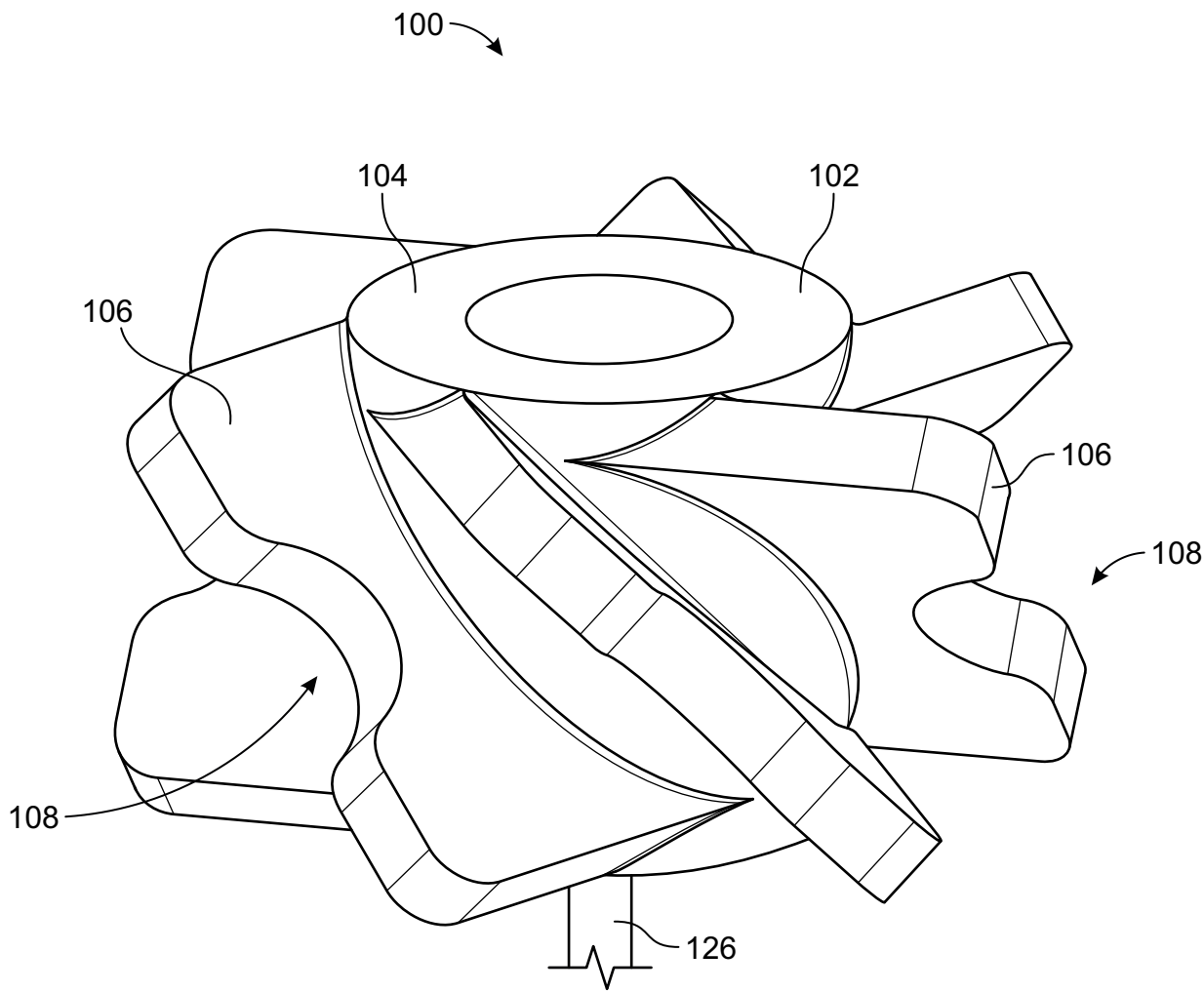


FIG. 1

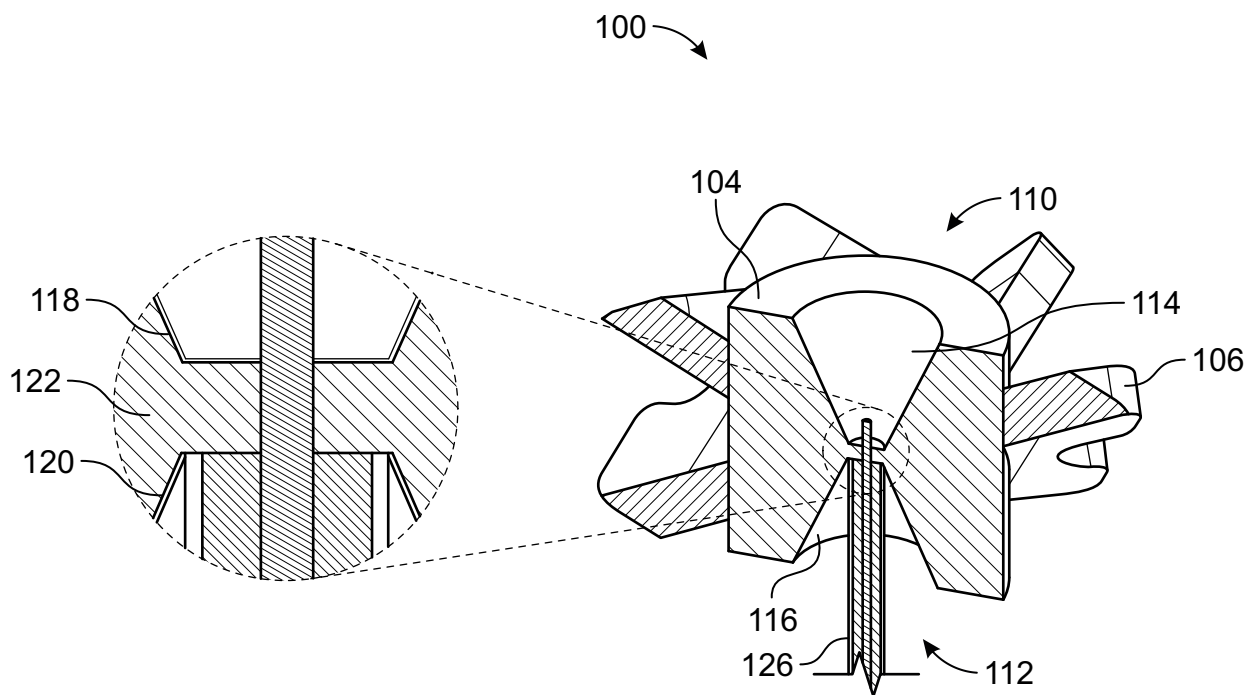


FIG. 2

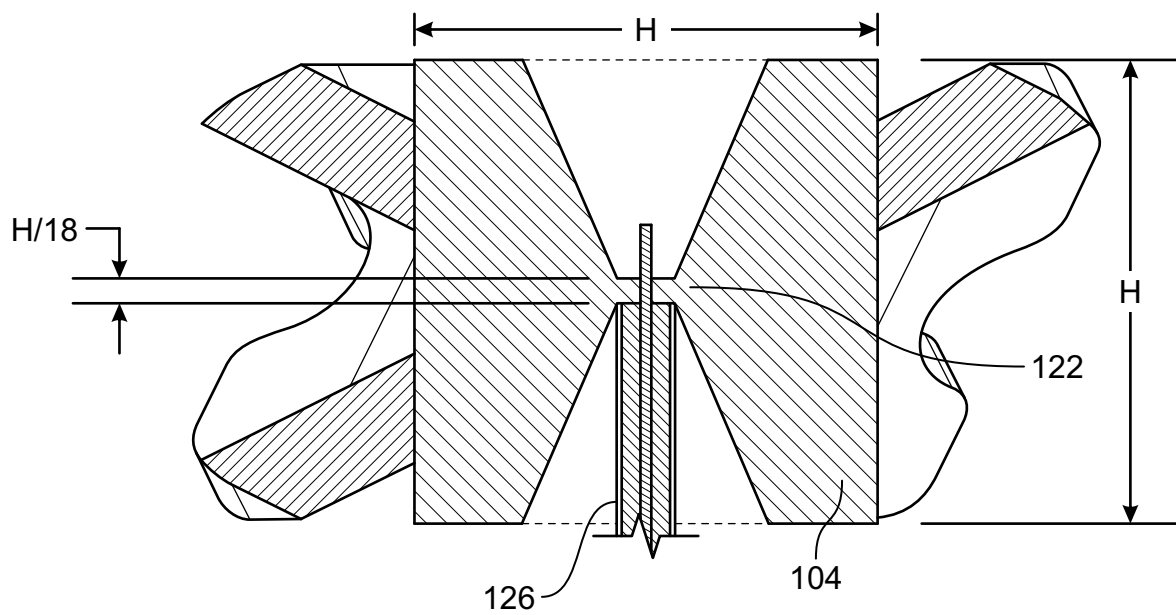


FIG. 3

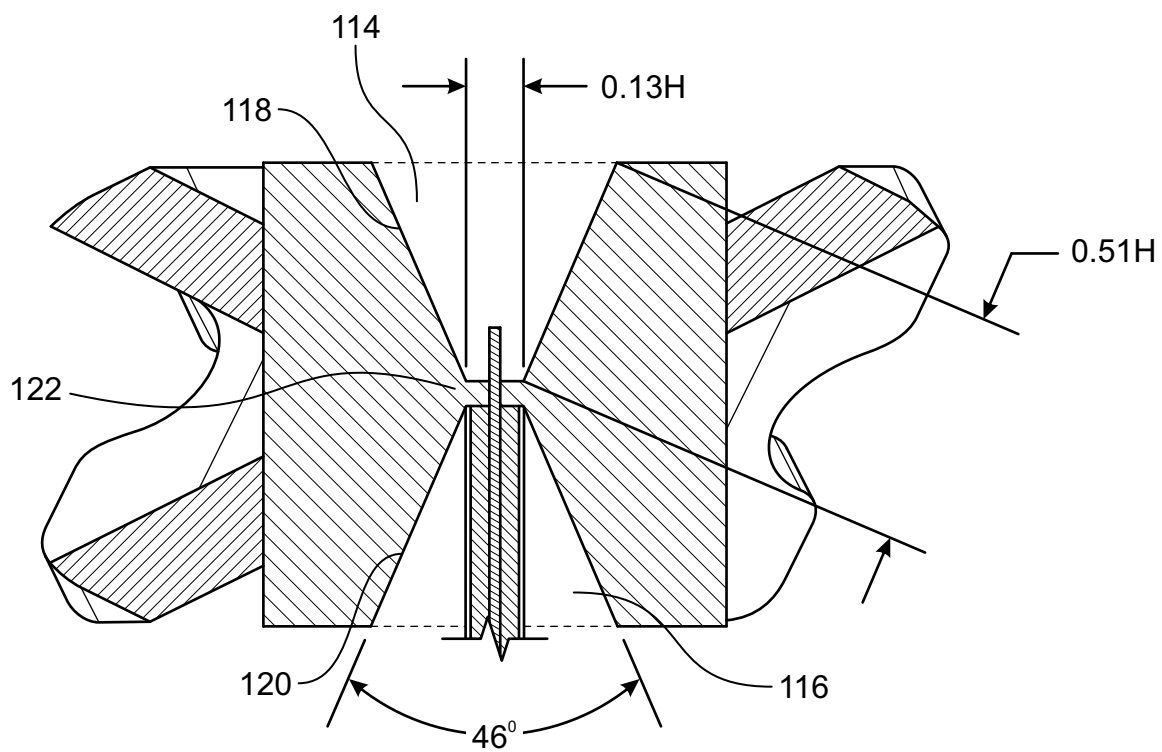


FIG. 4

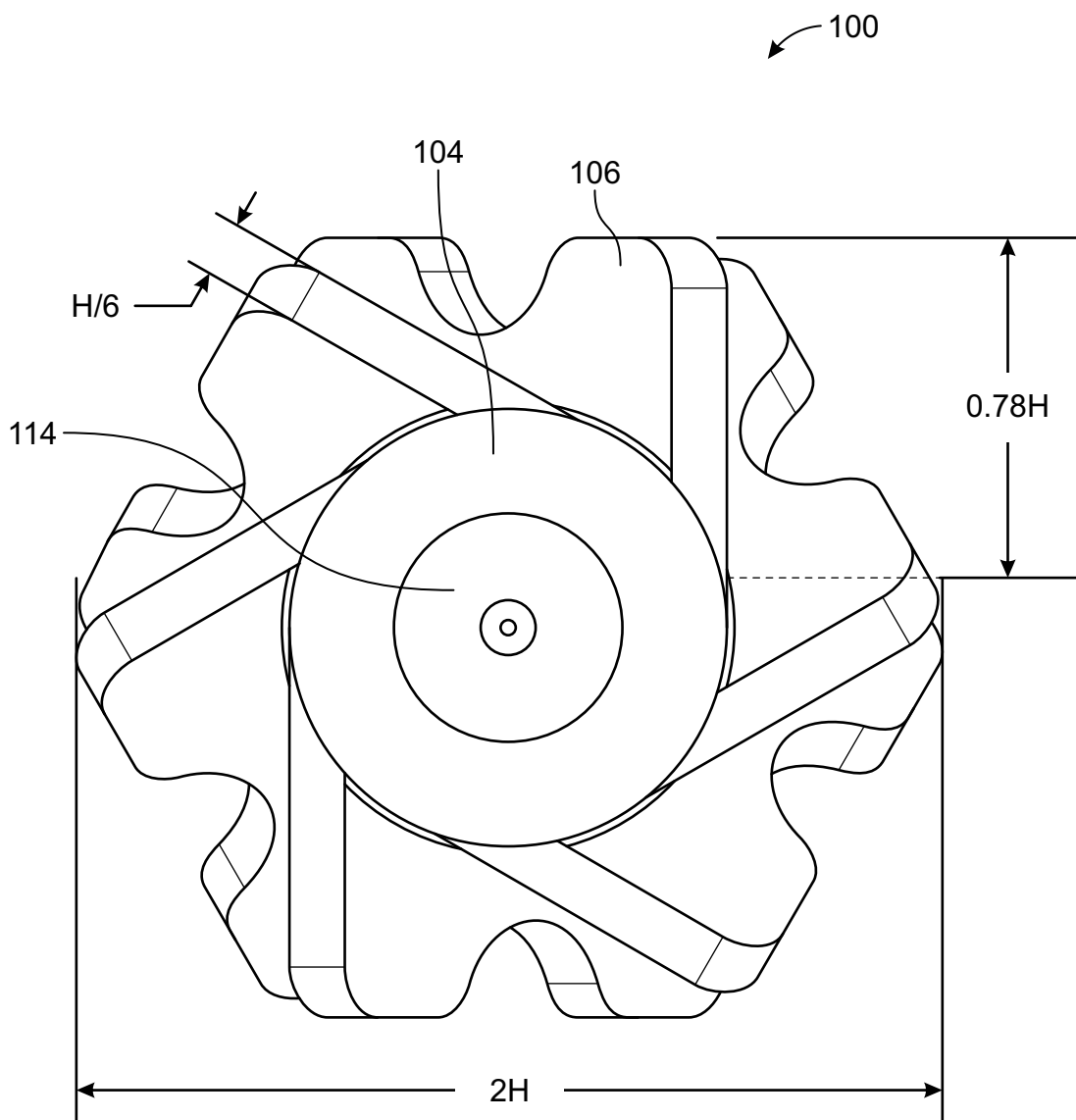


FIG. 5

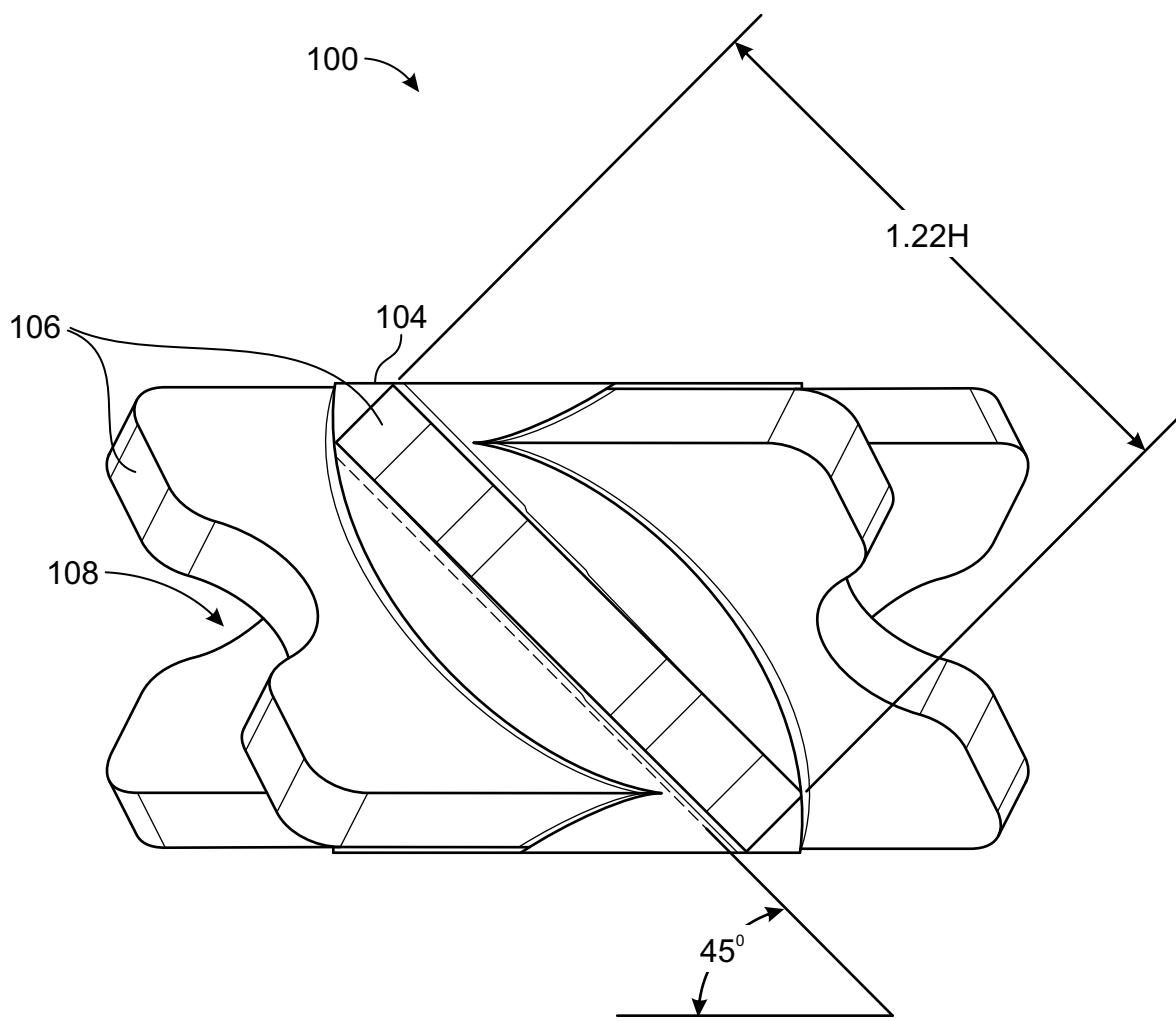


FIG. 6

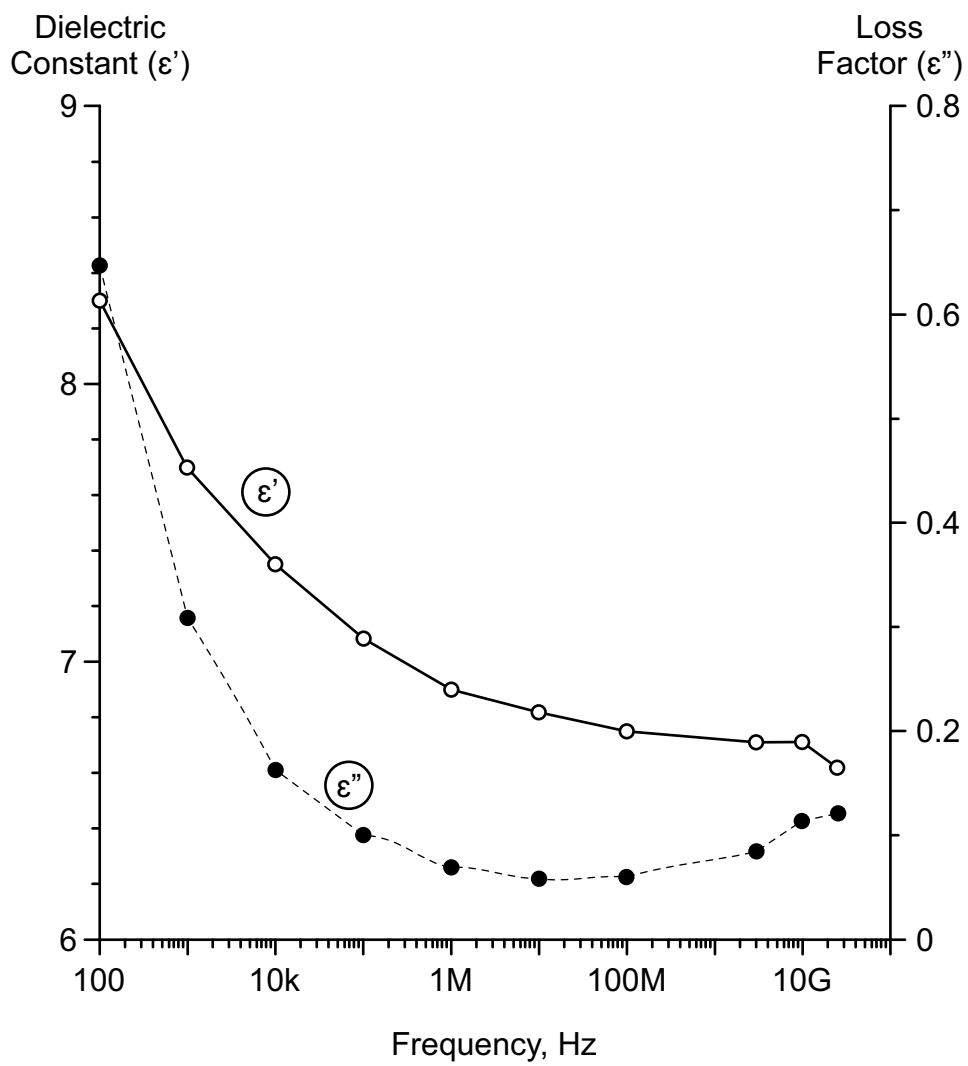


FIG. 7