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(71) Applicant: **RAYTHEON COMPANY**
141 Spring Street
Lexington Massachusetts 02173(US)

(72) Inventor: **Wada, Steven T.**
748 Litchfield Lane
Santa Barbara, California(US)
Inventor: **Jobsky, Robert**
407A Shasta Lane
Santa Barbara, California(US)
Inventor: **Maybell, Michael J.**
1926 E1 Camino Delaluz
Santa Barbara, California(US)

(74) Representative: **Jackson, David Spence et al**
REDDIE & GROSE 16, Theobalds Road
London, WC1X 8PL(GB)

(54) **Flush mount antenna.**

(57) An antenna (10) capable of being mounted flush with variously shaped surfaces comprises a dielectric filled radiating cavity (26) with two opposing tapered walls. The radiating cavity is excited by a microstrip horn (16) mounted on a dielectric board (14) below a second cavity (54) containing an absorber (52). The radiating cavity (26) is defined between a taper wall (50) of a metal top member (20) and an opposing taper wall (32) of a metal base member (12). A dielectric slab (18) fills the radiating cavity, and the top taper wall (50) acts as an extension of the microstrip horn (16). The upper surfaces of the base member (12), top member (20), and dielectric slab (18) conform to the surface in which the antenna (10) is mounted.

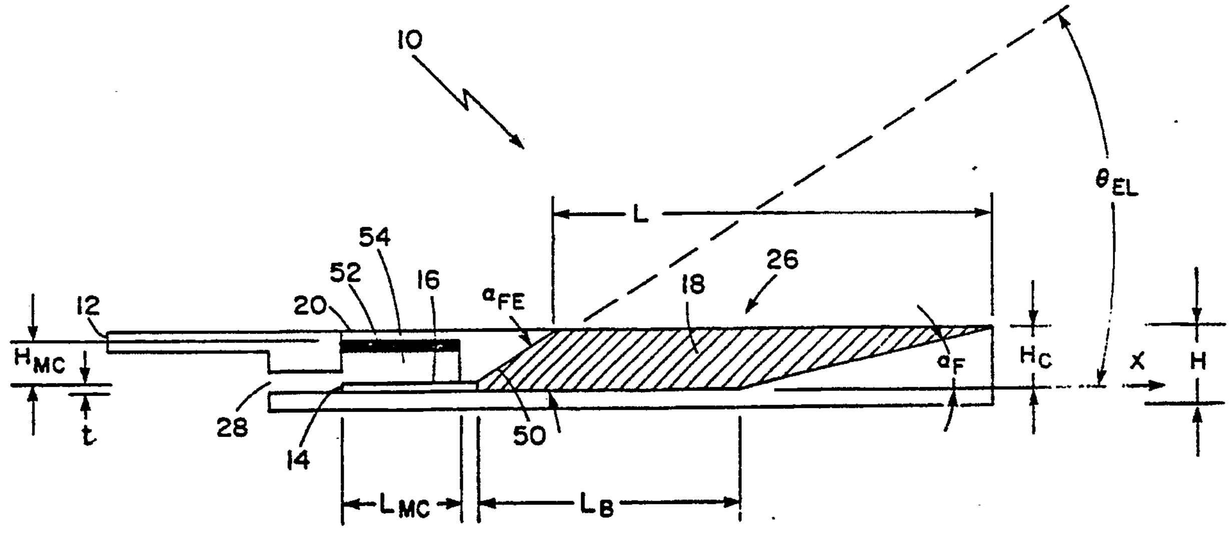

Fig. 3

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FLUSH MOUNT ANTENNA

Background of the Invention

This invention relates generally to antennas and more particularly to horn antennas.

In many radio frequency systems, limited space is available for antennas. Antennas designed for small spaces, however, must meet various performance requirements. For example, the antenna must have a specified angular coverage and frequency bandwidth. Thus, existing antennas may not meet both the size and performance requirements in a system.

One common size constraint in airborne systems is that the antenna not protrude beyond the aircraft carrying the RF system. Thus, a "flush mount" antenna is required.

Various forms of flush mount antennas are known. For example, annular slot antennas, cavity inductors, strip inductors, patch antennas, surface-wave antennas and slot antennas can all be mounted flush with a surface. However, these types of antennas generally have narrow frequency bandwidths. They are thus not well suited for systems requiring frequency bandwidths of 3:1. Printed log-periodic dipoles can be cavity backed and flush mounted. These antennas can be built with 3:1 frequency bandwidths, but cannot be made small enough to meet the size constraints of some applications.

Summary of the Invention

It is an object of this invention to provide an antenna that can be mounted flush with a surface.

It is also an object of this invention to provide an antenna which can conform to non-planar surfaces.

It is a further object of this invention to provide an antenna with a broad frequency bandwidth and wide angular coverage.

It is a further object of this invention to provide an antenna which fits in a relatively small volume.

It is yet a further object of this invention to provide an antenna which can be designed for end-fire or near broadside radiation patterns over a 3:1 frequency bandwidth.

The foregoing and other objects are achieved by an antenna having a radiating cavity filled with dielectric. The radiating cavity has two opposing tapered walls. Radio frequency energy is fed to the radiating cavity via a microstrip horn. The dielectric in the radiating cavity conforms with the upper surface of the antenna. The upper surface of the antenna, in turn, conforms with the surface in which the antenna is mounted.

Brief Description of the Drawings

The invention will be better understood by reference to the following more detailed description and accompanying figures in which

FIG. 1 shows an exploded view of an antenna constructed according to the invention;

FIG. 2 is the top view of the antenna of FIG. 1 with top 20 removed;

FIG. 3 is a cross-sectional view of the antenna of FIG. 1 taken along the line 3-3;

FIG. 4A is a plot showing the azimuthal beam pattern of the antenna of FIG. 1;

FIG. 4B is a plot showing the elevation beam pattern of the antenna of FIG. 1; and

FIG. 5 shows another embodiment of the invention mounted in an object with a curved surface.

Description of the Preferred Embodiment

FIG. 1 shows an exploded view of an antenna 10 constructed according to the present invention. The antenna 10 has a base 12 and a top 20 formed from a conductive metal.

A dielectric board 14 is mounted, for example by gluing or mounting screws, to the base 12. The relative dielectric constant of board 14 is ϵ_{rs}. A microstrip horn 16 is patterned, in a known manner, on the upper surface (not numbered) of dielectric board 14. In operation, base 12 is at ground potential and forms the second conductor of the microstrip. A signal is applied to microstrip horn 16 through feed 28. For example, a coaxial cable (not shown) could pass through feed 28 and have its center conductor connected to microstrip horn 16.

A dielectric slab 18 with relative dielectric constant ϵ_r is also mounted, such as by gluing or captivation by top 20, to base 12. Dielectric slab 18 has a tapered surface 34 which conforms to tapered surface 32 of base 12. Dielectric slab 18 has a second tapered surface 30 which conforms to a tapered surface (element 50, FIG. 3) in top 20.

Top 20 is secured to base 12 by screws through screw holes 22 and 24 or by any other convenient means such as conductive epoxy. With top 20 secured to the base, a radiating cavity 26 is formed. The radiating cavity 26 is bounded on the bottom by base 12. Two sides of radiating cavity 26 are bounded by the inside surface of prongs 42A and 42B of top 20. A third side of radiating cavity 26 is bounded by tapered surface 50 (FIG. 3) of top 20. The fourth side of radiating cavity 26 is bounded by tapered surface 32. Dielectric slab 18 thus fills radiating cavity 26.

The base 12, top 20 and dielectric slab 40 are constructed to form a flush upper surface. In particular, with the components of antenna 10 assembled, upper surfaces 36, 38 and 40 form a surface without discontinuities. In FIG. 1, that surface is shown to be a plane. Antenna 10 could thus be recessed into a planar surface to create a flush surface. The invention, however, is not limited to a planar flush surface.

FIG. 2 shows additional details of the antenna 10, as would be seen by looking at the top of antenna 10 (FIG. 1) with top 20 removed. In all the figures, like reference numbers denote like elements. Superimposed on the structure of FIG. 2 is an x-axis and an angle ϕ_{AZ} measured relative to the x-axis. The angle ϕ_{AZ} indicates the azimuthal direction relative to the antenna 10.

FIG. 2 also indicates various dimensions of components in antenna 10. Dielectric board 14 has a width W_S and a length L_S. Dielectric slab 18 has a width W. Upper surface 40 has a length L. The total length of dielectric board 14 and dielectric slab 18 is L_T.

FIG. 3 shows a cross-sectional view of antenna 10 taken along the line 3-3 of FIG. 1. Details of top 20 can be seen in FIG. 3. Top 20 has a tapered surface 50 which conforms with tapered surface 30 of dielectric slab 18. Additionally, top 20 has formed in it a cavity 54 of length L_{MC} and extending a height H_{MC} above microstrip horn 16. Inside cavity 54, there is an absorber 52, which is any known material which absorbs radio frequency energy. Cavity 54 and absorber 52 present a load to microstrip horn 16 very similar to the load that would be present if microstrip horn 16 were in free space. In addition, absorber 52 is selected to prevent resonance in cavity 54 while absorbing a minimum of RF energy.

Top 20 is in electrical contact with dielectric horn 16. Electrically, tapered surface 50 is like an extension of microstrip horn 16. Tapered surface 50 therefore launches electrical signals travelling down microstrip horn 16 into radiating cavity 26.

Various other dimensions of antenna 10 are shown in FIG. 3. Dielectric slab 18 is shown to have a height H_C. The bottom of dielectric slab 18 excluding tapered surface 34 is shown to have a length L_B. Dielectric board 14 is shown to have a height of t. In addition, tapered surface 50 is shown to make an angle α_{FE} with base 12. Tapered surface 32 is shown to make an angle α_f with the x-axis. Also, the angle θ_{EL} is shown. Angle θ_{EL} defines the elevation direction relative to antenna 10.

In constructing an antenna according to the invention, the various dimensions of the antenna are selected based on two major considerations. First, the dimensions are selected based on the wavelength, λ_0, of the center frequency, f_o, of operation of the antenna. Additionally, some parameters are selected such that antenna 10 projects a beam in the desired azimuthal and elevational angles.

EXAMPLE I

As an example, Table I shows dimensions selected for the various parameters of antenna 10. FIG. 4A shows the azimuthal beam pattern resulting when an antenna with the dimensions of Table I is operated at a frequency equal to $0.917f_o$. The abscissa of the plot shows azimuthal angle. The ordinate shows the gain relative to an isotropically radiating antenna measured in the far field at the azimuthal angle with the elevation angle of 0°.

FIG. 4B shows the elevation pattern when an antenna with the dimensions of Table I is operated at a frequency of $0.917f_o$. The abscissa of the plot shows elevation angle. The ordinate shows the gain relative to an isotropically radiating antenna measured in the far field at the elevation angle with an azimuthal angle of 0°.

TABLE I

ANTENNA PARAMETER	DIMENSIONS
L	1.17 λ_0
W	0.51 λ_0
L_B	0.61 λ_0
H	0.31 λ_0
t	0.03 λ_0
H_C	0.19 λ_0
H_{MC}	0.18 λ_0
W_S	0.51 λ_0
L_S	0.39 λ_0
L_{MC}	0.36 λ_0
L_T	1.78 λ_0
α_{FE}	40.4°
α_F	14.9°
ϵ_r	3.0
ϵ_{rs}	2.22

As seen by line 400A in FIG. 4A, antenna 10 has a 3dB beamwidth in the azimuthal plane of approximately 160°. Line 400B in FIG. 48 shows antenna 10 has a 3dB beamwidth in the elevation plane of approximately 60°. The beam center in the elevation plane occurs at an elevation angle of approximately 20°.

The performance of antenna 10 can be changed by varying the parameters of antenna construction. If the parameter L is shortened, the 3dB beamwidth in the elevation plane increases. In addition, the beam becomes centered closer to the value of θ_{EL} equal to 90°. In other words, the antenna has a near broadside radiation pattern. Conversely, an increase in L tends to concentrate the beam in the elevation plane closer to values of θ_{EL} near zero. In other words, the antenna has a end-fire radiation pattern.

Additionally, the width W of dielectric slab 18 can be varied. Increasing the value of W tends to decrease the 3dB beamwidth in the azimuthal plane. FIG. 5 shows an alternative embodiment of the antenna. Antenna 10A contains a dielectric slab 10A which tapers outwards away from microstrip horn 16 (not shown). The added width of the taper tends to decrease the 3dB beamwidth in the azimuthal direction.

EXAMPLE II

Near hemispherical elevation coverage over θ_{EL} = 0° to θ_{EL} = 170° can be achieved by varying some of the parmeters shown in Table I. With $L = 0.53\lambda_0$ and $\epsilon_r = 6$, there will be less than 8dB of gain variation and a front to back ratio of less than 3.5dB (at θ_{EL} = 20° and θ_{EL} = 160°). An antenna constructed with the dimensions oi this example can achieve an impedance matched peak gain of not less than 2dBi and a half power beamwidth of not less than 62° measured in the plane θ_{EL} = 0° over a 3:1 frequency band.

FIG. 5 also shows how an antenna can be flush mounted to a surfâce. Antenna 10A is recessed into surface 56. Here, surface 56 is curved. Upper surface 36A, 38A, and 40A are shaped to conform to surface 56.

Having described embodiments of the invention, it will be apparent to one of skill in the art that various modifications to the disclosed embodiments could be made. For example, the antenna has been described only in relation to tbe transmission of signals, but could be used to receive signals. Additionally, the antenna has been shown to mount flush with planar or curved surfaces, but could be readily extended to conform to any shape surface. The flush mount antenna could be arrayed, resulting in a flush mount array antennas Therefore, the invention should be defined by the spirit and scope of the appended claims.

Claims

1. An antenna mounted flush with a surface comprising:

a) a conducting structure having an upper surface conforming with the surface, said upper surface having a cavity formed therein;

b) dielectric material disposed within the cavity; and

c) means for coupling radio frequency energy into the cavity.

2. The antenna of Claim 1 wherein the means for coupling radio frequency energy comprises a microstrip horn.

3. The antenna of Claim 2 wherein the microstrip horn is separated from the upper surface by a second cavity.

4. The antenna of Claim 3 additionally comprising material absorbtive of radio frequency energy disposed in the second cavity.

5. The antenna of Claim 1 wherein the cavity is bounded by a first tapered surface of the structure.

6. The antenna of Claim 5 wherein the cavity is bounded by a second tapered surface of the structure opposite the first tapered surface.

7. The antenna of Claim 6 wherein the means for coupling radio frequency energy comprises a microstrip horn electrically connected to the second tapered surface.

8. The antenna of Claim 5 wherein the dielectric material has a first tapered surface conforming with the first tapered surface of the structure.

9. The antenna of Claim 8 wherein the dielectric material has a second tapered surface conforming to the second tapered surface of the structure.

10. The antenna of Claim 1 wherein the antenna is mounted flush with a planar surface.

11. The antenna of Claim 1 wherein the antenna is mounted flush with a curved surface.

12. An antenna comprising:

a) a base having an upper surface and a tapered surface; and

b) a top having:

i) an upper surface disposed flush with the upper surface of the base; and

ii) two prongs, each prong having an edge conforming with the tapered surface of the base.

13. The antenna of Claim 12 additionally comprising:

a) a dielectric slab having:

i) a first surface conforming with the tapered surface of the base; and

ii) a second surface and a third surface, each surface conforming with a surface of one of the prongs.

14. The antenna of Claim 13 wherein the base has a flat surface adjacent the tapered surface.

15. The antenna of Claim 14 additionally comprising:

a) a dielectric board mounted on the flat surface of the base.

16. The antenna of Claim 15 additionally comprising:

a) a microstrip horn formed on the dielectric board.

17. The antenna of Claim 16 wherein the top has a tapered surface adjacent to and disposed between the two prongs.

18. The antenna of Claim 17 wherein the dielectric slab has a fourth surface conforming with the tapered surface of the top.

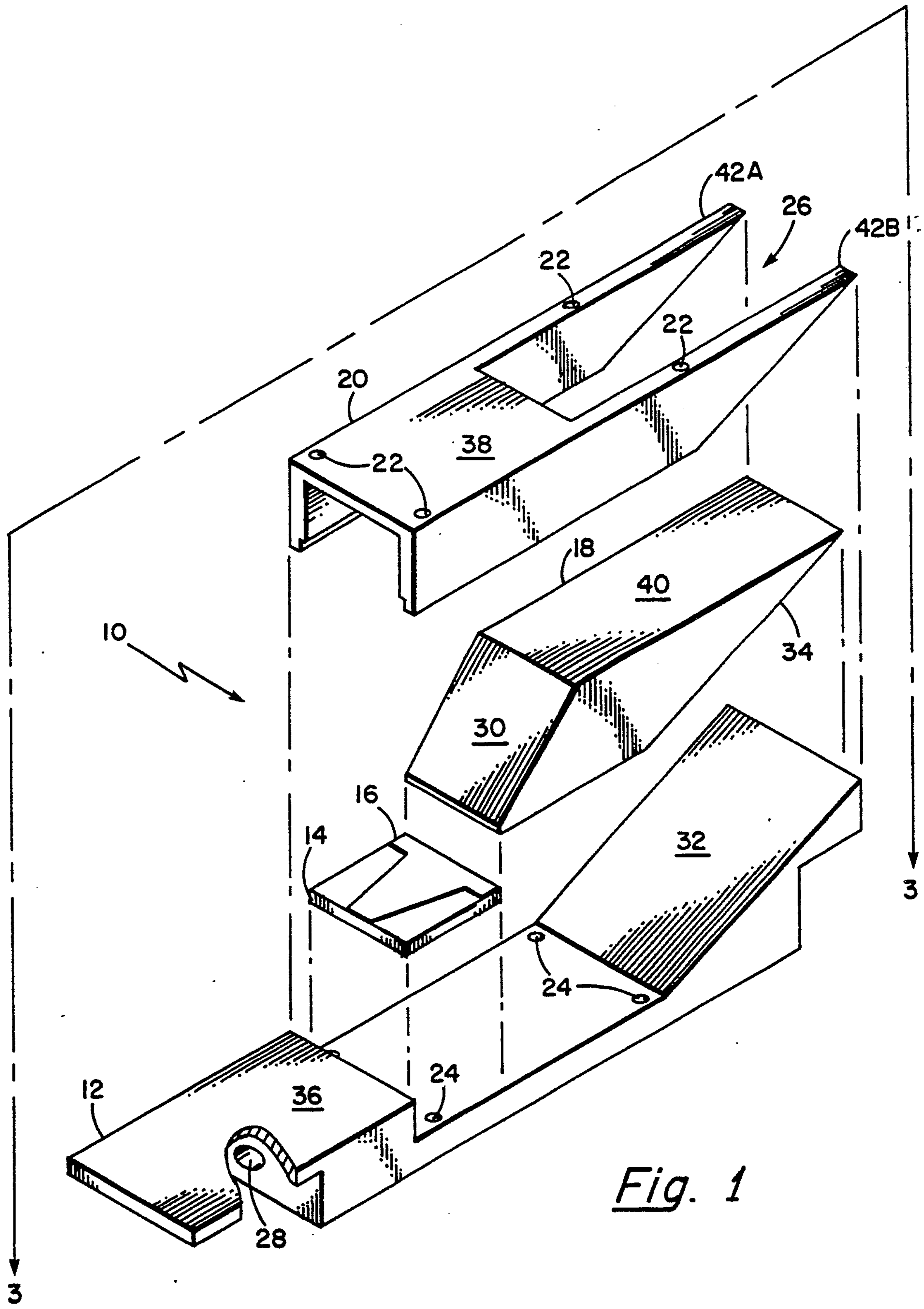

Fig. 1

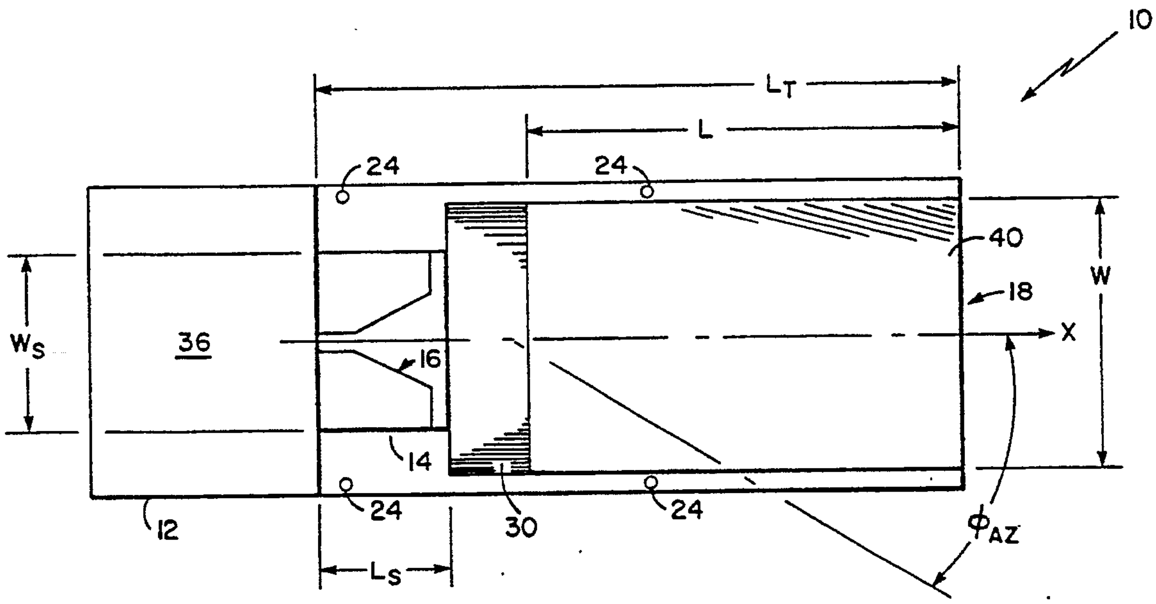
10
L_T
L
24
24
40
18
W
W_S
36
X
16
14
30
24
24
12
ϕ_{AZ}
L_S

Fig. 2

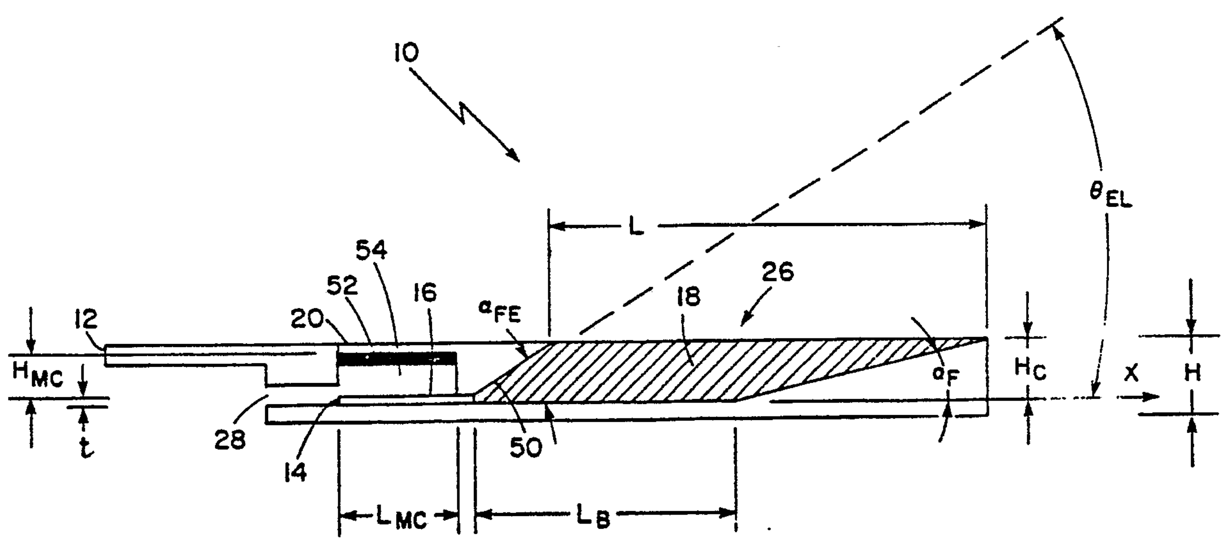
10
θ_{EL}
L
54
26
52
16
18
12
20
α_{FE}
H_{MC}
H_C
X
H
α_F
t
28
14
50
L_{MC}
L_B

Fig. 3

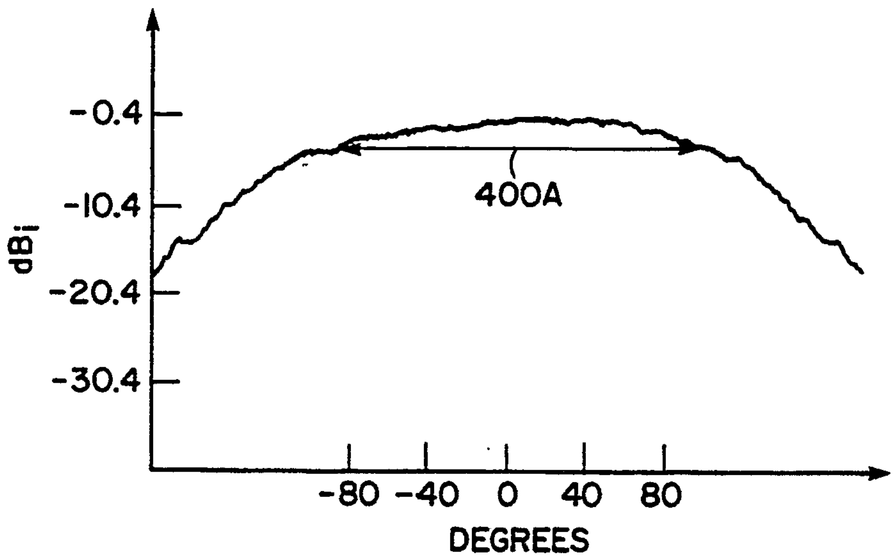
-0.4
-10.4
-20.4
-30.4
dBi
400A
-80 -40 0 40 80
DEGREES

Fig. 4A

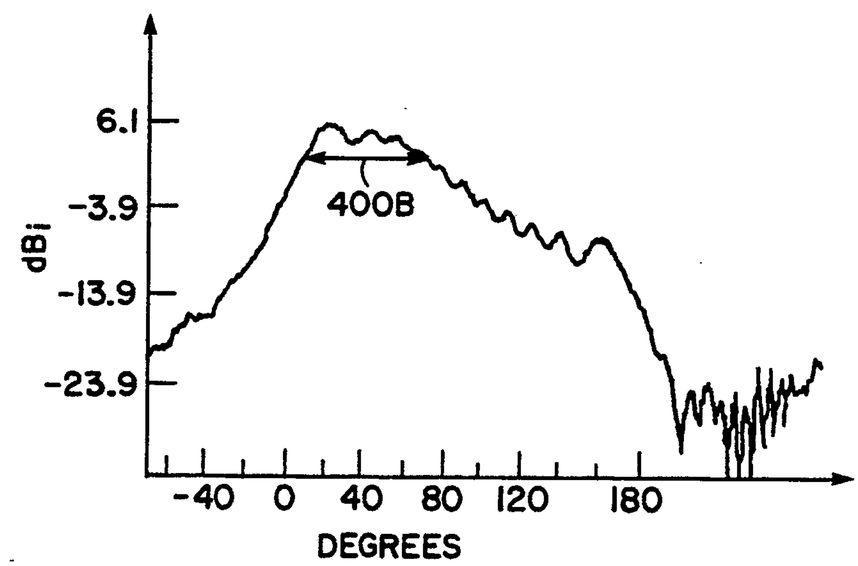
6.1
-3.9
-13.9
-23.9
dBi
400B
-40 0 40 80 120 180
DEGREES

Fig. 4B

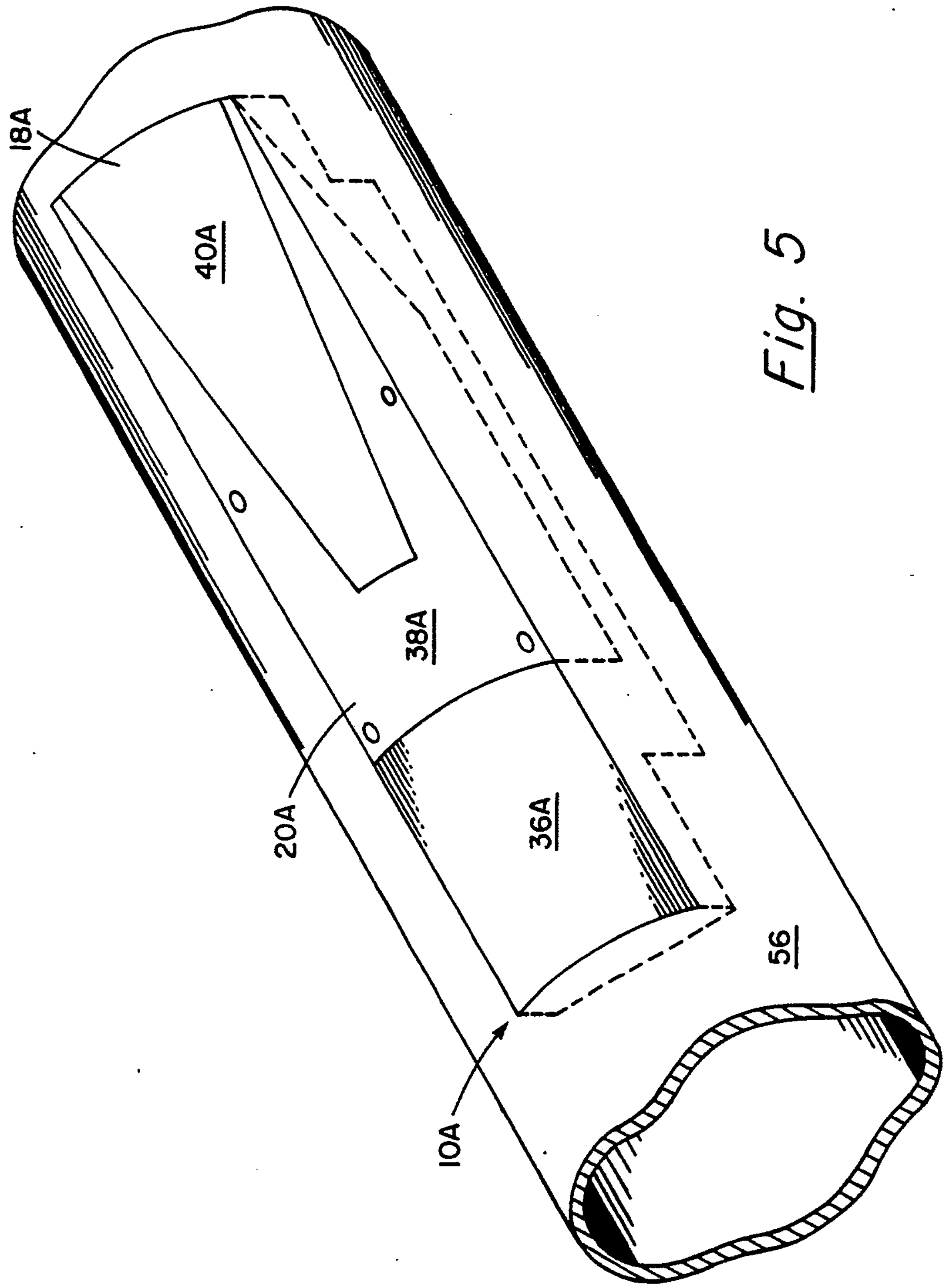

Fig. 5