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Graber

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(54) **RADIAL WAVEGUIDE FOR DOUBLE CONE TRANSDUCERS**

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(51) **Int. Cl.**
G10K 11/02 (2006.01)

(52) **U.S. Cl.**
USPC **181/192**; 181/144; 181/177; 381/343

(58) **Field of Classification Search**
USPC 181/144, 152, 155, 156, 177, 179, 181/185, 189, 192, 194, 196; 381/337, 338, 381/339, 340, 341, 342, 343, 352
See application file for complete search history.

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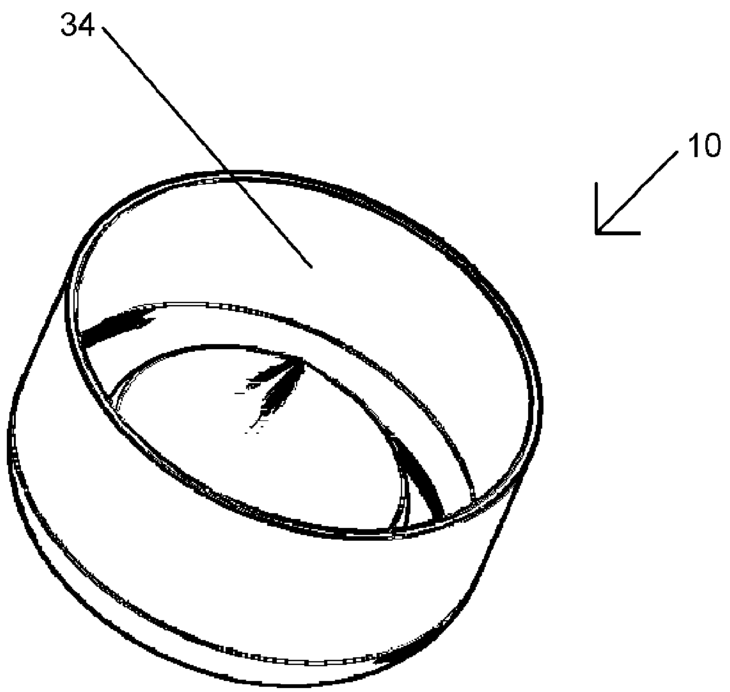
(57) **ABSTRACT**

A radial waveguide assembly comprises a transducer section and a waveguide section. The transducer section includes first and second cone loudspeakers arranged coaxially and in an opposed relationship. A compression plug having two input surfaces is mounted between diaphragms of the cone loudspeakers. Channels from the first and second cone loudspeakers feed common sound chambers located in a belt around the circular perimeter where they connect to external ports. A radial; folded waveguide has a circular throat which connects to the external ports.

3 Claims, 19 Drawing Sheets



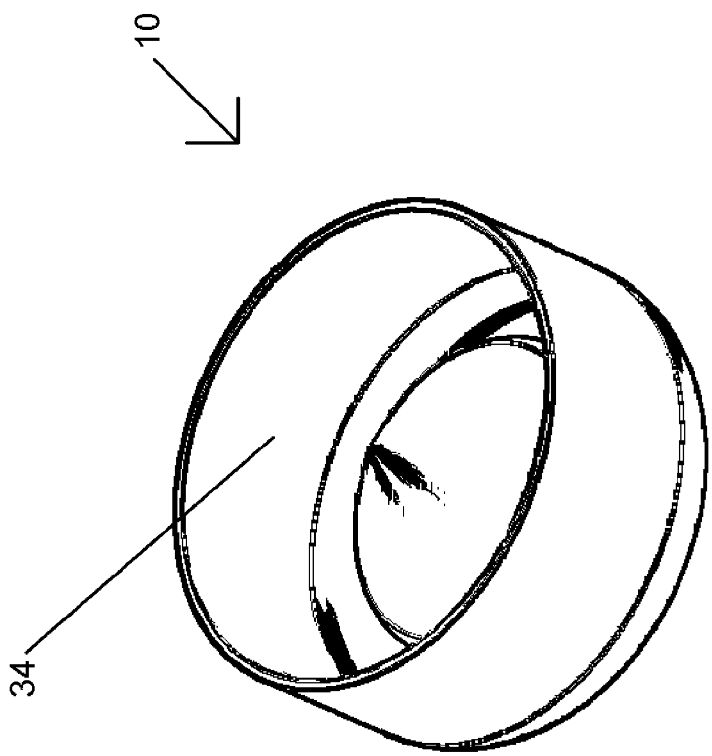


FIG. 1

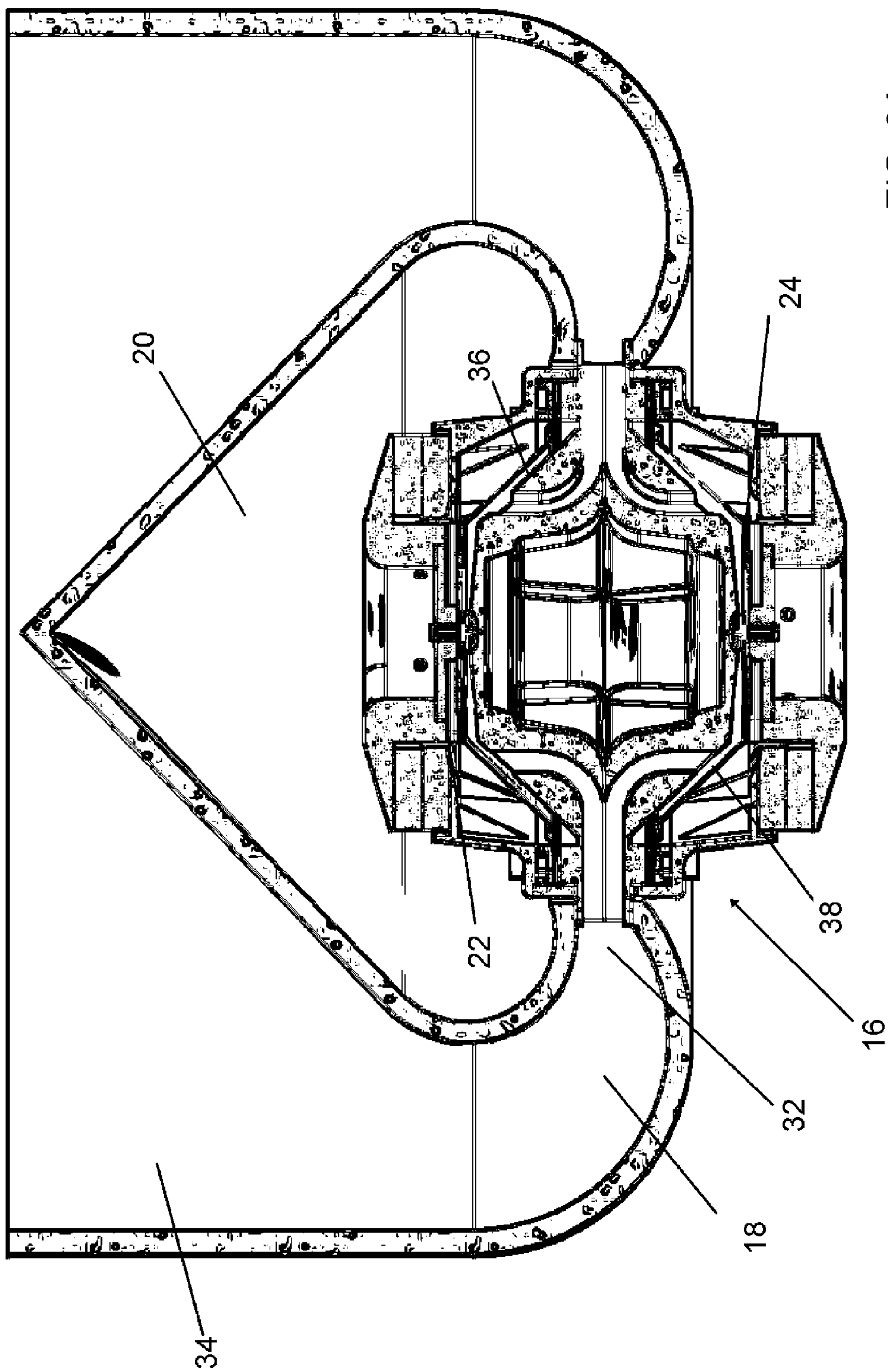


FIG. 2A

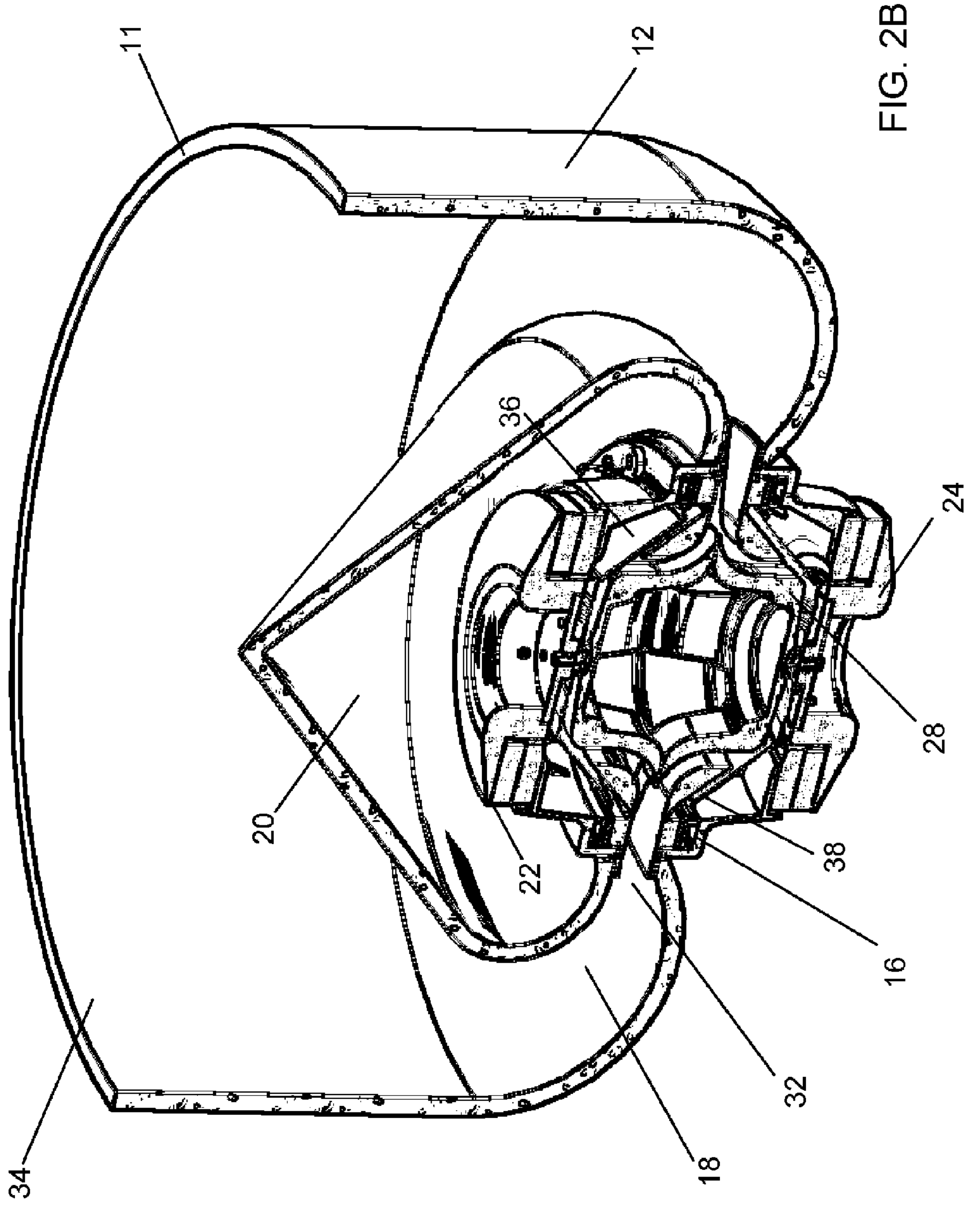


FIG. 2B

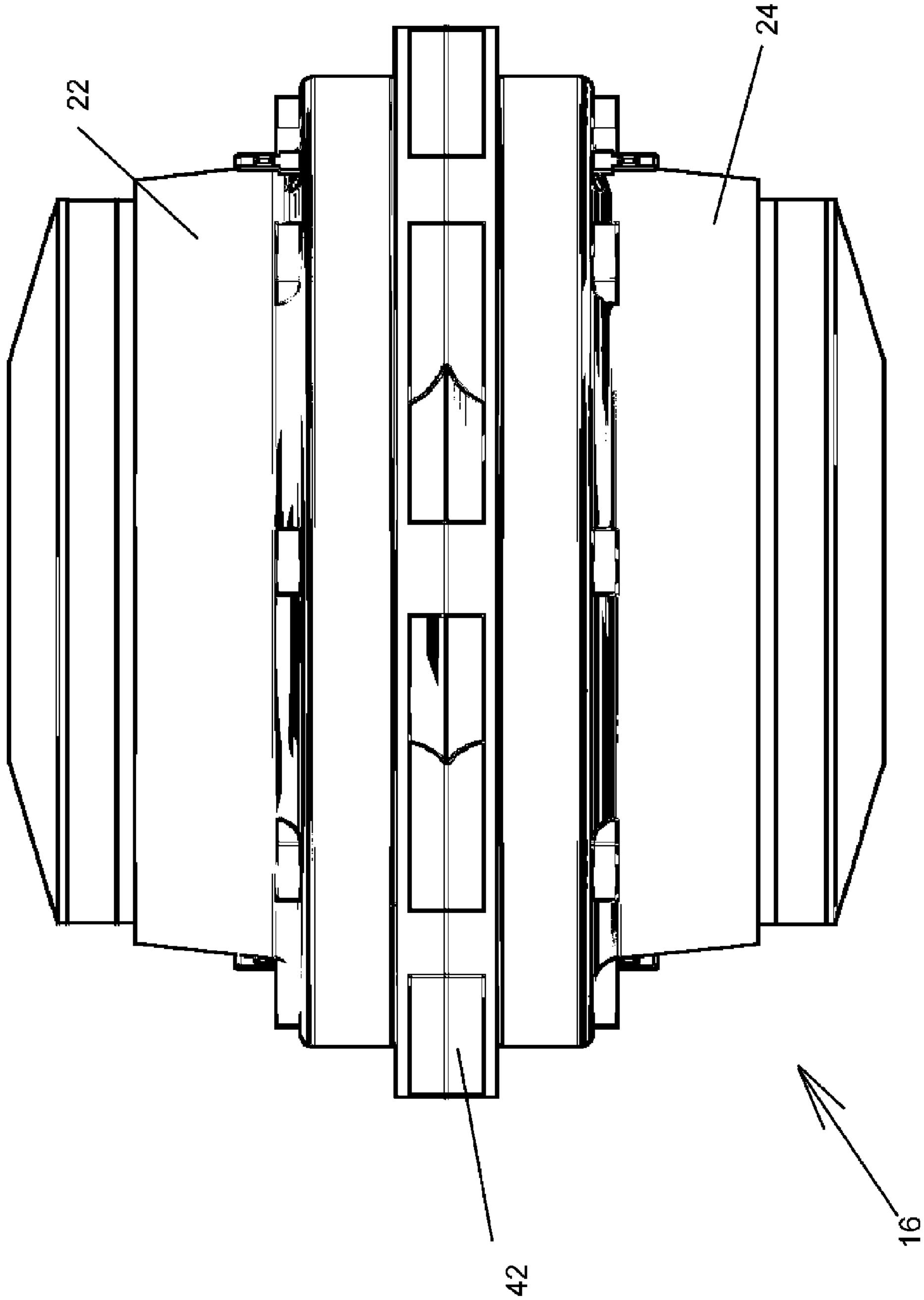


FIG. 3A

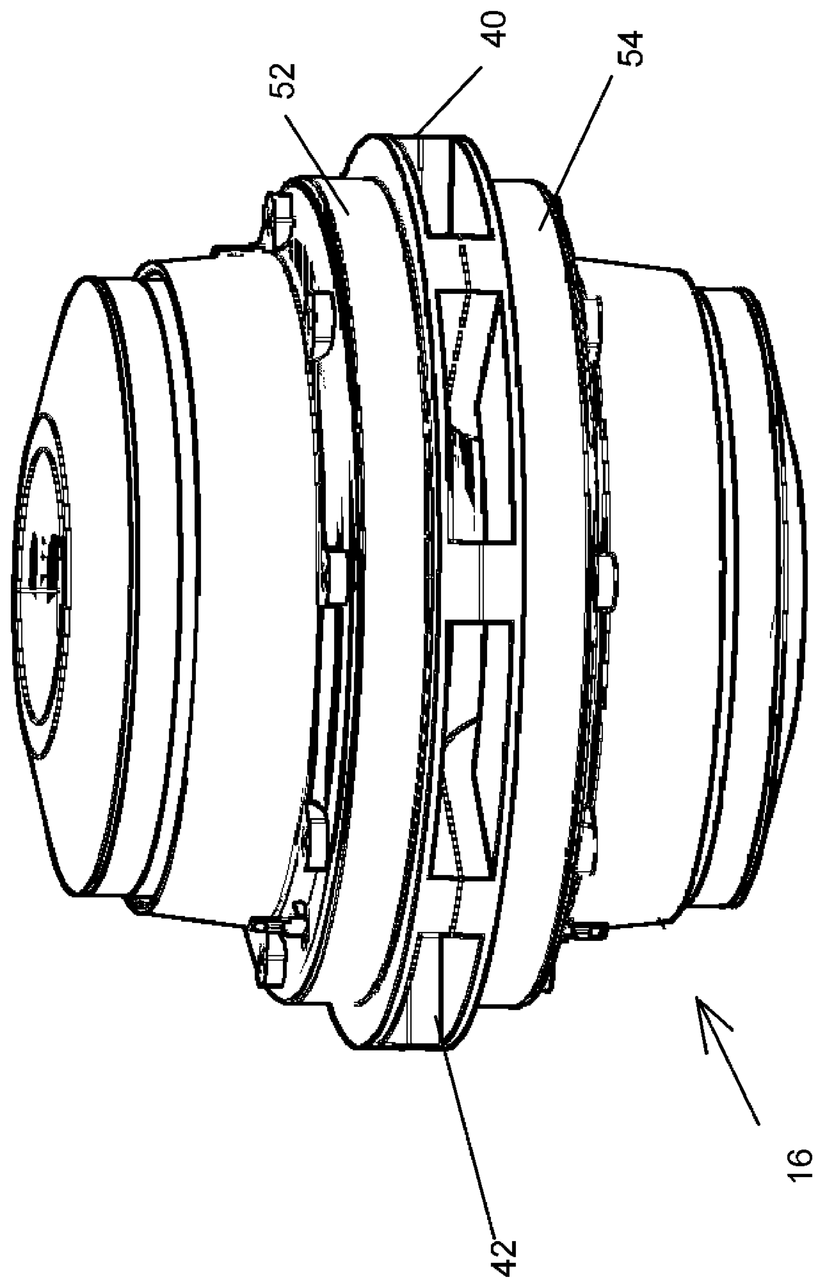


FIG. 3B

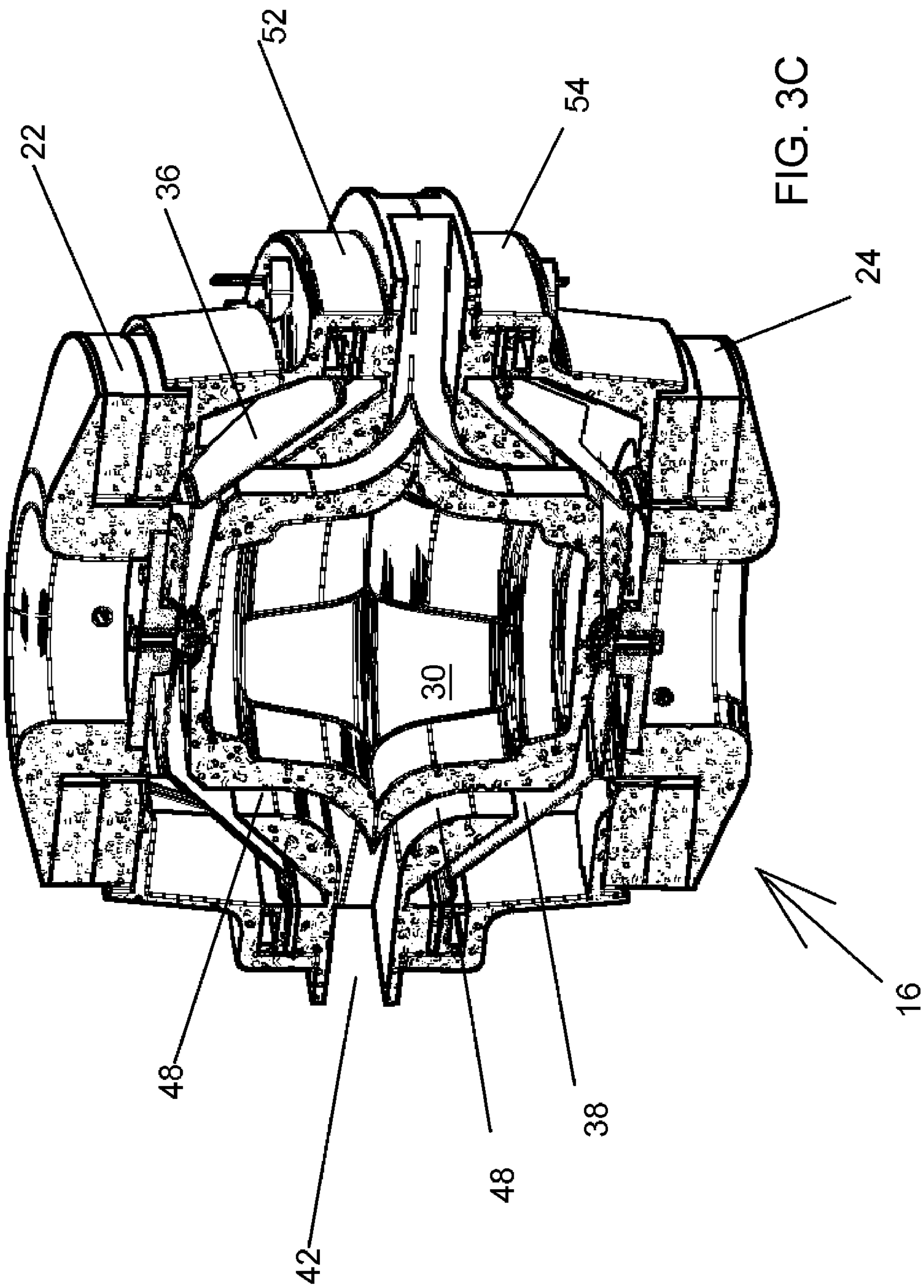


FIG. 3C

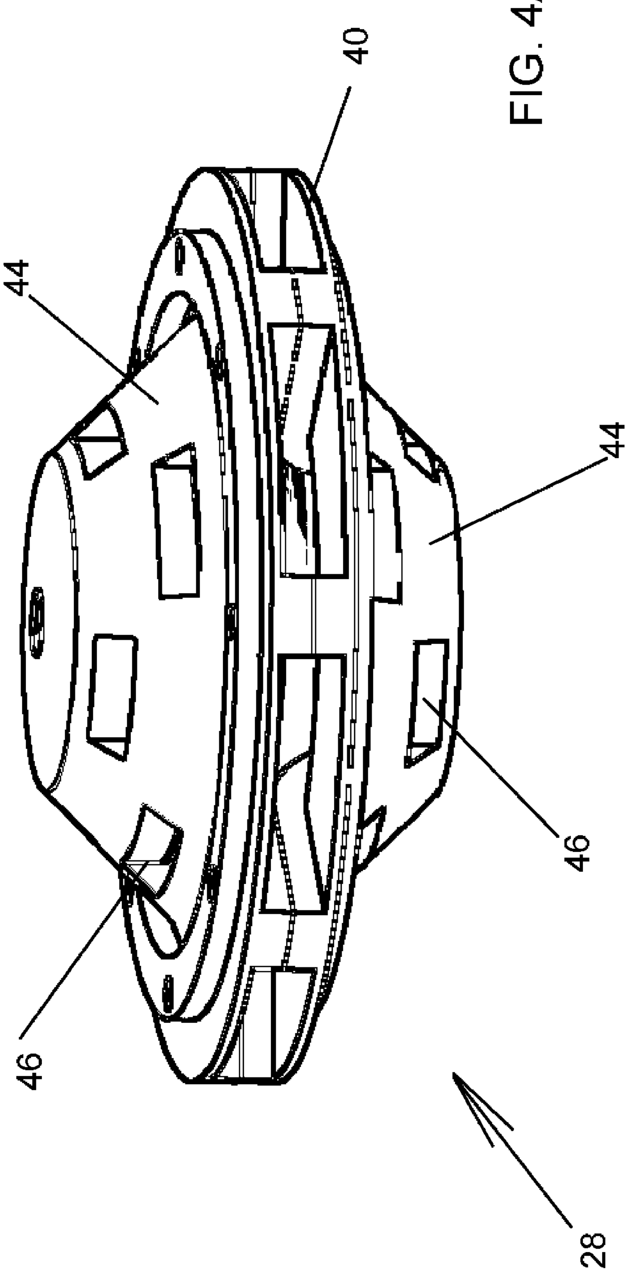


FIG. 4A

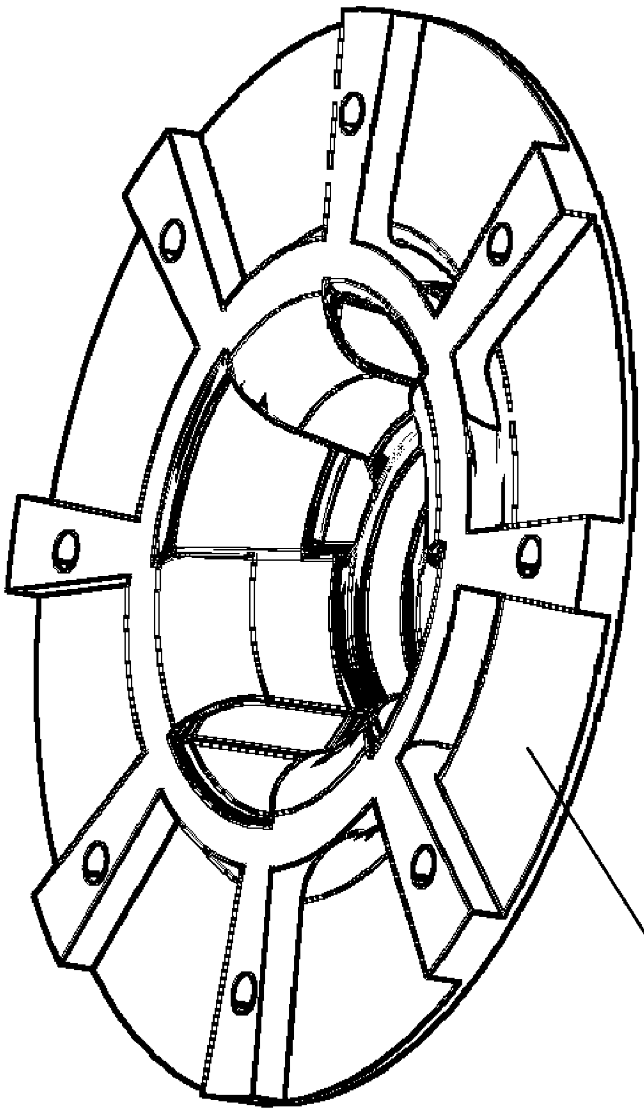


FIG. 4B

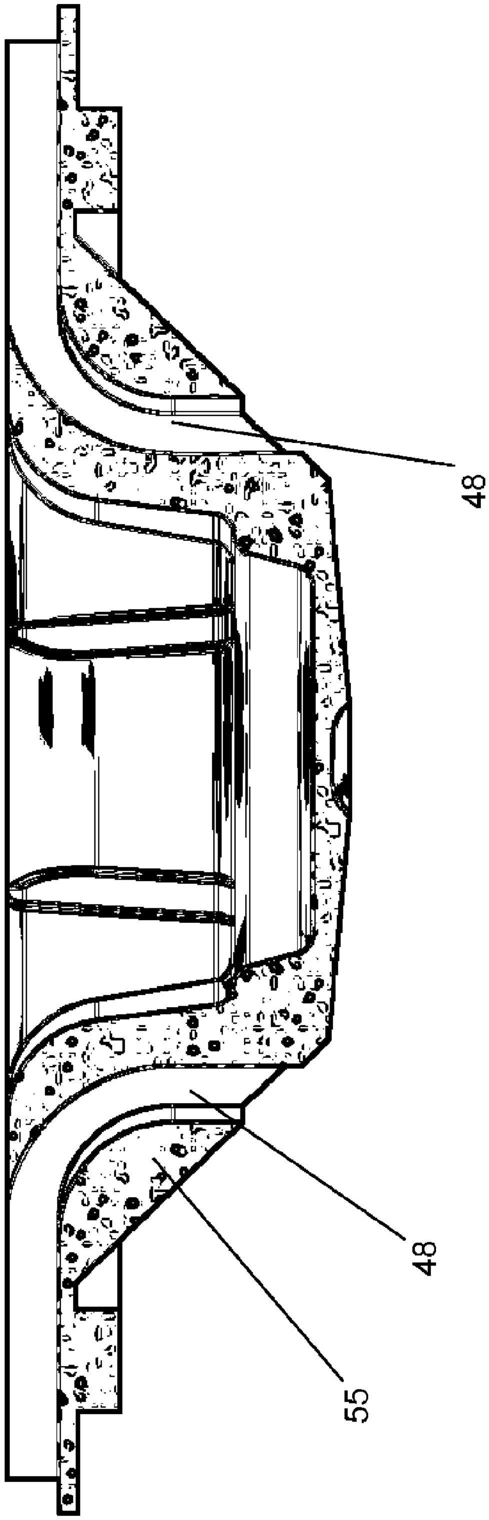


FIG. 4C

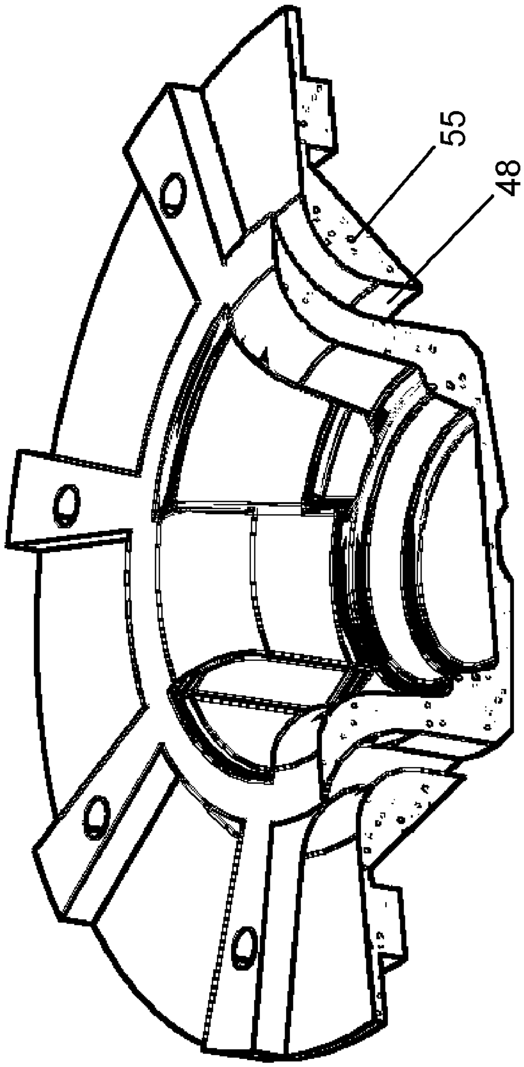
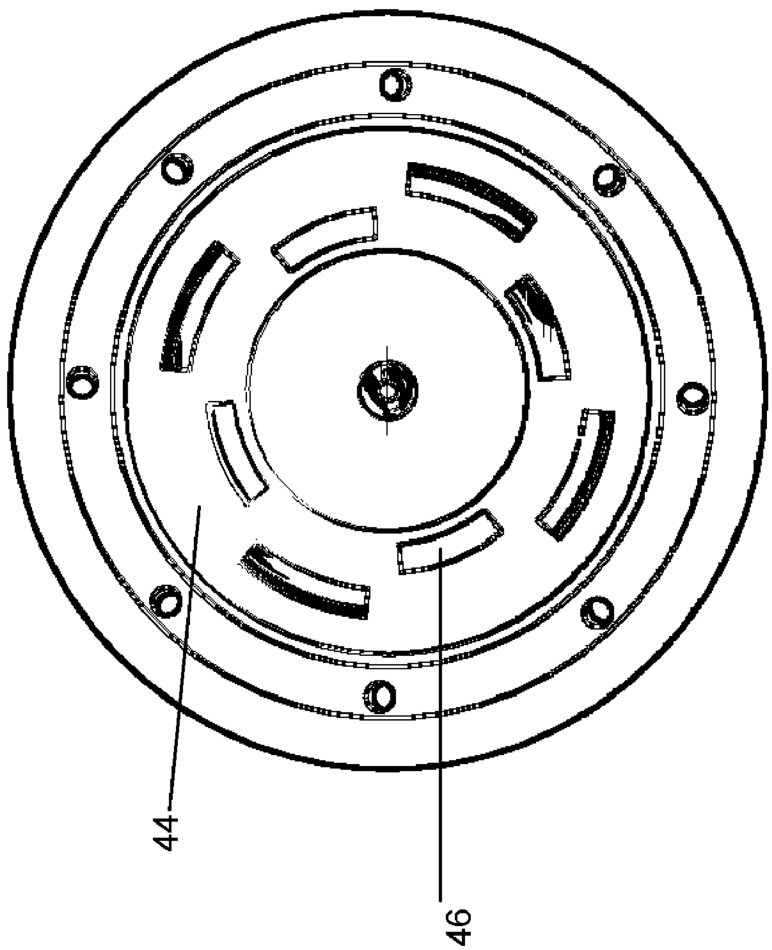


FIG. 4D

FIG. 4E



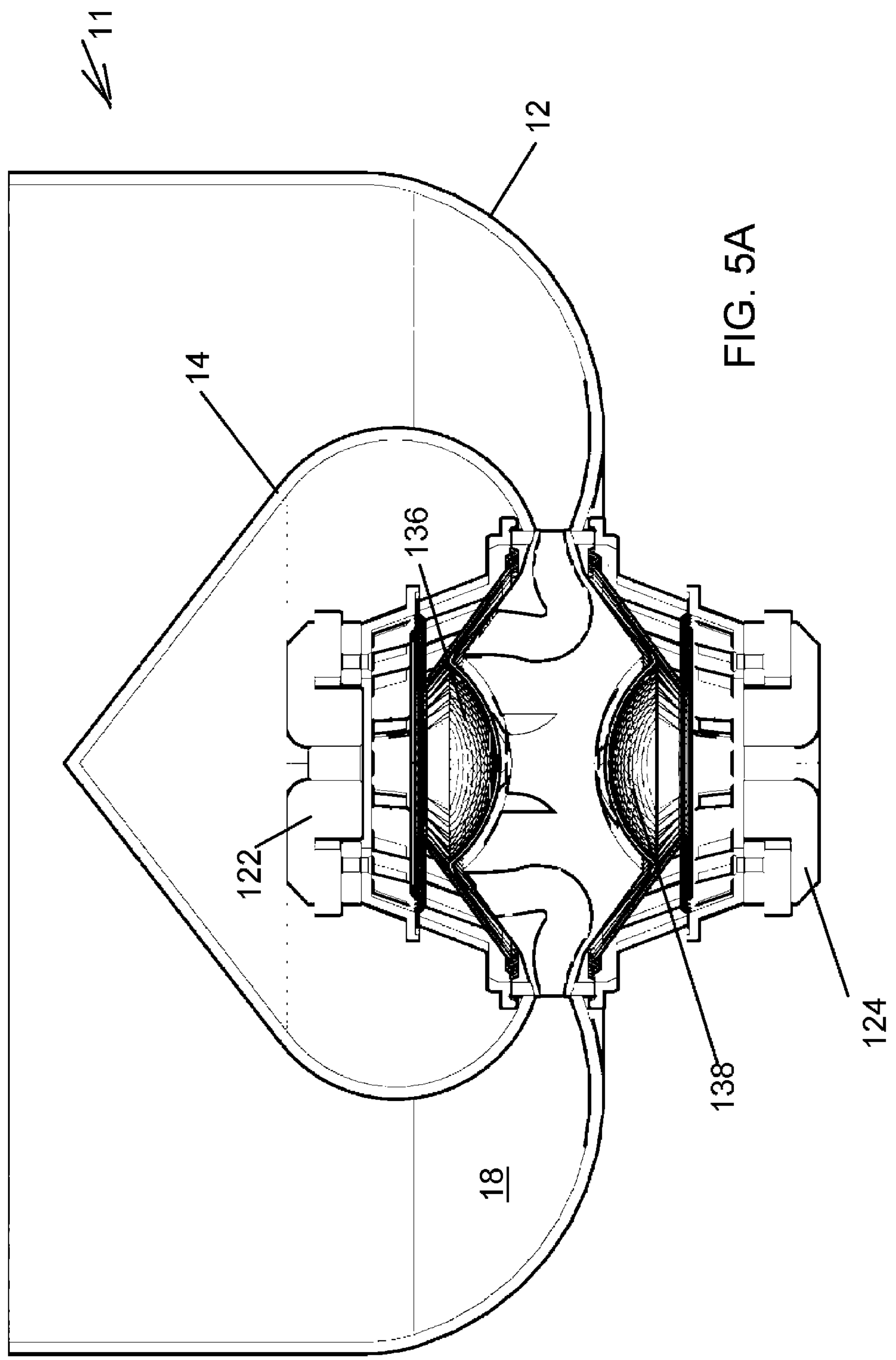


FIG. 5A

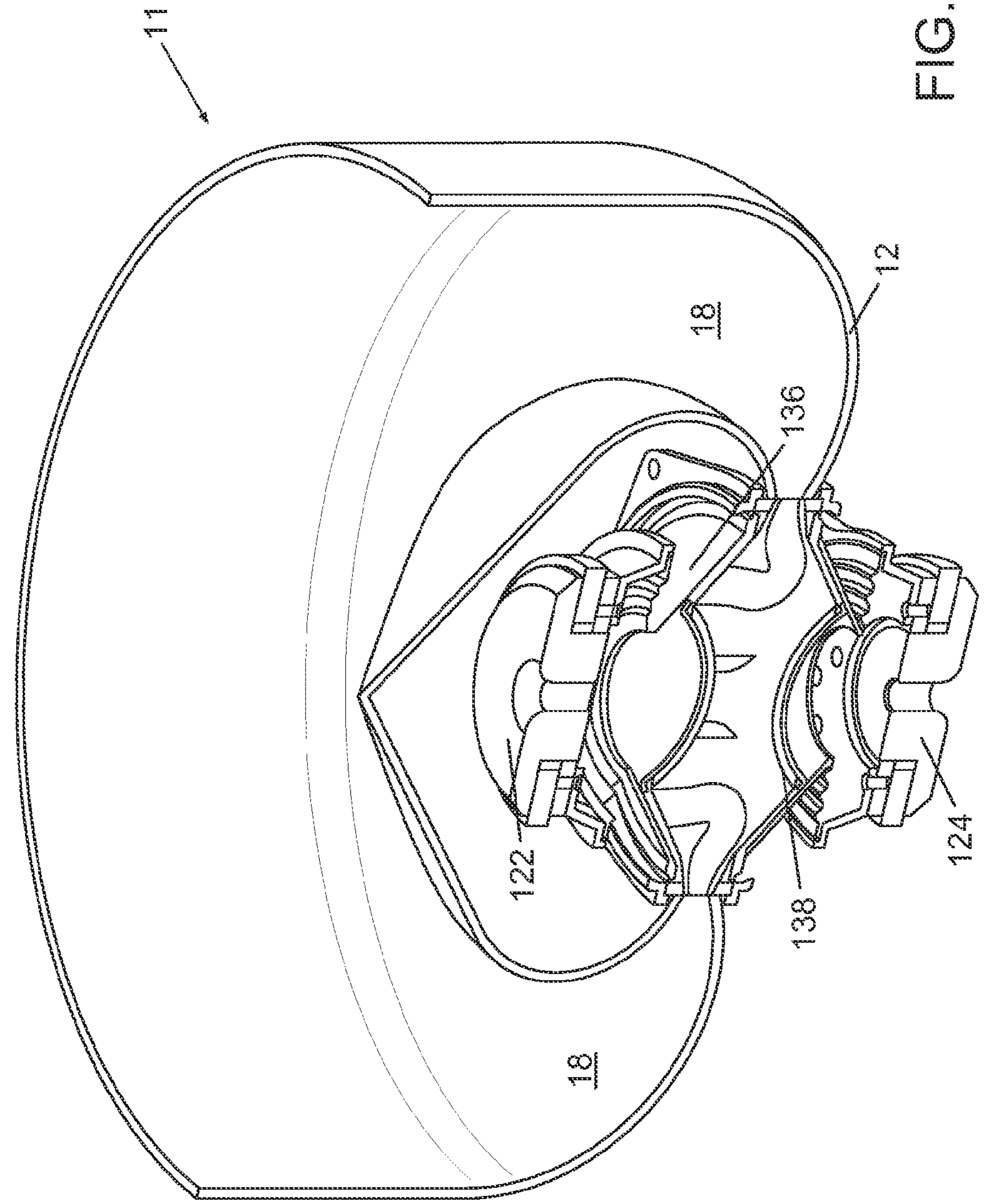
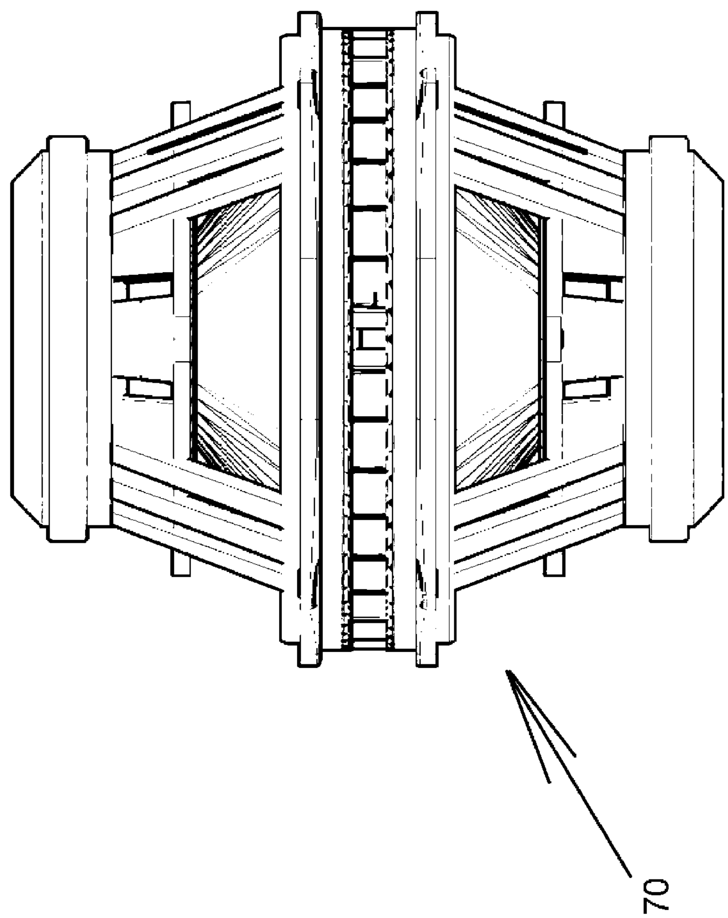


FIG. 5B

FIG. 6A



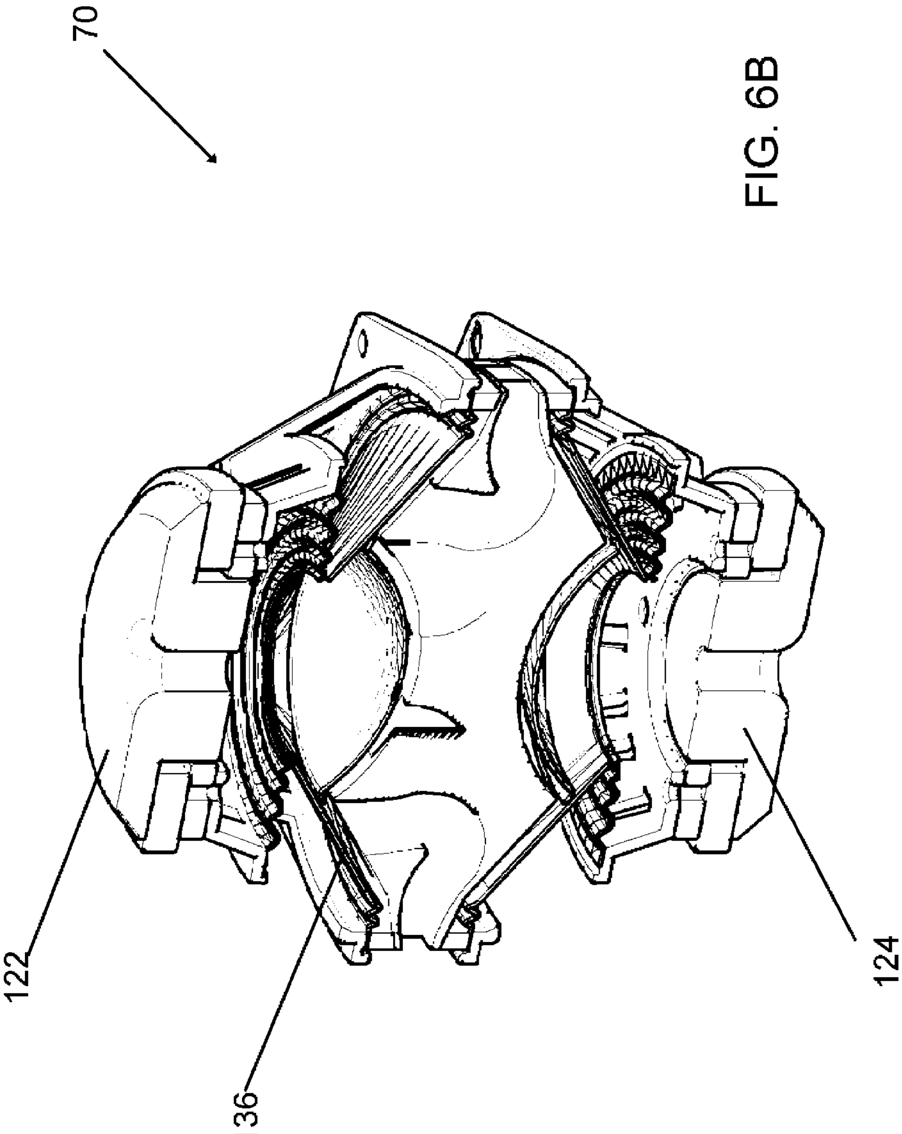


FIG. 6B

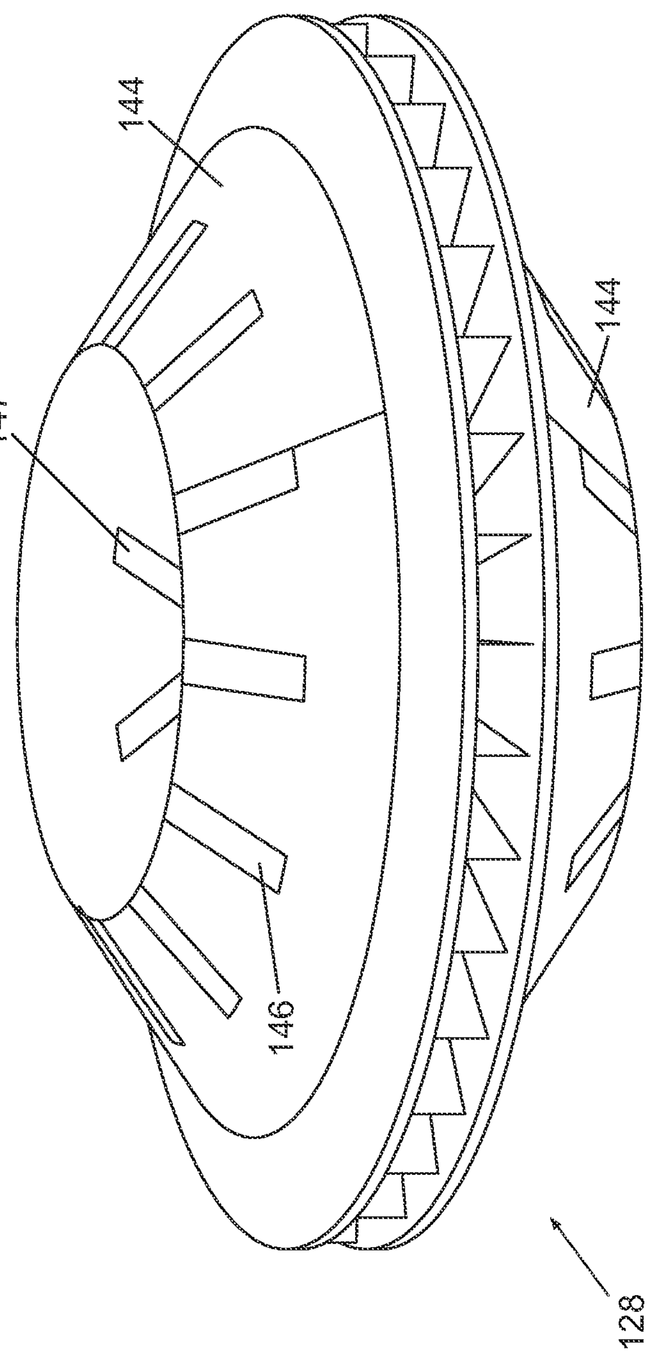


FIG. 7A

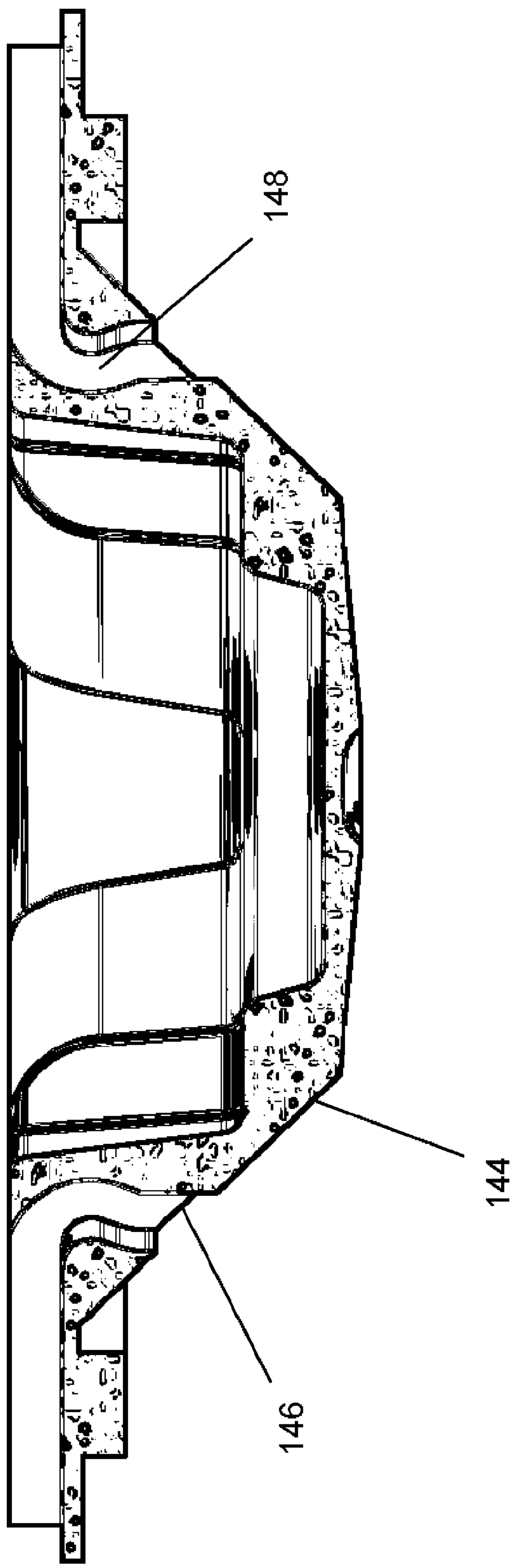


FIG. 7B

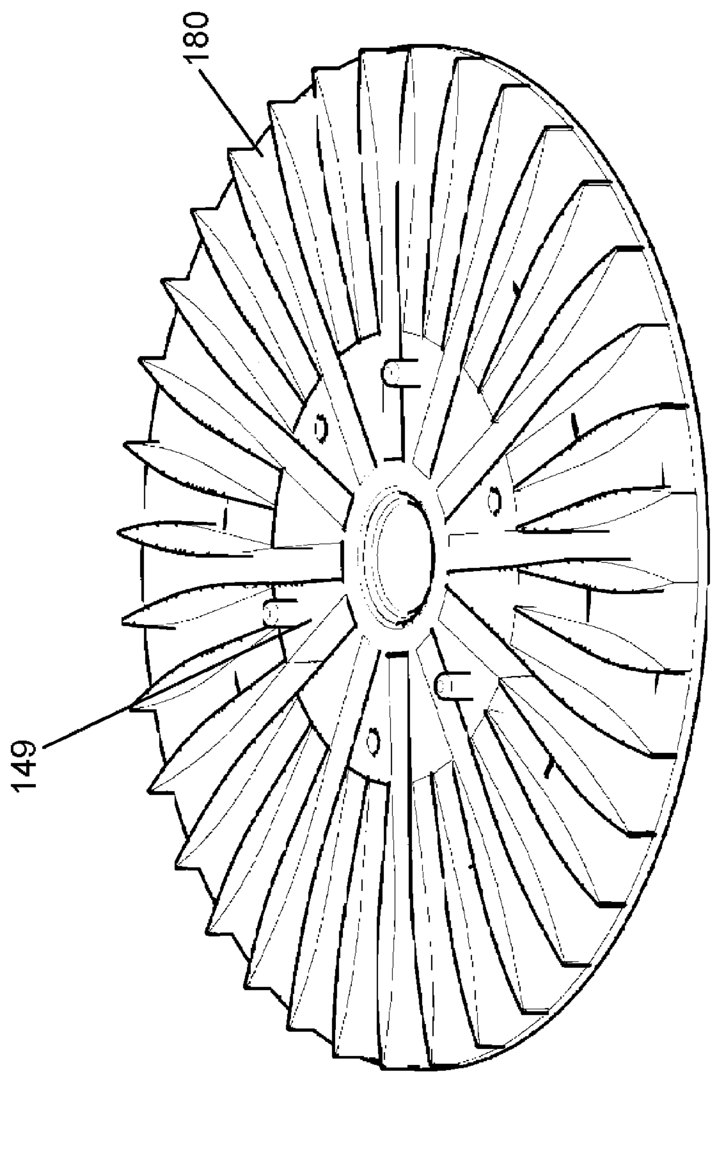


FIG. 7C

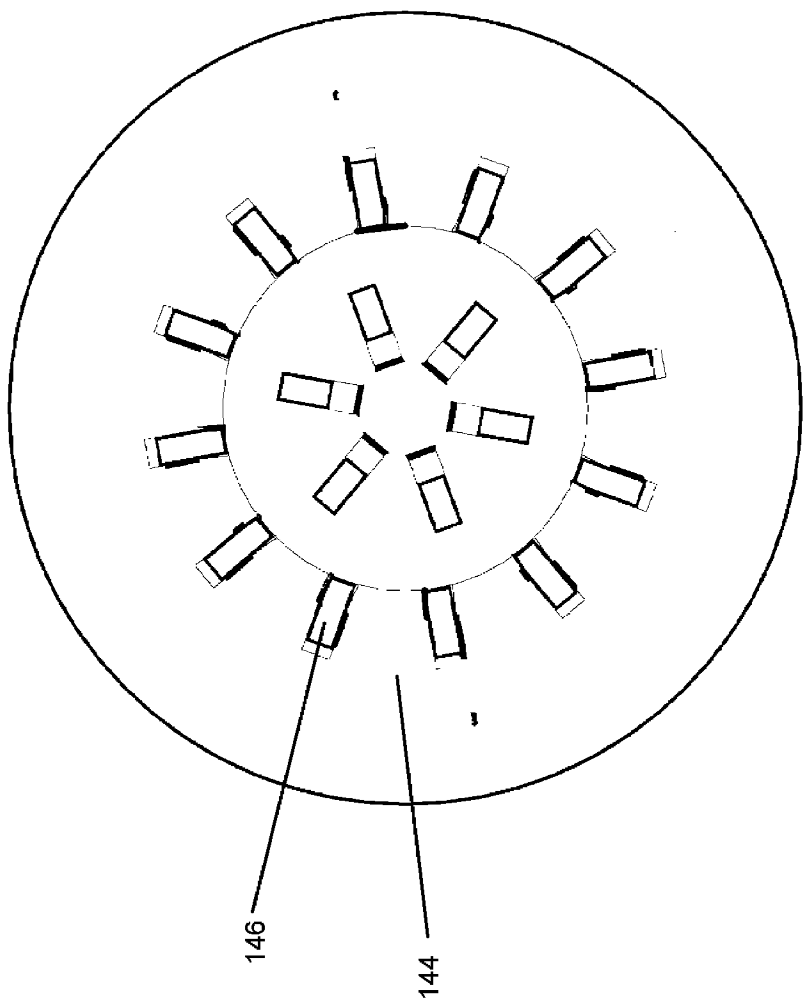


FIG. 7D

RADIAL WAVEGUIDE FOR DOUBLE CONE TRANSDUCERS

BACKGROUND

1. Technical Field

The field relates to sound reproduction and more particularly waveguides for collecting and directing sound from multiple sources at high intensities.

2. Description of the Problem

In U.S. Pat. No. 7,837,006 Graber described a sound field blending and projection system which combined inputs from a plurality of loudspeakers arranged in a circular or radial array. The loudspeakers were horn loaded with the effective mouths of the horns being differentially located for different frequencies. The horn mouth at lower frequencies was a blended mouth for what was in effect a multi-throated horn which exhibited a fold for low frequencies. Higher frequencies were directed inwardly against a spike or cone like reflector located at the center of the circle. The reflector was oriented to merge the higher frequency sound waves in a beam and to reflect the beam along a radiant axis at a right angle to the plane of the circle. For lower frequency sound the central spike or cone was largely ineffective with low frequency sound directed along the same radiant axis as for the higher frequencies by the blended horn mouth and horn fold.

Compression plugs are well known devices for increasing transducer efficiency and numerous references relate to their use with single transducers coupled with a horn.

SUMMARY

A radial waveguide assembly comprises a transducer section and a waveguide section. The transducer section includes first and second cone loudspeakers arranged coaxially and in opposed directions with the diaphragms pointed in toward one another. A compression plug having two input surfaces is mounted between diaphragms of the cone loudspeakers. The input surfaces are located along opposite ends of the compression plug. The input surfaces conform in shape with the diaphragms of the cone loudspeakers and are located juxtaposed the diaphragms. Channels through compression plug run from the input surfaces to outlets on a circular perimeter of the compression plug. Channels from the first and second cone loudspeakers feed common sound chambers located in a belt around the circular perimeter where they connect to external ports. A radial, folded waveguide has a circular throat which connects to the external ports. The radial, folded waveguide comprises inner and outer sections. The outer section or form is generally bowl or cup like with vertical outer sides. The transducer section is mounted at the bottom center of the bowl. The inner section of the waveguide is located inside the bowl and houses a portion of the transducer assembly. The contour of the inner section is selected to determine the rate of expansion of the waveguide if used as a horn.

BRIEF DESCRIPTION OF THE DRAWINGS

Understanding of the following description may be enhanced by reference to the accompanying drawings wherein:

FIG. **1** is a perspective view of a radial waveguide assembly;

FIG. **2**A is a cross sectional view of the radial waveguide assembly of FIG. **1**.

FIG. **2**B is a cross sectional view of the radial waveguide assembly of FIG. **1**.

FIG. **3**A is a side elevation of the transducer assembly of the radial waveguide assembly of FIG. **1**.

FIG. **3**B is a perspective view of the transducer assembly for the radial waveguide of FIG. **1**.

FIG. **3**C is a cross sectional view of the transducer assembly of FIG. **3**A.

FIG. **4**A is a perspective view of a compression plug from the transducer assembly of FIG. **3**A.

FIG. **4**B is a perspective view of a compression plug section molding.

FIG. **4**C is a cross sectional view of a compression plug section molding.

FIG. **4**D is a cutaway perspective view of a compression plug section molding.

FIG. **4**E is a top plan view of a compression plug section molding.

FIG. **5**A is a cross sectional view of the radial waveguide assembly incorporating an alternative transducer section.

FIG. **5**B is a cutaway view of the radial waveguide assembly incorporating the alternative transducer section of FIG. **5**A.

FIG. **6**A is a side elevation of the alternative transducer section.

FIG. **6**B is a cutaway view in perspective of the alternative transducer section.

FIG. **7**A is a perspective view of a compression plug of the alternative transducer section.

FIG. **7**B is a cross section view of half of the compression plug of FIG. **7**A.

FIG. **7**C is a perspective view of an interior face of half the compression plug of the alternative transducer section.

FIG. **7**D is a top plan view of an exterior face of the compression plug for the alternative transducer section.

DETAILED DESCRIPTION

FIG. **1** illustrates a radial waveguide assembly **10**. The radiant axis from the device is a line extending perpendicular to the plane of the mouth **34**. Referring generally to FIGS. **2-4** a first embodiment of a radial waveguide assembly is illustrated comprising a transducer section **16** and a waveguide section **11**. FIGS. **5-7** illustrate an embodiment incorporating an alternative transducer section **70**.

The transducer section **16** includes a first or upper cone loudspeaker **22** and a second or lower cone loudspeaker **24**. The upper and lower cone loudspeakers **22**, **24** are mounted in coaxial opposition, with the diaphragms **36**, **38** facing toward one another. A compression plug **28** is disposed between diaphragms **36**, **38** and has two input surfaces **44** which are juxtaposed to diaphragms **36**, **38**. Compression plug **28** is attached to upper and lower cone loudspeakers **22**, **24** by assembly rings **52**, **54**, which provide a framework allowing attachment of the inner and outer forms **14**, **12** used to construct the waveguide section **11** and which define the folded radial waveguide **18**. An outside lateral circular perimeter to the compression plug extends between assembly rings **52**, **54**, spacing the rings and allowing communication between outlet ports **42** and an inwardly oriented, circular waveguide throat **32**.

Compression plug **28** is roughly disk shaped with two major surfaces, those being input surfaces **44**. The input surfaces **44** are conformed to the shape of the diaphragms **36**, **38** of the cone loudspeakers **22**, **24**. Diaphragms **36**, **38** operate in phase with one another in contrast with the more usual push-pull, out of phase operational arrangements used in isobaric loudspeaker systems with facing diaphragms. In further contrast to isobaric systems the present system generates acoustic signals in the volume between the diaphragms **36**, **38**. The outlet ports **42** from the compression plug **28** are arranged in a circular band on a perimeter surface **40** of the compression plug. The outlet ports **42** are at substantially right angles to the inlet ports **46**.

Channels **48** through compression plug **28** connect inlet ports **46** on the input surfaces **44** to perimeter outlet ports **42**. Each outlet port **42** is fed by two channels **48**. One inlet port **46** from each of the two input surfaces **44** feeds outlet port along channels **48** of equal length.

Compression plug **28** is fabricated from two moldings **55** which define an anti-resonant cavity **30** upon assembly.

Inlet ports **46** may be configured as arcs which are centered on the diaphragms **36**, **38** upon assembly. These arcs may be differentially spaced relative to the center, but are displaced outwardly away from the central section of the cone diaphragm. A compression plug **60** for use with dome speakers has an input surface **68** including a central spherical section **62** and radially extending input ports **64**, **66**.

Waveguide section **11** is constructed from inner and outer forms **14**, **12**. Inner form **14** attaches along its one exposed edge to ring assembly element **52**. Inner form **14**. Inner form **14** is generally tear drop or kiss shaped with its base open at the center and resting on an edge defining the open base on the ring assembly element **52** adjacent the perimeter **40** of the compression plug **28**. The inner form **14** tapers upwardly leaving an inner cavity **20** which encloses the upper transducer **22**. The outer form **12** is cup shaped with an opening in the bottom center which fits around lower transducer **24** to attach along the edge defining the open bottom to assembly ring **54** adjacent the perimeter **40** of compression plug **28**. The opening defined by the lip of the outer form **12** defines a waveguide mouth **34** through which sound is directed.

Folded radial waveguide **18** has a circular throat **32** which connects the circular perimeter **40** of the compression plug. The contour of the inner form **14** largely determines the rate of expansion of the folded radial waveguide **18** defined by the waveguide assembly **11** if configured to operate as a horn.

FIGS. **5** through **7** illustrate an alternative transducer section **70** with loudspeakers **122**, **124** which incorporate diaphragms **136**, **138** with central dome sections. A compression plug **128** is positioned between the diaphragms **136**, **138** which provides both inner and outer radial inlets **147**, **146** on the major input surfaces **144**. Again perimeter outlet ports **142** are connected to the inlets by channels through the compression plug **128**. These channels are of two types providing for equalizing the distance traveled from the inner radial inlets **147** to perimeter outlet ports **142** and outer radial inlets **146** to the perimeter outlet ports **142**. Serpentine channels **148** connect the outer radial inlets **146** to perimeter outlet ports **142**. Relatively direct channels **149** provided in a central channel section **180** connect inner radial inlets **147** to perimeter outlet ports **142**.

What is claimed is:

1. A loudspeaker system assembly comprises:

at least a first cone loudspeaker having a radiating diaphragm;

a compression plug having a first surface juxtaposed to the radiating diaphragm of the first cone loudspeaker and a perimeter surface encircling the first surface;

outlet ports from the compression plug arranged in a circular band on the perimeter surface;

inlet ports on the first surface;

channels connecting the inlet ports to the outlet ports for coupling acoustic energy generated by the first cone loudspeaker to the outlet ports, the channels bending through substantially ninety degrees so that acoustic energy is radiated outwardly perpendicular to a radiant axis;

a waveguide section; and

the waveguide section having a inwardly directed ring throat which is coupled to the outlet ports and a folded waveguide collimating sound energy emitted from the outlet ports along the radiant axis.

2. The loudspeaker system of claim **1**, further comprising:

the folded waveguide having inner and outer forms with the outer form being generally cup shaped and the inner form being kiss shaped to enclose a back portion of the first cone loudspeaker and to define the expansion profile of the folded waveguide.

3. The loudspeaker system of claim **2**, further comprising:

a second cone loudspeaker arranged coaxially with and opposed to the first cone loudspeaker;

the compression plug having a second surface juxtaposed the second cone loudspeaker;

inlets through the second surface;

channels connecting the inlets through the second surface to the outlet ports for coupling acoustic energy generated by the second cone loudspeaker through substantially a ninety degree turn to the outlet ports; and

the first and second surfaces conformed to the shape of diaphragms for the first and second cone loudspeakers.

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