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(54) **DEEP WELL SUBMERSIBLE PUMP**

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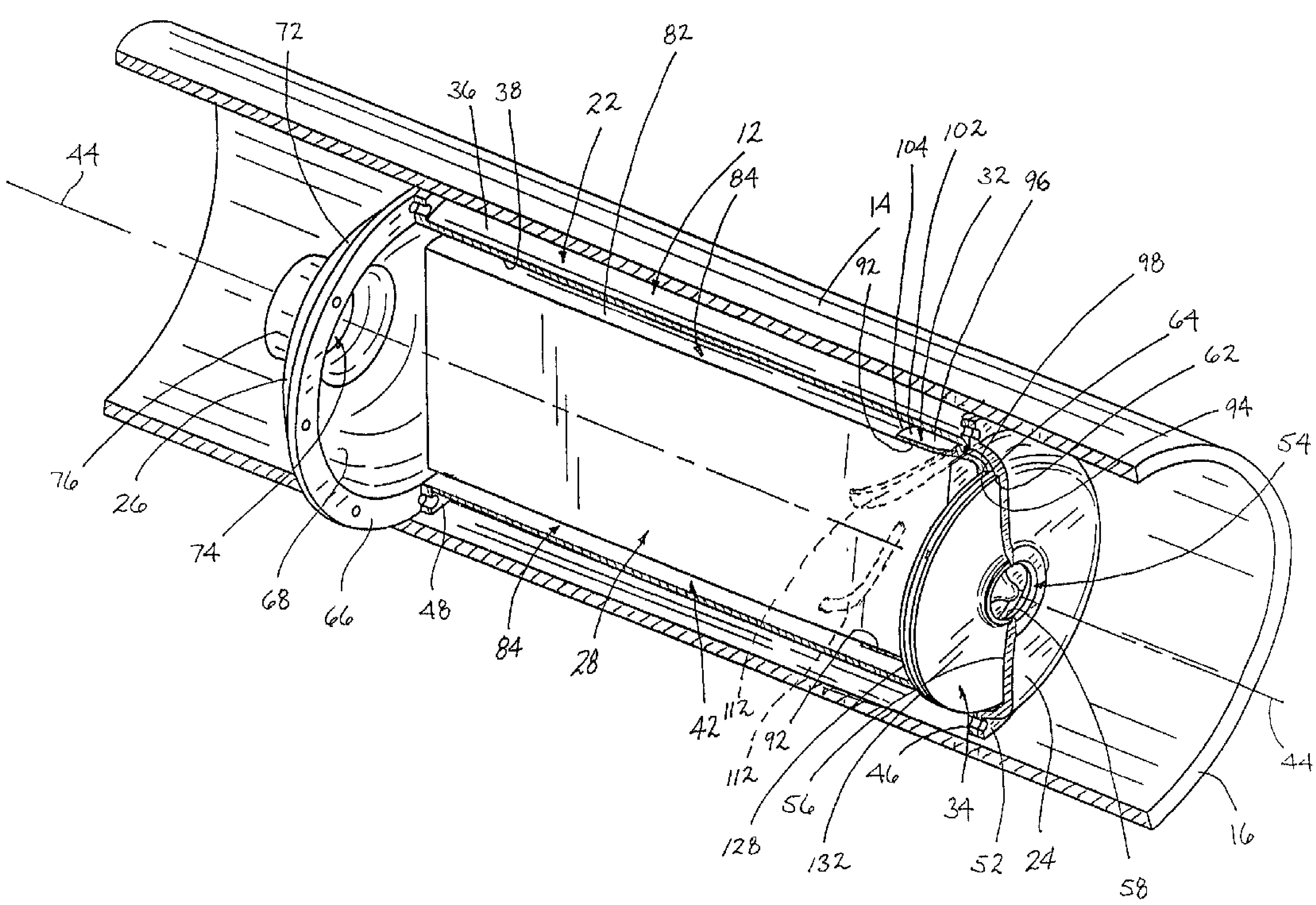
(57) **ABSTRACT**

A deep well submersible pump has a pump housing containing an electric motor. The motor is radially spaced from the pump housing interior surface defining an annular channel through the pump housing from an inlet opening to an outlet opening of the housing. The motor is mounted on a cowling that has an exterior surface. A plurality of deswirler blades extend between the pump housing interior surface and the cowling exterior surface. As the deswirler blades extend through the housing interior, a spacing between the cowling exterior surface and the housing interior surface expands radially. The cowling exterior surface and the pump housing interior surface define an annular liquid flow path that is first directed radially outward from the inlet opening and then curves around the cowling and is directed axially through the deswirler blades to the annular channel between the motor and the pump housing interior surface. An impeller mounted on the motor shaft has axially spaced inner and outer disks with a plurality of radiating vanes between the disks. The outer disk has a center hole with an annular rim surface in sealing engagement with the inlet cap and a peripheral surface in sealing engagement with the inlet cap. The impeller inner disk has a peripheral surface in sealing engagement with the cowling. Rotation of the impeller draws liquid through the inlet cap opening and pushes the liquid through the pump flow path.



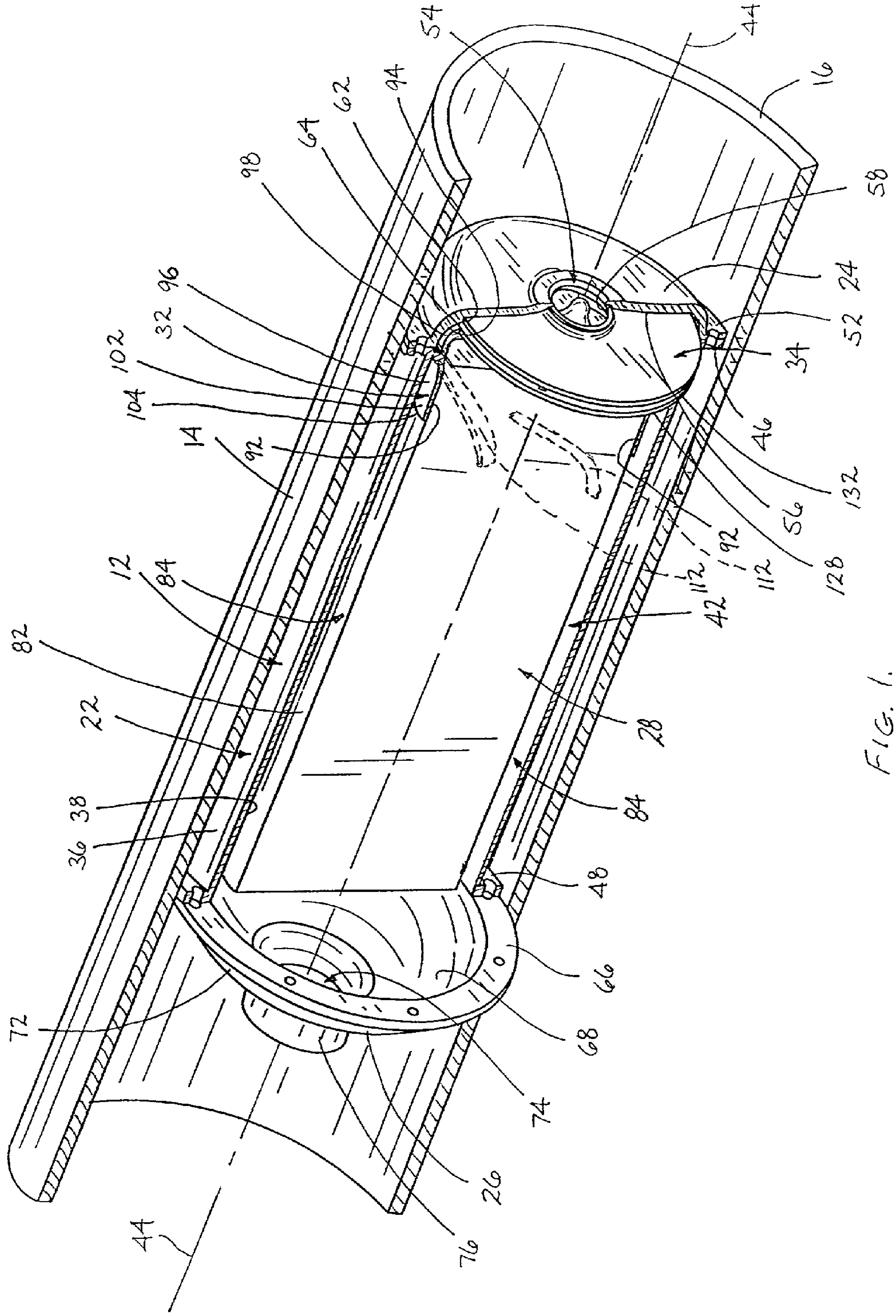

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FIG. 1.

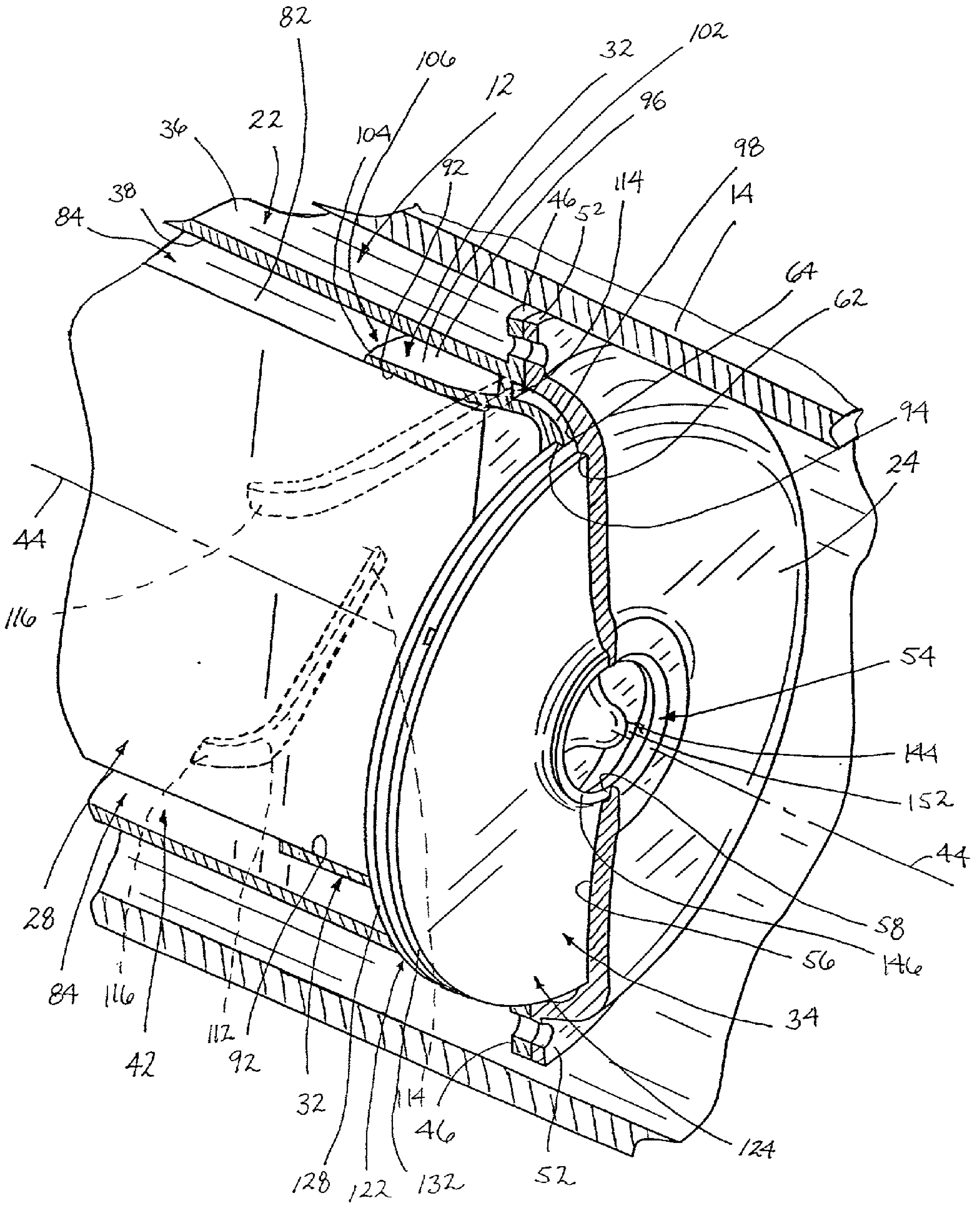
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FIG. 2.

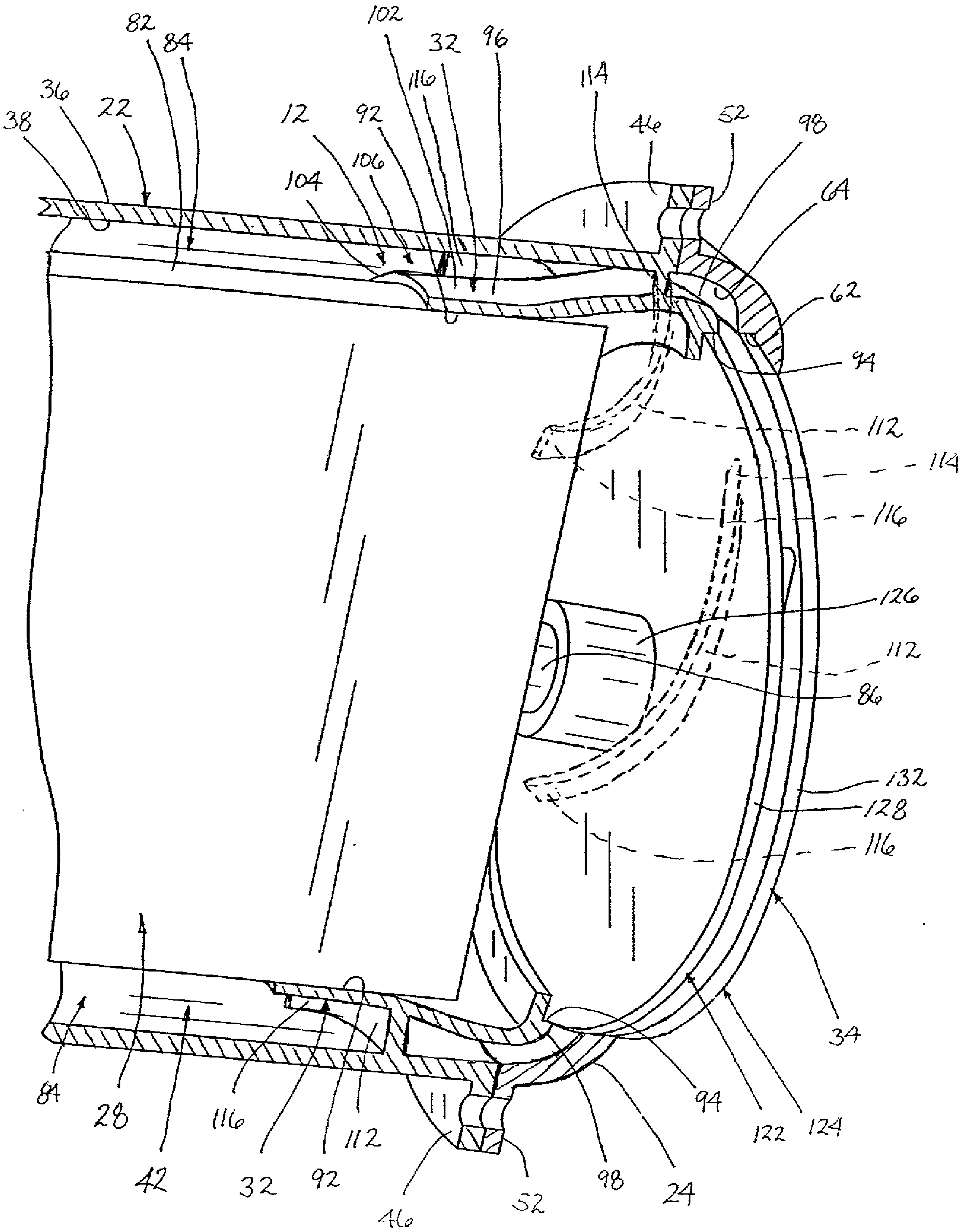
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FIG. 3.

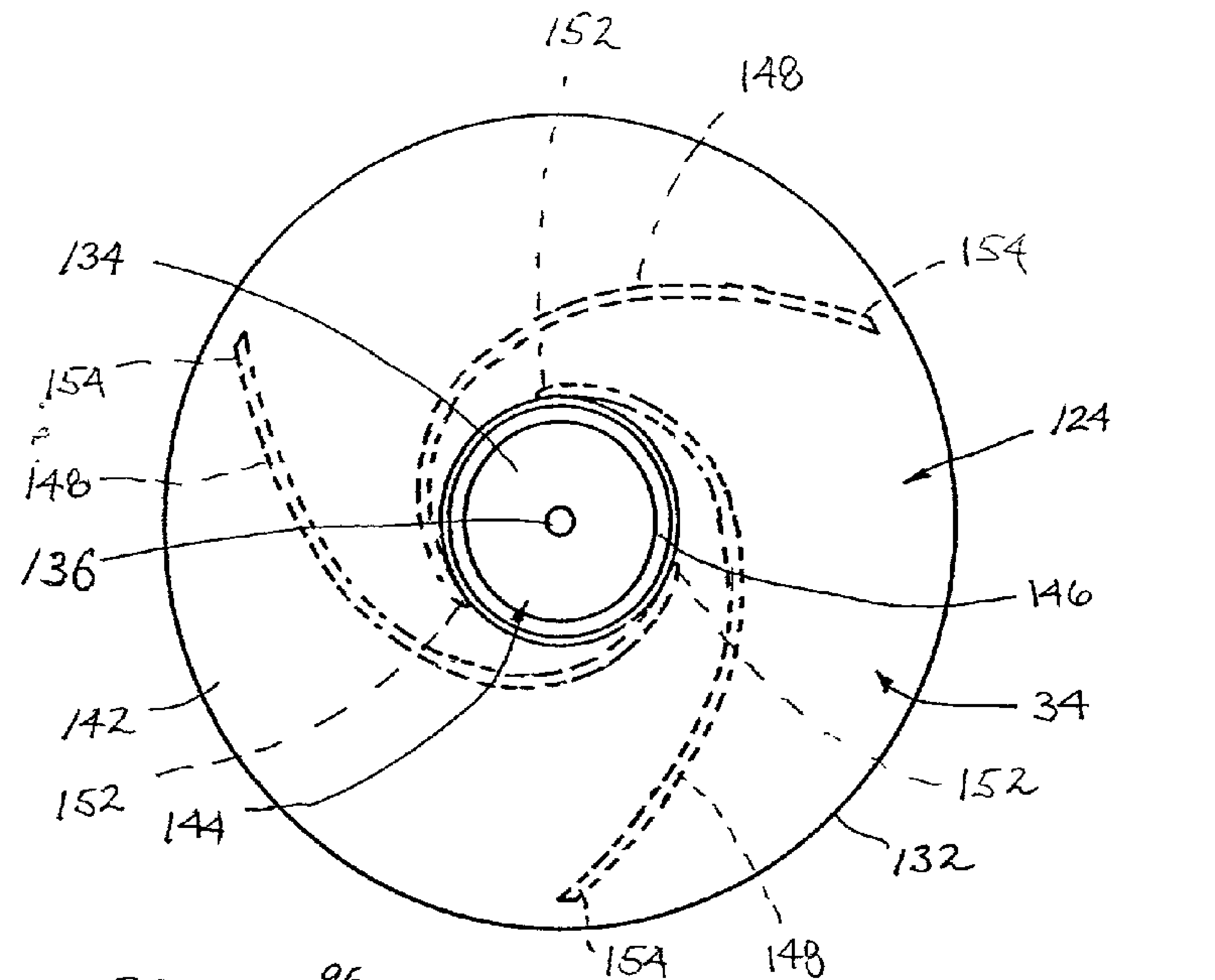
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FIG. 5.

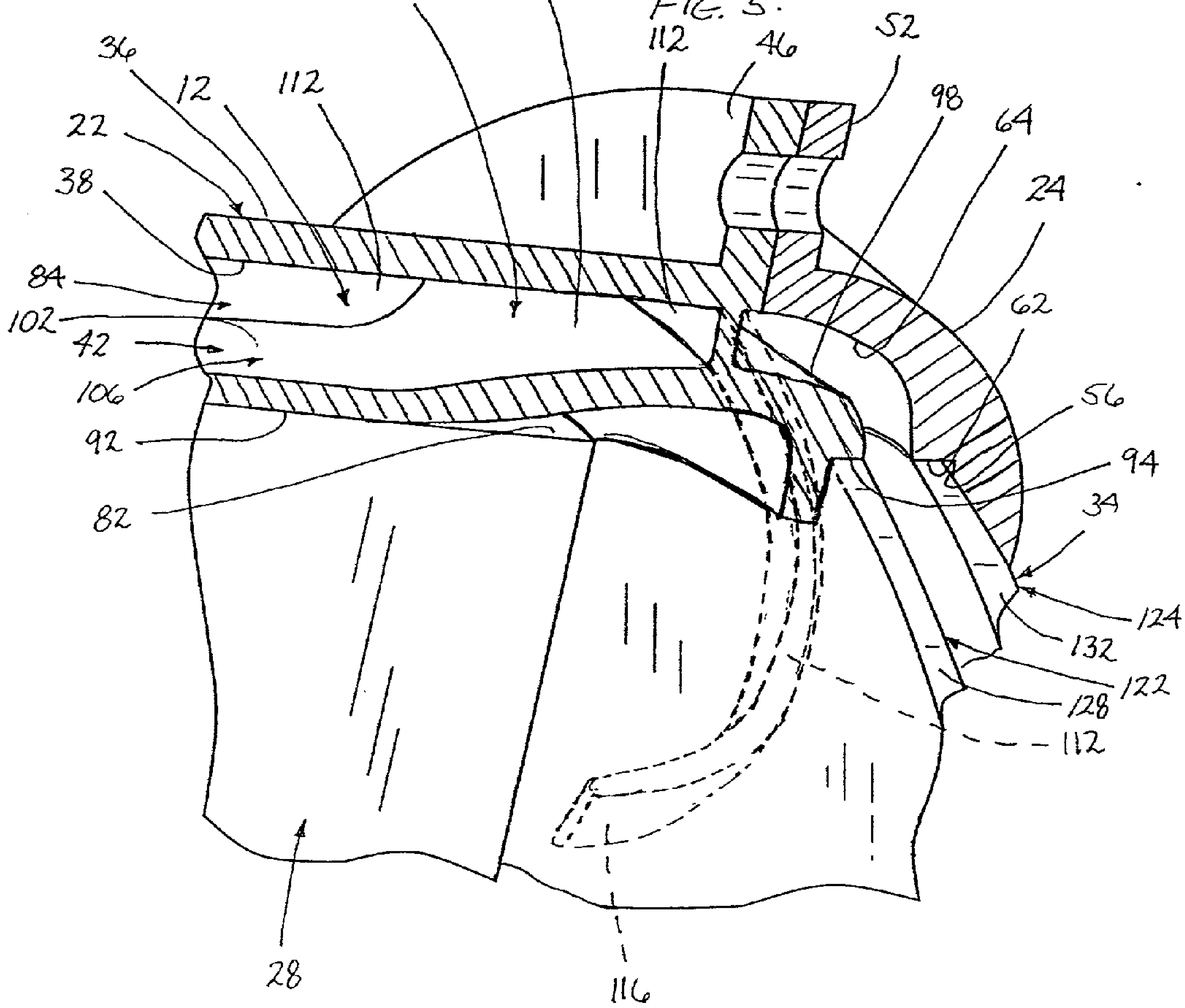
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FIG. 4.

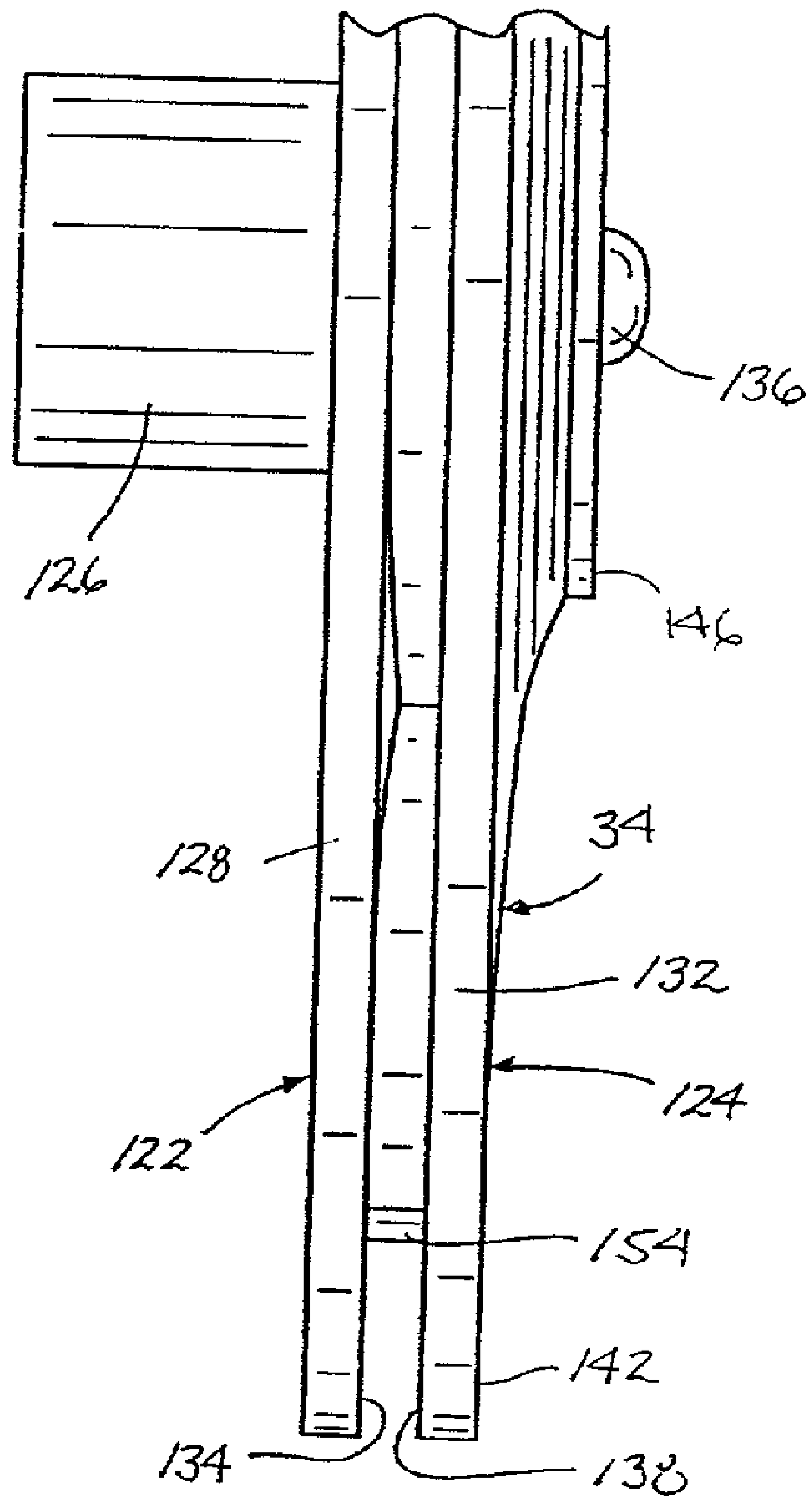
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FIG. 7.

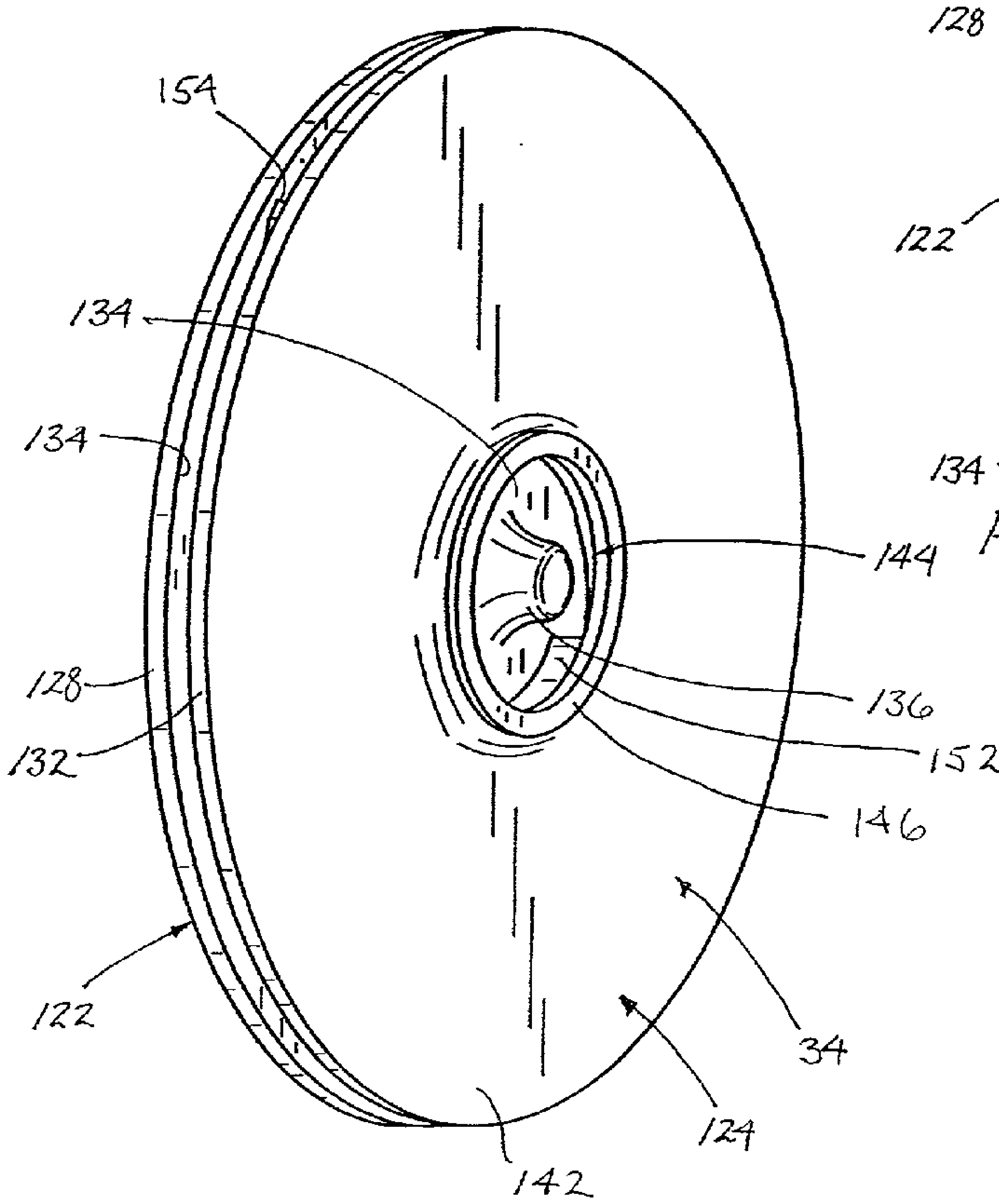
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FIG. 6.

DEEP WELL SUBMERSIBLE PUMP

BACKGROUND OF THE INVENTION

[0001] (1) Field of the Invention

[0002] The present invention pertains to a deep well submersible pump, and in particular a deep well submersible pump construction that employs fewer pump stages than prior art deep well pumps, resulting in reduced materials cost and easier assembly of the pump.

[0003] (2) Description of the Related Art

[0004] Deep well submersible pumps are employed in pumping liquids such as water from deep well holes having relatively small bore diameters. Pumps of this type are specially built for their environment and typically include a centrifugal pump having a series of vertically stacked radial impellers driven by an electric motor. The entire pump construction is dimensioned to enable the pump to be lowered into a well and suspended in the liquid at the bottom of the well by a series of interconnected downpipes. One example of a current design of a deep well pump consists of twenty stages, i.e. twenty impellers, and a motor driving the impeller stages at 3,600 RPM. This pump assembly measures 36 inches in length and 3.5 inches in diameter. Some pump designs have also employed electric motors that operate at greater speeds, for example 12,000 RPM, to reduce the number of impeller stages while obtaining the same performance. Pumps of this type typically employ three or four stages or impellers to obtain the desired performance. Both the impellers and the liquid return channels of these prior art pumps are of the radial type.

[0005] Deep well submersible pumps have limited diameter dimensions so that they can be operated in well bores of only 4-5 inches in diameter. The pump is mounted in the bottom downpipe of a series of downpipes suspending the pump in the well bore with the electric motor of the pump being oriented vertically. The impellers of the pump are mounted on the vertically oriented shaft of the motor in vertically spaced relative positions. On rotation of the motor shaft, the impellers draw liquid into the pump housing and force or push the liquid centrifugally outward and upward through the impeller and return channel stages, thereby lifting the liquid through the pump housing and the series of downpipes to the surface opening of the well.

[0006] Due to the multiple stages of impellers and return channels employed in current designs of deep well submersible pumps, considerable time and effort is needed to assemble the pumps. In addition, increasing the impeller and return channel stages of a pump increases its weight. The increased weight of a pump often requires the use of metal downpipes with increased side wall thicknesses to lower the pumps and suspend the pumps in the liquid at the bottom of the well, thereby further adding to the overall weight of the pump and its downpipes. The increased number of pump stages and the increased size of the pump downpipes also result in increasing the cost of the pump assembly. Furthermore, in order to obtain different performance levels from a pump assembly, it is often necessary to assemble different numbers of stages with different numbers of impellers and return channels or use a different family of impellers and return channels.

[0007] A more simplified pump construction that reduces the number of component parts of the pump and thereby reduces the weight of the pump and yet is capable of operating in a range of desired performance levels would overcome the disadvantages associated with prior art deep well submersible pumps.

SUMMARY OF THE INVENTION

[0008] The deep well submersible pump of the invention overcomes disadvantages associated with prior art deep well submersible pumps by providing a single stage 12,000 or higher RPM pump of simplified construction. The pump is designed to use only a single stage and is basically comprised of a radial impeller and an axial diffuser/deswirler in the pump housing.

[0009] The pump housing is comprised of a cylindrical side wall with axially opposite ends surrounding an interior volume of the housing. An inlet end of the side wall is covered by an inlet cap having a centered inlet opening and the axially opposite outward end of the side wall is covered by an outlet cap having a centered outlet opening.

[0010] An electric motor is contained in the side wall with a shaft of the motor projecting axially toward the inlet opening of the inlet cap. The exterior surface of the motor casing is spaced radially inward from the side wall interior surface, defining an open annular channel between the casing exterior surface and the side wall interior surface.

[0011] A tubular cowling is mounted on the motor casing adjacent the inlet cap. The cowling has an annular shoulder surface adjacent the inlet cap. The tubular cowling has an exterior surface that, together with the interior surface of the inlet cap and the interior surface of the side wall, defines an annular flow path that extends radially away from the inlet opening of the inlet cap and then curves and extends axially between the cowling exterior surface and the inlet cap and side wall interior surfaces. As the flow path extends axially between the cowling exterior surface and the side wall interior surface, the radial spacing between these two surfaces increases.

[0012] In addition, deswirl or a reduction in the swirl of the flow is provided by a plurality of circumferentially spaced blades between the cowling exterior surface and the side wall interior surface. Each blade has opposite inlet and outlet ends that are spaced axially from each other. The inlet ends of the blades are oriented in generally circumferential directions relative to the cowling and side wall and the trailing ends of the blades are oriented in generally axial directions relative to the cowling and side wall.

[0013] The interior surface of the inlet cap has a peripheral portion that extends radially outwardly away from the inlet opening of the cap and then curves continuously toward the side wall and extends axially and merges as a continuous surface with the interior surface of the side wall. An annular shoulder is formed in the interior surface radially inward of the peripheral portion of the cap interior surface and axially opposite the cowling annular shoulder. The inlet cap inlet opening is surrounded by a flat, annular rim surface on the cap interior surface.

[0014] The impeller of the pump is mounted on the motor shaft and is comprised of an axially inner disk and an axially outer disk that are spaced from each other by a plurality of impeller vanes between the disks. The axially outer disk has a center hole surrounded by a flat, annular rim surface. The flat, annular rim surface mates in sliding engagement with the flat, annular rim surface of the inlet cap inlet opening, thereby providing a sealing engagement between the two rim surfaces. The axially outer disk also has a flat, annular peripheral edge surface that opposes the annular shoulder on the inlet cap interior surface, thereby providing an additional seal between the outer disk and the inlet cap. The axially inner disk has a flat, annular peripheral edge surface that radially opposes the annular shoulder surface of the cowling and thereby provides a sliding seal between the inner disk and the cowling. The plurality of impeller vanes are circumferentially spaced around the axially spaced inner and outer disks. Each blade has an inner end adjacent the outer disk center hole and a radially opposite outer end adjacent the annular peripheral edge surfaces of the inner and outer disks.

[0015] On operation of the pump motor, the impeller is rotated drawing liquid from the well vertically upward through the inlet cap inlet opening and the outer disk center hole into the spacing between the impeller inner and outer disks. The impeller vanes then push or force the liquid radially outward toward the flow path defined between the cowling exterior surface and the interior surfaces of the inlet cap and side wall. The curved surface of the inlet cap interior surface peripheral portion turns the flow of liquid axially and directs the liquid through the blades of the axial diffuser/deswirler which direct the liquid flow through the annular channel between the motor casing exterior surface and the side wall interior surface. The liquid continues through the annular channel to the outlet end cap where it exists the pump interior volume through the outlet cap outlet opening.

[0016] The simplified construction of the deep well submersible pump of the invention reduces assembly time and the costs associated therewith, and reduces material costs significantly by reducing the number of stages of the pump. Using higher speeds allows the use of smaller motors which also significantly reduces the weight of the pump, enabling the pump to be used with plastic downpipes suspending the pump in the well which further reduces the overall weight of the pump assembly. The construction of the pump also enables the use of a smaller motor which also contributes to the reduction of manufacturing costs and the reduction of weight. With the desired type of motor employed in the pump, the speed of the pump can be varied to obtain different performance levels and a single pump may be employed to obtain a wide range of operating levels instead of adding stages or changing motors as was required with prior art deep well submersible pumps.

DESCRIPTION OF THE DRAWINGS

[0017] Further features of the invention are revealed in the following detailed description of the preferred embodiment of the invention and in the drawing figures, wherein:

[0018] **FIG. 1** is a partial sectioned view of the deep well submersible pump of the invention contained in a section of a well liner;

[0019] **FIG. 2** is an enlarged partial view of the inlet end of the pump shown in **FIG. 1**;

[0020] **FIG. 3** is an enlarged partial view of the inlet end of the pump shown in **FIG. 1** from the point of view of the outlet end of the pump;

[0021] **FIG. 4** is an enlarged partial view showing details of the pump construction of **FIG. 3**;

[0022] **FIG. 5** is an inlet end view of the pump impeller;

[0023] **FIG. 6** is a perspective view of the inlet end of the impeller; and

[0024] **FIG. 7** is a partial enlarged view of the side of the impeller.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] The deep well submersible pump **12** of the invention is shown installed inside a section of a well liner pipe **14** in **FIG. 1**. The well liner **14** has been sectioned to show the pump **12** which has also been sectioned to show interior components of the pump construction. In use of the pump **12**, the pump would be at the bottom of a series of downpipes connected end-to-end. The series of downpipes are suspended in a well hole with the pump **12** connected to and suspended in the well liner at the bottom of the series of interconnected downpipes. In use of the pump **12**, at least the bottom end of the suspended pump **12** would be submerged. As shown in **FIG. 1**, the basic component parts of the deep well submersible pump **12** of the invention include a cylindrical side wall **22**, a circular inlet cap **24** and a circular outlet cap **26** that comprise the housing of the pump, an electric motor **28** contained in the housing, a cowling **32** mounted on the motor and the pump impeller **34** contained in the housing interior adjacent the inlet cap **24**. The component parts of the pump **12** may be constructed of metals and/or plastics, depending on the particular performance levels desired of the pump which will determine the materials used in its construction as well as the material used in constructing the downpipe.

[0026] The side wall **22** of the housing has a cylindrical exterior surface **36** and an opposite cylindrical interior surface **38** that surrounds an interior volume **42** of the pump housing. The cylindrical interior surface **38** of the side wall has a center axis **44** that defines mutually perpendicular axial and radial directions relative to the pump **12**. The side wall has an annular inlet end flange **46** extending around an inlet end of the side wall and an annular outlet end flange **48** extending around an axially opposite end of the side wall. As shown in **FIGS. 1 and 2**, the side wall flanges **46**, **48** are dimensioned to fit loosely inside the series of interconnected well liners so that the pump **12** can slide easily down the well.

[0027] The circular inlet cap **24** has an annular flange **52** at its outer periphery that is connected to the inlet end flange **46** of the side wall **22** in attaching the inlet cap **24** to the inlet end of the side wall. The inlet cap flange **52** is attached to the side wall inlet end flange **46** by threaded fasteners (not shown) or other equivalent means. The inlet cap has a circular inlet opening **54** at its center that is coaxial with the side wall center axis **44**. The interior surface **56** of the inlet cap that faces toward the side wall interior volume **42** is provided with a flat, annular rim **58** that circles the cap center opening **54**. The inlet cap interior surface **56** extends radially outward from the flat, annular rim surface **58** to an annular shoulder surface **62** formed in the inlet cap interior surface. The annular shoulder surface **62** is parallel with the side wall center axis **44**. A peripheral portion **64** of the inlet cap interior surface extends radially away from the annular shoulder surface **62** and gradually curves toward the side wall interior volume **42** and extends axially. Where the inlet cap **24** attaches to the cylindrical side wall **22**, the interior surface peripheral portion **64** of the cap merges as a continuous surface with the side wall interior surface **38**.

[**0028**] The outlet cap **26** also has an annular flange **66** around its outer periphery that attaches to the side wall outlet end flange **48** in attaching the outlet cap **26** to the side wall **22**. The outlet cap flange **66** can be attached to the side wall outlet end flange **48** by threaded fasteners (not shown) or other equivalent means. The outlet cap **26** has a dome shape with opposite interior **68** and exterior **72** surfaces and a center outlet opening **74** that is coaxial with the housing side wall center axis **44**. A cylindrical collar **76** extends around the outlet opening **74**. The collar **76** can be connected to separate downpipes or conduits for suspending the pump in the well and conducting liquid pumped through the pump housing.

[**0029**] The electric motor **28** in the illustrated embodiment is preferably a motor that is capable of operating at 12000 RPM. However, depending on the particular operative environment in which the pump **12** will be employed, the characteristics of the motor **28** will change. Because the particulars of the construction of the motor **28** are not important to the invention, the motor is schematically shown in the drawing figures as a cylindrical block that has been cut in half to provide a better view of the component parts of the pump **12**. The motor is contained inside a cylindrical casing having an exterior surface **82** that is radially spaced from the interior surface **38** of the housing side wall **22**. These relative dimensions of the motor casing exterior surface **82** and the housing side wall interior surface **38** define an annular channel **84** between the exterior surface and interior surface that extends the entire length of the motor and communicates with the inlet opening **54** of the inlet cap **24** and the outlet opening **74** of the outlet cap **26**. A motor shaft **86** projects axially from the motor toward the inlet cap inlet opening **54**.

[**0030**] The motor **28** is supported in the housing interior volume **42** by the cowling **32**. The cowling **32** has a general cylindrical shape and is mounted on the motor adjacent the inlet cap **24**. The cowling has an interior surface **92** that engages around the motor casing exterior surface **82** in mounting the cowling on the motor. A forward end of the cowling adjacent the inlet cap **24** has a flat, annular shoulder surface **94** that extends completely around the cowling forward end. As best seen in FIGS. **2-4**, the annular shoulder surface **94** of the cowling is axially opposite the annular shoulder surface **62** of the inlet cap **24** and is also parallel to the housing center axis **44**. The cowling exterior surface **96** is spaced axially from the inlet cap interior surface **56** and is spaced radially from the housing side wall interior surface **38**. From the flat, annular shoulder surface **94** of the cowling the exterior surface **96** extends radially outwardly in an axially spaced relationship to the inlet cap interior surface **56** and then gradually curves toward the housing sidewall interior volume **42** following the curvature of the inlet cap interior surface peripheral portion **64**. The curved portion **98** of the exterior surface **96** gradually turns into an axially extending portion **102** of the surface that extends to a rearward edge **104** of the cowling axially opposite the annular shoulder surface **94** of the cowling. As the axially extending portion **102** of the cowling exterior surface **96** extends toward the cowling rearward edge **104**, a curvature formed in the cowling causes the exterior surface axial portion **102** to extend radially away from the housing side wall interior surface **38**. This configuration of the cowling **32** results in the radial spacing **106** between the cowling exterior surface axial portion **102** and the housing side wall interior surface **38** becoming larger as the cowling and side wall extend axially away from the inlet cap **24**. The configurations of the cowling exterior surface **96** and the inlet cap interior surface **56** and side wall interior surface **38** together define an annular flow path through the pump from the inlet opening **54** to the annular channel **84** where liquid directed through the flow path is first directed radially outward between the cowling exterior surface **96** and the inlet cap interior surface **56** and then turns around the cowling and the peripheral portion **64** of the inlet cap interior surface and is directed axially between the axial portion **102** of the cowling exterior surface **96** and the housing side wall interior surface **38** to the annular channel **84**.

[**0031**] A plurality of deswirl blades **112** extend between the housing side wall interior surface **38** and the axial portion **102** of the cowling exterior surface **96**. The diffuser blades **112** are circumferentially spaced around the cowling with each blade having a leading edge **114** adjacent the inlet cap **24** and an axially opposite trailing edge **116**. To avoid obstructing the view of other component parts of the pump **12**, some of the diffuser blades **112** and portions of the diffuser blades **112** are shown in dashed lines in FIGS. **1-4**. The blades **112** join the cowling exterior surface **96** to the housing side wall interior surface **38**. The leading edges **114** of the blades are positioned adjacent the curvature of the cowling exterior surface **96** where the exterior surface transitions from a radial direction to an axial direction. The leading edges **114** are oriented in a generally circumferential direction. The leading edges are angled slightly from the circumferential direction toward the inlet cap **24**. From the leading edges **114**, the blades gradually curve from the generally circumferential direction orientation of the blades to a generally axial direction orientation of the trailing edges **116**. Each blade is given a shape designed to deswirl the fluid flow with the trailing edge **116** of the blade given an angle to cause the flow to exit axially or close to axially from the blade. Each of the blades **112** extends between the housing side wall interior surface **38** and the cowling exterior surface **96** along their entire lengths.

[**0032**] The impeller **34** is comprised of an axially inner disk **122** and an axially outer disk **124** that are mounted by a hub or collar **126** to the motor shaft **86** in a conventional manner. The inner disk **122** has a flat, annular peripheral surface **128** that radially opposes the annular shoulder surface **94** of the cowling. A close tolerance is provided between the annular peripheral surface **128** of the inner disk and the annular shoulder surface **94** of the cowling that functions as a sliding liquid seal between these two radially opposed surfaces. The outer disk **124** also has a flat, annular peripheral surface **132** that radially opposes the flat, annular shoulder surface **62** of the inlet cap **24**. A close tolerance is also provided between these two radially opposed surfaces that functions as a sliding liquid seal between the two surfaces. An interior surface **134** of the inner disk **122** that opposes the outer disk **124** is generally flat adjacent the peripheral surface **128** of the disk but gradually tapers outwardly to a rounded cone apex **136** as the interior surface **134** extends to the center of the disk. The interior surface **138** of the outer disk **124** that opposes the inner disk **122** is also generally flat adjacent the peripheral surface **132** of the disk, but with the opposite exterior surface **142** of the outer disk **124** gradually curves away from the inner disk **122** as it extends to a circular center hole **144** in the outer disk. The center hole **144** communicates with the interior axial spacing between the two disks **122, 124**. The center hole **144** is bounded by a flat, annular rim surface **146** that extends around the hole and axially opposes the flat, annular rim surface **58** on the inlet cap interior surface **56** that surrounds the inlet opening **54** of the inlet cap. The sliding engagement between the flat, annular rim **146** surrounding the center hole **144** of the outer disk **124** and the flat, annular rim surface **58** surrounding the inlet opening **54** of the inlet cap **24** functions as a liquid seal between these two surfaces. A plurality of impeller vanes **148** are provided between the impeller inner disk **122** and the impeller outer disk **124**. The vanes **148** are circumferentially arranged around the outer disk center hole **144** and curve as they extend radially from inner ends or leading edges **152** of the vanes to outer ends **154** of the vanes. The vane inner ends or leading edges **152** are positioned adjacent the outer disk center hole **144** and the vane outer ends **154** are positioned adjacent the peripheral surfaces **128, 132** of the inner disk and outer disk. In alternate embodiments, the liquid seal provided by the opposed rim surface **58** of the inlet cap and the rim surface **146** of the impeller outer disk **124** could be replaced with other types of seals between the inlet cap and impeller, for example a labyrinth seal or a hydrodynamic seal. In addition, the impeller could be constructed without the outer disk **124** where the inlet cap interior surface **56** is in close proximity to the impeller blade vanes **148**.

[**0033**] The deep well submersible pump **12** of the invention is used in the conventional manner. The pump **12** is connected to the bottom of a series of interconnected downpipes and is lowered into the well through the well liners **14** until submerged in the liquid contained in the well. On operation of the electric motor **28**, the impeller **34** is rotated.

[**0034**] Rotation of the impeller **34** and the impeller vanes **148** draws liquid through the bottom end **16** of the downpipe and the center hole **144** of the outer disk **124** into the axial spacing between the inner disk **122** and the outer disk **124**. Rotation of the impeller **34** pushes or forces the liquid radially outward toward the flow path defined between the cowling exterior surface **96** and the inlet cap interior surface **56** and housing side wall interior surface **38**. As the liquid enters the flow path, it is first directed radially outwardly between the cowling exterior surface **96** and the peripheral portion **64** of the inlet cap interior surface. The curvature of these two surfaces redirects the flow of liquid from a radially outward direction to an axial direction toward the annular channel **84** between the motor **28** and housing side wall **22**. The liquid flow is directed through the plurality of deswirler blades **112** that turn the flow of liquid around the cowling exterior surface **96** to an axial direction of the flow. The flow of liquid is directed through the radially expanding area between the axial portion **102** of the cowling exterior surface **96** and the housing side wall interior surface **38** and past the cowling rearward edge **104** into the annular channel **84** between the motor casing exterior surface **82** and the housing side wall interior surface **38**. Diffusion of the liquid flow takes place due to the increasing flow area between the slanting axial portion of the cowling exterior surface **96** and the housing side wall interior surface **38**. The flow of liquid continues through the annular channel until it reaches the outlet cap **26** at the opposite end of the housing side wall **22** where it is discharged through the outlet opening **74**. The impeller and diffuser of the pump **12** enable the pump to operate as a single stage pump. The simplified construction of the pump reduces assembly time and its costs, as well as reducing material costs. The simplified construction is also much lighter than prior art deep well submersible pumps, enabling the submersible pump **12** of the invention to be used with plastic downpipes which also reduces the overall weight of the pump assembly.

[**0035**] While the present invention has been described by reference to a specific embodiment, it should be understood that modifications and variations of the invention may be constructed without departing form the scope of the invention defined in the following claims.

What is claimed:

1. A submersible pump comprising:

a cylindrical side wall having opposite exterior and interior surfaces, the interior surface surrounding an interior volume of the pump, the interior volume having a center axis defining mutually perpendicular axial and radial directions relative to the pump and the side wall having axially opposite inlet and outlet ends;

an inlet cap at the inlet end of the side wall, the inlet cap having an inlet opening and an interior surface that faces toward the pump interior volume, a peripheral portion of the inlet cap interior surface extending radially away from the inlet opening and curving toward the pump interior volume and then extending axially and merging with the side wall interior surface as a continuous surface.

2. The pump of claim 1, further comprising:

an electric motor in the pump interior volume, the electric motor having a motor casing with an exterior surface and a motor shaft projecting from the motor casing toward the inlet cap inlet opening, the motor casing exterior surface being spaced radially inward from the side wall interior surface defining an annular channel between the motor casing exterior surface and the side wall interior surface.

3. The pump of claim 2, further comprising:

an impeller mounted on the motor shaft, the impeller having a plurality of vanes, each vane having an inner end adjacent the inlet opening of the inlet cap and a radially opposite outer end adjacent the peripheral portion of the inlet cap interior surface whereby rotation of the motor shaft and impeller draws liquid through the inlet opening of the inlet cap and pushes the liquid radially outward across the peripheral portion of the inlet cap interior surface thereby redirecting a flow of liquid through the pump interior volume from a radial flow direction to an axial flow direction through the channel between the motor casing exterior surface and the side wall interior surface.

4. The pump of claim 1, further comprising:

a plurality of blades projecting radially inward from the side wall interior surface.

5. The pump of claim 2, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge oriented in a generally circumferential direction adjacent the inlet cap and an axially opposite trailing edge oriented in a generally axial direction.

6. The pump of claim 5, further comprising:

each blade contacts across the side wall interior surface as the blade extends from the blade leading edge to the blade trailing edge.

7. The pump of claim 3, further comprising:

a cowling in the pump interior volume and mounted on the motor, the cowling surrounding the motor and motor shaft and having an exterior surface that is spaced axially from the peripheral portion of the inlet cap interior surface and is spaced radially from the side wall interior surface whereby the cowling exterior surface and the peripheral portion of the inlet cap interior surface and the side wall interior surface define an annular flow path that is first directed radially outwardly between the cowling exterior surface and the peripheral portion of the inlet cap interior surface and then curves and is directed axially between the cowling exterior surface and the side wall interior surface to the annular channel between the side wall interior surface and the motor casing exterior surface.

8. The pump of claim 7, further comprising:

a plurality of blades connecting the side wall interior surface with the cowling exterior surface.

9. The pump of claim 8, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge oriented in a generally circumferential direction adjacent the inlet cap and an axially opposite trailing edge oriented in a generally axial direction.

10. The pump of claim 9, further comprising:

each blade contacts the side wall interior surface and the cowling exterior surface as the blade extends from the blade leading edge to the blade trailing edge.

11. The pump of claim 3, further comprising:

the impeller has an axially outer disk adjacent the inlet cap and an axially inner disk adjacent the motor shaft, the plurality of vanes extend radially between the outer disk and the inner disk, the outer disk has a center hole with a rim surface that is aligned with the inlet opening of the inlet cap; and,

the inlet opening has a rim surface that is in sliding engagement with the outer disk rim surface providing a liquid seal between the inlet opening rim surface and the outer disk rim surface.

12. The pump of claim 3, further comprising:

the impeller has an axially outer disk adjacent the inlet cap and an axially inner disk adjacent the motor shaft, the plurality of vanes extend radially between the outer disk and the inner disk, the outer disk has an annular peripheral surface; and

the inlet cap has an annular shoulder surface that opposes the outer disk peripheral surface.

13. The pump of claim 12, further comprising:

the peripheral portion of the inlet cap interior surface is positioned radially outward from the inlet cap shoulder surface.

14. The pump of claim 7, further comprising:

the impeller has an axially outer disk adjacent the inlet cap and an axially inner disk adjacent the motor shaft, the plurality of vanes extend radially between the outer disk and the inner disk, the inner disk has an annular peripheral surface; and,

the cowling has an annular shoulder surface adjacent the inlet cap and the shoulder surface opposes the inner disk peripheral surface.

15. A submersible pump comprising:

a cylindrical side wall having opposite exterior and interior surfaces, the interior surface surrounding an interior volume of the pump, the interior volume having a center axis defining mutually perpendicular axial and radial directions relative to the pump and the side wall having axially opposite inlet and outlet ends;

an inlet cap at the inlet end of the side wall, the inlet cap having an inlet opening, an interior surface that faces toward the pump interior volume and an annular shoulder surface on the interior surface; and

an impeller having an axially outer disk adjacent the inlet cap and an axially inner disk with a plurality of radially extending vanes between the outer disk and inner disk, the outer disk has a center hole that is aligned with the inlet cap inlet opening and the outer disk has an annular peripheral surface that is positioned radially inward and opposing the inlet cap shoulder surface.

16. The pump of claim 15, further comprising:

the inlet cap has a rim surface around the inlet opening and the outer disk has an annular rim surface around the outer disk center hole that is in sliding engagement with the inlet cap rim surface.

17. The pump of claim 15, further comprising:

a peripheral portion of the inlet cap interior surface extends radially outward from the shoulder surface and curves toward the pump interior volume and then extends axially and merges with the side wall interior surface as a continuous surface.

18. The pump of claim 15, further comprising:

an electric motor in the pump interior volume, the electric motor having a motor casing with an exterior surface and a motor shaft projecting from the motor casing toward the inlet cap inlet opening, the motor casing exterior surface being spaced radially from the side wall interior surface defining an annular channel between the motor casing exterior surface and the side wall interior surface; and

a cowling mounted on the motor in the pump interior volume, the cowling surrounding the motor and the motor shaft and having an exterior surface that is spaced axially from the inlet cap interior surface and is spaced radially from the side wall interior surface whereby the cowling exterior surface and the inlet cap and side wall interior surfaces define an annular flow path that is first directed radially outward between the cowling exterior surface and the inlet cap interior surface and then turns and is directed axially between the cowling exterior surface and the side wall interior surface to the annular channel between the side wall interior surface and the motor casing exterior surface.

19. The pump of claim 18, further comprising:

the inner disk has an annular peripheral surface and;

the cowling has an annular shoulder surface adjacent the inlet cap and the shoulder surface is positioned radially outward of and opposing the inner disk peripheral surface.

20. The pump of claim 15, further comprising:

a plurality of blades projecting radially inward from the side wall interior surface.

21. The pump of claim 20, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge adjacent the end cap and an axially opposite trailing edge.

22. The pump of claim 21, further comprising:

each blade contacts the side wall interior surface as the blade extends from the blade leading edge to the blade trailing edge.

23. The pump of claim 18, further comprising:

a plurality of blades connecting the side wall interior surface with the cowling exterior surface.

24. The pump of claim 23, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge oriented in a generally circumferential direction adjacent the end cap and an axially opposite trailing edge oriented in a generally axial direction.

25. The pump of claim 24, further comprising:

each blade contacts the side wall interior surface and the cowling exterior surface as the blade extends from the blade leading edge to the blade trailing edge.

26. A submersible pump comprising:

a cylindrical side wall having opposite exterior and interior surfaces, the interior surface surrounding an interior volume of the pump, the interior volume having a center axis defining mutually perpendicular axial and radial directions relative to the pump and the side wall having axially opposite inlet and outlet ends;

an inlet cap at the side wall inlet end, the inlet cap having an inlet opening and an interior surface that faces toward the pump interior volume; and

a cowling having an exterior surface that is axially spaced from the inlet cap interior surface and is radially spaced from the side wall interior surface with the radial spacing between the cowling exterior surface and the side wall interior surface becoming larger as the cowling and side wall extend axially away from the inlet cap, whereby the cowling exterior surface and the inlet cap and side wall interior surfaces define an annular flow path through the pump from the inlet opening to the side wall outlet end, where liquid directed through the flow path is first directed radially outward between the cowling exterior surface and the inlet cap interior surface and then turns around the cowling and is directed axially between the cowling exterior surface and the side wall interior surface.

27. The pump of claim 26, further comprising:

an electric motor in the pump interior volume, the electric motor having a motor casing with an exterior surface and a motor shaft projecting from the motor toward the inlet cap inlet opening, the motor casing exterior surface being spaced radially from the side wall interior surface defining an annular channel between the motor casing exterior surface and the side wall interior surface.

28. The pump of claim 27, further comprising:

an impeller mounted on the motor shaft, the impeller having a plurality of radially extending vanes with each vane having an inner end adjacent the inlet opening of the inlet cap and a radially opposite outer end adjacent the flow path whereby rotation of the motor shaft and impeller draws liquid through the inlet cap inlet opening and pushes the liquid through the flow path.

29. The pump of claim 26, further comprising:

a plurality of blades projecting radially inward from the side wall interior surface.

30. The pump of claim 29, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge oriented in a generally circumferential direction adjacent the inlet cap and an axially opposite trailing edge oriented in a generally axial direction.

31. The pump of claim 30, further comprising:

each blade contacts the side wall interior surface as the blade extends from the blade leading edge to the blade trailing edge.

32. The pump of claim 26, further comprising:

a plurality of blades connecting the side wall interior surface with the cowling exterior surface.

33. The pump of claim 32, further comprising:

the plurality of blades are circumferentially spaced around the side wall interior surface and each blade has a leading edge adjacent the inlet cap and an axially opposite trailing edge.

34. The pump of claim 33, further comprising:

each blade contacts the side wall interior surface and the cowling exterior surface as the blade extends from the blade leading edge to the blade trailing edge.

35. The pump of claim 28, further comprising:

the impeller has an axially outer disk adjacent the inlet cap and an axially inner disk adjacent the motor shaft, the plurality of vanes extend radially between the outer disk and the inner disk, the outer disk has an annular peripheral surface; and

the inlet cap has an annular shoulder surface that opposes the outer disk peripheral surface.

36. The pump of claim 28, further comprising:

the impeller has an axially outer disk adjacent the inlet cap and an axially inner disk adjacent the motor shaft, the plurality of vanes extend radially between the outer disk and the inner disk, the inner disk has an annular peripheral surface; and,

the cowling has an annular shoulder surface adjacent the inlet cap and the shoulder surface opposes the inner disk peripheral surface.

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