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(54) Benævnelse: **Motor til anvendelse i et kølemiddelmiljø**

(56) Fremdragne publikationer:

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DESCRIPTION

RELATED APPLICATION DATA

[0001] This application claims priority to Chinese Patent Application No. 201610055583.7, filed 27 January 2016 and U.S. Patent Application No. 15/049937, filed 22 February 2016 *(which is a continuation in part of* U.S. Non-provisional Application No. 14/166424, filed 28 January 2014, which claimed priority to U.S. Provisional Application No. 61/757380, filed 28 January 2013).

BACKGROUND

[0002] The present invention relates to electric motors for use in an ammonia environment. More specifically, the present invention relates to motors for use in an ammonia environment.

[0003] EP 1291528 A2 discloses a scroll compressor and a refrigerating system using an ammonia group refrigerant.

[0004] US 3,688,137 A discloses in a general way electric machines of the open type intended to operate in a fluid medium or in a corrosive atmosphere. US 2009/191074 A1 discloses an electrically powered pump that has an electric motor arrangement for driving a pump arrangement.

SUMMARY

[0005] In one aspect, a motor for use in a refrigerant atmosphere is defined in claim 1.

[0006] In another aspect, a method of assembling a motor for use in a refrigerant atmosphere is defined in claim 3.

[0007] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is a schematic illustration of a refrigeration system including a compressor and a motor;

FIG. 2 is a perspective view of a stator;

FIG. 3 is a more detailed perspective view of the stator of FIG. 2;

FIG. 4 is an end view of one of the slots illustrating the wire windings;

FIG. 5 is a cross-section of one of the winding wires;

FIG. 6 is a perspective view of a rotor; and

FIG. 7 is a cross-section of a lead wire.

[0009] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways, within the scope of the invention, which is defined by the appended claims. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

DETAILED DESCRIPTION

[0010] FIG. 1 illustrates a refrigeration system 10 that includes a compressor chamber 15 that contains a compressor 20 driven by an electric motor 25. The refrigeration system 10 also includes an evaporator 31, a condenser 32, and an expansion valve 33. The refrigeration system 10 is adapted for use with a refrigeration fluid such as ammonia. In one embodiment, the ammonia is refrigerant grade R-717 ammonia.

[0011] The compressor 20 could include one of a variety of different types of compressors including rotary screw, reciprocating, scroll, centrifugal, and the like. The actual style of compressor employed is not critical to the invention. Rather, all that is required is that the compressor 20 includes a stationary portion and a rotary portion coupled to a compressor shaft.

[0012] The motor 25 may be a hermetic motor specifically designed to be submerged within a refrigerant atmosphere. The motor 25 can utilize an external power supply that can be line-fed or inverter-fed.

[0013] Motors 25 for ammonia compressors 20 are typically located outside the compressor chamber 15 and use either a shaft seal or a magnetic coupling to connect the motor 25 to the compressor shaft. This has been necessary because of the chemical aggressiveness of refrigerant (e.g., ammonia) towards standard materials of motor construction. Additionally, exposure to high temperature/pressure ammonia causes typical insulation materials to lose their resistance, which in turn causes premature motor failure. The present invention constructs the motor 25 out of materials that are more resistant to ammonia and uses techniques and arrangements that enhance the effectiveness of the materials, thereby allowing the motor 25 to be placed in the ammonia environment while operating satisfactorily for a sufficient length of time.

[0014] As illustrated in FIG. 1, the motor 25 and the compressor 20 are positioned inside the compressor chamber 15 to save space and provide the motor 25 the benefit of cooling from the refrigerant. This cooling of the motor 25 potentially allows for the use of smaller motors to achieve the same performance. Additionally, placing the motor 25 inside the compressor chamber 15 eliminates any potential leakage paths through external shaft seals. Finally, placing the motor 25 inside the compressor chamber 15 allows for a lower cost unit due to the elimination of duplicate brackets and bearings required to connect the motor externally. The compressor shaft can also be made shorter, shaft seals are eliminated, and magnetic couplings are not needed.

[0015] In an example not forming part of the claimed invention, the motor 25 employs a Variable Frequency Drive (VFD) 30 to improve the efficiency of the refrigeration system 10 when compared to more conventional line-fed systems. The VFD 30 utilizes a control system that is sensitive to motor current draw and system leakage current.

[0016] The motor construction must be modified to assure that there are little or no areas in which the ammonia can make contact with electrically conductive areas within the motor windings or inter-pole connections. Because ammonia has a higher conductivity to electrical current then typical refrigerants used in hermetic compressors and because the motor stator resides in the ammonia, leakage current that might occur will likely be larger than on a motor not disposed in ammonia. Such current leakages would be more likely to cause the VFD motor protection to remove power to the motor 25. To reduce this likelihood, the motor 25 incorporates a stator winding in which no internal connections are present (i.e., each phase winding is continuous). The elimination of internal connections reduces the likelihood of any potential for leakage current to exist due to the ammonia refrigerant.

[0017] The motor 25 includes a stator 35 and a rotor 40 disposed adjacent the stator 35 and drivingly connected to the driven shaft of the compressor 20. In the illustrated construction, the rotor 40 includes a portion disposed within a cavity 45 of the stator 35. However, other motor arrangements could also be employed to drive the compressor 20.

[0018] The electric motor 25 is positioned within the refrigeration system 10 such that it is directly coupled to the compressor 20 and such that it is directly exposed to the refrigerant, in the illustrated example ammonia. Positioning the motor 25 in this way provides for more efficient transfer of power between the motor 25 and the compressor 20 and also provides more effective cooling of the motor 25 using the refrigerant as a coolant. However, refrigerant can be detrimental to many typical motor components.

[0019] With reference to FIGS. 2-4, the stator 35 defines a cavity 45 that receives a portion of the rotor 40. The stator 35 includes a core 50 defining opposite end portions 55, 60. The stator core 50 includes a plurality of circumferentially spaced stacked metal laminations 65 disposed parallel to a centerline 70 of the cavity 45. The metal laminations 65 may consist of electrical grade lamination steel with other materials or constructions such as powdered metal portions being possible. As is best illustrated in FIG. 4, the stator core 50 includes a plurality of teeth 75 that each defines a pair of circumferentially spaced longitudinal slot walls 80. The slot walls 80 of adjacent teeth 75 cooperate with one another to define longitudinal slots 85 in the periphery of the stator 35. Each tooth also defines two hooks 90.

[0020] Circumferentially spaced coils are arranged with each coil disposed on one of the teeth 75 such that each coil is disposed at least partially in two slots 85. Each coil consists of a plurality of windings of wire 95 with portions of the windings of wire 95 extending longitudinally in the slots 85 in which the coil resides. Thus, each coil is defined by a plurality of windings of the wire 95 repeatedly passing through a first slot 85a, around the first end portion 55, passing through a second slot 85b adjacent the first slot 85a, around the second end portion 60, and again through the first slot 85a.

[0021] As best shown in FIG. 5, the wire 95 consists of conductive material 100 immediately surrounded by wire insulation 105. In the illustrated construction, copper or aluminum wire 100 is used as the conductor 100 with aluminum being favored in an ammonia environment. Polyetheretherketone (PEEK) material may be used to form the insulation 105. While some constructions may use conductors 100 coated with PEEK insulation 105, extruded PEEK insulation 105 may also be used as testing has shown significant performance increases using this construction. Specifically, the extruded PEEK insulation 105 exhibits improved toughness and superior dielectric properties when compared to coated insulation.

[0022] Slot liners 110 are provided in the slots 85 between the windings of wire 95 and the respective slot walls 80 to further insulate the windings 95 from the magnetic core 50. According to the invention, the slot liners 110 are formed from sheets of polyphenylene sulfide (PPS). While various thicknesses of slot liners 110 are possible, slot liners 110 that are between about 0.01 and about 0.02 inches (0.25 to 0.5 mm) in thickness may be used in some constructions. The sheet material provides better formability and more robust properties than other materials that were tested.

[0023] In high voltage, multi-phase applications, the stator 35 may include interphase insulators 115, sometimes referred to as phase paper, between the coils to further insulate the different phases of the motor 25. According to one construction, phase paper 15 is employed and is made using sheets of a polyphenylene sulfide (PPS) material similar to that of the slot liners 110. As with the slot liners 110, the sheets provided improved characteristics when compared to other material choices.

[0024] When winding the stator 35, there is typically space within the slots 85 that is not filled. Wedges 120 are typically positioned within the slots 85 to take up this space, assure that the individual windings of wire 95 are packed as tightly as possible, and to limit unwanted movement of the wires 95. Although several different wedges 120 can be used to fill the desired space, in the illustrated construction longitudinally extending wedges 120 are employed. Each wedge 120 is positioned between a respective slot liner 110 and the stack of windings 95 within the slot 85. The wedge 120 engages the underside of two adjacent hooks 90 formed as part of the adjacent teeth 75 to apply a compressive force to the wires 95. In some constructions, pegs are positioned between the wires 95 and the wedge 120 to take up additional space and to provide a flatter engagement surface for the wedges 120. While many materials are available for wedges 120 and pegs, some constructions may employ wedges 120, and pegs if used, that are formed from one of an epoxide laminate, a polyphenylene sulfide (PPS), and a polyetheretherketone (PEEK) material. The wedges 120 and pegs (if employed) are secured in interlocking relationship with the stator core 50 to prevent radially outward movement of the coils 95 relative to the stator core 50. It should be noted that any combination of the three identified materials could be employed for the construction of the stator 35. For example, pegs could be formed from a PEEK material with wedges 120 formed from PPS if desired. Alternatively, components could be manufactured as composites. For example, pegs or wedges 120 could be formed with a wood core that is coated or covered with extruded PEEK, PPS, or epoxide laminate material.

[0025] In some constructions, the stator 35 includes lacing cord 125 laced about the end turns of the coils. The lacing 125 tightly secures the end turns of the coils, thereby reducing unwanted movement or vibration. Lacing tape 125 may be formed from a NOMEX® tape. Of course, other constructions may use other materials (e.g., KEVLAR®, other meta-aramids, para-aramids, etc.) for lacing 125.

[0026] The stator 35 also includes lead wire 130 that provides for a connection between the coils and the source of electrical power. As illustrated in FIG. 7, the lead wire 130 includes conductive material 125 (e.g., copper, aluminum, etc.) immediately surrounded by lead wire insulation 140. For example, one construction employs conductive material 135 consisting of wound strands of aluminum with lead wire insulation 140 formed from a fluoropolymer such as TEFLON® (i.e., polytetrafluoroethylene (PTFE)). The insulation 140 can be formed over the motor leads to seal the leads and provide the desired insulation. In some constructions, the insulating material is provided in the form of a tape that is wrapped in overlapping relationship about the conductor 135 such that the proportion of tape overlap is at least about 50%. The lead wire insulation 140 may include TEFLON® tape wrapped in overlapping relationship and strands or filaments of fiberglass overbraided over the TEFLON® tape. The fiberglass filaments provide a flexible abrasion-resistant covering over the TEFLON® tape. The motor can be leadless, such that the wire is directly connected to power terminals.

[0027] The stator 35 may also include sleeving 145 which protects the lead wire 130 and further insulates the lead wires 130 from each other at crossovers between the coils. In one embodiment, the sleeving 145 consists of a fluoropolymer such as TEFLON® (i.e., polytetrafluoroethylene (PTFE)).

[0028] The shell 150 encapsulates substantially the entire stator 25. In the invention, the shell 150 is free of apertures to reduce the amount of current leakage. The shell 150 may be opaque. The shell 150 may have any characteristics that enable the motor 25 to operate as described herein.

[0029] The shell 150 includes a low-viscosity epoxy in the form of an amine cured 100% solids epoxy topcoat, such as that available from ARCOR™ Epoxy Technologies, Inc. of South Dennis, MA under the trade name ARCOR™ EE11.

[0030] In the invention, the shell 150 has an average thickness in a range from about 4 mm to about 10 mm.

[0031] Moreover, the shell 150 is formed by coating the end turns of the coils and all exposed surfaces of the stator 35 with a liquid that cures to form the shell 150. The stator 35 is coated by dipping the stator 35 at least partially in the liquid which adheres to the stator 35 and solidifies to form the shell 150. The stator 35 may be coated by trickle application of a liquid that solidifies to form the shell 150. The shell 150 may also be formed in any manner that enables the motor 25 to operate as described herein. The shell 150 can be used to seal the coils from the ammonia environment, bond the wires 95 together to reduce movement of the wires 95 relative to one another, reduce noise from the motor 25, coat and bond the laminations 65 in the stator 35, and anchor the interphase insulation. Moreover, the shell 150 facilitates protecting the end turns of the coils from nicks or abrasions as the stator 35 is placed in the compressor chamber 15 and during operation of the refrigeration system 10. As a result, the shell 150 increases the resistance of the motor 25 to the ammonia environment and reduces the risk of current leakage from the coils of the stator 35.

[0032] The rotor 40 is formed using conventional materials and techniques. The rotor 40, illustrated in FIG. 6 includes a rotor core 155 formed from laminations of electrical grade steel or aluminum stacked along the rotational axis 70 to a desired length. In other constructions, portions of the core 155 may be formed from powdered metal or other components. Rotor bars 160 extend the length of the core 155 and are coupled to end rings 165, 170 disposed at each end of the core 155. Bars 160 and end rings 165, 170 may be formed using aluminum with other materials being possible.

[0033] The motor 25 formed of the indicated materials is more resistant to attack by ammonia than prior motors. The motor 25 can be mounted in the refrigeration system 10 in contact with ammonia, and the refrigeration system 10 is suitable for operation with the motor 25 in contact with ammonia. Therefore, the refrigeration system 10 can be simply and inexpensively constructed without sealing the motor 25 from the ammonia.

[0034] The invention is defined by the appended claims.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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- US04993716 **[0001]**
- US16642414A **[0001]**
- US61757380A **[0001]**
- EP1291528A2 **[0003]**
- US3688137A **[0004]**
- US2009191074A1 **[0004]**

PATENTKRAV

1. Motor (25) til anvendelse i en kølemiddelatmossfære, hvilken motor omfatter:

en rotor (40), som er konfigureret til at rotere omkring en akse;
en stator (35) i tilstødning til rotoren og omfattende en overflade, som definerer et hulrum (45), som er konfigureret til at modtage i det mindste en del af rotoren, hvilken stator omfatter:

en kerne (50), som definerer en ende;
adskillige tænder (75), som definerer adskillige noter (80);
adskillige notforinger (110) placerede i de adskillige noter (80) og dannede af polyphenylensulfid; og
adskillige spoler viklede omkring de adskillige tænder således, at hver spole blandt de adskillige spoler omfatter et par notdele (85) og et par viklingsender, hvilket par notdele strækker sig i det mindste delvis igennem tilstødende noter i de adskillige noter og i det mindste delvis igennem de adskillige notforinger (110), idet hver af viklingsenderne strækker sig imellem parret af notdele og i det mindste delvis på tværs af enden; og
en skal (150), som indkapsler statoren således, at viklingsenderne for de adskillige spoler og overfladen er i det væsentlige forseglet fra kølemiddel-atmosfæren, hvor skallen er dannet ved belægning af viklingsenderne og overfladen i det mindste delvis med en væske, som klæber til statoren og hærder for dannelse af skallen, hvor statoren er i det væsentlige fuldstændigt indkapslet af skallen, og hvor skallen er i det væsentlige fri for åbninger for at reducere strømlækage fra statoren, og hvor skallen har en gennemsnitlig tykkelse i området fra omkring 4 millimeter (mm) til omkring 10 mm og skallen yderligere omfatter et aminhærdet 100% faststof epoxydæklag.

2. Motor ifølge krav 1, hvor skallen er uigennemsigtig.

3. Motor ifølge krav 1, hvor statoren yderligere omfatter en indføringsledning, som tilvejebringer forbindelse imellem de adskillige spoler og en kilde for elektrisk energi, hvilken indføringsledning er omgivet af indføringsledningsisolation dannet af fluoropolymer.

4. Motor ifølge krav 1, hvor statoren yderligere omfatter et snørebånd (125) snøret omkring viklingsenderne på de adskillige spoler.

5. Motor ifølge krav 1, hvor statoren yderligere omfatter adskillige mellemfaseisolatorer (115) placerede imellem de adskillige spoler for yderligere at isolere forskellige faser for motoren.

6. Motor ifølge krav 1, hvor statoren yderligere omfatter adskillige kiler, placerede i de adskillige noter.

7. Motor ifølge krav 1 eller krav 6, hvor statoren omfatter adskillige stifter, placerede i de adskillige noter.

8. Motor ifølge ethvert af kravene 5, 6 eller 7, hvor de adskillige mellemfaseinsolatorer, adskillige kiler eller adskillige stifter er dannet af polyphenylensulfid.

9. Fremgangsmåde til samling af en motor (45) til anvendelse i en kølemiddelatmosfære, hvilken fremgangsmåde omfatter:

dannelse af en stator (35) omfattende en overflade, som definerer et hulrum (45), som er konfigureret til at modtage i det mindste en del af en rotor (40), en kerne (50), og adskillige tænder (75), som definerer adskillige noter, hvilken kerne definerer en ende af statoren;
placering af adskillige notforinger (110) i de adskillige noter, hvilke adskillige notforinger (110) er dannede af polyphenylensulfid;
vikling af adskillige spoler omkring de adskillige tænder således, at viklingsenderne for de adskillige spoler strækker sig på tværs af enden; og
dannelse af en skal (150) over statoren ved at belægge viklingsenderne og overfladen i det mindste delvis med en væske, som hæfter til statoren og hærder for dannelse af skallen således, at viklingsenderne for de adskillige spoler og enden af statoren og overfladen er i det væsentlige forseglede fra kølemiddelatmosfæren, hvor statoren er i det væsentlige fuldstændigt indkapslet af skallen, og hvor skallen er i det væsentlige fri for åbninger for at reducere strømlækage fra statoren, og hvor skallen har en gennemsnitlig tykkelse i området fra omkring 4 millimeter (mm) til omkring 10 mm, og skallen yderligere omfatter et aminhærdet 100% faststof epoxydæklag.

10. Fremgangsmåde ifølge krav 9, hvor dannelse af statoren omfatter stakning af adskillige lameller for dannelse af en stak, idet skallen strækker sig i det mindste delvis på stakken.

11. Fremgangsmåde ifølge krav 9, hvor dannelse af skallen omfatter belægning af enden af statoren med en væskeblanding og at tillade væskeblandingen i det mindste delvis at størkne.

12. Fremgangsmåde ifølge krav 11, hvor belægning af enden omfatter positionering af enden i et kar med den flydende blanding.

13. Kølesystem omfattende:

et kompressorkammer konfigureret til at indeholde kølemiddel;
en kompressor placeret i kompressorkammeret og konfigureret til at indsuge kølemidlet ved et tryk fra kompressorkammeret og afgive kølemiddel ved et højere tryk; og
motoren ifølge ethvert af kravene 1 til 8 placeret i kompressorkammeret og forbundet med kompressoren for at drive kompressoren.

14. Kølemiddelsystem ifølge krav 13, hvor kølemiddelsystemet er tilpasset til anvendelse med ammoniak.

DRAWINGS

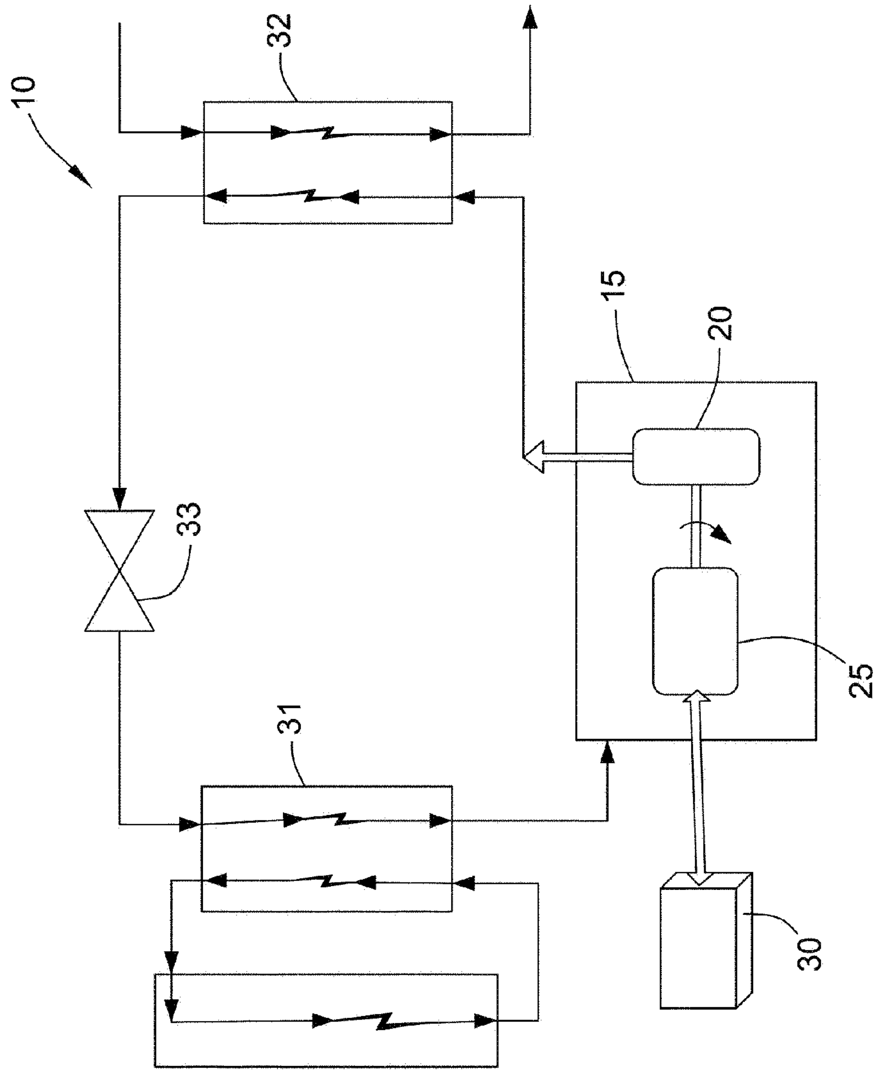

FIG. 1

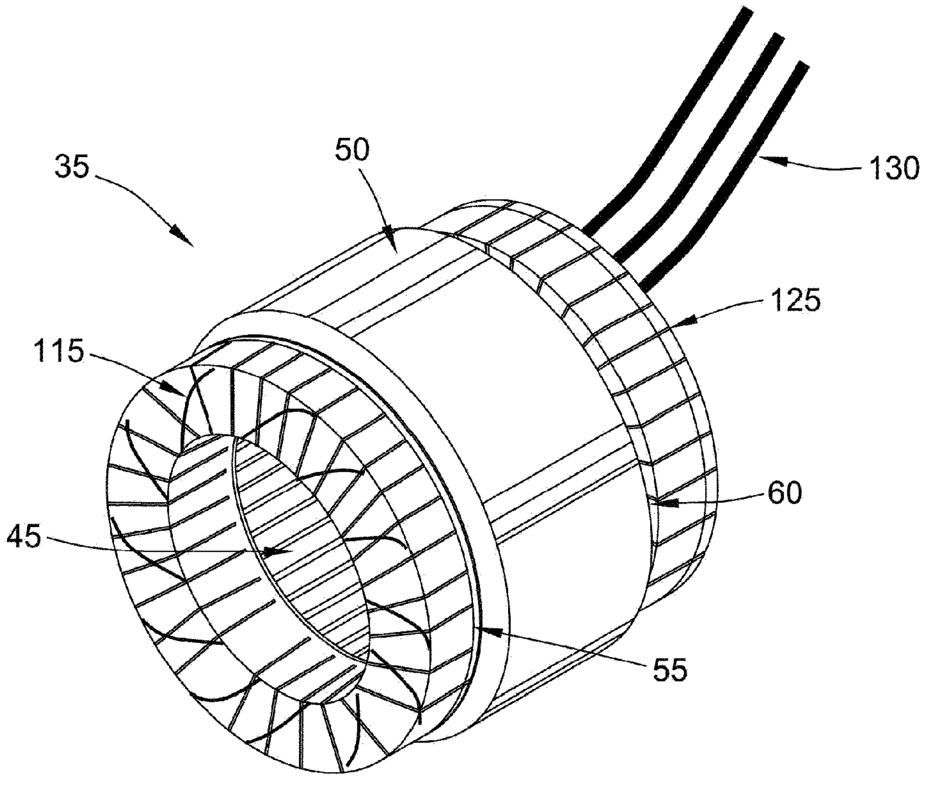

FIG. 2

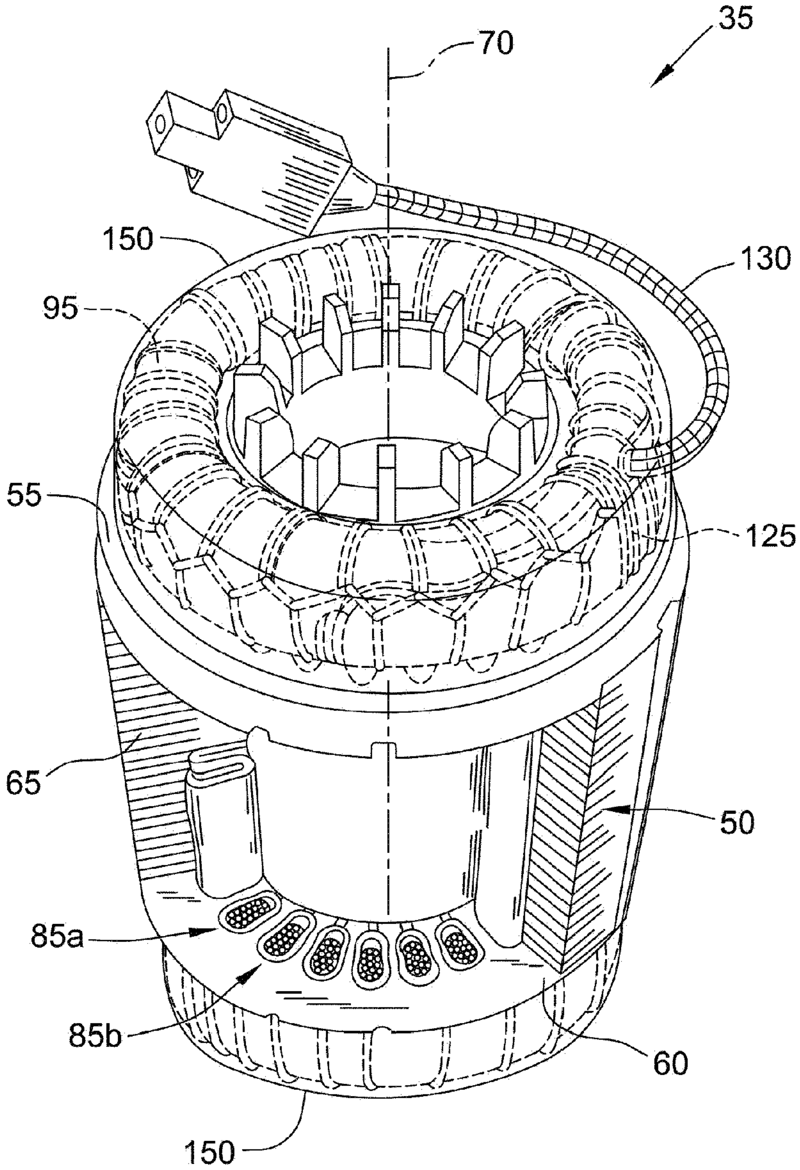

FIG. 3

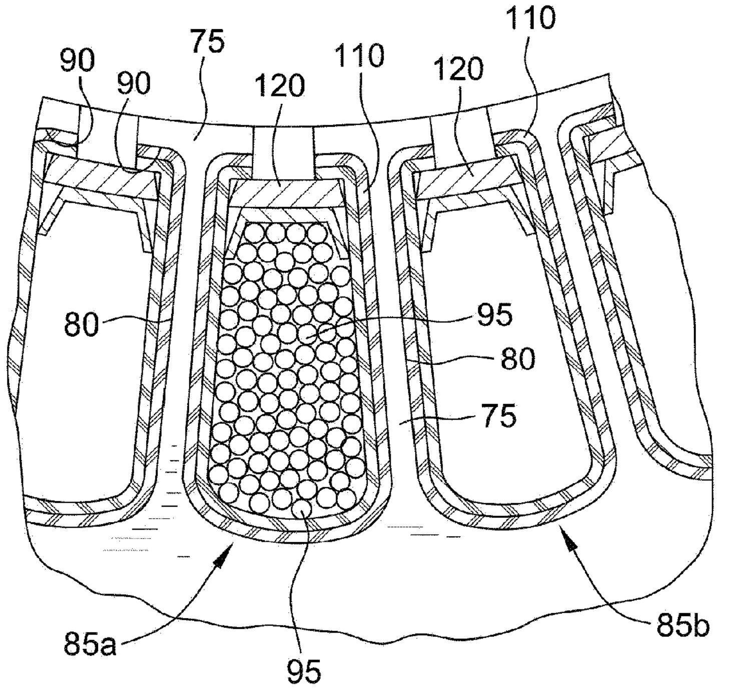

FIG. 4

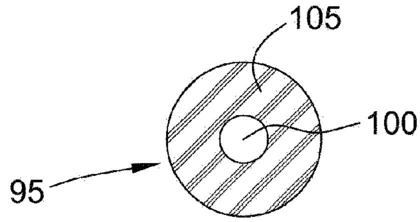

FIG. 5

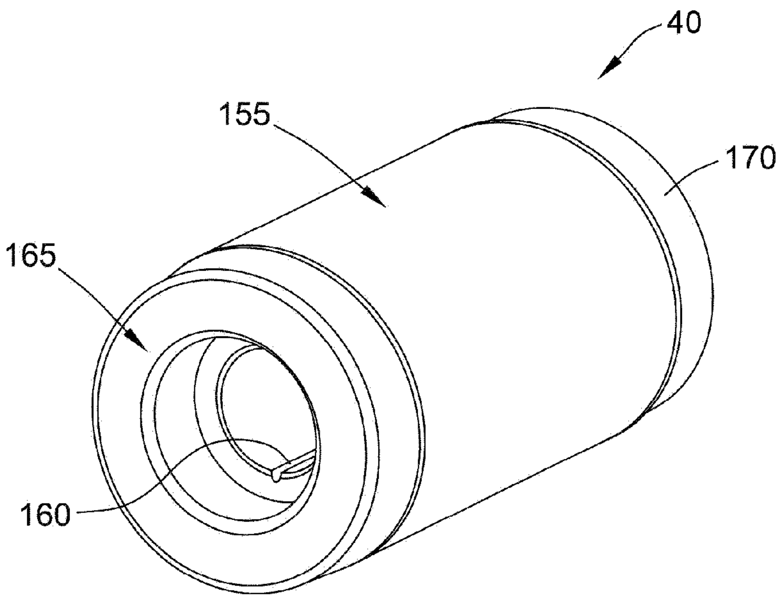

FIG. 6

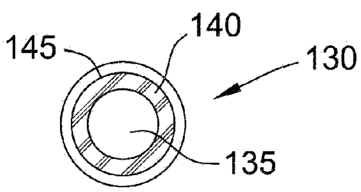

FIG. 7