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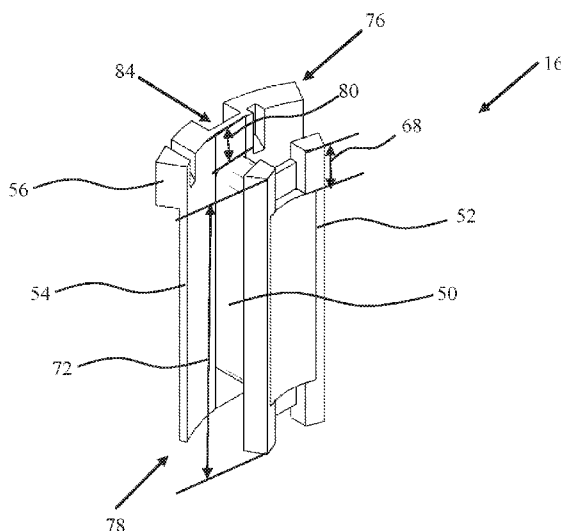


Fig. 5

(57) Abstract: A stator assembly comprises a stator yoke, a plurality of stator teeth, a plurality of windings, and a plurality of bobbins. The plurality of stator teeth are separate components to the stator yoke. The plurality of bobbins are arranged in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke. Each bobbin of the plurality of bobbins comprises a main body and a projecting portion. The main body is connected to a respective stator tooth of the plurality of stator teeth. A respective winding of the plurality of windings is wound around the main body. The projecting portion is integrally formed with the main body, projects from the main body, and is connected to an adjacent bobbin of the plurality of bobbins.



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A STATOR ASSEMBLY

BACKGROUND

There is a general desire to improve electric machines, such as motors, in a number of ways. For example, improvements may be desired in terms of size, weight, power density, manufacturing cost, efficiency, reliability, and noise.

SUMMARY

According to a first aspect of the present invention there is provided a stator assembly comprising: a stator yoke; a plurality of stator teeth, wherein the plurality of stator teeth are separate components to the stator yoke; a plurality of windings; and a plurality of bobbins, wherein: the plurality of bobbins are arranged in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke; and each bobbin of the plurality of bobbins comprises: a main body which is connected to a respective stator tooth of the plurality of stator teeth, and around which a respective winding of the plurality of windings is wound; and a projecting portion which is integrally formed with the main body, projects from the main body, and is connected to an adjacent bobbin of the plurality of bobbins.

The stator teeth being separate components to the stator yoke may be desirable to improve the manufacturability of the stator assembly when compared with a stator yoke which is integrally formed with the stator teeth. For example, each stator tooth may be connected to a respective bobbin and then a winding wound around each bobbin separately before assembling the bobbins, stator teeth and stator yoke together to form the stator assembly. This may enable winding techniques such as spindle or flyer winding to be used to wind the windings. Spindle or flyer winding may enable a greater winding fill factor to be achieved, reduce winding times, and/or reduce the number of winding machines required when compared with other techniques such as needle winding, which may be required if a stator yoke which is integrally formed with the stator teeth were used.

Connecting the bobbins together and radially constraining them using the stator yoke may provide a sufficiently mechanically stable stator assembly to withstand the vibration and forces generated during operation.

- 5 Additionally, by connecting the bobbins together, the mechanical stability of the stator assembly is less impacted by variation in the lengths of the stator teeth from manufacturing variability than, for example, stator assemblies where the stator teeth are secured between an outer stator yoke and a separate inner annular member.
- 10 By projecting from the main body, the projecting portion provides space around the main body for the winding to be wound around the main body, whilst also providing a feature that is used to join the bobbins together.

- 15 The stator yoke may be annular. The stator yoke may comprise a central axis. A radial direction of the stator assembly may be perpendicular to the central axis of the stator yoke. An axial direction of the stator assembly may be parallel to the central axis of the stator yoke.

- 20 The projecting portions may project circumferentially from the main body.

- Optionally, the plurality of stator teeth are connected to the stator yoke. This may increase the mechanical stability of the stator assembly when compared with the stator teeth merely, for example, abutting the stator yoke.

- 25 Optionally, the plurality of stator teeth are connected to an inner face of the stator yoke. As a result, the bobbins and stator teeth are held together inside the stator yoke with the stator yoke located around the outside of the bobbins and stator teeth. This may increase the mechanical stability of the stator assembly relative to the stator teeth being connected to an outside face of the stator yoke. The inner face of the stator yoke may be the face of the
- 30 stator yoke which is located closest to the central axis of the stator yoke when measured in the radial direction of the stator assembly.

Optionally, the main body comprises a radially innermost end and a radially outermost end; and the projecting portion projects from the radially innermost end. As a result, the stator yoke and projecting portions are located at opposite ends of the main body which may improve the mechanical stability of the stator assembly relative to if the projection portions and the stator yoke were located on the same side end of the main body. The radially innermost end may be the end of the main body which is closest to the central axis of the stator yoke in the radial direction of the stator assembly. The radially outermost end may be the end of the main body which is furthest from the central axis of the stator yoke in the radial direction of the stator assembly.

Optionally, the projecting portion projects axially from the main body by a distance of greater than or equal to 1mm. As a result, the projecting portion provides a retaining feature which reduces the likelihood of the winding slipping off the main body, around the end of the main body and contacting the stator teeth. By projecting axially, the projecting portion may project in the axial direction of the stator assembly.

Optionally, each bobbin of the plurality of bobbins comprises a wall which projects axially and/or circumferentially from a radially outermost end of the main body by a distance of greater than or equal to 1mm. The wall may provide electrical insulation between the windings and the stator yoke. This may reduce the likelihood of shorting between the stator yoke and the windings, which may improve the safety of the stator assembly.

Optionally, each bobbin of the plurality of bobbins comprises an overhang which projects radially from an outer face of the wall; and the stator yoke abuts the overhang. The overhang may perform two functions. Firstly, during assembly of the stator assembly, the overhang may act as a location feature to locate the bobbins relative to the stator yoke and ensure the bobbins are located at the correct depth within the stator yoke. This may improve the accuracy of alignment of the bobbins prior to connecting the bobbins together compared to omitting the overhang. Secondly, the overhang abuts the yoke and thereby may improve the mechanical stability of the stator assembly compare with omitting the overhang. The outer face of the wall may be the face of the wall which is located furthest

from the central axis of the stator yoke when measured in the radial direction of the stator assembly.

Optionally, each bobbin of the plurality of bobbins comprises a further overhang which projects radially from the outer face of the wall; the overhang and the further overhang are located at opposite axial ends of the wall; and the further overhang abuts the yoke. As a result, the stator yoke may be constrained between the overhangs, which may increase the mechanical stability of the stator assembly relative to omitting the further overhang.

Optionally, the overhang comprises a channel which at least partially overlies the stator tooth and extends through an axial thickness of the overhang. The channel may provide a line of sight for equipment (such as a welding torch) to access the stator tooth and connect the stator tooth to the stator yoke. The axial thickness of the overhang may comprise a thickness in the axial direction of the stator assembly.

Optionally, the projecting portion is welded or glued to the adjacent bobbin. As a result, molten material or glue may take up tolerance gaps between the bobbins, which may make the mechanical stability of the stator assembly less affected by manufacturing tolerances in the components of the stator assembly.

Welding may advantageously simplify the manufacture of the stator assembly when compared with gluing because glue may require additional manufacturing considerations such as shelf life, glue spread into undesirable locations, and maintaining the glue at an optimum processing temperature.

Optionally, the projecting portion is ultrasonically welded to the adjacent bobbin. Ultrasonic welding may produce a smaller heat affected zone than other welding techniques which may reduce the likelihood of other parts of the stator assembly, such as the stator teeth and yoke, becoming damaged by the welding process.

Optionally, the projecting portion is welded to the adjacent bobbin; and each of the plurality of bobbins is formed of a material having a melting point of less than or equal to

400°C. As a result, the temperature required to melt the material and weld the bobbins together may be significantly lower than a temperature at which the stator teeth and yoke start to degrade. This may reduce the likelihood of the stator teeth becoming damaged by the welding of the bobbins compared to using a different material having a higher melting point.

Optionally, the plurality of bobbins are formed of a material having a dielectric strength of greater than or equal to 15kV/mm. This may enable a higher voltage to be utilised in the stator assembly, compared to where a material of lower dielectric strength is used, which may enable the stator assembly to operate with increased efficiency and/or increased power density.

Optionally, the stator yoke comprises a plurality of protrusions, and each stator tooth of the plurality of stator teeth comprises a recess for receiving one of the protrusions of the plurality of protrusions; or each stator tooth of the plurality of stator teeth comprises a protrusion, and the stator yoke comprises a plurality of recesses for receiving one of the protrusions. This may provide a simple and robust mechanism for connecting the stator yoke to the stator teeth.

Optionally, the protrusion has a triangular shape. Using a simple geometry for the protrusion may improve the manufacturability of the stator assembly, especially at small motor scales, when compared to using more complex geometries such as a dove tail joint.

Optionally, the stator yoke comprises the plurality of protrusions, and each stator tooth comprises the recesses for receiving one of the protrusions of the plurality of protrusions. As a result, the stator yoke may be made thinner than if the stator yoke comprised the recesses, which may improve the electromagnetic performance of the stator assembly by increasing the space available for the windings.

Optionally, the projecting portion is connected to the adjacent bobbin along at least 50% of an axial length of the projecting portion. This may improve the mechanical integrity of the stator assembly and may reduce the likelihood of windings creeping from the main bodies

and contacting the stator teeth or the rotor assembly when compared with connecting the projecting portion along a lesser axial length of the projecting portion. The axial length of the project portion may comprise a length in the axial direction of the stator assembly.

- 5 According to a second aspect of the present invention there is provided a vacuum cleaner comprising a stator assembly according to the first aspect of the present invention.

According to a third aspect of the present invention there is provided a haircare appliance comprising a stator assembly according to the first aspect of the present invention.

10

- According to a fourth aspect of the present invention there is provided a method of manufacturing a stator assembly, comprising: providing a stator yoke; providing a plurality of windings; providing a plurality of stator teeth, wherein the plurality of stator teeth are separate components to the stator yoke; providing a plurality of bobbins, each bobbin of the plurality of bobbins comprising a main body which is connected to a respective stator tooth of the plurality of stator teeth, and a projecting portion which is integrally formed with the main body and projects from the main body; when the bobbins of the plurality of bobbins are separate to one another, winding a respective winding of the plurality of windings around the main body of each bobbin of the plurality of bobbins; arranging the plurality of bobbins in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke; and connecting the projecting portion of each bobbin of the plurality of bobbins to an adjacent bobbin of the plurality of bobbins.
- 15
- 20

- As described previously, winding the windings onto the separate bobbins before they are connected together may enable winding techniques such as spindle or flyer winding to be used which may result in benefits such as improved fill factor when compared to winding the windings around the already joined bobbins.
- 25

- Optionally, the method comprises connecting each stator tooth of the plurality of stator teeth to the stator yoke.
- 30

Optionally, arranging the plurality of bobbins in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke comprises holding the bobbins of the plurality of bobbins adjacent to one another within the stator yoke before connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent
5 bobbin of the plurality of bobbins. Using the stator yoke to hold the bobbins adjacent to one another may improve the geometric accuracy of the stator assembly compared to, for example, holding the bobbins adjacent to each other by hand.

Optionally, holding the bobbins of the plurality of bobbins adjacent to one another within
10 the stator yoke comprises holding the bobbins of the plurality of bobbins adjacent to one another within the stator yoke such that a minimum clearance of greater than or equal to 50um is provided between the bobbins of the plurality of bobbins. As a result, manufacturing tolerances in the geometry of the stator teeth may be accommodated for by the clearance. The clearance may then be taken up by glue or molten material when the
15 bobbins are glued or welded together.

Optionally, the minimum clearance is less than or equal to 0.5mm. If the clearance is too large either an excessively large area of glue may be provided, which may weaken the stator assembly compared with a lesser area of glue, or the shape of the bobbins may be
20 excessively distorted by molten material moving away from the original bobbin geometry to fill the clearance, which may weaken the stator assembly compared to if a lesser clearance were used.

A clearance of between 50um and 0.5mm may provide a good balance between the
25 competing needs of accommodating manufacturing tolerances and not excessively weakening or distorting the shape of the stator assembly.

Optionally, connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins comprises welding or gluing the projection
30 portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins.

Optionally, connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins comprises ultrasonically welding the projection portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins.

5

Optionally, the main body comprises a radially innermost end and a radially outermost end; the projecting portion projects from the radially innermost end; and the method comprises placing the projecting portion of each bobbin of the plurality of bobbins in abutment with a mandrel before connecting the projecting portion of each bobbin of the plurality of bobbins to an adjacent bobbin of the plurality of bobbins. As a result, the geometry of the projecting portions may be more accurately controlled than if the mandrel were not used. This may improve the control of the geometry of an airgap of a motor comprising the stator assembly. For example, the mandrel may prevent a burr which may be produced by glue used in the gluing or molten material produced during welding from projecting into the airgap.

15

Optionally, the method comprises heating the mandrel to weld the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins. Using the mandrel to weld the bobbins together, which may be referred to as heat staking, may enable the bobbins to be welded together along an axial length of each bobbin, whilst also being located around the mandrel.

20

Optionally, heating the mandrel to weld the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins comprises heating the mandrel for a duration of less than or equal to 5s. If the heating duration is too great, a large heat affected zone may be produced which may cause damage to the other components of the stator assembly, for example the stator teeth. By having a duration of less than or equal to 5s, this heat affected zone may be reduced compared to having a greater duration.

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Optionally, the duration is greater than or equal to 0.5s. If the heating duration is too short, the bobbins may not reach a temperature sufficient to weld the bobbins together. Having a

duration of between 0.5s and 5s may provide a good balance between reducing the heat affected zone and welding the material together.

Optionally, the respective winding of the plurality of windings is wound around the main
5 body of each bobbin of the plurality of bobbins using spindle winding or flyer winding.

Optionally, windings are wound around the main body of each bobbin of the plurality of bobbins using spindle winding. Spindle winding may be more efficient than flyer winding.

10 Optionally, providing the plurality of bobbins comprises forming the plurality of bobbins, and then connecting the main bodies of the plurality of bobbins to the stator teeth. This may reduce the cost of the bobbins because cheaper manufacturing processes may be used to produce the bobbins, such as injection moulding, compared to overmoulded the bobbins onto the stator teeth.

15

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an example stator assembly;

Figure 2 is a top view of the example stator assembly;

Figure 3 is a perspective view of a stator yoke of the example stator assembly;

20 Figure 4 is a perspective view of a stator tooth of the example stator assembly;

Figure 5 is a perspective view of a bobbin of the example stator assembly;

Figure 6 is a top view of the bobbin;

Figure 7 is a perspective view, viewed from the opposite side to the perspective view of Figure 5, of the bobbin;

25 Figure 8 is a perspective view of the bobbin, stator tooth, and a winding of the stator assembly;

Figures 9(a) – (f) show, by way of perspective views and sectional views, different stages in the manufacture of the example stator assembly;

Figure 10 shows a top schematic view of an alternative example stator tooth and stator
30 yoke;

Figure 11 shows a side schematic view of an alternative example bobbin comprising a further overhang;

Figure 12 is a schematic view of a motor comprising the example stator assembly;
Figure 13 shows a perspective view of a vacuum cleaner comprising the motor; and
Figure 14 shows a side view of a haircare appliance comprising the motor.

5 DETAILED DESCRIPTION

Figures 1 and 2 show a stator assembly 10 comprising a stator yoke 12, six stator teeth 14, six bobbins 16, and six windings 18.

10 The stator yoke 12 (shown in isolation in Figure 3) comprises a central axis 20, an inner face 22, and six recesses 24. The stator yoke 12 has an annular shape, and is formed from a number of laminations of electrical steel. A radial direction 26 of the stator yoke 12 (which is also a radial direction of the stator assembly 10) is perpendicular to the central axis 20 of the stator yoke 12. An axial direction 28 of the stator yoke 12 (which is also an axial
15 direction of the stator assembly 10) is parallel to the central axis 20 of the stator yoke 12. References to axial and radial herein refer respectively to the axial 26 and radial 28 directions of the stator yoke 12.

The inner face 22 of the stator yoke 12 is a face of the stator yoke 12 which is located
20 closest to the central axis 20 of the stator yoke 12 when measured in the radial direction 26 of the stator assembly 10. The recesses 24 are defined in the inner face 22 of the stator yoke 12 and have a triangular cross-section.

The stator yoke 12 has a radial thickness 36 of 0.5mm. The stator yoke 12 having a radial
25 thickness 36 of between 0.5mm and 2mm is also envisaged.

A stator tooth 14 is shown in isolation in Figure 4. The other stator teeth 14 are identical to the stator tooth 14 shown in Figure 4. The stator tooth 14 comprises a shank 40, a protrusion 42, and tooth tips 44. The shank 40 has a first end 46 and a second end 48. The
30 protrusion 42 is defined within the first end 46. The protrusion 42 has a triangular cross-sectional shape and is dimensioned to be received in one of the recesses 24 of the stator yoke 12. The tooth tips 44 extend circumferentially outwardly from the second end 48. The

stator tooth 14 is a separate component to the stator yoke 12. The stator tooth 14 is formed from a number of laminations of the same electrical steel as the stator yoke 12.

A bobbin 16 is shown in Figures 5 and 6. The other bobbins 16 are identical to the bobbin 16 shown in Figures 5 and 6. The bobbin 16 comprises a main body 50, a projecting portion 52, a wall 54, and an overhang 56.

The main body 50 comprises a radially innermost end 60 and a radially outermost end 62. The radially innermost end 60 is the end of the main body 50 which is closest to the central axis 20 of the stator yoke 12 in the radial direction 26 of the stator assembly 10 when the stator assembly 10 is assembled (as discussed below in more detail). The radially outermost end 62 is the end of the main body 50 which is furthest from the central axis 20 of the stator yoke 12 in the radial direction 26 of the stator assembly 10 when the stator assembly 10 is assembled.

The projecting portion 52 comprises a first circumferential end 64 and a second circumferential end 66. The projecting portion 52 projects axially in opposite axial directions 28 from the radially innermost end 60 of the main body 50 by a distance 68 of 2.7mm. It is also envisaged that the projecting portion 52 may project axially from the main body 50 by a distance 68 of greater than or equal to 1mm. The projecting portion 52 projects circumferentially in opposite circumferential directions 30 from the radially innermost end 60 of the main body 50 such that the projecting portion subtends an angle 70 of 60°. The projecting portion 52 has an axial length 72 of 10mm. Axial lengths 72 of between 5mm and 50mm are also envisaged.

The wall 54 comprises an outer face 74, a first axial end 76, and a second axial end 78. The outer face 74 of the wall 54 is a face of the wall 54 which, when the stator assembly 10 is assembled, is located furthest from the central axis 20 of the stator yoke 12 when measured in the radial direction 26 of the stator assembly 10. The first 76 and second 78 axial ends are located at opposite ends of the wall 54 in the axial direction 28 of the stator assembly 10. The wall 54 projects axially in opposite axial directions 28 from the radially outermost end 62 of the main body 50 by a distance 80 of 2.4mm. It is also envisaged that the wall 54

may project axially from the main body 50 by a distance 80 of greater than or equal to 1mm. The wall 54 projects circumferentially in opposite circumferential directions 30 from the radially outermost end 62 of the main body 50 by a distance 82 of 2mm. It is also envisaged that the wall 54 may project circumferentially from the main body 50 by a distance 82 of greater than or equal to 1mm.

The overhang 56 comprises a channel 84. The overhang 56 projects radially outwards from the outer face 74 of the wall 54 by a distance 86 of 1.1mm. The overhang 56 projecting radially outwards from the outer face 74 of the wall 54 by a distance 86 of between 0.5mm and 3mm is also envisaged. The overhang 56 is located at the first axial end 76 of the wall 54. The overhang 56 has an axial thickness 88 (shown in Figure 7) of 2.7mm. The overhang 56 having an axial thickness 88 of between 0.6mm and 5mm is also envisaged. The channel 84 extends through the axial thickness 88 of the overhang 56. As shown in Figure 6, when the stator assembly 10 is assembled, the channel 84 overlies the recess 42 of the stator tooth 14.

The main body 50, the projecting portion 52, and the overhang 56 are integrally formed such that the bobbin 16 is a monolithic component. The bobbin 16 is formed of PBT-30GF, which is an example of a fibre reinforced plastic. PBT-30GF has a melting point of 224°C and a dielectric strength of 36.0kV/mm. Other types of bobbin material having a melting point of less than or equal to 400°C and/or a dielectric strength of greater than or equal to 15kV/mm are also envisaged.

A winding 18 is shown in Figure 8. The winding 18 comprises a copper wire having a circular cross-sectional shape. The other windings 18 are identical to the winding 18 of Figure 8.

Manufacturing of the stator assembly 10 will now be described with the aid of Figures 9(a) to 9(f).

Referring now to Figure 9(a) and 9(b). The bobbin 16 is overmoulded onto (and thereby connected to) the shank 40 of the stator tooth 14 such that the channel 84 of the overhang 56 of the bobbin 16 overlies the recess 42 of the stator yoke 12.

- 5 The winding 18 is then spindle wound onto the main body 50 of the bobbin 16 (as shown in Figure 9(c)). Using flyer winding to wind the winding 18 onto the main body 50 is also envisaged.

Referring now to Figure 9(d), a mandrel 110 is located inside the stator yoke 12 such that a
10 central axis 112 of the mandrel 110 is coaxial with the central axis 20 of the stator yoke 12. The mandrel 110 has a generally cylindrical shape and comprises an upper portion 114 and a lower portion 116. The upper portion 114 has a greater diameter than a diameter of the lower portion 116. As shown in Figure 9(d), it is the lower portion 116 of the mandrel 110 which is located inside the stator yoke 12. The bobbin 16, stator tooth 14, and winding 18
15 are inserted between the stator yoke 12 and the lower portion 116 of the mandrel 110 such that the stator yoke 12 abuts the overhang 56 and the outer face 74 of the wall 54, and the projecting portion 52 of the bobbin 16 abuts the lower portion 116 of the mandrel 110. The protrusions 24 of the stator tooth 14 is received within one of the recesses 24 of the stator yoke 12 such that the stator tooth 14 extends radially inwards from the stator yoke 12.

20

The steps described above with reference to Figures 9(a) to 9(d) are then repeated for the remaining bobbins 16, stator teeth 14, and stator windings 18 of the stator assembly 10. As a result, the bobbins 16 are arranged in an array about the inner face 22 of the stator yoke 12 such that the bobbins 16 are radially constrained by the stator yoke 12 (as shown in
25 Figure 9(e)). When arranged in the array, the bobbins 16 have an annular shape.

The mandrel 110 is then lowered (Figure 9(f)) such that the upper portion 114 of the mandrel 110 abuts the projecting portions 52 of the bobbins 16. The movement of the mandrel 110 pushes the bobbins 16 and the stator teeth 14 connected to the bobbins 16
30 towards the stator yoke 12. The protrusions 42 are thereby press fitted into the recesses 24. Additionally, the movement of the mandrel 110 applies a holding force to the bobbins 16 such that the bobbins 16 are held adjacent to each other. At this stage a minimum clearance

120 between the bobbins 16 is 200um. The clearance is provided by selecting the minimum and maximum moulding tolerances. The clearance 120 is exaggerated in size in Figure 9(f) to aid clarity. Clearances 120 of between 50um and 0.5mm are also envisaged.

- 5 The first circumferential end 64 of the projecting portion 52 of each bobbin 16 is ultrasonically welded (and thereby connected) to a second circumferential end 66 of a projecting portion 52 of an adjacent bobbin 16 along 100% of the axial length 72 of the projecting portion 52 of the bobbin 16. The second circumferential end 66 of the projecting portion 52 of each bobbin 16 is ultrasonically welded (and thereby connected) to a first
- 10 circumferential end 64 of a projecting portion 52 of a second adjacent bobbin 16 along 100% of the axial length 72 of the projecting portion 52 of the bobbin 16. Ultrasonically welding the first 64 and second 66 circumferential ends along at least 50% of the axial length 72 of the projecting portion 52 of the bobbins 16 is also envisaged.
- 15 A welding tool (not shown) is then inserted into the channel 84. Protrusions 42, which have been press fitted into a corresponding one of the recesses 24 of the stator yoke 12, are then welded to the stator yoke 12 using the welding tool. The mandrel 110 is then withdrawn from the stator yoke 12.
- 20 In the above example, the stator yoke 12 comprises the recesses 24, and each stator tooth 14 comprises one of the protrusions 42. In another example (shown in Figure 10), the stator yoke 12 comprises the six protrusions 42, and the stator teeth 14 each comprise a respective recess 24.
- 25 In the above example, the bobbin 16 comprises a single overhang 56. In another example, shown in Figure 11, the bobbin comprises a further overhang 150. The further overhang 150 projects radially outwards from the outer face 74 of the wall 54 by a distance 152 of 1.1mm and thereby projects axially by the same extend as the overhang 56. The further overhang 150 projecting radially outwards from the outer face 74 of the wall 54 by a
- 30 distance 150 of between 0.5mm and 3mm is also envisaged. The further overhang 150 is located at the second axial end 78 of the wall 54 such that the overhang 56 and the further overhang 150 are located at opposite axial ends of the wall 54. The stator yoke 12 abuts the

overhang 56, the further overhang 150, and the outer face 74 of the wall 54 of each bobbin 16.

In the above example, the bobbin 16 is overmoulded onto the stator tooth 14. In other examples, the bobbin 16 is formed by injection moulding and then the stator tooth 14 is inserted into the bobbin 16 such that an interference fit is provided between the main body 50 of the bobbin 16 and the stator tooth 14 to connect the stator tooth 14 to the main body 50.

In the above example, the projecting portions 52 are ultrasonically welded. In other examples, the projecting portions 52 may instead be welded by other techniques (for examples, the application of heat without ultrasonic vibrations), or glued. In examples where the projecting portions 52 are welded by other techniques, when the upper portion 114 of the mandrel 110 is inserted into the stator yoke 12, the mandrel 110 is heated to apply heat to the projecting portions 52 for a duration of 1s to weld the projecting portions 52 to one another. Durations of between 0.5s and 5s are also envisaged.

A schematic illustration of a motor 200 is shown in Figure 12. The motor 200 comprises the stator assembly 10 and a rotor assembly 202 located internally of the stator assembly 10. In use, a voltage is applied to windings 18 such that a magnetic field is generated. The magnetic field interacts with the rotor assembly 202 to rotate the rotor assembly 202 within the stator assembly 10.

A schematic illustration of a vacuum cleaner 300 comprising the motor 200 is shown in Figure 13, whilst a schematic illustration of a hair care 400 appliance comprising the motor 200 is shown in Figure 14.

Whilst particular examples and embodiments have thus far been described, it should be understood that these are illustrative only and that various modifications may be made without departing from the scope of the invention as defined by the claims.

CLAIMS

1. A stator assembly comprising:
a stator yoke;
5 a plurality of stator teeth, wherein the plurality of stator teeth are separate components to the stator yoke;
a plurality of windings; and
a plurality of bobbins,
wherein:
10 the plurality of bobbins are arranged in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke; and
each bobbin of the plurality of bobbins comprises:
a main body which is connected to a respective stator tooth of the
plurality of stator teeth, and around which a respective winding of the
15 plurality of windings is wound; and
a projecting portion which is integrally formed with the main body,
projects from the main body, and is connected to an adjacent bobbin of the
plurality of bobbins.
- 20 2. A stator assembly as claimed in claim 1, wherein the plurality of stator teeth are connected to the stator yoke.
3. A stator assembly as claimed in claim 2, wherein the plurality of stator teeth are connected to an inner face of the stator yoke.
- 25 4. A stator assembly as claimed in claim 3, wherein:
the main body comprises a radially innermost end and a radially outermost end; and
the projecting portion projects from the radially innermost end.
- 30 5. A stator assembly as claimed in claim 3 or 4, wherein the projecting portion projects axially from the main body by a distance of greater than or equal to 1mm.

6. A stator assembly as claimed in any one of claims 3 to 5, wherein each bobbin of the plurality of bobbins comprises a wall which projects axially and/or circumferentially from a radially outermost end of the main body by a distance of greater than or equal to 1mm

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7. A stator assembly as claimed in claim 6, wherein:
each bobbin of the plurality of bobbins comprises an overhang which projects radially from an outer face of the wall; and
the stator yoke abuts the overhang.

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8. A stator assembly as claimed in claim 7, wherein:
each bobbin of the plurality of bobbins comprises a further overhang which projects radially from the outer face of the wall;
the overhang and the further overhang are located at opposite axial ends of the wall;
and
the further overhang abuts the yoke.

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9. A stator assembly as claimed in claim 7 or 8, wherein the overhang comprises a channel which at least partially overlies the stator tooth and extends through an axial thickness of the overhang.

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10. A stator assembly as claimed in any preceding claim, wherein the projecting portion is welded or glued to the adjacent bobbin.

25 11. A stator assembly as claimed in any preceding claim wherein the projecting portion is ultrasonically welded to the adjacent bobbin.

12. A stator assembly as claimed in claims any preceding claim, wherein:
the projecting portion is welded to the adjacent bobbin; and
each of the plurality of bobbins is formed of a material having a melting point of less than or equal to 400°C.

30

13. A stator assembly as claimed in any preceding claim, wherein:

the stator yoke comprises a plurality of protrusions, and each stator tooth of the plurality of stator teeth comprises a recess for receiving one of the protrusions of the plurality of protrusions; or

5 each stator tooth of the plurality of stator teeth comprises a protrusion, and the stator yoke comprises a plurality of recesses for receiving one of the protrusions.

14. A stator assembly as claimed in any preceding claim, wherein the projecting portion is connected to the adjacent bobbin along at least 50% of an axial length of the
10 projecting portion.

15. A vacuum cleaner comprising a stator assembly according to any preceding claim.

16. A haircare appliance comprising a stator assembly according to any preceding
15 claim.

17. A method of manufacturing a stator assembly, comprising:

providing a stator yoke;

providing a plurality of windings;

20 providing a plurality of stator teeth, wherein the plurality of stator teeth are separate components to the stator yoke;

providing a plurality of bobbins, each bobbin of the plurality of bobbins comprising a main body which is connected to a respective stator tooth of the plurality of stator teeth, and a projecting portion which is integrally formed with the main body and projects from
25 the main body;

when the bobbins of the plurality of bobbins are separate to one another, winding a respective winding of the plurality of windings around the main body of each bobbin of the plurality of bobbins;

30 arranging the plurality of bobbins in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke; and

connecting the projecting portion of each bobbin of the plurality of bobbins to an adjacent bobbin of the plurality of bobbins.

18. A method of manufacturing a stator assembly as claimed in claim 17, wherein the method comprises connecting each stator tooth of the plurality of stator teeth to the stator yoke.

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19. A method of manufacturing a stator assembly as claimed in claim 17 or 18, wherein arranging the plurality of bobbins in an array about the stator yoke such that the plurality of bobbins are radially constrained by the stator yoke comprises holding the bobbins of the plurality of bobbins adjacent to one another within the stator yoke before connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins.

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20. A method of manufacturing a stator assembly as claimed in claim 19, wherein holding the bobbins of the plurality of bobbins adjacent to one another within the stator yoke comprises holding the bobbins of the plurality of bobbins adjacent to one another within the stator yoke such that a minimum clearance of greater than or equal to 50um is provided between the bobbins of the plurality of bobbins.

15

21. A method of manufacturing a stator assembly as claimed in any one of claims 17 to 20, wherein connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins comprises welding or gluing the projection portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins.

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22. A method of manufacturing a stator assembly as claimed in any one of claims 17 to 21, wherein connecting the projecting portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins comprises ultrasonically welding the projection portion of each bobbin of the plurality of bobbins to the adjacent bobbin of the plurality of bobbins.

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23. A method of manufacturing a stator assembly as claimed in any one of claims 17 to 22, wherein:

the main body comprises a radially innermost end and a radially outermost end;

the projecting portion projects from the radially innermost end; and

the method comprises placing the projecting portion of each bobbin of the plurality of bobbins in abutment with a mandrel before connecting the projecting portion of each
5 bobbin of the plurality of bobbins to an adjacent bobbin of the plurality of bobbins.

24. A method of manufacturing a stator assembly as claimed in any one of claims 17 to 23, wherein the respective winding of the plurality of windings is wound around the main body of each bobbin of the plurality of bobbins using spindle winding or flyer winding.

10

25. A method of manufacturing a stator assembly as claimed in any one of claims 17 to 24, wherein providing the plurality of bobbins comprises forming the plurality of bobbins, and then connecting the main bodies of the plurality of bobbins to the stator teeth.

15

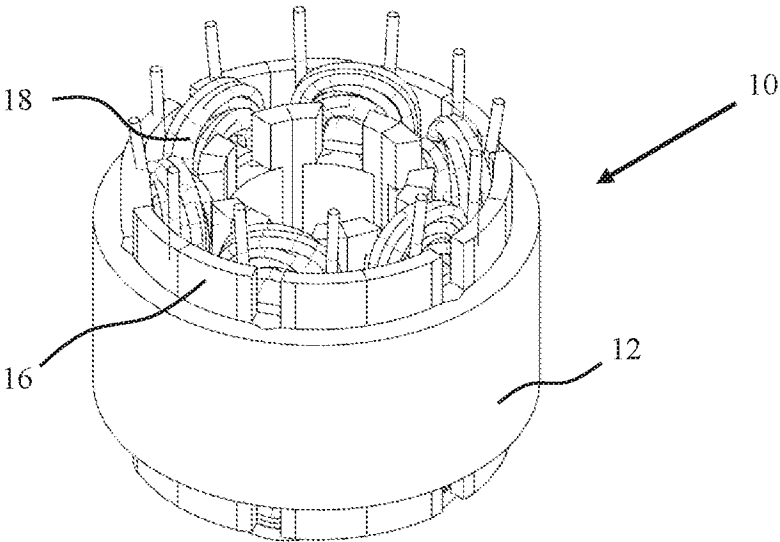


Fig. 1

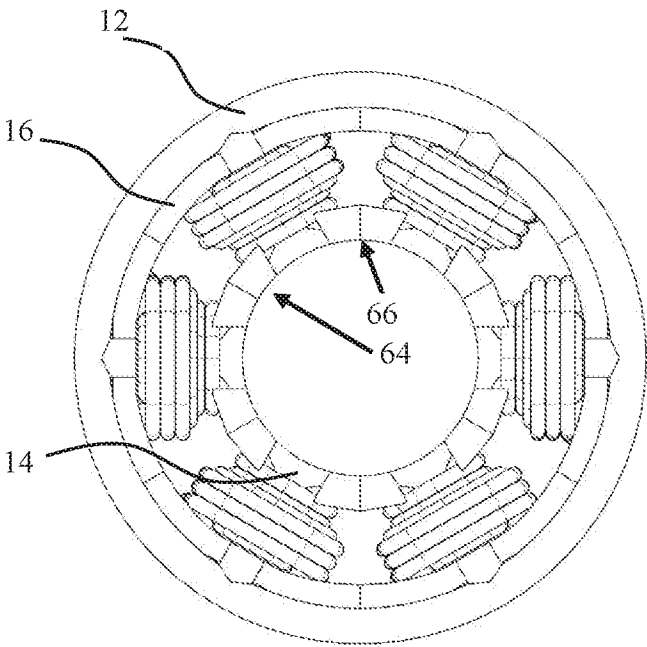
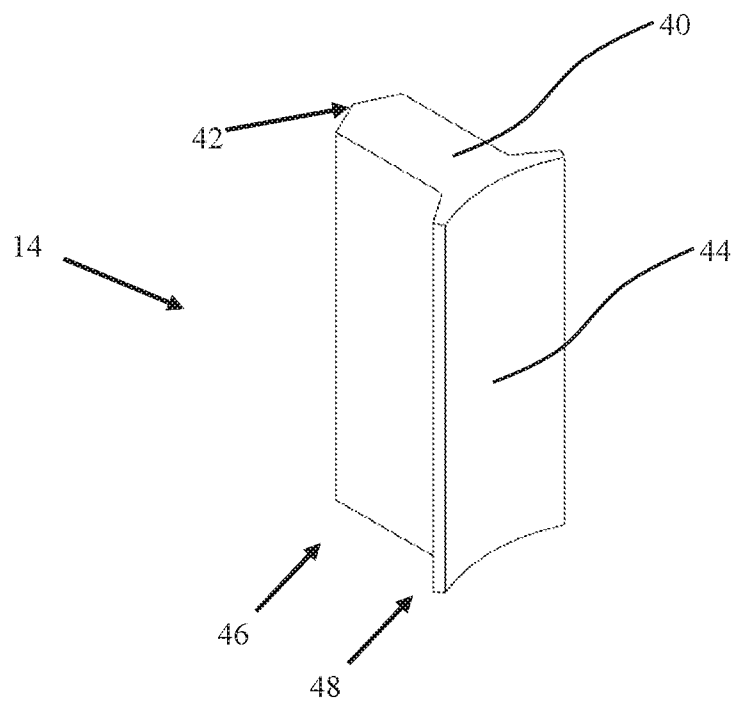
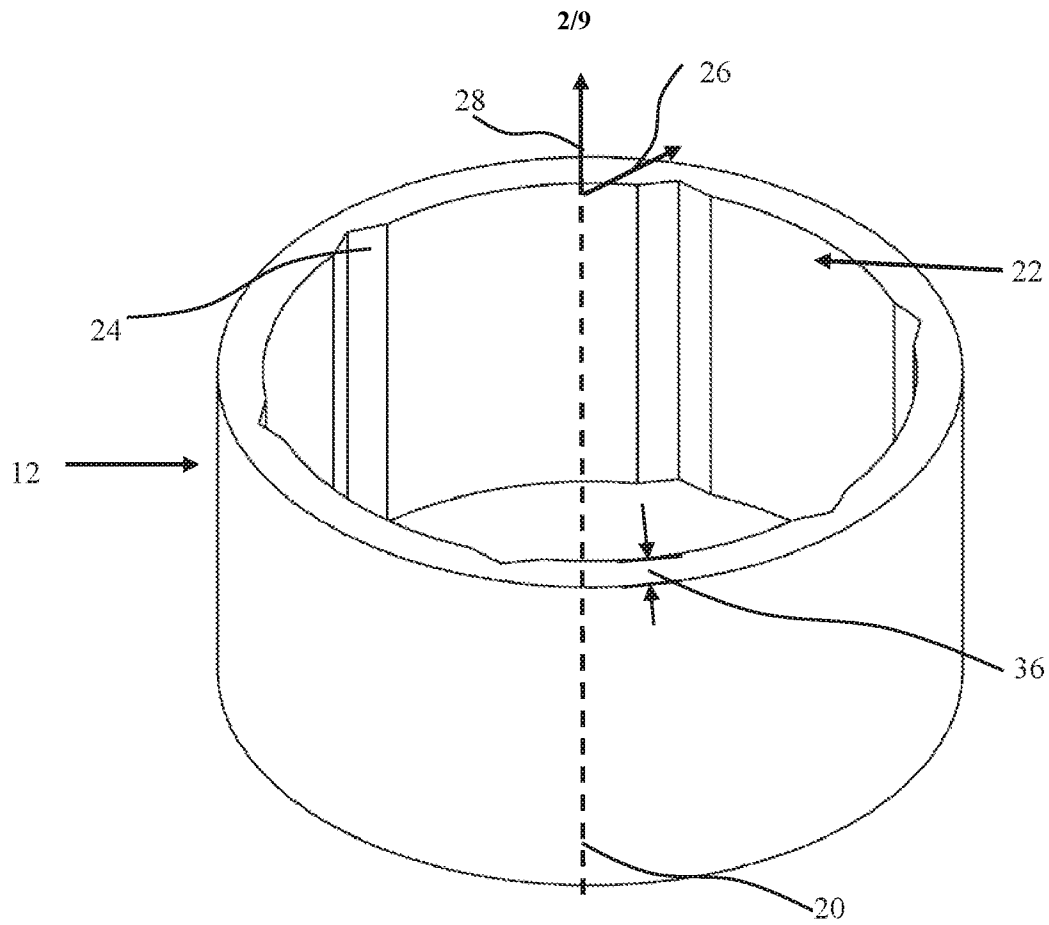


Fig. 2



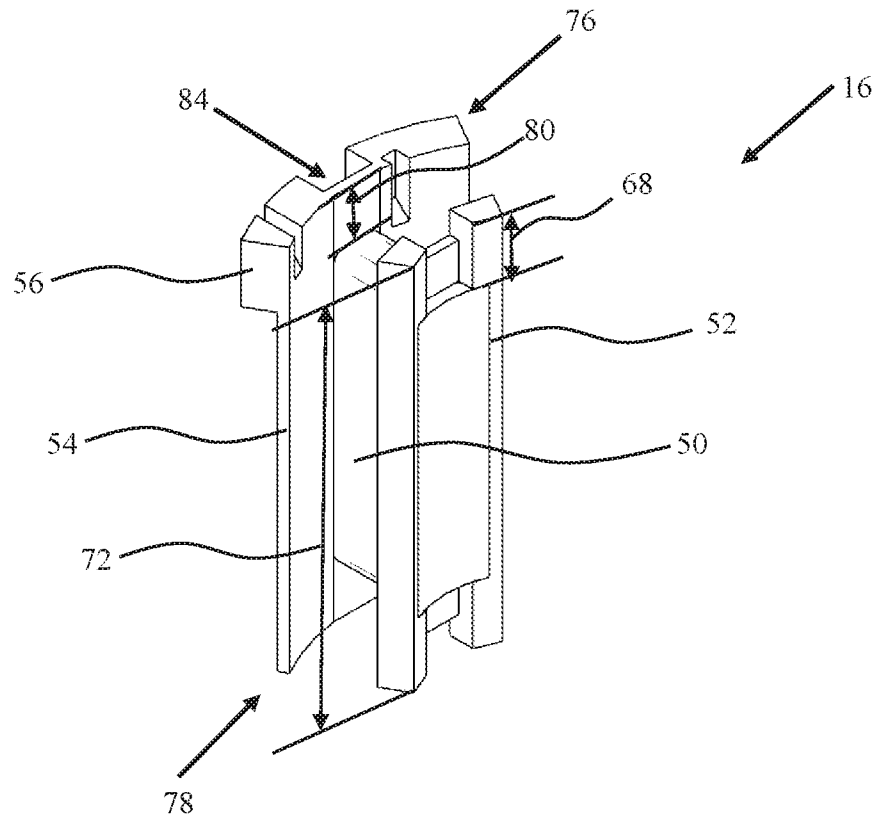


Fig. 5

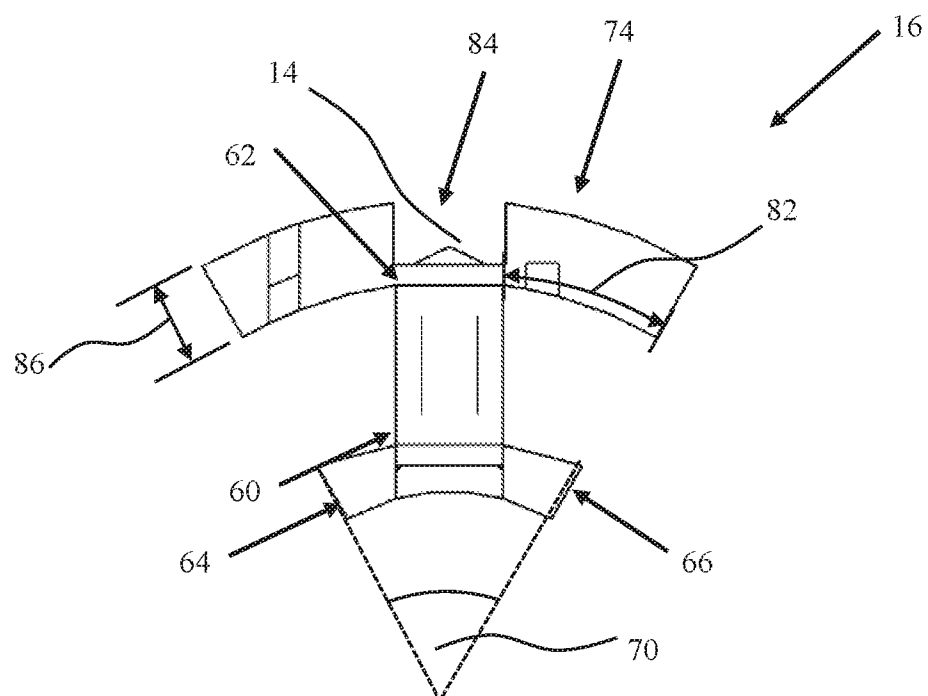


Fig. 6

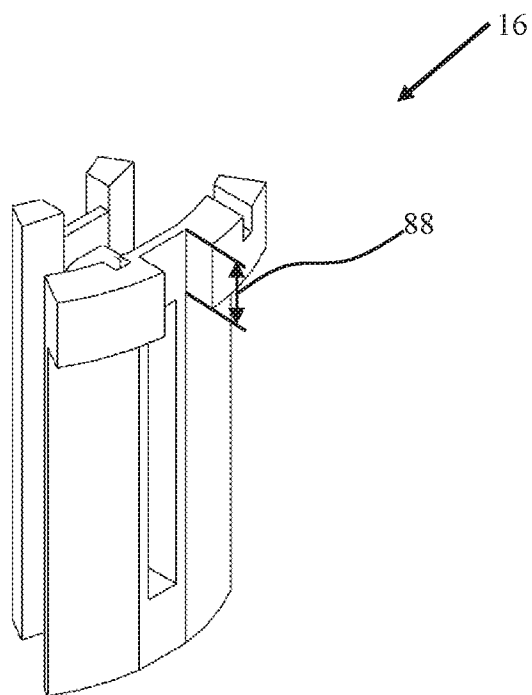


Fig. 7

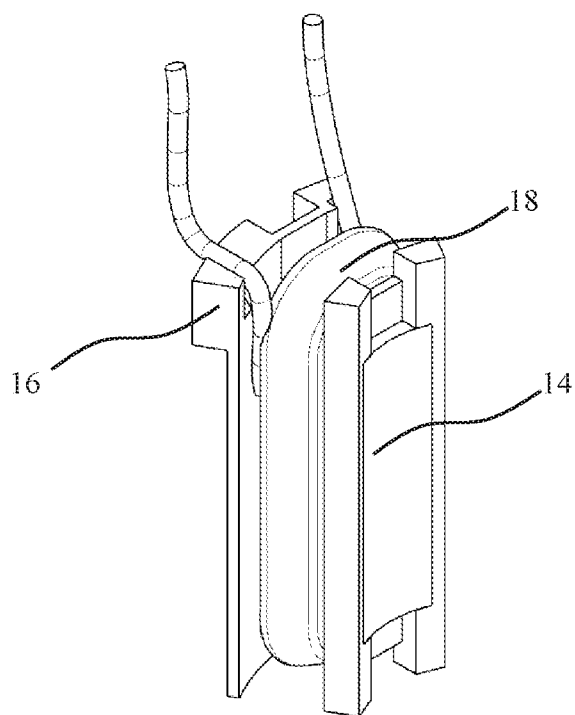


Fig. 8

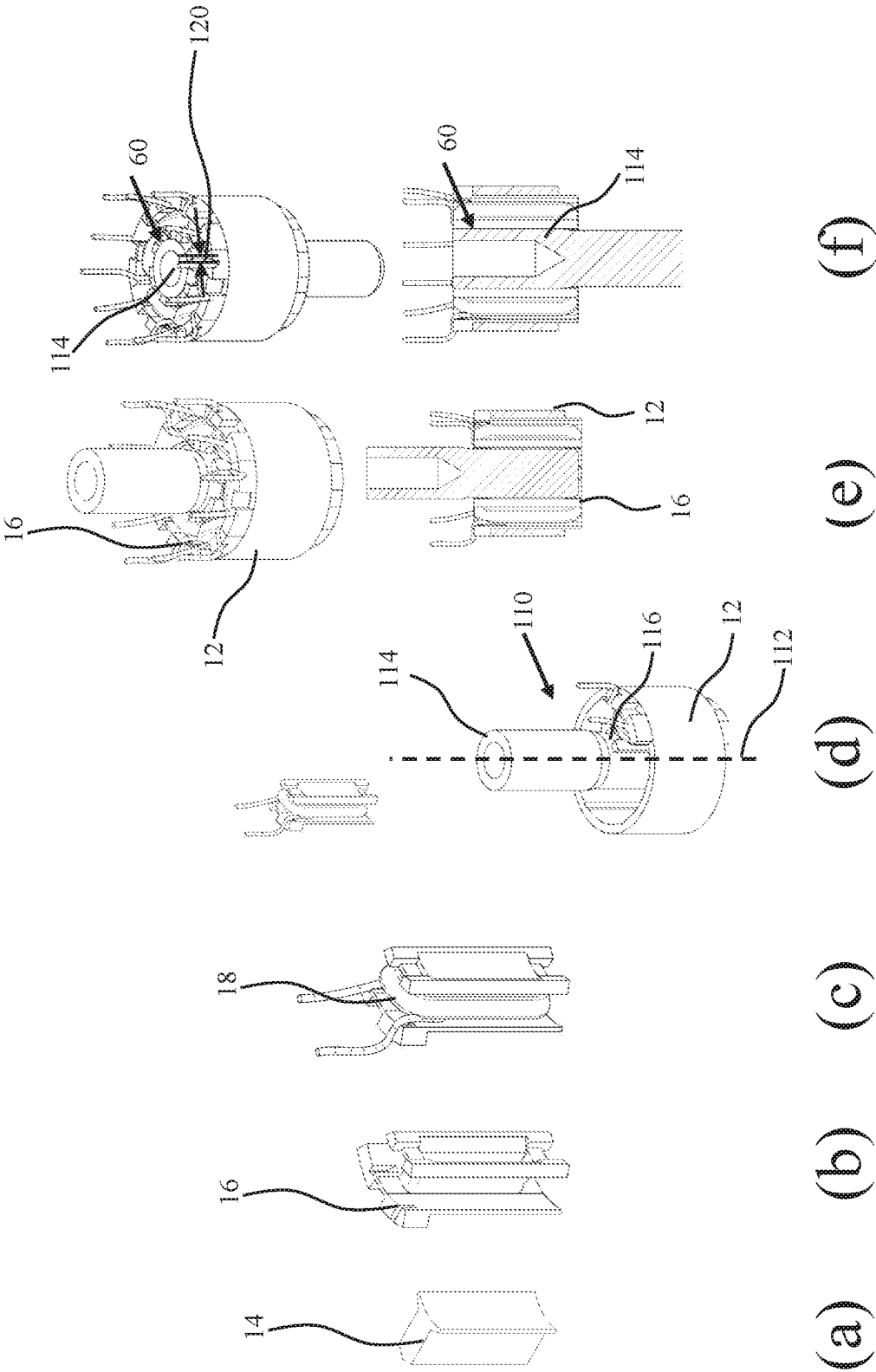


Fig. 9

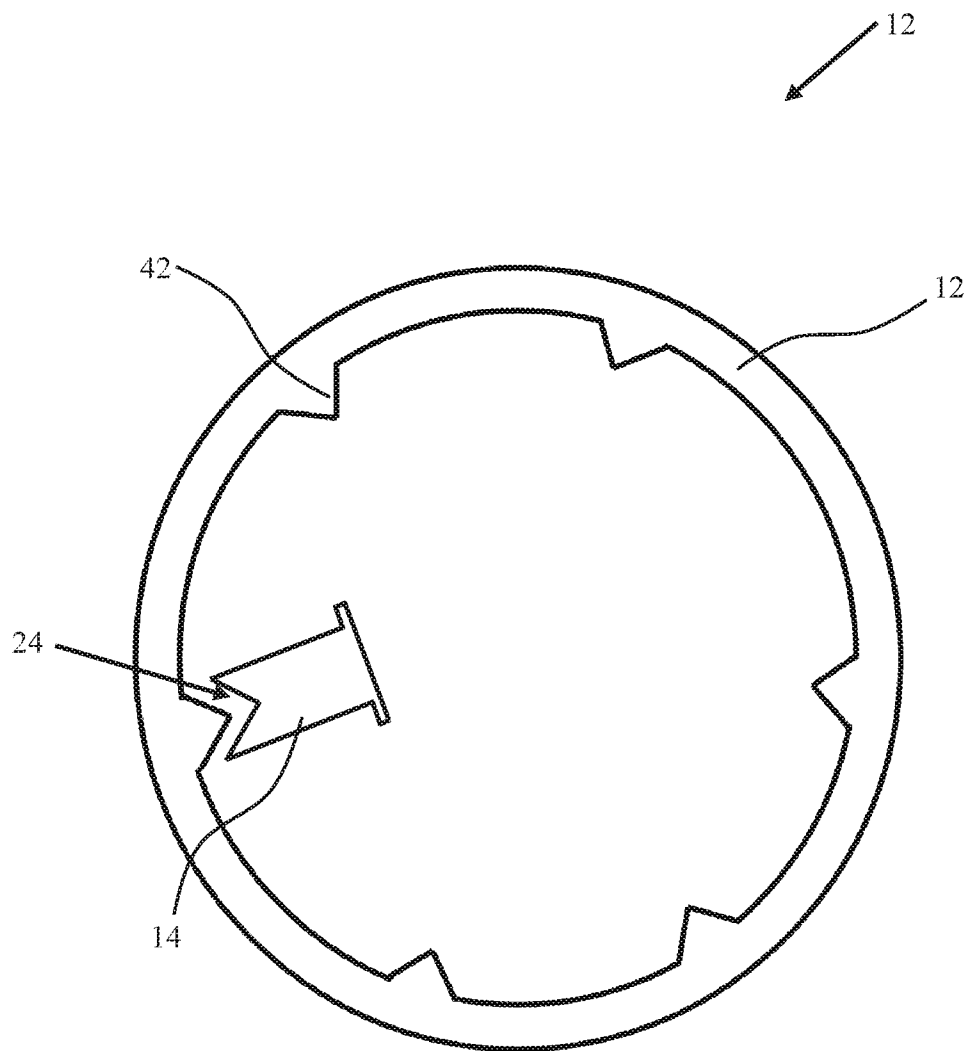


Fig. 10

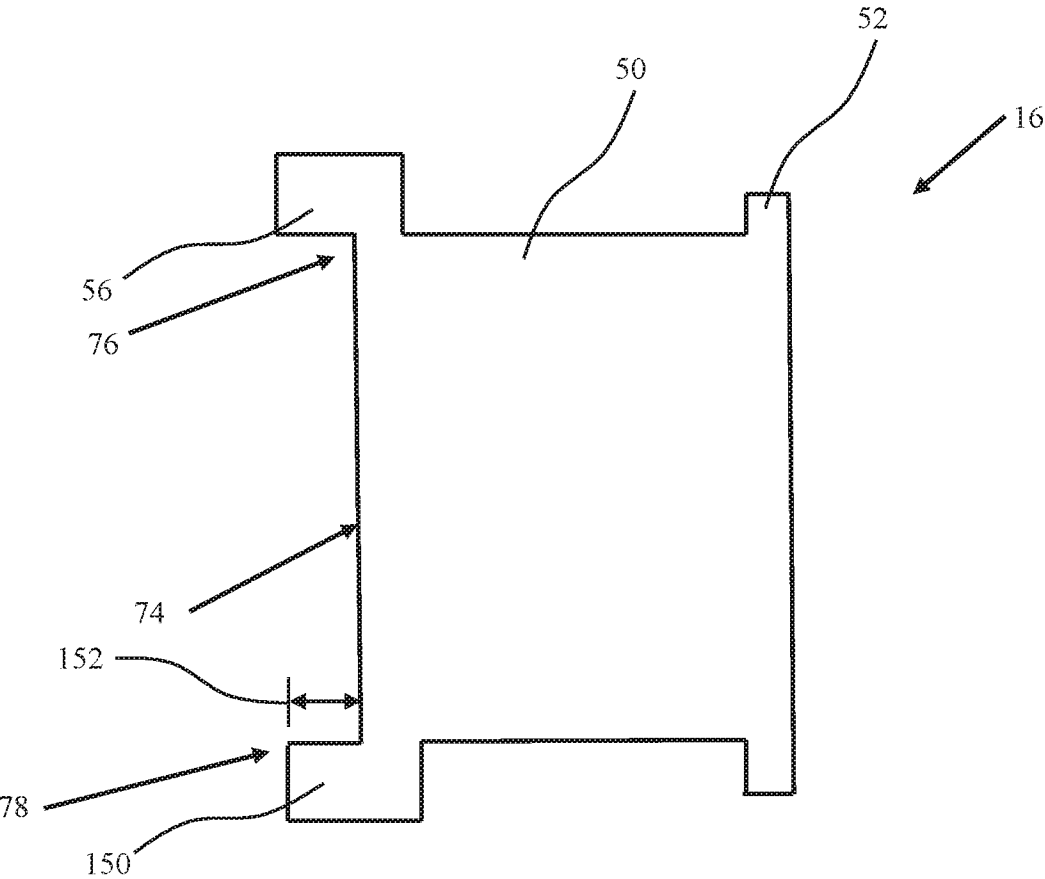


Fig. 11

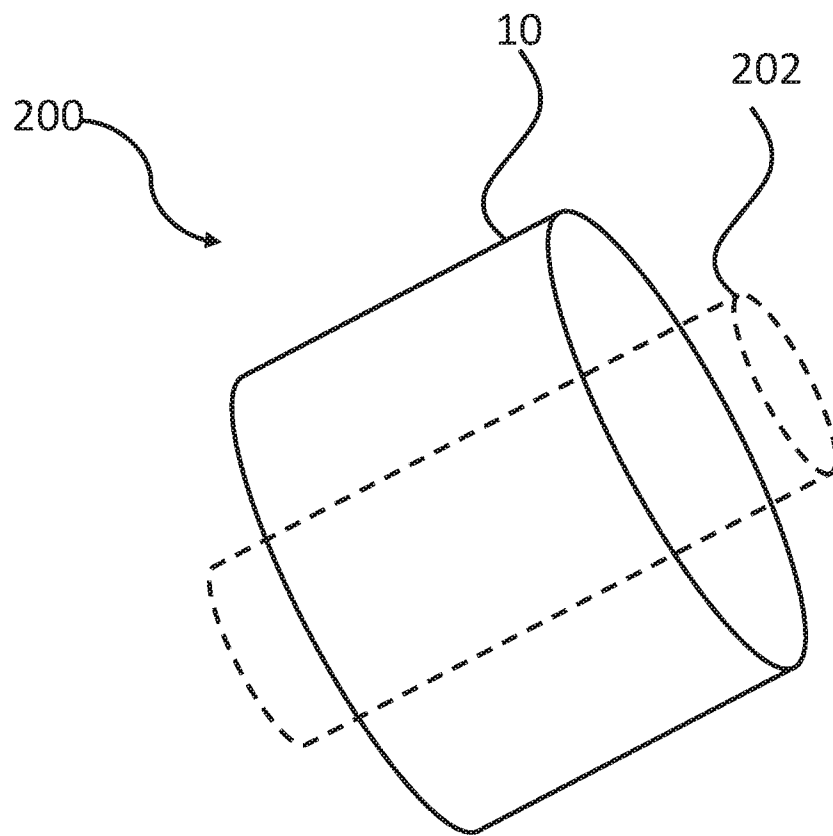


Fig. 12

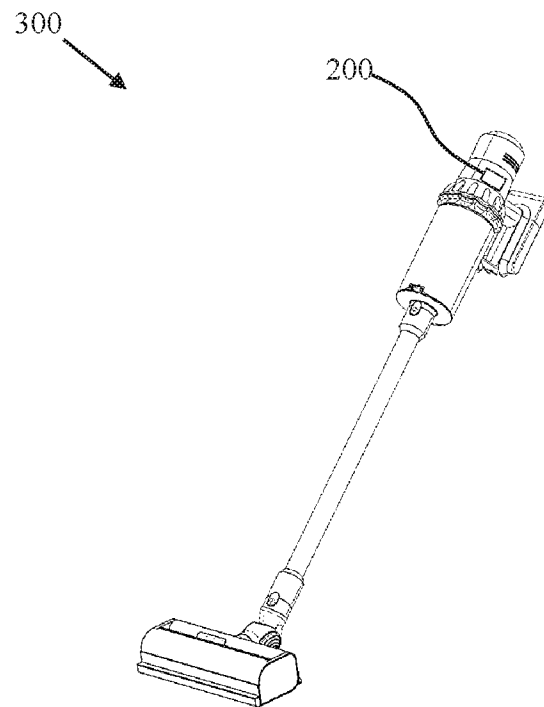


Fig. 13

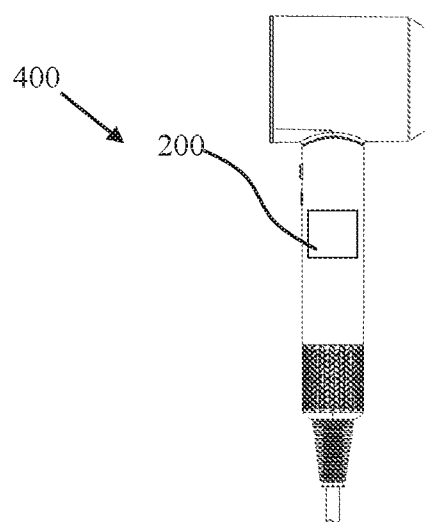


Fig. 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/055437

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02K1/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TW 201 325 028 A (HITACHI IND EQUIPMENT SYS [JP]) 16 June 2013 (2013-06-16) figures 1-5 -----	1 - 25
A	US 2020/052542 A1 (GENTZ MATTHIAS [DE] ET AL) 13 February 2020 (2020-02-13) figure 11 -----	7 - 9
A	JP 2004 088980 A (MITSUI HIGH TEC) 18 March 2004 (2004-03-18) figures 3,7 -----	13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

4 October 2024

Date of mailing of the international search report

14/10/2024

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Authorized officer

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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