

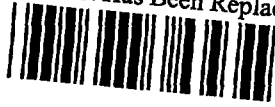
ELECTRIC MOTOR AND STATOR THEREFOR

This invention relates to a stator for electric motors wherein a resinous insulating cover is attached to a stator
5 core and coils are wound on the insulating cover covering the stator core.

A three-phase brushless dc motor includes a stator in which portions of a stator core on which coils are to be wound are covered by a resinous insulating cover and coils
10 constituting respective phases are wound on the insulating cover, for example. In this construction, the insulating cover has a circular groove-like concave portion formed in an end surface thereof. Coils of each phase are constituted by a single magnetic wire. A part of each magnet wire
15 between the coils is referred to as "intercoil wire" throughout the description. Intercoil wires of all the three-phase coils are inserted into the concave portion en bloc. Consequently, there is a possibility of occurrence of dielectric breakdown between the different phases.

20 Therefore, an object of the present invention is to provide a stator for the electric motor wherein an insulation performance can be improved between the intercoil wires of the coils of the different phases, and an electric motor provided with such a stator.

25 The present invention provides a stator for an electric motor comprising a stator core, a resinous insulating cover attached to the stator core so as to cover the stator core, coils of a plurality of phases wound on the insulating cover



attached to the stator core, the coils including intercoil wires respectively, and a plurality of concave portions formed in the insulating cover to extend abreast in a direction of disposition of the intercoil wires so that the
5 intercoil wires of the coils of the different phases are inserted therein respectively, the concave portions including those adjacent to each other and having respective bottoms stepped therebetween.

According to the above-described construction, the
10 intercoil wires of the different coils are inserted into the respective concave portions. The concave portions include those adjacent to each other and having respective bottoms stepped therebetween. Consequently, the intercoil wires are displaced axially with respect to the stator core.
15 Furthermore, the intercoil wires are isolated from one another by side walls of the concave portions. Consequently, the insulation performance between the intercoil wires can be improved to a large extent.

In the above-described construction, the insulating
20 cover preferably has opposite end faces. The intercoil wires of the coils of the plurality of phases are preferably located at both sides of the opposite end faces of the insulating cover. The plurality of concave portions are preferably formed in at least one of the end faces of the
25 insulating cover so that the intercoil wires of the coils of the different phases are inserted therein respectively. Thus, the intercoil wires of the coils of the plurality of phases are dispersed at the opposite end faces of the



insulating cover. Consequently, the insulating cover and accordingly, the stator can be rendered smaller in size as compared with the construction in which the intercoil wires of the plurality of phases are localized upon one of the end
5 faces of the insulating cover.

Each concave portion preferably extends along a circumference of the insulating cover and has a side wall formed with a notch into which the intercoil wire is inserted. Furthermore, at least one of the concave portions
10 preferably has a or the bottom located at approximately the same level as a termination of the wound coil. Consequently, the intercoil wires can easily be inserted into the concave portions when the coils are wound on the stator core. Furthermore, the insulating cover preferably
15 has a plurality of polygonal pillar-shaped or cylindrical terminal insertion sections integrally formed to correspond to positions of a beginning and a termination of each coil of each phase. Each terminal insertion section preferably has a groove into which the beginning or the termination of
20 each coil of each phase is inserted.

The concave portions preferably have respective side walls whose heights are varied stepwise. Furthermore, distances between bottom faces of the respective concave portions and the stator core are preferably decreased
25 gradually from the inner circumferential side toward the outer circumferential side of the stator core. Since the bottom faces of the concave portions are successively lowered, the intercoil wires of the different phases are



prevented from coming into contact with each other at
crossing portions when the coils are disposed along the
bottom faces of the concave portions. Consequently, the
insulation performance between the intercoil wires can
5 further be improved. Furthermore, the insulating cover
preferably includes a plurality of bobbin portions on which
the coils are wound and each bobbin portion has a groove
formed so as to correspond to a beginning of the wound coil
and into which a magnet wire constituting said wound coil
10 is inserted.

The invention will be described, merely by way of
example, with reference to the accompanying drawings, in
which:

FIG. 1 is a partial longitudinal section of a stator of
15 the electric motor of a first embodiment in accordance with
the present invention;

FIG. 2 is a partial longitudinal section of a lower
cover and a stator core of the motor;

FIG. 3 is a partial longitudinal section of an upper
20 cover and the stator core;

FIG. 4 is a partial longitudinal section of the lower
cover and the stator core viewed from a different angle;

FIG. 5 is a partial plan view of the upper cover;

FIG. 6 is a partial plan view of the upper cover
25 showing wound phase W coils;

FIG. 7 is a partial plan view of the upper cover
showing wound phase V coils;

FIG. 8 is a partial plan view of the upper cover



showing wound phase U coils;

FIG. 9 is a perspective view of the stator;

FIG. 10 is a perspective view of the stator viewed from a different angle;

5 FIG. 11 is a perspective view showing crossed portions of intercoil wires of different phase coils;

FIG. 12 is an exploded perspective view of the upper and lower covers and stator core;

10 FIG. 13 is a partial perspective view of the lower cover;

FIG. 14 is a schematic partial longitudinal section of the electric motor;

FIG. 15 is a partial perspective view of the upper cover and stator core of the electric motor of a second
15 embodiment in accordance with the present invention;

FIG. 16 is a partial plan view of the upper cover;

FIG. 17 is a partial bottom view of the lower cover;

FIG. 18 is a partial longitudinal section of the upper cover and stator core;

20 FIG. 19 is a partial longitudinal section of the stator of the electric motor of a third embodiment in accordance with the present invention; and

FIG. 20 is a partial perspective view of the upper cover and stator core.

25 A first embodiment of the present invention will be described with reference to FIGS. 1 to 14. In the embodiment, the present invention is applied to an electric motor for directly driving an agitator and a rotatable tub



of a full automatic washing machine, for example, a three-phase outer rotor type brushless dc motor. Referring first to FIG. 14, the overall construction of the three-phase outer rotor type brushless dc motor 21 is schematically shown. The motor 21 comprises a generally annular stator 22 (see FIG. 9) and a rotor 23 disposed for rotation outside the stator 22 so as to cover the same.

The rotor 23 comprises a generally short cylindrical cup-shaped rotor yoke 24 and a rotor magnet 25 mounted on an inner circumferential surface of the rotor yoke 24 so as to be opposed to an outer circumference of the stator 22. A shaft 26 is fixed to a central bottom wall of the rotor yoke 24. The shaft 26 is rotatably mounted on suitable bearing means (not shown). The stator 22 is mounted on a motor mounting plate 27 of the washing machine by a plurality of screws 28 one of which is shown in FIG. 14.

The construction of the stator 22 will be described in detail. A stator core 1 of the stator 22 comprises a plurality of, for example, three arcuate unit cores combined to one another into the annular shape. Each unit core is formed by stacking laminations of steel sheets. The stator core 1 includes an annular portion 30 and a plurality of teeth 31 radially projecting from an outer circumference of the annular portion 30. The stator core 1 is covered by upper and lower covers 2 and 3 at axially (vertically, in FIG. 12) opposite sides thereof respectively. Each of the upper and lower covers 2 and 3 is made of an electrically non-conductive synthetic resin (insulating resin). These



two covers 2 and 3 constitute an insulating cover in the invention.

The upper cover 2 includes a generally cylindrical wall rib 2a and a plurality of bobbin portions 2b (see FIG. 5) radially projecting from an outer circumferential surface of the wall rib 2a, as shown in FIGS. 1 and 12. The wall rib 2a constitutes an annular portion corresponding to the annular portion 30 of the stator core 1 and the bobbin portions 2b constitute teeth portions corresponding to the respective teeth 31 of the stator core 1. Each bobbin portion 2b has a generally U-shaped section. The teeth 31 of the stator core 1 are covered by the bobbin portions 2b respectively when the upper cover 2 is pushed in at the axial upper side of the stator core 1 to be attached thereto, whereupon an upper half of the stator core 1 is covered by the upper cover 2 except inner and outer circumferential surfaces thereof, as shown in FIG. 6. Reference symbol "1a" designates a plurality of teeth of the stator core 1 on which coils 4 constituting phase U are wound, as shown in FIGS. 1 and 8. Regarding the plurality of teeth 31 of the stator core 1, reference symbol "1b" designates a plurality of teeth of the stator core 1 on which coils 5 constituting phase V are wound, as shown in FIGS. 4 and 7. Reference symbol "1c" designates a plurality of teeth of the stator core 1 on which coils 6 constituting phase W are wound, as shown in FIGS. 2 and 6.

The lower cover 3 also includes a generally cylindrical wall rib 3a and a plurality of bobbin portions 3b radially



projecting from an outer circumferential surface of the wall rib 3a, as shown in FIGS. 1 and 12. The wall rib 3a constitutes an annular portion corresponding to the annular portion 30 of the stator core 1 and the bobbin portions 3b constitute teeth portions corresponding to the respective teeth 31 of the stator core 1. Each bobbin portion 3b has a generally U-shaped section. The lower cover 3 is pushed in at the axial lower side of the stator core 1 to be attached thereto such that the wall rib 3a and bobbin portions 3b of the lower cover 3 are placed opposite the wall rib 2a and bobbin portions 2b of the upper cover 2 respectively and such that the teeth 31 (1a to 1c) of the stator core 1 are covered by the bobbin portions 3b respectively. As a result, a lower half of the stator core 1 is covered by the lower cover 3 except inner and outer circumferential surfaces thereof, as shown in FIG. 10.

The coils 4 constituting phase U are wound on the bobbin portions 2b and 3b of the upper and lower covers 2 and 3 covering the phase U teeth 1a of the stator core 1 respectively, as shown in FIG. 8. These phase U coils 4 are composed of a single magnet wire 4f. More specifically, reference symbol "4s" designates a beginning of the magnet wire 4f. The magnet wire 4f is wound on one of the teeth 1a from the beginning 4s. Upon completion of winding, an intercoil wire 4a is extended in the direction of arrow A in FIG. 8, disposed at an upper end side of the upper cover 2. The magnet wire 4f is then wound on the subsequent tooth 1a located in the direction of arrow A relative to the tooth 1a



on which the magnet wire 4f has been wound. The winding operation is repeated in the same manner as described above so that the magnet wire 4f is wound on all the teeth 1a to constitute the phase U coils 4. Reference symbol "4e" 5 designates a termination of the magnet wire 4f. Regarding each tooth 1a, the magnet wire 4f is wound in the direction of arrow B as shown in FIG. 9.

The coils 5 constituting phase V are wound on the bobbin portions 2b and 3b of the upper and lower covers 2 10 and 3 covering the phase V teeth 1b of the stator core 1 respectively, as shown in FIG. 7. These phase V coils 5 are composed of a single magnet wire 5f. More specifically, reference symbol "5s" designates a beginning of the magnet wire 5f. The magnet wire 5f is wound on one of the teeth 1b 15 from the beginning 5s. Upon completion of winding, an intercoil wire 5a is extended in the direction opposite to arrow A in FIG. 7, disposed at a lower end side of the lower cover 3. The magnet wire 5f is then wound on the subsequent tooth 1b located in the direction opposite to arrow A 20 relative to the tooth 1b on which the magnet wire 5f has been wound. The winding operation is repeated in the same manner as described above so that the magnet wire 5f is wound on all the teeth 1b to constitute the phase V coils 5. Reference symbol "5e" designates a termination of the magnet 25 wire 5f. Regarding each tooth 1b, the magnet wire 5f is wound in the direction opposite to arrow B as shown in FIG. 10.

The coils 6 constituting phase W are wound on the



bobbin portions 2b and 3b of the upper and lower covers 2 and 3 covering the phase W teeth 1c of the stator core 1 respectively, as shown in FIG. 6. These phase W coils 6 are composed of a single magnet wire 6f. More specifically, reference symbol "6s" designates a beginning of the magnet wire 6f. The magnet wire 6f is wound on one of the teeth 1c from the beginning 6s. Upon completion of winding, an intercoil wire 6a is extended in the direction opposite to arrow A in FIG. 6, disposed at a lower end side of the lower cover 3. The magnet wire 6f is then wound on the subsequent tooth 1c located in the direction opposite to arrow A relative to the tooth 1c on which the magnet wire 6f has been wound. The winding operation is repeated in the same manner as described above so that the magnet wire 6f is wound on all the teeth 1c to constitute the phase W coils 6. Reference symbol "6e" designates a termination of the magnet wire 6f. Regarding each tooth 1c, the magnet wire 6f is wound in the direction opposite to arrow B as shown in FIG. 10.

The upper cover 2 has a concave portion 7 formed on an upper end surface thereof to extend along the cylindrical wall rib 2a at an inner circumferential side of the rib, as shown in FIG. 1. The concave portion 7 is defined by the wall rib 2a of the upper cover 2, an annular bottom plate 7a integrally formed on the wall rib 2a and a cylindrical wall rib 7b integrally formed on the bottom plate 7a. An upper surface of the bottom plate 7a is located approximately at the same level as the terminations of the wound phase U



coils 4. An upper end surface of the wall rib 2a is located farther away from the stator core 1 than an upper end surface of the wall rib 7b.

The wall rib 2a has a plurality of upwardly open
5 notches 7c. The notches 7c are disposed to be opposed to the teeth 1a for phase U respectively, as shown in FIG. 9. The intercoil wire 4a of each phase U coil 4 is inserted through the notch 7c into the concave portion 7 and drawn outward or toward the subsequent tooth 1a side through the
10 adjacent notch 7c, held on the bottom plate 7a.

The lower cover 3 has a first concave portion 8 formed to extend along the cylindrical wall rib 3a at an inner circumferential side of the rib, as shown in FIG. 2. The concave portion 8 is defined by the wall rib 3a of the lower
15 cover 3, an annular bottom plate 8a integrally formed on the wall rib 3a and a cylindrical wall rib 8b integrally formed on the bottom plate 8a. An underside surface of the bottom plate 8a is located approximately at the same level as the terminations of the wound phase W coils 6. A lower end
20 surface of the wall rib 3a is located farther away from the stator core 1 than a lower end surface of the wall rib 8b.

The wall rib 3a has a plurality of downwardly open notches 8c. The notches 8c are disposed to be opposed to the teeth 1c for phase W respectively, as shown in FIG. 10.
25 The intercoil wire 6a of each phase W coil 6 is inserted through the notch 8c into the concave portion 8 and drawn outward or toward the subsequent tooth 1c side through the adjacent notch 8c, held on the bottom plate 8a.



The lower cover 3 further has a second concave portion 9 formed at an inner circumferential side of the first concave portion 8 to be juxtaposed therewith on an underside end surface of the lower cover, as shown in FIG. 4. The concave portion 9 is defined by the wall rib 8b of the concave portion 8, an annular bottom plate 9a integrally formed on the wall rib 8b and a cylindrical wall rib 9b integrally formed on the bottom plate 9a. A bottom face of the bottom plate 9a is located farther away from the stator core 1 than that of the bottom plate 8a of the first concave portion 8, and a lower end surface of the wall rib 8b is located farther away from the stator core 1 than a lower end surface of the wall rib 9b.

The wall ribs 3a and 8b are formed with a plurality of downwardly open notches 9c and 9d respectively. These notches 9c and 9d are disposed to correspond to the respective teeth 1b, as shown in FIG. 10. The level of a bottom face of each notch 9c is set to be approximately equal to that of a bottom face of each notch 9d. The bottom faces of the notches 9c and 9d are located farther away from the stator core 1 than that of the bottom plate 8a, as understood from FIG. 4. The intercoil wire 5a of each phase V coil 5 is inserted through the notches 9c and 9d into the concave portion 9 and drawn outward or toward the subsequent tooth 1b side through the adjacent notches 9d and 9c, held on the bottom plate 9a, as shown in FIG. 10.

The upper cover 2 is formed with a horizontal seating face 2c as shown in FIG. 5. The seating face 2c has six



integrally formed hollow rectangular pillar-shaped terminal insertion sections 10 to 15. The terminal insertion sections 10-15 may be cylindrical. The three terminal insertion sections 10, 11 and 12 are disposed to be opposed
5 to the positions of the beginnings 4s, 5s and 6s of the magnet wires 4f, 5f and 6f respectively and to be in the vicinity of the bobbin portions 2b. Upwardly open grooves 10a to 12a are formed on upper end surfaces of inner and outer circumferential side walls of the terminal insertion
10 sections 10-12. The width of each of the grooves 10a-12a is set to be approximately equal to a diameter of each of the magnet wires 4f, 5f and 6f. The beginnings 4s-6s of the magnet wires 4f-6f are inserted into the grooves 10a-12a respectively as shown in FIGS. 6-8.

15 The other three terminal insertion sections 13, 14 and 15 are disposed to be opposed to the positions of the terminations 4e, 5e and 6e of the magnet wires 4f, 5f and 6f respectively. Upwardly open grooves 13a, 14a and 15a are formed in upper end surfaces of inner and outer
20 circumferential side walls of the terminal insertion sections 13-15. The width of each of the grooves 13a-15a is set to be approximately equal to the diameter of each of the magnet wires 4f, 5f and 6f. The terminations 4e-6e of the magnet wires 4f-6f are inserted into the grooves 13a-15a
25 respectively as shown in FIGS. 6-8.

External connecting terminals (not shown) are inserted into the terminal insertion sections 10-12, and common connecting terminals (not shown) are inserted in the



terminal insertion sections 13-15, respectively. Each of these connecting terminals comprises a poke-in terminal, for example. The connecting terminals break through an insulating coating of the magnet wires 4f, 5f and 6f to be
5 electrically connected to core wires thereof when the external and common connecting terminals are inserted into the terminal insertion sections 10-12 and 13-15, respectively.

The procedure for assembly of the stator 22 will now be
10 described. First, the upper and lower covers 2 and 3 are fitted with the stator core 1 from the axially opposite sides thereof to be attached thereto, respectively, as shown in FIG. 14. The phase U coils 4 are then wound. More specifically, the beginning 4s of the magnet wire 4f is
15 pushed into the grooves 12a of the terminal insertion section 12, and the external connecting terminal is inserted into the terminal insertion section 12, as shown in FIG. 8. Consequently, the beginning 4s of the magnet wire 4f is held by the external connecting terminal.
20 Subsequently, the magnet wire 4f is wound on the initial tooth 1a so that the phase U coil 4 is constituted. The winding of the magnet wire 4f is carried out by an automatic winding machine (not shown).

The winding machine is moved in the direction of arrow
25 A in FIGS. 8 and 9 when the magnet wire 4f is wound up on the initial tooth 1a to constitute the phase U coil 4. The magnet wire 4f is wound on the subsequent tooth 1a to constitute the phase U coil 4 after the intercoil wire 4a



has been inserted into the concave portion 7, hung on the wall rib 2a. The above-described operation is repeated so that the magnet wire 4f is successively wound on the plurality of teeth 1a to constitute the phase U coils 4.

5 Upon completion of the winding of the magnet wire 4f on the last tooth 1a, the termination 4e of the magnet wire 4f is inserted into the grooves 13a of the terminal insertion section 13 and then, the common connecting terminal is inserted into the terminal insertion section 13 so that the

10 termination 4e is held by the common connecting terminal. The constitution of the phase U coils 4 is completed.

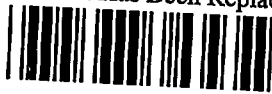
The phase W coils 6 are subsequently wound. More specifically, the beginning 6s of the magnet wire 6f is pushed into the grooves 10a of the terminal insertion

15 section 10, and the external connecting terminal is inserted into the terminal insertion section 10, as shown in FIG. 6. Consequently, the beginning 6s of the magnet wire 6f is held by the external connecting terminal. Subsequently, the magnet wire 6f is wound on the initial

20 tooth 1c so that the phase W coil 6 is constituted.

The winding machine is moved in the direction opposite to arrow A in FIGS. 6 and 10 when the magnet wire 6f is wound up on the initial tooth 1a to constitute the phase U coil 6. The magnet wire 6f is wound on the subsequent tooth

25 1c to constitute the phase U coil 6 after the intercoil wire 6a has been inserted into the concave portion 7, hung on the wall rib 3a. The above-described operation is repeated so that the magnet wire 6f is successively wound on the



plurality of teeth 1c to constitute the phase W coils 6. Upon completion of the winding of the magnet wire 6f on the last tooth 1c, the termination 6e of the magnet wire 6f is inserted into the grooves 14a of the terminal insertion
5 section 14 and then, the common connecting terminal is inserted into the terminal insertion section 14 so that the termination 6e is held by the common connecting terminal. The constitution of the phase W coils 6 is completed.

The phase V coils 5 are wound upon completion of the
10 constitution of the phase V coils 6. The beginning 5s of the magnet wire 5f is pushed into the grooves 11a of the terminal insertion section 11, and the external connecting terminal is inserted into the terminal insertion section 11, as shown in FIG. 7. Consequently, the beginning 5s of
15 the magnet wire 5f is held by the external connecting terminal. Subsequently, the magnet wire 5f is wound on the initial tooth 1b so that the phase V coil 5 is constituted.

The winding machine is moved in the direction opposite to arrow A in FIGS. 7 and 10 when the magnet wire 5f is
20 wound up on the initial tooth 1b to constitute the phase V coil 5. The magnet wire 5f is wound on the subsequent tooth 1b to constitute the phase V coil 5 after the intercoil wire 5a has been inserted into the concave portion 8, hung on the wall rib 3a. The above-described operation is repeated so
25 that the magnet wire 5f is successively wound on the plurality of teeth 1b to constitute the phase V coils 5. Upon completion of the winding of the magnet wire 5f on the last tooth 1b, the termination 5e of the magnet wire 5f is



inserted into the grooves 15a of the terminal insertion section 15 and then, the common connecting terminal is inserted into the terminal insertion section 15 so that the termination 5e is held by the common connecting terminal.

5 The constitution of the phase V coils 5 is completed.

According to the above-described embodiment, the concave portions 8 and 9 are disposed abreast on the lower end surface of the lower cover 3. The intercoil wire 5a of the phase V coils 5 is inserted in the concave portion 9,
10 and the intercoil wire 6a of the phase W coils 6 is inserted in the concave portion 8. Since the intercoil wires 5a and 6a are displaced axially with respect to the stator core 1 and isolated from each other by the wall rib 8a, the insulation performance between the intercoil wires 5a and 6a
15 of the coils 5 and 6 constituting the different phases can be improved. Consequently, the dielectric breakdown can reliably be prevented between the intercoil wires 5a and 6a.

Three concave portions need to be formed abreast on the end face of either one of the upper and lower covers 2 and 3
20 when the intercoil wires 4a, 5a and 6a of the three-phase coils 4, 5 and 6 are concentrated on either the upper or lower cover side. This construction results in large-sized upper and lower covers. In the foregoing embodiment, however, the intercoil wires 4a of the phase U coils 4 are
25 disposed at the upper cover 3 side and the intercoil wires 5a and 6a of the phase V and W coils 5 and 6 are disposed at the lower cover 3 side. Consequently, since the three concave portions need not be formed abreast, the covers 2



and 3 can be prevented from being rendered large-sized.

The circumferential concave portions 7, 8 and 9 are provided in the above-described embodiment. The notches 7c are formed in the wall rib 2a defining the concave portion 7. The notches 8c are formed in the wall rib 3a defining the concave portion 8. The notches 9d are formed in the wall rib 8b defining the concave portion 9. Since the intercoil wires 4a, 6a and 5a of the coils 4, 6 and 5 are circumferentially drawn along the concave portions 7, 8 and 9 respectively, the length of each of the intercoil wires 4a, 5a and 6a is reduced, and the length of each of the magnet wires 4f, 5f and 6f of coils 4, 5 and 6 is also reduced. Consequently, the resistance of each magnet wire is lowered and accordingly, the electric characteristics of the motor can be improved.

The bottom plates 7a and 8a of the concave portions 7 and 8 are located approximately at the same levels as the terminations of the phase U and W coils 4 and 6 wound respectively. Accordingly, the intercoil wires 4a and 6a of the phase U and W coils 4 and 6 are easily inserted into the concave portions 7 and 8 respectively. Consequently, since the assembly efficiency and the process efficiency are improved, a shortening of lead time, an improvement in the product quality and a reduction in the production cost can be achieved.

The terminal insertion sections 10 to 15 are provided on the upper cover 2. The connecting terminals are inserted in the terminal insertion sections 10 to 15 after the



beginnings 4s, 5s and 6s and terminations 4e, 5e and 6e of the magnet wires 4f, 5f and 6f constituting the three-phase coils 4, 5 and 6 have been inserted in the grooves 10a to 15a of the terminal insertion sections 10 to 15, respectively. Since the beginnings 4s, 5s and 6s and terminations 4e, 5e and 6e of the magnet wires 4f, 5f and 6f are easily connected and held in this construction, the assembly efficiency and the process efficiency can further be improved.

10 The terminal insertion sections 10 to 15 are disposed to correspond to the beginnings 4s, 5s and 6s and terminations 4e, 5e and 6e of the magnet wires 4f, 5f and 6f respectively. Since the beginnings 4s to 6s and terminations 4e to 6e of the magnet wires 4f to 6f are
15 easily inserted into the grooves 10a to 15a of the terminal insertion sections 10 to 15 respectively, the ends of the magnet wires 4f to 6f can further easily be treated. Furthermore, the terminal insertion sections 10 to 15 are formed integrally on the upper cover 2. This construction
20 reduces the number of parts and the number of assembly steps as compared with the case where separate terminal insertion sections are mounted on the upper cover. Consequently, the production cost can further be decreased.

 The heights of the wall ribs 3a and 8b of the
25 respective concave portions 8 and 9 are varied stepwise in the foregoing embodiment. Accordingly, the winding machine is moved in the winding of the magnet wires 5f and 6f constituting the phase V and W coils 5 and 6 so that the



intercoil wires 5a and 6a are inserted into the concave portions 9 and 8, hung on the wall ribs 8b and 3a, respectively. Consequently, since the intercoil wires 5a and 6a can easily be inserted in the respective concave portions 9 and 8, a further shortening of lead time, a further improvement in the product quality and a further reduction in the production cost can be achieved.

The bottom of the concave portion 9 is located farther away from the stator core 1 than that of the concave portion 8. Since the concave portions 8 and 9 are thus stepped axially with respect to the stator core 1, the intercoil wires 5a and 6a can reliably be prevented from contacting in their crossing portions when disposed along the bottom faces of the concave portions 9 and 8 respectively. Consequently, the insulation performance between the intercoil wires 5a and 6a can further be improved and the dielectric breakdown can reliably be prevented.

The bottom face of each notch 9c is located farther away from the stator core 1 than that of the bottom plate 8a of the concave portion 8. Since the intercoil wires 5a of the phase V coils 5 are positioned by the bottom faces of the notches 9c, the intercoil wires 5a can further reliably be prevented from contacting with the intercoil wires 6a.

FIGS. 15 to 18 illustrate a second embodiment of the present invention. The identical parts are labeled by the same reference symbols in the second embodiment as in the first embodiment. Referring first to FIG. 18, the bottom plate 7a of the upper cover 2 has a plurality of grooves 7d



into which the intercoil wires 4a of the phase U coils 4 are inserted. Only one of such grooves 7d is shown. Each of the wall ribs 2a and 3a of the upper and lower covers 2 and 3 has a plurality of grooves 7e formed in the outer circumferential surface thereof to extend axially with respect to the stator core 1. Only one of the grooves 7e is shown in FIG. 16. Each groove 7e is disposed in the vicinity of a proximal end of the corresponding tooth 1a as shown in FIG. 15. Each intercoil wire 4a of the phase U coils 4 is inserted into the groove 7d of the concave portion 7 and then drawn out of the groove 7d to be inserted into the groove 7e so that the magnet wire 4f is wound on the subsequent tooth 1a.

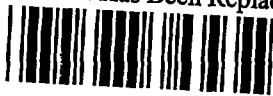
The bottom plate 8a of the lower cover 3 has a plurality of grooves 8d only one of which is shown in FIG. 17. The bottom plate 9a of the concave portion 9 also has a plurality of grooves 9e only one of which is shown in FIG. 17. The intercoil wires 5a and 6a of the phase V and W coils 5 and 6 are inserted in the grooves 9e and 8d.

Furthermore, each of the wall ribs 3a and 2a of the lower and upper covers 3 and 2 has a plurality of grooves 8e formed in the outer circumferential surface thereof to extend axially with respect to the stator core 1. Only one of the grooves 8e is shown in FIG. 17. Each groove 8e is disposed in the vicinity of a proximal end of the corresponding tooth 1c. Each intercoil wire 6a of the phase W coils 6 is inserted into the groove 8d of the concave portion 8 and then drawn out of the groove 8d to be inserted



into the groove 8e such that the magnet wire 6f is wound on the subsequent tooth 1c. Each of the wall ribs 3a and 2a of the lower and upper covers 3 and 2 further has a plurality of grooves 9f formed in the outer circumferential surface thereof to extend axially with respect to the stator core 1. Only one of the grooves 9f is shown in FIG. 17. Each groove 9f is disposed in the vicinity of a proximal end of the corresponding tooth 1b. Each intercoil wire 5a of the phase V coils 5 is inserted into the groove 9e of the concave portion 9 and then drawn out of the notches 9d and 9c to be inserted into the groove 9f so that the magnet wire 4f is wound on the subsequent tooth 1b.

Each of the grooves 7d, 8d and 9e has a depth set in a range of about one fifth to two thirds of a diameter of each of the magnet wires 4f, 5f and 6f. Each of the grooves 7e, 8e and 9f has a depth set at about one half of the diameter of each magnet wire. The other construction of the motor in the second embodiment is the same as in the first embodiment. Accordingly, the same effects are achieved in the second embodiment as in the first embodiment. In the second embodiment, particularly, the grooves 7d, 8d and 9e are formed in the bottom plates 7a, 8a and 9a of the concave portions 7, 8 and 9 respectively. The intercoil wires 4a, 5a and 6a are inserted in these grooves 7d, 8d and 9e respectively. Since the intercoil wires 4a, 5a and 6a are positioned and guided by the grooves 7d, 8d and 9e respectively, the length of each intercoil wire can be rendered minimum. Consequently, the resistance of each



magnet wire is lowered and accordingly, the electric characteristics of the motor can further be improved. Furthermore, since the length of each magnet wire can be uniformed or equalized, the resistance of the magnet wires 4f, 5f and 6f can be maintained at a constant value. This results in further improvement in the motor electric characteristics and the coils 4 to 6 can reliably be prevented from loosening.

The grooves 7e are formed in the upper cover 2 and the grooves 8e and 9f are formed in the lower cover 3. Parts of the magnet wires 4f to 6f corresponding to first turns of the respective phase coils 4 to 6 are inserted in the grooves 7e, 8e and 9f respectively. In this construction, since the parts of the magnet wires from which the wires are wound are positioned, a normal or regular winding of the magnet wires 4f to 6f can easily be carried out. Consequently, a further shortening of lead time, a further improvement in the product quality and a further reduction in the production cost can be achieved and the coils 4 to 6 can reliably be prevented from loosening.

FIGS. 19 and 20 illustrate a third embodiment of the invention. The identical parts are labeled by the same reference symbols in the third embodiment as in the first embodiment. Referring first to FIG. 19, each bobbin portion 2b of the upper cover 2 has a groove 2c formed in an upper face of a proximal end thereof. Each bobbin portion 3b of the lower cover 3 also has a groove 3c formed in an upper face of a proximal end thereof. Each of the grooves 2c and



3c has a depth set at one half of the diameter of each magnet wire. The other construction of the motor in the third embodiment is the same as in the first embodiment. Accordingly, the same effects are achieved in the third
5 embodiment as in the first embodiment. In the third embodiment, particularly, a part of each magnet wire serving as a first turn is inserted in the grooves 2c and 3c. Parts of each magnet wire serving as an upper stage are wound so as to be caused to fall between the parts of each magnet
10 serving as a lower stage (regular or normal tight winding). Thus, since the first turn of each coil is positioned, each magnet wire can easily be wound into the regular winding. Consequently, the motor electric characteristics can be stabilized and the product quality can be improved.

15 In the third embodiment, each of the bobbin portions 2b and 3b has the single groove 2c or 3c formed in the end thereof at the side where the winding of the magnet wire is initiated. However, two or more such grooves may be formed abreast in the entire area of each bobbin portion, instead.

20 In the first to third embodiments, the magnet wires are wound so that the phase U, W and V coils 4, 6 and 5 are constituted in this order. However, the magnet wires may be wound so that the phase W, V and U coils 6, 5 and 4 are constituted in this order. What is essential is that the
25 magnet wires needs to be wound so that the phase W coil 6 is constituted prior to the phase V coil 5. Furthermore, the lower cover 3 has the three wall ribs 9b, 8b and 3a in the foregoing embodiments. The wall rib 3a located at the outer



circumferential side extends from the stator core 1 farther than the wall rib 8b located between the wall ribs 9b and 3a. The wall rib 8b extends from the stator core 1 farther than the wall rib 9b located at the inner circumferential side. However, the inside wall rib 9b may extend farther than the wall rib 8b, and the wall rib 8b may extend farther than the outside wall rib 3a, instead. Furthermore, the upper cover 2 has the two wall ribs 7b and 2a in the foregoing embodiments. The wall rib 2a located at the outer circumferential side extends from the stator core 1 farther than the wall rib 7b. However, the wall rib 7b may extend farther than the wall rib 2a, instead. Additionally, the present invention is applied to the outer rotor type brushless dc motor in the foregoing embodiments. The invention may be applied to inner rotor type brushless dc motors having a rotor disposed inside a stator.

The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the invention as defined by the appended claims.



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WE CLAIM:

1. A stator for an electric motor comprising:
a stator core;
5 a resinous insulating cover attached to the stator core
so as to cover the stator core;
coils of a plurality of phases wound on the insulating
cover attached to the stator core, the coils including
intercoil wires respectively; and
10 a plurality of concave portions formed in the
insulating cover to extend abreast in a direction of
disposition of the intercoil wires so that the intercoil
wires of the coils of the different phases are inserted
therein respectively, the concave portions including those
15 adjacent to each other and having respective bottoms stepped
therebetween.

2. A stator according to claim 1, wherein the
insulating cover has opposite end faces, wherein the
20 intercoil wires of the coils of the plurality of phases are
located at both sides of the opposite end faces of the
insulating cover, and wherein the plurality of concave
portions are formed in at least one of the end faces of the
insulating cover so that the intercoil wires of the coils of
25 the different phases are inserted therein respectively.

3. A stator according to claim 1, wherein each concave
portion extends along a circumference of the insulating

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cover and has a side wall formed with a notch into which the intercoil wire is inserted.

4. A stator according to claim 1, wherein at least one
5 of the concave portions has a or the bottom located at approximately the same level as a termination of the wound coil.

5. A stator according to claim 1, wherein the
10 insulating cover has a plurality of polygonal pillar-shaped or cylindrical terminal insertion sections integrally formed to correspond to positions of a beginning and a termination of each coil of each phase and each terminal insertion
15 section has a groove into which the beginning or the termination of each coil of each phase is inserted.

6. A stator according to claim 1, wherein the concave portions have respective side walls whose heights are varied stepwise.

20

7. A stator according to claim 1, wherein distances between bottom faces of the respective concave portions and the stator core are gradually decreased from the inner circumferential side toward the outer circumferential side
25 of the stator core.

8. A stator according to claim 1, wherein the insulating cover includes a plurality of bobbin portions on





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which the coils are wound and each bobbin portion has a groove formed so as to correspond to a beginning of the wound coil and into which a magnet wire constituting said wound coil is inserted.

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9. A stator according to claim 1, wherein the stator core includes an annular portion and a plurality of teeth radially projecting from an outer or inner circumference of the annular portion, wherein the insulating cover comprises
10 two covers covering the stator core at axially opposite sides thereof, wherein each of the two covers includes an annular portion corresponding to the annular portion of the stator core and a plurality of teeth portions corresponding to the teeth of the stator core, and wherein the concave
15 portions are formed on end faces of the annular portions of the covers.

10. An electric motor comprising:

a stator including a stator core, a resinous insulating
20 cover attached to the stator core so as to cover the latter, coils of a plurality of phases wound on the insulating cover attached to the stator core, the coils including intercoil wires respectively, and a plurality of concave portions formed in the insulating cover to extend abreast in a
25 direction of disposition of the intercoil wires so that the intercoil wires of the coils of the different phases are inserted therein respectively, the concave portions including those adjacent to each other and having respective

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bottoms stepped therebetween; and

a rotor rotatable relative to the stator and including a permanent magnet.

5 11. An electric motor according to claim 10, wherein:
the stator core includes an annular portion and a plurality
of teeth radially projecting from an outer circumference of
the annular portion;

the insulating cover includes two covers covering the
10 stator core at axially opposite sides thereof;

each of the covers includes an annular portion
corresponding to the annular portion of the stator core and
a plurality of teeth portions corresponding to the teeth of
the stator core respectively;

15 the coils of the plurality of phases comprise three-
phase coils;

two of the concave portions into which the intercoil
wires of the coils constituting two of the three phases are
inserted are formed on an axial end face of the annular
20 portion of one of the covers, and the intercoil wires of the
coils constituting the other phase are disposed on an axial
end face of the annular portion of the other cover; and

the rotor comprises an outer rotor disposed in opposite
relation to an outer circumference of the stator.

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