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(51) INT CL⁴
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(56) Documents cited
GB 1079815 EP A 0114260

(58) Field of search
B3A
H2A
Selected US specifications from IPC sub-class H02K

(54) Alternator stator with inserted windings

(57) The stator includes a core 2 having a plurality of slots formed in its inner periphery; a stator winding 7 partially inserted in each of said slots of said stator core; and an electrically insulating material inserted between said stator winding and the surface of said stator core opposing said stator winding, wherein said slots formed in said stator core have a substantially rectangular cross-sectional form and the portions of said stator winding to be inserted into said slots also have a substantially rectangular cross-sectional form, with the other portions 7b having a circular cross-sectional form. The rectangular cross-section of the winding portions is achieved before insertion in the slots by a hydraulic presser plate 15. The winding conductor initially may be of hollow cross-section.

FIG. 4

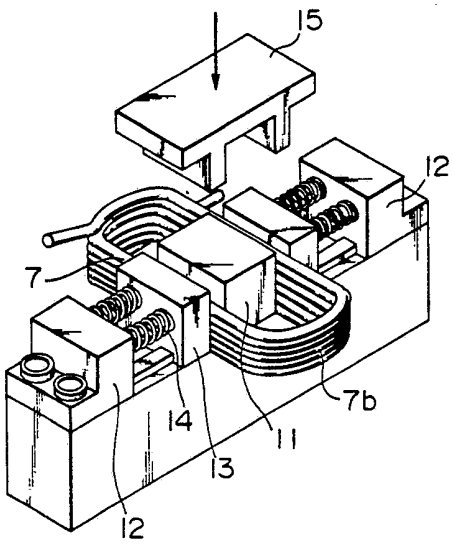

FIG. 7B

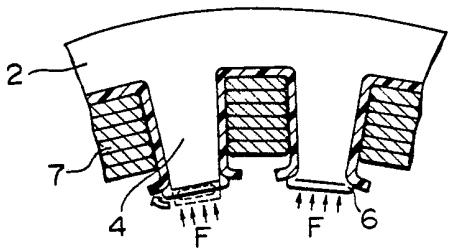

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FIG. 1

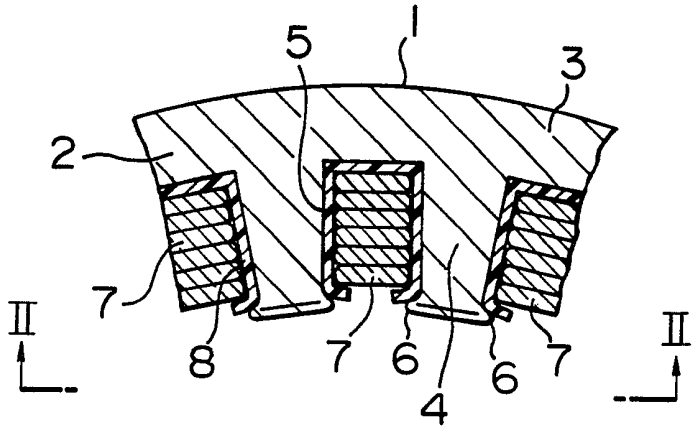

FIG. 2

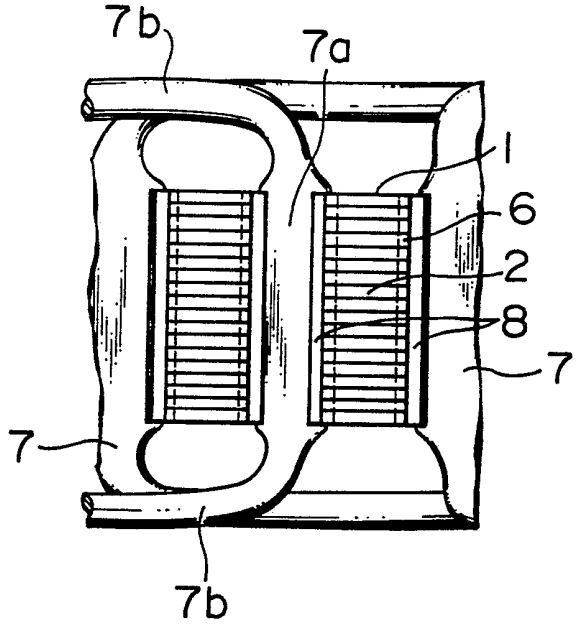

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FIG. 3

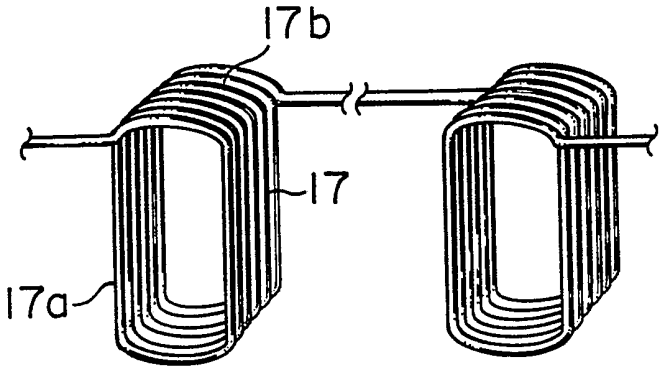

FIG. 4

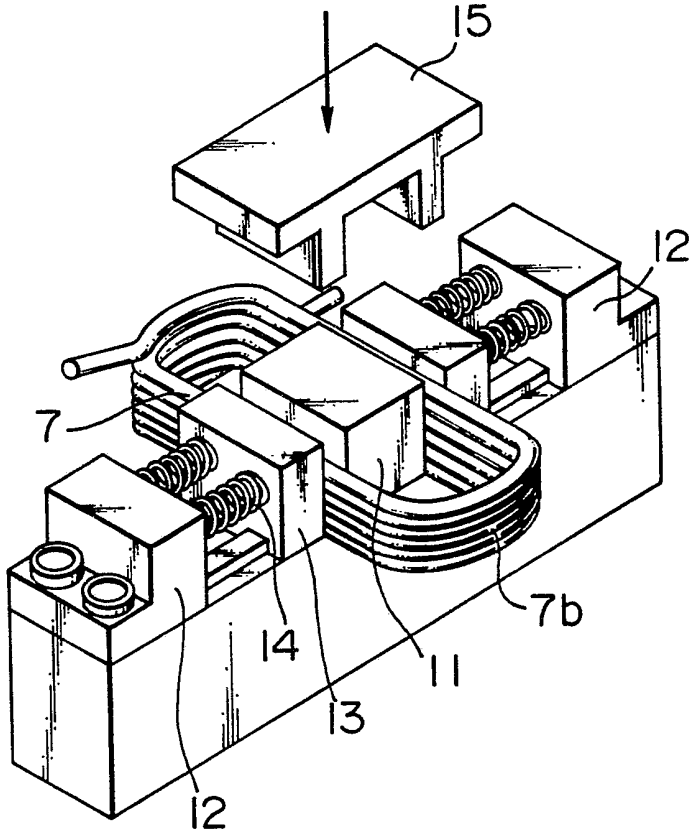

FIG. 5

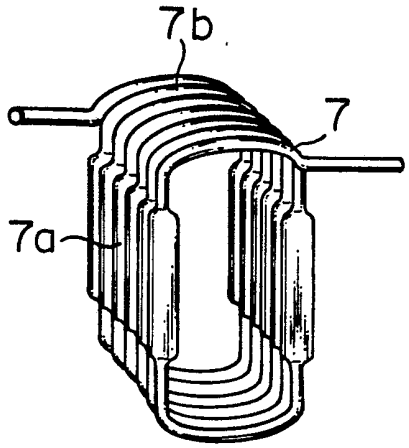

FIG. 6

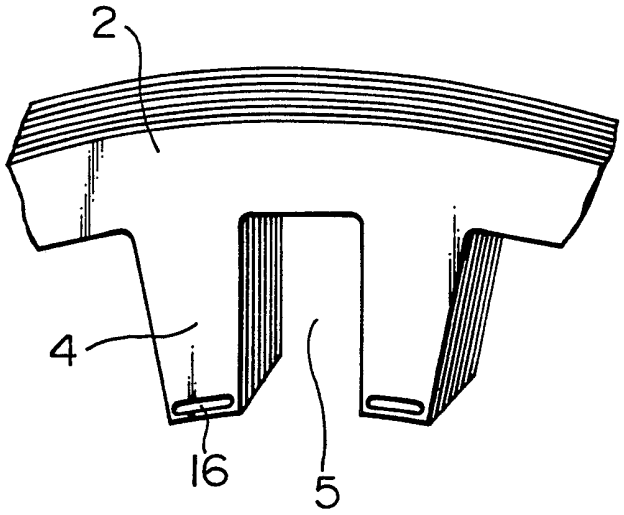

FIG. 7A

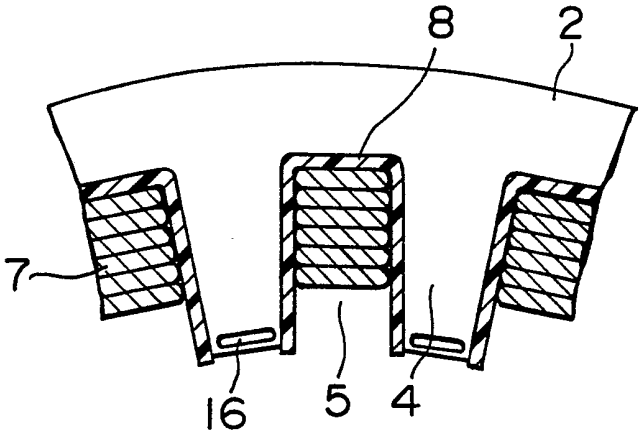

FIG. 7B

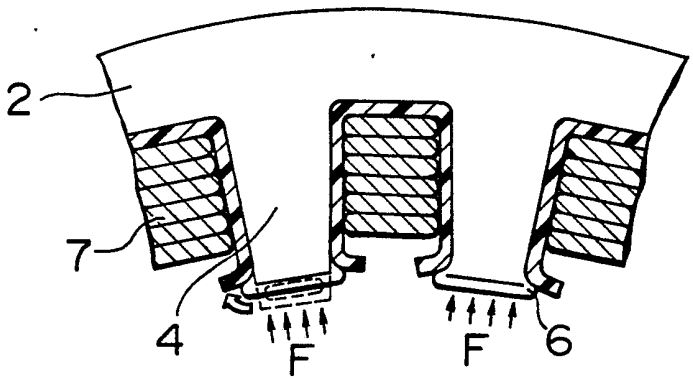

FIG. 8A

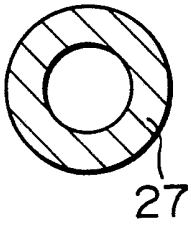

FIG. 8B

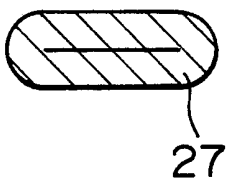

FIG. 9

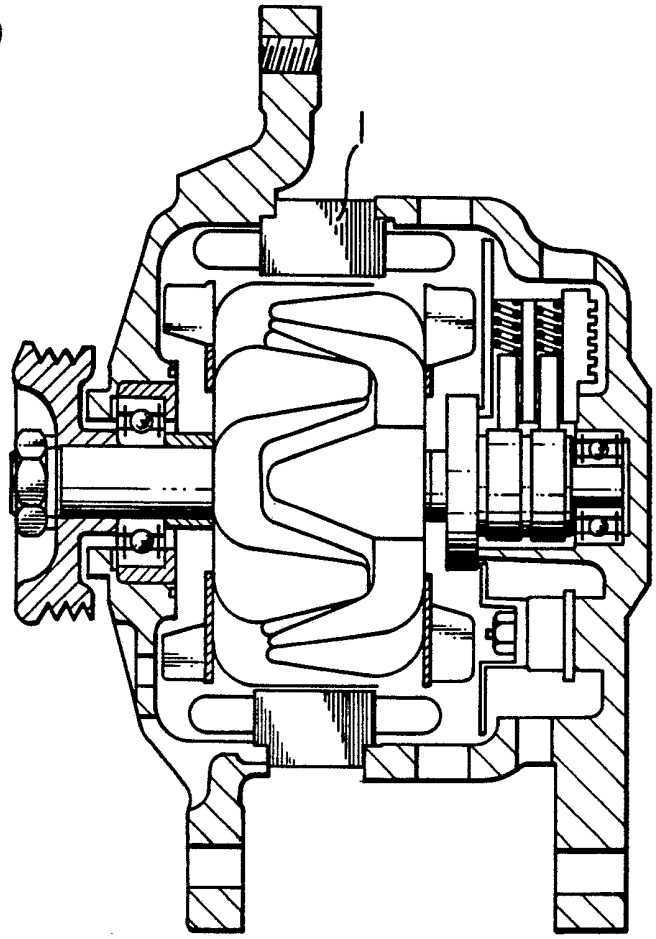
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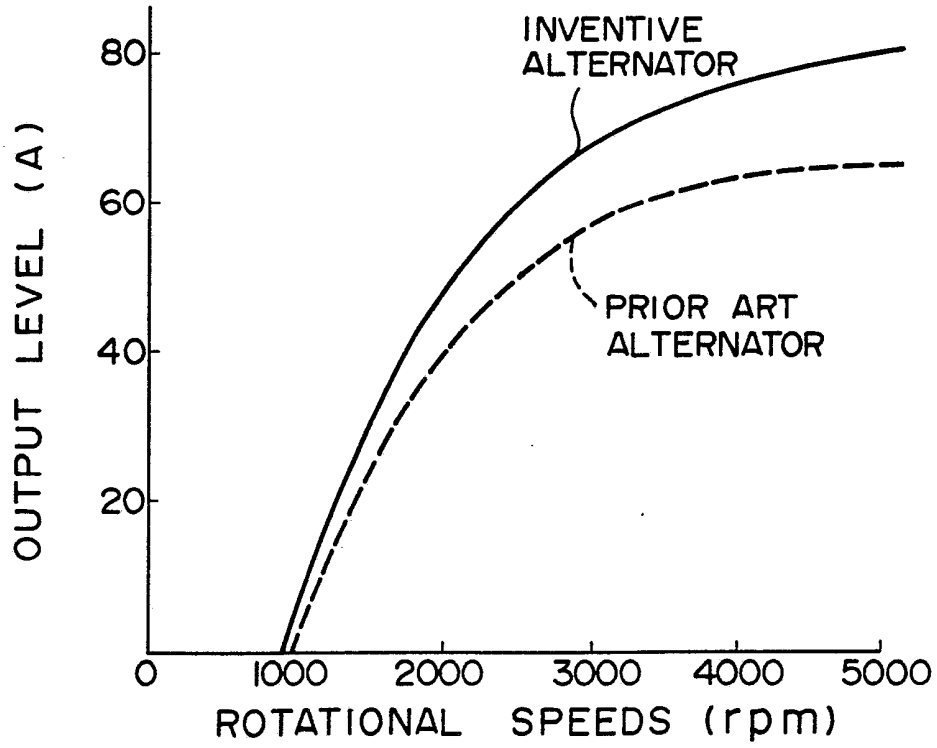
FIG. 10


INVENTIVE ALTERNATOR
PRIOR ART ALTERNATOR
OUTPUT LEVEL (A)
80
60
40
20
0
1000
2000
3000
4000
5000
ROTATIONAL SPEEDS (rpm)

STATOR FOR USE IN ALTERNATOR FOR VEHICLE AND METHOD OF PRODUCING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to alternators and, in particular, to a stator which is suitable for use in an alternator for a vehicle or the like and which is capable of being reducted in size and of providing an increase in output, as well as to a method of producing the same.

2. Description of the Related Art

In such a stator for use in an alternator for a vehicle, a solid electric wire having a circular cross section as disclosed, for example, in Japanese Patent Laid-open No. 55-79660 is fitted into slots formed in the stator while retaining its cross-sectional form, extensions formed along circumferentially opposing edges of the end of each toothed portion of a stator core are folded to form partially closed apertures for the slots.

As disclosed in Japanese Patent Laid-open No. 55-94567, a similar solid electric wire having a circular cross section is fitted into slots formed in the stator and in turn the wire or winding is pressed in the direction of the depth of the slots in order to improve the ratio of the area occupied by the winding to that of the slot (hereinafter referred to as "space factor"). Finally, opposing edges of the ends of the

toothed portions of the stator core are circumferentially extended to form partially closed apertures for the slots.

In the above-described related arts, however, since the solid electric wire or winding having a circular cross section is fitted into the slots without having its cross-sectional form changed, the above space factor cannot be improved owing to the fact that spaces are necessarily formed between successive turnes of the winding. This makes it difficult to improve the level of output of the alternator. In the type in which pressure is applied to the solid electric wire or winding of circular cross section which has been fitted into the slots, the turns of the winding within the slots may partially cross each other, so that it might become impossible to maintain the proper arrangement of the turns of the winding. As a result, while the winding is being pressed, the electrically insulating film coated over the surface of the winding may be damaged and, hence, the windings might be short-circuited. Accordingly, adoption of such a method results in an increased proportion of defects occurring during a mass-production process and, hence, a lowering in productivity.

It is widely known that large electric rotary machines in particular employ a flat rectangular wire in place of a round wire. However, if such flat rectangular wire is used, as it is, in small alternators

or the like to which the present invention pertains, the following disadvantages will result. In general, before being fitted into the slots, the winding needs to be formed into a predetermined shape. However, in a mass-production process for producing a large volume of windings in a short period of time by means of winding machines, use of this type of flat rectangular wire is not suitable, since such wire is inferior in workability as compared with the round wire because of the presence of curvature or twisting at its end coil portions.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a structure for a stator suitable for use in an alternator for a vehicle and a method of producing such a stator in which the space factor of a winding is greatly improved to increase the level of output of the alternator; in which the winding coating is in no way damaged during assembly; and which is superior in productivity.

The above object is achieved by providing a stator suitable for use in an alternator for a vehicle comprising a stator core having a plurality of slots formed in its inner periphery; a stator winding partially inserted in each of the slots of the stator core; and an electrically insulating material inserted between the stator winding and the surface of the stator core

opposing the stator winding, wherein the slots formed in the stator core have a substantially rectangular form in cross section and the portions of the stator winding to be inserted into the slots also have a substantially rectangular form in cross section, with the other portion having a circular cross-sectional form.

In accordance with the present invention, part of the winding fitted into the slots of the stator is so formed that the portions of the winding inserted into the slots are provided with a substantially rectangular cross-sectional shape by the application of pressure, whereby the space factor of the winding within the slots is greatly improved. In addition, since the winding is made from winding material having at least a circular cross-sectional form, it is possible to eliminate various disadvantages which might have heretofore been involved in winding formation.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross section of a portion of a stator for use in an alternator for a vehicle in accordance with the present invention;

Fig. 2 is a view taken in the direction indicated by an arrow II of Fig. 1;

Figs. 3 through 5 are diagrammatic views illustrating the formation of stator winding for the stator incorporated in an alternator for a vehicle in accordance with the present invention;

Fig. 3 illustrates the wound state of winding material to which the invention pertains;

Fig. 4 is a diagrammatic perspective view illustrating the process of pressing the winding material shown in Fig. 3 by means of a pressure former;

Fig. 5 is a diagrammatic perspective view illustrating a stator winding which is formed in accordance with the present invention;

Fig. 6 is a diagrammatic perspective view of a stator core of an alternator for a vehicle in accordance with the present invention, and illustrates a state wherein extensions serving as magnetic flux collecting portions have not yet been formed;

Figs. 7A and 7B are schematic views illustrating a method of producing the magnetic flux collecting portions of the stator for an alternator for a vehicle in accordance with the present invention, with Fig. 7A showing a state wherein a stator winding is fitted into the slots of the stator while Fig. 7B showing a state wherein the end surface of each toothed portion of the stator core is formed under pressure;

Figs. 8A and 8B are cross sections of another example of the stator winding of the stator of an alternator for a vehicle in accordance with the present invention, with Fig. 8A being a cross section of a hollow conductor wire while Fig. 8B shows the hollow conductor wire which is formed under pressure in a substantially rectangular cross section.

Fig. 9 is a diagrammatic cross section of an alternator for a vehicle which incorporates the stator of the invention;

Fig. 10 is a characteristic chart illustrating a comparison between the output characteristic of the alternator for a vehicle which incorporates a stator of the invention and the output characteristic of a conventional type of vehicle alternators.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A stator suitable for use in an alternator for a vehicle in accordance with the present invention and a method of producing the same will be described below in conjunction with an illustrated preferred embodiment. In the drawings, like reference numerals are used to identify like or corresponding elements.

Fig. 1 illustrates in cross section a portion of the armature of an alternator for a vehicle, that is, a stator 1. The stator 1 has a stator core 2 composed of laminated steel plates each having a predetermined stamped form. The stator core 2 has a cylindrical portion 3 and a plurality of toothed portions 4 each of which projects radially inward of the cylindrical portion 3, and each slot 5 is defined between adjacent toothed portions 4. The slot 5 has a rectangular cross section. In the present embodiment, the stator 1 which is suitable for use in an alternator for a vehicle has twelve slots formed in

the cylindrical portion 3 of the stator core 2 on the side of its inner periphery. In Fig. 1, only three of these slots are shown, by way of example. A pair of extensions 6, which are elongated circumferentially in opposite directions, are formed on the circumferentially opposing edges of the inner end of each of the toothed portions 4. Each of the extensions 6 serves to collect magnetic flux and to define the partially closed aperture of the slot 5 for the purpose of preventing projection of a winding which will be described in detail later.

In the present embodiment, a stator winding 7 composed of six turns is inserted in each of the slots 5 of the stator 1. As a matter of course, this stator winding is wound so that three-phase output may be provided in a similar manner to that of prior art vehicle alternators. An electrically insulating sheet 8, such as "Nomex", having a high degree of heat resistance is interposed between the stator core 2 and the stator winding 7. Thus electrical insulation is positively provided between the stator core 2 and the stator winding 7.

Fig. 2 is a plan view of the alternator stator 1 shown in Fig. 1, taken in the direction indicated by an arrow II of Fig. 2. As clearly shown in Fig. 2, the stator winding 7 accommodated in the slot 5 of the stator core 2 has a portion 7a and coil end portions 7b. The portion 7a is inserted in the slot 5 and has a flat or

rectangular cross section. The remaining portions or coil end portions 7b have a circular cross-sectional form. As can be seen from the foregoing, since each of the slots 5 having a substantially rectangular form in cross section receives the winding which has a similarly rectangular form in cross section, the space factor of the winding within the stator slot 5 is improved.

A method of producing the above-described stator winding 7 will now be described.

As shown in Fig. 3, a solid electric-wire material 17 having a circular cross section is wound several times, e.g., six times, into a substantially rectangular form, thereby preparing a winding having a predetermined form. In the illustrated example, the winding material 17 is wound into a substantially rectangular form and coil end portions 17b are shaped in an arc. Therefore, when the winding is inserted into the slot 5 of the stator core 2, the coil end portion 17b is adapted to be easily worked. Also, since electric-wire material having a circular cross sectional form is used, no deterioration in workability occurs due to twisting of the electric wire in contrast to the case in which the aforesaid winding is formed from a so-called rectangular wire. It is therefore unnecessary to take account of twisting of electric wires. Accordingly, it is evident that the present winding material is suitable for use in a mass-production process because

of the superior workability.

After the stator winding material 17 has been shaped into a predetermined form in the above-described manner, its portion 17a thereof which is to be inserted into the slot 5 is shaped in a flat form by a pressure former 9. The pressure former 9 has a base 10, a stopper 11 provided on the mid portion half way along the base 10 in the lengthwise direction, a pair of blocks 12 provided at the longitudinal opposite ends of the base 10, a pair of sliders 13 longitudinally slidable over the base 10, springs 14 each secured at one end to the block 12 and at the other to the slider 13, and a pusher 15 moved vertically by means of hydraulic pressure or the like. The winding material which has been formed as shown in Fig. 3 is inserted between the stopper 11 and the sliders 13, and the portions 17a thereof which are to be inserted into the slots, that is, the portions other than the coil end portions 17b are retained therebetween by the force of the springs 12. Thereafter, the inserted portions 17a are pressed by the pusher 15 in the direction indicated by an arrow shown in Fig. 4. As the result of this application of pressure, the stator winding material 17 is formed into a stator winding 7 such as that shown in Fig. 5 in which the portion other than the coil end portions 7b, that is, the portions 7a to be inserted into the slot 5, has a substantially square, e.g., rectangular form in cross section. In the above-

described embodiment, after the winding material has been wound and the thus-obtained winding have been placed in such a manner that its turns are superimposed, predetermined portions of the superimposed turns are pressed. However, after the predetermined portions alone of the winding material have been pressed, the obtained winding material may be wound into a desired form.

The stator winding 7, which has been formed in the above-described manner, is securely inserted into each of the slots 5 defined between the adjacent toothed portions 4 of the stator core 2 shown in Fig. 6, with an electrically insulating sheet interposed therebetween. As shown in Fig. 6, a substantially ellipsoidal through hole 16 is axially formed through each of the toothed portions 4 of the stator core 2. As will be described later, the previously-mentioned extensions 6 serving as magnetic-flux collecting portions are formed by pressing the end surface of each of the toothed portions 4. It is thus possible to prevent the inserted winding from coming out of the slots 5. As will be evident from the foregoing, after the winding 7 has been inserted into each of the slots 5, the extension 6 serving as a magnetic-flux collecting portion is formed on the end surface of the toothed portion 4 of the stator core 2. Accordingly, even the winding 7 that is formed in a substantially rectangular shape can be easily inserted into each of the slots 5.

It will be appreciated that the efficiency of assembly is remarkably improved, particularly, in a mass-production process.

The following is a description of a method of forming the extensions that serve as magnetic-flux collecting portions of the stator core 2.

Referring to Fig. 7A, six turns of the stator winding 7 are inserted into each of the slots 5 with the electrically insulating sheet 8 interposed between the winding 7 and the surface of the slot 5.

Subsequently, as shown in Fig. 7B, the end surface of the toothed portion 4 of the stator core 2 is pressed by means of a suitable pressing means (for example, a press or a roller) in the direction indicated by illustrated arrows F. As shown by solid lines in Fig. 7B, the through holes 16 axially formed through the end portions of the toothed portions 4 are crushed and at the same time the portions of the stator core 2 adjacent to the circumferentially opposing sides of the through hole 16 are squeezed outwardly parallel to the circumference of the stator core 2. It is therefore possible to form the magnetic-flux collecting portions 6 so that each has an ideal shape close to an arc.

In the above-described embodiment, by way of example, the solid electric-wire material having a circular cross-sectional form is used to form the stator winding. In the present invention, however, a hollow conductor wire 27 such as that shown in Fig. 8A may be

used in place of the circular wire material. As illustrated, the hollow conductor core 27 originally has an annular cross section. If the conductor core 27 is pressed, it assumes an elongated form with rounded ends such as that shown in Fig. 8B. As is evident from the foregoing, if the hollow conductor 27 is employed in the pressing process explained previously in connection with Fig. 4, the level of pressure required for pressing can be reduced as compared with the solid round wire, and it is possible to easily and positively shape the round wire into a rectangular cross-sectional form. As a matter of course, the portions of the hollow conductor 7 to be inserted into the slots are formed in a flat shape. In addition, the degree of pressure required for working the hollow conductor wire can be reduced as compared with that required when working a solid conductor wire. Accordingly, an electrically insulating film coated over the winding is less likely to be damaged during pressing, and the proportion of defects can be reduced to an extremely low level.

Fig. 9 shows in cross section an alternator for a vehicle which incorporates the above-described stator 1. Fig. 10 illustrates a comparison between the output characteristic of a typical prior art alternator and that of an alternator which incorporates the stator of the present invention. As can be seen from Fig. 10, with the arrangement of the present invention, it is possible to improve the ratio of the area occupied by

the winding to that of the slot, that is, the space factor to a level equivalent to about 80%. In consequence, as shown in the characteristic chart of Fig. 10, it is possible to enhance the level of output over the range of all rotational speeds of the alternator as compared with the output level of the prior art vehicle alternator having the same size (its output characteristic is shown by a dashed line). In particular, it was confirmed that the level of output at a rated rotational speed of 5000 rpm could be increased by about 25% as shown by a solid line.

As is evident from the foregoing description, the present invention succeeds in providing a stator having a large space factor suitable for use in an alternator for a vehicle so that it is possible to achieve a vehicle alternator which is capable of being reducted in size and of providing an increase in output.

CLAIMS:

1. A stator suitable for use in an alternator for a vehicle comprising:

a stator core having a plurality of slots formed in an inner periphery thereof;

a stator winding having portions inserted in each of said slots of said stator core; and

an electrically insulating material inserted between said stator winding and said stator core;

wherein said slots formed in said stator core have a substantially rectangular cross-sectional form, and said portions of said stator winding inserted into said slots also have a rectangular cross-sectional form and a remainder of said stator winding has a circular cross-sectional form.

2. A stator according to Claim 1, wherein said remainder of said stator winding has a hollow cross-sectional form.

3. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of press-forming the portions of said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially

rectangular cross-sectional form.

4. A method according to Claim 3, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

5. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of winding a winding material having a circular cross-sectional form into a predetermined winding shape; and subsequently press-forming the portions of said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form.

6. A method according to Claim 5, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

7. A method of producing a stator suitable for use in an alternator for a vehicle, said stator including a stator core having a plurality of slots formed in an inner periphery thereof, a stator winding having portions inserted in each of said slots of said stator core, and an electrically insulating material inserted between said stator winding and said stator core, comprising the steps of press-forming the portions of

said stator winding to be insetted into each said slot from its circular cross-sectional form into a substantially rectangular cross-sectional form; and subsequently winding said winding material into a predetermined winding form, thereby forming said stator winding.

8. A method according to Claim 7, wherein said stator winding is produced from a winding material having a hollow cross-sectional form.

9. A stator substantially as herein described with reference to and as shown in Figures 1 to 7B, 9 and 10 or 8A or 8B of the accompanying drawings.

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