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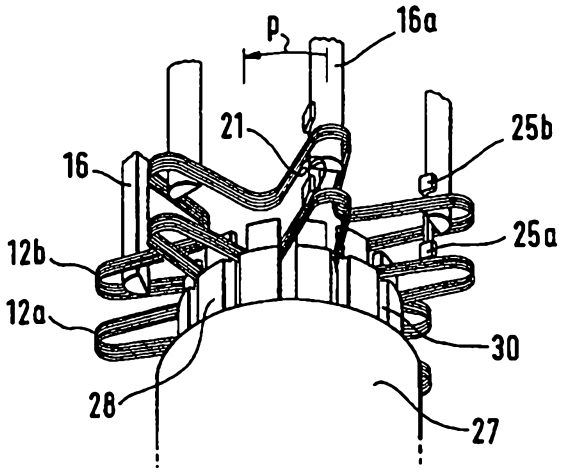
(54) Title: METHOD AND DEVICE FOR PRODUCING WAVE WINDINGS FOR ELECTRICAL MACHINES

(54) Bezeichnung: VERFAHREN UND VORRICHTUNG ZUM HERSTELLEN VON WELLENWICKLUNGEN FÜR ELEKTRISCHE MASCHINEN

(57) Abstract

The invention relates to a method and to a device for producing wave windings for electrical machines, more particularly, for three–phase generators. Each phase is formed by wave windings (12) that are split into two halves (12a, 12b), are initially shaped to form an undulated star, are staggered in relation to each around a pole pitch and finally drawn into the grooves of a stator coil. Said wave winding can be easily and reliably produced by initially winding the first half (12a) of the winding in the form of a circle or a polygon in a first winding direction and subsequently inserting the passing winding wire (15) into a winding loop (21) in the opposite winding direction so that the second half (12b) of the winding is wound in the opposite direction and both winding halves are equally shaped to form a star. Subsequently, both winding halves (12a, 12b) are spun around a pole pitch (p) in relation to each other in such a way that the winding loop (21) is inserted in the star shape between both winding halves



(57) Zusammenfassung

Es wird ein Verfahren sowie eine Vorrichtung zum Herstellen von Wellenwicklungen für elektrische Maschinen, insbesondere Drehstromgeneratoren vorgeschlagen, bei denen jede Phase aus einer in zwei Hälften (12a, 12b) aufgeteilten Wellenwicklung (12) gebildet wird, die zunächst zu einer gewellten Sternform umgeformt, gegeneinander um eine Polteilung versetzt und schließlich gemeinsam in die Nuten eines Statorblechpakets eingezogen werden. Eine einfache und sichere Herstellung dieser Wellenwicklung besteht darin, daß zunächst die erste Wicklungshälfte (12a) in einer ersten Wickelrichtung kreisförmig bzw. polygonal gewickelt und danach der durchgehende Wicklungsdraht (15) in einer Wickelschlaufe (21) in die entgegengesetzte Wickelrichtung überführt wird, daß sodann die zweite Wicklungshälfte (12b) in die entgegengesetzte Richtung gewickelt wird und daß beide Wicklungshälften gleichförmig zu einem Stern verformt werden, daß anschließend die beiden Wicklungshälften (12a und 12b) um eine Polteilung (p) gegeneinander derart verdreht werden, daß dabei die Wicklungsschlaufe (21) zwischen den beiden Wicklungshälften in die Sternform mit übergeht.

23.12.97 Ws/Pi

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Procedure and device for the manufacture of wave windings for electric motors

Prior Art

The invention relates to a procedure and a device for the manufacture of wave windings in accordance with US-PS 4, 857, 789. There, the winding of each phase of an alternator is first wound on a drum or a polygon with the requisite number of turns and formed in the shape of a star. Thereafter, the winding is folded upwards in two halves so that both halves lie alongside one another. Then the two halves are swivelled in such a way that the other winding halves fit into the gaps in the star-shaped loop or wave of a winding half. After this, the wave winding of the one phase prepared in this way is axially drawn into the slots of a stator coil. Similarly, the windings of the second and third phase are then preformed, separated, offset with respect to one another, swivelled one above another and drawn into the stator coil.

The splitting of the phase winding into two parts and the swivelling with respect to one another is relatively expensive and, because of handling automatons for the manufacture of a large batch, can only be realised by means of a multiplicity of manufacturing steps prone to faults.

The automatic large batch manufacture of two-part wave windings whose waves are offset with respect to one another is simplified and improved by means of this solution.

Advantages of the invention

The procedure of the invention and the device provided for it for the manufacture of wave winding halves offset with respect to one another according to the characteristics of Claims 1 and 3 have the advantage that already on a winding bell, the two winding halves wound

behind one another are wound in opposite directions to one another and are star-shaped. The two winding halves can then be turned to the left or the right counter to each other over a winding loop formed between both winding halves around a pole pitch so that the star-shaped waves of the two winding halves are offset with respect to one another around the pole pitch. The wave winding preformed in this way is then drawn into a stator coil of an alternator. All three phase windings of the alternator are manufactured individually as wave windings in the same way and are drawn one after another into the stator coil. In this way, the wave windings with winding halves offset with respect to one another can be manufactured easily and simply in a few procedural steps at one winding station and be fed to a drawing-in station.

Drawing

Details of the invention are depicted in an embodiment in the drawing and described in some detail in the following. Shown are:

Figure 1 the coiling of the first half of the winding schematically represented, Figure 2 the coiling of the loop with reversal of the winding direction, Figure 3 the winding of the second half of the winding; Figure 4 shows the winding device with a drawing tool arranged below it, Figure 5 shows the star-shaped, preformed wave winding, Figure 6 shows the wave device whose one half is drawn into the drawing tool, Figure 7 shows the winding of the upper half of the winding, Figure 8 shows the finished wave winding in the drawing tool, Figure 9 shows the drawing tool in longitudinal section after the drawing in of the wave winding, Figure 10 shows a stator coil with the one separated wave winding and Figure 11 the finished stator with the three-phase windings.

Description of the embodiment

For the manufacture of a stator 10 as in Figure 11 with a three-phase wave winding 11, each of the three phase windings are prefabricated on a winding device 13 as in Figure 4 by means of a wave winding 12 with winding halves 12a and 12b offset with respect to one another. The Figures 1 to 3 schematically show the manufacture of such a wave winding 12 of Figure 10. A wire clamp 14 holds one end 15a of a winding wire 15 in accordance with Figure 1b on the lower end of a forming jaw 16. Six forming jaws of this type are arranged as shown in Figure 1a in a star shape in the winding device 13. The winding wire 15 is received through a wire aperture 17 of a delivery spool not depicted. The forming

jaws 16 are arranged radially moveable in a winding bell 18 of the winding device 13 as in Figure 4. For the manufacture of the first winding half 12a, the forming jaws 16 are turned in a clockwise direction with the winding bell 18, so that the first winding half 12a results with four complete windings in the form of a polygon.

The winding device is now arrested, the forming jaws 16a at the top of the wire aperture 17 remaining still. It is recognisable from Figure 2 that the forming jaws 16a has, in its front piece, a segment-shaped recess in which an axially-running web-shaped loop drawer 20 stops. The wire aperture 17 is now directed to this loop drawer and the winding wire 15 is led around the loop drawer 20 from below to above, the forming jaws 16 and 16a and the winding bell 18 being pushed axially downwards.

The winding bell 18 is now turned further slowly in a counterclockwise direction and the wire aperture 17 is directed back to its outer position. In this process a winding loop 21 results on the loop drawer 20 as can be seen in Figure 2b.

In accordance with Figure 3, the second winding half 12b is manufactured in an opposite winding direction by means of a corresponding number of revolutions of the winding bell 18.

Figure 4 shows the winding device 13 for the manufacture of the wave winding 12 in a stereoscopic picture. It can be seen there that, on the underside of the winding bell 18, the six forming jaws 16 are arranged, moveable, in polygonal arrangement on axes 22 running radially inwardly, the drive 16b being supplied hydraulically by means of Bowden cables or by other means. Forming levers 23 are arranged between the forming jaws 16 respectively which are also moveable over a drive 23a respectively on radially arranged axes 24 by hydraulic, Bowden cables or other means. The six forming levers 23 are depicted in their outer position swivelled upwards and inwardly in Figure 4, so that during the winding of the first and second winding halves 12a and 12b, they cannot extend into the winding area. A stripper 25 is arranged axially moveably on the rear side of the forming jaws 16 and projects with a stripping arm 25a above the first winding half 12b and with a further stripping arm 25b above the second winding half 12b, as can be seen in the Figures 1b to 3b. The winding bell 18 is rotatable over a drive 26 in the direction indicated by the arrows axially and in both directions.

Below the winding bell 18 is a drawing tool 27 with a reception crown 28 and a drawing needle 29 lying inside (recognisable in Figure 8). Between the drawing needles 29 is the

reception crown 28 with longitudinal slots 30. The drawing tool 27 sits on a swivelable tool bench 31 and is also height-adjustable.

Now, in a further procedural step according to Figure 5, the upper and lower winding halves 12a and 12b are formed as stars simultaneously, the six forming jaws being folded out at right angles to its drive 23a and are then moved inwardly over the axles 24 as is shown by means of arrows in Figure 5. At the same time the forming jaws 16 are pushed onto their axles 22 radially inwardly, also shown through arrows in Figure 5. Both winding halves 12a and 12b now sit, spaced and star-shaped, one above the other on the forming jaws 16 and the form lever 23.

In further steps the forming jaws 16 are moved 3 mm in the direction of the arrow in accordance with Figure 5, the coil is destressed, the wire clamp 14 is opened and then, in accordance with Figure 6, the winding half 12a is stripped from the forming jaws 16 being taken up by their star-shaped legs in longitudinal slits 30 of the receiving crown 18 of the drawing tool 27. The upper winding half 12b is also pushed down with the strippers 25b but remains in the lower area of the forming jaws. Upper and lower winding halves 12a and 12b are now connected via the winding loop 21.

In the following procedural step, the winding bell 18 is now turned to the left around a pole pitch p of a twelve pole wave winding 12, ie. by 30° in the direction of the arrow so that the star shaped waves of both winding halves 12a and 12b are opposed to one another. The winding loop 21 is tilted to the left so that it, too, follows the course of the upper winding halves 12b.

In a further procedural step, the upper winding half 12b is stripped with the stripper 25 of the forming jaws 16 and is inserted in the longitudinal slots 30 on the receiving crown 28 of the drawing tool. As Figure 8 shows, the waves of both winding halves 12a and 12b are now offset with respect to one another in the longitudinal slots 30 of the reception crown. The strippers 25 are raised again in this condition. The shaping levers are moved again into the outer position, swivelling back into the output position as depicted in Figure 4 and the winding bell 18 moves upwards. A stator coil 32 is fixed on the upper part 28a (Figure 4) of the reception crown 28. The tool bench 31 then swivels to a drawing station 34 shown schematically in Figure 9. There, the preformed wave winding 12 is dropped into the grooves of the stator coil 32 in the customary manner by means of a drawing stamp 33 and the upper winding heads 12c are pressed outwardly in the position recognisable in Figure 10. Apart from this, the groove is closed at this station. In this way, alternating

winding heads 12c are formed on both sides over the extent of the stator coil 32. The stator coil 32 is held by a coil locking ring 36 on the reception crown 28.

In the way previously described, a further wave winding is produced on the winding device according to Figure 4 and formed into a star shape. The both halves of the winding are turned against each other in the manner described around a pole pitch and are then taken up by the drawing tool and then into the stator coil alongside the first wave winding into the grooves provided for the purpose. In the same way, the production and drawing in of the third wave winding takes place so that finally, in accordance with Figure 11, a completed stator with a three-phase winding 11 results. There, the beginnings and ends of the three phases of the three phase winding are indicated with U, V, W and X, Y and Z.

In these wave windings with the wave winding halves in negative sequence with respect to one another, the groove filling factor in the stator coil 32 is increased relative to the one-piece wave windings by up to 10%. In alternators with greater output, the groove filling factor can also be increased, instead of a winding wire with relatively large diameter, by two or more winding wires with correspondingly small diameter being wound parallel and connected to one another.

The rotating of both winding halves 12a and 12b against one another in the winding device according to Figure 4 can take place in the same way by means of turning the upper winding half 12b against the lower 12a to the right. In this case, the winding loop 21 would tilt, not toward the upper winding half 12b (in accordance with Figure 7), but to the lower winding half 12a. So that in this case the lower winding half 12a does not become longer and the upper does not shorten, the beginning of the wave of the lower winding half 12a and the winding end of the upper winding half 12b should be positioned appropriately. In the same way the two winding halves 12a and 12b can be alternatively wound - the first half around to the right and the second half around to the left - on the forming jaws. The loop drawer must in this case be arranged on the left side of the forming jaws 16a. The winding device can be used for both wave directions in an arrangement of the loop drawer 21 in the centre of the forming jaw 16a.

In any case, the current flow into the winding sections inside the grooves of the coil is, by means of rotating by 30°, ie. around a pole pitch, always constant.

As, at the groove outlet, the winding separates in both directions, the three phase belts cross at the coil ends only with half the number of line wires of a neighbouring phase

winding. This leads, over against an unseparated winding, to a flatter end winding with a uniform guiding of the wire with a decrease in flow noise and better cooling.

23.12.97 Ws/Pi

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Claims

1. Procedure for the manufacture of wave windings for electrical machines, in particular for the stator of three-phase alternators, each of the three wave windings (12) being formed of a wave winding separated into two halves (12a, 12b) which is formed from at least one continuous wire (15) and is wound in a circle or a polygon and is formed into a waved star-shape, the two winding halves (12a, 12b) being offset with respect to each other around a pole pitch (p) and are then drawn together into the grooves of a stator coil (32) by means of which, on both sides over the extent of the stator coil, alternating winding ends (12c) of both winding halves are formed, characterised in that first, the first winding half (12a) is wound in a first winding direction in the form of a sphere or polygon and then the continuous winding wire (15) is directed in a winding loop (21) into an opposite winding direction, that further, both winding halves (12a and 12b) are formed, preferably simultaneously, in the same star shape and then the two winding halves are wound against one another around a pole pitch (p), the winding loop (21) between the two winding halves (12a and 12b) moving with it.

2. Procedure according to Claim 1, characterised in that on winding bell (18), driveable in both directions, with radially moveable forming jaws (16), firstly the first winding half (12) is wound on the forming jaws (16), then the winding wire (15) wound on a loop

drawer (20) preferably arranged on a form jaw (16a) is formed into a connection loop (21) for the opposite winding direction, in that then, axially offset, the second winding half (12b) is, with a change of rotational direction, wound on the forming jaws (16), then both winding halves are shaped simultaneously by means of a forming lever (23) moving radially from outside to inside into a waved star, in that thereafter one winding half (12a) is taken up into a receiver, preferably a drawing tool (27) and now the winding bell (18) with the other remaining winding half (12b) wound around a pole pitch (p) preferably in the first rotational direction is then stripped from the winding bell (18) and placed in the receiver above the first winding half (12a).

3. Device for the manufacture of wave windings for electric machines, in particular for the stator of three-phase alternators in accordance with the procedure of Claim 1, characterised in that on a winding bell (18) drivable in both rotational directions with forming jaws (16) distributed, radially moveable, on the periphery, a winding half (12a) is windable, that further a loop drawer (20) is provided over which the winding wire (15) on the end of the first winding half (12a) can be directed in a winding loop (21) into the second winding half (12) and can then be wound in the opposite direction onto the forming jaws (16) and that between the forming jaws (16), forming bodies pushable from inside to outside respectively, in particular forming levers, are arranged, by means of which the two winding halves are to be formed into a star shape simultaneously.

4. Device as in Claim 3, characterised in that, in the area of the forming jaws (16), strippers (25) are arranged, axially moveable with which, firstly, the lower winding half (12a) is to be stripped in order to turn it against the upper winding half (12b) around a pole pitch (p) so that the winding loop (21) moves with it into the star shape.

5. Device as in Claim 3 or 4, characterised in that a loop drawer (20) in the form of an axial web in a segment shaped recess (19) is arranged on at least one of the forming jaws (16) on the front side of the forming jaws (16a).

FIG. 1

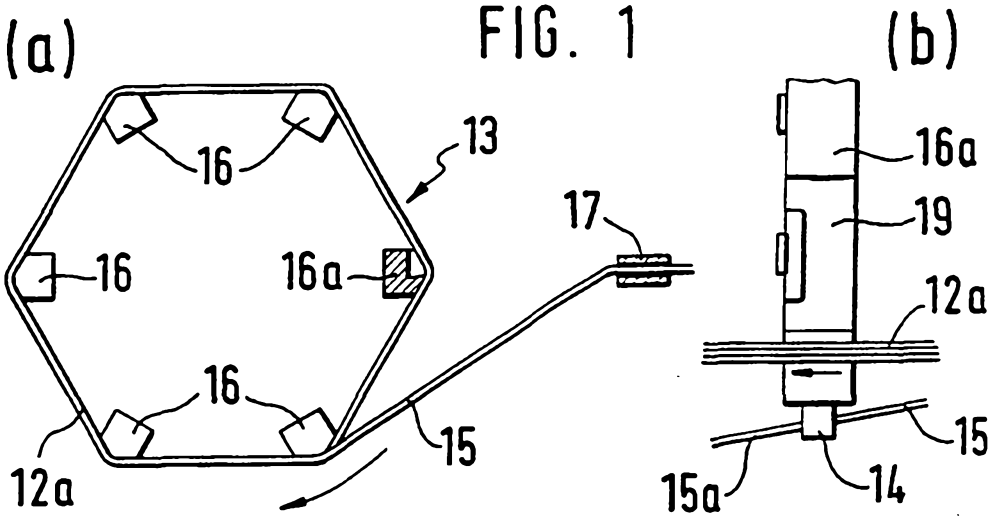


FIG. 2

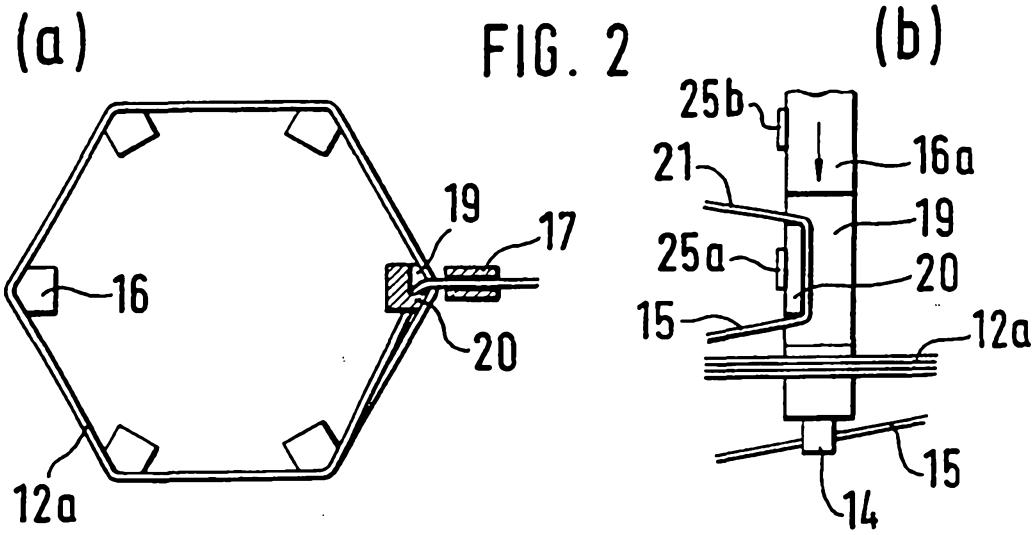
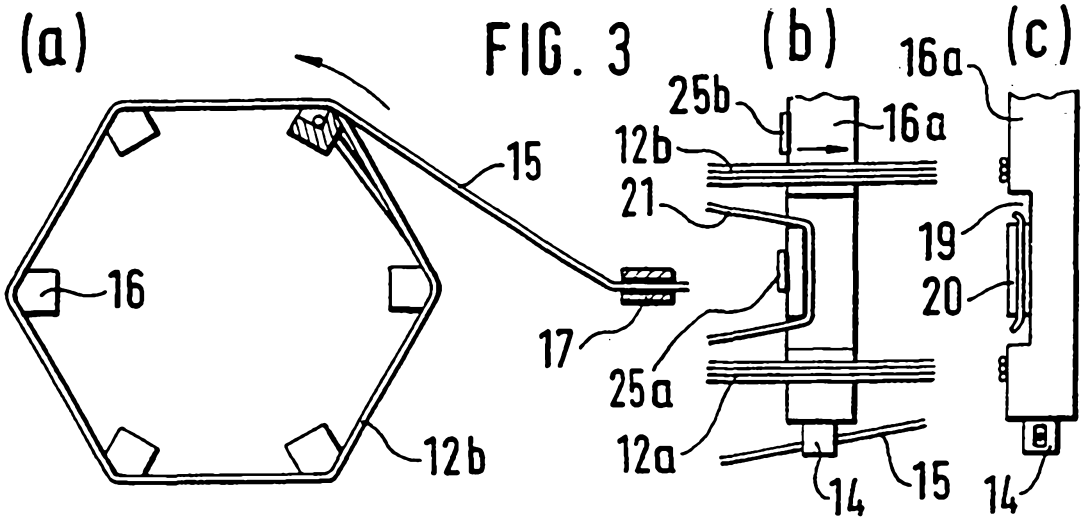


FIG. 3



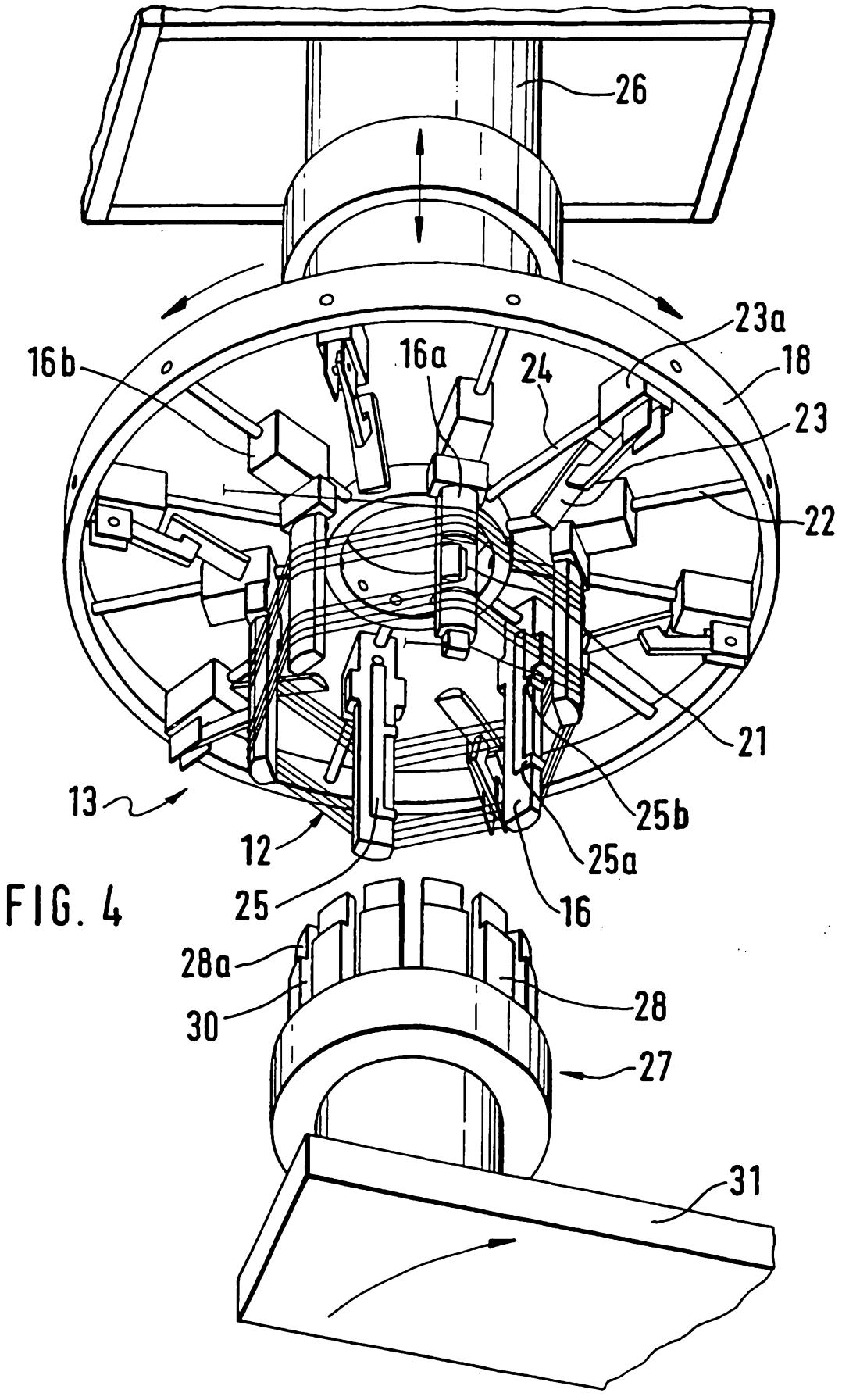


FIG. 4

FIG. 5

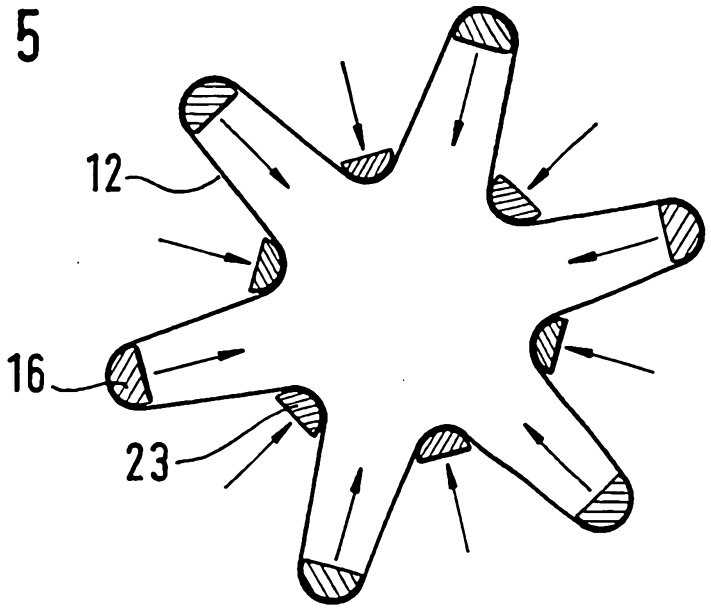


FIG. 6

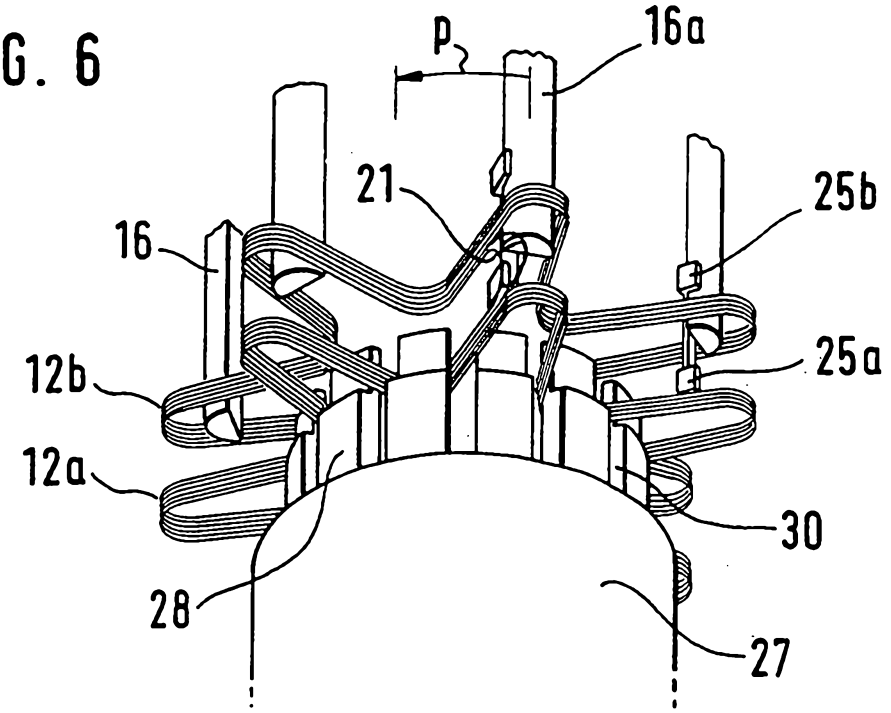


FIG. 7

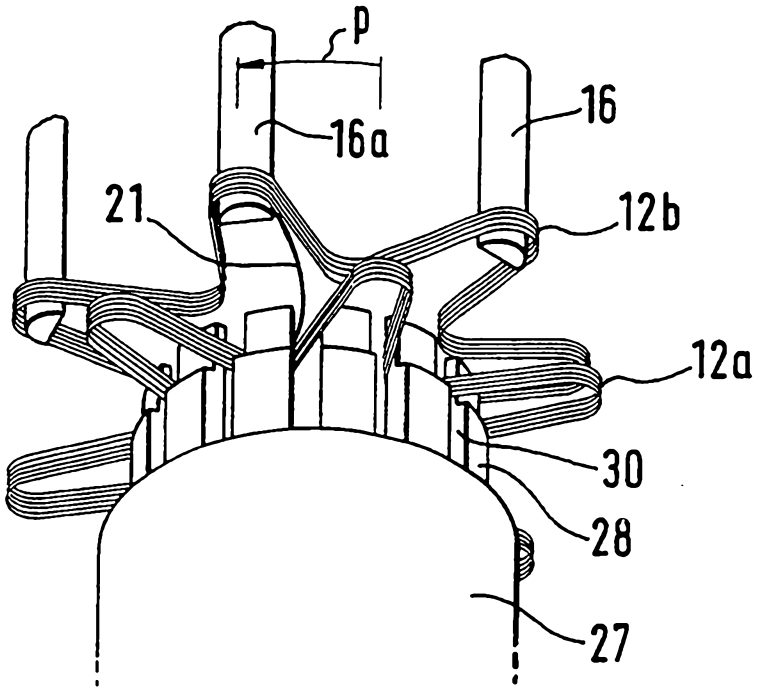


FIG. 8

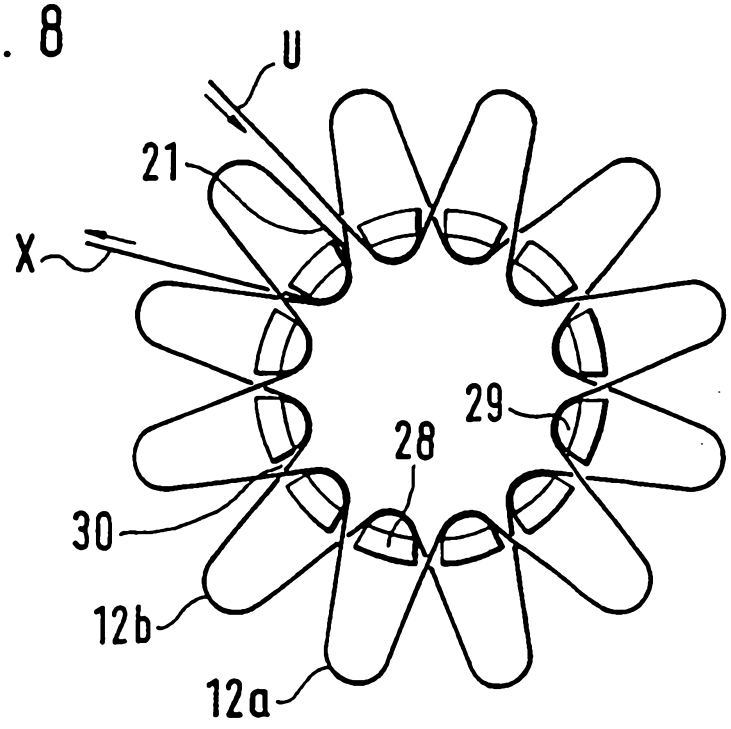


FIG. 9

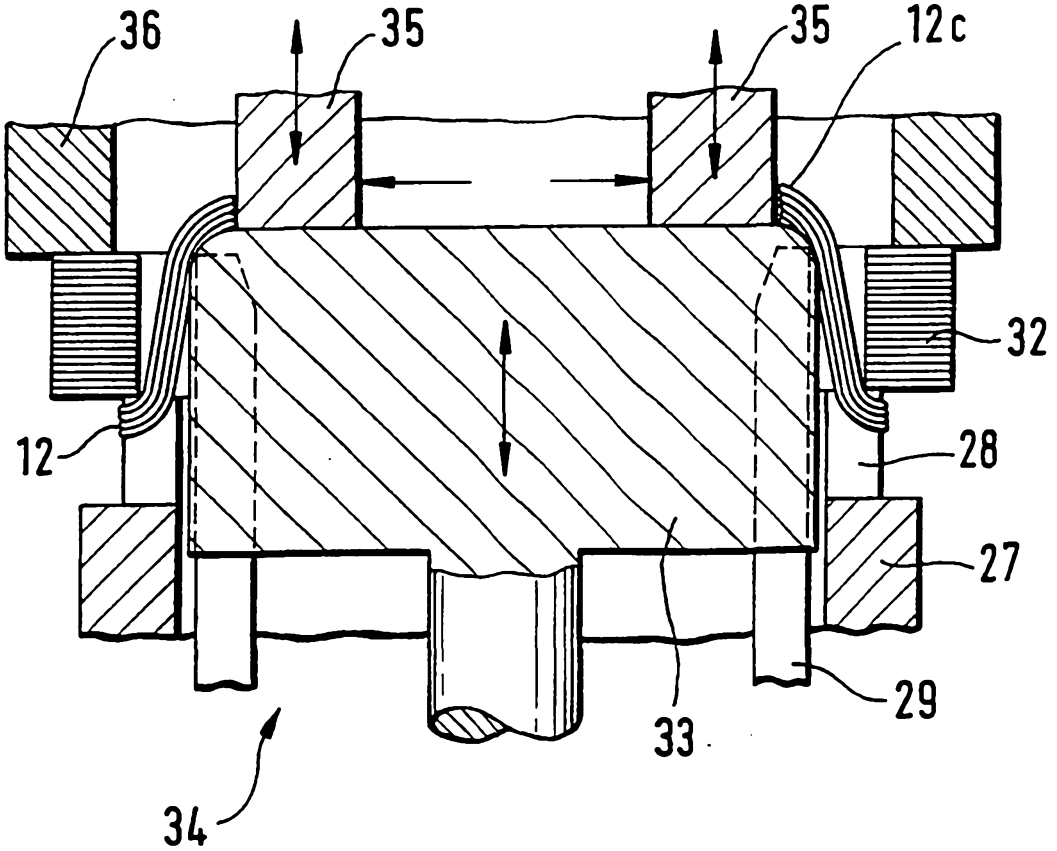
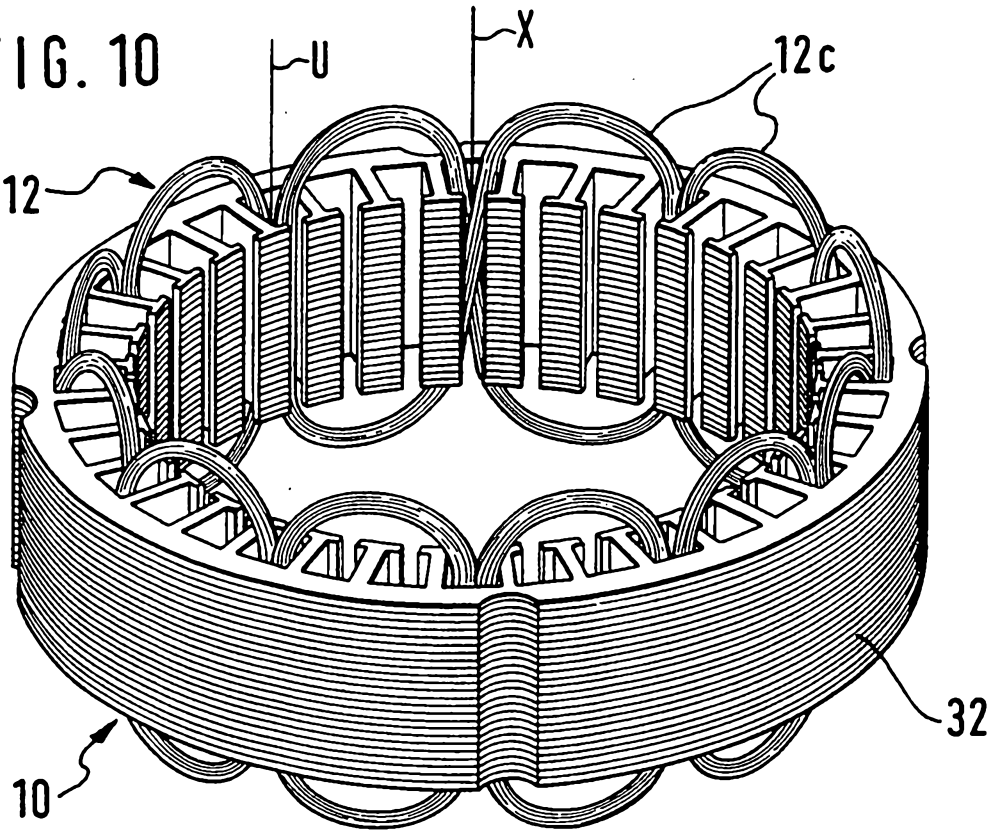


FIG. 10



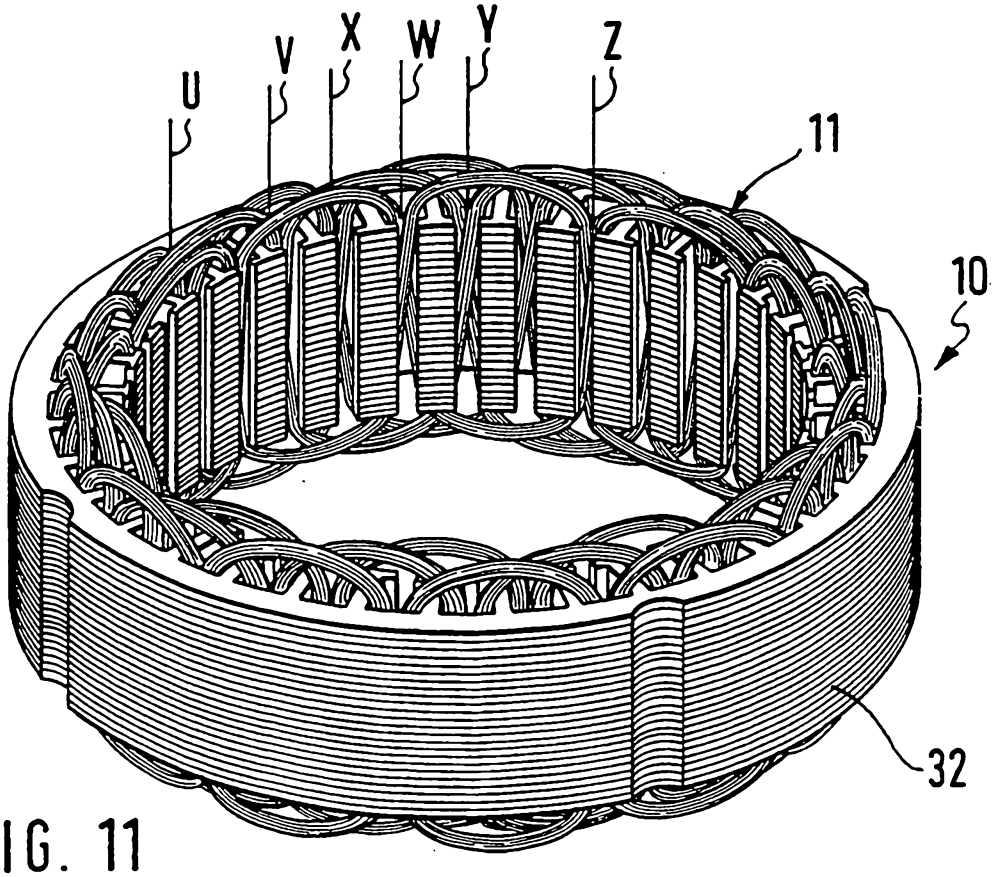


FIG. 11