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- (73) Patenthaver: **Flender GmbH, Alfred-Flender-Strasse 77, 46395 Bocholt, Tyskland**
- (72) Opfinder: **Schäfer, Rüdiger, Gorgasring 48, 13599, Berlin, Tyskland**
MÖHLE, Axel, Zimmermannstraße 16, 12163 Berlin, Tyskland
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Description

Coil schematic for a segmented stand of a dynamo electric machine

- 5 The invention relates to a segment for an annular stator of a dynamoelectrical machine. The invention is particularly applicable to very large electrical machines. Generators for wind power installations, tidal power stations, ring motors or drives for construction machines such as mechanical diggers may be mentioned as examples of machines such as these.
- 10 Energy recovery from regenerative energy sources is becoming evermore important. Correspondingly, the components used for energy conversion are subject to evermore stringent requirements. One consequence of this is that, for example, generators for wind power installations require an ever greater physical volume.
- 15 As the rating class rises, wind energy installations without gearboxes are becoming competitive with installations in which a mechanical gearbox is connected between the rotor blades that are driven by the wind and a synchronous generator. The main advantage of a design such as this without a gearbox is that the design is considerably simpler than that of wind power installations with a gearbox. The lack of the gearbox means that fewer rotating
- 20 machine components are required. This results in less maintenance effort and increased installation availability.

In particular, very large wind power installations generally operate at comparatively low rotation speeds. In an embodiment without a gearbox, installations such as these must

25 therefore be equipped with very large and heavy generators. In this case, the diameter of these machines easily exceeds 4 or 5 m.

As the size of the wind power generators which the higher ratings of these installations necessarily result in become larger, their assembly becomes ever more difficult. Turbines

30 without gearboxes for wind-power or else tidal power stations also result in stringent requirements, however, for transport and logistics.

Generators for wind power installations without gearboxes frequently have an annular rotor with a hollow shaft. One such electrical machine is disclosed, for example, in WO 2006/032969 A2. This document discloses a stator which is subdivided into a plurality of segments in the circumferential apparatus. Each stator segment has a dovetail profile which engages in a window in a stator ring. Each of these sectors can therefore be pulled out in the axial direction without having to remove the entire stator.

EP 1 093 207 A2, DE 10 2005 029895 A1 and EP 1 780 869 A2 disclose segments for an annular stator of a dynamoelectrical machine. EP 2 166 645 A1 discloses a lengthened end connection.

A segment according to the preamble of Claim 1 is known from EP 2 166 645 A1.

The invention is based on the object of making it easier to transport and assemble large electrical machines.

- This object is achieved by a segment for an annular stator of a dynamoelectrical machine having the features according to Claim 1.

Advantageous embodiments of the invention are specified in the dependent claims.

The essence of the invention is that the segments of the stator are designed such that there is no need for the segments to be electrically connected to one another. A connection such as this would be highly complex. In order to provide it, special coils would have to be manufactured, which would also have to have a certain amount of flexibility in the coil nose and would then have to be inserted retrospectively into the stator slots in order to electrically bridge the segment boundaries.

These coils would then also have to be subsequently insulated manually after the actual process of impregnation of the winding.

An alternative solution for electrical connection of the segments of the stator would be for each of the coils which are arranged on the segment boundaries to be designed only as half-

coils, and for these to be soldered together after the construction of the stator. However, subsequent insulation is also required in this case. The disadvantageous methods mentioned above have the common feature that subsequent non-destructive separation of the segments, for example for maintenance or repair purposes, is no longer possible.

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The invention is based on the discovery that the problematic electrical connections described above between the individual segments of the stator can be eliminated if all the coils in a segment are closed within that segment. This means that the coils which are arranged at the segment boundaries are also closed within the segment. This can be done by connecting the first conductor, which is arranged at the first segment boundary, to the second conductor, which is arranged at the second segment boundary, via a lengthened end connection on the end winding. The first conductor therefore need not be connected to a further conductor of an adjacent further segment across the left-hand segment boundary. In fact, the second conductor, which is located on the right-hand segment boundary, is used as the return conductor for the first conductor.

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The coil which is created by the connection of the first and second conductors surrounds the at least two remaining coils. Overall, the segment according to the invention therefore comprises at least three coils. The segment can be impregnated as a complete, closed unit.

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There is no need for subsequent coil connections across the segment boundaries. The segments according to the invention created in this way can be fitted as closed functional elements and, for example, can be removed for maintenance or repair purposes. In this case, a single segment can be stocked as a spare part, instead of a complete stator.

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The electrical machine according to the invention may be both a generator and a motor. The segmentation of the stator according to the invention is advantageously independent, particularly in the case of very large bore diameters of whether the machine is intended for use primarily as a motor or as a generator.

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In one advantageous refinement of the invention, a polyphase current can be passed through the coils independently of further coils of the further segments, in order to produce a first pole pair of a rotating field.

The segment may, of course, also have even more coils, thus allowing it to be used to produce a greater number of pole pairs than one. For example, in one advantageous embodiment of the invention, the segment for each phase of the polyphase system has at least one second coil, which is closed within the segment in order to produce a second pole pair, through which the polyphase current can be passed independently of further coils of the further segments in order to produce a second pole pair of the rotating field.

The windings which are expediently in the form of a circumferential winding, are in one advantageous refinement of the invention designed such that the coils are arranged as a tier winding, such that the conductors of the three coils of a pole pair are superimposed in the area of the end windings.

In a further advantageous refinement of the invention, a segment such as this can in this case be produced easily by the coils being in the form of a single-layer winding.

Alternatively, however, a refinement of the invention is, of course, feasible in which the coils are in the form of a two-layer winding.

Particularly in the case of very large electrodynamic machines, a considerable transport advantage is achieved in that the closed annular shape of the stator can be interrupted by separating the segments from one another. In the case of a refinement such as this, there is, for example, no longer any need to transport the complete hollow cylinder, which forms the complete stator by road. The individual segments when disassembled occupy considerably less volume than in the assembled state.

In another advantageous refinement of the invention, a dynamoelectrical machine having at least two segments of one of the embodiments described above is in the form of a directly driven generator for a wind power installation or a tidal power station. Generators such as these require a large physical volume in order to allow them to produce a high electrical power, because of the low rotation speeds which can be produced by the drive forces that are used here. It is likewise advantageous to use an electrodynamic machine with a segmented stator corresponding to one embodiment of the invention in numerous other fields of operation, which require a high torque and therefore a large machine diameter.

A wind power installation having a dynamoelectrical machine whose stator is manufactured from individual segments in the form of partial rings according to one of the embodiments described above, can be assembled very easily at the location where it will later be used. The individual segments of the stator can be transported very much better to the installation location, for example by road, than a complete dynamoelectrical machine.

The invention will be described and explained in more detail in the following text with reference to the exemplary embodiments which are illustrated in the figures, in which:

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Figure 1 shows a winding plan for a conventional embodiment of a segment of a stator,

Figure 2 shows a winding plan for a segment according to a first refinement of the invention,

Figure 3 shows a winding plan for a segment according to a second refinement of the invention, and

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Figure 4 shows a wind power installation having a dynamoelectrical machine which has a segmented stator.

Figure 1 shows a winding plan for a conventional embodiment of a segment 1 of a stator which is not part of the claimed invention. The illustrated winding plan is intended for a very large dynamoelectrical machine whose stator is segmented, in order to reduce its transport volume to such an extent that the stator can be transported by road to a subsequent installation location, where it can be assembled. One typical example of a dynamoelectrical machine such as this is a wind power generator, which is in the form of a hollow-shaft generator.

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A segment 1, which is illustrated in the center of Figure 1, is connected to two further segments 4 during assembly of the wind power generator. The further segments 4 are connected to the segment 1 at a first and a second segment boundary 2, 3. The segment 1 and the further segments 4 are largely physically identical. Each of the segments is designed with coils which allow a rotating field to be produced. However, not all the coils within the segment 1 are closed. At the first segment boundary 2 and at the second segment boundary 3 there is in each case a half-coil which must be electrically connected to a half-coil in one of

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the further segments 4. In order to make this possible, after the segment 1 has been joined to the further segments 4, special connecting coils 15 are used, which electrically connect said half-coils across the segment boundaries 2, 3. These also have to have a certain amount of flexibility in the coil nose. The connecting coils 15 can therefore not also be insulated during the course of the impregnation process of the winding, but must be insulated manually, subsequently.

Figure 2 shows a winding plan for a segment 1 according to a first refinement of the invention. Once again, it is assumed here that the winding plan or the segment 1 is intended for a hollow-shaft generator of a wind power installation. The segment 1 shown in the center is mechanically connected to further segments 4, during construction of the wind power generator, at a first segment boundary 2 and at a second segment boundary 3. When N segments are provided for the hollow-shaft generator, then the cross-sectional area of each of the segments 1 covers a circular arc with an angle of $360^\circ/N$.

Each of the segments 1 comprises three coils 5, 6, 7 - in each case one coil 5, 6, 7 for each phase of a polyphase system. A pole pair can thus be provided with each segment 1 for the dynamoelectrical machine. Two of these coils 5, 6, 7 are closed in the conventional manner within the segment 1. A third coil 5 is formed by connecting a first conductor 8, which is arranged in the vicinity of the first segment boundary 2, via an end connection 10 to a second conductor 9 which is arranged in the vicinity of the second segment boundary 3. This results in the coil 5 formed in this way surrounding two conventionally closed coils 6, 7. The magnetic response of a segment 1 such as this corresponds essentially to a magnetic response as achieved with a conventional winding as shown in Figure 1. However, no connecting elements are required to electrically connect the coils 5, 6, 7 to further coils 11 in the further segments 4. A hollow-shaft generator such as this can be assembled considerably more easily, since current can be passed autonomously through each segment 1 and there is no need for an electrical connection, or the retrospective insulation associated with this across the segment boundaries 2, 3. This refinement of the hollow-shaft generator also considerably simplifies maintenance and repair tasks. If a defect occurs on a segment 1, then this can be replaced without having to disconnect the connecting elements, of whatever type for this purpose which cross the segment boundaries 2, 3. Individual segments 1 can be stored as

spare parts, thus allowing replacement in the event of a defect promptly. Shutdown times are considerably reduced in this way.

Figure 3 shows a winding plan for a segment 1 according to a second refinement of the invention. In contrast to the first refinement as shown in Figure 2, there are three slots per pole and winding section in this case. This resulting from the fact that a coil group comprising three coils arranged concentrically with respect to one another is provided for each phase. The winding of these coils is designed analogously to the winding illustrated in Figure 2. This means that, in this case as well, conductors 8, 9 which are arranged at the segment boundaries 2, 3 are connected to one another via end connections 10. The advantages which result from this have already been mentioned in the description in relation to Figure 2.

Figure 4 shows a wind power installation having a dynamoelectrical machine which has a segmented stator. The electrical machine 14 is in the form of a hollow-shaft generator. In this case, there is no gearbox, as a result of which the stator of the dynamoelectrical machine 14 has a very large diameter. The stator is segmented, such that it can be assembled by joining the individual segments together at the location where it will subsequently be used. The hollow-shaft generator can be assembled comparatively easily because of the advantageous configuration of these segments, in the form of an embodiment according to the present invention. There is no need for the individual segments to be electrically connected to one another in order pass current through the coils of the segments. This considerably simplifies the assembly process, since electrical segment connections which are formed subsequently at the building site between the coils of the segments would have to be insulated, which is also complex. In contrast, the generator described here consists of individual segments which are completely electrically functional and do not require this connection.

Patentkrav

1. Segment (1) til en ringformet stator på en dynamoelektrisk maskine (14), som omfatter et i det væsentlige cirkelbueformet tværsnit, hvor segmentet (1) indeholder:
- 5 - en første og en anden segmentgrænse (2,3), hvortil der kan tilføjes et yderligere segment (4),
 - mindst en spole (5,6,7) til hver fase af et trefasestrømsystem,
 - mindst en første leder (8) og mindst en anden leder (9),
hvora
 - 10 - den første leder (8) ved den første segmentgrænse (2) er forbundet med den anden leder (9) ved den anden segmentgrænse (3) via en forlænget endeforbindelse (10) i området med spolehovederne, sådan at den således dannede spole (5) i det mindste omslutter de to resterende spoler (6,7),
hvor spolerne (5,6,7) uafhængigt af yderligere spoler (11) i de yderligere segmenter (4) til dannelse af et første polpar i et drejefelt kan påføres trefasestrøm, **kendetegnet ved, at** segmentet (1) til hver fase af trefasestrømsystemet indeholder mindst en
 - 15 lukket anden spole inden for segmentet (1) til dannelse af et andet polpar, som kan påføres trefasestrømmen uafhængigt af de yderligere spoler (11) i de yderligere segmenter (4) til dannelse af et andet polpar i drejefeltet.
- 20
2. Segment ifølge krav 1,
hvor spolerne (5,6,7) er anbragt som etagevikling, sådan at lederne i de tre spoler (5,6,7) af et polpar overlapper hinanden i området med spolehovederne.
- 25
3. Segment ifølge et af de foregående krav,
hvor spolerne (5,6,7) er udformet som enkeltlagsvikling.
4. Segment ifølge et af de foregående krav,
hvor spolerne (5,6,7) er udformet som tolagsvikling.
- 30
5. Segment ifølge et af kravene 1 til 4,
hvor den lukkede ringform af statoren kan ophæves ved at skille segmenterne (1,4) fra hinanden.
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6. Dynamoelektrisk maskine (14) med mindst to segmenter (1,4) ifølge et af kravene 1 til 5.
7. Dynamoelektrisk maskine (14) ifølge krav 6, hvor den dynamoelektriske maskine (14) er udformet som direkte drevet generator til et vindkraftanlæg eller et tidevandskraftværk.
- 40
8. Vindkraftanlæg med en dynamoelektrisk maskine (14) ifølge et af kravene 6 eller 7.

FIG 1

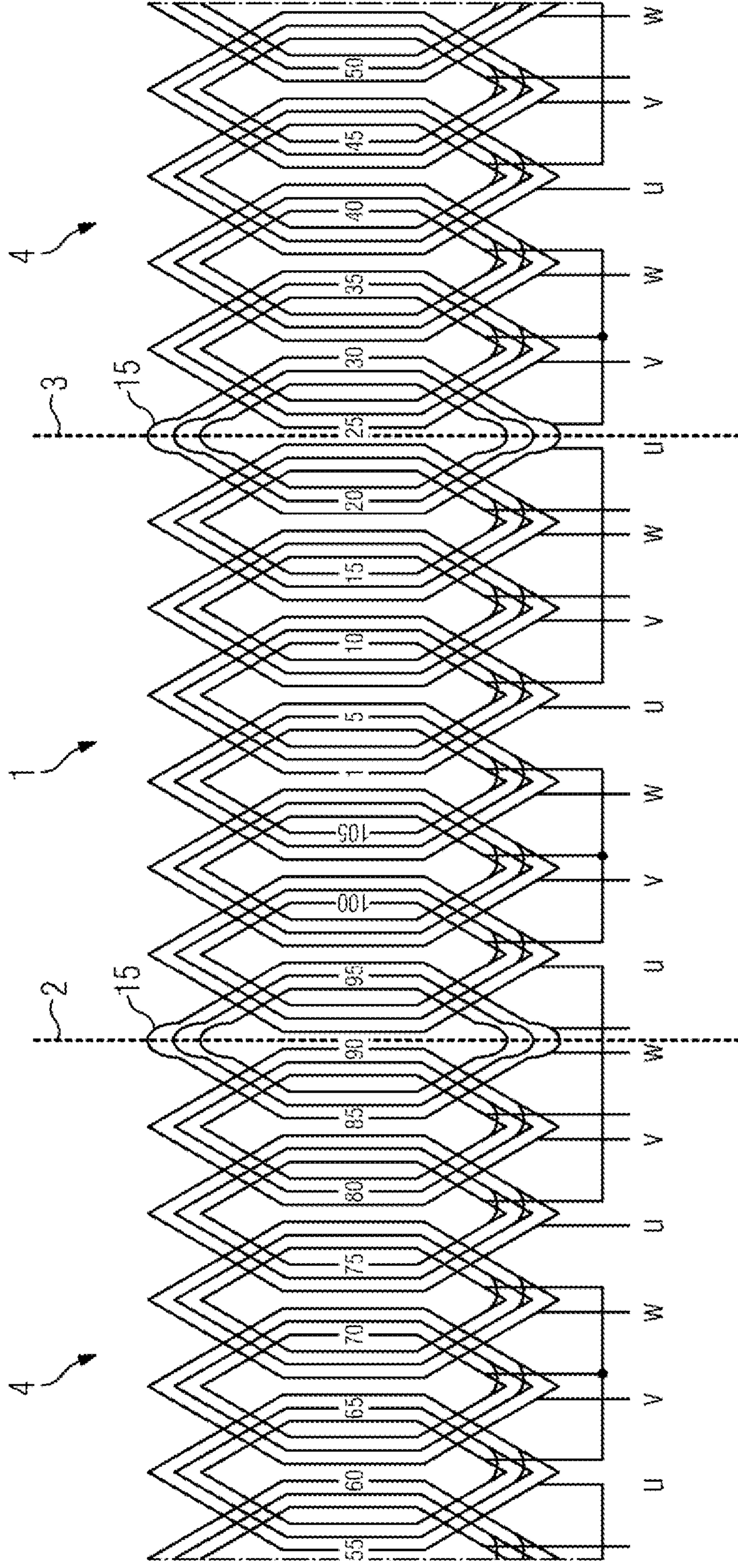


FIG 2

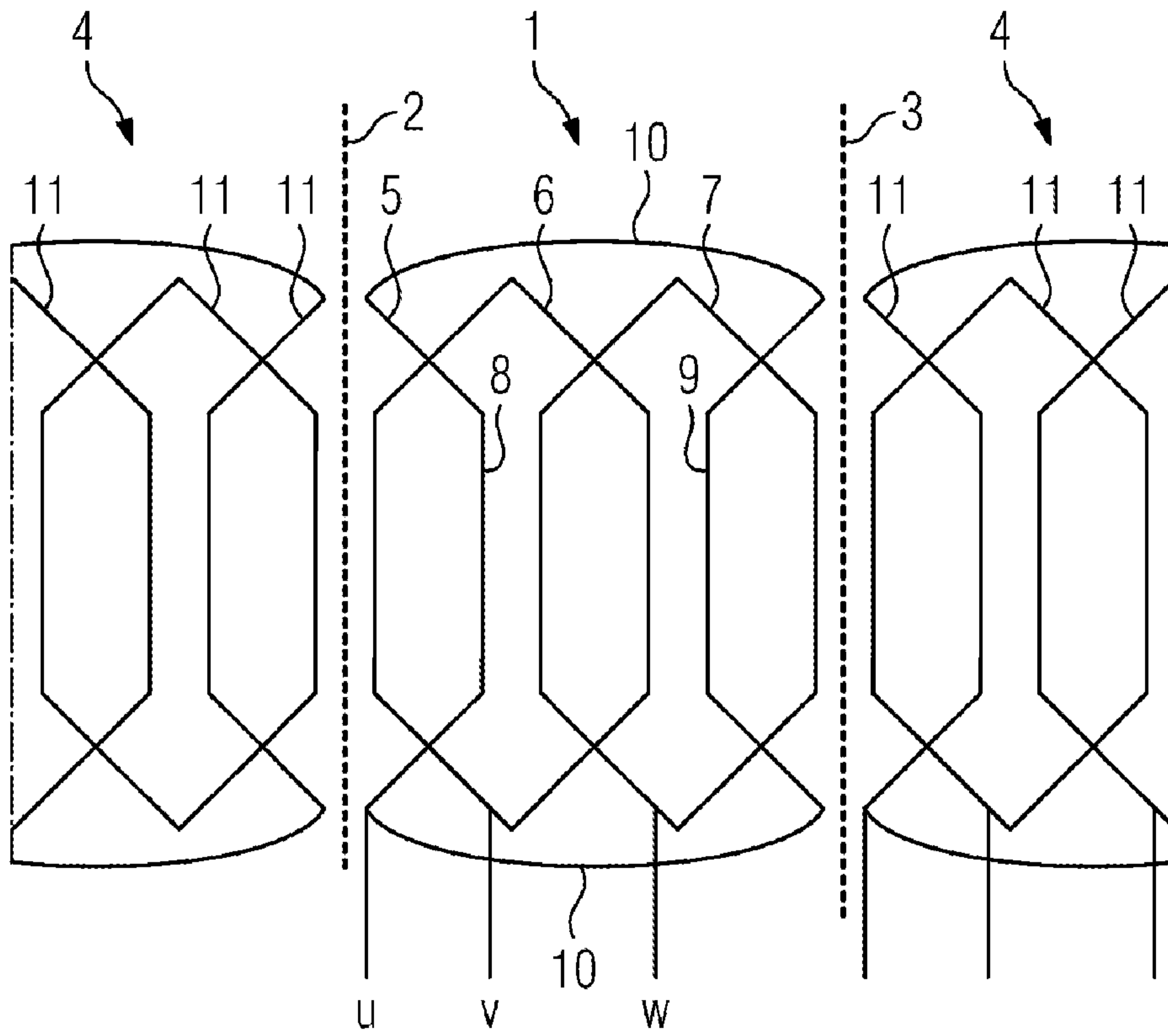


FIG 3

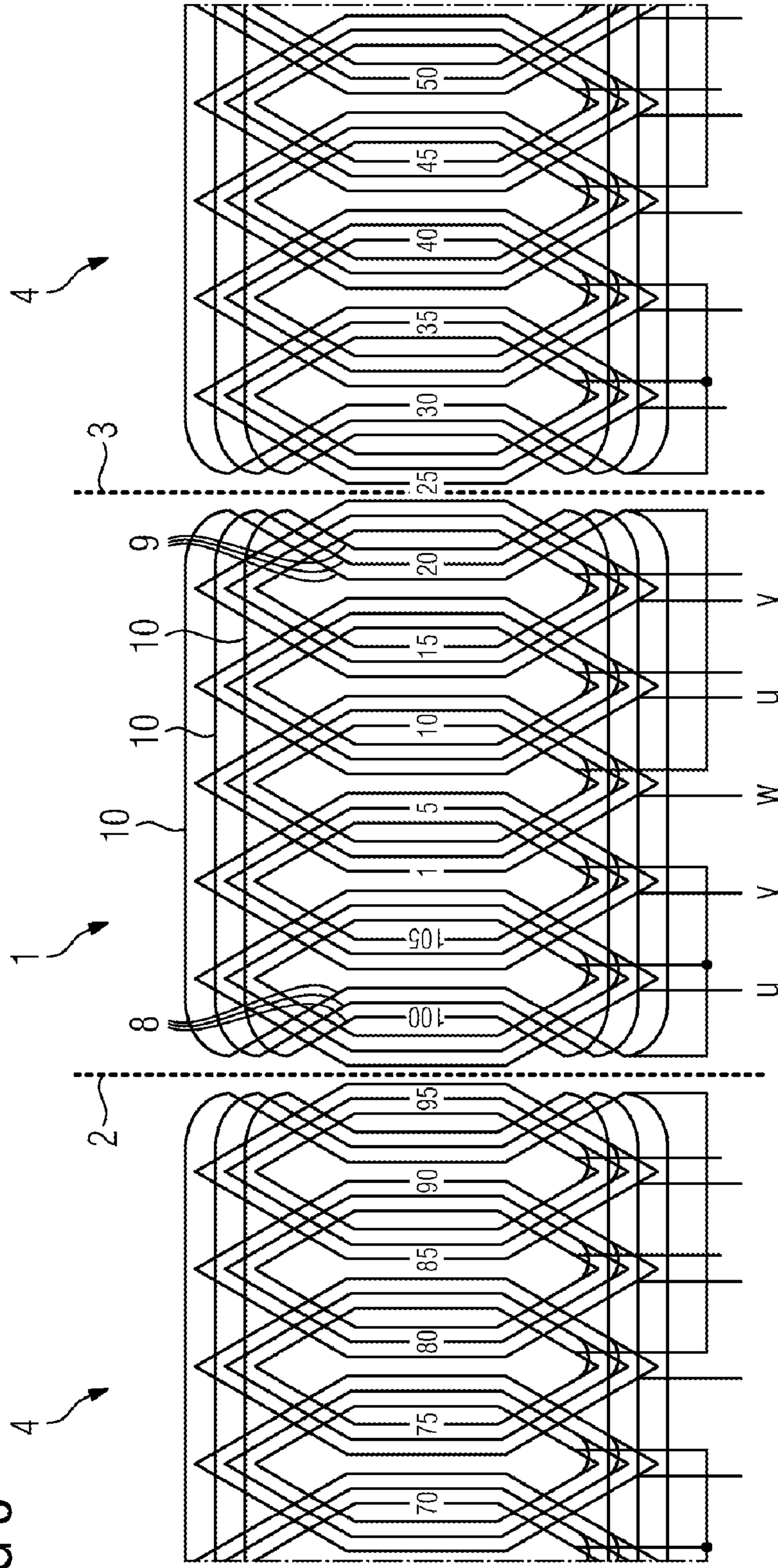


FIG 4

