

PATENT SPECIFICATION

(11) 1 528 770

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- (21) Application No. 44938/75
- (22) Filed 30 Oct. 1975
- (31) Convention Application No. 2451876
- (32) Filed 31 Oct. 1974 in
- (33) Fed. Rep of Germany (DE)
- (44) Complete Specification published
18 Oct. 1978
- (51) INT. CL.² H02K 1/14
- (52) Index at acceptance H2A 16M 16P
16W 16X

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(54) IMPROVEMENTS IN AND RELATING TO SYNCHRONOUS MOTORS

(71) We, AGFA-GEVAERT AKTIENGESELLSCHAFT, a body corporate organised according to the laws of the Federal Republic of Germany, of Leverkusen, Federal Republic of Germany do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement.

The invention relates to a synchronous motor, especially to a stepping motor.

The use of two stators which are staggered with respect on one another by half the pole pitch angle of each stator makes it possible for the armature to execute for each revolution a number of steps which is double the number of pole teeth of each stator. In a known device, the staggering of the two stators by half a pole pitch angle is produced by the fact that a housing which serves to accommodate the two stators has grooves which are off-set with respect to one another by half a pole pitch angle and by means of which the stators, which are provided with extensions, are fixed in their respective positions.

The aim of the invention is to create a synchronous motor of the type mentioned initially which will be of simple construction, inexpensive, and suitable for mass production.

According to the invention there is provided a synchronous motor having first and second coaxially mounted stators, each stator comprising two pole carriers, each carrier having a plurality of equi- angularly spaced pole teeth which mesh with the pole teeth of the other pole carrier of the stator, a pole carrier of one stator lying adjacent to a pole carrier of the other stator in an axial direction, and the pole teeth of each stator lying between a coil and an armature having north and south magnetic poles distributed alternately about its periphery, wherein those pole carriers of the first and second stators which are adjacent to each other in an axial direction are generally planar and substantially identical, each of the substantially identical pole carriers has a plurality of recesses, and/or apertures, and/or projections arranged symmetrically with respect to a plane containing the bisector of the angle between a

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- pole tooth of the stator of which the pole carrier forms a part and a line angularly offset with respect to that pole tooth by half the pole pitch angle of the stator, the plane of symmetry being at right angles to the plane of the pole carrier, and the axially adjacent pole carriers of the first and second stators respectively are aligned so that their respective recesses, and/or apertures, and/or projections are in register whereby the first and second stators are positioned so as to be angularly offset with respect to each other by an angle which is equal to half the pole pitch angle of a stator.
- Each of the axially adjacent pole carriers is preferably provided with an engaging means which engages with co-operating means fixed with respect to the other pole carrier of the stator, the engaging means of each of the axially adjacent pole carriers being located along a line angularly offset with respect to a pole tooth of its respective stator by an angle equal to a half of the pole pitch angle of the stator and the respective engaging means of the axially adjacent pole carriers are offset with respect to each other by an angle equal to one half the pole pitch angle of the stators. The engaging means and the co-operating means serve to fix the pole carriers of a stator with respect to each other so that the pole teeth of one of the pole carriers are located in the correct position in the interstices between the pole teeth of the other pole carrier.
- In an advantageous manner, the plurality of recesses and/or apertures and/or projections provided are boreholes, preferably three in number, which all serve to accommodate connecting components. When three boreholes are provided one borehole may lie on the axis of symmetry. This particular arrangement of the three boreholes offers the advantage that when the two axially adjacent pole carriers have been joined together by means of connecting components engaging through the boreholes, the engaging means of one pole carrier is offset by the required angle of half the pole pitch angle with respect to the engaging means of the other pole carrier. Thus, in a simple manner, the two pole carriers of a stator cannot be fitted together other than in the correct position.
- The construction and connection of the two axially adjacent stator pole carriers renders any further components for the production of the required staggering of the stator pole angle by half the pole pitch angle unnecessary.
- Each stator preferably includes a housing, which is preferably pot-shaped. For each stator, the housing and the teeth of the pole carrier that is not the axially adjacent pole carrier may form one unit that is to say, the housing may itself be a pole carrier. The advantage is thereby offered that the two stators may be built up from similar individual parts and that the off-setting of the pole pitch angle of the two stators may be fixed or determined before final assembly.
- The engaging means on each axially adjacent pole carrier may comprise a projection or a recess and the co-operating means may then comprise a recess or a projection, as the case may be, on the housing of the stator.

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In order to separate the magnetic circuits of the two stators, a non-magnetic layer is preferably provided between the two annular pole plates.

In order that the pole teeth of each of the two axially adjacent pole carriers may be of any required length, the pole teeth may be L-shaped extensions of the pole carrier, which may be an annular plate, with the shanks adjacent to the pole carrier bent parallel to the plane of the pole carrier and running inwards in a radial direction, whilst the free shanks are bent in a direction normal to the plane of the pole carrier. By means of this construction of the pole teeth, optimum rigidity of the pole teeth is also achieved. The free ends of the pole teeth are approximately flush with the inside diameter of the internal bore of the pole carrier, in which is located the permanently magnetic armature.

The invention further provides a generally planar pole carrier for a synchronous motor, the pole carrier having a plurality of equi-angularly spaced pole teeth and a plurality of recesses, and/or apertures, and/or projections arranged symmetrically with respect to a plane containing the bisector of the angle between a pole tooth of the pole carrier and a line angularly offset with respect to that pole tooth by a quarter of the angle between the pole teeth of the pole carrier, the plane of symmetry being at right angles to the plane of the pole carrier.

Apparatus constructed in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 shows a section through two stators of a stepping motor connected to one another;

Fig. 2 is a perspective partial view of a stepping motor;

Fig. 3 is a front view of a first embodiment of a pole plate as used in the motor shown in Fig. 2;

Fig. 4 shows a second embodiment of a pole plate used in a motor according to the invention;

Fig. 5 shows a third embodiment of a pole plate used in a motor according to the invention.

With reference to the drawings, and initially to Fig. 1, a stepping motor indicated generally by reference numeral 1, comprises a first annular stator pole plate 2 which is connected by way of a rivet connection 3 to an identically constructed second annular stator pole plate 4. Between the first and second annular pole plates 2 and 4 there is positioned a disc 5 which is made of non-magnetic material. The annular pole plates 2 and 4 are each provided with pole teeth, those on the first annular pole plate 2 being indicated generally by the reference numeral 8 and those on the second annular pole plate 4 being indicated generally by the reference numeral 9. Two pot-shaped housings, indicated generally by the reference numerals 6 and 7, respectively, engage with the annular pole plates 2 and 4, respectively, the housing 6 having pole teeth, indicated generally by the reference numeral 10, which mesh with the pole teeth 8 of the first annular pole plate 2, and the housing 7

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having pole teeth, indicated generally by the reference numeral 11, which mesh with the pole teeth 9 of the second annular pole plate 4. The respective combinations of the pole plate 2 and the housing 6, and of the pole plate 4 and the housing 7, form first and second
5 stators.

Referring now to Fig. 2, the pole teeth 8 of the stator pole plate 2 are five in number and are arranged equiangularly about the pole plate. The pot-shaped housing 6 also has five, equiangularly arranged pole teeth 10. The teeth 10 of the housing 6 mesh in the
10 interstices between the pole teeth 8 of the pole plate 2. In the stator 2, 6 there is a coil 12 and in the stator 4, 7 there is a coil 13.

The pot-shaped housings 6 and 7 are, like the annular pole plates 2 and 4, of identical construction.

15 The pole teeth 8, 9 are formed from extensions of the pole plates 2 and 4, respectively, which originally projected radially away from the centres of the annular pole plates. The pole teeth 8, 9 were formed by bending each extension radially inwards to form a shank parallel to and adjacent the plane of the pole plate 2 or 4,
20 as the case maybe, and then bending the free end of the extension in a direction normal the plane of its pole plate to form an L-shaped pole tooth. This method of production offers the advantage that pole teeth of any required length can be produced, and that due to their L-shaped construction the pole teeth can be bent into the
25 required position independently of the diameter of the central stator aperture necessary to accommodate the permanently magnetic armature of the motor (not shown) within the pole ring, thus maintaining mechanical stability.

Each pole plate 2 or 4 has on its periphery an extension 14 or 15,
30 respectively, which co-operates with a corresponding aperture 16 in its associated housing 6 or 7. The extension 14 or 15 of the identically constructed pole plates 2 and 4 is off-set to one side of a pole tooth 8 or 9 by half the pole pitch angle 17 of the stator to which the pole tooth belongs. The extension 14 or 15 of the pole
35 plate 2 or 4 is therefore offset with respect to a pole tooth 8 or 9 of its pole plate by an angle which is equal to a quarter of the angle between two adjacent pole teeth of that pole plate.

Similarly, the co-operating aperture 16 of the pot-shaped housing 6 or 7 is off-set by half the pole pitch angle of a stator with
40 respect to a pole tooth 10 or 11 of the housing 6 or 7.

On the bisector of the angle between the extension 14 and the pole tooth 8, shown in Fig. 3 by the dash-dotted line 18, there is a borehole 19. Two further boreholes 20 and 21 are provided symmetrical to the bisector 18 on the pole plate 2. The pole plate 4 is identical to the pole plate 2. Since the rear sides of the two stator
45 pole rings 2 and 4 face one another when the latter are joined together, when the boreholes 19 to 21 are exactly aligned over the corresponding boreholes on the pole plate 4, both the extensions 14 and 15 and also the pole teeth 8 and 9 are staggered with respect to
50 each other by an angle equal to quarter the angle between adjacent

pole teeth on the pole plate 2 or 4, that is to say, by half the pole pitch angle of a stator. The stator pole plates 2 and 4, which are joined together by means of the rivet connection 3, fix the positions of the pot-shaped housings 6 and 7. Hence the stator 2, 6 and 4, 7 can be assembled in a simple manner from similar parts in each case, and the staggering of the pole teeth of each stator by half a pole pitch angle with respect to the pole teeth of the other stator is achieved automatically due to the construction of the component parts of the stators and without any additional aids.

10 The pole plate shown in Fig. 4, indicated generally by the reference numeral 2', and which may be used, with an identically constructed pole plate, in place of the pole plates 2 and 4, has three notches 19', 20' and 21' instead of boreholes. The notches 19', 20' and 21' are distributed around the pole plate 2' in a similar manner to the

15 distribution of the boreholes 19, 20 and 21 about the pole plate 2. When the notches 19', 20' and 21' of two identically constructed stator pole plates 2' are aligned exactly over one another, an interlocked connection can be produced by welding, and the same result is achieved, with regard to the staggering of the poles, as is achieved

20 using the pole plates 2 and 4, which is described above.

On the pole plate shown in Fig. 5, indicated generally by the reference numeral 2'', instead of boreholes two projections 20'' and 21'', are provided, these projections being symmetrically distributed about the bisector of the angle between the extension 14'' and the

25 nearest pole tooth 8''. When the projections 20'' and 21'' of two identically constructed pole plates 2'' are exactly aligned over one another, the stators of which the pole plates form part are again offset with respect to each other by half a pole pitch angle of a stator.

30 WHAT WE CLAIM IS:

1. A synchronous motor having first and second coaxially mounted stators, each stator comprising two pole carriers, each carrier having a plurality of equi-angularly spaced pole teeth which mesh with the pole teeth of the other pole carrier of the stator, a pole

35 carrier of one stator lying adjacent to a pole carrier of the other stator in an axial direction and the pole teeth of each stator lying between a coil and an armature having north and south magnetic poles distributed alternately about its periphery, wherein those pole carriers of the first and second stators which are adjacent to each other in an axial direction are generally planar and substantially

40 identical, each of the substantially identical pole carriers has a plurality of recesses, and/or apertures, and/or projections arranged symmetrically with respect to a plane containing the bisector of the angle between a pole tooth of the stator of which the pole carrier

45 forms a part and a line angularly offset with respect to that pole tooth by half the pole pitch angle of the stator, the plane of symmetry being at right angles to the plane of the pole carrier, and the axially adjacent pole carriers of the first and second stators respectively are aligned so that their respective recesses,

50 and/or apertures, and/or projections are in register whereby the



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pole teeth on the pole plate 2 or 4, that is to say, by half the pole pitch angle of a stator. The stator pole plates 2 and 4, which are joined together by means of the rivet connection 3, fix the positions of the pot-shaped housings 6 and 7. Hence the stator 2, 6 and 4, 7 can be assembled in a simple manner from similar parts in each case, and the staggering of the pole teeth of each stator by half a pole pitch angle with respect to the pole teeth of the other stator is achieved automatically due to the construction of the component parts of the stators and without any additional aids.

- 10 The pole plate shown in Fig. 4, indicated generally by the reference numeral 2', and which may be used, with an identically constructed pole plate, in place of the pole plates 2 and 4, has three notches 19', 20' and 21' instead of boreholes. The notches 19', 20' and 21' are distributed around the pole plate 2' in a similar manner to the
15 distribution of the boreholes 19, 20 and 21 about the pole plate 2. When the notches 19', 20' and 21' of two identically constructed stator pole plates 2' are aligned exactly over one another, an interlocked connection can be produced by welding, and the same result is achieved, with regard to the staggering of the poles, as is achieved
20 using the pole plates 2 and 4, which is described above.

On the pole plate shown in Fig. 5, indicated generally by the reference numeral 2'', instead of boreholes two projections 20'' and 21'', are provided, these projections being symmetrically distributed about the bisector of the angle between the extension 14'' and the
25 nearest pole tooth 8''. When the projections 20'' and 21'' of two identically constructed pole plates 2'' are exactly aligned over one another, the stators of which the pole plates form part are again offset with respect to each other by half a pole pitch angle of a stator.

30 WHAT WE CLAIM IS:

1. A synchronous motor having first and second coaxially mounted stators, each stator comprising two pole carriers, each carrier having a plurality of equi-angularly spaced pole teeth which mesh
35 with the pole teeth of the other pole carrier of the stator, a pole carrier of one stator lying adjacent to a pole carrier of the other stator in an axial direction and the pole teeth of each stator lying between a coil and an armature having north and south magnetic poles distributed alternately about its periphery, wherein those pole carriers of the first and second stators which are adjacent to each
40 other in an axial direction are generally planar and substantially identical, each of the substantially identical pole carriers has a plurality of recesses, and/or apertures, and/or projections arranged symmetrically with respect to a plane containing the bisector of the angle between a pole tooth of the stator of which the pole carrier
45 forms a part and a line angularly offset with respect to that pole tooth by half the pole pitch angle of the stator, the plane of symmetry being at right angles to the plane of the pole carrier, and the axially adjacent pole carriers of the first and second stators respectively are aligned so that their respective recesses,
50 and/or apertures, and/or projections are in register whereby the

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first and second stators are positioned so as to be angularly offset with respect to each other by an angle which is equal to half the pole pitch angle of a stator.

2. A synchronous motor as claimed in claim 1, wherein each of the 5 axially adjacent pole carriers is provided with engaging means which engages with co-operating means fixed with respect to the other carrier of the stator, the engaging means of each axially adjacent pole carrier being located along the line angularly offset with respect to a pole tooth of its respective stator by an angle equal to 10 half the pole pitch angle of the stator and the respective engaging means of each of the axially adjacent pole plates are offset with respect to each other by an angle equal to half the pole pitch angle of a stator.

3. A synchronous motor as claimed in claim 1 or claim 2, wherein 15 the plurality of recesses, and/or apertures, and/or projections on each axially adjacent pole carrier comprises a plurality of boreholes for accommodating components for connecting the axially adjacent pole carriers.

4. A synchronous motor as claimed in any one of claims 1 to 3, 20 wherein the pole teeth of each axially adjacent pole carrier comprise radial extensions of the pole carrier formed into an L-shape, each radial extension having been bent radially inwards to form a shank in a plane parallel to and adjacent the plane of the pole carrier, and the free end portions having been further bent in a direction at 25 right angles to the plane of the pole carrier.

5. A synchronous motor as claimed in any one of claims 1 to 4, wherein each stator includes a housing.

6. A synchronous motor as claimed in claim 5, wherein, for each stator, the housing and the pole teeth of the pole carrier which is 30 not the axially adjacent pole carrier, are formed in one unit.

7. A synchronous motor as claimed in claim 2 and claim 5 or claim 6, wherein the engaging means on each of the axially adjacent pole carrier comprises a further projection or recess and the co-operating means comprises a recess or projection, as the case may be, on the 35 respective stator housing.

8. A synchronous motor as claimed in any one of claims 1 to 7, which is a stepping motor.

9. A synchronous motor substantially as hereinbefore described with reference to, and as shown in, Figs. 1 to 3 or Fig. 4 or Fig. 5 40 of the accompanying drawings.

10. A generally planar pole carrier for a synchronous motor, the pole carrier having a plurality of equi-angularly spaced pole teeth and a plurality of recesses, and/or apertures, and/or projections arranged symmetrically with respect to a plane containing the bisector 45 of the angle between a pole tooth of the pole carrier and a line



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angularly offset with respect to that pole tooth by a quarter of the angle between the pole teeth of the pole carrier, the plane of symmetry being at right angles to the plane of the pole carrier.

11. A pole carrier for a synchronous motor substantially as hereinbefore described with reference to, and as shown in, Fig. 3, or Fig. 4, or Fig. 5 of the accompanying drawings.

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Printed by Her Majesty's Stationery Office
Reprographic Centre, Basildon, Essex, 1978.
Published at the Patent Office, 25 Southampton Buildings
London, WC2A 1AY, from which copies may be obtained.