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H2A

(71) Applicant
Caterpillar Tractor Co. (USA-Illinois),
100 Northeast Adams Street, Peoria, Illinois 61629, United States of America

(72) Inventors
John David Marsh,
Craig Anthony Nazzer,
Edouard Hendrikus Damhuis

(74) Agent and/or Address for Service
Gill Jennings & Every,
53-64 Chancery Lane, London WC2A 1HN

(54) Modular motor construction

(57) An electromagnetic machine comprises a plurality of n stators (1), each stator including an annular coil (7) and a plurality of U-shaped pole pieces (6) in straddling relationship to the coil. Adjacent ones of the pole pieces open in opposite radial directions. A plurality of n + 1 rotors (2) are disposed alternately with the stators on a common axis. The rotors each include a plurality of permanent magnets (3) equal in number to the number of pole pieces in the stator. Each of the n − 1 rotors which have stators on both sides carries two series of permanent magnets arranged equidistantly around the periphery of the rotor on opposite sides of a central axial plane of the rotor.

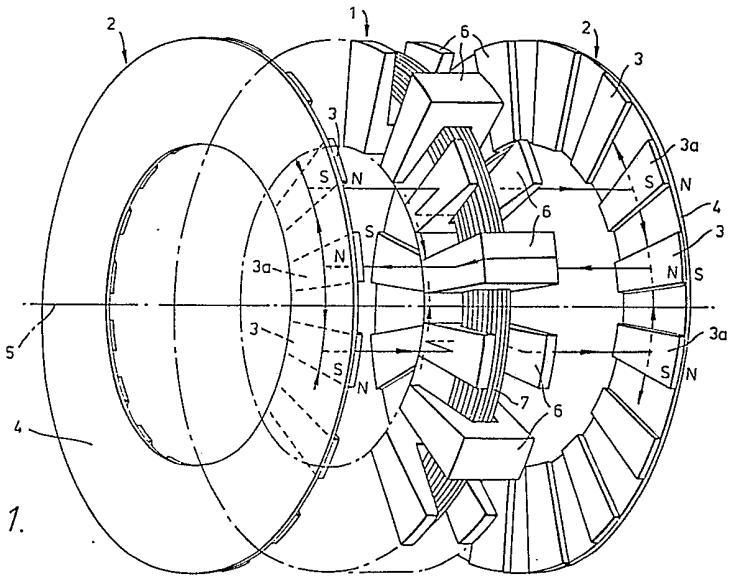

Fig. 1.

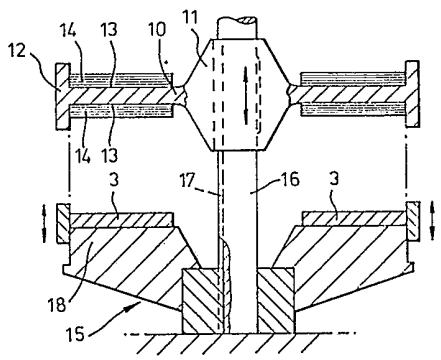

Fig. 2.

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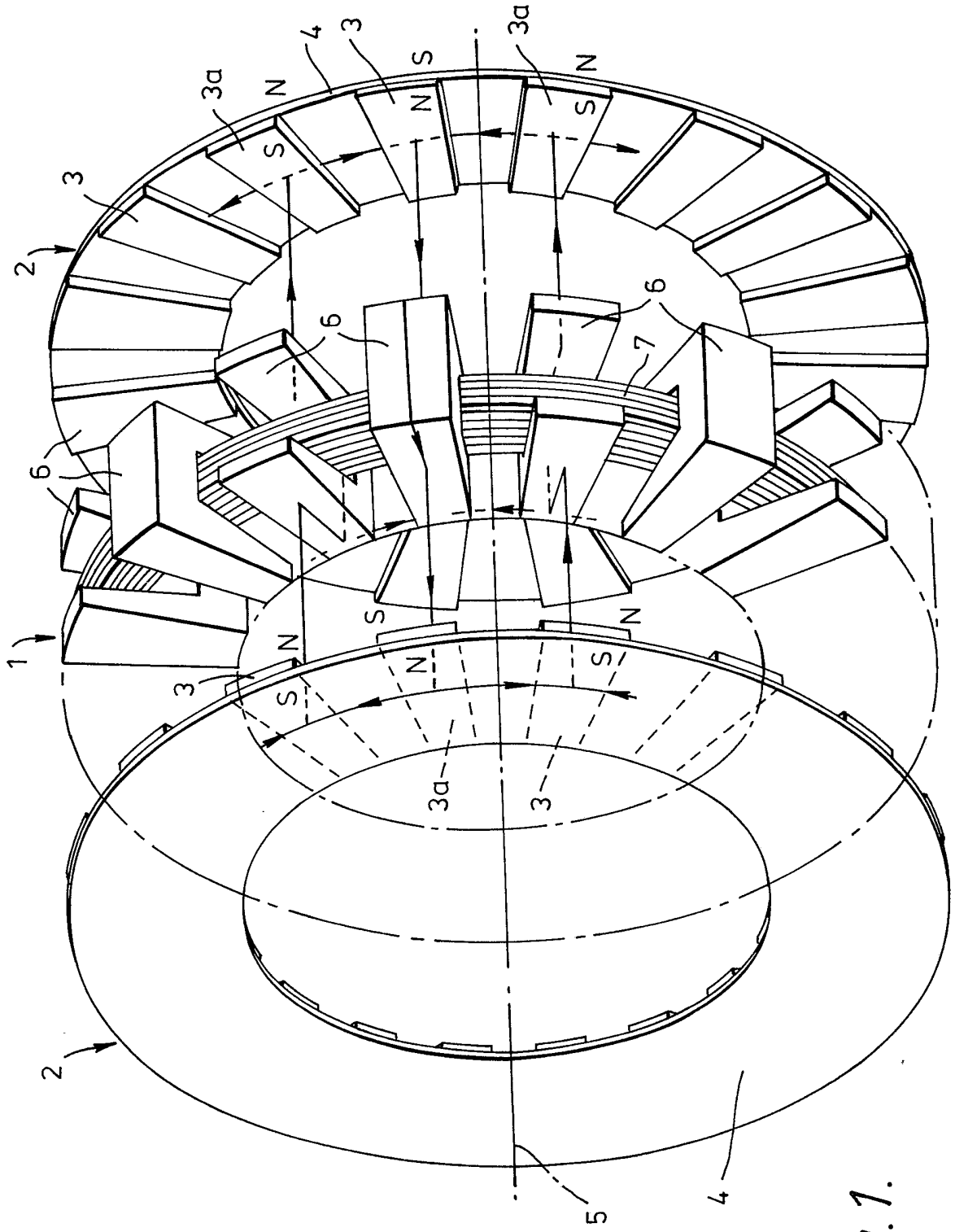


Fig. 1.

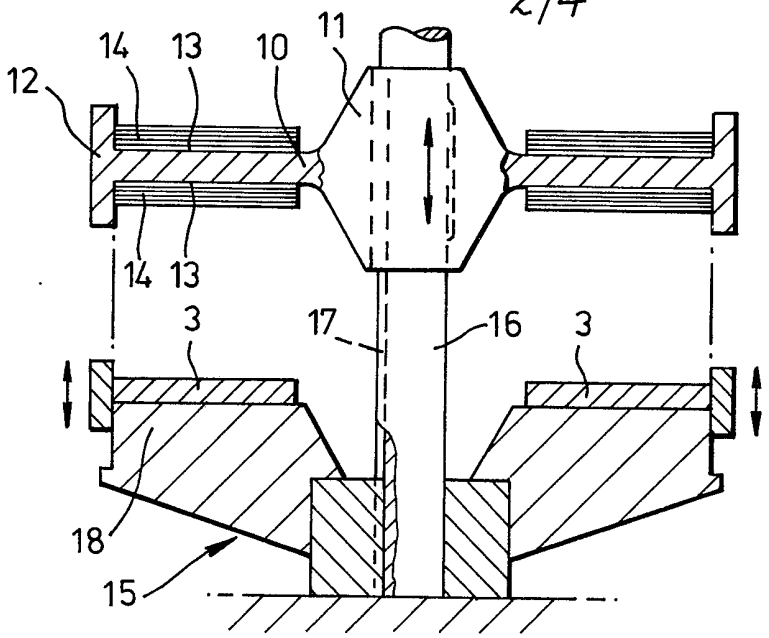


Fig. 2.

Fig. 4.

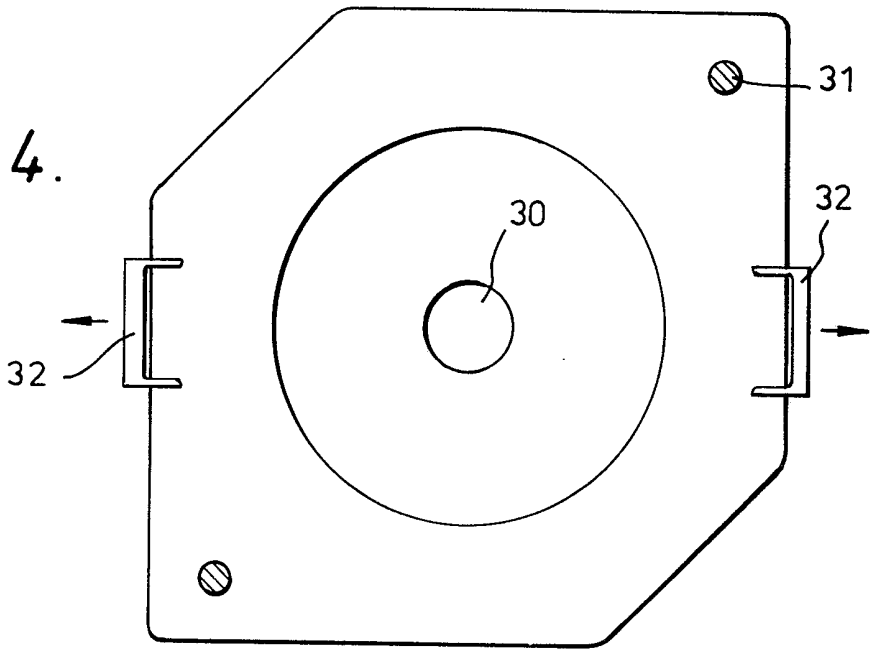
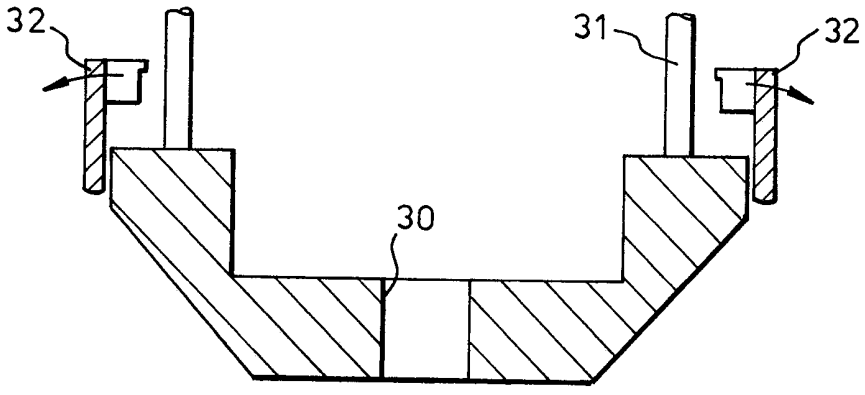


Fig. 5.



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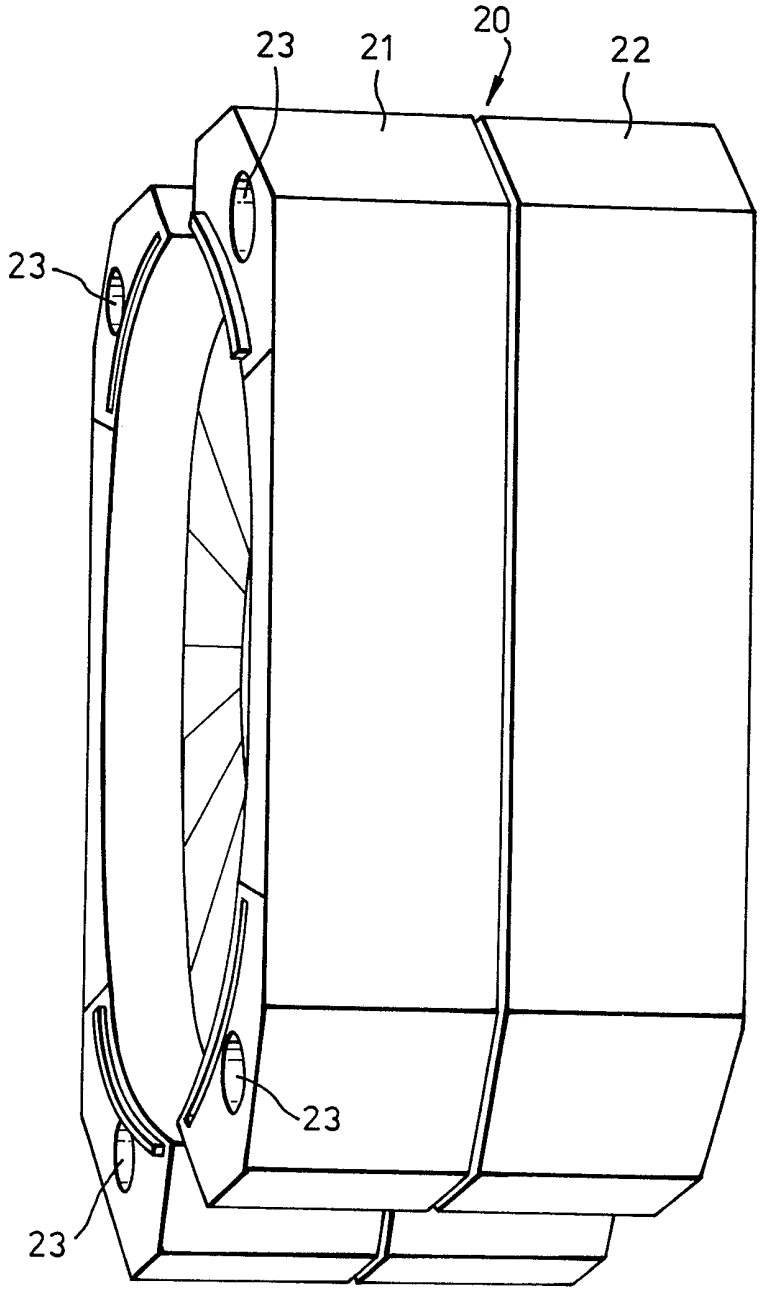

Fig. 3.

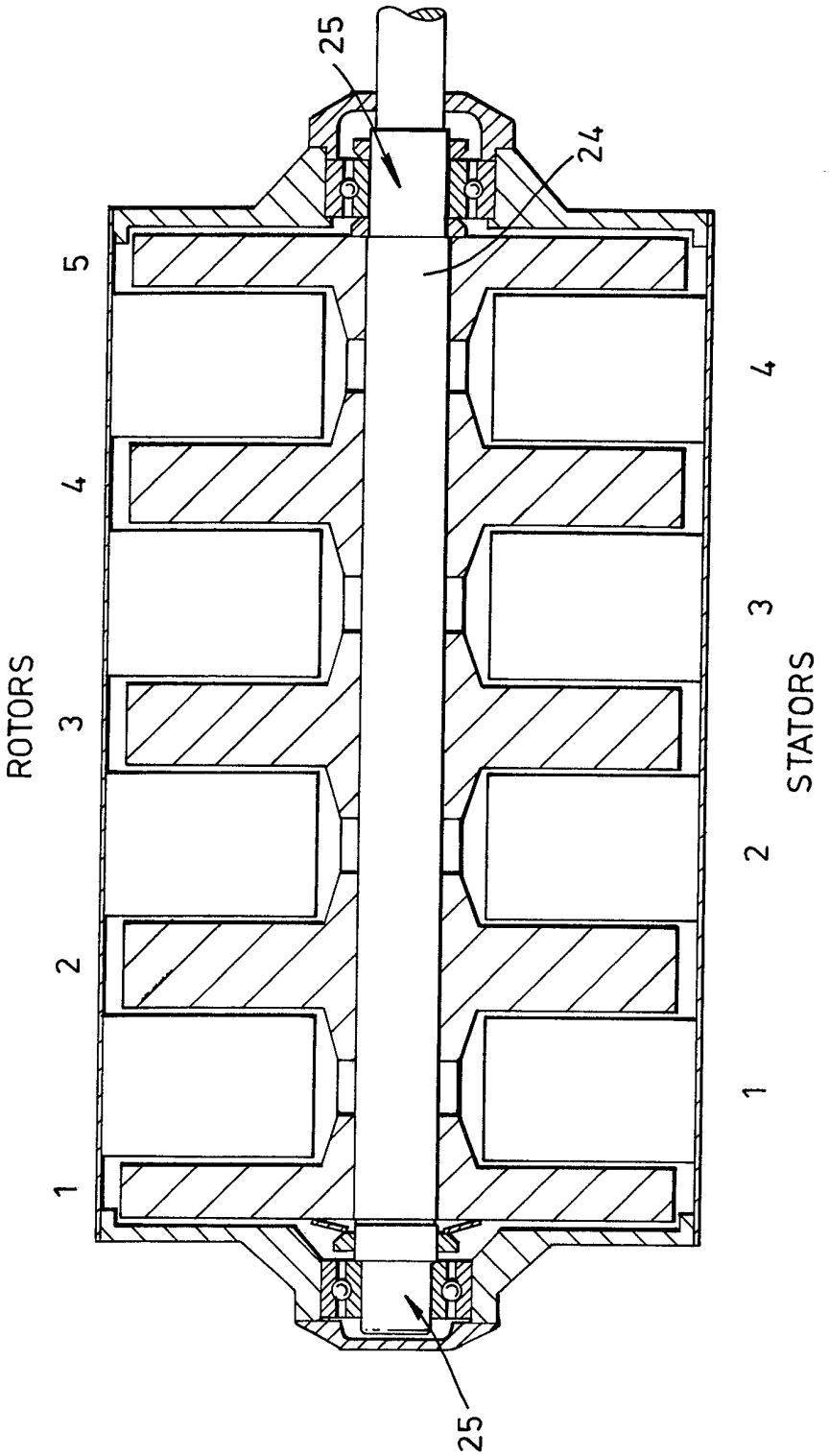

Fig. 6.

SPECIFICATION

Modular motor construction

The present invention relates to electromagnetic machines, such as motors, of the type described in GB-A-1 541 211.

Figure 1 shows, diagrammatically, the basic elements of such a machine. The machine has a stator 1 and a pair of rotors 2, each of the rotors carrying a series of permanent magnets 3, 3a, arranged equidistantly around the periphery of the rotor on a magnetically permeable steel annulus 4. Alternate ones of the magnets 3, 3a, have their north and south poles facing in opposite directions and a south pole on one rotor faces a north pole on the other rotor and vice-versa. The rotors 2 and stator 1 are positioned on a common central axis 5, the rotors being held in fixed position on a common shaft (not shown) for rotation. The stator 1 has plurality of U-shaped pole pieces 6 alternately arranged opening inwards and outwards and equidistantly arranged around the periphery of the rotor at the same spacing as the permanent magnets 3, 3a. The pole pieces thus provide paths for the magnetic flux between the magnets, on the two rotors, on opposite sides of the stator the alternating arrangement of the pole pieces providing a magnetic flux path alternately inwardly and outwardly of a coil 7 which runs through the pole pieces. By continuously changing the direction of the current through the coil the rotors can be arranged to rotate about the axis 5 relative to the stator.

According to the present invention such a machine comprises a plurality of n stators, each stator including an annular coil and a plurality of U-shaped pole pieces in straddling relationship to the coil, adjacent ones of the pole pieces opening in opposite radial directions; and a plurality of n + 1 rotors disposed alternately with the stators on a common axis, the rotors each including a plurality of permanent magnets equal in number to the number of pole pieces in the stator, wherein each of the n − 1 rotors which have stators on both sides carries two series of permanent magnets arranged equidistantly around the periphery of the rotor on opposite sides of a central axial plane of the rotor.

Preferably, the two outer rotors are of a different construction having but a single annular series of permanent magnets equidistantly arranged arround one face of the rotor.

Each of the rotors may comprise a supporting disc integrally formed with a central hub for locating the rotor on a common shaft along the axis of the motor and a plurality of annular laminations of a magnetically permeable material stacked one on top of another on one or both faces of the supporting disc, an annular series of magnets being bonded to the or each stack of laminations.

Preferably, the supporting disc and hub comprise aluminium or aluminium alloy, being cast and then machined to the desired dimensions. The magnetically permeable laminations comprise steel annuli which are bonded, for example, by an epoxy resin, to the supporting disc and additionally reveted together onto the disc.

Advantageously, the support disc has an outer rim against which the or each annular array of magnets abut to provide a measure of support in addition to physical bonding of the magnets to the respective laminations.

One example of a machine constructed in accordance with the present invention will now be described with reference to Figures 2 to 6 of the accompanying drawings in which:-

Figure 2 is a side elevation of a double-sided rotor assembly jig showing how the magnets can be mounted on a rotor;

Figure 3 is a perspective view of a completed stator;

Figures 4 and *5* show an assembly table for the motor; and,

Figure 6 shows a schematic view of an assembled motor.

Each rotor comprises an aluminium support disc 10 integrally formed with a central hub 11 and a peripheral rim 12. The hub is formed with a conventional key slot for enabling the rotor to be keyed to a common shaft of the motor. On each face 13 of the supporting disc 10 an annular stack of laminations 14 is formed, the laminations being bonded to one another and to the respective face of the disc 10, and, additionally for security of fixing, held by rivets (not shown) extending through the disc.

The rotor shown in Figure 2 is a double-sided rotor, that is to say one having laminations and magnets on both sides, and the two end rotors can be of a simple, one-sided construction, that is to say having a stack of laminations and respective magnets on only one side. The end rotors can thus be of a substantially reduced overall thickness to reduce the overall length of the motor.

To mount the magnets on the respective laminations a simple assembly jig 15 is used, the centre of the jig having a dummy shaft 16 with a keyway 17 for supporting each rotor disc above the magnets which are located in precise positions on an annular table 18. Using the keyway as a guide the magnets and disc are aligned correctly and brought together after the application of a fast-curing adhesive to the magnet surfaces.

The magnets, like the laminations, abut the peripheral rim 12 which thus provides a measure of lateral support as an added measure of security.

The stator is preferably of a construction as described in our copending application, reference 90/2103/01 (84-10975), that is to say the stator comprises a spider formed with a plurality of bearing surfaces to positively locate the pole pieces therein and has an external housing, such as shown in Figure 3. The housing 20 is formed in two parts, 21, 22, and has bores 23 parallel to the axis of the stator by means of which, in cooperation with bolts passing therethrough, the stators can be series mounted in alignment.

To assemble a plurality of rotors and stators on a common shaft an assembly table as illustrated in Figures 4 and 5 is used. Figure 4 shows a plan view and Figure 5 a side elevation of the assembly table. The assembly table has a central hole 30 for gripping

the motor shaft 24, hold it vertically, and two vertcial guide bars 31 for supporting the stators.

The method of assembly is as follows, firstly the first rotor with its key, an end ring and suitable end plate and a fixed bearing assembly are slid onto a splined end of the shaft and the splined end of the shaft is then fixed vertically into the assembly table, the end plate being rotated until the guide bars locate into two diagonally opposite bolt holes. The rotor is then clamped down against the end rim by fixing clamps 32 which attach to the rotor rim on opposite sides and which align with the open sides of the stator housing. The first stator is then slid over the guide bars and as the stator approaches the rotor already mounted on the shaft, the magnetic attraction rises and as the rotor is held down, having to be lowered gently towards the rotor. The stator will bear against an end plate leaving a gap between the pole pieces on the and the rotor itself.

At this stage tie bolts can be fixed into the remaining corner holes of the stator. A spacer plate is then located on the shaft and the second rotor attached. The same procedure is then continued for the remaining rotors and stators until the end rotor is attached together with a suitable end plate and bearing assembly. Tie bolts extending parallel with the shaft and through the bores in the stator housings can then be tightened and the clamps on the first rotor released. After removal of the motor from the jig the second pair of tie bolts can be inserted and tightened.

At this stage the auxiliary elements of end caps, bus bars, commutator and covers over open sections of the stator housing can be attached.

Figure 6 shows the completed motor in schematic cross-sectional view, the rotors and stators being independently numbered respectively from 1 to 5 and from 1 to 4, the three central rotors being double-sided and the end rotors single-sided, and the whole assembly, including the shaft and suitable bearing assemblies 25 being held firm by the two pairs of tie bolts (not shown).

CLAIMS

1. An electromagnetic machine comprising a plurality of n stators, each stator including an annular coil and a plurality of U-shaped pole pieces in straddling relationship to the coil, adjacent ones of the pole pieces opening in opposite radial directions; and a plurality of n + 1 rotors disposed alternately with the stators on a common axis, the rotors each including a plurality of permanent magnets equal in number to the number of pole pieces in the stator, wherein each of the n − 1 rotors which have stators on both sides, carries two series of permanent magnets arranged equidistantly around the periphery of the rotor on opposite sides of a central axial plane of the rotor.

2. A machine according to claim 1, wherein the two outer rotors are of a different construction having but a single annular series of permanent magnets equidistantly arranged around one face of the rotor.

3. A machine according to claim 1 oc claim 2, wherein each the rotor comprises a supporting disc, integrally formed with a central hub for locating the rotor on a common shaft along the axis of the machine; a plurality of annular laminations of a magnetically permeable material stacked one on top of another on at least one face of the supporting disc; and an annular series of magnets bonded to the at least one stack of laminations.

4. A machine according to claim 3, wherein each supporting disc and hub comprise aluminium or aluminium alloy.

5. A machine according to claim 3 or claim 4, wherein the magnetically permeable laminations comprise steel annuli bonded to the supporting disc and additionally riveted together onto the disc.

6. A machine according to any of claims 3 to 5, wherein each supporting disc has an outer rim against which the annular array of magnets abuts to provide a measure of support in addition to physical bonding of the magnets to the respective laminations.

7. A machine according to claim 1, substantially as described with reference to Figures 2 to 6 of the accompanying drawings.

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