Nov. 8, 1949 P. H. J. BROUWER 2,487,692

LAMINATED MAGNETIC CIRCUIT ELEMENT

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Fig. 1a.

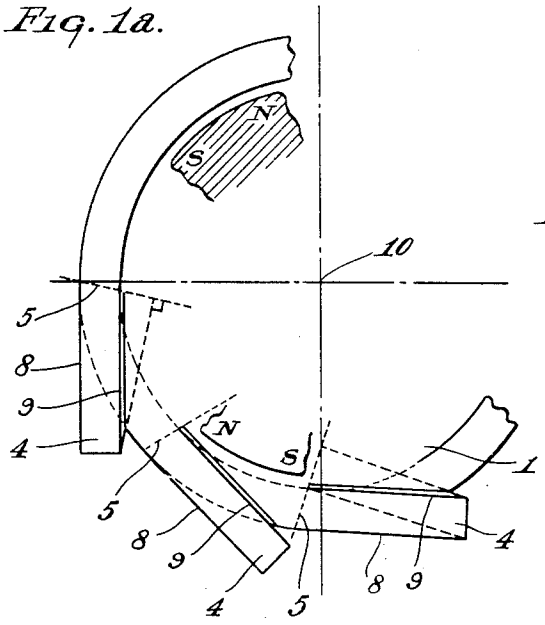


Fig. 1c.

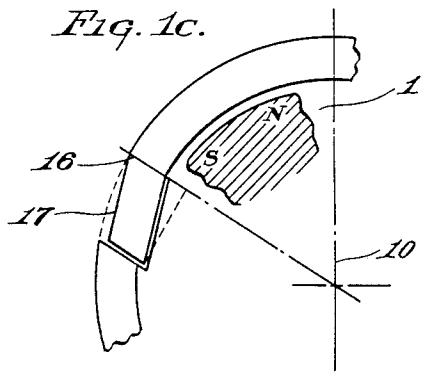


Fig. 1d.

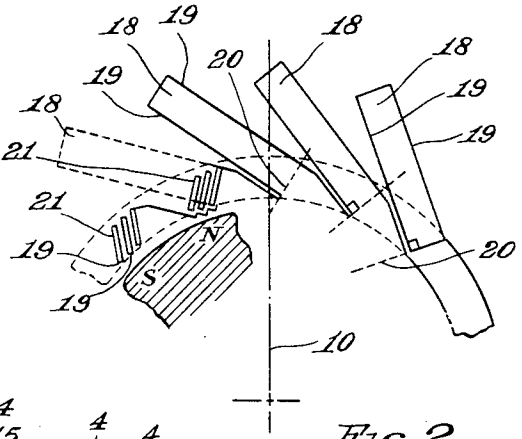


Fig. 1b.

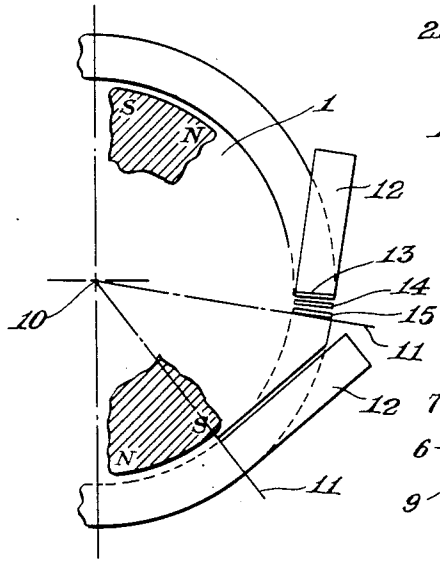


Fig. 2.

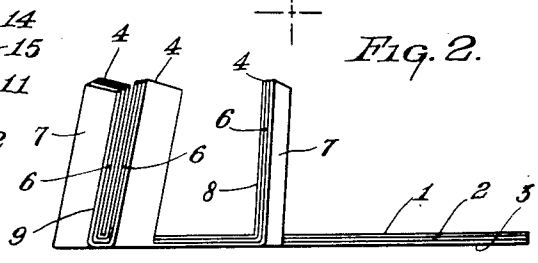


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Fig. 3.

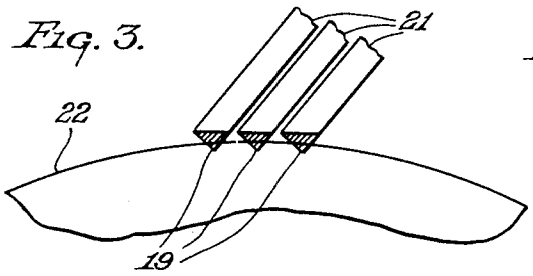



Fig. 4.

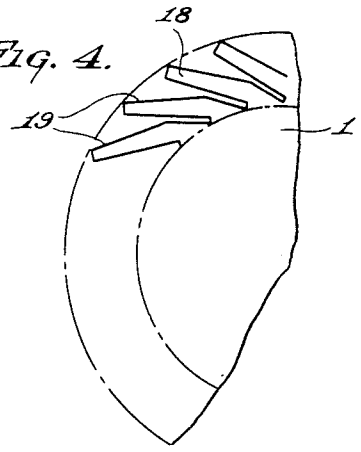



Fig. 5.

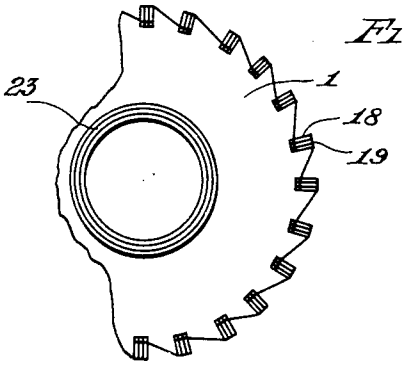



Fig. 6.

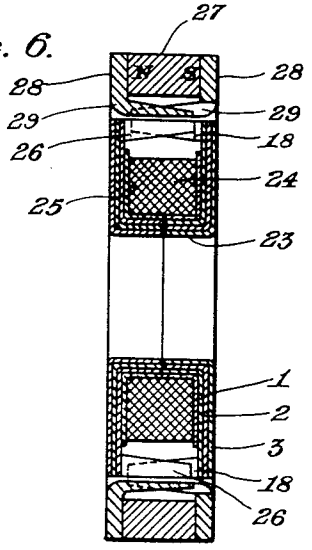
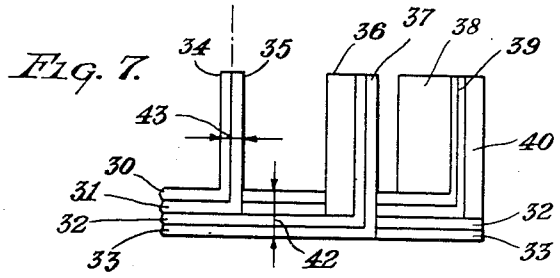



Fig. 7.



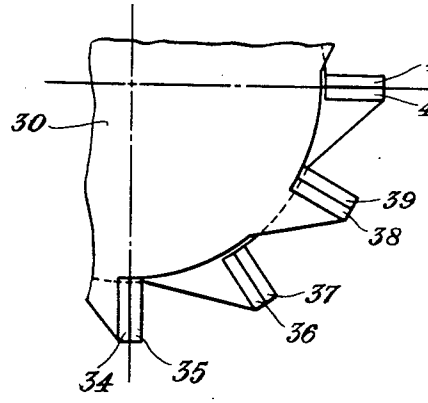




Fig. 8.

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## LAMINATED MAGNETIC CIRCUIT ELEMENT

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Application February 28, 1948, Serial No. 11,926
In the Netherlands March 29, 1947

6 Claims. (Cl. 171—252)

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The invention relates to a laminated magnetic circuit which comprises two or more piled plates and is characterized in that the plates are provided with a number of laminated poles arranged on edge and formed by such bending-over of tags of the plates, which tags extend in a more or less tangential direction, that the upright edges of the poles provided on the same side are located on a surface of revolution. The surface of revolution may be, for example, a hyperboloid of revolution, a truncated cone and so forth.

Laminated magnetic circuits comprising laminated poles arranged on edge are known per se, but in contradistinction to the method of invention according to which this is realized by a suitably chosen form of the plates with tags and by bending thereof, they were realized by simply arranging separate laminated poles so that the lamination planes extend in a radial direction, the poles still requiring to be brought into magnetic contact with one another through a separate structural member which provides a path for the lines of force (see, for example, Dutch patent specification 50,255).

In the magnetic circuit according to the inventiton each plate is integral with its tags, so that an ideal path of lines of force without interruptions is formed.

The poles arranged on edge have the advantage known per se that the passage of the magnetic lines of force at the air gap from or towards the poles is not adversely affected by the reluctance prevailing between the laminations.

Finally, realizing the magnetic circuit in accordance with the invention permits the use of a very large number of poles, so that this lay-out is excellently suitable for use in hub- (or shaft) dynamos for bicycles, for low-speed synchronous motors, for example for clocks and the like.

A particularly simple embodiment of the invention convenient for mass production is obtained when the tags are bent-over to such an extent that the plane of the tags is at right angles to the original plane of the plates before the tags are bent out of the plate.

According to a further feature of the invention, the tags are bent-over in such manner that the upright edges of the poles are located on a cylindrical shell.

Bending-over may be effected in such manner that the plane of the tags is with the cylindrical surface at an angle which diverges from 90°. If, in such a construction those sides on edge of each of the poles which face the cylindrical

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shell are caused to be located, for example by grinding, in planes which are concentric or substantially concentric to the cylindrical shell, this results in a frequently desired enlargement of the pole surface area through which the lines of force enter or leave the poles at the air gap.

In order that the invention may be more clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which the diagrammatic figures show, by way of example, embodiments of the invention.

Figs. 1*a*, 1*b*, 1*c* and 1*d* show in a plan view laminations with the poles formed by bending tags out of the plane of the laminations at various angles in accordance with the invention;

Fig. 2 is a side elevational view showing the positions of the tags in Fig. 1*a*;

Fig. 3 is a plan view of a section of a pole;

Fig. 4 shows a diagrammatic plan view of the magnetic circuit element for a dynamo according to the invention;

Fig. 5 shows an elevational view of the magnetic circuit element shown in Fig. 4;

Fig. 6 shows a magnetic circuit assembly including the laminated element shown in Fig. 5;

Fig. 7 shows a side-view of another form of a magnetic circuit element according to the invention; and

Fig. 8 shows a plan view of the magnetic circuit element shown in Fig. 7.

Referring to Fig. 1*a*, the three plates from which the laminated circuit is built up are designated 1, 2 and 3 respectively, as illustrated in Fig. 2. According to the invention the plates are each provided with a tag 4 which extends more or less tangentially. The tags 4 are bent over along dotted lines 5 so as to extend at right angles to the plane of the drawing, which results in a form as shown in side-elevation in Fig. 2. The corresponding tags of plates 2 and 3 are designated in Fig. 2 as 6 and 7 respectively. The previously tangentially directed edges 8 and 9 of the tags are thus caused to be located in a surface of revolution, which in the present case is the surface of a hyperboloid of revolution, since all the edges 8 and 9 cross the perpendicular axis 10 at equal angles and at equal distances. The bent-over tags thus form a plurality of laminated poles, arranged on edge, of the magnetic circuit, inside or outside which the counter poles of, for example, a permanent magnet may be arranged. It is, of course, likewise preferable to arrange the latter poles as well to lie in a surface of revolution of correspond-

ing form, i. e. of a hyperboloid of revolution, so that the air gap between the poles and the counter poles is of invariable width throughout its length.

When choosing the direction of the bending lines **5** it is essential that the bending should ensure that the lines of force enter or leave the poles at least substantially on their sides arranged on edge.

Choosing the bending lines of tags extending accurately in a tangential direction to be exactly radial, as denoted by lines **11** near the tags **12** in Fig. 1*b*, for example, causes the ends of the tags which form the poles to lie on a surface of revolution which is a cylinder and this also allows the aforesaid counter poles to be arranged on a surface of revolution which is a cylinder which is concentric with the first cylindrical surface. This ensures not only a uniform air gap but also a simple shape. The three bent-over tags of plates **1** to **3** are designated in Fig. 1*b* by **13** to **15**.

When using radial bending lines and tags, the longitudinal direction which diverges from the tangential direction towards the material of the plate **1**, designated in Fig. 1*c* by **16** and **17**, the lateral edges of such tags **17** are bent at right angles are caused to be located on the surface of a truncated cone, so that, while maintaining a uniform air gap, counter poles are required which are also located in a conical surface.

For obtaining a large number of poles, such as is most desirable in the case of hub dynamos for bicycles, the tags must extend towards their ends in a direction which is remote from the material of the plates. Thus, when using plates the outer edges of which carry the tags, as in the case of Fig. 1*d*, the tags **18**, for example, fulfil this condition. It is obvious from the Fig. 1*d* that a larger number of tags can be provided than in the case of a choice according to the arrangement of the tags **4**, **12** or **17** as shown in Figs. 1*a*, 1*b* and 1*c*, respectively.

When using annular plates with which the tags are arranged at the inner edge, the same condition obtains, it being necessary for the tags also to extend in a direction which is directed towards the centre to a greater extent than the exactly tangential direction.

By bending-over the tags **18** shown in Fig. 1*d* along the bending lines **20** which are at right angles to the lateral edges **19**, provision is made of poles arranged on edge, as designated by **21**, the lateral edges **19** of which are again located on a cylindrical shell. Part of the permanent magnetic rotor arranged inside the circuit and provided with poles S and N is designated **22**. In such cases it is advisable to perfect the edges, at least on the side facing the rotor **22**, as shown in Fig. 3, where the cross-hatched part of the lateral edges **19** has been removed by a grinding operation, during which the magnetic circuit comprising the bent-over tags is supported, for example, in a fitting templet, and a smooth surface is thus obtained. The advantage of such positioning of poles arranged on edge consists in larger pole surface due to the bevelled edges.

Figs. 4, 5 and 6 show diagrammatically the construction of a hub dynamo.

As in Fig. 1*d*, three plates **1**, **2** and **3** in Fig. 4 are provided with tags **18** which are bent-over in such manner that the outer edges **19** are at right angles to the plane of the drawing. In addition, the tags are slightly turned so as



to cause the planes of the tags to occupy an accurately radial position, as may be seen from Fig. 5. The central part of each of the plates **1** to **3** is provided with a pressed-through, cylindrical part **23** (Figs. 5 and 6) so that an annular body is formed. Two of such bodies are assembled together with their cylindrical parts and a coil **24** and its coil former **25**, in such manner that the bent-over tags **18** of the ring on the right-hand side (Fig. 6) fall between the tags **26** of the ring on the left-hand side, so that a magnetic circuit is formed with poles alternatively extending from the left to the right and conversely, the external edges forming a cylindrical surface.

This circuit is surrounded by a second circuit which is constituted by an annular permanent magnet **27** and of two annular plates **28**, which are also provided with poles **29** extending alternatively from the left to the right and conversely. The operation of this circuit will be obvious without further explanation. In principle, the annular plates **28** and the associated poles **29** may be constructed in the manner according to the invention.

Finally Figs. 7 and 8 are a side-view and a plan view respectively of part of a magnetic circuit, the thickness of the poles being less than the wall thickness of the magnetic circuit. For this purpose use is made of two sets of plates **30**, **31** and **32**, **33**, the poles of which alternate with one another. Poles **34**, **35** associated with the plates **30**, **31** are arranged adjacent to poles **36**, **37** of the plates **32**, **33** and poles **36**, **37** are followed by poles **38**, **39**, which in turn are associated with the plates **30**, **31**. Adjacent to the poles **38**, **39** are poles **40**, **41** associated with the plates **31**, **33** and so forth. It consequently comes to this that the poles of one set of plates should be sufficiently spaced apart to accommodate other poles of another set of associated plates. Instead of two sets of plates being combined, three or more sets of plates may be combined in a corresponding manner. It may be seen from Fig. 7 that the wall thickness of the circuit **42** is double the thickness **43** of the poles.

As an alternative, use may be made of an expedient as shown in Fig. 6 and designated **23**, with the result that the lines of force need not pass from one plate to a subjacent one.

What I claim is:

1. A laminated magnetic circuit element comprising a plurality of stacked generally circular plate-like laminations, each lamination having a plurality of pole-pieces which form poles arranged on edge around each lamination, each of the pole-pieces being constituted by a tag-like projection of the lamination extending substantially tangentially therefrom and which is inclined with the plane of the lamination to form an angle therewith of substantially 90°.

2. A laminated magnetic circuit element comprising a plurality of stacked generally circular plate-like laminations, each lamination having a plurality of pole-pieces which form poles arranged on edge around each lamination, each of the pole-pieces being constituted by a tag-like projection of the lamination extending substantially tangentially therefrom and inclined with the plane thereof to form an angle of substantially 90°, the pole-pieces having upright edges which have their loci on the surface of a cylinder.

3. A laminated magnetic circuit element comprising a plurality of stacked generally circular

plate-like laminations each having a plurality of pole-pieces which form poles arranged on edge of each lamination, each of the pole-pieces being constituted by a tag-like projection of the lamination extending substantially tangentially therefrom and inclined with the plane thereof to form an angle of substantially 90°; the pole-pieces having upright edges which have their loci on the surface of a cylinder of revolution, each of the pole-pieces being planar, the plane of which forms an angle with the cylindrical surface which diverges from 90°.

4. A magnetic circuit element as defined in claim 3 in which the sides on edge on each of the pole-pieces which face the cylindrical surface are substantially concentric therewith.

5. A magnetic circuit element as defined in claim 3 in which the pole-pieces extend endwise in a direction which is remote from the plane of the laminations.



6. A magnetic circuit element as defined in claim 3 in which the pole-pieces are arranged around the periphery of the laminations and the central portion of each lamination is deformed to have the general shape of a cylindrical core perpendicular to the plane of each of the laminations.

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