April 24, 1945. W. L. HANSEN ET AL 2,374,347

ROTOR

Original Filed Dec. 2, 1940

FIG. 1.

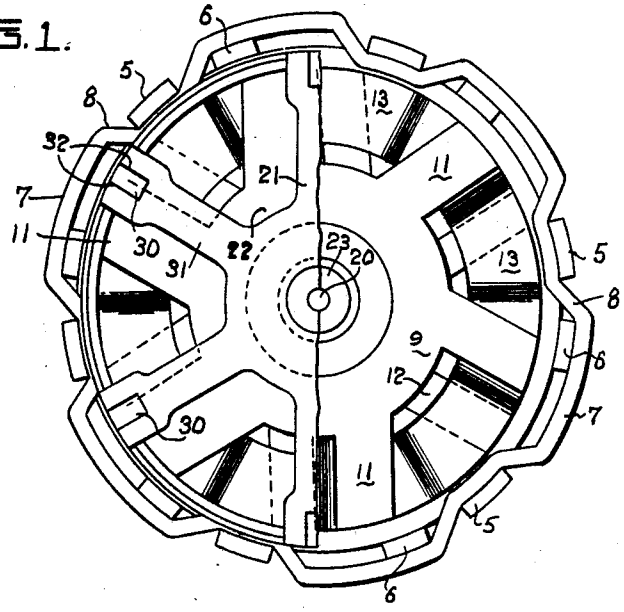


FIG. 2.

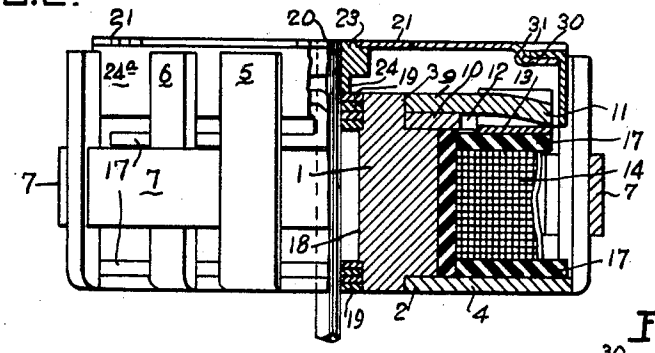


FIG. 4.

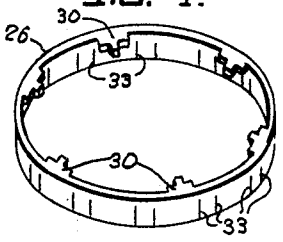


FIG. 3.

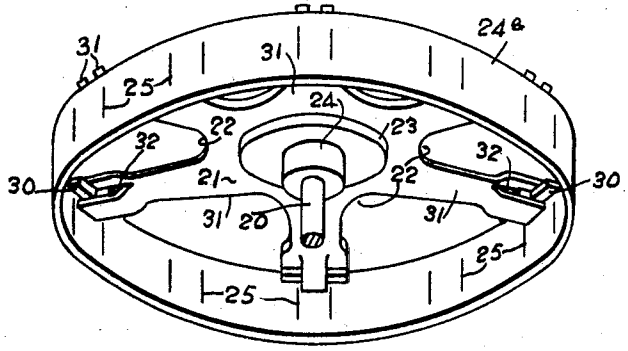
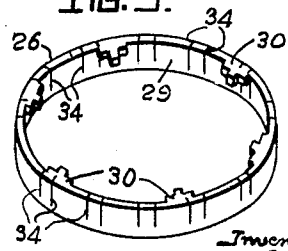


FIG. 5.



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ROTOR

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Original application December 2, 1940, Serial No. 368,138. Divided and this application April 29, 1942, Serial No. 440,993

3 Claims. (Cl. 172—278)

The present invention relates to synchronous motors, and more particularly to the rotor element thereof.

This application is a division of our copending application, Ser. No. 368,138, filed December 2, 1940, now Patent No. 2,349,620 and entitled "Rotors."

In the fabrication of synchronous motors it has been customary to provide a rotor formed out of spring strip magnetic material, the strip being provided with arcuate incisions while in flat form, and then sprung into circular shape and held in that shape by a flanged retaining member. Rotors of this type have given satisfactory performance, but it has been found that at the place where the two ends of the strip abut there is left a small air space which constitutes a virtual air gap, even when great precaution is taken to assure a complete contact over the entire areas of the abutting strip ends. This small but effective air gap represents a discontinuity of the magnetic circuit, of which the rotor forms a part, so that all parts of the rotor may not react in a strictly uniform manner to the magnetic fields produced by the pole pieces. It will be understood that these ends cannot normally be welded together without increasing the thickness of the rotor at the place of the weld, or without causing deleterious effects within the metal of the rotor introduced by the heat of the weld.

In addition to the disadvantage mentioned above, a further consideration is the fact that a rotor formed of spring strip metal and sprung to a circular configuration requires considerable hand labor of an expensive character.

The primary object of the present invention is to provide an improved rotor for synchronous motors.

A more specific object is to provide a rotor in which the magnetic band is completely continuous, i. e., without any abutting ends which might introduce small but effective air gaps of an undesired character.

The above objects are attained, in brief, by starting out with a flat piece of magnetic material of circular disc form, and bending the edges of the disc into a cup-shaped configuration, and thereafter removing the flat portion of the cup-shaped element to leave the upturned ring portion which constitutes the rotor. Incisions of any desired shape and at any desired position are formed in the rotor while the material is in the flat disc form, so that these incisions appear in the final rotor band.

The invention will be better understood when the specification is perused in connection with the accompanying drawing.

In the drawing:

Figure 1 is a top plan view of a motor which employs the improved rotor of this invention. A portion of the rotor structure has been broken away to show the magnetic circuit, including the shading rings.

Figure 2 is an elevational view of the motor shown in Figure 1, one-half of the view being in cross section.

Figure 3 is a perspective view of one form of the improved rotor, including the arms by which the rotor is mounted on its shaft.

Figures 4 and 5 represent perspective views of two modified forms of the improved rotor.

The use of the improved rotor has been typically illustrated in Figures 1 and 2 in connection with a synchronous motor of the annular air gap type. In these figures reference numeral 1 designates a magnetic tubular hub having reduced diameter portions 2, 3, upon which are mounted the outer and inner field pole assemblies. The outer field pole structure consists of a disc 4 having an aperture by which it is mounted on the portion 2 of the hub 1, and having axially extending pole pieces 5, 6 disposed alternately in a cylindrical path about the hub 1. The pole pieces 5 and 6 are preferably arranged in pairs around the periphery of the disc. The alternate pole pieces 5 are of greater width than the pole pieces 6, and are shaded by an undulating ring 7 of non-magnetic material such as copper. This ring passes over the outer surfaces of the pole pieces 6 and therefore does not shade them. However, the shading ring is provided with undulating portions 8 which pass around three sides of the pole pieces 5 to shade these pole pieces, thus providing a phase lag when the field structure is magnetized by an alternating flux.

The inner pole piece assembly consists of a pair of star-shaped discs 9, 10 (Figure 2), having an aperture by which they are mounted on the portion 3 of the hub 1. The discs 9, 10 are provided with pole pieces 11, 12, respectively, which extend outwardly. The pole pieces 11 are bent slightly downward at their tips, while the pole pieces 12 are bent upwardly to give a dished appearance, as is clearly indicated in Figure 2. A shading ring 13, fabricated of copper and having an undulating ribbon-like configuration, is threaded loosely over the pole pieces 12, and then extends under the adjacent pole pieces 11 about three sides thereof in order to shade these

pole pieces and therefore to provide a magnetic phase lag when the field structure is magnetized by an alternating flux. In order to improve the operation of the motor it is desirable that the shaded radial pole pieces 11 and the shaded axial pole pieces 5 shall be of somewhat greater width than the corresponding unshaded pole pieces 12 and 6, respectively. The field structure formed by the radial pole pieces 11, 12 and the axial pole pieces 5, 6 is magnetized by a field coil 14 wound on a drum 16 of insulating material and contained between a pair of insulating webs 17. There is a pair of leads (not shown) connected to opposite sides of the coil 14 and adapted to be connected to a suitable source of alternating current.

The magnetic hub 1 is provided with an axial bore 18, plugged at each end by three or more washers 19. The washers 19 have an opening at the center for receiving the shaft 20 of a rotating disc 21, made of light material such as aluminum and provided with equi-distantly spaced openings 22 (Figure 3). These openings are provided mainly to cut down the weight of the metal. The disc 21 is secured to the shaft 20, preferably through a hub member 23 which has a downwardly extending shoulder 24 bearing against the uppermost thrust washer 19. The material of the disc 21 between the openings 22 constitutes the arms which carry at their extremities, in a manner which will be described presently, a cylindrical band of magnetic material which forms the rotor 24^a or rotating element of the motor.

The outwardly extending pole pieces 11, 12 terminate short of the inner surfaces of the axially extending pole pieces 5, 6 to leave an annular gap, and the diameter of the rotor 24^a and its thickness are such as to extend within this gap. As shown in Figure 3, the rotor band has a number of axially extending incisions or slits, indicated at 25, appearing in pairs to magnetically isolate a portion of the rotor band between each pair of incisions. These portions become permanently magnetized and constitute virtual pole pieces which react with the pole piece pairs 11, 6 also 12, 5 in such a way as to cause rotation of the rotor when the coil 14 is energized by alternating current. The distance between the slits of each pair is preferably the same as the width of the shaded pole pieces 11, 5. It will be understood that the shading rings 7, 13 constitute short-circuiting windings of such a character as to produce a rotating field.

It will be noted that the slits 25 are symmetrically positioned with respect to the upper and lower edges of the rotor, and that these slits do not extend out to the edge but have a length less than the thickness of the rotor. A preferred way in which the rotor is secured to its supporting spider is shown in Figures 2 and 3. The arms 31 of the disc 21 extend radially from the center of the rotor and are secured at the center to the hub 23 in any suitable manner, for example, by peening. The outer ends of the arms 31 terminate in an element which is provided with a pair of slits 32, and the portion between the slits is bent downwardly so as to extend along the inner surfaces of the tabs 30. The upper or unbent portions of the arms 31 bear against the upper surfaces of the tabs, the arrangement being such that the ends of the arms strongly grip the tabs and thus secure the rotor to its shaft 20.

In operation, assuming that the rotor shaft has been placed in position in the bearings 19 and the rotor element is positioned in the annular groove between the sets of radial pole pieces 11, 12 and the axial pole pieces 5, 6, the energization of the coil 14 by alternating current will set up a rotating field which reacts on the rotor in such a way as to rotate the latter. The rotor portions between each pair of adjacent slits 25 become permanently magnetized, due to the magnetic isolating effects of the slits, and these portions do not change polarity in either starting or when the rotor has reached synchronism. A motor having a rotor, in which slits of the character described are provided, has been found to give a strong starting characteristic, as well as strong synchronizing effects to maintain the rotor in step with the frequency of the voltage applied to the coil. It will be noted that the rotor is of unbroken continuity, and consequently presents a uniform cross section to all parts of the magnetic field as it rotates, thus giving to the motor more uniform starting and running characteristics than in the case of motors in which the rotor is formed of a band of magnetic material having ends abutting one another. Even if these ends are welded together to increase the continuity of the band, the welding material may not have magnetic qualities, so that there is a virtual air gap set up between the welded ends of the band. In any case the metal at the weld presents a section to the pole pieces which may be of greater thickness than the remaining portions of the rotor, thus introducing irregularities of performance.

Instead of locating the slits 25 at positions intermediate the upper and lower edges of the rotor, the slits may extend from either the upper or the lower edges of the rotor. In Figure 4 there is shown a rotor in which the slits start from one edge and extend toward the other edge, but stop short of said other edge. In Figure 5, we have shown the slits extending downwardly from the same edge of the rotor at which the tabs 30 are located, and thus at the opposite edge from that shown in Figure 4. The use of the slits positioned intermediate the upper and lower edges of the rotor, as illustrated in Figure 3, has been found to give slightly better results than in the case of those rotors in which the slits extend to either one edge or the other of the rotor. For certain applications of the motor, the rotors shown in Figures 4 and 5 have some advantages over the rotor shown in Figure 3.

It will be understood that we desire to comprehend within our invention such modifications as come within the scope of the claims and the invention.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. A rotor for a synchronous motor comprising a circular band of magnetic material of continuous configuration having inwardly projecting support lugs at one edge, and axially aligned incisions around the band, said incisions stopping short of each edge of the band, said incisions occurring in pairs and the incisions of each pair being spaced apart a distance substantially equal to the width of the pole pieces of the motor, said distance being less than the distances between the respective pairs of incisions.

2. In a synchronous motor, a magnetic core, a magnetic field member mounted on one end of said core and having outer pole pieces disposed

axially in a substantially cylindrical path, a second magnetic field member mounted on the other end of said core and having inner pole pieces disposed radially with their tips spaced from the tips of the axial pole pieces to leave an annular opening between the pole tips, a rotor positioned within said annular opening, a shading member encircling said cylindrical path of said outer pole pieces and arranged to shade alternate outer pole pieces, and a second shading member positioned adjacent said inner pole pieces and arranged to shade alternate inner pole pieces, the width of the shaded pole pieces being greater than the unshaded pole pieces, said rotor having a plurality of poles of axially aligned rectilinear incisions about the periphery thereof, the distance between the incisions of each pair being substantially equal to the width of the shaded pole pieces.

3. A rotor for a synchronous motor comprising a circular band of magnetic material of continuous configuration having inwardly projecting support lugs at one edge and axially aligned incisions around the band, said incisions occurring in pairs and the incisions of each pair being spaced apart a distance substantially equal to the width of the pole pieces of the motor, said distance being less than the distance between the respective pairs of incisions.

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