Oct. 7, 1930.

G. W. McCOLLUM

1,777,320

ROTOR

Filed Oct. 14, 1929

2 Sheets-Sheet 1

Fig. 1.

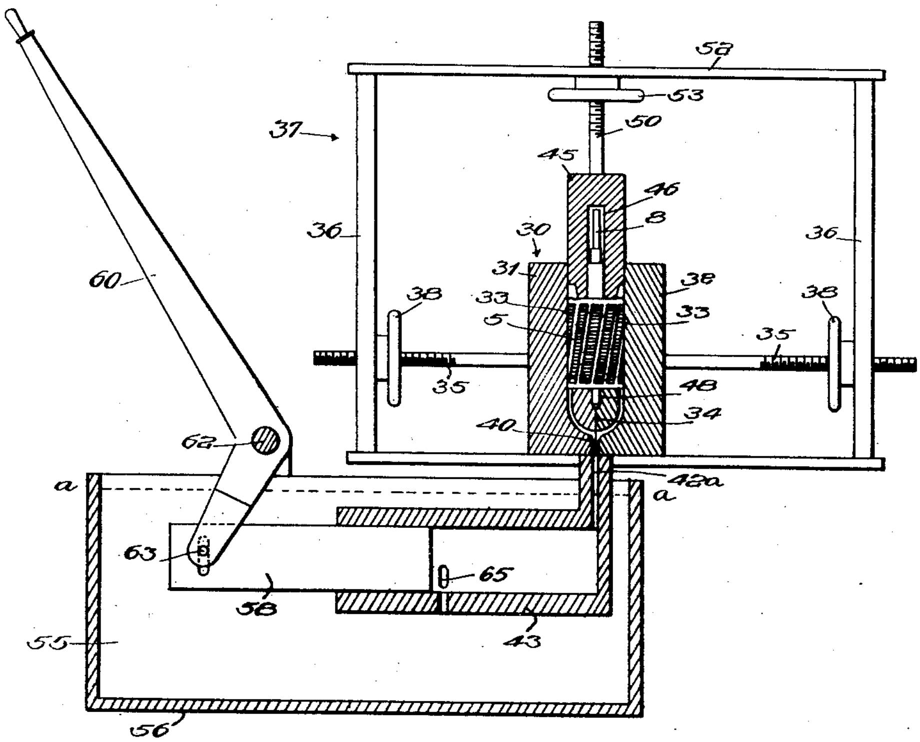

Fig. 2.

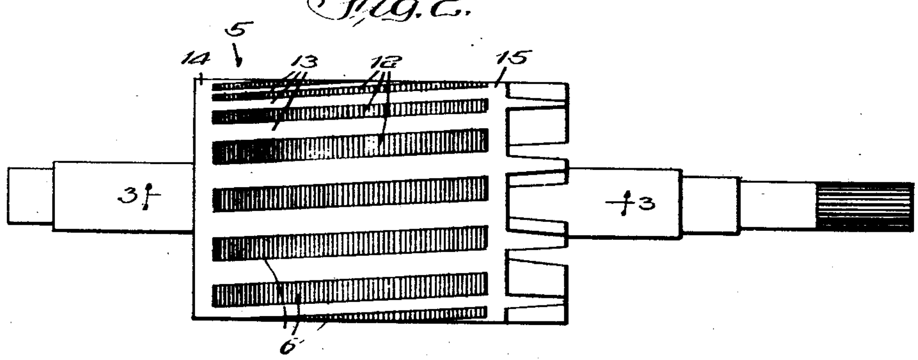

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Fig. 3.

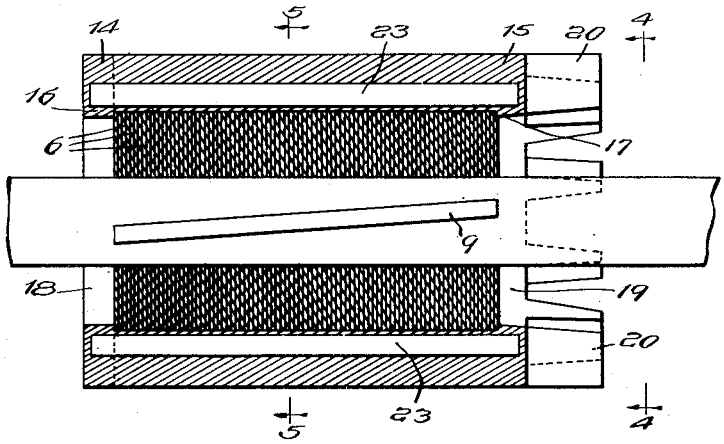


Fig. 4.

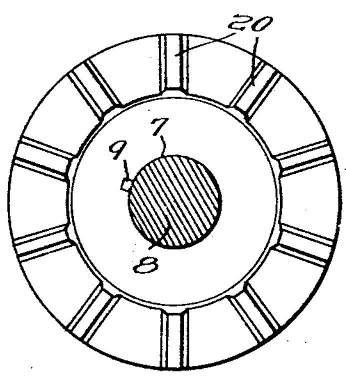
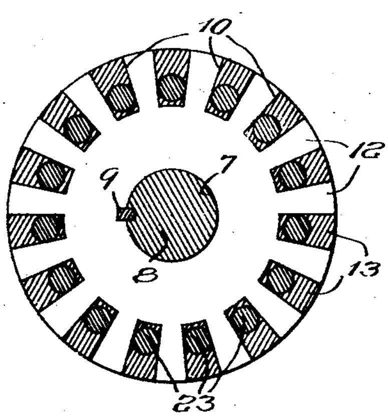


Fig. 5.



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Patented Oct. 7, 1930 1,777,320

UNITED STATES PATENT OFFICE

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ROTOR

Application filed October 14, 1929. Serial No. 399,437.

This invention relates to induction motors, particularly to rotors or secondary members therefor and its objects are the provision of an improved rotor and an improved method of and means for forming the same.

This application is a continuation in part of my copending application, Serial No. 219,949, filed September 16, 1927.

Heretofore the winding of the rotor has commonly comprised suitable conducting wires, ribboned strips or bars laid in the conductor openings or radial notches of the laminated core. The laying of windings of this sort has been relatively expensive, air spaces have been present and any joints in the winding elements have reduced the starting torque.

It has also been found that the expansion and contraction which occurs in a device of this sort will break welded joints and windings of this sort tend to work loose, shift or move, thereby producing a defective rotor and some provision, commonly in the form of separate holding strips or pieces interlocked with the core pieces have usually been necessary to hold the winding elements in the core openings or notches.

According to more recent developments it has been proposed to pour the winding and cast same in unitary, monolithic or molecularly united form, but numerous difficulties and shortcomings have been encountered. Pre-heating of the soft iron core and the mold has been necessary to get the mold to fill at all. If not pre-heated the alloy or other winding material has been found to set as the pouring of the molten winding material begins and the recesses for the conductor bars will not be completely filled. Voids and blow holes commonly occur and the poured metal is placed under stress and will crack, separate or have other imperfections.

While such cast windings, as have been proposed, have advantages over the windings previously referred to, the loss through imperfections is usually exceedingly high, it being well understood in the art that any appreciable variation in the cross sectional area of any winding bar at any place will render the entire rotor unusable.

According to the present invention, which has proven exceedingly satisfactory and relatively inexpensive, in actual practice, rods of copper or other metal of high conductivity are inserted in the conductor openings of the core, and the molten winding metal is forced, under pressure, into a mold or die cavity surrounding the magnetic core of the rotor and die-cast in the form of a unitary winding element. The forcing of the molten winding metal, or alloy, under pressure, into the conductor or winding receiving openings in the core completely and uniformly fills the openings or recesses and assures against imperfections or undesirable variations in the cross sectional areas of the winding bars. The presence of the copper rods increases the conductivity of the winding bars, and since these copper rods occupy a substantial part of the conductor openings they materially reduce the amount of alloy required in making a casting so that therefore the time for making a single casting is reduced. These copper rods also act to absorb heat from the molten metal forced into the mold by the operation of the piston, thereby producing a finer grained casting, a quicker set, and fewer blow holes. The introduction of the molten winding metal, under pressure, gets the winding metal, or alloy into the core recesses and die cavity so rapidly that all recesses or openings are completely or uniformly filled before the metal has congealed or set. Any air which might otherwise tend to be trapped is effectively and positively forced out of the core openings. There is no premature or localized setting and voids, blow holes, cracking and other imperfections are avoided.

In addition, in die-casting the winding in this manner, the core need not be pre-heated and the die may be maintained sufficiently warm by the repeated operations of forcing the molten metal or alloy into the die. The latter operation can be performed and repeated very quickly in view of the fact that the cylinder and piston are in the kettle containing the molten metal. Smaller conductor bars or winding elements may be cast in this manner with positive assurance that the recesses in the core and die will be uniformly and completely filled.

The conductor end rings of the winding are preferably cast integral or as a unit with the longitudinally extending winding bars and where desired suitable fan blades or cooling fins may be cast integral, or as a unit, with the winding at either or both ends thereof, although it is to be understood that these may be omitted, or otherwise formed and other variations may be made within the scope of the present invention.

Another improvement which I have made is in the material of the winding element itself, I have discovered that a zinc base alloy known in trade as "Zamak" and containing four percent (4%) of aluminum, three percent (3%) of copper and the balance of high grade zinc, provides a highly satisfactory winding material. This material is particularly suited because it will not only attack the steel pressure, and it flows freely, under pressure and completely and uniformly fills the winding openings in the core laminæ. Aluminum has heretofore been frequently proposed in poured cast windings, but I find that it is not desirable because it will attack the pressure cylinders and pistons and its shrinkage is great and its fluidity not as desirable as it might be in this connection. The alloy which I propose, as referred to above, flows freely, as already pointed out. Its shrinkage is very low and it will not attack the pressure cylinders or pistons. In addition its strength is great and I find that where it is employed the possibility of cracking, separating or other imperfections is still further avoided.

The invention is illustrated in the accompanying drawings, in which:

Fig. 1 is a more or less diagrammatic sectional view of one form of means for compressing the rotor laminations and for die-casting the winding;

Fig. 2 is a side elevational view of a secondary member or rotor of an induction motor, embodying the present invention;

Fig. 3 is an enlarged longitudinal section taken on the line 3—3 of Fig. 2;

Fig. 4 is a cross section taken on the line 4—4 of Fig. 3, and

Fig. 5 is a cross section taken on the line 5—5 of Fig. 3.

It is to be understood that the invention is not limited to the particular embodiments shown and described and that variations are contemplated within the scope of the appended claims.

In the embodiment shown in Figs. 1, 2, 3, 4, and 5, the rotor or secondary member is designated, in its entirety, at 5 and is adapted to form the rotor or secondary member of an induction motor. Its outer periphery is cylindrical and the rotor 5 comprises a magnetic core member, preferably of soft iron and composed of a plurality of disc-like core laminæ or pieces 6 having concentric openings 7 for receiving the rotor shaft 8 and the core pieces 6 which are alike, are stacked upon the shaft 8 and keyed thereto at 9. The laminæ 6 may be punched in the usual or any suitable manner.

The core member is provided with substantially longitudinally extending conductor or winding receiving openings. These openings are preferably formed by peripheral notches 10 in the laminæ 6, these notches 10 preferably opening from the periphery of the core, as shown, and being preferably radially elongated to increase the starting torque, as well understood in the art. It is to be understood that the notches 10 may be shaped to give the desired characteristics to the rotor. The notches 10 are separated by the radial core extensions 12 and the longitudinally extending winding portions 13 are die-cast in the notches 10, as will be hereafter described, as a unitary winding and with the end rings 14 and 15 die-cast integrally or as a unit therewith and molecularly joined as a monolithic or unitary winding element. Insterted in each of the notches 10 is a rod or member 23 of copper or other conductor of high conductivity, and these rods preferably extend at each end beyond the stacks of core pieces 6, as shown in Fig. 3. These rods just extend into the end rings 14 and 15, and they serve not only as a means for increasing the conductivity of the winding as a whole but also as a means for increasing the mechanical strength of the winding as well as functioning to secure a quicker set of the casting whereby blow holes and the like are eliminated and the amount of casting metal required for each rotor is decreased. The end rings 14 and 15 preferably extend in radially of the periphery of the core slightly at 16 and 17, overlapping the laminæ at the opposite ends of the core and binding the same axially together in their axially compressed condition. The end rings 14 and 15 have concentric openings 18 and 19, exposing the laminæ at the opposite ends of the core within the inward extensions 16 and 17, these exposed portions being cooperable with the die and plunger in compressing the laminations in the die.

The key 9 is preferably placed at a slight angle with respect to the axis of the shaft 8 to give the winding openings or slots 10 and thereby winding bars 13 a slight spiral effect to do away with any locking tendency the rotor might have when assembled in the stator of the motor.

If desired suitable cooling or fan blades 20, peripherally arranged and extending from either or both ends of the rotor may be cast integral or as a unit with the end rings

14 and 15. These cooling blades or fins 20 may be formed as shown or otherwise as desired and when the motor is assembled they operate to provide a cooling effect upon rotation of the rotor.

In the lamination compressing and die-casting operation a die 30 is employed. The die 30 comprises two halves 31 and 32 having supplementary cylindrical cavities 33 and the two halves are separted on the line 34. The two halves 31 and 32 of the die 30 are closed by means of screws 35 extending through the uprights 36 of a suitable frame 37 and provided with suitable hand wheels 38 for operating the screws to open and close the two halves of the die 30. It is to be understood, of course, that the two halves of the die may be closed by any other suitable means such as air pressure or levers.

The semi-cylindrical cavities 33, when closed form a cylindrical cavity which is adapted to receive the core or laminations 6 and to give the periphery of the winding the desired cylindrical formation. The usual or any suitable operating clearances may, of course, be provided. When the two halves of the die 30 are closed they come together in such a position as to bring the sprue 40 leading to the die cavity 33, 33 directly over the port 42^a, which port 42^a leads from the pressure cylinder 43 to the die cavity.

Operable reciprocably in the top of the die cavity 33, 33 is a plunger 45, which fits in the die cavity sufficiently loosely to allow any air in the die cavity to escape around the plunger in the die-casting operation. The plunger 45 is axially recessed at 46 to receive one end of the rotor shaft 8 and there may be a suitable axially aligned recess 48 for receiving the opposite end of the rotor shaft.

For depressing the plunger 45 there is a screw 50 extending through a horizontal cross piece 52 on the frame 37 and provided with a suitable hand wheel 53. It is to be understood that the screw may also raise the plunger or it may be lifted or otherwise raised independently of the screw and any other suitable or preferred plunger operating means may be employed. The entire frame work 37 carrying the die may be raised from the port 42^a.

The pressure cylinder 43 is immersed in the molten alloy 55 in a kettle or suitable receptacle 56, the level of the molten alloy in the receptacle 56 being preferably normally maintained at about the line *a—a* of Fig. 1. The receptacle 56 is heated to bring and maintain the alloy in the desired fluid condition by gas, oil, electricity, or in any other suitable or preferred manner.

Reciprocable in the cylinder 43 is the pressure piston 58 which may be operated by a lever 60 pivoted at 62. The lever 60 may be operated mechanically or by air or in any other suitable or preferred manner and the connection 63 between the lever 60, which is shown of bell crank formation, and the piston 58 is preferably such as to permit the swinging movement of the lever relative the piston in the operation thereof. The cylinder 43 is provided with ports 65 for admitting molten alloy from the receptacle 56 into the cylinder 43 when the piston 58 is drawn back or outwardly from the cylinder.

A relatively deep recess 68 may be provided in the die 30 at the upper end of the rotor core for casting the fan blade or other projections and in the casting operation the metal or alloy will be forced into these recesses, it being understood that the die 30 is also suitably recessed to form the end rings 14 and 15. It is also understood that the fan blades projections may be provided at both ends of the rotor core.

By the first step in the process the core laminations 6 are stacked and keyed upon the shaft 8 by engagement of the key 9 in the key-ways 75. The two halves of the die 30 are opened or separated and the compressing plunger 43 is raised upwardly. The rotor shaft 8 together with the core laminations 6 are then placed in the die 30 and the two halves of the die are closed together by the wheels 38 and screws 35. The plunger 45 is then brought down by means of the wheel 53 and screw 50 and the core laminations 6 are thereby compressed tightly together. Then with the die closed and held in this position and the core laminations compressed in this manner the piston 58 in the cylinder 43 is brought forward or moved inwardly into the cylinder 43. The forward movement of the pressure piston 58 in the pressure cylinder 43 forces the alloy into the die cavity and end ring and blade casting recesses, completely filling the recesses in the laminated core and the recesses in the die for the conductor end rings and fan blades, as well as for the longitudinally extending winding portions 13.

The pressure at which the alloy is forced into the die is in the neighborhood of 150 pounds per square inch and may vary with the amount of metal to be forced into the die and with the shape and design of the die and sprue, also with the temperature of the die. The die and the core being much below the melting point of the alloy, the alloy is immediately congealed or set. The copper rods or members in the notches 13 materially aid in absorbing the heat from the molten metal. The cylinder 43 being immersed in the molten alloy keeps the port 42 and the metal in it above the melting point of the alloy, and therefore, the alloy in the port 42 does not set. As already pointed out, the entire frame work carrying the die may be raised from the port 42 from the cylinder. Then when the piston 58 is brought back beyond the ports 65 more molten alloy is allowed to enter the cylinder and the cycle of operation may be repeated. This factor of continuous operation is of great importance in reducing the expense of manufacturing the rotors, being very adaptable to mass production.

As already pointed out the die-casting of the conductor bars has a decided advantage over the pouring of the molten alloy into the die or mold. Smaller conductor bars may be cast as the metal can be forced into smaller recesses with almost positive assurance that the recess in the die will be completely filled. The die-casting under pressure gets the alloy into the die cavity and into the recesses in the core so rapidly that the whole recess is filled before the alloy congeals or sets. With this die-casting method the core need not be pre-heated at all and the die is kept sufficiently warm by the repeated operations of forcing the molten alloy into the die. In fact, if the die is opened and closed mechanically the cycle of operation may be repeated so rapidly that it may be necessary to water cool the die and suitable water or other cooling provisions for this purpose are contemplated.

Any air which might otherwise tend to be trapped is effectively and positively forced out of the core openings in the die casting under pressure and escapes out around the plunger 45. There is no premature or localized setting and voids, blow holes, cracking and other imperfections are avoided and the loss through imperfections is materially reduced.

The diameters or peripheral dimensions of the core laminations 6 are preferably slightly oversize and after the die casting of the winding element the outer generally cylindrical periphery of the rotor may be machined or finished to the desired diameter.

The alloy which I employ as the winding material is also of importance. The alloy preferably employed is a zinc base alloy, known in the trade as "Zamak." A typical alloy of this sort contains four percent (4%) of aluminum, three percent (3%) of copper and the balance high grade zinc. This material is particularly suited because it furthers the complete and uniform distribution of the winding and further reduces the rotor loss from inequalities or imperfections. This alloy will not attack the steel pressure cylinders or pistons for die casting the same under pressure and it flows freely under pressure, a heat application of from 900 to 950° F. being sufficient without preheating the die or core and the shrinkage of this alloy is very low. I find that this material further reduces premature or localized setting and voids, blow holes, cracking, separating and other imperfections. The resulting winding has great strength and a rotor may be inexpensively constructed in this manner and has no joints in the winding element. Air spaces with their poor magnetism conducting qualities are entirely avoided and I find that the above alloy conducts the magnetism much better than copper windings and the path of magnetism between the stator and the rotor is increased by the magnetism conducting properties of the winding.

One tenth of one percent (1/10 of 1%) or other suitable proportion of magnesium may be added to this alloy and further increases the resistance to oxidation strength to swelling and warping after use.

I claim:—

1. As an article of manufacture, a rotor comprising a magnetic core having longitudinal winding receiving openings and a die-cast squirrel cage winding having die-cast conductor portions extending longitudinally through said openings, separately formed conductors embedded in said portions, and die-cast end rings formed integrally with said longitudinal conductor portions.

2. As an article of manufacture, a rotor comprising a laminated magnetic core having longitudinal winding receiving openings, and a die-cast squirrel cage winding having die-cast conductor portions extending longitudinally through said openings, separately formed conductors embedded in said portions, and die-cast end rings formed integrally with said longitudinal conductor portions, said end rings overlapping the ends of the core along the periphery thereof to bind the laminations together and having openings exposing the end laminations.

In witness whereof, I hereunto subscribe my name this 10th day of October, 1929.

GEORGE W. McCOLLUM.