April 2, 1940. W. R. COX 2,196,059

INDUCTION MOTOR ROTOR

Filed Feb. 25, 1938

Fig. 1.

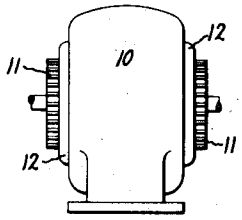


Fig. 2.

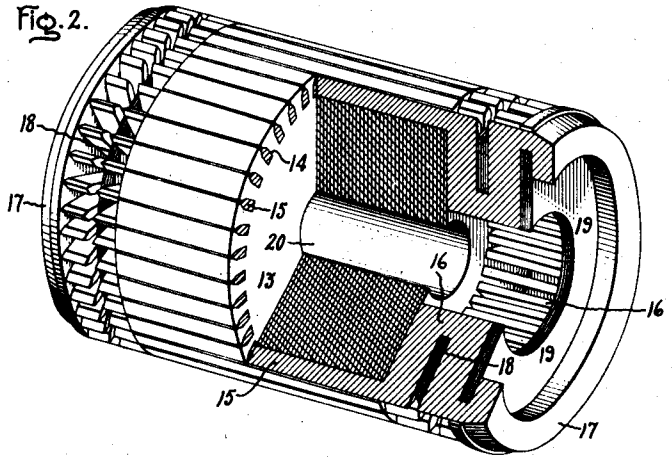


Fig. 3.

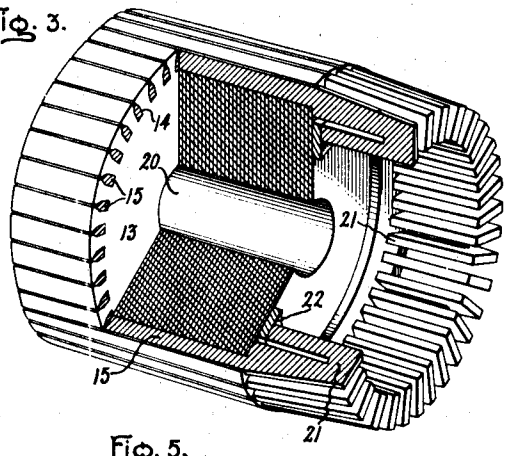


Fig. 4.

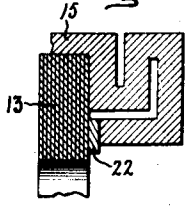
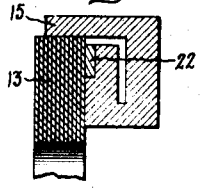


Fig. 5.



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Patented Apr. 2, 1940 2,196,059

UNITED STATES PATENT OFFICE

2,196,059

INDUCTION MOTOR ROTOR

William R. Cox, Lynn, Mass., assignor to General Electric Company, a corporation of New York

Application February 25, 1938, Serial No. 192,606

5 Claims. (Cl. 172—120)

My invention relates to the secondary rotor constructions of squirrel cage induction motors and its objects are to provide a rotor which is easy to manufacture by the casting method, is strong in construction so that it will withstand high speed and reversing stresses, has high resistance and has an end construction in the form of a fan to keep it from excessive heating during operation. The construction also lends itself to a winding in which the reactance may be varied considerably by the optional use of magnetic material associated with one or both ends of the winding.

The casting of high resistance squirrel cage windings for medium sized motors has heretofore not been universally successful or practicable. Successful casting necessitates that the bar slots shall have sufficient cross-section to cause the molten casting metal to flow freely therein during the casting operation and also it is desirable that the bars shall be of sufficient cross-section and have such mechanical connection with the end rings as to withstand high temperatures and mechanical stresses. These factors call for a relatively large bar cross-section which is inconsistent with high resistance unless special and expensive high resistance alloy material is employed.

According to my invention, a slot and bar cross-section consistent with successful casting and mechanical strength is used and the requisite high resistance is obtained by extending the length of the secondary current path without greatly extending the length of the rotor. This is accomplished by providing one or more loops in the bars between the rotor core and end ring, preferably at both ends of the rotor. This loop shape of the bars is easily obtained by using suitable molds and casting the winding, and the resulting structure is mechanically strong and of such shape that the loops act as effective cooling fan blades when the rotor is running.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention reference is made in the following description to the accompanying drawing in which Fig. 1 represents a complete induction motor to which my invention pertains. Fig. 2 is a perspective view partially in section of an embodiment of my invention which may include magnetic ring material between the sides of the loops in the squirrel cage bars for increasing the reactance of the winding; Fig. 3 is another modification of the invention with no magnetic material within the loops or bends of the squirrel cage bars and Figs. 4 and 5 represent other forms of loops or grids that may be used.

In Fig. 1, 10 represents the stator of an induction motor and 11 the rotor assumed to have been constructed in accordance with the present invention. The part marked 12 may represent the stator winding end shields or the end turns of the stator windings themselves. It will be noted that the rotor construction does not add appreciably to the axial length of the motor shown. The motor bearings are not shown but it will be evident that the slightly increased length of the rotor will not interfere with the usual type of bearings as substantially normally spaced at the two ends of the rotor and hence no material over-all increase in motor length is required by reason of the present invention.

In Fig. 2, 13 represents the usual rotor core made up of laminated magnetic material having slots 14 in its periphery and shaft opening 20. The slots and the bars 15 therein are appreciably relatively larger as compared to the rotor diameter than would be called for in a rotor of usual design and having an equivalent high resistance squirrel cage winding. The reason for the larger slots is that if the rotor is to be cast and it is to be mechanically strong and able to withstand high temperatures, the slots should be large enough to permit them to be completely filled with the molten metal without leaving cavities and the cross-section of the bars should be sufficient to have appreciable heat storage capacity below a melting temperature and to withstand mechanical stresses incident to quick starting and stopping and high speed operation. Generally speaking, heretofore in rotors of relatively small sizes such as are generally used in motors below 15 horse-power, the bar size consistent with a high resistance rotor was too small for the squirrel cage to be cast in a satisfactory manner. Increasing the size of the bars for mechanical reasons obviously lowers the resistance of the squirrel cage. According to my invention the bars are made large enough to be cast in a satisfactory manner and to be sufficiently strong mechanically and the reduction in resistance per unit of length is made up by an increase in the effective length of secondary current path by the loop-shaped extensions at the ends of the bars. Thus, in Fig. 1 the bars 15 have an inwardly extending radial connecting loop 16 at each end before they are joined by the end rings 17. The straight and looped bar sec-

tions and the end rings are, or may be, cast in one operation by providing suitable molds, which molds preferably include the ring punchings shown at 18 and 19.

Where it is desirable to increase the rotor reactance or to give it the equivalent of some double squirrel cage effect, one or both of the rings 18 and 19 at the ends of the rotor may be made of laminated magnetic material, such as is used in the rotor laminations 13, and left in place after the squirrel cage is cast. Likewise, one or both rings at either end may be made in sections so as to be removed after the winding is cast. Where such rings are left in the rotor for increasing the reactance or for mechanical strength, they will be made of a high resistance material or have an insulating coating or scale so as not to short circuit the squirrel cage bars. It would also be possible to cast the squirrel cage material without using the molding rings 18 and 19, and after the casting operation, to place the rotor in a lathe and cut grooves in the places which are shown as being occupied by such rings.

It is seen that the structure represented considerably increases the length to the path of the current in a squirrel cage bar by reason of the added radial directions in which such current must flow in passing between the end rings 17 at opposite ends of the rotor but without correspondingly increasing the length of the rotor.

It is seen that the loops in the various bars form with the bars a series of effective clamps about the rotor for the core laminations 13 and the structure is otherwise mechanically well anchored—strong and rugged. The radial loops or grids make effective centrifugal ventilating fans at opposite ends of the rotor which assist in keeping the rotor cool. It will be noted that these fans are very effectively placed at the points where the rotor winding resistance is most highly concentrated and where maximum heating is likely to occur and afford a large heat radiating surface directly in the path of the fan blast.

In Fig. 3 a modified form of the invention is shown at one end of the rotor only. In this case the loops 21 are formed of U-shaped, inwardly turned loop or grid sections which are joined by an end ring 22 at the smaller diameter next to the rotor core. Here again the extra grid-like resistance material is confined within the diametrical limits of the rotor core and utilizes space at the ends of the rotor radially inward from the rotor periphery. It provides the fan construction, added winding resistance and is mechanically satisfactory in strength.

In this case the open end of the U-shaped loops face axially inward with the outer limbs of the loops comprising axial extensions of the bars. The end rings are secured against the ends of the laminated core by their connections with the inner legs of the loop.

Other examples are represented in Figs. 4 and 5 where 13 represents the rotor core, 15 the squirrel cage bar and 22 the end ring. Each squirrel cage bar is extended to the end ring by a resistance grid loop section which also forms a radial fan blade. The length, size and number of resistance loops or grid sections may be varied to suit the design required. So far as possible, however, the loop end sections will conform to the shape and disposition of radial fan blades and these connections as well as the end rings will be confined within the peripheral dimensions of the rotor so as not to increase its maximum diameter. The material used in the squirrel cage winding may be any suitable conductor material that can be cast, for example, aluminum or copper.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An induction motor secondary rotor comprising a laminated magnetic core containing peripheral slots and a high resistance squirrel cage winding having bars contained in said slots, end rings at the ends of the rotor and looped connections between said bars and at least one end ring for increasing the resistance of the winding, said looped connections forming radial fan blades at the end of the rotor, said squirrel cage winding comprising a casting and the end portions thereof forming clamping structure for the core laminations.

2. An induction motor secondary rotor comprising a magnetic core containing peripheral slots, a high resistance, cast squirrel cage winding having bars in said slots, end rings therefor and looped shaped connections between said bars and end rings extending beyond the ends of the core and forming fans at either end of the rotor and a ring of magnetic material secured in the slots of such loops at least at one end of the rotor for increasing the reactance of said winding.

3. A secondary rotor for induction motors comprising a laminated core of magnetic material containing peripheral slots, a high resistance squirrel cage winding having bars cast in said slots, end rings therefor and connections between said bars and end rings cast with said bars, said connections comprising radially extending loops confined within the outer periphery of the core and occupying space at the ends of the core, the loops at either end of the rotor forming a fan of which each loop is a radial blade, said loops and bars also serving as clamps for the laminated rotor core.

4. A secondary rotor for induction motors comprising a laminated magnetic core having slots in its periphery, a high resistance, cast squirrel cage winding having bars in said slots, end rings therefor and U-shaped loop connections between the ends of the bars and the end rings, said U-shaped connections extending radially inward from the bars and end rings and snugly fitting over the end laminations of the rotor core with the opening in the loops facing outward, said loops forming centrifugal ventilating fans at either end of the rotor.

5. A secondary rotor for induction motors comprising a laminated magnetic core having peripheral slots, a cast squirrel cage winding having bars in said slots, said bars having grid-like extensions extending beyond the ends of the core and inwardly within the peripheral limits thereof for the purpose of increasing the length of the squirrel cage current path and its resistance without correspondingly increasing the length of the rotor, and end rings having a maximum diameter no greater than that of the core joining the otherwise free ends of said extensions, said extensions being disposed to form centrifugal fans at the ends of the rotor and also serving as clamping structure at the ends of the rotor core to prevent axial displacement of the core laminations.

WILLIAM R. COX.