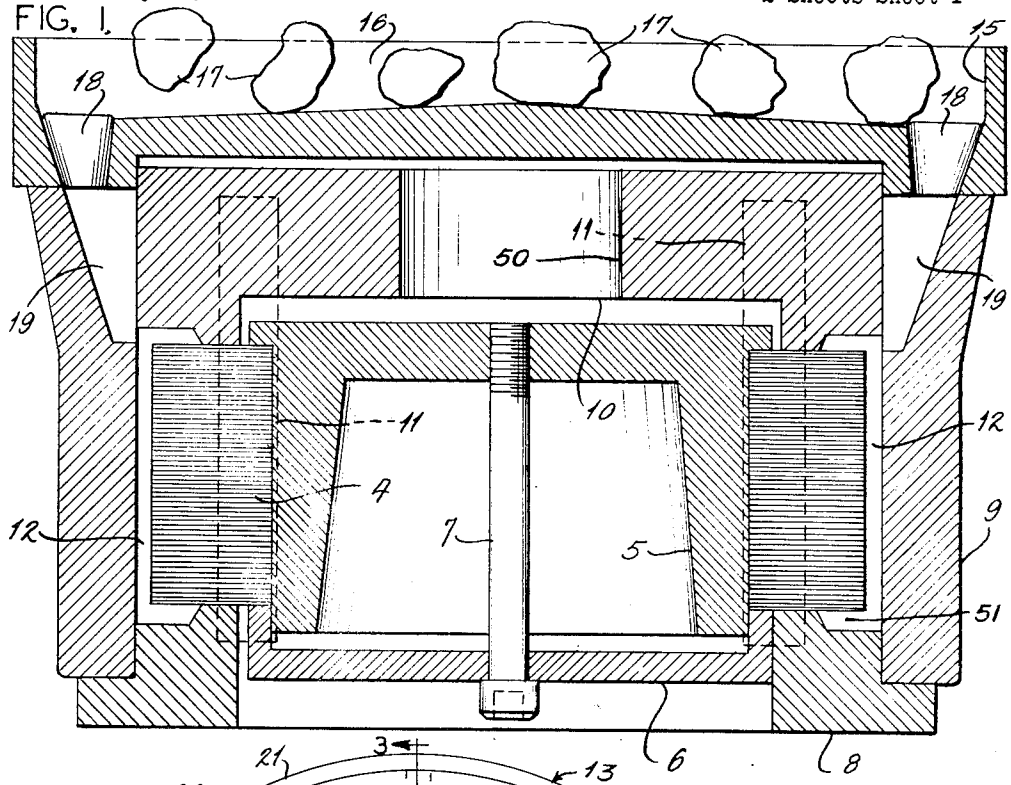
June 21, 1955 E. C. BALLMAN 2,711,492

STATOR FOR ELECTRIC MOTORS

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FIG. 1.



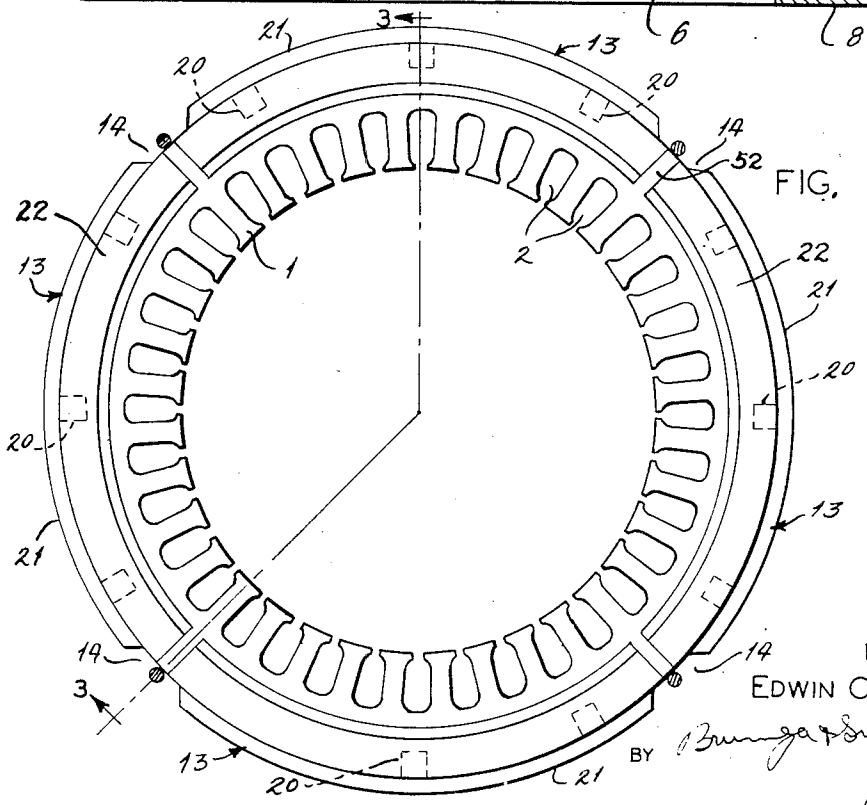


FIG. 2.

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FIG. 5.

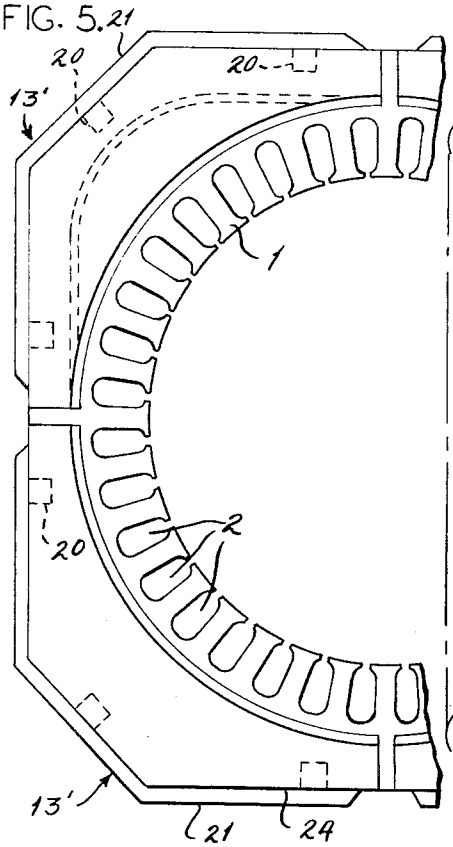
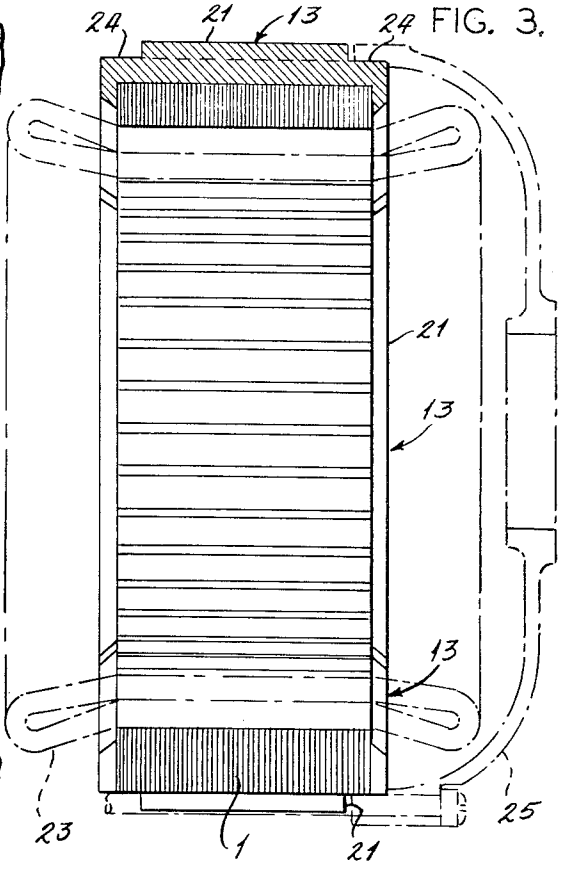


FIG. 3.



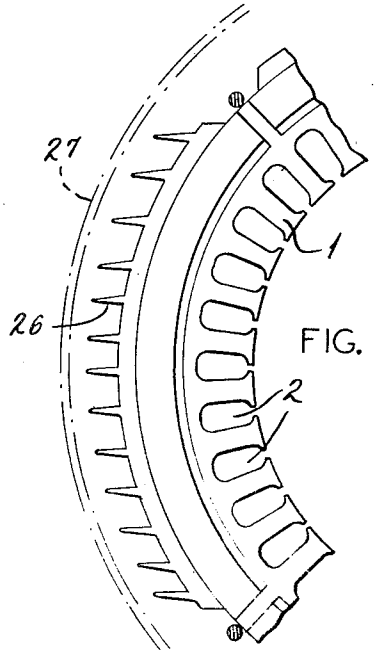
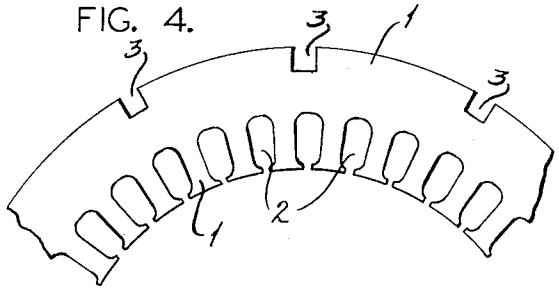


FIG. 6.

FIG. 4.



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STATOR FOR ELECTRIC MOTORS

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Application May 15, 1950, Serial No. 161,915

6 Claims. (Cl. 310—254)

This invention pertains to stator structures for electric motors, which structures have laminated cores, and to an improved method of making the same.

In the construction of laminated stator cores of this type difficulty has been experienced heretofore in securing the stacked assembly of laminae in such a manner as to render the finished structure rigid. The laminae must be pressed together sufficiently to make a substantially solid core and their tendency to slip on each other must be overcome. Heretofore clamping bolts have been used. These methods are unsatisfactory, however, on account of lack of sufficient rigidity or high cost of manufacture. While it has been proposed to cast on a stator, a structure of light metal such as aluminum, care must be taken to avoid flow of the metal in between the lamina so as to avoid short circuiting magnetically. Moreover, the tension transverse of the stator core should be limited when the light metal cools and shrinks so as to avoid breaking of the cross elements and too high a tension otherwise.

One of the objects of this invention therefore, is to provide a simple construction which will both make a rigid stator core and entail a low manufacturing cost.

Another object is to provide such a structure and method whereby such shrinkage pressure may be applied without danger of cracking the cast metal upon solidification.

Another object is to provide such a structure which, though held together by cast-metal elements, is dimensionally independent of the high thermal expansion rate of such cast metal.

Further objects will appear from the following description in which will be set forth an illustrative embodiment of this invention. It is to be understood, however, that this invention is susceptible of various embodiments, within the scope of the appended claims, without departing from the principles or spirit of the invention.

In accordance with an illustrative embodiment of this invention, generally stated, the assembled stack of stator laminae is clamped in assembled relation so as to form a core, which is placed in a mold. The mold is of the permanent type, i. e., of ferrous metal like iron or steel. The mold and the core therein are then heated. The laminae, when placed in the mold, may be unannealed and the heating may be carried to the annealing temperature of the laminae. This can be accomplished by heating the mold and the core to at least the melting point of aluminum but not in excess of 300° F. thereabove which is below the welding point of aluminum as related to the ferrous laminae of the core. While so heated, molten casting metal is flowed into the mold to cast a holding structure upon the stack of laminae. By "light-metal" as used in this specification and the appended claims, is meant aluminum or magnesium or their alloys or similar metals having a relatively light weight but a high crystallization shrinkage and a co-efficient of thermal expansion higher than that of the iron or steel of which the laminae are made. Said holding structure is cast around the outer periphery of the core but is divided into independent

sectors each extending only part way around the circumference thereof. Each sector has end portions overlapping the ends of the core and these end portions are connected by bars, also cast in recesses in the core so that when the cast metal solidifies and shrinks upon cooling, the shrinkage pressure is applied to press the stack of laminae together. These bars form keys or lugs on the cast-metal sectors which engage in spaced recesses in the core so that the shrinkage pressure is applied circumferentially as well, particularly where they are cast to the circumferential section. The mold is cooled gradually and progressively from the bottom upward so that the cast metal sets progressively and shrinkage cavities are avoided. By heating the mold and core to at least the melting point of the casting metal and then permitting the whole to cool to solidify the casting metal progressively, crystallization shrinkage will be compensated for and a superior structure will be attained. Since the core has been heated to annealing temperature, the laminae are annealed during the casting process. The core is then wound with any desired winding, and is then dipped in insulating varnish so as to impregnate winding and core with the varnish. The wound core is then baked to harden the varnish. Finally the core is mounted on a mandrel concentric with its bore and endplate rabbets are machined on the outer edges of the core, cutting clear through the cast metal down to the outer circumference of the laminae. Thus the end-plate bearing is on the outer edges of the laminae and their seat and alignment with the stator bore are independent of the thermal expansion of the cast metal.

An illustrative embodiment of this invention is shown in the accompanying drawings, in which

Figure 1 is a vertical section of a mold with a stator core mounted therein in accordance with this invention;

Figure 2 is an end view of a stator core structure embodying this invention;

Figure 3 is a sectional view of a wound stator taken on line 3—3 of Figure 2.

Figure 4 is a fragmentary view of one of the stator punchings;

Figure 5 is a partial end view, similar to Fig. 2 showing the application to another type of punching, and

Figure 6 is a fragmentary end view, partly in section, of a stator, illustrating one application of cooling fins.

Referring now to the drawings, the stator punchings are made as shown in Fig. 4 in which **1** designates a single lamina made of sheet iron or steel in the usual manner and having the usual slots **2** to receive the winding. In the embodiment shown the outer periphery of the lamina **1** is provided with spaced notches or recesses **3**.

In accordance with the illustrative embodiment of this invention a suitable number of laminae punchings **3** is assembled in a stack as indicated at **4** in Fig. 1 to form a ferrous core. The stack is placed on a mandrel **5** and a clamping plate **6** is arranged to press the punchings together by means of a clamping screw **7**. The stack, so clamped, is placed on the bottom plate **8** of a mold **9**. The latter is usually circular in horizontal section and may be split diametrically or otherwise to provide for separating the parts to free the finished casting. A top ring **10** is placed on top of the stack and provided with a central riser **50**. Aligning devices **11** of any suitable kind may be provided to insure proper relations between these parts. The mold parts **8**, **9** and **10** are formed with matching cavities indicated at **12** and **51** adapted to form the cast metal into a plurality of separate circumferential sector elements **13** with gaps **14** between them and with side sectors **22** also spaced by gaps **52** as shown in Fig. 2. The gaps **14** and **52** are formed by parts extening inwardly from the mold into the cavities **12** and **51**. A melting cup **15** rests on top of the mold **9** and is rotatable on the

ring 10. This cup is formed with an upper space 16 adapted to receive solid chunks 17 of casting metal, and is provided with a plurality of gates 18 which may be moved into registry with gates 19 in the mold 9 by rotating with cup 15. A gate 19 communicates with each of the cavities 12.

When the stack 4 has been placed in the mold and the mold assembled as shown in Fig. 1, the cup 15 is rotated to move the gates 18 out of registry with the gates 19 and the casting metal 17 in proper amount is placed in the cup. The mold is then placed in a furnace for heating. The heating of the mold, core and casting metal is continued to at least the melting point of the casting metal which is at least the annealing temperature of the core punchings involved. Such annealing temperature is ordinarily not more than about 300° F. above the melting point of the casting metal 17 but which is below the welding point of aluminum as related to the ferrous laminae of the core, and, of course, that metal is melted during such heating and is retained in molten condition in the cup 15. When these temperature conditions have been attained the operator, by use of a suitable implement, rotates the cup 15 to bring the gates 18 into registry with the gates 19 and the molten metal then flows down into the cavities 12 and 51 and rises in the riser 50. When these cavities have been filled, the mold is moved out of the furnace onto a cooling table adapted to withdraw heat from the bottom of the mold, so that the mold and its contents are cooled gradually and progressively from the bottom upward, and accordingly the casting metal sets progressively from the bottom upward and solidification shrinkage in the casting is compensated for by molten metal from above.

When the structure has cooled sufficiently it may be removed from the mold. In this condition the core has the sectors 13 permanently cast thereon. The casting metal which enters the recesses 3 forms lugs or keys 20 which provide dovetail connections between the sectors 13 and the core. These lugs extend inward from the rim portion 21 and connect the end sectors 22 at opposite ends of the core. It will be noted that the form of each sector is such as to embrace or surround portions of the core between the recesses 3. Accordingly, as the assembly cools after the cast metal has set the higher rate of contraction of the cast metal causes it to grip the core both endwise and circumferentially with a strong pressure due to such shrinkage. However, since each sector embraces only a limited part of the circumference of the core the total difference in the shrinkage of the two metals is not sufficient to cause excessive stresses in the sectors.

The finished core may now be wound with a winding 23 of any desired type. The wound core may then be dipped in insulating varnish and baked in the conventional manner to impregnate the winding and core and render them moisture proof. In accordance with this invention the wound and impregnated core is mounted on a mandrel, inserted in the bore of the punchings, and rabbets 24 are machined thereon to provide bearings for the end plates 25 which clamp the sectors therebetween. In machining the rabbets 24 the cast metal of the rim portion 21 is cut away down to the outer circumference of the punchings as shown Figure 3 at the bottom. This insures a bearing for the end plate which is not affected by the thermal expansion of the cast metal of the sectors 13. Accordingly, as both punchings and end plates are usually made of iron or steel they have the same rate of expansion and their fit is unaffected by changes in temperature. The sectors 13, however, remain connected by the lugs or keys 20.

This invention can be applied to practically any kind of stator core. Many motors are made with punchings having a square outline. Fig. 5 shows light-metal sectors 13' applied to a stator of this kind. Cooling fins may be formed on the sectors 13 in casting the same as shown in

Fig. 6 in which the fins 26 are shown running lengthwise of the core, together with an outer enclosure 27 with which many motors are provided within which a flow of cooling air is induced by a fan or otherwise which enclosure does not engage the sectors. Such fins may, of course, be arranged to run circumferentially and may be used without any enclosure.

It will be seen, therefore, that this invention accomplishes its objects in providing a simple structure which is very effective for its purpose and low in manufacturing cost. The sectors 13 and 22 grip the punchings with a strong grip both axially and circumferentially under the shrinkage pressure due to the greater contraction of the cast metal than that of the punchings. The dovetail relation of the lugs or keys 20 provides a hold on the punchings capable of supporting a strong circumferential grip while the end sectors 22 compress the punchings axially. The circumferential stress in the secors may be limited as desired by increasing the number of sectors in accordance with the increase in diameter of the punchings.

By the method of this invention the annealing of the punchings is accomplished simultaneously with the casting of the sectors and is, therefore, entirely eliminated as a separate step. This involves a very substantial saving in time and expense. Also by varnishing before machining the end-plate rabbets the necessity of cleaning off the baked varnish is eliminated. Thus both the cost and the time of production of the motor are substantially reduced. It will also be noted that, since the keys 20 are entirely outside of the magnetic circuit of the core of the motor and since the connected parts 22 and 13' are interrupted circumferentially by extending only partly around the ferrous core, there will be no magnetic linkage and no tendency to set up eddy-current losses.

Having thus described the invention, what is claimed is:

1. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and an aluminum sector cast on the outside of said core and having a circumferential part extending partly around said core, and bars in said recesses integral with said circumferential part.

2. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and an aluminum sector cast on said core and having a part extending part-circumferentially, along the side of said core and bars in said recesses integral with said circumferential part.

3. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and an aluminum sector cast on said core and having parts extending circumferentially along the sides of said core and bars in said recesses integral with said circumferential parts.

4. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and an aluminum sector cast on said core and having a part extending circumferentially outside of said core and having parts extending circumferentially along the sides of said core and bars in said recesses integral with said circumferential parts.

5. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and aluminum segments extending in spaced relation circumferentially outside of said core and bars in said recesses integral with said segments.

6. A stator for electric motors, comprising, a laminated ferrous stator core having recesses in its outside periphery, spaced therearound and extending crosswise thereof, and aluminum segments extending in spaced relation circum-

ferentially on each side of said core and bars in said recesses integral with said segments.

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