Feb. 23, 1971 R. B. GRAF ET AL 3,566,323

C-SHAPED MAGNETIZABLE CORE

Filed May 1, 1969 2 Sheets-Sheet 1

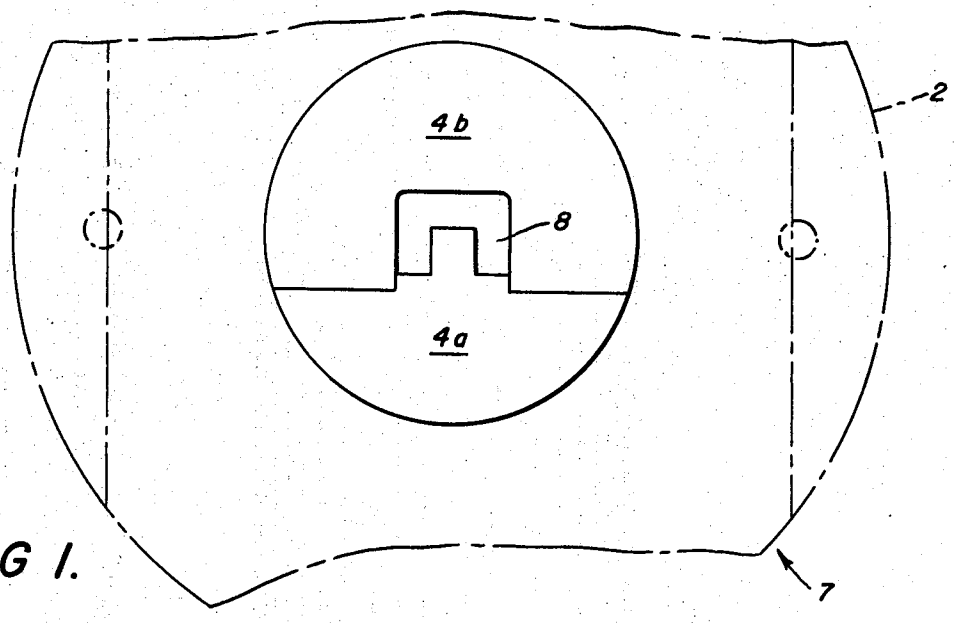


FIG 1.

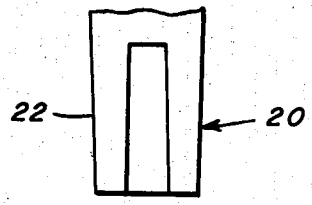
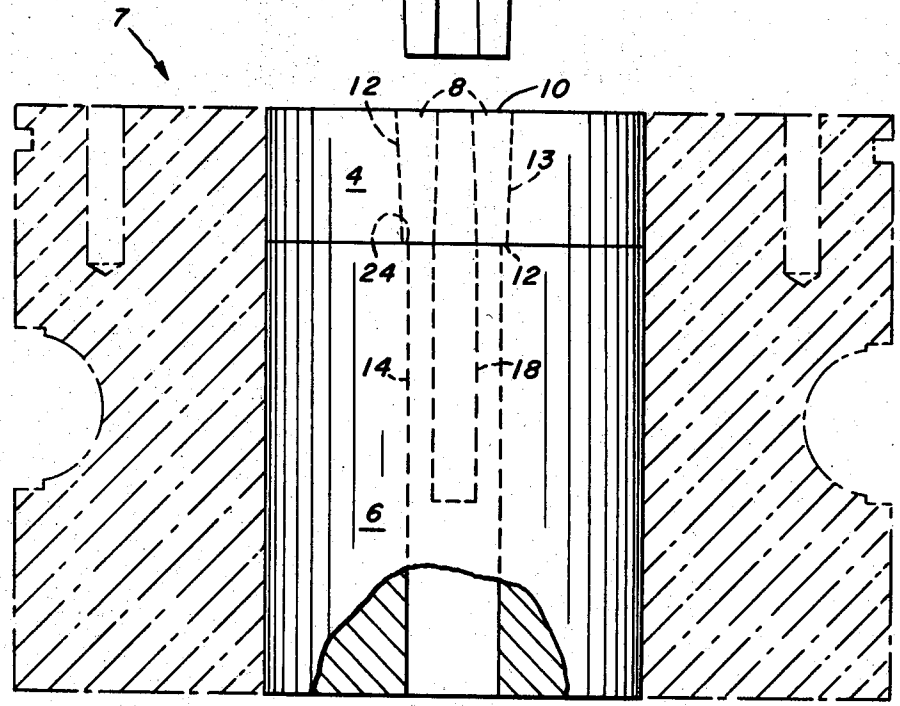
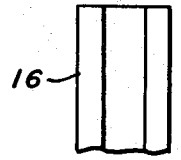


FIG. 2.





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FIG. 5.

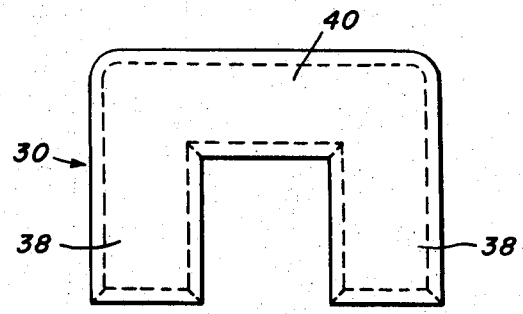


FIG. 3.

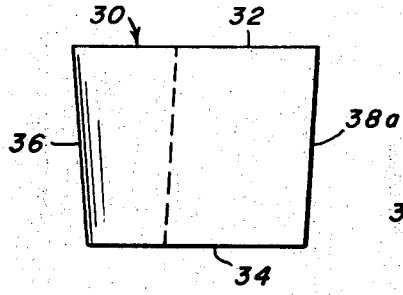


FIG. 4.

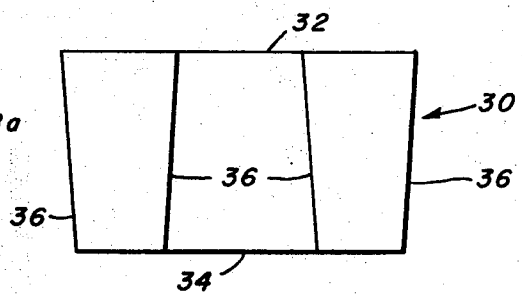


FIG. 6.

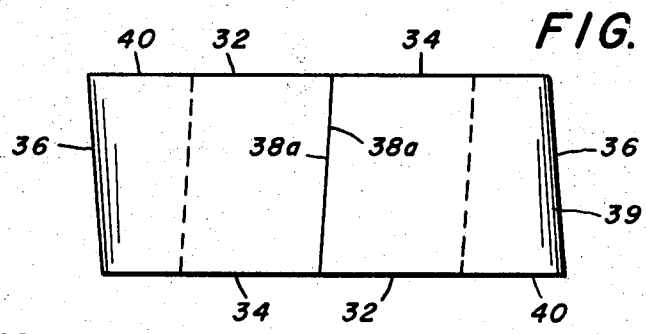
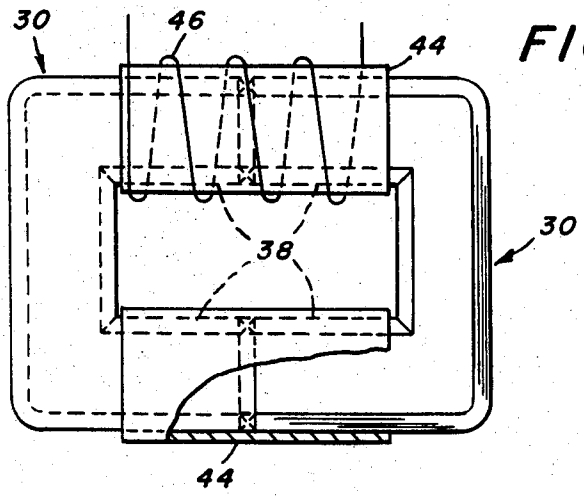


FIG. 7.



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C-SHAPED MAGNETIZABLE CORE

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U.S. Cl. 336—233 4 Claims

ABSTRACT OF THE DISCLOSURE

A C-shaped magnetizable core and method of making same of powdered material manufactured by filling a predetermined quantity of the powdered material into a C-shaped mold having two ends and having a trapezoidal cross section, compressing said powdered material to a density of at least 6.0 g./cm.^{3} by a cooperating, C-shaped ram from the larger trapezoidal base toward the smaller trapezoidal base, withdrawing the ram and ejecting the core from the die with a comparably C-shaped rod from the smaller trapezoidal base toward the larger trapezoidal base, the core uniformly expanding laterally as it is ejected from the die having a uniform density of improved structural, magnetic and electrical properties.

BACKGROUND OF THE INVENTION

The utilization of high permeability material such as powdered molybdenum iron-nickel alloy in the cores of loading coils has been long known in the communications industry. Such materials are conventionally compressed at extremely high pressures such as 100 to 150 tons per square inch and then annealed to improve magnetic and structural properties, and then insulated as by varnish coating and then baking. One piece cores have been made in full torroids, however, that shape presents several disadvantages in the industry. By virtue of its single surface construction, the torroidal core requires any coil being placed around the core to be wound directly about the shape. Thus, any insulation required between the winding and the core material must be either placed on the winding or coated directly on the torroid which further necessitates special handling of the winding and the core to prevent damage to the insulation. Additionally, there are limitations to the winding of a coil around the core in that automatic winding on such a shape is difficult, and in the cases of a heavy conductor, is impossible thereby necessitating hand winding. In order to circumvent these manufacturing problems, cores have been made in L shapes with two of these shapes subsequently assembled to form torroidal cores. It has been necessary in the past in making sectional cores to employ a molding die made up of a plurality of removable die sections in order to permit withdrawal of the formed L from the die cavity. The die sections forming the L-shaped cavity conventionally are individually clamped on a suitable platform in an abutting sort of relationship and after the required pressure has been applied to a charge of powdered material within the cavity the die sections are unclamped from the platform and moved away from the formed body to permit removal of the compressed core. Both the core section shape and the method of making that shape present serious disadvantages which are overcome by the shape and method of manufacture of my invention.

The necessity of repetitive clamping and unclamping of the plurality of die sections in the forming operation for L shapes results in rapid deterioration of the die sections which further results in varying core shapes. Further, the occurrence of gaps between the sections upon reassembly for another molding contributes to further non-uniformity of the shape of the product formed therein. The ability of the die sections to be disassembled contributes to non-rigidity of the combined shape and allows non-uniform compression of the charge of powdered material within the cavity under the high compressing pressures. Non-uniform compression results in a non-uniform density of material, an irregular shape, as well as internal stresses within the material, all of which contribute to further disadvantages. The necessity of unclamping and clamping the die sections to remove the formed core and to prepare for another compression does not lend to any sort of automatic operation of manufacture.

SUMMARY OF THE INVENTION

The present invention generally provides a method for forming a C-shaped, trapezoidal cross-section of a core of compressed powdered material by uniformly subjecting the powdered material contained in a die cavity to a uniform high pressure and of uniformly releasing the pressure following the compression and of removing the formed section of compressed powdered material from the pressure cavity in such a manner to avoid flexure or deformation of the body during the removal. In particular the present invention includes a method for forming C-shaped sections of cores in an automatic operation having a cavity surrounded by a unitized die structure symmetric about one central axis. The cores produced by the method of the present invention are of more uniform density, permeability and physical dimension and possess improved magnetic, electrical and structural characteristics. Additionally, the novel shape of the core from the unitized die structure exhibits more uniform magnetic and electrical characteristics in a torroidal combination with another section. The sectional C-shaped cores are capable of receiving machine wound coils of conductors of no special size limitations, wound on a core form and insertable over the legs of the sections as they are assembled. Further, in assembled relation the juncture between the sections falls within the physical limits of the core winding, thus minimizing any non-uniformity of magnetic field distribution which might exist in that juncture. These and other features of the present invention will appear more fully from the following detailed description and drawings which accompany the specification.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial plan view showing die construction for making C cores.

FIG. 2 is an elevational view partially in section illustrating die apparatus for performing the invention.

FIG. 3 is a side elevation of a C core of the invention.

FIG. 4 is a front elevation of the C core of the invention.

FIG. 5 is a plan view of the C core of the invention.

FIG. 6 is an elevation of a torroid formed of C cores of the invention.

FIG. 7 is a plan view of a torroid formed of C cores of the invention including windings.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings reference numeral **2** indicates a die sleeve having die inserts **4***a* and **4***b* of a hard material such as a carbide and a table **6** upon which inserts **4** and **4***b* are seated, all of which form unitized die structure **7**. Die inserts **4***a* and **4***b* form a C-shaped die cavity **8** having a top opening **10** and bottom opening **12**. Tapered walls **13** give the cavity **8** a trapezoidal cross-section with walls **13** being the non-parallel sides. Table insert **6** has an opening **14** to receive an ejector **16** having a C-shaped portion **18** adapted to cooperate with opening **12**. In the example disclosed inserts **4***a* and **4***b* and table **6** are retained in sleeve **2** by a shrink fit. The sleeve **2** is adapted to be received into automatic stamping equipment, not shown but well known in the industry, which operates ejector **16** at appropriate intervals and in which also is mounted actuating means for compressing punch **20** having a C-shaped portion **22** adapted to cooperate with opening **10** for compressing material placed in the cavity **8** of the die. In the preferred arrangement table **6** meets die molding insert **4** forming a shoulder **24** in the vicinity of opening **12**. With such an arrangement ejector **16**'s outer perimeter describes an envelope smaller than die opening **8**. It is to be noted, however, that shoulder **24** and ejector **16** in the retracted position as shown by the dotted line of FIG. 2 form the bottom of cavity **8**, against which the compression of ram **20** is developed.

Referring now to FIGS. 3, 4 and 5, reference numeral **30** indicates a magnetizable C-shaped core having a trapezoidal cross-section formed by parallel bases **32** and **34** being the upper and lower bases, respectively, and by non-parallel sides **36**. It is to be noted that both the arms **38** of the C-shaped and the connecting portion **40** have a trapezoidal cross-section as well as the overall cross-section illustrated by the end view in FIG. 3.

FIGS. 6 and 7 illustrate the use of two C-shaped cores **30** in a coil application wherein legs **38** of each of the C's are joined but one of the coils is inverted with respect to the other such that the composite torroid **39** formed by the two cores **30** has parallel bases **40** and **42** which are co-planar with bases **32** and **34**. FIG. 7 also illustrates torroid **39** having a coil form **44** and a winding **46** wound thereon surrounding legs **38** of the composite cores **30**. It is to be noted that any air gap that might exist between the two composite cores within the juncture of legs **38** is well within the internal field of the windings **46** surrounding legs **38**.

To manufacture C-shaped magnetizable cores the die structure shown in FIG. 1 and 2 may be installed in the stations provided in automatic pressing machines for compressing insulated powdered material as is well known in the industry. Such a machine would perform particular mechanical functions, such as introducing the measured quantity of powdered metal into the die cavity, initiating the actuating mechanism to compress the material into an integral core and further initiating the ejecting action to remove the core from the molding die. The specific sleeve **2**, punch **20** and ejector **16** may be adapted to be received in the appropriate cooperating sections of such automatic machinery. The commencement of the manufacturing operation occurs with lubrication of the die mold walls **13**, as by an atomized lubricant followed by the introduction of a measured quantity of powdered material into the cavity **8**. Following this the automatic machinery, not shown, initiates the downward thrust of the punch **20** so that the C-shaped portion **22** enters the die mold cavity **8** at oepning **10** contacting the powdered material. The area and shape of the C-shaped compressing face **23** of punch **20** is slightly less than opening **10**, however, it closely approaches that of cavity **8** at the maximum downward stroke of punch **20**. This is due to the taper of the side walls **13**, which in the example is 1° from the vertical. This insures that the compressive stroke at the downward extent provides a uniform compacting action within the cavity such that the material throughout the cross section of the core is uniformly compacted. Since the walls **13** of the cavity **8** are only slightly tapered and since the corners formed by the meeting of punch **20** and the walls **13** in the base formed by shoulder **24** and the ejector **16** are substantially squared, a uniform compression exists throughout the cross section at the instant of maximum compression.

In the example disclosed, a core of insulated powdered material is produced having a uniform high permeability throughout. The uniformity of permeability is achieved through the uniform compression and absence of additional stresses in the form due to fluctuations in the die. High pressures may be used to achieve the higher permeabilities to compress the core because of the core and die geometry. Cores exhibiting permeabilities of 100 to 350 may be pressed under pressures of 80 to 150 tons/square inch in the shape and die of the invention. Cores thus pressed from insulated powdered metal such as the nickel-iron alloys having at least 30% nickel, commonly known as the permalloys, exhibit a uniform density of about 7.0 to 8.75 g./cm.^{3}. Such cores of insulated powder may be produced of base alloys including up to 90% nickel in the base alloy and may also include additions of one or more of copper, cobalt, chromium, molybdenum and silicon as is well known in the art. Further, cores of a powder alloy containing at least 80% iron, 8% silicon and 4% aluminum have been pressed in C-shapes of uniform density of about 6.0 at pressures of about 100 tons and having a permeability of about 200. Uniform compression equalizes the distribution of forces throughout the core thereby minimizing the development of local stresses within the core structure, which minimizes deterioration of the magnetic and electrical properties of the core.

Upon completion of the compression stroke, punch **20** is removed from opening **8** thus clearing the way for the ejection of the core **30** from the die cavity **8**. The ejection is initiated by ejector **16** being moved by the automatic equipment, not shown, in an upward direction. Due to the trapezoidal cross-section in all aspects of the C-shaped mold discussed above, as soon as core C is raised in the cavity **8** its side walls **36** clear the side walls **13** of the mold at a uniform rate. The ability of the core **30** to expand equally in all directions as it is ejected from the mold further minimizes any stresses or non-unformities in density that might be developed within the core if it were otherwise ejected from the mold.

Referring now to FIGS. 6 and 7 a torroidal core is shown formed by two C-shaped cores with their legs **38** in abutting relationship. The illustration shows one of the two cores in an inverted condition with reference to the other such that the ends **38***a* of the legs are in juxtaposed relation minimizing any air gap which might otherwise occur. It will be further noted that this juncture of leg **38** occurs well within the field of the winding **46** forming an integral part of a coil. The juncture of the two L sections would fall outside the coil **46** allowing a deterioration in the uniformity of the field strength which would otherwise occur within the core in coil combination. Since the windings **46** may be wrapped around a form **44** which may serve as an insulator, the steps necessary to insulate a solid torroidal core may be avoided. Additionally, the coils may all be machine wound on the form **44**, including heavy conductor windings. Thus, the invention contributes substantially to the automation of manufacture of wound cores.

We claim:

1. A magnetizable core of compressed powdered material comprising a center section, two parallel leg sections extending substantially perpendicularly to the ends of said center section forming a C-shaped core, said center section and said leg sections having a substantially

trapezoidal cross-section, the parallel bases of which form the C-shaped sides of said core.

2. A magnetizable core according to claim 1 of compressed insulated powder material and from the group consisting of nickel-iron base alloys containing at least 30% nickel and iron-silicon-aluminum alloys containing at least 80% iron, at least 8% silicon and at least 4% aluminum.

3. A magnetizable core according to claim 2 wherein the nickel-iron alloy includes at least one of copper, cobalt, chromium, molybdenum and silicon.

4. A magnetizable core according to claim 3 having a density of at least 6.0 g./cm.^{3}.

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