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3,256,591

METHOD OF MAKING MAGNETICALLY ANISOTROPIC PERMANENT MAGNETS

Filed April 26, 1963

2 Sheets-Sheet 1

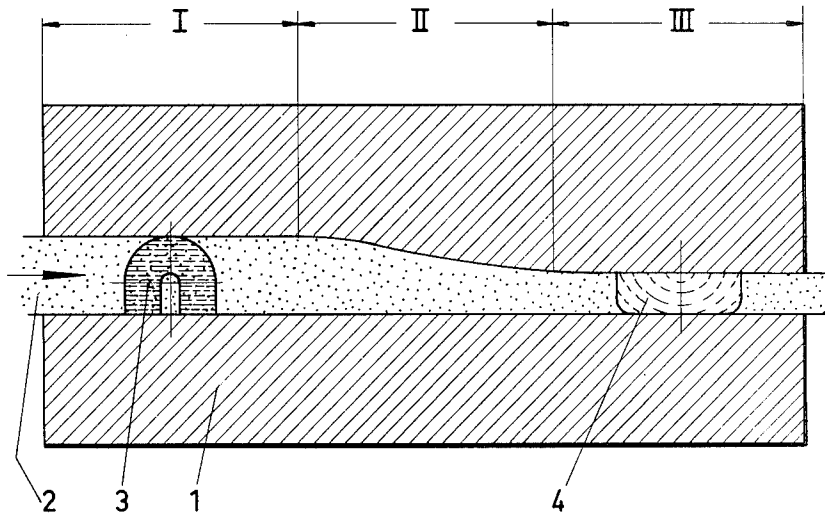


Fig. 1

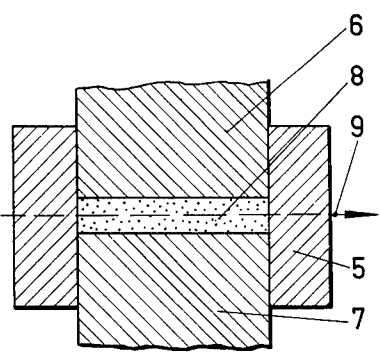


Fig. 2

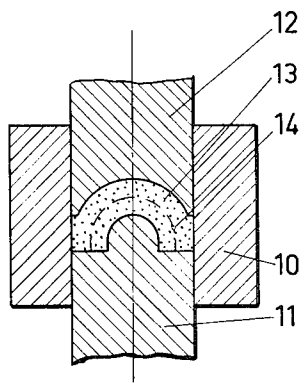


Fig. 3

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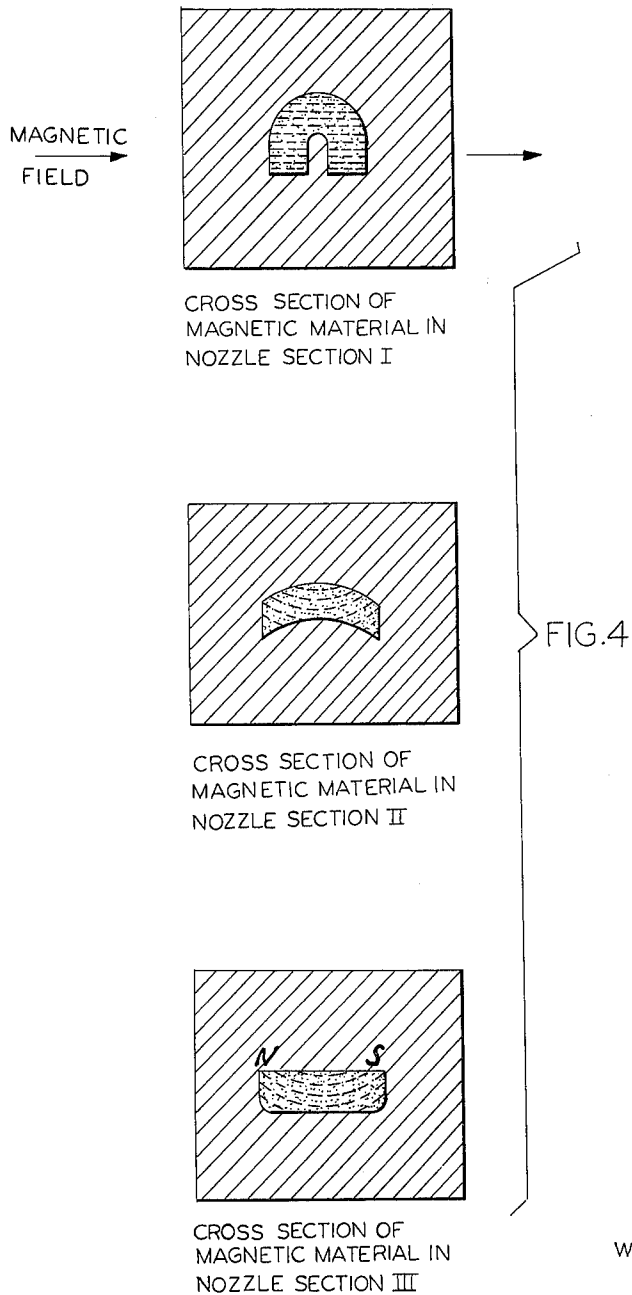
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METHOD OF MAKING MAGNETICALLY ANISOTROPIC PERMANENT MAGNETS

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8 Claims. (Cl. 29—155.6)

This invention relates to a method of making magnetically anisotropic permanent magnets from powdered materials.

It is known to prepare magnetically anisotropic permanent magnets from powdery materials by pressing the powder in a magnetic field with a binder and then curing the binder. Such method has been used for the preparation of permanent magnets from Alnico powder and synthetic resin binders. Anisotropic permanent magnets can also be formed by compressing finely divided barium ferrite in a magnetic field without a binder and then solidifying the shaped bodies by sintering. In this method, the powdery particles are oriented in the magnetic field so as to produce a preferential direction in the finished magnetic body in the direction of the applied magnetic field. Finally, it is also known that on compression of barium ferrite powder, without application of a magnetic field, alone by mechanic forces, wall friction, or by the platelet form of the particles, magnetic anisotropy can be produced. In this last method, the direction of anisotropy is determined by the direction of the compression or the direction of the applied magnetic field, so that only simple, generally linear preferential directions can be produced.

The principal object of the present invention is to provide a simple method for producing non-linear, for instance arcuate preferential directions in permanent magnets which are prepared from finely divided magnetic materials.

Other objects and advantages will be apparent from a consideration of the specification and claims. According to the invention, an initially produced preferential direction is converted into a direction of a different geometric shape by mechanical deformation of the form and/or surface of the cross section of the magnet.

The invention will be better understood with reference to the accompanying drawing wherein

FIG. 1 is an elevational view of a die compressing a magnetic powder, the mass of said powder being partly shown in cross section;

FIGS. 2 and 3 show elevational views of subsequent steps of another embodiment of the invention, and

FIG. 4 shows cross sections of the nozzle 1 in sections I, II, and III of FIG. 1, indicating the direction of the applied magnetic field.

Referring now first to FIG. 1 of the drawing, it represents an extrusion nozzle 1 into which a magnetic powdery material 2 is introduced in direction of the arrow. It may be mixed with a binder, preferably a thermoplastic resin. In the section I, the nozzle has a U-shaped profile cross-section, as shown at 3, where said cross section is shown turned by an angle of 90° to the plane of the longitudinal section of the nozzle. In section I, a strong magnetic field is applied transversely to the axis of the nozzle, which produces a preferential direction as indicated in dotted lines. The material then passes into the portion II of the nozzle where the U-shaped cross-section is bent to a substantially rectangular profile 4 which receives its final form in portion III of the nozzle. In this way, the preferential direction of the magnetic particles is so bent as to produce approximately the form shown at 4 in broken lines. This

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form is particularly suitable for a one-sided arcuate magnetization as used, for instance, for portable magnets, flexible breaker strips for refrigerator doors, and the like, and has high values of adhesive power. Said adhesive power of magnets having a profile 4 can be further enhanced by additional magnetization after the magnets have been extruded.

According to the invention, the powdered magnetic materials may also be employed suspended in a suitable medium for instance water, to a paste, formed, dried, and finally sintered to a solid body.

In the embodiment of the invention illustrated in FIGS. 2 and 3, the magnetic powder 8 is formed in a molding die 5 by means of rams 6 and 7 whereby a preferential direction is impressed by means of a magnetic field 9 disposed in a direction transversely of the direction of compression. The thus obtained body is then transferred to a second die 10 equipped with rams 11 and 12; said rams have cooperating heads bending the magnetic body into a U-shape 13 which finished body has then a curved preferential magnetic direction 14.

In a further embodiment of the invention, the magnetic powder may be preformed by rollers, for instance by pass rollers, and be given a preferential direction by a magnetic field or by mechanical forces, and a different geometric form of the preferential direction may be produced by additional rolling with change of the forms and/or surface of the cross section.

As magnetic powders, preferably magnetic materials of high coercivity are used, such as ferric oxides of the type $\text{BaO} \cdot 6\text{Fe}_2\text{O}_3$, Alnico, manganese-bismuth alloys, or manganese-aluminum alloys, if desired with conventional additions.

I claim:

1. A method for making magnetically anisotropic permanent magnets having a desired alignment of the domains from finely divided magnetic materials comprising shaping said powder to a magnetic body, magnetically imparting to said body a preferential direction of magnetization, and subsequently mechanically deforming said magnetic body to change it to a different geometric shape and transform said preferential direction to a different direction.

2. The method as claimed in claim 1 wherein said magnetic material is used together with a thermoplastic resin binder.

3. The method as claimed in claim 1 wherein said magnetic material is used as an aqueous paste.

4. The method as claimed in claim 1 wherein a magnetic material of high coercive force is used.

5. A method for making magnetically anisotropic permanent magnets from powdered magnetic materials comprising passing said material through an extrusion nozzle, providing in said nozzle a first and a second compression zone, said zones having dissimilar cross sections, and imparting a preferential magnetic direction to the material passing through said first zone, said preferential direction being changed to a different direction on passage of the material through said second zone of dissimilar cross section.

6. A method for making magnetically anisotropic permanent magnets from powdered magnetic materials comprising preforming said magnetic powder in a die to a shaped body, imparting to said powder while it is preformed a preferential magnetic direction, and compressing said shaped body in a second die to a final magnetic body having a cross section dissimilar to that of the shaped body, thereby changing said preferential magnetic direction to a different direction.

7. A method for making magnetically anisotropic permanent magnets from powdered magnetic materials comprising rolling a powdery magnetic material to a first

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shape, imparting to said powder while it is rolled a preferential magnetic direction, and subsequently rolling said first shape to a final second shape having a cross section dissimilar to that of the first shape, thereby changing said preferential magnetic direction to a different direction.

8. A method for making a flat substantially rectangular magnetically anisotropic elongated permanent magnet having its N and S poles at the same side of one of its flat surfaces comprising extruding a magnetic powder through a U-shaped nozzle, applying to said powder while it is extruded a magnetic field transversely to the axis of said nozzle, and subsequently deforming the thus obtained U-shaped magnetic body into a substantially flat rectangular shape.

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JOHN F. CAMPBELL, *Primary Examiner.*

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