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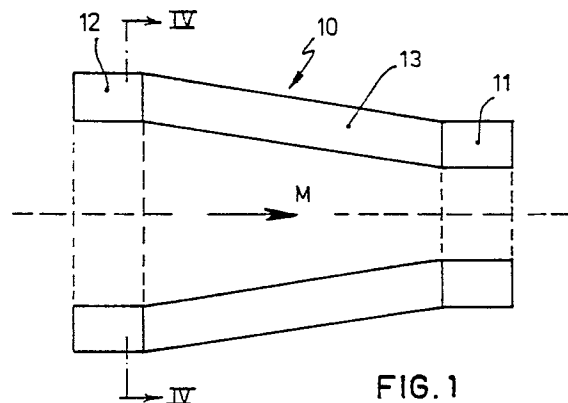
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(54) **Multipolar rotor.**

(57) Method and devices for producing a magnetic object, to be moulded in a moulding device from a mixture of grains of magnetic material and hardening binding agent, said object having pole areas of small dimensions, the mixture being subjected in a moulding cavity of a moulding body of the moulding device to temperature changes, gravity, mechanic forces or magnetic forces, or combinations of those. The invention comprising the reduction of a strong, permanent magnet to fully magnetized anisotropic permanently magnetic material, the reduction of the fragments of fully magnetized anisotropic permanently magnetic material to grains, until all grains are smaller than the width of a pole area, mixing those grains with the hardening binding agent, inserting the mixture into the moulding device, and ensuring that the mixture hardens in the moulding device, providing the permanently magnetized object as the final product.



Multipolar rotor

The invention relates to a method and device for producing permanently magnetized objects, and multipolar rotors of small dimensions in particular.

The method according to the invention relates to the production of a magnetic object to be moulded in a moulding device from a mixture of grains of magnetic material and hardening binding agent, said object having pole areas of small dimensions, the mixture being subjected in a moulding cavity of a moulding body of the moulding device to temperature changes, gravity, mechanic forces or magnetic forces, or combinations of those.

It is generally known to produce magnetic bodies by means of magnetic material bound by resin or a suitable synthetic material in which method pulverized or granulated sintered magnetic material such as SmCo_5 , and $\text{Sm}_2\text{Co}_{17}$ is processed to semi-finished product magnetic elements while adding a suitable binding agent in a mass production process. By using the correct grain size for the magnetic material, desired filling factors can be obtained. The produced semi product magnetic elements, having no or only slight net-magnetization, can then be processed further, e.g. to adhering strips, during which they can be permanently magnetized in the end so as to perform the function they are supposed to perform.

The art does not teach how the above magnetic material can be used in a production process so, that in subsequent process steps multipolar permanently magnetized objects can be produced which incorporate the desired magnetic properties and magnetic pole configurations. In the case of pole areas of small dimensions, e.g. to be made in a multipolar rotor for a stepper motor with a diameter of up to 4 mm and 60 poles with alternately N- and Z-poles, along its periphery, it is desirable to provide the product that is to be made already with strong poles in the production stage. Although it is possible with the known method to establish high filling factors with the grains, it is extremely difficult, not to say impossible, to magnetize those afterwards to poles with a width of about 0.2 mm.

In order to solve this problem, the method according to the invention is characterized by the reduction of a strong, permanent magnet to fragments of fully magnetized anisotropic permanently magnetic material,

the reduction of the fragments of fully magnetized anisotropic material to grains, until all grains are smaller than the width of a pole area, mixing those grains with the hardening binding agent,

inserting the mixture into the moulding device, and ensuring that the mixture hardens in the moulding

device, thus providing the permanently magnetized object as the final product.

This method can particularly be used to obtain grains that are smaller than 150 μm from desired, fully magnetized anisotropic permanently magnetic material or of another required size.

The invention also provides a method and device for reducing fragments of fully magnetized anisotropic permanently magnetic material, in which the fragments are introduced between grinder bodies of which at least the surfaces that face the fragments are made of the same magnetic material. Specifically the fragments are inserted between two grinder bodies of which at least the surfaces that face each other have mutually opposite magnetic poles.

Moreover, the invention provides a method and device in which the mixture inserted in the moulding device is led from at least a second moulding body that is larger than and similar in structure to the first stated moulding body to the first moulding body through a passage member, periodically replacing said filled first moulding body by an equal moulding body that is to be filled next, the first filled moulding body providing a permanently magnetized object as the final product.

A special characteristic of this method and moulding device is that the mixture is led to the first moulding body, while being subjected for at least a part of the passage member to magnetic forces originating from magnetic means near the surface at the passage member's inner circumference.

Another feature of the moulding device is that at least the inner circumference of a cross-section of the passage member is similar in structure to the inner circumference of a moulding body, the dimensions of the inner circumference gradually declining from that of the second moulding body to that of the first moulding body, the arrangement in which each cross-section near the inner circumference of the passage member is similar in structure to that of the moulding body and the inner circumference of the passage member extends conically from the second moulding body to the first moulding body being preferred.

Apart from that the moulding device according to the invention is characterized by an axially symmetrical presser means that, under axial displacement thereof in the moulding device, presses the mixture in the direction of the first moulding body, while the presser means, composed of a mandrel protruding at least partially into the moulding device and having a closely fitting sleeve between the moulding device and the mandrel for pressing the

mixture to the first moulding body, is preferred.

Another feature of the moulding device according to the invention is formed by the mandrel provided at at least a part of its surface with magnetic poles, the magnetic poles being aligned with those that are situated near the inner circumference of the second moulding body and with at least part of a passage member.

Such a moulding device may comprise fixed ribs that extend partially or entirely between interpolar areas between the poles of the magnetic means in the mandrel and the magnetic means in the moulding device, the sleeve comprising a periphery that closely fits to these ribs and can be displaced up to the passage member.

A system according to the invention is characterized by the above-mentioned moulding device and grinding device, to which suitable supply and discharge means have been added.

Further details, characteristics and properties will be elucidated in the following description. Several figures will be referred to, of which

figure 1 represents a section along the axis of a schematically drawn moulding device according to the invention,

figures 2A, 2B, 2C represent a similar section of a part of the moulding device, in which a presser means has been inserted into the moulding device,

figure 3 also represents a longitudinal section along the axis of the schematically drawn moulding device according to the invention, in which a composed presser means has been inserted into the moulding device,

figure 4 provides a cross-sectional view along the line IV-IV in figure 1,

figure 5 shows a cross-sectional view along the line V-V in figure 3,

figure 6 represents a view similar to figure 5, in which the mandrel comprises magnetic means,

figure 7 gives a view similar to figures 5 and 6, in which mandrel and moulding device are connected through ribs,

figure 8 represents a schematic view of the positioning of the fragments of fully magnetized anisotropic permanently magnetic material that are to be ground,

figure 9 schematically represents the grinding device according to the invention, and

figures 10A, 10B and 10C schematically represent a top view with enlargement and side view, respectively, of a permanently magnetized object as the final product, obtained with the moulding device according to the invention.

The merit of the invention can particularly be elucidated by means of figures 1, 4, 8, 9 and 10.

figure 8 shows fragments (60) of fully magnetized anisotropic permanently magnetic material,

which have been obtained by breaking a strong magnet of sintered permanently magnetic material such as SmCo_5 or $\text{Sm}_2\text{Co}_{17}$ or other desired strong, permanently magnetic material into small fragments. This material has to be reduced to grains, e.g. in a grinding device as described hereafter and represents the starting material then. In order to have the grains take up a fixed position in the final product they are combined in a mixture with a hardening binding agent. From this mixture, an object (80) of small dimensions will have been moulded as can be seen in figures 10A and 10C. This object could e.g. be a stepper motor with stator poles of a clockwork with a diameter of 4 mm for the rotor and along the periphery 60 pole areas (90, 91) applied therein of alternately north poles N and south poles Z.

For the production of such a rotor, the invention shows in a moulding device (10) a first moulding body (11), a second moulding body (12), and a passage member (13) that can be connected between the two bodies. Both the moulding bodies (11, 12) are similar in structure, although they are not of the same size. They incorporate, inserted near their inner surfaces, magnetic means (30, 31) as indicated in figure 4, in which magnetic poles, referred to as N and Z for north and south, are situated at the inner circumference (32) of the moulding bodies. These magnetic means serve to magnetically influence the mixture of the starting material and the hardening binding agent, and in particular the portion near the inner circumference (32), in order to establish pole areas, particularly linking up at the N, Z poles, to which in the mixture a garland (92) of magnetic flux lines links up. This magnetic manipulation begins with the introduction of the mixture into the second moulding body (12). When carefully feeding the mixture through the moulding device in the direction of the arrow indicated by M to the first moulding body (11), the pole patterns in the mixture will be maintained. When a part of the mixture has arrived in the first form body (11) it will be able to harden there, or it will have hardened almost or completely, so that the first moulding body (11) can be removed and a subsequent similar moulding body (11') can be placed before it, the filled first moulding body thus providing a permanently magnetized object as the final product.

The magnetic means (30, 31) in the two moulding bodies (11, 12) can be slices or discs of desired permanently magnetic material. Strong magnets with high remanence B_r are preferred. For this purpose certain iron compounds, SmCo alloys such as SmCo_5 , and $\text{Sm}_2\text{Co}_{17}$, as well as B-doped, Nd-Fe alloys.

The passage member (13) will preferably run gradually from the second moulding body (12) to

the first moulding body (11). E.g. the inner circumference can be a truncated cone, however, other shapes of the inner circumference are also possible. Preferably each cross-section of the passage member will have to be similar to that of a moulding body in order to disturb the pole pattern formed in the mixture as little as possible when passing it through the moulding device.

Thus one can also think of an inner circumference for the two moulding bodies that consists of a regular polygon. Then each side of the polygon will have a magnetic N-pole or Z-pole. Accordingly, the passage member will be a truncated pyramid, the cross-section of which transversely to the axis being a regular polygon, which polygon is similar to the cross-section of the two moulding bodies. Provided that there is a gradual transition, it is possible that the cross-section of the passage member (13) begins as a circle and ends as a regular polygon, or the other way around, to which the two moulding bodies (11, 12) have to link up accordingly.

In order to maintain the pole pattern in the mixture in the best possible way it is preferred to also apply magnetic means as found in the two moulding bodies in at least a part of the passage member (13) near the surfaces at the inner circumference. Slices or discs of desired permanently magnetic material extending accordingly from the second moulding body (12) in the direction of the first moulding body (11) will prevent the possible disturbance of the pole patterns in the mixture. On the other hand, with a suitable binding agent in the mixture, a passage member of iron or other low-magnetic material can provide sufficient guidance of magnetic flux lines from the poles in the mixture.

Suitable size ratios of the moulding body (11, 12) are e.g. for the respective inner diameters 10 mm and 4mm, while the length of the passage member (13), i.e. the height of the truncated cone, is 30 mm. However, other dimensions are also possible and even desirable if the hardening of the binding agent requires such. It will be clear to an expert that the reduction factor 2.5 can be easily deviated from.

In figure 10B the dotted part in figure 10A of the object (81) to be produced is shown enlarged. The drawing represents a possible structure of pole areas (90, 91) composed from grains of fully magnetized anisotropic permanently magnetic material for an N-pole (90) or a Z-pole (91).

On the dimensions of the grains, the following can be remarked.

In order to have the poles in the pole areas (90, 91) of the final product (80) to be as strong as possible, it is necessary that the mixture in the pole areas comprises an as large as possible fraction of starting material. In other words: the filling factor, to

be determined as the ratio of the volume of starting material per volume unit of mixture, should be as close to 1 as possible. Such a mixture should comprise grains of the maximally admissible size, viz. the width of a pole in the final product on the one hand, and a graded composition of smaller grains in order to fill up the space between the larger grains on the other hand. It should be remarked that the small grains are preferably not so small that they can form an inextricable conglomerate, having, as a consequence of differences in orientation of the separate parts, a highly reduced magnetic moment as a whole. Such a mixture will provide a minimal surface to be enveloped by the binding agent and will thus result in the largest possible filling factor.

From the above it can be easily deduced that with a diameter of 4 mm the maximum pole width at the surface of an above-described rotor (80) with 60 poles is about 0.2 mm (= 200 μ m). For the grains to be positioned correctly and somewhat interspaced, i.e. not in the interpolar areas, they should not be bigger than about 150 μ m. Similar calculations are possible for other rotor dimension.

With the moulding device (10) as discussed by means of figures 1 and 4, having magnetic means (30, 31) on the inner circumference (32) of said moulding device, the pole patterns can be established in the desired structure, as indicated in figure 10B. It will be understood that when introducing the mixture into the second, larger moulding body (12) the grains can be positioned correctly.

Particularly in the second, larger moulding body (12) the grains can be positioned in the right direction, for in said moulding body, the grains are the most movable on the one hand, since the binding agents is at its most flowing there, and because the grains will have enough space to do so on the other hand. Once they have been arranged in patterns, the pole patterns will be maintained in the passage member (13) up to the first moulding body, where the final product is provided as described above.

Before the mixture is composed the fragments (60) will have to be reduced to the above-described grains of desired dimensions. In this respect the following should be noted.

Figure 8 shows a collection of fragments (60) of the fully magnetized anisotropic permanently magnetic material that is to be processed. These fragments have been obtained by breaking strong, permanent magnets of desired magnetic material into small fragments. These fragments (60) have to be reduced to granulated material or granulate of desired dimension. In order to prevent the fragments (60), and, after grinding, the grains from lumping in a head-to-tail arrangement, the present invention provides a solution by means of a grind-

ing device, as schematically shown in figure 9. The fragments (60) are introduced between two grinder bodies (70, 71) with facing magnetic surfaces (72, 73) of matching polarity. Since the fragments (60) will be directed accordingly by this arrangement a more regular processing of all the fragments is possible and the grains are more easily separated from one another after grinding. The grinder bodies (70, 71) can be permanent magnets, or electromagnets, or a combination of those. In order to guide the flux lines these grinder bodies (70, 71) can partly consist of iron or another magnetic material, e.g. in a portion (74) as indicated in figure 9. The grinder bodies (70, 71) can be rotated about a joint axis (A), and they can be pressed, either or not adjustably, as indicated in the direction of the arrows (f). The entire grinding device can be incorporated in a yoke of suitable magnetic material, again intended to guide the flux lines, in which a bottom portion (75) can be integrated with the yoke.

Passing the mixture through the moulding device (10) in the direction of the arrow, indicated by M, can be established in several ways. The hardening rate of the binding agent, the length of the moulding device (10) and its positioning (horizontally, inclined, vertically, with removable moulding body (11) above or below) will also determine the passing through of the mixture. Thus even the elimination of gravity can be taken into account. The passing through will particularly be established by presser means (20, 21, 22, 23) as indicated in figures 2A, 2B, 2C and 3. In these figures, the displacement of these means has been indicated by arrows (a, b, c, d and e). It will be understood that the presser means preferably are of non-magnetic material so as not to disturb the pole patterns. It can also be remarked that the filling material between the magnetic means (30, 31) is non-magnetic, e.g. a synthetic material or metal, so that the flux line pattern at the inner circumference (32) of the moulding device is not disturbed either. Possibly the two moulding bodies (11, 12), and, if necessary, the passage member (13), can be enveloped by a sleeve of magnetically conductive material in order to guide the flux lines.

In figure 2A the presser means (20) is a cylindrical block that closely fits into the supply opening of the second moulding body (12). When a large quantity of the present mixture is introduced into the moulding device (10), the mixture can be pressed to the first moulding body (11) by careful pressing, with which the pole pattern will have to be maintained, and during which in the meantime the mixture can be topped up, or the temperature can be increased or decreased for a part of the moulding device. It is clear that the block (20) can only be displaced up to the passage member (13).

Figure 2B shows an alternative way to leave an interspace (33) between the presser means (21), also being a cylindrical block, and the moulding device (10). Although the length of the block (21) is the same as that in figure 2A, it may vary, dependent on the requirements at the used position of the moulding device (10), the binding agent used, and the chosen passage length. It will be clear that the form and the cross-section dimensions of the interspace (33) are important to the preservation of the pole pattern in the mixture. Preferably the respective circumferences of the block (21) and the inner circumference (32) of the second moulding body (12) will be concentric to the axis of the moulding device (10).

Figure 2C shows a presser means in the form of a mandrel (22), also having an interspace (35) between the mandrel and the moulding device (10) as indicated above, in which the interspace (33) extends over at least a part of the passage member (13). In a favourable manner the mandrel (22) can extend, contrary to the way it has been drawn in figure 2, up to the first moulding body (11). The mandrel (22) can even end there, where the first moulding body (11) begins, in a point at dimensions chosen for that purpose for the diameter of the cylindrical part of it at regularly extending interspace (33), as indicated above.

Figure 3 shows a preferred embodiment of a presser means according to the invention. The presser means is composed of a the above-described mandrel (22), and a cylindrical presser sleeve (23) to be displaced over the mandrel (22) in the second moulding body (12) in a close-fitting arrangement. After inserting the mixture, and subsequently the mandrel, as indicated in the position of the figure, the mixture can be regularly pressed with the sleeve (23). Topping up the mixture, removing the first moulding body (11) and possible heating or cooling can be performed as indicated above. It will be clear that the sleeve (23) can be pressed up to the passage member (13).

Figure 5 shows a view of a cross-section along the line V-V in figure 3. Interpole areas 34, situated between alternating N- and Z-poles, are also schematically indicated.

Figure 6 shows a view similar to that of figure 5, but here magnetic means (40, 41) have also been incorporated in the mandrel (22). These magnetic means have at the surface of the mandrel alternating N- and Z-poles. When inserting the mandrel, the N- and Z-poles on the inner circumference (32) of the moulding device (10), and the N- and Z-poles on the surface of the mandrel (22) will have to be aligned in the manner as drawn in the figure. This can e.g. be established by positioning the mandrel (22) fixedly with respect to the moulding device (10). The thus formed magnetic

areas in the mixture will have the shape of bar magnets according to this cross-section.

Figure 7 represents the case in which the inter-polar areas (34, 44) of the moulding device (10) and the mandrel (22), respectively, are interconnected by ribs (50). These ribs can also merely extend partially from the moulding device (10) to the mandrel (22), or vice versa. In accordance with the three stated cases the presser sleeve (23) will comprise a cylindrical comb-like means, or a sleeve wall provided with relief, respectively, fitting into respective channels (51), as indicated in figure 7, or grooves, which, in the other stated case, will be formed between the ribs (50) that protrude there. It has to be remarked that the ribs (50) will possibly not extend quite up to the first moulding body (11). On the one hand this is due to lack of room, on the other hand the bar magnets as indicated above will get so close to one another that further extending ribs will narrow down the pole areas of these bar magnets and thus hamper their operation.

In order to have the pressing of the mixture performed as gradually and regularly as possible, the inner circumference (32) of the moulding device (10) and the surfaces of the fixedly positioned mandrel (22) in figures 5, 6 or 7, and of the ribs (50) in figure 7, be provided with a coating that slides well, e.g. of teflon. The ribs (50) can also be entirely made of teflon.

It has not been indicated in figures 1 and 3 that the first moulding body (11) that is to be filled may comprise a bottom portion, with which also a shaft, extending from the bottom along the axis in the moulding device (10), e.g. over the entire length of the moulding body (11), can be provided. Such a recess could function as the place to secure a shaft.

In order to further increase the filling factor, the method according to the invention for producing permanently magnetized objects of the type as described above may also comprise the mixing, in a suitable manner, of binding agent and starting material, and feeding this mixture to the moulding device on the one hand, and sucking the mixture by means of vacuum into the first moulding body (11) on the other hand. The first measure is met by feeding the starting material through a thin layer of binding agent by channels or tracks, and particularly by drawing the starting material through it by means of magnets. In case of a moulding device (10) according to figures 5, 6 and 7 the channels are preferably injection moulding channels. Along a supply end thereof, magnets can be periodically passed. Of course it is important that during this mixing, the layer of binding agent around a grain is as thin as possible. The second measure, viz. sucking by means of vacuum, will ensure that possible air or gas bubbles are sucked off. The

density of the starting material can be further improved by this method.

An object (80), obtained as final product with the above-described devices and methods, can have a shape as drawn in figures 10A, 10C, showing a top and side view, respectively, of such an object. The N- and Z-poles (90, 91) applied therein alternate and in this way can provide a multipolar rotor for a stepper motor in a clockwork. The possible recess, extending along the shaft, destined for later securing of the rotor in a clockwork, has not been drawn. If the dimensions of the shaft give rise to such actions, it can be made of soft iron, so that it can serve as a magnetic guidance in the magnetic circuit of stator and rotor. It then forms a well-guiding internal closing path for the permanently magnetized poles of the rotor, and improves the external close way for the electromagnetically powered stator poles. The described magnetic function can also be performed by a plate, ring or collection of ring segments made of soft iron and inserted in a recess in the rotor body (80).

Multipolar rotors with diameters smaller than 4 mm can be produced by means of the above-described methods and devices. If such rotors are applied in stepper motors with a small stepping angle (e.g. 6°) for clockworks, this could result in a considerable saving of space in the clockwork housing.

Superfluously it is pointed out that the above-described method and devices can also be applied for producing other objects having pole areas arranged at the surface.

It will be clear to any expert that changes and alterations can be made in a suitable manner to the present methods and devices. One could e.g. think of specially chosen atmospheric circumstances. The object (80) could also incorporate an iron core or iron ring for guiding the flux lines. It goes without saying that such changes are not beyond the scope of the present invention, as determined in the enclosed claims.

Claims

1. Method for producing a magnetic object, to be moulded in a moulding device from a mixture of grains of magnetic material and hardening binding agent, said object having pole areas of small dimensions, the mixture being subjected in a moulding cavity of a moulding body of the moulding device to temperature changes, gravity, mechanic forces or magnetic forces, or combinations of those, **characterized by** the reduction of a strong, permanent magnet to fully magnetized anisotropic permanently magnetic material,

the reduction of the fragments of fully magnetized anisotropic permanently magnetic material to grains, until all grains are smaller than the width of a pole area,

mixing those grains with the hardening binding agent,

inserting the mixture into the moulding device, and ensuring that the mixture hardens in the moulding device, providing the permanently magnetized object as the final product.

2. Method according to claim 1, **characterized by** the reduction of the fragments (60) of the fully magnetized anisotropic permanently magnetic material to grains, until the grains are smaller than 150 μm .

3. Method according to claim 1, **characterized by** the reduction of the fragments (60) to grains, until the grains are smaller than 100 μm .

4. Method according to claim 1, 2 or 3, **characterized in that** the reduction of the fragments (60) is performed by means of a grinding device, in which the fragments (60) are introduced between grinder bodies (70, 71) of which at least the surfaces that face the fragments (72, 83) are made of the same magnetic material.

5. Method according to claim 4, **characterized in that** the fragments (60) are inserted between two grinder bodies (70, 71) of which at least the surfaces that face each other (72, 73) have mutually opposite magnetic poles.

6. Method according to claim 5, **characterized in that** the grinder bodies (70, 71) are rotated with respect to each other about a joint axis (A).

7. Method according to claims 4, 5 or 6, **characterized in that** the grinder bodies (70, 71) are pressed against the fragments (60) in an adjustable manner.

8. Method according to claim 1, **characterized in that** the mixture inserted in the moulding device is led from at least a second moulding body (12) that is larger than and similar in structure to the first stated moulding body (11) to the first moulding body through a passage member (13).

9. Method according to claim 1 or 8, **characterized in that** said filled first moulding body (11) is replaced periodically by an equal moulding body (11') that is to be filled next.

10. Method according to claim 8, **characterized in that** the mixture is led to the first moulding body (11), while being subjected for at least a part of the passage member (13) to magnetic forces originating from magnetic means (30, 31) near to the surface at the passage member's inner circumference.

11. Method according to claim 8, **characterized in that** an axially symmetrical presser means (20, 21, 22, 23) presses the mixture in the mould-

ing device (10) in the direction of the first moulding body under axial displacement of the presser means.

12. Method according to claim 11, **characterized in that** the presser means, which is a cylindrical block (20) that closely fits into the second moulding body (12), can be axially displaced up to the passage member (13).

13. Method according to claim 11, **characterized in that** the presser means, which is a cylindrical block (21), can be axially displaced in the moulding device (10), forming between the moulding device (10) and the cylindrical block (21) an interspace at least in the second moulding body (12) and a portion of the passage member (13).

14. Method according to claim 11, **characterized in that** the presser means (22), formed by a mandrel, can be axially displaced in the moulding device (10) up to the first moulding body (11).

15. Method according to claim 14, **characterized in that** in an interspace (33) between the fully inserted mandrel and the moulding device the mixture can be displaced to the first moulding body (11) between the second moulding body (12) and the passage member (13) on the one hand and the mandrel (22) on the other hand.

16. Method according to claim 8, **characterized in that** the presser means, composed of a cylindrical block (22) being displaceable in the direction of the moulding device (10) and having a cylindrical sleeve around it, the joint section of which fits precisely into the second moulding body (12), can be displaced together with the sleeve (23) up to the passage member (13) when pressing the mixture.

17. Method according to claim 15 or 16, **characterized in that** the presser means, being a mandrel (22), protrudes at least partially into the passage means (13).

18. Grinding device, **characterized by** grinder bodies (70, 71) for grinding fragments (60) of fully magnetized anisotropic permanently magnetic material to grains, of which bodies at least the surfaces (72, 73) facing the fragments (60) are formed of said magnetized material.

19. Grinding device according to claim 18, **characterized by** two grinder bodies (70, 71) of which at least the surfaces facing each other (72, 73) consist of anisotropic magnetic material and have opposite magnetic poles, the material of which is the same as the starting material that is to be ground from fragments (60) of fully magnetized anisotropic permanently magnetic material.

20. Grinding device according to claim 19, **characterized by** a rotation device that rotates the grinder bodies (70, 71) with respect to each other about a joint axis (A).

21. Grinding device according to claims 19 or 20, **characterized by** an adjustable pressing device for pressing the grinder bodies (70, 71) during grinding.

22. Grinding device according to one of claims 19, 20 or 21, **characterized in that** the grinding device is surrounded by a yoke body for guiding the magnetic flux lines.

23. Moulding device for producing a magnetic object with pole areas of small dimensions, from a mixture of grains of magnetic material and hardening binding material, the mixture being subjected in a moulding cavity of a moulding body of the moulding device to temperature changes, gravity, mechanic forces or magnetic forces or combinations of those, **characterized by** at least a second moulding body (12) that is larger than and equal in structure to the first-mentioned moulding body (11), and at least a passage member (13), to which the moulding bodies (11, 12) can be connected and that is intended for passing the mixture from the second moulding body (12) to the first moulding body (11) through it.

24. Moulding device according to claim 23, **characterized in that** at least the inner circumference of a cross-section of the passage member (13) is similar to the inner circumference (32) of a moulding body (11, 12), the dimensions of the inner circumference gradually running from that of the second moulding body (12) to that of the first moulding body (11).

25. Moulding device according to claim 24, **characterized in that** each cross-section near the inner circumference of the passage member (13) is similar in structure to that of a moulding body (11, 12).

26. Moulding device according to claim 24, **characterized in that** that a part of the cross-sections near the inner circumference of the passage member (13) is similar in structure to the cross-sections of a moulding body (11, 12).

27. Moulding device according to claim 24, **characterized in that** at least a part of the cross-section, near the inner circumference of the passage member (13), is provided with magnetically conductive material.

28. Moulding device according to one of claims 23-27, **characterized in that** that the envelope of the cross-sections of at least the inner circumference of the passage member (13) forms a truncated cone, the ends of which link up with the inner circumferences of the moulding bodies (11, 12), respectively.

29. Moulding device according to claim 23 or 24, **characterized by** an axially symmetrical presser means (20, 21, 22, 23) that, under axial

displacement thereof in the moulding device (10), presses the mixture in the direction of the first moulding body (11).

30. Moulding device according to claim 29, **characterized in that** the presser means is a cylindrical block (20) that fits closely into the second moulding body (12) and that can be axially displaced up to the passage member (13).

31. Moulding device according to claim 30, **characterized in that** the presser means is a cylindrical block (21) that can be displaced axially in the moulding device (10), forming at least in the second moulding body (12) and in a first portion of the passage member (13) an interspace between the moulding device (10) and the cylindrical block (21).

32. Moulding device according to claim 29, **characterized in that** the presser means (22) is formed by a mandrel that can be axially displaced in the moulding device (10) up to the first moulding body (11).

33. Moulding device according to claim 32, **characterized in that** between the completely inserted mandrel and the moulding device an interspace (33) is formed, the mixture being displaceable between the second moulding body (12) and the passage member (13) on the one hand and the mandrel on the other hand to the first moulding body (11).

34. Moulding device according to claim 29, **characterized in that** the presser means is composed of a cylindrical block that is axially displaceable in the moulding device (10) with a cylindrical sleeve (23) around it, the joint section of which fits precisely into the second moulding body (12), the sleeve (23) being displaceable up to the passage member (13) while pressing the mixture.

35. Moulding device according to claims 33 and 34, **characterized in that** the presser means is a mandrel (22) protruding at least into a portion of the passage member (13).

36. Moulding device according to claim 34 or 35, **characterized in that** the presser means comprises magnetic means (40, 41) over at least a portion towards the inside of the moulding device (10), the poles of which are aligned with and correspond magnetically to the poles of magnetic means (30, 31) situated near the surfaces of the second moulding body (12) and the passage member (13).

37. Moulding device according to claim 36, **characterized in that** the presser means (22) with magnetic means (40, 41) is fixedly positioned with respect to the moulding device.

38. Moulding device according to claim 37, **characterized by** fixed ribs (50) that extend partially or entirely between interpolar areas (34, 44) between the poles of the magnetic means (40, 41)

in the mandrel (22) and the magnetic means (30, 31) in the moulding device (10), the sleeve (23) comprising a periphery that corresponds to these ribs (50) and being displaceable up to the passage member (13).

39. Moulding device according to one of claims 23-38, **characterized in that** the moulding bodies (11, 12), the passage member (13) and the ribs (50) are coated at their passage surfaces with a layer of material that has a sliding effect upon the mixture.

40. Moulding device according to claim 39, **characterized in that** this sliding material is teflon.

41. Moulding device according to claim 38 or 39, **characterized in that** the ribs (50) are made of a material that slides well.

42. Moulding device according to claim 40 or 41, **characterized in that** this sliding material is teflon.

43. Moulding device according to one of claim 23-42, **characterized in that** the second moulding body (12) comprises closely connecting supply means.

44. Moulding device according to claim 43, **characterized in that** the supply means comprise injection moulding channels.

45. A system for the manufacture of a permanently magnetized object, **characterized by**, subsequently,

a grinding device according to one of claims 18-22, means for removing the ground, fully magnetized anisotropic permanently magnetic material from the grinding device,

means for mixing this ground fully magnetized anisotropic permanently magnetic material with a binding agent, and

a moulding device according to one of claims 23-44 with pertaining supply means, in which device the mixture is formed into a permanent magnetized object with magnetic poles situated near its surface.

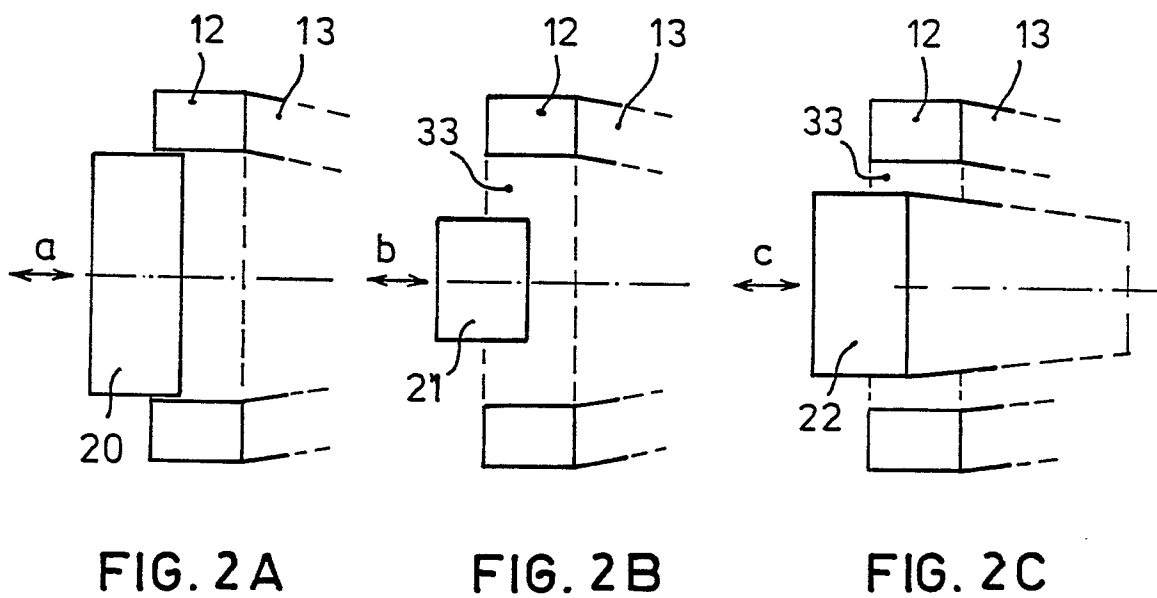
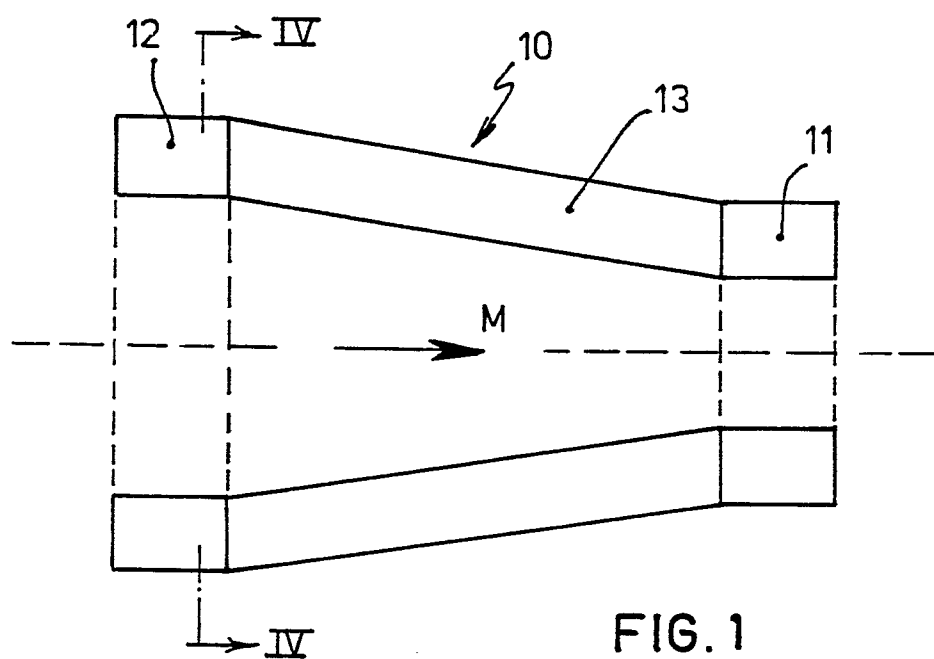
46. Object obtained by method or moulding device of system according to one of the preceding claims.

47. Object according to claim 46, **characterized in that** that it consists of a cylindrical block (80) having alternately north poles (90) and south poles (91) near its cylindrical surface.

48. Object according to claim 46, **characterized in that** it consists of a cylindrical sleeve having alternately north poles (90) and south poles (91) near the external cylindrical surface.

49. Object according to claim 47 or 48, **characterized in that** on the cylindrical outer surface of the object alternately thirty north poles (90) and thirty south poles (91) are situated.

50. Object according to claim 47, 48, or 49, **characterized in that** the outer diameter is smaller than 5 mm.



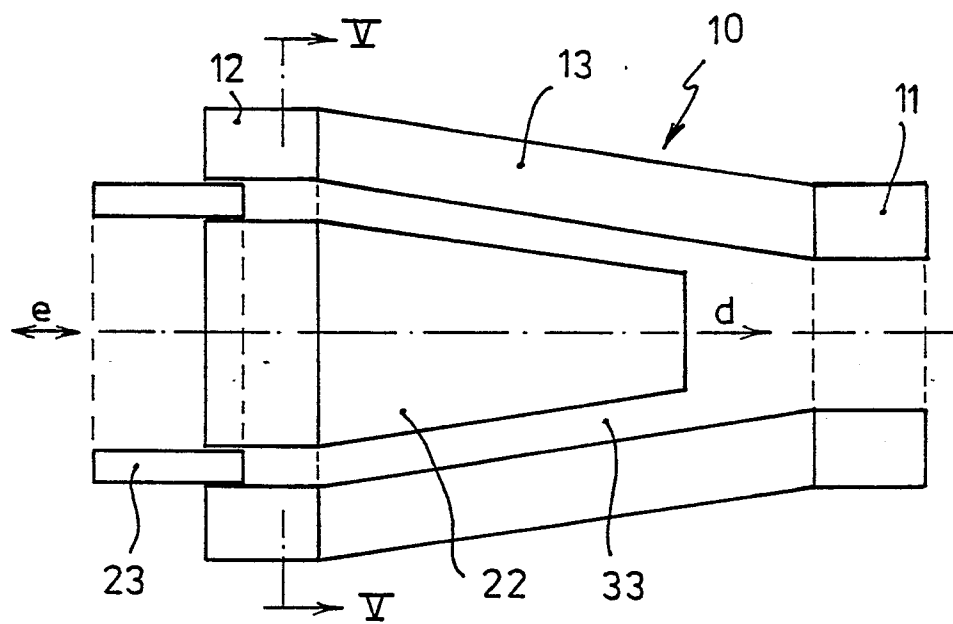


FIG. 3

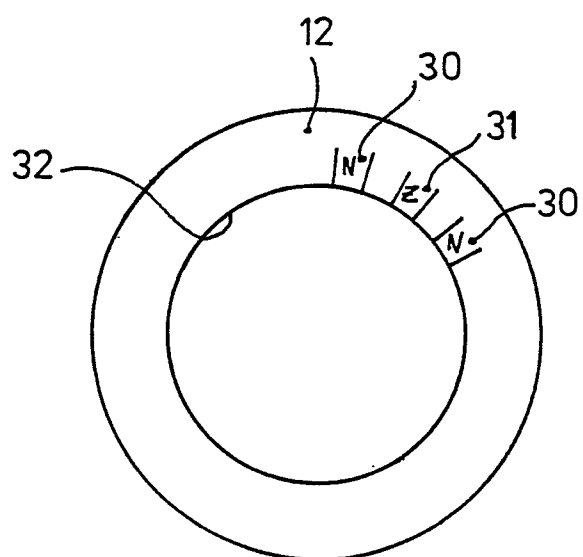


FIG. 4

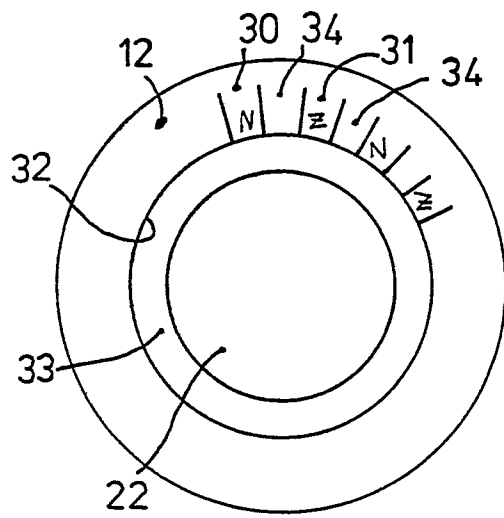


FIG. 5

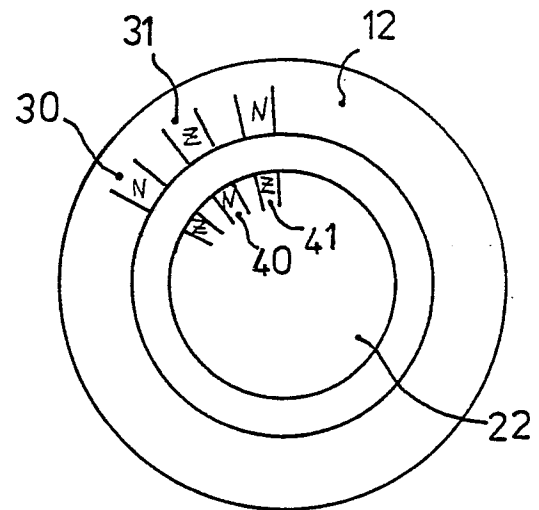


FIG. 6

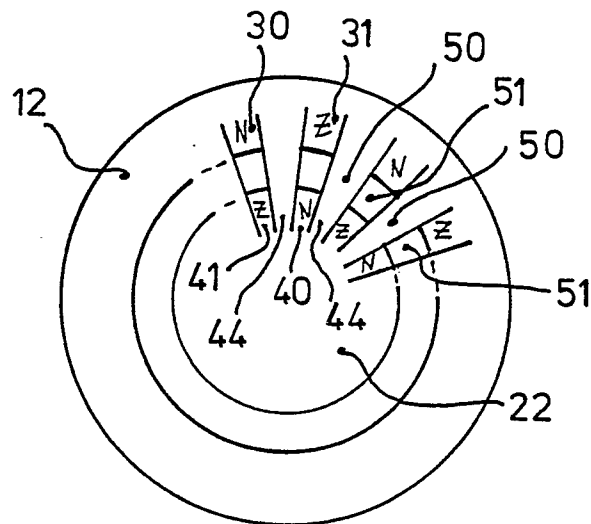


FIG. 7

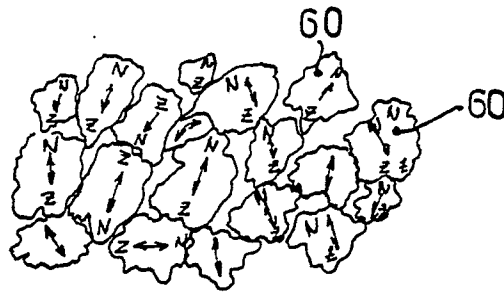


FIG. 8

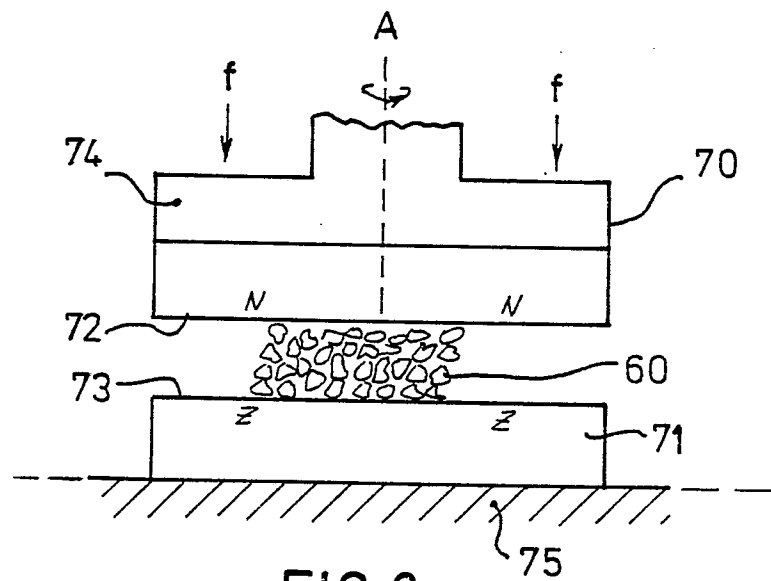


FIG. 9

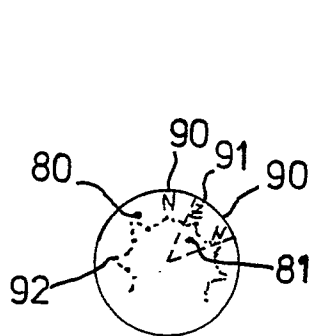


FIG. 10 A

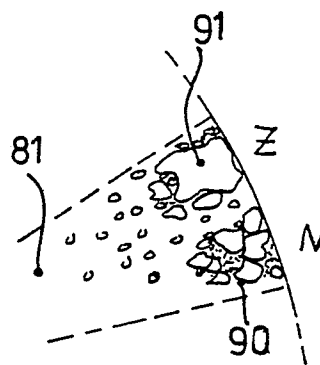


FIG. 10 B

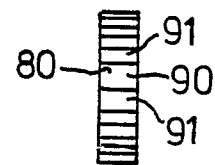


FIG. 10 C



EP 88 20 1180

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 11, no. 288, 17th September 1987, page 76 E 542; & JP-A-62 88 312 (TOHOKU METAL IND. LTD) 22-04-1987 * Abstract * ---	1	H 01 F 41/02
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 259 (E-434)[2315], 4th September 1986; & JP-A-61 87 309 (MATSUSHITA ELECTRIC WORKS LTD) 02-05-1986 * Abstract * ---	1-3	
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 75 (E-390)[2132], 25th March 1986; & JP-A-60 223 107 (SUWA SEIKOSHA K.K.) 07-11-1985 * Abstract * ---	1,8,10-13,46-48	
A	PATENT ABSTRACTS OF JAPAN, vol. 11, no. 240 (E-529)[2687], 6th August 1987; & JP-A-62 52 913 (HITACHI METALS LTD) 07-03-1987 * Abstract * ---	1,8,10,46-48	
A	PATENT ABSTRACTS OF JAPAN, vol. 8, no. 181 (E ³ 261)[1618], 21st August 1984; & JP-A-59 72 701 (MATSUSHITA DENKI SANGYO K.K.) 24-04-1984 * Abstract * ---	1,8,11,12	TECHNICAL FIELDS SEARCHED (Int. Cl.4) H 01 F 41/00 H 02 K 15/00 H 02 K 21/00
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 65 (E-388)[2122], 14th March 1986; & JP-A-60 214 515 (SUWA SEIKOSHA K.K.) 26-10-1985 * Abstract * ---	1,8,11,14-17	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 27-09-1988	Examiner VANHULLE R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	PATENT ABSTRACTS OF JAPAN, vol. 11, no. 70 (E-485)[2517], 3th March 1987; & JP-A-61 225 814 (TOSHIBA CORP.) 07-10-1986 ---		
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 313 (E-448)[2369], 24th October 1986; & JP-A-61 125 010 (HITACHI METALS LTD) 12-06-1986 ---		
A	PATENT ABSTRACTS OF JAPAN, vol. 10, no. 65 (E-388)[2122], 14th March 1986; & JP-A-60 216 512 (SUWA SEIKOSHA K.K.) 30-10-1985 ---		
A	EP-A-0 092 422 (MATSUSHITA ELECTRIC IND. CO.) ---		
A	US-A-3 840 763 (GENERAL ELECTRIC CO.) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 27-09-1988	Examiner VANHULLE R.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	