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(54) **Multipole magnetizing device and method for producing such device**

Vorrichtung zur vielpoligen Magnetisierung und Verfahren zur Herstellung einer solchen Vorrichtung
Dispositif d'aimantation multipolaire et procédé de sa fabrication

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(56) References cited:
**CH-A- 184 107 DE-A1- 3 506 757
DE-A1- 3 901 303 US-A- 3 158 797
US-A- 4 638 280**

- **DATABASE WPI Week 199429 Thomson
Scientific, London, GB; AN 1994-240172
XP002555285 -& SU 1 813 219 A3 (MYSLIN V A)
30 April 1993 (1993-04-30)**
- **DATABASE WPI Week 199222 Thomson
Scientific, London, GB; AN 1992-181991
XP002555284 -& SU 1 670 705 A1 (LOW CAPACITY
ELEC MACH TECHN INST) 15 August 1991
(1991-08-15)**

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Description

FIELD OF INVENTION

[0001] This invention relates in general to apparatus and processes for magnetizing and demagnetizing hard magnetic materials, and in particular to multipole magnetizing devices.

BACKGROUND

[0002] The present invention concerns a device for multipolar magnetization of hard magnetic materials, such as rare earths and ferrites, and a method for producing such magnetizing device. To reach the point of magnetic saturation, the hard magnetic materials require a very high magnetic field strength concentrated on precisely defined sections. The device should withstand high mechanical loadings produced by magnetic forces of the strong magnetic field. Besides, the magnetizing device warms itself intensively as the magnetic field is generated by high current impulses. So, the design of the magnetizing device and the method for producing the said device should be such as to ensure that the geometrical form of the device would be precise and symmetric and that the heat released during the magnetization process would be conveyed away efficiently.

[0003] In the patent US4470031 a multipolar magnetizing device for permanent magnets is described, having a supporting structure, which can be either a solid block, or a series of superimposed sheets, made of electrically insulating material, which may be of fiberglass, with prepared apertures to receive the electrically conductive magnetizing winding. The apertures are arranged to firmly support the winding to prevent displacement despite the strong magnetic fields generated by a high-current impulse discharge. The winding can be arranged to produce a variety of polar patterns on flat magnets or, by providing a suitable opening in the supporting structure, on cylindrical magnets.

[0004] Highly coercive magnet materials are known to be magnetized primarily with high current pulses through a current conductor arranged to form a sequence of current loops around a round magnet, or a sequence of current loops along the flat magnet. In the material to be magnetized the required magnetic field is created by means of the said current loops, which are generally made of wire in prior art magnetizers.

[0005] In US 4 638 280 A is described multipolar magnetizing device provided with cooling means. The invention undertakes the task of preventing undue heating of the current conductors, and of effecting increased conduction of heat from the current conductors by interspersing the electrical circuit array on the supporting plate with cooling sections formed by twisting sections of the wire, or rod, forming the array together in the shape of a closely-wound double helix which extends through a suitable opening to a location remote from the sections of the

array that generate the magnetic poles.

[0006] While the electrically conductive array may be formed from a continuous length of wire, or rod, the array may be conveniently formed from sections of wire, or rod, whose respective ends project through the supporting plate, the ends of adjacent sections being twisted together to provide a maximum surface area exposed to the air or other cooling fluid. To ensure low-resitivity in the array, the twisted portions may be bonded, as by soldering, or brazing.

[0007] DE 39 01 303 A1 of July 1990 described magnetising device for permanent magnets. Magnetizing device for continuous magnets with a high current leader and a bobbin, in/in order/through that the high current leader is guided for pole production in a suitable way, characterised in that bobbins are made from a composite material from a good heat-conductor and/or ferromagnetic powders and an electrical insulated bonding agent, whereby the volume fraction of the bonding agent is lower as 20%.

[0008] DE 35 06 757 A1 of 28 August 1986 disclosed a magnetising device for multi-pole permanent magnets has high-current conductors which are constructed integrally and have lateral webs which project through a retaining plate such that they dissipate the heat produced in the current conductor. The current conductors are produced from a copper strip by stamping out the intermediate spaces between the cooling webs.

[0009] In SU 1 813 219 A3 (MYSLIN V A) inductor for pulsed multi-pole magnetization of magnets is described.

[0010] In US 3 158 797 A of 24 November 1964 described a device for magnetizing circular magnets, comprising a circular magnetic return member provided with an even number of laterally spaced radial poles, and a continuous electrical conductor having a first portion extending from pole to pole around said member in one direction and having a second portion extending back in reverse direction around said member from pole to pole, said first portion of the conductor extending around the odd number poles in one direction and around the even number poles in the opposite direction, and said second portion of the conductor extending in the same direction around each pole as said first portion, the conductor being insulated from poles.

[0011] In SU 1 670 705 A1 inductor for pulsed multipole magnetization of magnets is described. In CH 184 107 A of 15 May 1936 inductor for pulsed multi-pole magnetization of magnets is known.

[0012] All of cited solutions fundamentally differ from the arrangement of the present invention in their geometrical form.

SUMMARY OF THE INVENTION

[0013] The essential aspect of the magnetizing device according to the present invention is that it can magnetize highly coercive magnet materials, such as rare earths, which require a high value of magnetic field strength to

reach the point of magnetic saturation. The device is designed to concentrate the magnetic field on very thin sections enabling narrow magnetic pole pitches to be formed; consequently, a series of pole pairs can be arranged around a cylindrical magnet or along the surface of a flat magnet. Another object of the invention is to provide a stable magnetizing process as well as small dissipation of widths and amplitudes of the magnetic fields of the pole pairs. This object is achieved by ensuring suitable accuracy of the geometric shape of the magnetizing head.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The multipole magnetizing device according to the present invention and the method for producing such device will be better understood by means of the drawings wherein

- FIG. 1 is a front plan view of the device in accordance with the invention, including the section views of some portions of the device;
- FIG. 2 is a front plan view of the body 8;
- FIG. 3 is a side plan view of the body 8 of the multipolar magnetizing head 6;
- FIG. 4 is a top plan view of the body 8 of the multipolar magnetizing head 6;
- FIG. 5 is a transverse section of the body 8;
- FIG. 6 shows a diagram of the magnetic potential and magnetic density in the magnetizing slot;
- FIG. 7 is an illustration of the main portion of the current flow during the pulse magnetizing.

[0015] The frame structure of the multipole magnetizing device consists of a base 1, two supports, 2 and 3, affixed on the edges of the base 1, and a cooling plate 14, which is affixed to the supports 2 and 3 by means of fastening sockets 14a. In the center of the base 1 a support 4 for a thorn 5 is affixed, the thorn 5 being designed to accept the magnet, which should be magnetized. A magnetizing head 6 is disposed in the center of a mechanical protecting block 7 in such a way, that its longitudinal axis coincides with the longitudinal axis of the thorn 5. The block 7 with the integrated magnetizing head 6 is fastened onto the supports 2 and 3 in such a manner that it can be moved along the said supports. The block 7 is made of nonconductive and nonmagnetizable material and has adequate mechanical strength to ensure proper support to the magnetizing head 6 in its radial direction, so that the magnetizing head can withstand high forces of strong magnetic field produced by high-current impulses.

[0016] In the center of the cooling plate 14, which comprises a conduit 16 for outflow of cooling liquid, a cooling thorn 15 is affixed, which has a cooling system built in such a way, that within the thorn 15 a tube 15b is inserted, which is to a small degree thinner than the cylindrical cavity of the thorn (15) and is cut obliquely on its lower

end. The cooling liquid flows downwards the tube 15b to the end of the cooling thorn 15, where the liquid is turned upwards to flow between the outer wall of the tube 15b and the wall of the cylindrical cavity of the thorn 15 towards the outlet conduit 16 in the cooling plate 14.

[0017] The multipole magnetizing head 6 is manufactured in the shape of a tubular body 8, made of a solid material, which must be a good electrical conductor. In the body 8, vertical cuttings 9 and 11 are arranged in alternating succession, the said cuttings being cut across the entire width of the wall of the body 8, while in vertical direction their length is equal to approximately 8/9 of the height of the body 8, wherein the said cuttings 9 commence at the top of the body 8 and the said cuttings 11 commence at the bottom of the body 8. Between the first and the last cutting 9, to which the terminals 12 and 13 are connected, instead of a cutting 11 a cutting 10 is made, which runs across the entire height of the body 8.

[0018] The sequence of cuttings 9, 10 and 11 forms a series of electrically conductive columns in the body 8. The geometric shape of the columns creates a current loop that begins at cutting 10. Through the terminals 12 and 13 the current flows along the current loops in the columns of the magnetizing head 6 in such a way that the direction of current in adjacent columns is opposite. The shape of the columns that form the current loop ensures that during magnetizing process the main portion of the current is sufficiently close to the surface of the magnet material, which is evident from the figure 6. The width of the magnetic poles is defined by the arrangement of cuttings 9, 10, and 11 around the body 8, i.e. by the gaps between the said cuttings. The best conditions can be achieved by lamellization of the body 8, as in this case at high current impulses with the order of magnitude of 80 kA the order of magnitude of the magnetic flux density on the surface of the magnetic material can be 2 T.

[0019] The cuttings 9, 10, and 11 on the body 8 of the magnetizing head 6 can be produced by means of wire erosion or immersing erosion process or by any other metal removal process. These processes can produce geometrically precise symmetric current conducting paths ensuring thereby the required symmetry of magnetic poles. In addition, focusing of the magnetic field in narrow portions of the magnetic material can be achieved. The symmetry of the magnetic poles is important also as it ensures compensation of strong transversal forces arising due to high current impulses in the magnetizing head 8. An efficient compensation of transversal forces prolongs the life span of the magnetizing device. Adequate mechanical strength of the magnetizing device is accomplished by the precise geometrical shape of the body 8 and the cuttings 9, 10, and 11, which provide the required symmetry of current conducting paths and thereby ensure a uniform distribution of forces against the supporting walls of the mechanical protecting block 7.

[0020] The openings of the cuttings 9, 10, and 11 separating the individual current paths are filled with synthetic resin re-enforced with glass fibers or Kevlar® fibers.

[0021] As the current conductive section of the device in which high energy is released during magnetization process, is surrounded by a material that can withstand strong mechanical forces yet is a bad heat conductor, the removal of heat is carried out by means of the cooling thorn 15, which is made of material with good heat conducting properties and is also cooled by means of a cooling system integrated in the thorn, the said cooling system ensuring efficient removal of heat from the thorn 15. Besides, by means of cooling liquid the cooling thorn 15 releases the heat also into the cooling plate 14. When the magnetization process is finished, the mechanical protecting block 7 with the integrated magnetizing head 6 is moved towards the cooling thorn 15, which is thereby inserted into the vacant place where the permanent magnet was installed during the magnetization process. As a consequence, the thorn 15 is brought into physical contact with the columns of the body 8, i.e. with the current conducting paths, and can therefore accept the built-up heat energy even faster. The cooling time is defined so that a working temperature around 100°C is maintained to ensure longer life span of the device and a stable magnetization process.

[0022] In the alternative embodiment I of the present invention the body 8 is made of an insulated band, which is a good electrical conductor. In a device for magnetizing flat magnets, the said insulated band is formed in the shape of a block, while in a device for magnetizing cylindrical magnets the said band is rolled into a coil of a toroidal shape.

[0023] In the alternative embodiment II of the present invention the body 8 is made of insulated concentric tubes, which are put together into a block in the case of a device for magnetizing flat magnets, while in the case of a device for magnetizing cylindrical magnets, the said insulated concentric tubes are rolled into a coil having a toroidal shape. As a consequence, the current conducting paths have a rectangular section, when the body 8 is formed into a block, and a section in the form of a ring, when the body 8 has a cylindrical shape.

[0024] The number of possible pole pairs in the body 8 can be expressed by means of the following equation: $p = 1 + N$, where N represents the multitude of natural numbers.

[0025] By means of the multipole magnetizing device in accordance with present invention high intensity magnetic field can be produced: the order of magnitude of the magnetic field intensity can be as high as 2500 kA/m. Besides, such intensity can be generated on very narrow sections around a cylindrical magnet or along the surface in case of a flat magnet. Such high intensity is necessary for magnetizing rare earth magnetic materials as demonstrated in the figures 6 and 7.

Claims

1. A multipole magnetizing device for producing

multipolar permanent magnets with symmetric and alternately opposite poles, whereby the permanent magnets are made of highly coercive materials such as hard magnetic ferrites and rare earths based materials, **characterized in that**

- on the edges of base (1) two supports (2 and 3) are affixed,
- in the center of the base a support (4) for a thorn (5) is affixed, the thorn (5) being designed to accept the magnet, which should be magnetized;
- a magnetizing head (6) is disposed in the centre of a mechanical protecting block (7) in such a way, that the longitudinal axis of the magnetizing head (6) coincides with the longitudinal axis of the thorn (5);
- supports (2 and 3) cross through the block (7) and through fastening sockets (14a) of a cooling plate (14), so that the cooling plate (14) is affixed to the supports (2 and 3);
- in the centre of the cooling plate (14), which comprises a conduit (16) for outflow of cooling liquid, a cooling thorn (15) for removal of heat is affixed, which has a cooling system built in such a way, that within the thorn (15) a tube (15b) is inserted, which is to a small degree thinner than the cylindrical cavity of the thorn (15) and is cut obliquely on its lower end;
- the block (7) with the integrated magnetizing head (6) is fastened onto the supports (2 and 3) in such a manner that it can be moved along the said supports between a position where the magnetization head (6) is surrounding the thorn (5) and a position where the magnetization head (6) is surrounding the cooling thorn (15);
- the block (7) is made of non-conductive and non-magnetisable material and has adequate mechanical strength to ensure proper support to the magnetizing head (6) in its radial direction.

2. A device as in claim 1, wherein the multipole magnetizing head (6) is in the shape of a tubular body (8), made of a solid material, which must be a good electrical conductor; that in the body (8) vertical cuttings (9) and (11) are arranged in alternating succession, the said cuttings being cut across the entire width of the wall of the body (8), while in vertical direction their length is equal to approximately 8/9 of the height of the body (8), wherein the said cuttings (9) commence at the top of the body (8) and the said cuttings (11) commence at the bottom of the body (8); that between the first and the last cutting (9), to which the terminals (12 and 13) are connected, instead of a cutting (11) a cutting (10) is made, which runs across the entire height of the body (8).

3. A device as in claim 1, wherein the multipole mag-

netizing head (6) is in the shape of a tubular body (8) and made of an electrically conducting insulated band, which is rolled into a coil of a toroidal shape.

4. A device as in claim 1, wherein the multipole magnetizing head (6) is in the shape of a tubular body (8) and made of insulated concentric tubes. 5
5. A device as in claim 2, wherein the cuttings in the tubular body (8) of the multipole magnetizing head (6) are produced by means of a wire erosion or immersing erosion process and wherein the openings of the cuttings are filled with synthetic resin re-enforced with glass fibers or Kevlar® fibers. 10
6. A device as in claim 2, wherein the cuttings in the tubular body (8) of the multipole magnetizing head (6) are produced by means of a metal removal process and wherein the openings of the cuttings are filled with synthetic resin re-enforced with glass fibers or Kevlar® fibers. 15 20
7. A device as in claim 1, wherein during the magnetizing process and especially upon the conclusion of the magnetizing process the cooling liquid is conveyed through the cooling system of the device, first downwards through the tube (15b) disposed in the cooling thorn (15), then upwards between the outer wall of the tube (15b) and the wall of the cylindrical cavity of the thorn (15) towards the outlet conduit (16) disposed in the cooling plate (14), and finally through the outlet conduit (16). 25 30

Patentansprüche 35

1. Vorrichtung zur vielpoligen Magnetisierung zur Herstellung mehrpoligen Dauermagneten mit symmetrischen und abwechselnden Gegenpolen, wobei die Dauermagneten aus stark koerzitiven Materialien wie hartmagnetischen Ferriten und Materialien auf Basis von Seltenen Erden hergestellt werden, **dadurch gekennzeichnet, dass** 40
 - an den Kanten einer Basis (1) zwei Träger (2 und 3) befestigt sind, 45
 - in der Mitte der Basis ein Träger (4) für einen Stift (5) befestigt ist, wobei der Stift (5) ausgelegt ist, um den zu magnetisierenden Magneten zu empfangen;
 - ein Magnetisierungskopf (6) in der Mitte eines mechanischen Schutzblocks (7) derart angeordnet ist, dass die Längsachse des Magnetisierungskopfs (6) mit der Längsachse des Stifts (5) zusammenfällt;
 - die Träger (2 und 3) durch den Block (7) und durch die Befestigungsbuchsen (14a) einer Kühlplatte (14) derart durchtreten, dass die

Kühlplatte (14) an den Träger (2 und 3) befestigt ist;

- in der Mitte der eine Leitung (16) zum Ablauf von Kühlflüssigkeit umfassenden Kühlplatte (14) ein Kühlstift (15) zur Wärmeableitung befestigt ist, der ein Kühlsystem derart eingebettet hat, dass innerhalb des Stifts eine Röhre (15b) eingesetzt ist, die etwa dünner als der zylindrische Hohlraum des Stifts (5) ist und an seinem unteren Ende schräg geschnitten ist;
- der Block (7) mit dem integrierten Magnetisierungskopf (6) an den Trägern (2 und 3) derart befestigt ist, dass er entlang der genannten Träger zwischen einer Position, in welcher der Magnetisierungskopf (6) den Stift (5) umgibt, und einer Position, in welcher der Magnetisierungskopf (6) den Kühlstift (15) umgibt, verschiebbar ist;
- der Block (7) aus nicht leitendem und nicht magnetisierbarem Material ausgefertigt ist und eine ausreichende mechanische Festigkeit aufweist, um die richtige Unterstützung des Magnetisierungskopfs (6) in seiner Radialrichtung zu gewährleisten.

2. Vorrichtung nach Anspruch 1, wobei der vielpolige Magnetisierungskopf (6) in Form eines, aus einem festen Material hergestellten röhrenförmigen Körpers (8) vorliegt, der ein guter elektrischer Leiter sein muss; dass im Körper (8) senkrechte, über die gesamte Breite der Wand des Körpers (8) geschnittene, in Wechselfolge hintereinanderliegende Schlitze (9 und 11) angeordnet sind, während ihre Länge in senkrechter Richtung gleich etwa 8/9 der Höhe des Körpers (8) ist, wobei die genannten Schlitze (9) an der Oberseite des Körpers (8) und die genannten Schlitze (11) an der Bodenseite des Körpers beginnen; dass zwischen dem ersten Schlitz und dem letzten Schlitz (9), an welchen die Anschlüsse (12 und 13) angeschlossen werden, ein Schlitz (10) anstatt des Schlitzes (11) ausgeführt ist, der sich über die gesamte Höhe des Körpers (8) erstreckt. 30
3. Vorrichtung nach Anspruch 1, wobei der vielpolige Magnetisierungskopf (6) die Form eines röhrenförmigen Körpers (8) aufweist und aus einem elektrisch leitenden, isolierten Band ausgefertigt ist, das zu einer Spule in Toroidform aufgerollt ist. 35
4. Vorrichtung nach Anspruch 1, wobei der vielpolige Magnetisierungskopf (6) die Form eines röhrenförmigen Körpers (8) aufweist und aus isolierten konzentrischen Röhren ausgefertigt ist. 40
5. Vorrichtung nach Anspruch 2, wobei die Schlitze im röhrenförmigen Körper (8) des vielpoligen Magnetisierungskopfs (6) mit dem Drahterodierungs- oder Senkerodierungsverfahren ausgefertigt werden und 45 50 55

wobei die Öffnungen der Schlitze mit Kunstharz, das mit Glasfasern oder Kevlar®-Fasern verstärkt ist, gefüllt sind.

6. Vorrichtung nach Anspruch 2, wobei die Schlitze im röhrenförmigen Körper (8) des vielpoligen Magnetisierungskopfs (6) mit dem Metallabtragungsverfahren ausgefertigt werden und wobei die Öffnungen der Schlitze mit Kunstharz, das mit Glasfasern oder Kevlar®-Fasern verstärkt ist, gefüllt sind. 5 10
7. Vorrichtung nach Anspruch 1, wobei während des Magnetisierungsvorgangs und insbesondere nach Abschluss des Magnetisierungsvorgangs die Kühlflüssigkeit durch das Kühlsystem der Vorrichtung hindurchgeleitet wird, zuerst nach unten durch die im Kühlstift (15) angeordnete Röhre (15b), dann nach oben zwischen der Außenwand der Röhre (15b) und der Wand des zylindrischen Hohlraums des Stifts (15) gegen die in der Kühlplatte (14) angeordnete Auslassleitung (16), und schließlich durch die Ablaufleitung (16). 15 20

Revendications 25

1. Un dispositif de magnétisation multipolaire pour la production d'aimants permanents multipolaires avec pôles alternativement opposés et symétriques, les aimants permanents étant constitués de matériaux extrêmement coercitifs tels que des ferrites magnétiques dures et des matériaux à base de terres rares, **caractérisé en ce que** 30
 - sur les bords d'une base (1) deux supports (2 et 3) sont fixés, 35
 - au centre de la base, un support (4) pour une broche (5) est fixé, la broche (5) étant conçue pour recevoir l'aimant à magnétiser;
 - une tête de magnétisation (6) est disposée au centre d'un bloc de protection mécanique (7) de sorte que l'axe longitudinal de la tête de magnétisation (6) coïncide avec l'axe longitudinal de la broche (5); 40
 - les supports (2 et 3) traversent le bloc (7) et les douilles de fixation (14a) d'une plaque de refroidissement (14), de sorte que la plaque de refroidissement (14) est fixée sur les supports (2 et 3); 45
 - au centre de la plaque de refroidissement (14) comprenant un conduit (16) pour l'écoulement du liquide de refroidissement est fixée la broche de refroidissement (15) pour l'évacuation de la chaleur, la broche ayant un système de refroidissement incorporé de telle sorte qu'un tube (15b) est inséré dans la broche (15), ledit tube étant légèrement plus étroit que la cavité cylindrique de la broche (15) et étant découpé obli- 50 55

quement sur son extrémité inférieure;

- le bloc (7) avec la tête de magnétisation (6) intégrée est fixé sur les supports (2 et 3) de telle sorte qu'il peut être déplacé le long desdits supports entre une position où la tête de magnétisation (6) entoure la broche (5) et une position où la tête de magnétisation (6) entoure la broche de refroidissement (15);
- le bloc (7) est constitué d'un matériau non conducteur et non magnétisable et présente une résistance mécanique adéquate pour assurer un support approprié à la tête de magnétisation (6) dans sa direction radiale.

2. Le dispositif selon la revendication 1, dans lequel la tête de magnétisation multipolaire (6) se présente sous la forme d'un corps tubulaire (8) constitué d'un matériau solide qui doit être un bon conducteur électrique; que le corps (8) est muni d'encoches verticales (9 et 11) qui sont disposées en une succession alternée, lesdites encoches étant découpées sur toute la largeur de la paroi du corps (8), tandis que dans le sens vertical, leur longueur est égale à environ 8/9 de la hauteur du corps (8), lesdites encoches (9) commençant au sommet du corps (8) et lesdites encoches (11) commençant au bas du corps (8); qu'entre la première et la dernière encoche (9), auxquelles les bornes (12 et 13) sont raccordées, une encoche (10) est faite à la place d'une encoche (11), qui s'étend sur toute la hauteur du corps (8). 25 30
3. Le dispositif selon la revendication 1, dans lequel la tête de magnétisation multipolaire (6) se présente sous la forme d'un corps tubulaire (8) constitué d'une bande isolante électroconductrice qui est enroulée en une bobine de forme toroïdale. 35
4. Le dispositif selon la revendication 1, dans lequel la tête de magnétisation multipolaire (6) se présente sous la forme d'un corps tubulaire (8) constitué de tubes concentriques isolés. 40
5. Le dispositif selon la revendication 2, dans lequel les encoches dans le corps tubulaire (8) de la tête de magnétisation multipolaire (6) sont produites au moyen d'un procédé d'électro-érosion par fil ou par enfonçage et dans lequel les ouvertures des encoches sont remplies de résine synthétique renforcée avec des fibres de verre ou des fibres Kevlar®. 45
6. Le dispositif selon la revendication 2, dans lequel les encoches dans le corps tubulaire (8) de la tête de magnétisation multipolaire (6) sont produites au moyen d'un procédé d'élimination de métal et dans lequel les ouvertures des encoches sont remplies de résine synthétique renforcée avec des fibres de verre ou des fibres Kevlar®. 50 55

7. Le dispositif selon la revendication 1, dans lequel, pendant le procédé de magnétisation et notamment à la fin du procédé de magnétisation, le liquide de refroidissement est transporté à travers le système de refroidissement du dispositif, tout d'abord vers le bas à travers le tube (15b) disposé dans la broche de refroidissement (15), ensuite vers le haut entre la paroi extérieure du tube (15b) et la paroi de la cavité cylindrique de la broche (15) vers le conduit de sortie (16) qui est disposé dans la plaque de refroidissement (14), et enfin à travers le conduit de sortie (16).

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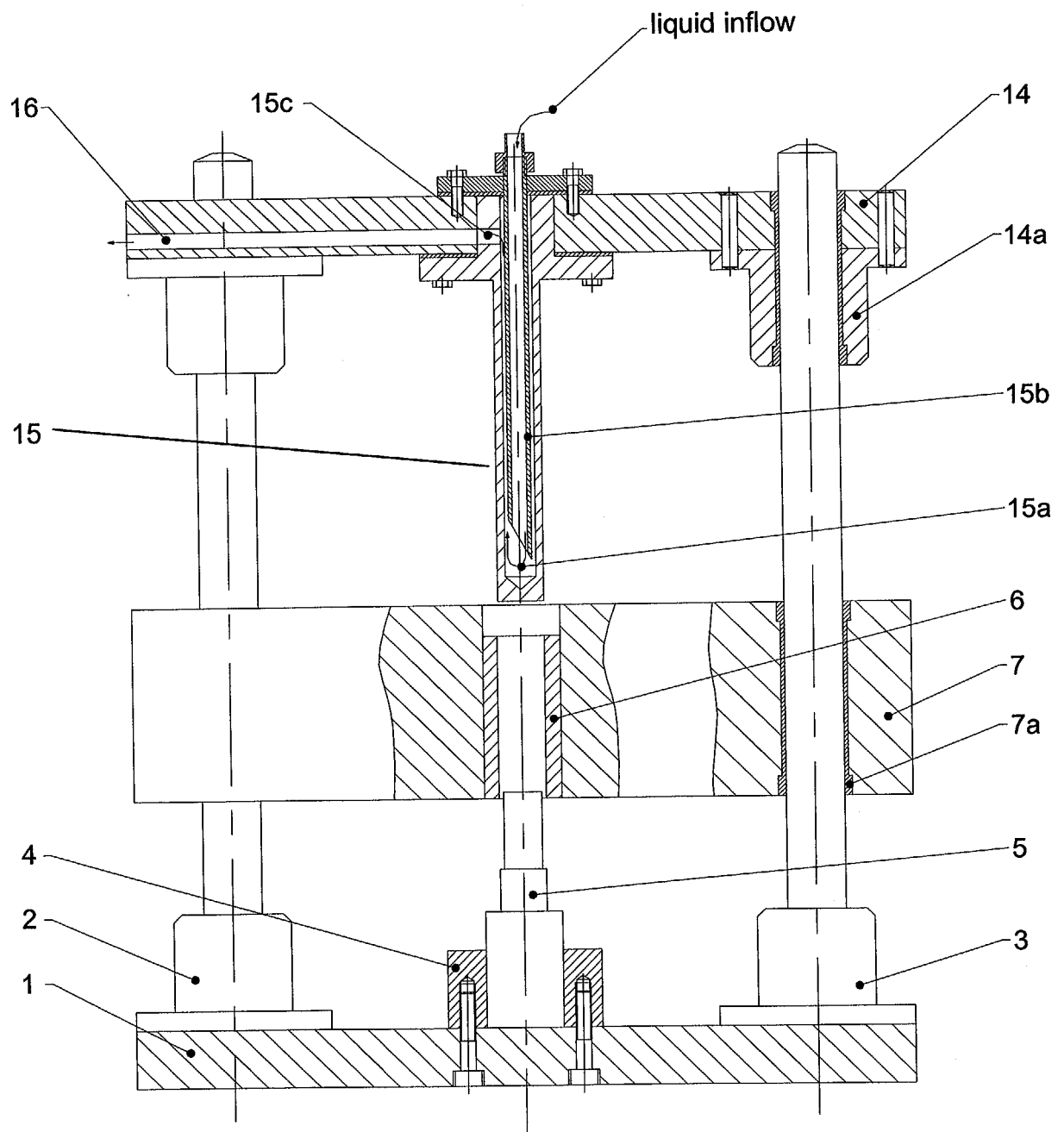


Fig. 1

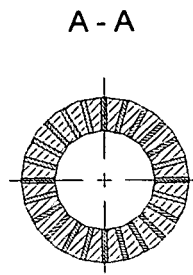


Fig. 5

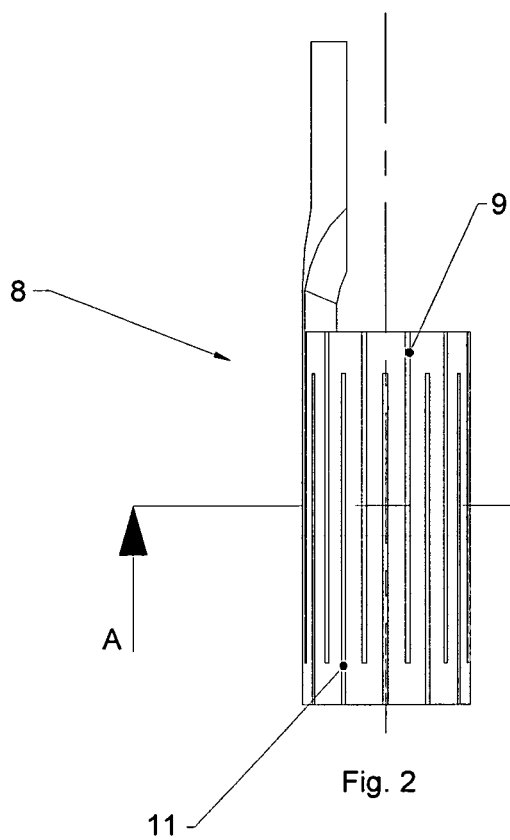


Fig. 2

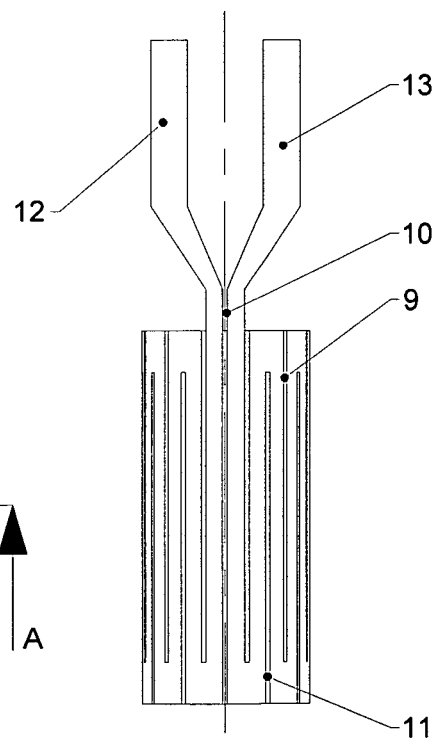


Fig. 3

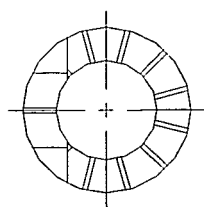


Fig. 4

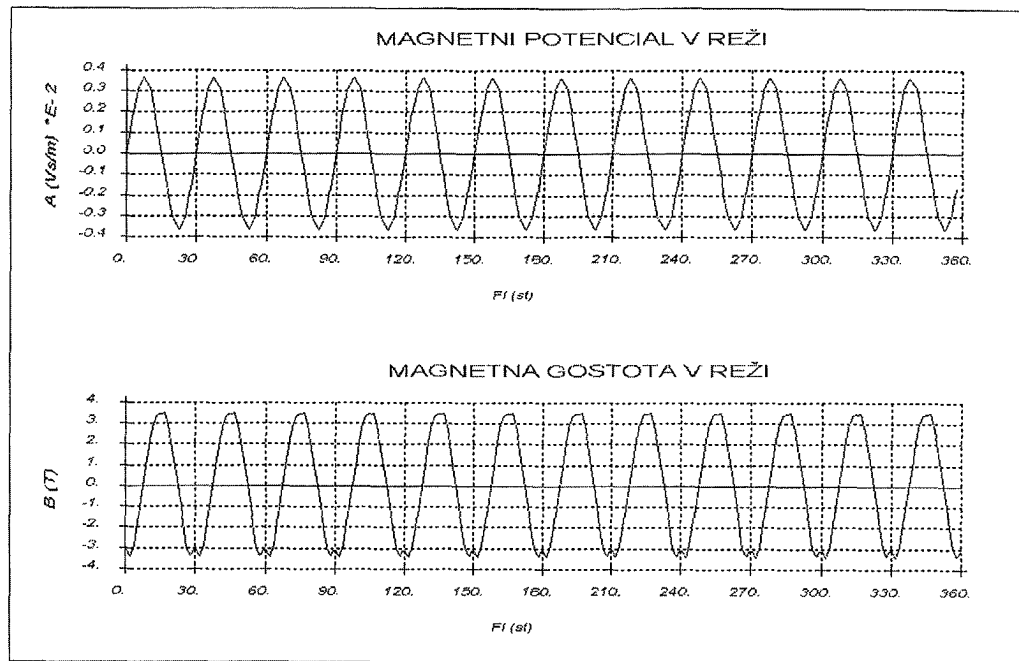


Fig. 6

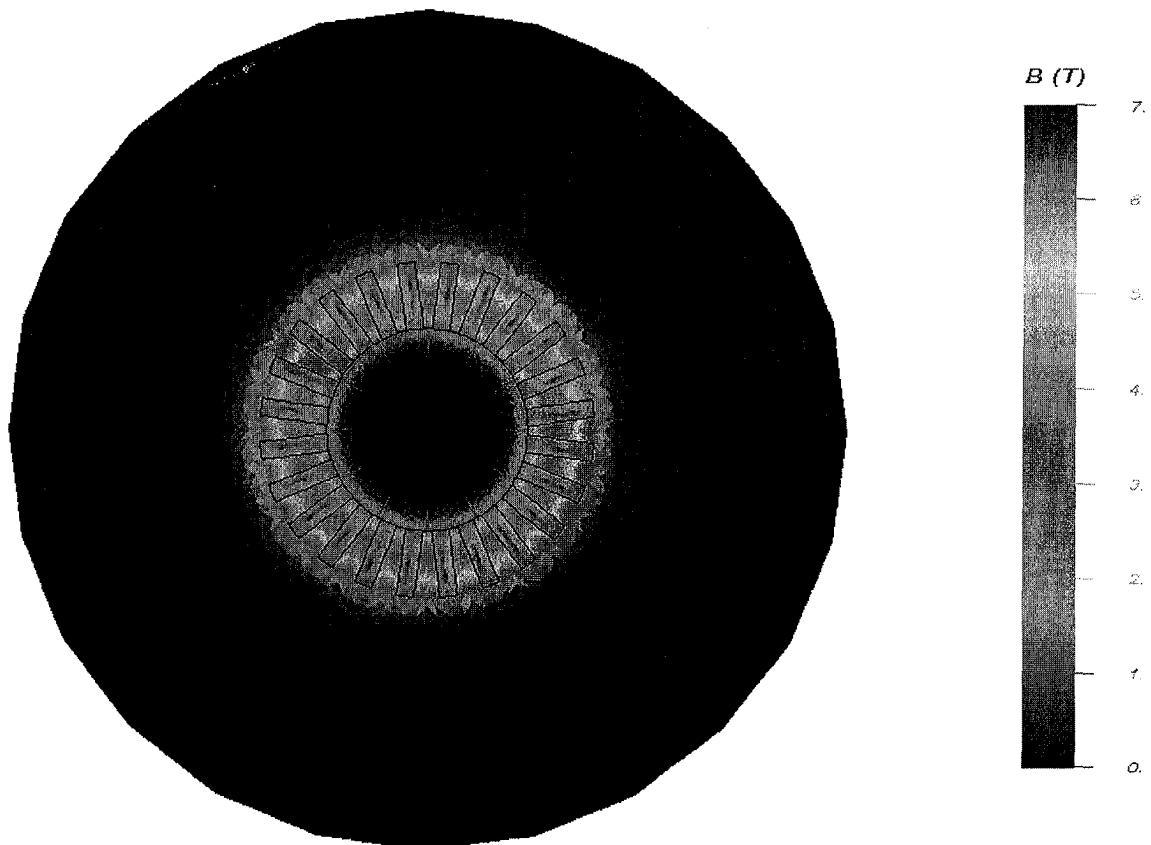


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4470031 A [0003]
- US 4638280 A [0005]
- DE 3901303 A1 [0007]
- DE 3506757 A1 [0008]
- SU 1813219 A3 [0009]
- US 3158797 A [0010]
- SU 1670705 A1 [0011]
- CH 184107 A [0011]