(19) Octrooicentrum Nederland

(11) **2010515**

(12)C **OCTROOI**

(21) Aanvraagnummer: **2010515**

(22) Aanvraag ingediend: **25.03.2013**

(51) Int.Cl.:
B03C 1/28 (2006.01)
B03C 1/01 (2006.01)
B03B 5/30 (2006.01)
H01F 7/02 (2006.01)
B03C 1/033 (2006.01)
B03C 1/32 (2006.01)
B03B 5/44 (2006.01)

(43) Aanvraag gepubliceerd:
-

(47) Octrooi verleend:
29.09.2014

(45) Octrooischrift uitgegeven:
08.10.2014

(73) Octrooihouder(s):
Technische Universiteit Delft te Delft.

(72) Uitvinder(s):
Hendrik Polinder te Delft.
Peter Carlo Rem te Delft.

(74) Gemachtigde:
ir. C.M. Jansen c.s. te Den Haag.

(54) **Magnet and device for magnetic density separation including magnetic field correction.**

(57) A planar magnet for magnetic density separation, comprising an array of pole pieces succeeding in longitudinal direction of a mounting plane, each pole piece having a body extending transversely along the mounting plane with a substantially constant cross section that includes a top segment that is curved to distribute the magnetic field associated with the top surface of the pole piece such that its strength transverse to the mounting plane is substantially uniformly distributed in planes parallel to the mounting plane, the curved top segments having a width (w) in longitudinal direction of the mounting plane and a maximum height (h) transverse to the mounting plane, wherein the top segments of successive pole pieces are unequal in height and/or width.

NL C 2010515

Title: Magnet and device for magnetic density separation including magnetic field correction

The invention relates to a magnet and a device for magnetic density separation (MDS).

Density separation is used in raw materials processing for the classification of mixed streams into streams with particles of different types of materials. In an accurate form of density separation, a liquid medium is used in which the lighter material float and the heavier materials sink. The process requires a liquid medium that has a density that is intermediate between the density of the light and heavy materials in the feed, yet is inexpensive and safe. In magnetic density separation this is provided using a magnetic liquid. The magnetic liquid has a material density which is comparable to that of water. However, when a gradient magnetic field is applied to the magnetic liquid, the force on a volume of the liquid is the sum of gravity and the magnetic force. In this way, it is possible to make the liquid artificially light or heavy, resulting in a so called cut density. For magnetic density separation, use is made of a large planar magnet. The field decays with the height above the magnet, preferably exponentially with the height above the magnet surface. EP 1 800 753 and WO 2009/108047 disclose a method and apparatus for magnetic density separation.

For accurate separation on density in a magnetic liquid preferably a magnet is used that, within the volume of magnetic liquid above the magnet, creates a field with a substantially constant intensity in each plane parallel to the magnet. The result is that magnetic forces on the liquid are essentially perpendicular to these planes, and depend essentially only on the coordinate perpendicular to the plane.

The magnet proposed in EP 1 800 753 requires a relatively large amount of complex-shaped permanent magnetic material, which is expensive. In an attempt to economize on material, an improved magnet for magnetic density separation has been proposed in “Magnet designs for

magnetic density separation of polymers', The 25th conference on solid waste, technology and management, March 27-30, 2011, Philadelphia, PA, USA, The journal of solid waste technology and management, ISSN 1091-8043 (2011) 977-983.

In this publication, a planar magnet according to the preamble of claim is proposed, which includes a flat steel support, onto which a series of poles is mounted. The poles are alternately made from steel and from a magnetic material, and have a specially shaped cap made from steel. A gap filled with air or non-magnetic compound such as a polymer resin separates consecutive poles.

Although successful in its efficient construction, in contrast to what was expected, the field of the magnet did not have substantially constant intensity in the respective parallel planes.

The invention aims to provide a planar magnet for magnetic density separation which is of cost effective construction, yet maintains a field of substantially constant intensity in each plane parallel to the magnet.

Thereto the invention provides for a planar magnet for magnetic density separation, comprising an array of pole pieces succeeding in longitudinal direction of a mounting plane, each pole piece having a body extending transversely along the mounting plane with a substantially constant cross section that includes a top segment that is curved to distribute the magnetic field associated with the top surface of the pole piece such that its strength transverse to the mounting plane is substantially uniformly distributed in planes parallel to the mounting plane, the curved top segments having a length (l) in transverse direction of the mounting plane, a width (x) in longitudinal direction of the mounting plane and a height (h) transverse to the mounting plane, characterized in that the top segments of successive pole pieces are unequal in length (l), height h) and/or width (x).

Within this context, the term unequal in length, height or width is to be understood as a respective length, height or width of a pole that is neither the same nor a natural integer multiple of a successive pole.

Arranging the top segments of successive poles to be curved in accordance to the same function of shape, yet to extend over a different length, width and/or be positioned at different heights, differences in the intensity of the magnetic fields of the successive poles can be compensated for, while maintaining the uniform characteristics of the individual fields. It has been found, that a shift in height of the top portion does not require a different shape of the top portion to generate the uniform field distribution in planes parallel to the magnet. Alternatively or in addition, a difference in length and or width of the top segment may also be used for field correction if the top segments of the poles are provided with the same basic curvature.

In longitudinal direction of the mounting plane, each successive pole piece in longitudinal direction in the array of pole pieces may be unequal in height, length and/or width to its predecessor, or only a part of the total number of poles pieces in longitudinal direction in the array may be unequal in height, length and/or width to its predecessor, e.g. a subgroup of two, three or more successive pole pieces. The poles pieces at odd and/or even positions may be identical, and the leading and/or trailing pole pieces may be of smaller width than the interposed pole pieces.

To facilitate construction, the mounting plane may be a support plate onto which the pole pieces are mounted. Preferably, the support plate is made of a magnetisable material, in particular ferromagnetic material, in particular steel. As an alternative, the pole pieces may be mounted individually or in smaller groups onto a support.

By having the pole pieces extend parallel in transverse direction of the mounting plane uniform distribution of the field in transverse direction of the field may be achieved relatively easily. As an alternative,

the magnetic permeability of the gaps between successive pole pieces may be changed to compensate for an alignment of pole pieces.

To reduce the number of pole pieces further, the successive poles may be spaced apart in longitudinal direction of the mounting plane. Gaps between the successive poles may be filled with magnetically permeable filler material, for example air, non magnetisable metal and/or polymer resin.

To save costs of construction, in longitudinal direction of the mounting plane, the pole pieces may alternatingly be embodied as magnets and magnetisable poles. The magnets may e.g. be permanent magnets, such as neodymium magnets, or electro-magnets. The magnetisable poles may be made of a magnetisable material, preferably a ferromagnetic material, in particular steel. In such arrangement, successive pole pieces that are embodied as magnets may be of the same polarity, in particular in a north to south or south to north configuration transverse to the mounting plane.

To save costs on construction, the magnets may include a magnetic base portion and a separate top portion of magnetisable material that includes the curve top segment. For example, the magnet pole may include a base portion that is rectangular in cross section onto which a steel top portion is placed which is machined to have a curved top.

Seen in longitudinal direction, the pole pieces at the leading end and/or trailing end of the mounting plane may be magnetic pole pieces.

Seen in longitudinal direction, the pole pieces at the leading end and/or trailing end of the mounting plane may have a width that is be more than half the width of any of the interposed pole pieces. The width may, however be less than the width of any of the interposed pole pieces.

The invention also relates to a magnetic density separation device including a planar magnet.

The invention will be further elucidated on the basis of a non-limitative exemplary embodiment which is represented in a drawing. In the drawing:

Fig. 1 shows a schematic exploded view of a planar magnet for magnetic density separation;

Fig. 2 shows a schematic side view of a detail of the array of pole pieces of the planar magnet of Fig. 1, in which the difference in height and or width of the pole pieces has been drawn exaggeratedly to increase visibility;

Fig. 3 shows a schematic side view of a magnetic separation device including the magnet of Fig.1.

It is noted that the figures are merely schematic representations of a preferred embodiment of the invention. In the figures, identical or corresponding parts are represented with the same reference numerals.

Fig. 1 shows a planar magnet 1 for magnetic density separation. The magnet 1 comprises an array of pole pieces 2, 3 succeeding in longitudinal direction l of a mounting plane 4. In the embodiment shown, the mounting plane 4 is a thick steel support plate 5 onto which the pole pieces 2, 3 are mounted. Each pole piece 2, 3 has a body 6 extending in transverse direction t along the mounting plane 4. Each body 6 extends transversely along the mounting plane 4 with a substantially constant cross section 7. In the embodiment shown, the pole pieces 2, 3 extend parallel in transverse direction t of the mounting plane 4. The cross section 7 of the body 6 of each pole piece 2, 3 includes a top segment 8 that is curved to distribute a magnetic field associated with the top surface 9 such that its strength transverse to the mounting plane is substantially uniformly distributed in planes parallel to the mounting plane 4. This is illustrated in Fig. 2.

The top segments of the pole pieces in the array are provided with the same basic curvature.

As set out in the publication "Magnet designs for magnetic density separation of polymers, The 25th International conference on solid waste, technology and management, March 27-30, 2011, Philadelphia, PA, USA, The journal of solid waste technology and management, ISSN 1091-8043 (2011) 977-983", in particular pages 979-981 the curvature of the top surface may be mathematically represented by the following formula:

$$z = \frac{p}{\pi} \ln \sin\left(\frac{\pi x}{p}\right)$$

In this formula, z is de height of points at the top surface with respect to a fixed reference point (the highest point) of the top surface, as a function of the horizontal coordinate x, $0<x<p$, running along the cross-section of the magnet as in Figs. 1 and 2. The parameter p is the interval in x over which the profile is periodic.

As can be taken from Fig. 2, the curved top segments 8 have a width x in longitudinal direction l of the mounting plane 4 and a maximum height h transverse to the mounting plane 4.

In accordance with the invention, the top segments 8 of successive pole pieces in longitudinal direction l are unequal in height h and/or width x. In the embodiment shown, in longitudinal direction l of the mounting plane 4, each successive pole piece 2,3 in the array of pole pieces is unequal in height h or width x to its predecessor. The leading and trailing pole pieces 2' at the respective leading end 15 and trailing end 16 of the magnet 1 are of smaller width x1 than the width x2 of the pole pieces 2, 3 interposed between the leading and trailing pole pieces 2'. The width x1 of the leading and trailing pole pieces 2' can e.g. be60 mm, while the width x2 of the interposed pole pieces 2, 3 of the interposed pole pieces can e.g. be **80 mm.** The leading and trailing pole pieces 2' are magnetisable pole pieces. Their

width x1 is however larger than half the width x2 of the interposed magnetisable pole pieces 2. This allows to reduce loss of laterally extending magnetic flux at the leading and trailing end of the support plate 5.

In the embodiment shown, the interposed pole pieces 2, 3 are embodied as magnets 2 at odd pole positions, and as magnetisable pole pieces 3 at even positions. The interposed magnetisable pole pieces 3 have a top surface 9 that is identical in shape to the top surface 9 of the interposed magnetic pole pieces 2, and the width x of these pieces is identical, but the position of their top surfaces 9 is shifted vertically upward in the same orientation so that the height h2 of the magnetisable pole pieces 3 is higher than the height h1 of the magnetic pole pieces 2. In practice, the height h1 can e.g. be 60 mm, the height h2 can be e.g. 80 mm.

This allows the magnetisable pole pieces 2 to have more volume of material, so that the weaker field strength of the magnetisable material compared to the magnetic material can be compensated for, yet the distribution of the field lines over the top surface is still such that it creates a field with a substantially constant intensity in each plane parallel to the pole piece and, due to the compensation, for the whole planar magnet.

The length (l) of the top segments 8 of the pole pieces 2, 3 transverse to the longitudinal direction is in this embodiment the same for all pole pieces, but may also be varied to compensate. In particular, the leading and/or trailing pole pieces may be provided with a greater length (l).

As can be taken from Fig. 2, in this exemplary embodiment, successive pole pieces that are embodied as magnets 2 are of the same polarity. In particular, the north-south orientation of these pole pieces 2 is aligned and transverse to the mounting plane 4.

With reference to Figures 1 and 2, it is shown that successive poles 2, 3 may be spaced apart in longitudinal direction l of the mounting plane 4. Gaps 10 between successive poles are in this example filled with magnetically permeable filler material, in this example polyester resin 11.

This prevents clogging of the gaps 10 with foreign material. The resin 11 also extends over the tops of the pole pieces 2, 3 to provide a smooth surface 12 of the magnet 1. The gaps are filled with magnetically permeable filler material.

In longitudinal direction of the mounting plane 4, the pole pieces 2, 3 are alternatingly embodied as magnets 2 and magnetisable poles 3. In the embodiment shown, the pole pieces with reference numeral 2 are embodied as neodymium magnets, and the pole pieces provided with reference numeral 3 are embodied as steel magnetisable pole pieces. For ease of manufacture, the magnets 2 include a magnetic base portion 13 with a rectangular cross section, and a top portion 14 of steel that has been machined to include the curved top surface 9.

In accordance with the invention, the top segments 8 of successive pole pieces 2,3 are unsymmetrical in a mirror plane normal to the mounting plane and extending in transverse direction trough the center of the gap 10 between successive magnets: the height positions of the successive interposed top segments is not equal, and the width of the pole pieces at the ends is not such that the successive poles each other's whole or half image.

As an example, in Table 1 below, measurements are provided of the extremes of the magnetic field along the x-axis of a magnet (p=0.12 m) designed with a corrective widening of the magnet poles at the upper and lower edges. It is shown that the corrective widening improves the field homogeneity with respect to the uncorrected version in the sense that the differences between the extremes is now everywhere less than 0.05 Tesla. Especially near the leading or trailing end where the separation of the products takes place and the field homogeneity is most important, the differences are even smaller.

Table 1:

X [mm]	Bz [Tesla]
-600	0.22
-480	-0.20
-360	0.25
-240	-0.20
-120	0.25
0	-0.20
+120	0.25
+240	-0.20
+360	0.25
+480	-0.20
+600	0.22

Fig. 3 shows a magnetic density separation device 17, including a planar magnet 1 of the type discussed above. In this example, the magnet may have a surface area of $4m^2$. Material to be separated, e.g. a mix of scrapped bottles 18 made of a lighter and a heavier plastic material, is fed in a preferably laminar flow of magnetic liquid, in this example ferrofluid, through a channel 19 of the separation device 17 in a flow direction f . A wall 20 of the channel includes the planar magnet 1 arranged with its longitudinal direction aligned with the flow direction. The magnet 1 applies a cut density to the magnetic liquid flowing through the channel 19. The cut density causes the bottles 18a made of the lighter plastic to flow in an upper portion of the channel 19, and the bottles 18b made of the heavier plastic flow to a lower portion 19 of the channel. The surface 12 of the magnet 1 is covered by a portion of an endless conveyor belt 20 circulating between diverting wheels 21, so that debris is conveyed away from the surface 12 of the magnet 1. Downstream of the magnet 1 a dividing wall 22

is positioned in the channel 19 that splits the channel 19 in a top portion 19a for the bottles18a made of material of lower density, and a bottom portion 19b for the bottles 18b made of material of higher density.

The invention is not limited to the exemplary embodiment represented here. For example, successive pole pieces in longitudinal direction may be embodied as magnets, e.g. electro-magnets, and may have alternating polarity. Such variations shall be clear to the skilled person and are considered to fall within the scope of the invention as defined in the following claims.

Reference numerals

1	Magnet
2	Pole piece, magnet
3	Pole piece, magnetisable
4	Mounting plane
5	Support plate
6	Body
7	Cross section
8	Top segment
9	Top surface
10	Gap
11	Resin
12	Surface
13	Base portion
14	Top portion
15	Leading end
16	Trailing end
17	Separation device
18	Bottles (a lower density, b higher density)
19	Channel (a top, b bottom)
20	Conveyor belt
21	Diverting wheels
22	Dividing wall (a top, b bottom)
f	Flow direction
l	Longitudinal direction
t	Transverse direction
h	Height
x	Width
l	Length

Conclusies

1. Een vlakke magneet voor magnetische dichtheidsscheiding, omvattende een reeks poolstukken die elkaar in longitudinale richting van een montagevlak opvolgen, waarbij elk poolstuk een lichaam heeft dat zich transversaal langs het montagevlak uitstrekt met een in hoofdzaak constante doorsnede die een topsegment omvat dat is gekromd om het magnetische veld dat met het topoppervlak van het poolstuk is geassocieerd zodanig te verdelen dat de sterkte daarvan transversaal op het montagevlak in hoofdzaak uniform is verdeeld in vlakken die parallel aan het montagevlak zijn gelegen, waarbij de gekromde topsegmenten in transversale richting van het montagevlak een lengte (l) hebben, in longitidinale richting van het montagevlak een breedte (x) hebben en transversaal op het montagevlak een hoogte (h) hebben, met het kenmerk, dat de topsegmenten van opeenvolgende poolstukken ongelijk zijn in lengte, hoogte, en/of breedte.

2. Magneet volgens conclusie 1, waarbij het montagevlak een steunplaat is waarop de poolstukken zijn gemonteerd.

3. Magneet volgens één der voorgaande conclusies, waarbij de poolstukken zich parallel uitstrekken in transversale richting van het montagevlak.

4. Magneet volgens één der voorgaande conclusies, waarbij de opeenvolgende polen in longitudinale richting van het montagevlak uiteen zijn geplaatst.

5. Magneet volgens één der voorgaande conclusies, waarbij de poolstukken in longitudinale richting van het montagevlak afwisselend zijn uitgevoerd als magneten en magnetiseerbare polen.

6. Magneet volgens één der voorgaande conclusies, waarbij opeenvolgende poolstukken die zijn uitgevoerd als magneten van dezelfde polariteit zijn.

7. Magneet volgens één der voorgaande conclusies, waarbij de magneten een magnetisch basisdeel omvatten en een topdeel van magnetiseerbaar materiaal dat het gekromde topsegment omvat.

8. Magneet volgens één der voorgaande conclusies, waarin de gekromde topsegmenten van de poolstukken in de reeks zijn voorzien van dezelfde basiskromming.

9. Magneet volgens conclusie 8, waarbij de kromming van de topsegmenten van de poolstukken wordt uitgedrukt door de formule:

$$z = \frac{p}{\pi} \ln \sin\left(\frac{\pi x}{p}\right)$$

10. Magneet volgens één der voorgaande conclusies, waarbij de voorste en/of achterste poolstukken bij het respectieve voorste en/of achterste einde van de magneet een breedte x hebben die kleiner is dan de breedte x van enig poolstuk dat is ingelegen tussen de voorste en achterste poolstukken, en die groter is dan de helft van de breedte van enig poolstuk dat is ingelegen tussen de voorste en achterste poolstukken.

11. Magnetische dichtheidsscheidingsinrichting, omvattende een kanaal voor het daar doorheen in een stroomrichting stromen van magnetische vloeistof, waarbij een wand van het kanaal een vlakke magneet volgens één der conclusies 1-10 omvat die is opgesteld met zijn langsrichting opgelijnd met de stroomrichting om een versneden dichtheid op te leggen aan de magnetische vloeistof die door het kanaal heen stroomt.

12. Magnetische dichtheidsscheidingsinrichting volgens conclusie 11, waarbij het oppervlak van de magneet is afgedekt door een deel van een eindloze transportband die tussen omloopwielen omloopt.

13. Magnetische dichtheidsscheidingsinrichting volgens conclusie 12, waarbij stroomafwaarts van de magneet in het kanaal een scheidingswand is gepositioneerd die het kanaal splitst.

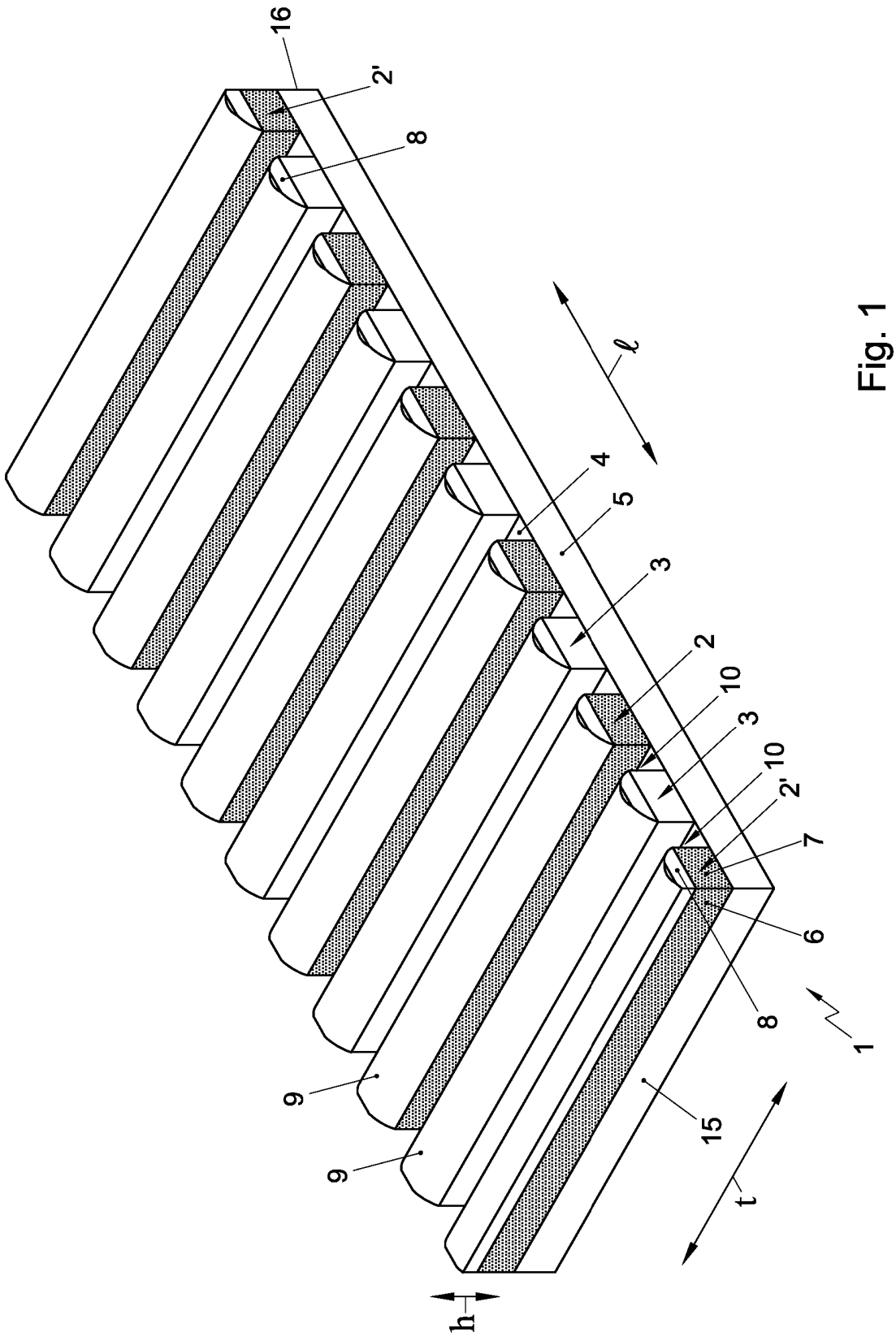

Fig. 1

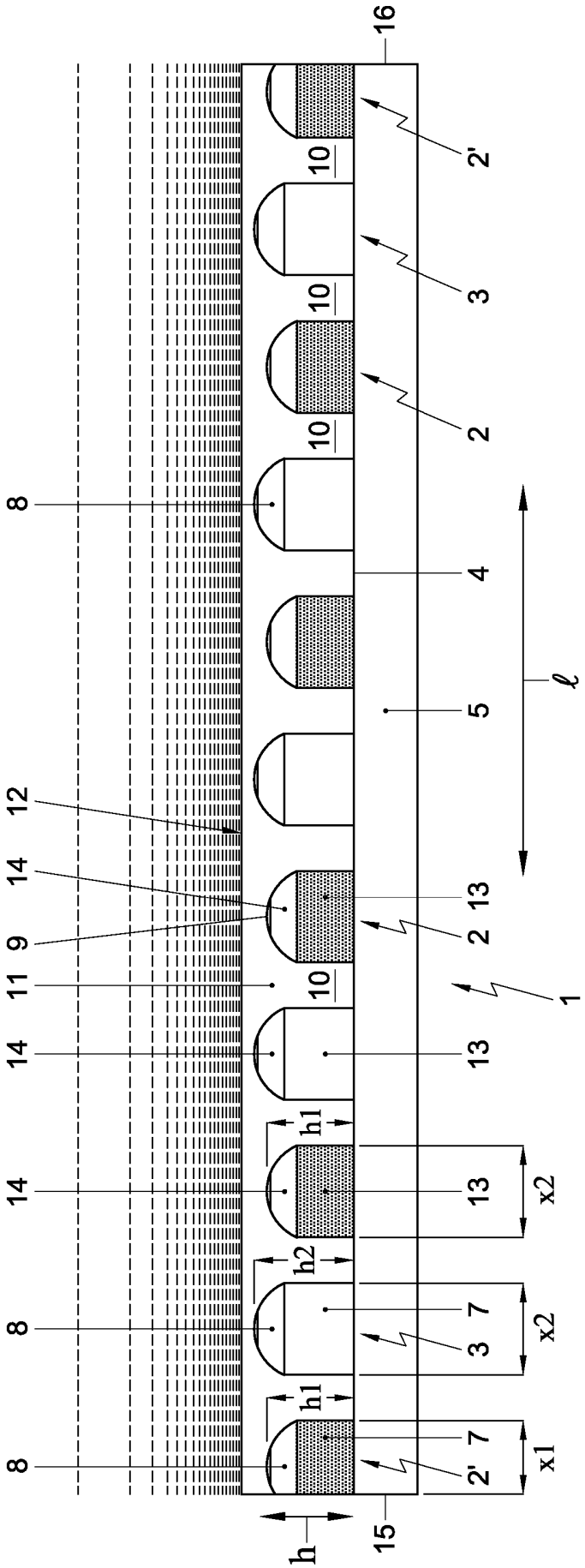

Fig. 2

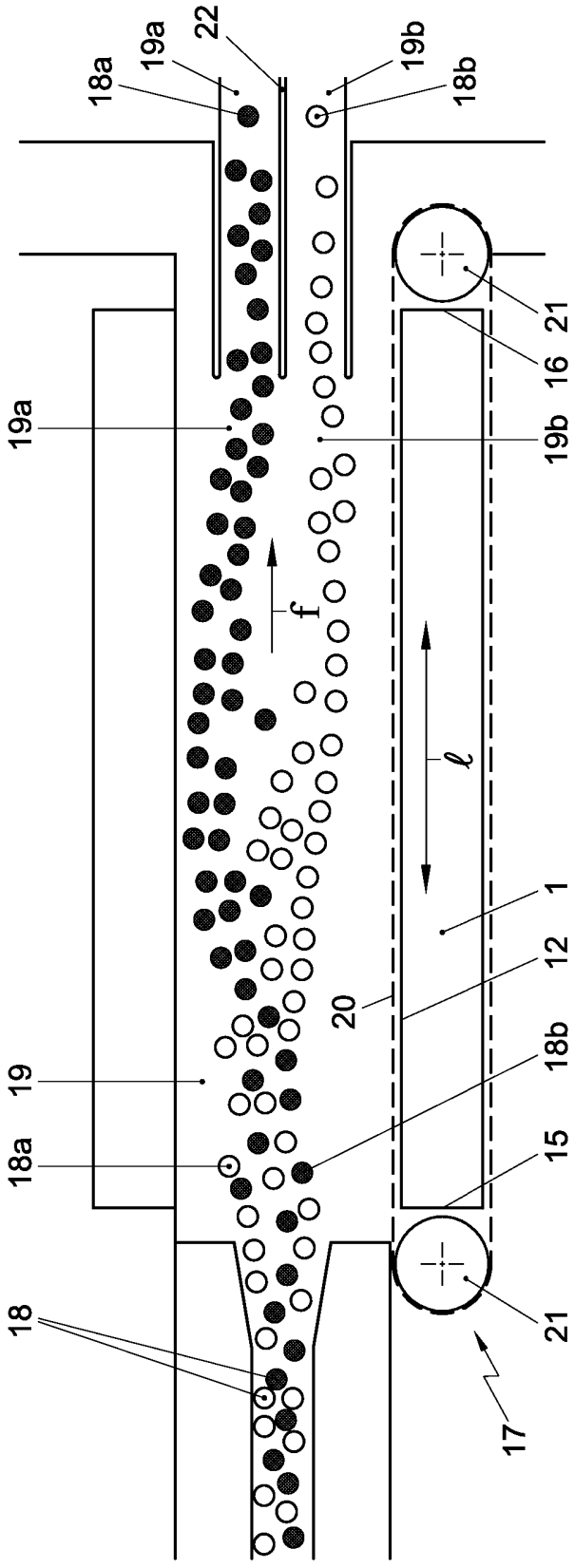

Fig. 3

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	P100328NL00
Nederlands aanvraag nr. **2010515**	Indieningsdatum **25-03-2013**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Technische Universiteit Delft, et al**	
Datum van het verzoek voor een onderzoek van internationaal type **20-07-2013**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN 60401**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

B03C1/28 **B03C1/033** **B03C1/01** **B03C1/32**
B03B5/30 **B03B5/44** **H01F7/02**

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen		
IPC	**B03C**	**B03B**	**H01F**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III. ☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV. ☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2010515

A. CLASSIFICATIE VAN HET ONDERWERP
INV. B03C1/28 B03C1/033 B03C1/01 B03C1/32 B03B5/30
B03B5/44 H01F7/02
ADD.
Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
B03C B03B H01F

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X,D	DOMENICO LAHAYE ET AL: "Magnet designs for magnetic density separation of polymers", INTERNATIONAL CONFERENCE ON SOLID WASTE TECHNOLOGY AND MANAGEMENT : ICSW; THE 25TH CONFERENCE ON SOLID WASTE, TECHNOLOGY AND MANAGEMENT, PHILADELPHIA, PA, 1 januari 2011 (2011-01-01), bladzijden 977-983, XP008166490, ISSN: 1091-8043 in de aanvraag genoemd * figuren 2, 4, 5 * * bladzijde 978 - bladzijde 982 * ----- -/--	1-13

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
9 januari 2014	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Menck, Anja

2

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2010515

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A,D	WO 2009/108047 A1 (UNIV DELFT TECH [NL]; REM PETER CARLO [NL]; BERKHOUT SIMON PETER MARIA) 3 september 2009 (2009-09-03) in de aanvraag genoemd * figuren 1, 2 *	1-13
A,D	EP 1 800 753 A1 (BAKKER HOLDING SON B V [NL]) 27 juni 2007 (2007-06-27) in de aanvraag genoemd * figuren 2-6 *	1-13
A	GB 2 278 231 A (EEV LTD [GB]) 23 november 1994 (1994-11-23) * figuur 3 *	1-13
A	US 2004/004523 A1 (HUMPHRIES DAVID E [US] ET AL) 8 januari 2004 (2004-01-08) * figuren 3, 4 *	1-13

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek: NL 2010515

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
WO 2009108047	A1 03-09-2009	DK	2247386 T3	10-09-2012
		EP	2247386 A1	10-11-2010
		EP	2247387 A1	10-11-2010
		ES	2389287 T3	24-10-2012
		NL	2001322 C2	31-08-2009
		PL	2247386 T3	30-11-2012
		PT	2247386 E	04-09-2012
		US	2011042274 A1	24-02-2011
		US	2011049017 A1	03-03-2011
		WO	2009108047 A1	03-09-2009
		WO	2009108053 A1	03-09-2009
EP 1800753	A1 27-06-2007	AT	502697 T	15-04-2011
		CA	2572051 A1	23-06-2007
		DK	1800753 T3	11-07-2011
		EP	1800753 A1	27-06-2007
		ES	2363787 T3	16-08-2011
		JP	5242912 B2	24-07-2013
		JP	2007167850 A	05-07-2007
		NL	1030761 C2	29-06-2007
		PT	1800753 E	01-07-2011
		SI	1800753 T1	31-08-2011
		US	2007163926 A1	19-07-2007
GB 2278231	A 23-11-1994	GEEN		
US 2004004523	A1 08-01-2004	GEEN		

OCTROOICENTRUM NEDERLAND

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN60401	25.03.2013		NL2010515

International Patent Classification (IPC)
INV. B03C1/28 B03C1/033 B03C1/01 B03C1/32 B03B5/30 B03B5/44 H01F7/02

Applicant
Technische Universiteit Delft, et al

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner
	Menck, Anja

Application number

WRITTEN OPINION

NL2010515

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-13
	No:	Claims	
Inventive step	Yes:	Claims	
	No:	Claims	1-13
Industrial applicability	Yes:	Claims	1-13
	No:	Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 **Introductory comment**

Reference is made to the following documents:

D1 DOMENICO LAHAYE ET AL: "Magnet designs for magnetic density separation of polymers", INTERNATIONAL CONFERENCE ON SOLID WASTE TECHNOLOGY AND MANAGEMENT : ICSW; THE 25TH CONFERENCE ON SOLID WASTE, TECHNOLOGY AND MANAGEMENT, PHILADELPHIA, PA, 1 januari 2011 (2011-01-01), bladzijden 977-983, XP008166490, ISSN: 1091-8043
in de aanvraag genoemd

D2 WO 2009/108047 A1 (UNIV DELFT TECH [NL]; REM PETER CARLO [NL]; BERKHOUT SIMON PETER MARIA) 3 september 2009 (2009-09-03)in de aanvraag genoemd

2 **Independent claim 1**

2.1 The present application does not meet the criteria of patentability because the subject-matter of claim 1 does not involve an inventive step.

The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and discloses (the references in parentheses applying to this document):

Een vlakke magneet (see figures 1 and 4) *voor magnetische dichtheidsscheiding* (see the introduction and figure 2), *omvattende*

- een reeks poolstukken (see figures 1 and 4) *die elkaar in longitudinale richting van een montagevlak opvolgen, waarbij elk poolstuk een lichaam heeft dat zich transversaal langs het montagevlak uitstrekt met een in hoofdzaak constante doorsnede die een topsegment omvat dat is gekromd* (see figures 4 and 5 as well as the equation on page 981) *om het magnetische veld dat met het topoppervlak van het poolstuk is geassocieerd*

zodanig te verdelen dat de sterkte daarvan transversaal op het montagevlak in hoofdzaak uniform is verdeeld in vlakken die parallel aan het montagevlak zijn gelegen (see figure 5),

- waarbij de gekromde topsegmenten in transversale richting van het montagevlak een lengte (l) hebben, in longitidinale richting van het montagevlak een breedte (x) hebben en transversaal op het montagevlak een hoogte (h) hebben (see figure 1 and the corresponding passages of the text).

The subject-matter of claim 1 therefore differs from this known D1 in that "*de topsegmenten van opeenvolgende poolstukken ongelijk zijn in lengte, hoogte, en/of breedte*". The subject-matter of claim 1 is therefore new.

The technical effect of this differentiating feature has been presented by the applicant in the description on page 7 (see lines 13-18) in that by varying the volume of material used for the pole pieces non-uniformities in the magnetic field strength can be compensated for.

Claim 1 in its present wording encompasses inter alia the case in which all pole pieces consist of the identical material and identical cross-section 7 of the body 6 of the pole piece. In this case choosing the top segments of successive pole pieces such that they are unequal in length l, height h and/or width x would result in an inhomogeneity of the magnetic field strength in planes parallel to the mounting plane of the pole pieces. In other words, in this case the differentiating feature has a disadvantageous effect and it, therefore, cannot be regarded inventive.

The present wording of claim 1 also encompasses the embodiment as presented in figure 2 of the present application wherein the pole pieces 2 are embodied as magnets at odd pole positions and the pole pieces 3 are embodied as magnetisable pole pieces at even positions. The same configuration has been proposed in the document D1 in figure 4 as an alternative magnet design. It is credible that in this case the magnetic field strength at the even positions may be weaker compared to the magnetic field strength at the odd positions when the pole pieces have identical sizes but different magnetic susceptibility. However, the skilled person, when putting the teaching of D1 into practice, will without doubt recognise the problem of non-uniform magnetic field strength in planes parallel to the mounting plate of the pole pieces and he will inevitably try to find a solution to this problem. In this context it belongs to the skilled person's routine tasks to choose the materials, the dimensions and the arrangement of magnets relative to each other in such a way that the configuration of the magnetic field strength needed is achieved. The skilled person will, therefore, when starting from the teaching of D1, and

in particular from the alternative magnet design presented in figure 4, and being faced with the above problem arrive at the subject matter of claim 1 of the application with the help of his common general knowledge and practice only, thereby not having made an inventive step.

3 **Dependent claims**

3.1 The dependent claims 2-13 do not appear to contain any additional features which, in combination with the features of any claim to which they refer, meet the requirements of patentability with respect to inventive step, because the features of these claims are disclosed in the documents D1 (see the figures 2, 4 and 5 as well as the accompanying text, in particular on page 981) or D2 (see figures 1 and 2) or they are merely several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed.

4 **Industrial applicability**

Claims 1-13 relate to subject-matter regarding magnetic density separation, consequently the industrial applicability of the subject-matter of these claims is fulfilled.

Re Item VII

Certain defects in the application

5 The features of claims 1-13 are not provided with reference signs placed in parentheses.

Re Item VIII

Certain observations on the application

6 Claims 1, 4-7, 9, 10 and 12 are not clear and/or not supported by the description, the reasons being as follows:

6.1 Claim 1 refers to "*het magnetische veld*" and "*het topoppervlak*" while no such features have been defined before. This renders the subject-matter of claim 1 unclear.

6.2 Claim 1 defines that "*de topsegmenten van opeenvolgende poolstukken ongelijk zijn in length, hoogte en/of breedte*". This definition appears not to be supported by the description as the only embodiment presented shows that it is not the top segments 8 which vary in height but the bodies 6.

6.3 The term "*in hoofdzaak*" used in claim 1 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear.

6.4 Claim 1 defines that "*elk poolstuk (...) een topsegment omvat dat is gekromd om het magnetische veld dat met het topoppervlak van het poolstuk is geassocieerd zodanig te verdelen dat de sterkte daarvan transversaal op het montagevlak in hoofdzaak uniform is verdeeld in vlakken die parallel aan het montagevlak zijn gelegen*". In other words, claim 17 broadly defines the feature "*een gekromd topsegment*" in terms of its function. However, the description (see page 6, lines 1-16) conveys the impression that this function can only be carried out in a particular way, namely by a curvature represented by the formula given in line 10 of page 6, and no alternative means are envisaged. Hence, claim 1 is not supported by the description.

Moreover, it is known that the spatial distribution of the magnetic field strength mainly depends on the orientation of the magnetic poles within the arrangement. This feature must therefore be regarded essential for the definition of the invention. Since independent claim 1 does not contain this feature it does not meet the requirement of clarity that any independent claim must contain all the technical features essential to the definition of the invention.

6.5 Claims 4 and 5 refer to "*polen*" while no such feature has been defined before. This renders the subject-matter of claims 4 and 5 unclear.

6.6 Claim 5 refers to "*Magneet volgens één der voorgaande conclusies*" but also to "*poolstukken (...) uitgevoerd als magneten*". It appears that the same term ("*magnet*") is used for two different features. This renders the subject-matter of claim 5 unclear.

6.7 A similar objection as raised in section 6.6 is raised against claims 6-8 and 10.

6.8 Claim 9 defines a mathematical formula but does not define the meaning of the variables z and p. This renders the subject-matter of claim 9 unclear.

6.9 The terms "*voorste*" and "*achterste*" used in claim 10 are not defined and leave the reader in doubt as to the meaning of the technical features to which they refer, thereby rendering the definition of the subject-matter of said claim unclear.

6.10 Claim 12 refers to "*het oppervlak*" while no such feature has been defined before. This renders the subject-matter of claim 12 unclear.