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(54) **Process and apparatus for the production of a spunbond web**

(57) In an apparatus for the production of a non-woven fabric of filaments, a plurality of filaments (11) are extruded from a spinneret (2), and they are cooled in a cooling chamber (10) by at least one airflow (Y) that crosses at least part of the filaments and that at least partly leaves the cooling chamber through exits (14) located above the point of entry of the cooling airflow into the cooling chamber, to cause the cooling airflow (Y,X) to pass through the filaments (11) at least twice, at two different positions on the plurality of filaments.

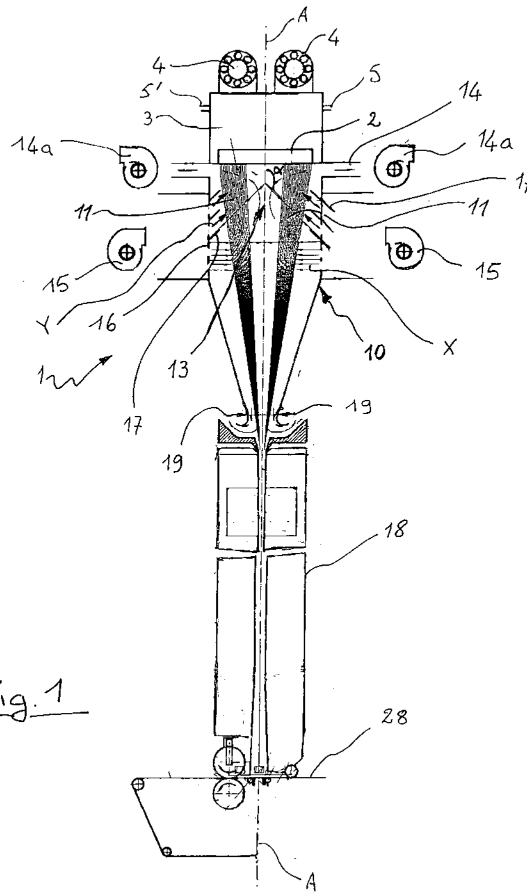

Fig. 1

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Description

[0001] The present invention relates to a process and an apparatus for the production of spunbond yarn non-woven fabric; in particular, the invention relates to a process and a device for the production of yarns stretched in a current of air (i.e. by aerodynamics) and formed into a layer of non-woven fabric.

[0002] A typical apparatus for the production of spunbond yarn includes a spinneret fed by extruders, a cooling chamber where the filaments undergo a first partial cooling, a stretching unit and a deposition unit where the stretched filaments are deposited on a mobile support where the required non-woven fabric is formed. A description of the apparatus and the related production process can be retrieved from, for instance, the website utk.edu

Textiles/Spunbond.

[0003] All these modules (extrusion, cooling, stretching and deposition) are very important to achieve a good final product.

[0004] Among these modules, particular importance attaches to the cooling unit or chamber immediately downstream of the extruder spinneret. Air is fed to this chamber to partially cool the filaments extruded by the spinneret, i.e. the filaments are solidified to such a degree as to be able to be stretched to the desired dimensions in the following step of exposure to high-speed air.

[0005] IT 1245831 in the name of the applicant Farè, describes an annular spinneret in whose interior are located two cooling chambers that feed two airflows at different temperatures and different speeds onto the extruded filaments to progressively cool the bundle of filaments. For this purpose, the cooling airflows are superimposed vertically, with the upper flow at a higher temperature than the lower flow. The cooling airflows are directed from the center towards the outside of the annular bundle of filaments.

[0006] This concept of two cooling chambers that direct airflows at different temperatures and speeds onto the bundle of filaments has recently been used in the application US2003/0178742 in the name of Reifenhauser. In this application, an apparatus is described for the production of a spun-bond non-woven fabric in which the cooling zone of the filaments leaving the spinneret provides a plurality of chambers (generally two) to which air is fed at different temperatures to accelerate the cooling of the filaments and therefore to increase the rate of production.

[0007] Furthermore, according to this patent, the cooling air is fed to the filaments in a passive way, i.e. it is dragged along by the same filaments as they move at high speed toward the bottom of the apparatus.

[0008] In the solution described above, the cooling air dragged along by the filaments enters the underlying filament-stretching duct and thus influences and interferes with the conditions of the lower or stretching zone of the apparatus. In other words, there is not the necessary pneumatic un-coupling between the cooling and stretching zones.

[0009] The aim of the present invention is to solve the aforementioned problems by providing a process and an apparatus for the production of spun-bond non-woven fabric that enables progressive cooling of the filaments while operating at high speed and maintains a pneumatic separation between the cooling zone and stretching zone of the filaments.

[0010] Such purpose is achieved by the present invention that relates to a process for the production of non-woven fabric by extrusion of a plurality of filaments, cooling said filaments, stretching same filaments and depositing them on a mobile support in the form of non-woven fabric, characterized according to Claim 1.

[0011] As will be discussed in more detail in the following description, the process provides for at least part of the cooling airflow being made to pass through the bundle of filaments twice, and for the second passage being in a position closer to the extrusion spinneret, i.e. where the filaments are hotter. In such a way, the air that contacts the filaments is heated by the first passage and when it crosses the bundle on the second passage it has a higher temperature than initially. Thus progressive cooling is achieved; the filaments are initially in contact with warmer air and subsequently with cooler air.

[0012] Another object of the invention is an apparatus for the execution of the process described above, characterized according to Claim 6.

[0013] According to a preferential aspect of the invention, the filaments are extruded in two separate groups separated by a portion of spinneret that has enough width to become, inside the cooling chamber, an expansion zone for the air after its first passage through the bundles of filaments.

[0014] According to a further aspect of the invention, in addition to the first cooling airflow described above there is a second flow that is fed to the bundles of filaments in a direction substantially perpendicular to the same, i.e. horizontally. The temperature of the second flow can be lower than that of the first flow.

[0015] According to a further aspect of the invention, there is a pressure balancing zone corresponding to the lower extremity of the cooling chamber, provided with a flow deflector.

[0016] The flow deflector has the function of balancing the pressures and separating the air flow to be discharged to the outside.

[0017] The invention has numerous advantages over the known art. In fact it enables the air - heated by its first passage through the filaments - to be recycled to cool the more upstream filaments, at a distance between around 50 and 250 mm inclusive from the extrusion spinneret, obtaining in such a way more gradual and uniform cooling than that obtainable with known methods. This improved cooling allows the filaments to be stretched and therefore to be spun with very thin counts, up to 0.9 dtex in mono-component filaments and 0.05-0.3 dtex in bicomponent split and/or side-by-side filaments.

[0018] Filaments with such low counts allow non-woven fabric to be produced that can be used for filters and for products that are required to have a barrier action for fluids, as for instance surgical coveralls and masks for medical and hospital use.

[0019] The invention will now be described in more detail with reference to the enclosed drawings which are by way of illustration and not limiting, where:

- Fig. 1 is a schematic side view of the apparatus according to the present invention;
- Fig. 1A is a schematic side view of a variation of the apparatus of Fig. 1;
- Fig. 2 is a magnified view of the cooling chamber of the apparatus of Fig. 1;
- Fig. 3 is a partial view from below of the spinneret according to the present invention;
- Fig. 4 is a magnified view of the exit portion of the cooling chamber according to the invention;
- Figures from 5 to 11 are views in section of fibers obtainable with the method and device according to the present invention;
- Figure 12 is a schematic view in section of an extrusion head suited for use with the device according to the present invention.

[0020] With reference to Fig. 1, the apparatus 1 for the production of a non-woven fabric of filaments according to the present invention provides for an extrusion head 3, comprising a spinneret 2 to extrude a plurality of filaments, to which head are connected one or more extruders (not shown) for the extrusion or the co-extrusion of mono-, bi- or tri-component filaments as already known in the art and as described and claimed in, for instance, the applications for patent EP-A-00112329.8 and EP-A-96830305.7, both in the name of Fare.

[0021] The polymer is distributed to the holes of the spinneret 2 through satellite gear pumps 4, generally from two to eight ways. There is at least one pump for each type of polymer and in the embodiment shown there are two satellite pumps 4, each of which feeds a section of the spinneret 2. In the case of a process that provides for the use of two different polymers, as for the production of co-extruded cored-fiber, for every portion of spinneret two pumps 4 will be necessary to feed the two different polymers. In such case, the two polymers are fed by two different entrances 5 and 5' of the extrusion head 3. The channels of distribution of the polymer from the pump to the holes of the spinneret 2 are of such dimensions (length and section) so as to have uniforms loading losses on all the holes, in a way already known in the art, for instance by having all lengths and cross-sections identical.

[0022] The extrusion head and the spinneret 2 are preferably produced as described in the patent European n. 0995822 and in the patent USA n. 6168409 in the name of Farè. In these patents (here included for reference), an extrusion device is described that is particularly suited to the production of two or more polymer spunbond yarns like those discussed here. The device of EP 0995822, shown in Fig.12 of the present description, comprises a first extrusion spinneret 110 provided with a plurality of ducts 140 and extrusion holes 116 for a polymer B and a second spinneret 112 having a second plurality of extrusion holes 144 and ducts 138 for a polymer A, in which the extrusion holes and holes are co-axial and aligned to give between them the required co-extruded structure to the filament. From the second spinneret 112, set upstream (in relation to the flow of the polymers) of the first spinneret 110, the extrusion ducts 138 extend into the ducts 140 of the first spinneret 110 until they are close to the extrusion holes 116, i.e. in proximity of the nozzles 116 from which two (or more) polymers are extruded.

[0023] The extrusion ducts of the second spinneret 112 are made of a material, generally steel, that is sufficiently flexible to allow the necessary movement to compensate for the different thermal expansions to which the two spinnerets 110 and 112 are subjected during their operation because of the different temperatures of extrusion of the polymers A and B. Furthermore, there are means of maintaining the flexible steel ducts 138 aligned and co-axial with the ducts of the spinneret in which they are lodged; such means including, for instance, fins or projections 142 made on the terminal portion of the flexible duct.

[0024] Due to the spinneret as described above, it is possible to make very wide spinnerets, i.e. with co-extrusion widths even of six meters achieved with a single spinneret, something not possible with traditional spinnerets.

[0025] The apparatus according to the invention can also include more than one spinneret to give the same width of extrusion or the same width of spinneret.

[0026] For greater simplicity, the term spinneret in the following description is intended to mean the device that comprises the extrusion holes of the filaments, independently of the number of elements that composes it.

[0027] Preferably, the spinneret 2 is provided with a plurality of holes 6 forming the filaments into two groups 7 and 8, which groups are parallel and separated by a zone 9 of the spinneret 2 that is without holes 6.

[0028] The ratio between the width L2, i.e. the sum of the widths of the perforated zones 7 and 8 and the zone without holes 9, and the width L1 of zone 9 is L2/L1 and ranges between 2 and 5.

[0029] The distance between the holes transversal to the spinneret (width L2) and in longitudinal sense (i.e. perpendicular to the width L2) can vary or be constant. In the preferential embodiment shown, the distance between the holes in a transverse sense increases as the central part of the spinneret is approached from the extremity of the same, i.e. passing from the extremity to zone L1. The purpose for such an arrangement will be clarified in the following description.

[0030] A cooling chamber 10 is connected to the extrusion head 3 to cool the filaments leaving the spinneret 2 by flows of cooling air, before the filaments 11 pass into the underlying stretching duct 12. According to the present invention, the cooling chamber 10 includes means of producing at least one airflow that crosses at least part of the filaments 11 and that is directed toward an expansion zone 13 of the cooling air and a means of exit 14 for the removal of at least part of said cooling airflow from the cooling chamber 10.

[0031] In particular, part of the cooling airflow is removed from the cooling chamber after such airflow has again crossed the filaments in a different point from that of the first crossing.

[0032] The means of feeding the cooling air includes blowers 15 that send an airflow to the walls 16 of the cooling chamber 10; the walls 16 are provided with holes and deflectors 17 located externally or internally to the chamber 10 to redirect a deflected airflow Y into the upper part of the chamber 10, toward the expansion zone 13 of the chamber.

[0033] As can be seen, the flow Y of cooling air crosses the filaments 11 and is directed at an angle toward the expansion zone 13 that corresponds to the space of chamber 10 that underlies the non-perforated portion 9 of the spinneret 2. The plane of the deflectors 17 forms an angle with the vertical axis A of the apparatus ranging between 80 and 45 degrees and preferably about 70 degrees; i.e. that the complementary upper angle β formed by the deflectors 17 with the vertical wall of the cooling chamber 10 is in the interval between 10 and 45 degrees, preferably around 20 degrees.

[0034] The means of exit 14 include at least one exit duct connected to an aspirator 14a and located above the means of input 15-17 to make said flow Y of cooling air pass through said filaments at least twice, at two different positions of the plurality of filaments. In other words, the flow Y produced by the deflectors 17 crosses the filaments 11 to arrive in the zone 13 and from there it again crosses the filaments 11 to exit at least in part from the expansion chamber 10 through the ducts 14, under the action of the aspirators 14a.

[0035] In the embodiment shown in Fig. 1 and 2, the expansion zone 13 of the air heated by the passage through the filaments is located between the two bundles of filaments 11 and corresponds to the space in the chamber 10 underlying the non-perforated zone 9 of the spinneret 2. The same process, i.e. removing part of the cooling air through exit ducts located above the entrance ducts of the air, can also be carried out with cooling chambers in which there is only one bundle of filaments, provided that there is an equivalent expansion zone 13. A similar embodiment could, for instance, be obtained by tracing the structure of half the apparatus illustrated in Figures 1 and 2, i.e. putting in a wall corresponding to the axis A-A of the chamber 10; in such an embodiment, the input and exit ducts of the cooling air are on the same side in relation to the wall corresponding to the axis A-A.

[0036] As shown in the drawings, besides the cooling airflow Y directed at an angle toward the spinneret 2, the cooling chamber can provide a further flow X, obtained from the same flow XY produced by the blowers or blowers 15.

[0037] Flow X is substantially directed onto the filaments 11 in a horizontal direction and after having crossed them it will be located in an expansion zone lying below the expansion zone of airflow Y.

[0038] Fig. 1A shows a variation of the embodiment described above, in which, according to the text of patent IT1245831, flow X and flow Y have different characteristics and are produced by two different blowers or blowers. In particular, the cooling airflow Y is produced by blowers or blowers 15 while flow X is produced by distinct and separate blowers 15A, so flow X can have a different temperature than flow Y (generally lower). The speed of flow Y can also be different from that of flow X and generally it will be higher.

[0039] The volume of flow X is between 20% and 50% of the total cooling airflow sent to the chamber 10.

[0040] During operation of the cooling chamber, the air exiting the blowers 15 passes through the holes provided in the wall 16 of the cooling chamber 10 and is at least partly redirected (flow Y) by the deflectors 17 toward a zone 13 located between the two bundles of filaments 11.

[0041] The humidity and temperature of the cooling air will be controlled. In particular, the temperature will be between 20° and 75°C and the relative humidity between 30% and 80%. The blowers 15 produce a flow with pressure and speed controlled and adjustable; speed is preferably between 0.5 and 3.6 m/s inclusive, preferably between 0.8 and 2.5 m/s. The pressure is between 400 and 1800 Pa.

[0042] The temperature of the filaments 11, that are crossed by the flow Y, depends on the type of thermoplastic material used and is generally between around 210°C and 335°C. The filaments surrender heat to the cooling air that crosses them and that air will accordingly expand in the expansion zone 13. The arrangement of the holes shown in Fig. 3, i.e. with distance between the adjacent holes increasing with increasing distance from the external zone towards the interior (adjacent to the non-perforated zone 9) of the spinneret, favors the crossing of the bundle of filaments by the cooling air, that has already expanded on contact with the first filaments 11 located more externally. During this first crossing of the filaments by the air that passes from the holes in the wall 16 to the expansion zone 13, the air of flow Y receives heat but it is still able to cool (to a lesser extent) the filaments at the point corresponding to the second crossing of the bundles of filaments, when the air passes from the expansion zone 13 to the aspiration ducts 14. Such point of second crossing is generally located at a distance of between 50 and 250mm inclusive from the spinneret; such distance is adjustable and can be modified by regulating the inclination of the deflectors 17, which are therefore fitted adjustably on the wall 16.

[0043] Thus two crossings and two successive coolings of the extruded filaments are obtained by the same flow Y of cooling air. This fact is important because in the said zone between 50 and 250 mm below the spinneret, the temperature of the cooling flow must not be so low as to prevent stretching and the surface oxidation reaction of the polymer by which the filaments themselves are produced.

[0044] The use of two flows Y and X translates into a further advantage: The flow Y, tilted in relation to the axis A-A, follows a longer course to arrive in the expansion zone 13 and therefore arrives at a lower speed than the flow X which, being directed horizontally, has a shorter course and arrives in its own expansion zone 13A with higher speed. The static pressure will therefore be different in the two zones and that in 13 will be lower than that in 13A. In this way, a zone of depression will be produced below spinneret 2 placed above a zone of higher pressure corresponding to zone 13A. This distribution of the pressure field favors the re-crossing of the filaments by the cooling airflow.

[0045] The process of gradual cooling by recycling air according to the present invention enables very stable stretching and spinning of the thermoplastic filaments to be carried out. In particular, it is possible to produce very thin counts, e.g. up to 0.9 dtex for mono-component filaments and up to 0.05 - 0.3 dtex for the bi-component and split side-by-side filaments.

[0046] Besides the regulation of the pressure and volume of the blowers 15, and where necessary 14a, to avoid the setting up of turbulence in the cooling chamber 10, there are also flow regulators 19 at the exit of the same, comprising oscillating portions 21 that interact with a flow deviator 20 located at the exit of the cooling chamber.

[0047] Figure 4 shows the structure of the flow regulation complex at the exit of the chamber 10. One part of the cooling flow escapes into the ambient atmosphere and another part is dragged into the stretching duct 18. As mentioned above, the flow regulators 19 include oscillating portions 21 hinged at 22 onto the wall 16 of the chamber 10. Actuators 23 (Fig. 2) control the position, or the angle, of the oscillating portions 21; the oscillating portions 21 are provided with a flat portion and extremity curved toward the outside. The angle η formed by the plane of the flat part of the portion 21 with the axis A-A is between 2 and 30 degrees, preferably between 5 and 20 degrees.

[0048] The oscillating portions 21 interact with the flow deflector 20, which has a central conical portion 23, tapering toward the mouth of the stretching duct 18. The planes corresponding to the internal wall 25 and to the external wall 24 of the said conic portion 23 form angles η and θ respectively, ranging from 3 to 25 degrees with the axis A-A and preferably between 9 and 15 degrees for the angle η, and between 12 and 35 degrees and preferably 20-24 degrees, for the angle θ.

[0049] The entrance to the stretching duct 18 has a tapered portion with walls 26 leaning out toward the conic portion 23 and forming an angle δ with the axis A-A of between 12 and 35 degrees and preferably between 18 and 22 degrees. The tapered walls 26 of the duct 18 are part of sections 27 of the duct 18 fitted horizontally mobile in order to vary the distance between the walls 26 and the walls 24 of the flow deflector 20. The minimum distance between the walls is between 15 and 30mm and preferably between 20 and 24 mm. The structure described above thus forms a Venturi system able to produce an influx of air into the duct 18 with adjustable speed and generally between 30 and 45 m/s.

[0050] After being passed into the stretching duct 18, the filaments are deposited on a mobile support 28 and calendered between two or more rolls 29 to form the non-woven fabric.

[0051] As mentioned above, the device of the invention enables very thin counts to be produced, e.g. up to 0.9 dtex for the mono-component filaments and up to 0.05 - 0.3 dtex for the bi-component and splittable side-by-side filaments.

[0052] Figures 5-11 show structures of yarns obtainable with the method and the device according to the invention.

[0053] Fig. 5 shows a known yarn, comprising a core portion A and skin portion B; in Fig. 6, the portions of polymer A and B are in the side-by-side arrangement, also already known, particularly for the "splittable" fibers, i.e. for those fibers that are divided after they have been collected on the belt 28 following "mechanical" treatment, e.g. with jets of water. Fig. 9 shows a "side-by-side" embodiment in which the central portion of the filament is absent.

[0054] Other embodiments, not known until now, are shown in Figures 7 and 8 and in the corresponding hollow embodiments of figures 10 and 11. In these embodiments, the yarn is composed of a plurality of adjacent portions radially located and alternating with each other, of polymer A and polymer B. A central core can be present (Fig. 7) or absent (Fig.8, 10,11). The yarns shown are obtained by spinnerets of the type shown in the patents US 6168409 and EP0995822, modified with the addition of a suitable number of radial channels that connect the interior part of the flexible duct 138 (Fig.12) with the surrounding duct 140 of the first spinneret 110. For instance, the polymer A in Fig. 7 is present in five peripheral portions and therefore there will be five channels present in the flexible duct138 connecting the interior of the same with the surrounding duct 140.

[0055] The above also applies, changing what needs to be changed, for the other embodiments shown; if a central core is not required, the lower nozzle 144 of the duct 138 is not present and the polymer A escapes from the flexible duct 138 through channels cut into the wall of the duct 138.

[0056] The polymers A and B are preferably of the non-compatible type so as to have good subdivision of the yarn into so many smaller fibers during the step of "splitting" the yarn.

Claims

1. Process for the production of a non-woven fabric of filaments, comprising the steps of extruding a plurality of filaments (11) from a spinneret (2), cooling said filaments in a cooling chamber (10), stretching said filaments in a stretching duct (18) located below the cooling chamber and depositing the stretched filaments on a support (28), **characterized by** said filaments being cooled by at least one airflow (Y) that crosses at least part of the filaments (11) and that at least partly leaves the said cooling chamber (10) through exits (14) located above the point of entry of the said at least one cooling airflow (Y) into the cooling chamber to cause said cooling airflow to pass at least twice through said filaments (11), at two different positions of the plurality of filaments.

2. Process according to Claim 1, in which said filaments are extruded by said spinneret (2) in at least two groups at least partly separated from each other and in which at least one cooling airflow (Y, X) is directed on each group, the distance (L1) between said groups furnishing sufficient space (13) to allow the expansion of the air of said flow (Y, X) heated by its passage through the filaments.

3. Process according to Claim 1 or 2, in which said at least one flow (Y) it is at an angle to the plane of the said filaments, and is directed toward the upper portion of the said cooling chamber (10).

4. Process according to any of the preceding claims in which at least one flow of additional air (X), located below said flow at an angle (Y), is directed through said filaments (11) to said expansion zone (13).

5. Process according to Claim 4, in which said additional flow (X) is substantially directed perpendicular to the plane of the said filaments and has temperature and/or speed different from the temperature and/or speed of the said flow at an angle (Y).

6. Apparatus for the production of a non-woven fabric of filaments, comprising a spinneret (2) to extrude a plurality of filaments (11), a cooling chamber (10) to cool said filaments by flows of cooling air, a stretching duct (18) located below the cooling chamber (10) to stretch said filaments (11) and a means of depositing the stretched filaments on a support (28), **characterized by** said cooling chamber (10) comprising means (15, 15A) of feeding at least one airflow (Y, X) that crosses at least part of the filaments and that is directed toward an expansion zone (13) of the cooling air and a means of exit (14, 14a) for the removal of at least part of said cooling airflow from the said cooling chamber, said means of exit (14, 14a) being located above the said means of feeding (15, 15A) to cause sais cooling airflow to pass at least twice through said filaments, at two different positions of the plurality of filaments (11).

7. Apparatus according to Claim 6, in which said extrusion spinneret (2) presents at least two groups of extrusion holes (6) separated by (L1) from each other to extrude two distinct and separated groups of filaments (11) and to form sufficient space (9) between said groups to allow an expansion (13) of the air of said flow heated by its passage through the filaments.

8. Apparatus according to Claim 6 or 7, in which said means of feeding of said airflow (Y) comprises means of deflection (17) to direct said flow (Y) at an angle in relation to the plane of the said filaments, toward the upper portion of the said cooling chamber (10).

9. Apparatus according to Claim 8, in which said means of deflection (17) forms an angle between 15 and 40 degrees inclusive, with the vertical plane of the cooling chamber.

10. Apparatus according to any of Claims from 6 to 9, in which said extrusion spinneret (2) presents two groups of holes (6) separated by a zone (9) deprived of holes, the width (L1) of said zone being between 15% and 28% of the sum of the total widths of the perforated and non-perforated zones (L2).

11. Non-woven fabric, as obtained with the process according to any of Claims from 1 to 5.

12. Fibers as obtained by co-extrusion of two or more polymers (A, B) according to any of Claims from 1 to 5.

13. Fibers according to Claim 12, as obtained by a further step of "splitting" treatment.

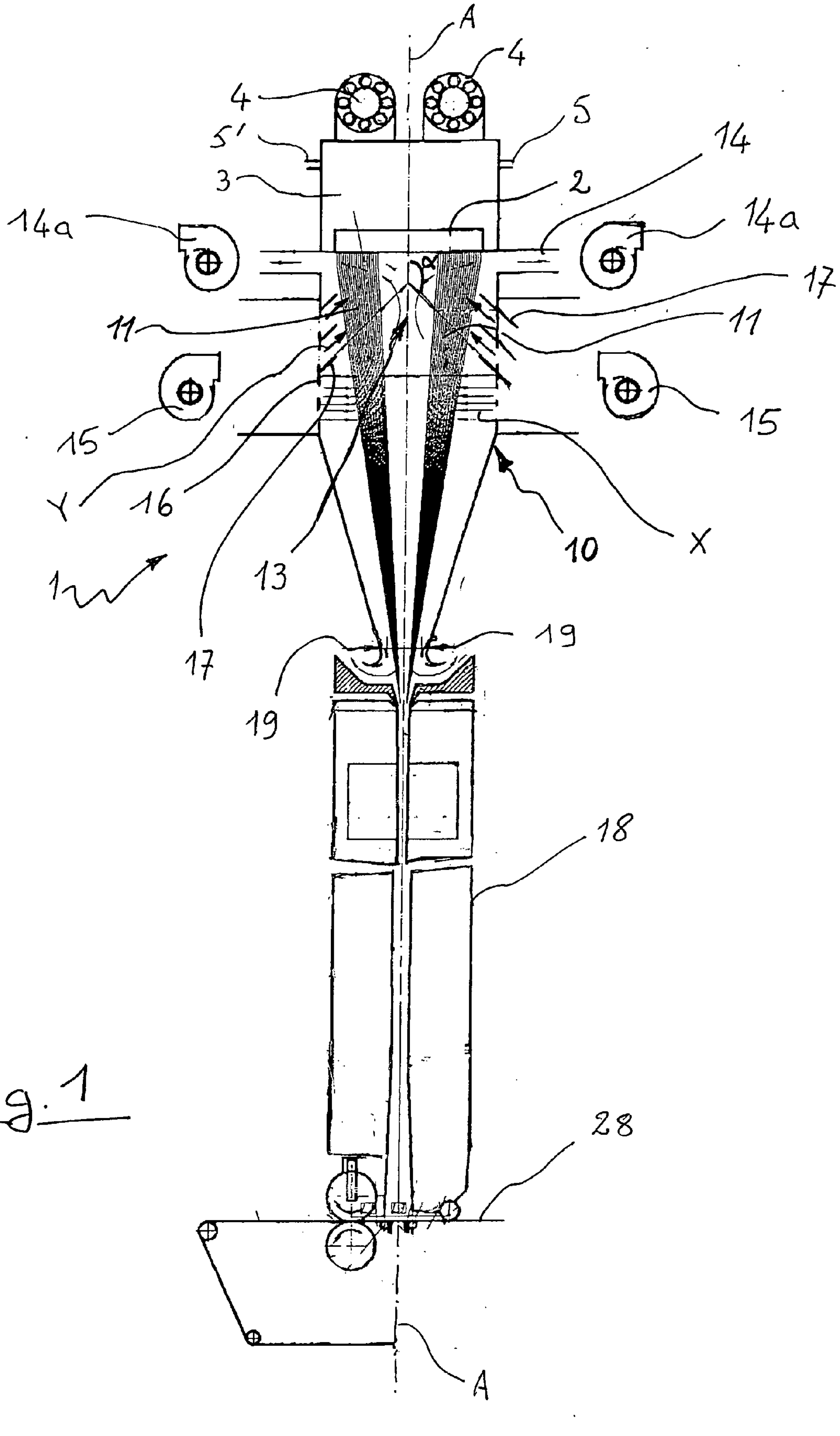

Fig. 1

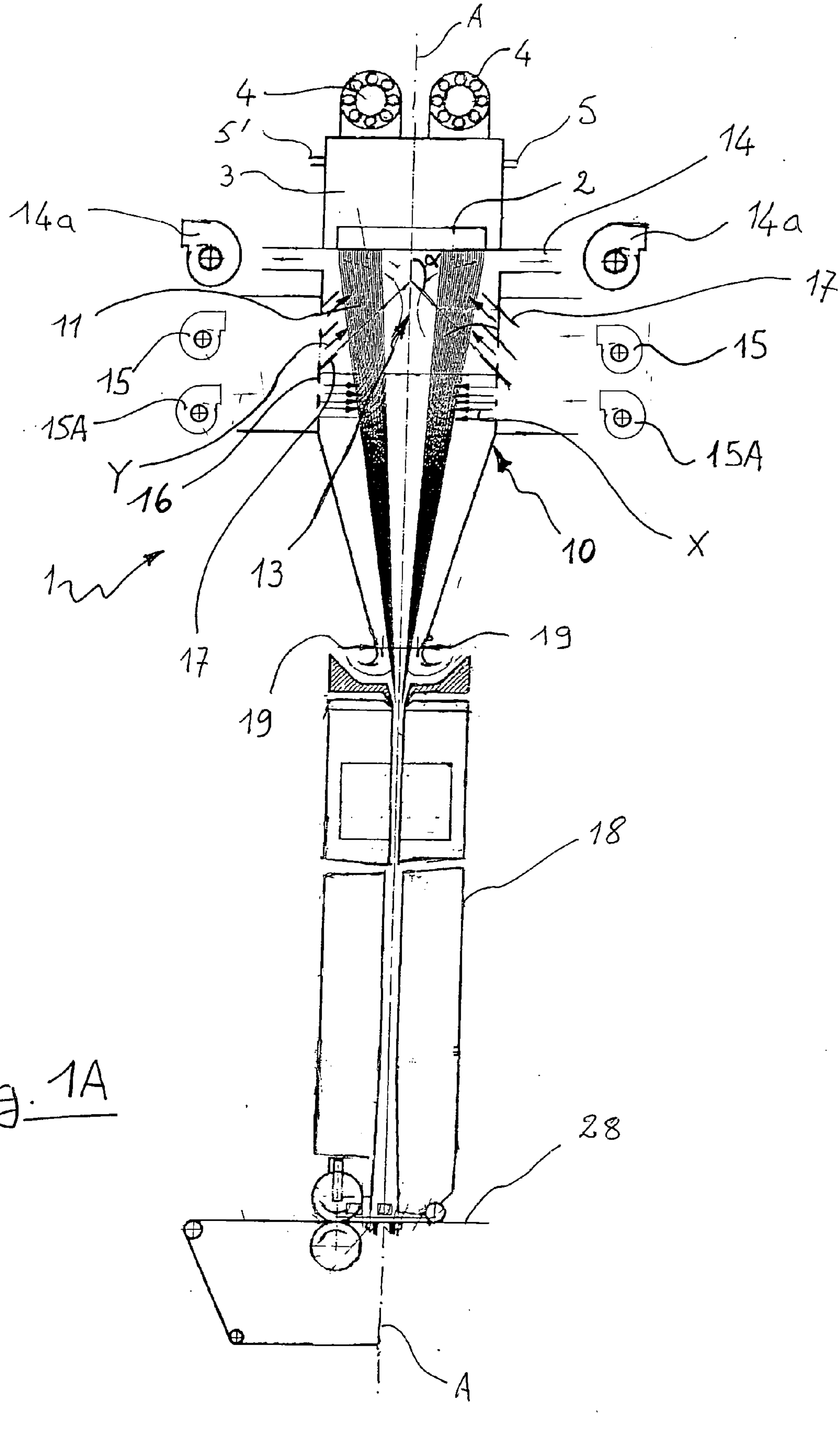
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Fig. 1A

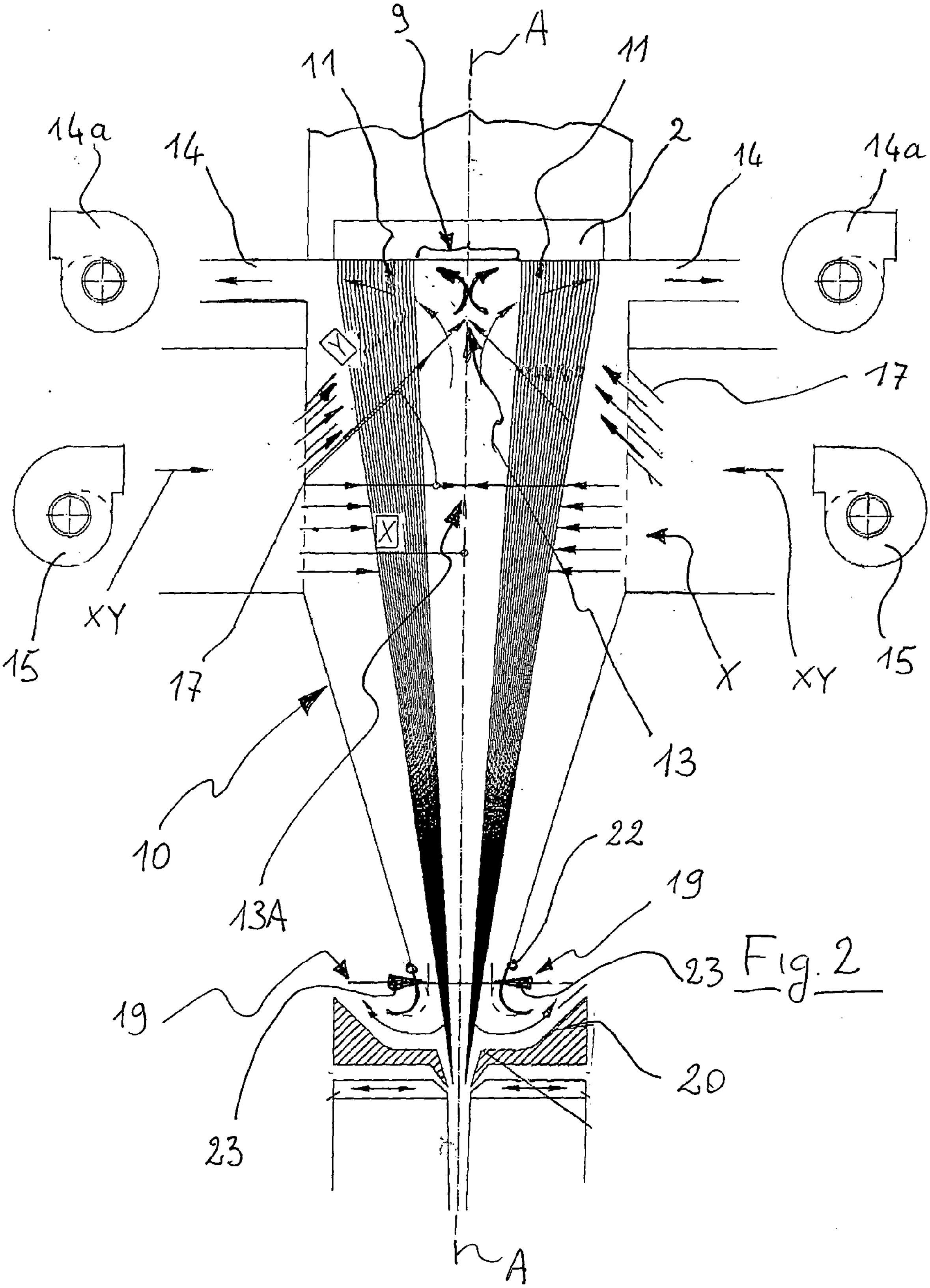
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Fig. 2

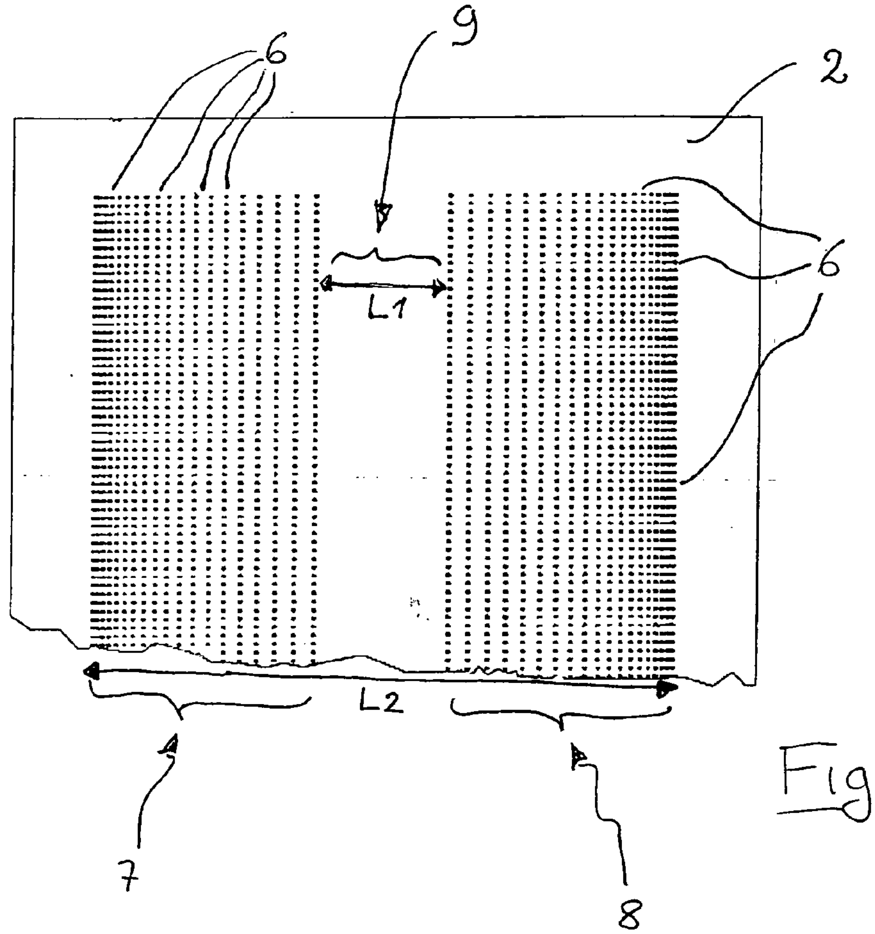

Fig. 3

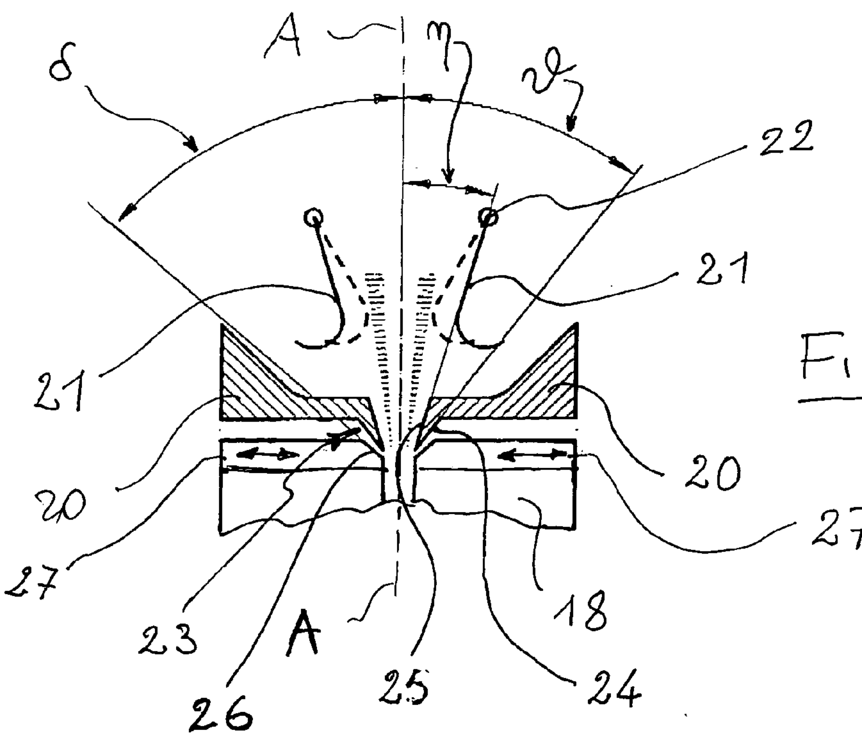

Fig. 4

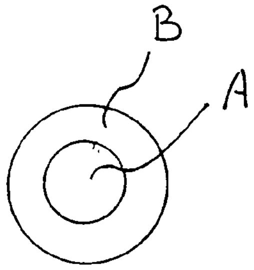

Fig. 5

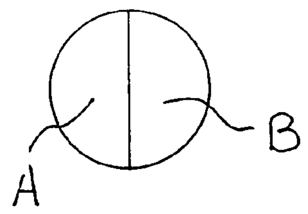

Fig. 6

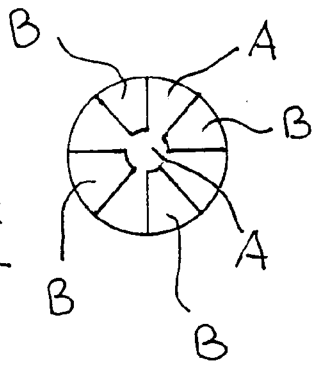

Fig. 7

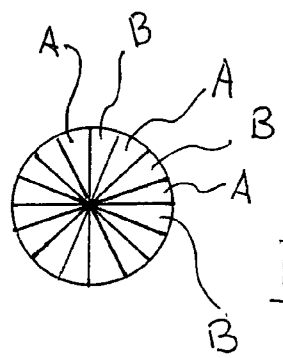

Fig. 8

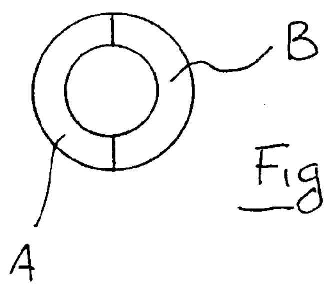

Fig. 9

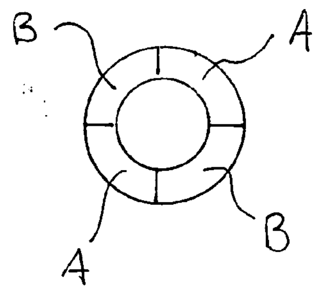

Fig. 10

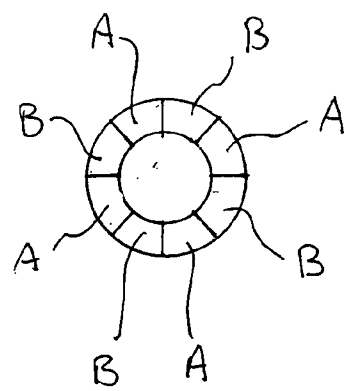

Fig. 11

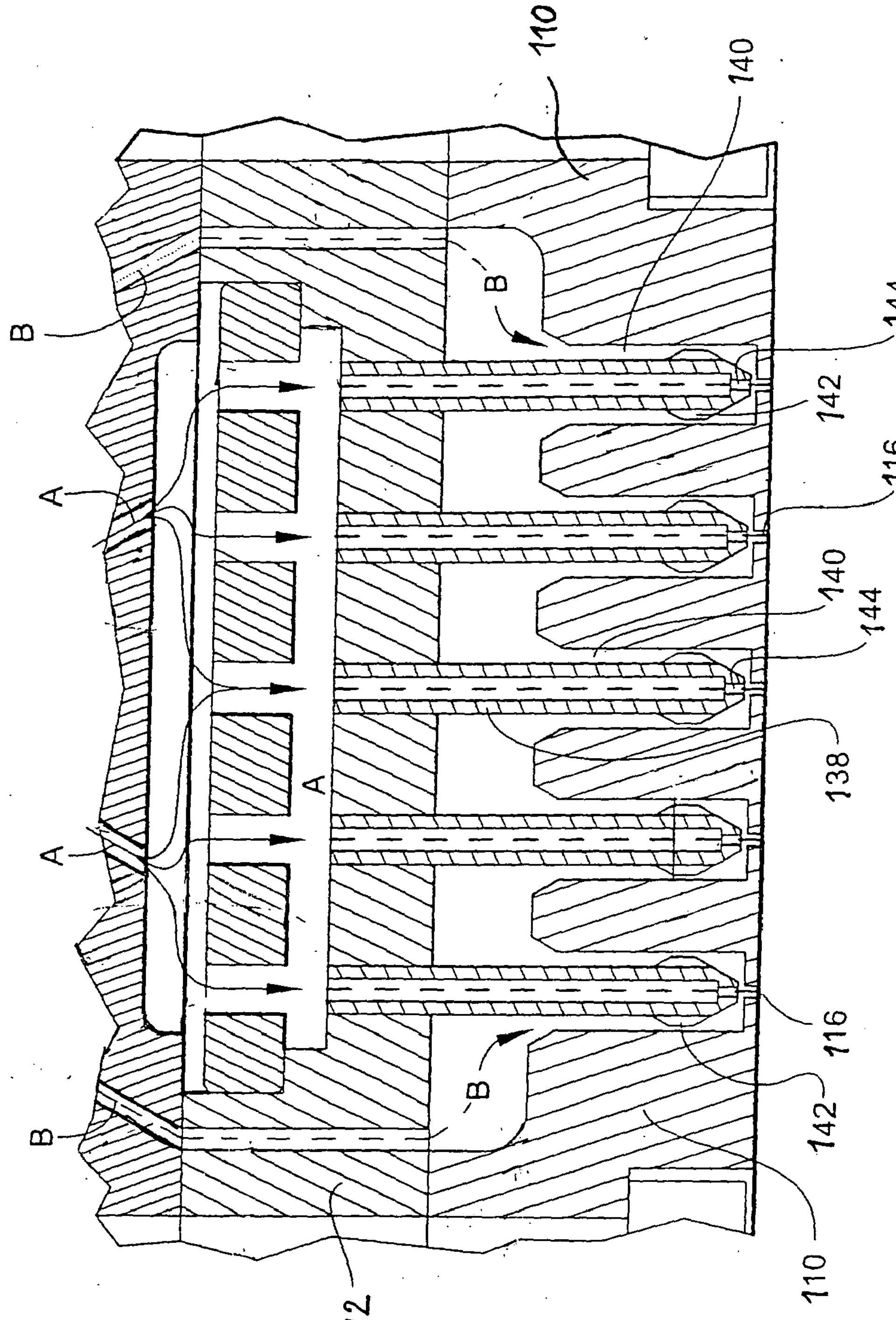

Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
The Hague	29 May 2007	Fiocco, Marco

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