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(54) PROCESS AND APPARATUS FOR THE MANUFACTURE OF NON-WOVEN WEBS

(71) We, HOECHST AKTIENGESELLSCHAFT a body corporate organised according to the laws of the Federal Republic of Germany, of 6230 Frankfurt/Main 80, Postfach 80 03 20, Federal Republic of Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to a process and apparatus for laying down filaments on a moving surface to form a non-woven web having a defined distribution of weight per unit area.

Numerous processes and devices are known for the deposition of filaments to form non-wovens webs. One of the most serious problems to be solved is the distribution of the filaments mass in the non-woven web, which distribution should preferably be as uniform as possible. The present invention is concerned with the possibility of controlling the distribution of the filament mass in the non-woven web, and more particularly with the realization of a defined, preferably rather uniform, distribution of weight per unit area in the non-woven web when using a rotating deposition system.

It is known that non-woven webs of good uniformity and high strength in all directions may be manufactured by means of rotating deposition system. German Offenlegungsschrift No. 24 60 755 describes a process for the manufacture of a non-woven web on the basis of filaments, according to which the filaments or filament bundles are deflected by rotating deflectors having a plane impinging zone, scattered and collected on a moving surface. That Offenlegungsschrift discloses furthermore that the distribution of the filament mass in the non-woven web can be influenced by a helical design of the deflector below the point of impact of the filament bundle.

German Offenlegungsschrift No. 22 00 782 also proposes a process by means of which filaments are laid down in rotating movement to yield a non-woven web. In this case, for spreading out the filaments to form a non-woven web, the centrifugal forces which develop are utilized.

Japanese Patent Publication Sho 48—41785 also discloses a device for the manufacture of non-woven webs in which filaments are laid down in rotating movement. Furthermore, devices laid down in filaments in circular manner are mentioned in U.S. Patent No. 3,756,893 and French Patent No. 20 45 331.

In previously proposed processes and apparatus which provide vertical feed of the filament bundle, vertical arrangement of the rotational axis of the deflecting mechanism and horizontal area of deposition, a circular filament deposit is formed in which the filament mass laid down is arranged with rotational symmetry in such a manner that a substantial part of the filament mass forms an annular mound near the rim of the circular deposit. When the collector surface is moving this distribution of the filament mass in the deposit does not yield the especially desired trapezoidal area weight profile in the non-woven web laid down. In the cited state of the art, indications as to a satisfactory realization or modification of the filament mass distribution in the circular deposit in order to meet requirements such as, for example, high uniformity of the non-woven web are non-existent or completely insufficient. These properties cannot be attained by deposition systems where practically no filaments at all are laid down in the center of the circular deposit.

German Offenlegungsschrift No 16 35 585 discloses laying down filaments to form a trapezoidal deposit by using a slit nozzle, and claims to attain a certain control of the shape of the filament deposit by using a permeable, perforated conveyor belt in combination with air suction. However, the means described for guiding the filaments to a defined place in the deposit are insufficient.

It is therefore an object of the present invention to provide a deposition process which avoids the above disadvantages and which makes it possible to guide the filaments to places in the deposit where they are required in order to obtain a web with a defined, preferably very uniform, distribution of weight per unit area.

The present invention provides a process for laying down filaments on a moving surface to form a non-woven web having a defined distribution of weight per unit area, in which process a filament bundle propelled towards the said surface is deflected and spread out by a rotating deflector which is inclined with respect to its axis of rotation and with respect to the said surface, and the resulting veil of deflected filaments encounters a guide plate which is spaced apart from the deflector but is arranged to rotate therewith, the guide plate also being so curved downwardly (and optionally also rearwardly towards the said axis of rotation), and so located, as to lead back at least a proportion of the deflected filament veil downwardly and towards the intersection between the said axis of rotation and the deposition surface.

In a process in accordance with the present invention, the rotating deflector deflects the filaments away from its axis of rotation and the co-rotating guide plate leads at least parts of the deflected filament bundle back again towards the intersection of the rotational axis and the deposition surface, which marks the centre of the deposit.

It is especially advantageous to arrange that not all of the filaments are led back to the same extent by the guide plate, but that part of them is led back more heavily and part of them less, in accordance with the intended distribution of weight per unit area.

Advantageously, therefore, the guide plate is so shaped and located as to lead back different parts of the filament veil to different extents. Preferably, the parameters of the process are so chosen that the non-woven web product has a substantially trapezoidal profile of weight per unit area across its width.

The invention also provides apparatus for laying down filaments on a moving deposition surface to form a non-woven web having a defined distribution of weight per unit area, which comprises a rotatable deflector for deflecting and spreading out a filament bundle propelled towards the said surface, and a guide plate, the deflector being inclined with respect to its axis of rotation and with respect to the said surface, the guide plate being spaced apart from the deflector but arranged to rotate therewith, and the guide plate also being so curved downwardly (and optionally also rearwardly towards the said axis of rotation), and being so located, that, in operation, at least a proportion of the veil of deflected filaments formed by the deflector is led back downwardly by the guide plate and towards the intersection between the rotation axis and the deposition surface.

In apparatus according to the invention, the deflector is inclined with respect to its axis of rotation, and the angle between the deflector and the axis is advantageously in the range of from 10° to 80°, preferably from 30° to 70°. The deflector is advantageously substantially planar. In the case of a curved deflector, the angle taken is that between its axis of rotation and the tangential plane at the point of intesection with that axis.

Advantageously, in operation, the angle of incidence between the filament veil and the surface of the guide plate or the tangent thereto at the point of incidence does not exceed 60°.

The guide plate may take various forms, depending on the desired distribution of weight per unit area in the product web.

Thus, for example, the guide plate may be in the form of part of the surface of a cylinder, and may then have a filament discharge edge in the form of a helix. Instead, the guide plate may be in the form of part of the surface of a sphere.

Advantageously, the guide plate tapers, optionally approximately to a point, towards its end remote from the deflector.

For certain desired distributions of filament weight per unit area in the product web, the filament discharge edge of the guide plate may be of stepped form.

Advantageously, the guide plate is adjustable laterally and/or rotationally with respect to the deflector. Such adjustment possibilities permit further control of the filament distribution.

In a preferred form of apparatus, the guide plate is formed on a planar extension which overlaps the deflector and is spaced apart therefrom.

The process of the invention is suitable for use in processing all textile materials in the form of filaments, especially filaments of polyesters, polyamides, polyolefins, polyacrylonitrile, or blended or compound filaments.

If desired, the process of the invention can be used to lay a plurality of non-woven webs simultaneously with their adjacent edge portions in overlapping relationship.

One form of process and apparatus in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an apparatus demonstrating the process of the invention;

Figure 2 represents deflector, guide plate, filament bundle and filament veil, as well as the differentiated leading back of the individual sectors of the filament veil,

Figure 3 shows a guide plate;

Figure 4*a* represents a plan view of a filament deposit in the form of an annular mound (not in accordance with the invention);

Figure 4*b* in its upper part, shows the weight per unit area distribution in the filament deposit on standstill of the deposition surface, and, in its lower part, the corresponding distribution in the non-woven web laid down on a moving deposition surface (not in accordance with the invention);

Figure 4*c* in its upper part, shows the ideal distribution according to the invention of the filament mass in the deposit on standstill of the deposition surface, and, in its lower part, the corresponding weight per unit area distribution of the filament mass plotted against the cross-section of the non-woven web on a moving deposition surface; and

Figure 5 represents a schematic view of a very uniform non-woven composite web which consists of several individual webs laid down one beside the other in overlapping manner, each one having the ideal trapezoidal distribution of the weight per unit area.

The filaments to be processed are fed directly from the spinneret or a filament reservoir in the form of a bundle or strand which has a titer of from 10 to 20,000 dtex, preferably 100 to 2,000 dtex.

The individual filament titer is from about 0.5 to 50 dtex, preferably 1 to 20 dtex. The feeding operation may be combined with a drawing or other treatment of the filament bundle. As shown in Figure 1, the filament bundle 1, which is adjusted to a speed of from 100 to about 10,000 m/min, preferably 2,000 to 8,000 m/min, by means of, preferably a gas nozzle in filament-axial direction, is forwarded generally vertically from above to a deflector 3 which rotates around an axis 2 at 0.5 to about 100 revolutions per second, preferably 5 to 50 rps, and which is preferably plane, but may instead be curved. The rotational axis of the deflector is generally vertical and coincides with the longitudinal axis of the incident filament bundle.

Figure 2 shows that there is a clearance angle α between the deflector and the rotational axis and the coincident axis of the incident filament bundle which angle may be from 10 to 80°, preferably from 30 to 70°.

The filament bundle hitting the deflector at high speed is scattered to form a flat ribbon or veil 4 which would hit the deposition surface 5 in the form of track 6 if the guide plate 7 as shown in Figures 1 and 2 was not present. Without this guide plate, the track 6 would, on rotation of the deflector about its axis, spread over an annular area 8 as shown in Figure 4*a* and a filament deposit having the shape of an annular mound would form the deposition surface 5.

Figure 4*b* shows in its upper part a diaphragm which demonstrates the dependence of the weight per unit area T(r) or T(x,y) on the distance *r* to the center of the filament deposit in this case, *y* is the coordinate of the conveying direction of the non-woven web and *x* is in vertical position thereto.

When the deposition surface is moving, a non-woven web is formed, of which the weight per unit area D(x) is not uniformly distributed over the cross-section, as is demonstrated in the lower part of Figure 4*b*. The dependence of D(x) on T(r) or T(x,y) is given by the following relation

$$D(x)=\int T(r)\,dy$$

This distribution of the filament mass in the non-woven web laid down does not have the intended trapezoidal shape by which a uniform non-woven web is distinguished.

Suprisingly, it has been observed that by leading back at least part of the filament veil in the direction of the intersection of the rotational axis 2 of deflector 3 and the deposition surface 5 the distribution of the filament mass in the filament deposit can be controlled and, if desired a very uniform trapezoidal distribution of the filament mass in the cross-section of the non-woven web can be obtained. This leading back, or second deflection, is achieved by means of a guide plate arrnged to rotate with the deflector. The function of a guide plate 7 is shown in Figure 1 and 2. A perspective view of a preferred guide plate is shown in Figure 3, comprising a rectangular plane part continued seamlessly to a curved part of which the development yields approximately a triangle. This curved surface in Figure 3 has the shape of a (broken-line) cylinder jacket 7′ the cylinder axis being in a position parallel to the edge of the rectangular part of the guide plate. Advantageously, the guide plate is made of a metal, glass or plastics material.

In a further preferred embodiment, the curved part of the guide plate may be in the form of part of the surface of a sphere.

Alternatively, it is possible to dispense with the plane part of the guide plate.

After having left the deflector, the filament veil is captured at least in part by the guide plate and led back in a manner as shown for example in Figure 1, where the plane part of the guide plate is in a position parallel to the plane surface of the deflector plate. Alternatively, it may form an angle with the plane surface of the deflector. The filament veil hits the guide plate at an angle of from 0 to about 60° on the plane and/or curved part thereof. In Figure 1, the sector of the veil at the far right (arrow A) does not touch the guide plate and is forwarded directly in a striaght line onto the deposition surface 5. The central sectors of the veil, however, are led back by the guide plate in the direction of the arrow B. The sector C of the veil at the far left is led back in such a manner that it hits the deposition surface near the intersection of the rotational axis and the deposition surface, that is, near the center of the filament deposit.

The secondary leading back of the filament shifts the track 6 of Figure 1 in such a manner that, on standstill of the deposition surface, it would have an approximately radial direction (9), relative to the circular filament deposit.

While maintaining its spatial orientation, the guide plate may be shifted horizontally in the direction of the arrows 10, so that control can be exercised on the portion of the filament veil which is led back on how far in the direction of the centre of the deposit that portion is led back.

The guide plate may alternatively turn around a vertical axle (not shown in the drawings), for example in order to adjust the guide plate in such a manner that the sector of the filament veil passing over the tip of the guide plate is led back to the point where the rotational axis of the deflector intersects the deposition surface. In principle, any adjustment of the guide plate is possible provided that the intended filament deposit is thereby ensured.

By adjusting the position and shape of the guide plate, the manufacturer of non-woven webs is able to distribute continuously the filament mass between the circumferential limits and the center of the filament deposit. When only a small amount of filaments is needed in the center of the deposit, the guide plate Figure 1 is shifted to the left, or the pointed end of it which is directed towards the center of the deposit is kept narrow; when a high weight per unit area is required in the center of the deposit, the guide plate of Figure 1 is shifted to the right, or the pointed end of the plate is given a broader shape.

The filament discharge edge 11 of the guide plate which has a helical shape in Figure 3 may have any shape and can be used for forwarding the individual sectors of the filament veil to a defined place of the filament deposit. A corresponding spherical curvature of the guide plate makes it possible to lay down the filament veil in such a manner on the deposition surface 5 of Figure 1 that its track 9 is precisely radial. If desired the filament discharge edge of the guide plate may have the form of steps.

For example, when a non-woven web having a trapezoidal distribution of the filament mass over its cross-section is to be obtained, a mass distribution T(r) in the filament deposit is required on standstill of the deposition surface, as shown in the diagram of the upper part of Figure 4*c*. Shape and adjustment of the guide plate is chosen accordingly and determined empirically or computationally, calculation and empirical method being in good agreement.

The process of the invention is furthermore suitable for the manufacture of large non-woven webs by simultaneously laying down individual non-woven webs one beside the other in overlapping manner. The structure of such a composite non-woven web is shown in Figure 5.

The following comparison of an Example according to the state of the art and an Example in accordance with this invention illustrates the invention.

EXAMPLE 1:

(State of the art, without guide plate)

Polethylene terephthalate is spun according to the melt spinning process from a spinneret having 92 circular holes, and the filament bundle is taken off vertically downward by means of an air nozzle, and drawn. After drawing, the individual filaments of the bundle have a titer of 4 dtex. The filament bundle accelerated to a speed of 85 m/sec and accompanied by an air jet is forwarded, in the manner shown in Figure 1, to a plane deflector having a width of 40 mm and a length of 60 mm which turns at 15 rps. The clearance angle of the deflector, that is, the angle between the deflector and its rotational axis, which coincided in Fig. 1 with the longitudinal axis of the filament bundle hitting the deflector, is 60°. The angle formed at the point of impact by the opening filament veil is also 60°. The guide plate 7 as shown in Figures 1 and 2 is not used, so that the filament veil formed on the deflector hits the deposition surface in track 6. A perforated conveyor is used as deposition surface, through which air is sucked downward at speed of 4 m/sec in order to hold the depositing filaments on the deposition surface. On standstill of the belt, a circular mound of filaments having an outer diameter of 400 mm and an inner diameter of 150 mm is formed.

When the continuous belt is moving at a speed of about 8 m/min, a non-woven web having a width of 400 mm is formed. The weight per unit area distribution of this web, being vertical to the direction of the moving belt, is characterized by two lateral maxima (see diagram 13 in Figure 4b).

In order to obtain a large non-woven web, six filament bundles instead of only one are laid down simultaneously by means of six deposition devices positioned one beside the other at a lateral distance of 200 mm.

By combining six deposits, a non-woven having a width of 1.20 m and a mean weight per unit area of 115 g/m^2 is obtained. The uniformity of the distribution so attained is characterized by the difference of the weight per unit area between the heaviest and lightest 5×5 cm sample which can be found relative to the average value of weight per unit area (ratio of the width at the foot of a distribution to its average value), and it is 0.45, in other words: the weight per unit area at the thinnest spots of the non-woven web is lower by about 23%, and at the thickest spots it is higher by about 22% than the over-all average value of 115 g/m^2.

EXAMPLE 2:
(According to the invention, with guide plate)

Operations for the manufacture of a non-woven web are as described in Example 1; however, the filament veil leaving the deflector is guided back in such a manner that it hits the deposition surface, that is the sieve web, in track 9. Leading back is ensured by a guide plate having approximately the shape of guide plate 7 of Figures 1 and 3, and approximately the spatial position relative to the deflector as shown in Figure 1.

The rectangular plane part of the guide plate is arranged at a distance of 8 mm above and parallel to the deflector. The horizontally positioned rim of the rectangular part of the guide plate, which rim is most adjacent to the point of impact of the filament bundle on the deflector, has a width of 50 mm, and the other rim of the rectangular part has a length of 15 mm. The curved part of the guide plate into which the rectangular part merges is a section of the surface of a cylinder having a radius of 30 mm. The axis of this hypothetical cylinder is positioned horizontally and parallel to that rim of the plane part of the guide plate which has a width of 50 mm. The development of the curved guide plate is a triangle, one of the small sides of it (having both a length of 50 mm) forms the line of contact with the plane part. The average distance between the point of impact of the filament bundle on the deflector and the track of impact of the filament veil on the guide plate is about 52 mm. The direction of rotation of the deflector and the co-rotating guide plate is chosen in such a manner that the part of the filament veil which is led back towards the rotational axis to a great extent is at the front of the rotating movement.

The guide plate may be shifted horizontally in the sense of arrows 10 of Figure 1, relative to the deflector, and it is adjusted in such a manner that the trapezoidal distribution of the weight per unit area in the cross-section of the non-woven web on the moving deposition surface as shown in diagram 14 of Figure 4*c* is obtained. The weight per unit area may be determined in simple manner, for example by photometric means. When adjusting the guide plate, care has to be taken that those parts of the filament veil which are led back leave the guide plate via the filament discharge edge (or "rim") only, which is shown in Figures 1 and 3 under the reference numeral 11.

By simultaneously laying down six non-woven webs one beside the other, a composite non-woven web having a width of about 1.20 m and a considerably improved uniformity is obtained. The maximum variation of the weight per unit area in the non-woven web is only ±12%.

These Examples prove that the process of the invention makes it possible to manufacture non-woven webs the quality of which is superior to that of the state of the art. Apart from excellent uniformity, the non-woven webs have very good strength in all directions.

The non-woven webs manufactured according to the process of the invention may be used in a variety of applications, for example, as reinforcing layers in roofing sheets, in plastic floor coverings, for the manufacture of needled felts, or in road and water engineering.

WHAT WE CLAIM IS:—

1. A process for laying down filaments on a moving surface to form a non-woven web having a defined distribution of weight per unit area, in which process a filament bundle propelled towards the said surface is deflected and spread out by rotating deflector which is inclined with respect to its axis of rotation and with respect to the said surface, and the resulting veil of deflected filaments encounters a guide plate which is spaced apart from the deflector but is arranged to rotate therewith, the guide plate and also being so curved downwardly (and optionally also rearwardly towards the said axis of rotation), and so located, as to lead back at least a proportion of the

deflected filament veil downwardly and towards the intersection between the said axis of rotation and the deposition surface.

2. A process as claimed in claim 1, in which the guide plate is so shaped and located as to lead back different parts of the filament veil to different extents.

3. A process as claimed in claim 2, in which the non-woven web product has a substantially trapezoidal profile of weight per unit area across its width.

4. A process as claimed in any one of claims 1 to 3, in which a plurality of non-woven webs is laid simultaneously with their adjacent edge portions in overlapping relationship.

5. A process as claimed in claim 1 and conducted substantially as described herein with reference to the accompanying drawings.

6. Apparatus for laying down filaments on a moving deposition surface to form a non-woven web having a defined distribution of weight per unit area, which comprises a rotatable deflector for deflecting and spreading out a filament bundle propelled towards the said surface, and a guide plate, the deflector being inclined with respect to its axis of rotation and with respect to the said surface, the guide plate being spaced apart from the deflector but arranged to rotate therewith, and the guide plate also being so curved downwardly (and optionally also rearwardly towards the said axis of rotation), and being so located, that, in operation, at least a proportion of the veil of deflected filaments formed by the deflector is led back downwardly by the guide plate and towards the intersection between the rotation axis and the deposition surface.

7. Apparatus as claimed in claim 6, wherein the deflector is substantially planar.

8. Apparatus as claimed in claim 6 or claim 7, wherein the angle (as hereinbefore defined) between the deflector and its axis of rotation is in the range of from 10° to 80°.

9. Apparatus as claimed in claim 8, wherein the said angle is in the range of from 30° to 70°.

10. Apparatus as claimed in any one of claims 6 to 9, wherein the guide plate is in the form of part of the surface of a cylinder.

11. Apparatus as claimed in claim 10, wherein the guide plate has a filament discharge edge in the form of a helix.

12. Apparatus as claimed in any one of claims 6 to 9, wherein the guide plate is in the form of part of the surface of a sphere.

13. Apparatus as claimed in any one of claims 6 to 12, wherein the guide plate tapers towards its end remote from the deflector.

14. Apparatus as claimed in claim 13, wherein the plate tapers approximately to a point.

15. Apparatus as claimed in any one of claims 6 to 9, wherein the guide plate has a filament discharge edge of stepped form.

16. Apparatus as claimed in any one of claims 6 to 15, wherein the position and/or orientation of the guide plate in relation to the deflector is adjustable.

17. Apparatus as claimed in claim 16, wherein the guide plate is adjustable laterally and/or rotationally with respect to the deflector.

18. Apparatus as claimed in any one of claims 6 to 17, wherein the guide plate is formed on a planar extension which overlaps the deflector and is spaced apart therefrom.

19. Apparatus as claimed in any one of claims 6 to 18, wherein, in operation, the angle of incidence between the filament veil and the surface of the guide plate or the tangent thereto at the point of incidence does not exceed 60°.

20. Apparatus as claimed in claim 6, substantially as hereinbefore described with reference to the accompanying drawings.

21. A non-woven web whenever made by a process as claimed in any one of claims 1 to 5 or with apparatus as claimed in any one of claims 6 to 20.

ABEL & IMRAY,
Chartered Patent Agents,
Northumberland House,
303—306 High Holborn,
London, WC1V 7LH.

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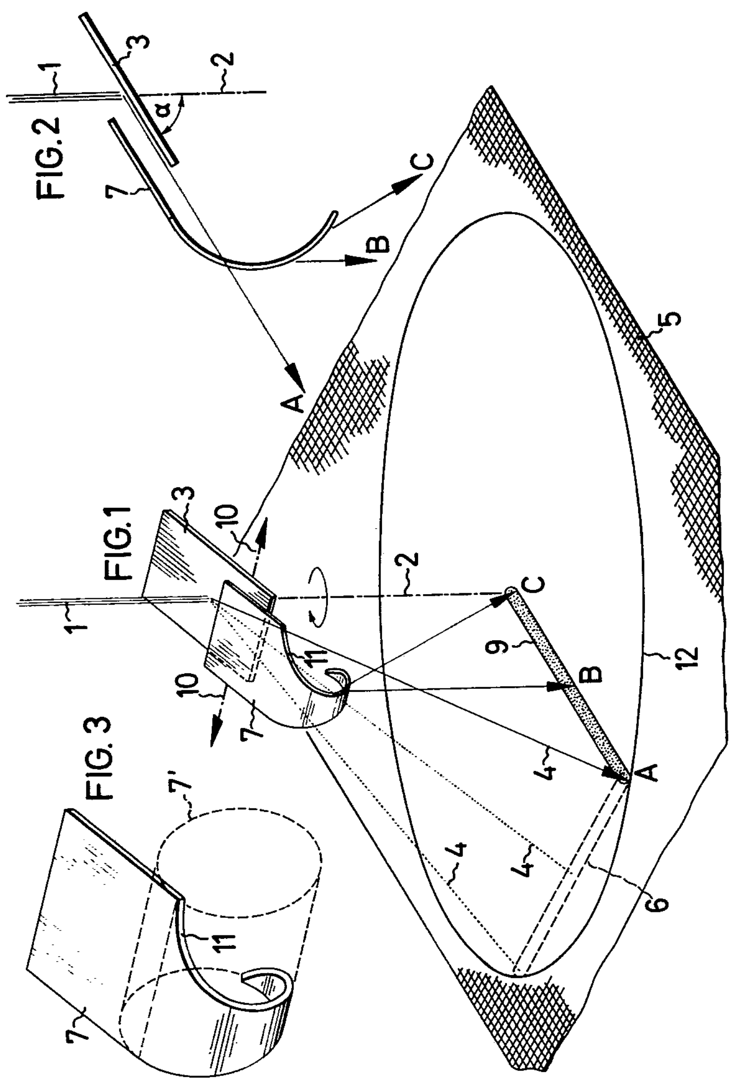
1602012 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1



1602012 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

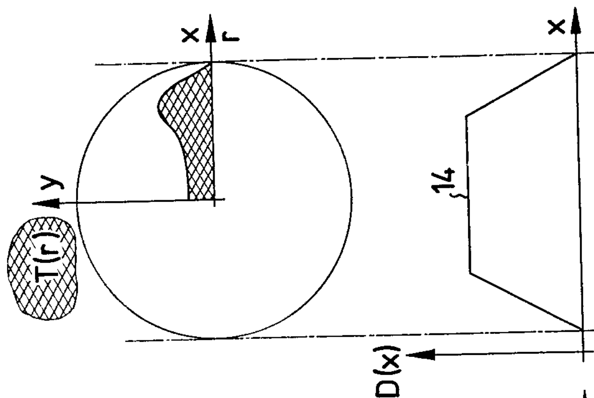


FIG. 4c

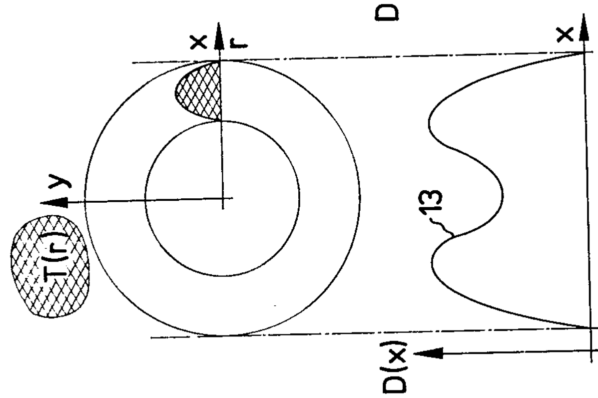


FIG. 4b

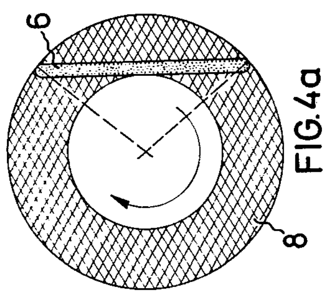


FIG. 4a

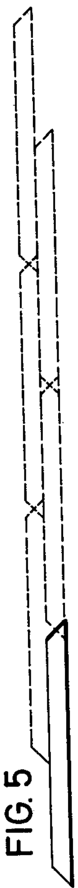


FIG. 5