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(71) Applicant: J & M Laboratories, Inc.
Dawsonville, Georgia 30534-5124 (US)

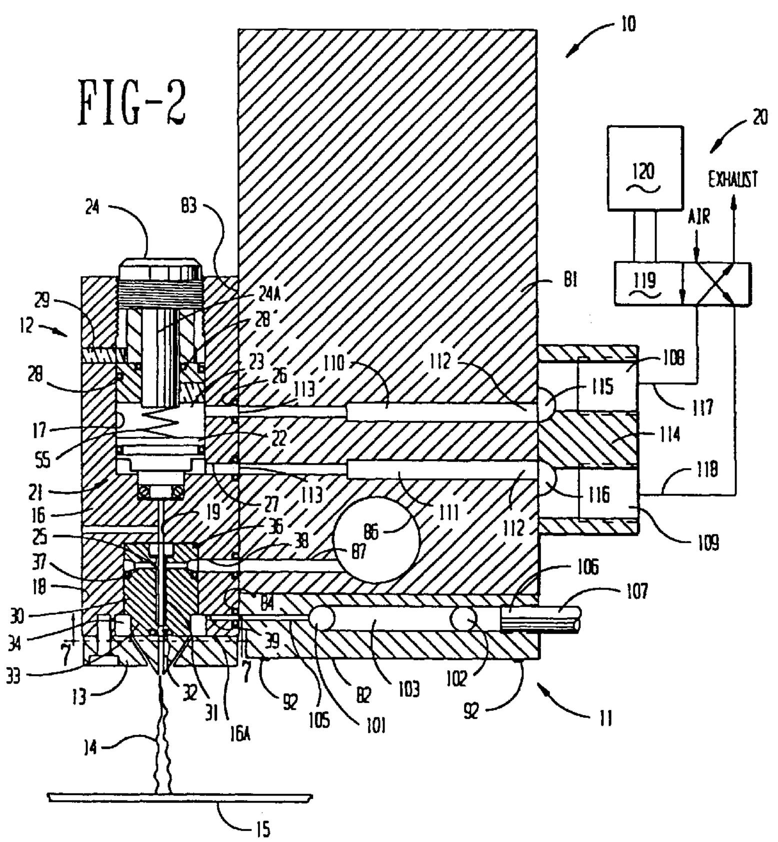
(72) Inventor: Allen, Martin A.
Dawsonville, Georgia 30534 (US)

(74) Representative: Jones, Helen Marjorie Meredith
Gill Jennings & Every,
Broadgate House,
7 Eldon Street
London EC2M 7LH (GB)

(54) **Meltblowing apparatus and process**

(57) A meltblowing die (10) includes a die tip (13) having an outwardly projecting triangular nosepiece (52) defining an apex (56) therealong, orifices spaced along the apex (56), and air holes flanking the apex. The air holes include a center air hole positioned at right angles to the apex, and air holes flanking the center air holes and positioned at an angle with respect to the apex so that fibers discharging from some of the orifices are caused to flare outwardly and increase the width of the pattern deposition.

FIG-2



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Description

BACKGROUND OF THE INVENTION

This invention relates generally to a meltblowing die system. In one aspect the invention relates to a meltblowing die comprising a plurality of self-contained, interchangeable modular units. In another aspect, the invention relates to a meltblowing die for meltblowing polymer onto a substrate or collector wherein the deposition pattern is wider than the effective length of the die. In still another embodiment, the present invention relates to a modular meltblowing die wherein adhesive is deposited uniformly across a substrate.

Meltblowing is a process in which high velocity hot air (normally referred to as "primary air") is used to blow molten fibers extruded from a die onto a collector to form a web, or onto a substrate to form a coating or composite. The process employs a die provided with (a) a plurality of openings (e.g. orifices) formed in the apex of a triangular shaped die tip and (b) flanking air passages. As extruded rows of the polymer melt emerge from the openings, the converging high velocity air from the air passages contacts the filaments and by drag forces stretches and draws them down forming microsized filaments. The microsized filaments are deposited in a random pattern on a collector or substrate.

In some meltblowing dies, the openings are in the form of slots. Generally, however, the die openings are in the form of orifices. In either design, the die tips are adapted to form a row of filaments which upon contact with the converging sheets of air are carried to and deposited on a collector or a substrate in a random manner.

Meltblowing technology was originally developed for producing nonwoven fabrics but recently has been utilized in the meltblowing of adhesives onto substrates. In meltblowing adhesives, the filaments are drawn down to their final diameter of 5 to 50.0 μm, preferably 10 to 20.0 μm, and are deposited at random on a substrate to form an adhesive layer thereon onto which may be laminated another layer such as film or other types of materials or fabrics.

In the meltblowing of polymers to form nonwoven fabrics (e.g. webs), the polymers, such as polyolefin, particularly polypropylene, are extruded as filaments and drawn down to an average fiber diameter of 0.5 to 10 μm and deposited at random on a collector to form a nonwoven fabric. The integrity of the nonwoven fabric is achieved by fiber entanglement with some fiber-to-fiber fusion. The nonwoven fabrics have many uses including oil wipes, surgical gowns, masks, filters, etc.

The filaments extruded from the die may be continuous or discontinuous. For the purpose of the present invention, the term "filament" is used interchangeably with the term "fiber" and refers to both continuous and discontinuous strands.

The meltblowing process grew out of laboratory research by the Naval Research Laboratory which was published in Naval Research Laboratory Report 4364 "Manufacture of Superfine Organic Fibers," Apr. 15, 1954. Exxon Chemical developed a variety of commercial meltblowing dies, processes, and end-use products as evidenced by US-A-3,650,866, US-A-3,707,198, US-A-3,755,527, US-A-3,825379, US-A-3,849,241, US-A-3,947,537 and US-A-3,978,185 by Beloit and Kimberly Clark. Representative meltblowing patents of these two companies include US-A-3,942,723, US-A-4,100,324, and US-A-4,526,733. More recent meltblowing die improvements are disclosed in US-A-4,818,463 and US-A-4,889,476.

US-A-5,145,689 discloses die constructed in side-by-side units with each unit having separate polymer flow systems including internal valves.

SUMMARY OF THE INVENTION

A first aspect of the invention relates to a meltblowing system comprising

(a) a moving substrate or collector;
(b) a meltblowing die having

- (i) a die body; and
- (ii) a die tip mounted on the die body and having (a) a row of fiber forming means formed therein, said row of fiber forming means being adapted to discharge a row of molten thermoplastic fibers therefrom, and deposit the same on the moving substrate or collector in a pattern thereon, and (b) two rows of air passages flanking the fiber forming means, the rows of air passages being positioned to discharge air therefrom to contact opposite sides of the row of fibers and to cause at least some of the fibers to flare outwardly from the center of the row of fiber forming means, whereby the fiber pattern on the substrate or collector has a lateral dimension larger than the length of the row of fiber forming means.

A second aspect of the invention relates to a meltblowing die comprising

(a) a die body; and

(b) a die tip secured to the die body and having

(i) a base and
(ii) an outwardly converging triangular nosepiece defined by first and second surfaces that meet at an apex
(iii) a plurality of fiber forming means formed in the die body having their outlets spaced along the apex
(iv) a first row of air holes formed in the base and positioned to discharge along the first of said surfaces at spaced intervals therealong, and parallel thereto; and
(v) a second row of air holes formed in the base and positioned to discharge along the second of said surfaces at spaced intervals therealone and parallel thereto.

A third aspect of the invention (the modular aspect) modular meltblowing die assembly for the meltblowing system of claim 1 comprising

(a) first and second die modules, each having (i) a die body and (ii) a die tip having a row of fiber forming means for discharging a row of fibers therefrom, the die tip of the first and second modules being positioned in end-to-end relation whereby the fiber forming means of the modules and fibers discharged therefrom form a row, each module having air holes on each side of its row of fiber forming means, said air holes being positioned and shaped to cause air discharging therefrom to contact fibers discharged from the fiber forming means and cause at least some of the fibers of each module to flare outwardly along the length of its fiber forming means.

The meltblowing die of the present invention may be modular in structure, comprising a plurality of self-contained meltblowing modules. The modules are mounted in side-by-side relationship on a manifold so that the length of the die can be varied by merely adding modules to, or removing modules from, the structure. In a preferred embodiment, the modules are interchangeable and each includes an internal valve for controlling polymer flow therethrough.

The modular meltblowing die comprises a manifold and plurality of modules mounted on the manifold. The manifold has formed therein polymer flow passages for delivering a hot melt adhesive polymer to each module and hot air flow passages for delivering hot air to each module.

Each module includes a body, a die tip, and polymer and air flow passages for conducting hot melt adhesive and hot air from the manifold through each module.

The die tip of each module comprises (a) a triangular nosepiece terminating in an apex and polymer discharge means (i.e. fiber forming means) at the apex for discharging a row of closely spaced fibers, and (b) two rows of air passages flanking the row of fiber forming means. The fiber forming means may be in the form of an elongate slot or slots but preferably is in the form of a row of orifices. In either design a row of fibers are discharged from the die.

Hot air which flows through the manifold and each module is discharged as two rows of converging hot air streams at or near the apex. The polymer melt (such as hot melt adhesive) flows through the manifold and each module and discharges as a plurality of fibers into the converging air streams. The air streams contact and draw down the fibers depositing them as random fibers onto a collector or a substrate.

The air passages flanking the row orifices are shaped and positioned in relation thereto so that the discharging air streams contact opposite sides of the row of fibers and preferably causes, at least some of the filaments, to flare out longitudinally in relation to the row of orifices. The pattern of fiber deposition on the substrate thus has a lateral dimension larger than the length of the row of orifices.

In a preferred embodiment, the air passages are in the form of air holes drilled in the die. The flanking air passages thus comprise two rows of converging air holes which lie in converging planes which intersect at or near the nosepiece apex. The converging planes define an included angle of between above 60° - 90°. The air hole design eliminates the need for air plates commonly used in meltblowing dies and thus represents a significant improvement over conventional meltblowing die designs.

A particularly advantageous feature of the modular die construction of the present invention is that it offers a highly versatile meltblowing die. The die tip is the most expensive component of the die, requiring extremely accurate machining (a tolerance of 0.0005 to 0.001 inches (12.5 to 25 μm) on die tip dimensions is typical). The cost of long dies is extremely expensive (on the order of US$1,300/inch). By employing the modules, which are relatively inexpensive (US$300/inch), the length of the die can economically be extended to lengths of 200 or more inches (5 m or more). The air hole design permits controlled deposition of the fibers along the die length.

Another advantageous feature of the modular die construction is that it permits the repair or replacement of only the damaged or plugged portions of a die tip. With continuous die tips of prior art constructions, even those disclosed in US-A-5,145,689, damage to or plugging of the die tip requires the complete replacement, or at least removal, of the die tip. With the present invention, only the damaged or plugged module needs replacement or removal which can be done quickly which results in reduced equipment and service costs. Another advantage of the preferred die constructed according to the present invention is as noted above, expensive and troublesome (e.g. plugging) air plates are not needed.

A still further advantage of the invention is the ability of the die to deposit the adhesive uniformly across on the substrate a plurality of modules. The outwardly flaring of the filaments permits the adhesive to deposit on the substrate in a lateral spacing, greater than the length of the row of orifices. With modular die tips, thus permits the orifice spacing on the die tip to be smaller than the spacing of prior art modular designs and still retain uniform properties across the length of the die. Also, the orifices at each end of the row of orifices receive more process air than those of the prior art designs.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front elevation view of the meltblowing modular die constructed according to the present invention.

Figure 2 is an enlarged sectional view of the die shown in Figure 1 with the cutting plane taken along line 2-2 of Figure 1.

Figure 3 is an enlarged view of the die tip shown in Figure 2.

Figure 4 is an enlarged front elevation view of two modules of the die shown in Figure 1, illustrating the fiber discharge from adjacent modules.

Figure 5 is a cross sectional view of the die tip shown in Figure 3 with the cutting plane taken along line 5-5 thereof.

Figure 6 is a bottom elevation view of the die tip shown in Figure 3, shown from the perspective of the plane indicated by line 6-6 thereof.

Figure 7 is a bottom view of the die body shown in Figure 2 with the cutting plane along line 7-7 thereof.

Figure 8 is enlarged sectional view of the die tip shown in Figure 3, with the cutting plane taken along line 8-8 thereof.

Figure 9 is an enlarged, fragmentary view of Figure 8 illustrating the angle β of the air holes in relation to the apex.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to Figures 1 and 2, a modular meltblowing die assembly 10 of the present invention comprises a manifold 11, a plurality of side-by-side self contained die modules 12, and a valve actuator assembly (including actuator 20) for controlling the polymer flow through each module. Each module 12 includes a die body 16 and a die tip 13 for discharging a plurality of fibers 14 onto a substrate 15 (or collector). The manifold 11 distributes a polymer melt and hot air to each of the modules 12. Each of these components is described in detail below.

Die Modules:

As best seen in Figure 2, die body 16 has formed therein an upper circular recess 17 and a low circular recess 18 which are interconnected by a narrow opening 19. The upper recess 17 defines a cylindrical chamber 23 which is closed at its top by threaded plug 24. A valve assembly 21 mounted within chamber 23 comprises piston 22 having depending therefrom stem 25. The piston 22 is reciprocally movable within chamber 23, with adjustment pin 24A limiting the upward movement. Conventional o-rings 28 may be used at the interface of the various surfaces for fluid seals as illustrated. Threaded set screws 29 may be used to anchor cap 24 and pin 24A at the proper location within recess 17.

Side ports 26 and 27 are formed in the wall of the die body 16 to provide communication to chamber 23 above and below piston 22, respectively. As described in more detail below, the ports 26 and 27 serve to conduct air (referred to as instrument gas) to and from each side of piston 22.

Referring to Figures 2 and 7, lower recess 18 is formed in a downwardly facing surface 16A of body 16. This surface serves as the mounting surface for attaching the die tip 13 to the die body 16. Mounted in the lower recess 18 is a threaded valve insert 30 having a central opening 31 extending axially therethrough and terminating in valve port 32 at its lower extremity. A lower portion 33 of insert member 30 is of reduced diameter and in combination with die body inner wall 35 define a downwardly facing cavity 34 best seen in Figure 7. Threaded bolt holes 50A formed in the mounting surface 16A of the die body receive bolts 50. As described later, bolts 50 maintain the die tip 13 secured to the die body 16. Upper portion 36 of insert member 30 abuts the top surface of recess 18 and has a plurality (e.g. 4) of circumferential ports 37 formed therein and in fluid communication with the central passage 31. An annular recess extends around the upper portion 36 interconnecting the ports 37.

Valve stem 25 extends through body opening 19 and axial opening 31 of insert member 30, and is adapted to seat on valve port 32 (as illustrated in Figure 2). The annular space between stem 25 and opening 31 is sufficient for polymer melt to flow therethrough. The lower end of stem 25 seats on port 32 with piston 22 in its lower position within chamber 23 as illustrated in Figure 2. As discussed below, actuation of the valve moves stem end 25 away from port 32 (open position), permitting the flow of polymer melt therethrough, through port 37, through annular space, discharging through port 32 into the die tip 13. Conventional o-rings may be used at the interface of the various surfaces as illustrated in the drawings.

As shown in Figure 3, the die tip 13 comprises a base member 46 which is generally coextensive with the mounting of surface 16A of die body 16, and a triangular nosepiece 52 which may be integrally formed with the base 46. The nosepiece 52 is defined by converging surfaces 53 and 54 which meet at apex 56. The apex 56 may be discontinuous, but preferably is continuous along the die 10. The height of the nosepiece 52 may vary from 100% to 25% of the overall height of the die tip 13, but preferably is more than 50% and most preferably between 20% and 40%.

The portions of the base 46 extending outwardly from the nosepiece 52 serve as flanges for mounting the die tip 13 to the assembly and provide means for conducting air through the base. As best seen in Figure 6, the flanges of the base 46 have two rows of air holes 57 and 58, and mounting holes 51 which register with the mounting holes 50 of the body 16.

The rows of air holes 57 and 58 formed in the die tip base 46 define converging planes. The plane defined by air holes 57 extends at the same angle as nosepiece surface 53, and the plane defined by air holes 58 extend at the same angle as nosepiece surface 54 (see Figure 3). The included angles (α) of the planes and surfaces 52 and 53 ranges from 30° to 90°, preferably from 60° to 90°. (It is to be understood that reference to holes lying in a plane means the axes of the holes lie in the plane).

While each row of air holes 57 and 58 lie in their respective planes, at least some of the air holes 57 or 58 within their respective planes are not parallel. As best seen in Figures 8 and 9, the die tip 13 is provided with an odd number (e.g. 17) of air holes 57, each having an inlet 59 and an outlet 60. (Note the row of air holes 58, on the opposite side of the nosepiece 52 is preferably the mirror image of the row of orifices 57, although they need not be. For example the air holes 58 may be offset from air holes 52).

The die tip 13 further includes surface 47 which is mounted on surface 16A of the die body 16, closing cavity 34. Surface 47 also seats on the downwardly facing surface of insert member 30, with o-right providing a fluid seal at the junction of these two surfaces.

With the die tip 13 mounted on the die body 16 (see Figure 2), the inlets 59 of all of the air holes 57 and 58 register with cavity 34 as shown in Figure 2.

The central air holes (in this embodiment air hole 57A) extends perpendicular to the apex 56 as shown in Figure 8. One or more air holes 57 located at the longitudinal center of the die tip 13 may extend parallel to air hole 57A. In designs with an even number of air holes 57, at least two of the center air holes 57A are preferably provided.

The air holes 57 flanking the center air hole 57A form an angle β (see Figure 9) with the apex 56 which decreases progressively (arithmetic) and symmetrically from the center hold 57A outwardly. The outermost holes are shown as 57B on Figures 8 and 9. The air holes 57B form an angle with the apex 56 that decreases in constant increments outwardly. For example center air hole 57A forms an angle of 90° with the apex 56. If the angle increment is -1°, then the two air holes 57 adjacent air hole 57A forms an angle of 89° with the apex 56. Continuing the incremental arithmetic progression to the eighth (outermost) air holes 57B, the angle of these air holes would be 82°. Of course, the incremental angle may vary, but preferably is between 1/2 and 4°, most preferably between 1° and 3.5°. The arithmetic progression may be represented by the following equation:

Angle $\beta = 90° - ni$

Where n is the hole position or each side of the center air hole and preferably ranges from 4 to 15, most preferably 5 to 10 and i is the constant incremental degree change.

For descriptive purposes, center air holes 58 are referred to as 58A and flanking air holes 58 are referred to as 58B.

Polymer passages 65 are formed in the die tip 13, as shown in Figures 3 and 5. The passages may be in the form of a distribution system comprising a plurality of passages 65 connected to inlet 67 by passage 68. Inlet 67 registers with die body port 32 with die tip 13 mounted on die body 16.

The passages 65 have outlets at 69 which are uniformly spaced along the apex 56. Passages 65 preferably extend perpendicular to apex 56. The design illustrated in Figure 5 serves well for small modules (i.e. lengths less than about 3" to 4" (75 to 100 mm)). For longer dies, a pressure balance coathanger design may be preferred. The passages 65 are preferably small diameter orifices and serve as the fiber forming means. In an alternate embodiment, the fiber forming means may be in the form of a slot as described in US-A-5,618,566.

The Manifold

As best seen in Figure 2, the manifold 11 is constructed in two parts: an upper body 81 and a lower body 82 bolted to the upper body by spaced bolts 92. The upper body 81 and lower body 82 have mounting surfaces 83 and 84, respectively, which lie in the same plane for receiving modules 12.

The upper manifold body 81 has formed therein polymer header passages 86 extending longitudinally along the interior of body 81 and side feed passages 87 spaced along the header passage 86 for delivering polymer to each module 12. The polymer feed passages 87 have outlets which register with passage 38 of its associated module 12.

The polymer header passage 86 has a side inlet at the end of the body 81 and terminates at near the opposite end of the body 81. A connector block 94 (see Figure 1) bolted to the side of body 81 has a passage for directing polymer from feed line to the header channel 86. The connector block 94 may include a polymer filter. A polymer melt delivered to the die 10 flows from a source such as an extruder of metering pump through inlet passages to passage 86 and in parallel through the said feed passages 87 to the individual modules 12.

Valve and Instruments

Returning to Figure 2, air is delivered to the modules through the lower block 82 of the manifold 11. The air passages in the lower block 82 are in the form of a network of passages comprising a pair of passages 101 and 102, interconnecting side ports 103, and module air feed ports 105 longitudinally spaced along bore 101. Air inlet passage 106 connects to air feed line 107 near the longitudinal center of block 82. Air feed ports 105 register with air passage 39 of its associated module.

Heated air enters body 82 through line 107 and inlet 106. The air flows through passage 102, through side passages 103 into passage 101, and in parallel through module air feed ports 105 and module passages 39. The network design of manifold 82 serves to balance the air flow laterally over the length of the die 10.

The instrument air for activating valve 21 is delivered to the chamber 23 of each module 12 by air passages formed in the block 81 of manifold 11. As best seen in Figure 2, instrument air passages 110 and 111 extend through the width of body 81 and each has an inlet 112 and an outlet 113. Outlet 113 of passage 110 registers with port 26 formed in module 12 which leads to chamber 23 above piston 22; and outlet 113 of passage 111 registers with port 27 of module 12 which leads to chamber 23 below piston 22.

An instrument air block 114 is bolted to block 81 and traverses the full length of the instrument air passages 110 and 111 spaced along body 81 (see Figure 1). The instrument air block 114 has formed therein two longitudinal channels 115 and 116. With the block 114 bolted to body 81, channels 115 and 116 communicate with the instrument air passages 110 and 111, respectively. Instrument tubing 117 and 118 delivers instrument air from control valve 119 to flow ports 108 and 109 and passages 110 and 111 in parallel.

For clarity, actuator 20 and tubing 117 and 118 are shown schematically in Figure 2. Actuator 20 comprises three-way solenoidal air valve 119 coupled with electronic controls 120.

The valve 21 of each module 12 is normally closed with the chamber 23 above piston 22 being pressurized and chamber 23 below piston 22 being vented through valve control 119. Spring 55 also acts to maintain the closed position. To open the valves 21 of the modules 12, the 3-way control valve 119 is actuated by controls 120 sending instrument gas through tubing 118, channel 116, through passage 111, port 27 to pressurize chamber 23 below piston 22 and while venting chamber 23 above piston 22 through port 26, passage 110, channel 115 and tubing 117. The excess pressure below piston 22 moves the piston and stem 25 upwardly opening port 32 to permit the flow of polymer to the die tip 13.

In the preferred embodiment all of the valves are activated simultaneously using a single valve actuator 20 so that polymer flows through all the modules 12 in parallel, or there is no flow at all through the die. In other embodiments, individual modules or groups of modules may be activated using multiple actuators 20 spaced along the die.

More details of the valve 21, manifold 11, and instruments are presented in US-A-5,618,566, the disclosure of which is incorporated herein by reference.

Assembly and Operation

A particularly advantageous feature of the present invention is that it permits the construction of a meltblowing die with a wide range of possible lengths using standard sized manifolds and interchangeable, self-contained modules and achieve uniform fiber deposition along the length of the modular die. Variable die length may be important for coating substrates of different sizes from one application to another. The following sizes and numbers are illustrative of the versatility of modular construction.

Die Assembly	Broad Range	Preferred Range	Best Mode
Number of Modules	3-6,000	5-100	10-50
Length of Modules (inches) (mm)	0.25-3.00 6.3-75	0.5-1.50 13-38	0.5-0.8 13-20

(continued)

Die Assembly	Broad Range	Preferred Range	Best Mode
Orifice Diameter (inches) (mm)	0.005-0.05 0.13-1.3	0.01-0.04 0.25-1.0	0.015-0.03 0.38-0.76
Orifices (for each module)/Inch /mm	5-50 0.2-2	10-40 0.4-1.6	10-20 0.4-0.8
No air holes (57) /inch /mm	15-50 0.6-2	20-40 0.8-1.6	25-35 1-1.4
No air holes (58) /inch /mm	15-50 0.6-2	20-40 0.8-1.6	25-35 1-1.4
Air hole Diameter (inches) (mm)	0.05-0.050 0.13-1.3	0.010-0.04 0.25-1.0	0.15-0.03 0.38-0.76
No. Air hole/ No.Orifices	1-10	3-8	4-6

Depending on the desired length of the die, standard sized manifolds may be used. For example, a die length of one meter could employ 54 modules mounted on a manifold 1 m long. For a 20 inch (0.5 m) die length 27 modules would be mounted on a 20 inch (0.5 m) manifold.

For increased versatility in the present design, the number of modules mounted on a standard manifold (e.g. one meter long) may be less than the number of module mounting places on the manifold. For example, Figure 1 illustrates a die having a total capacity of 16 modules. If, however, the application calls for only 14 modules, two end stations may be sealed using plates 99A and 99B disposed sealingly over the stations and secured to the die manifold using bolts. Each plate will be provided with a gasket or other means for sealing the air passages 105, polymer passage 87, and instrument air passages 110 and 111.

The plates 99A or 99B may also be useful in the event a module requires cleaning or repair. In this case the station may be sealed and the die continue to operate while the module is being worked on.

The die assembly may also include electric heaters (not shown) and thermocouple (not shown) for heat control and other instruments. In addition, air supply line 107 may be equipped with an in-line electric or gas heater.

As indicated above, the modular die assembly can be tailored to meet the needs of a particular operation. In Figure 1, 14 modules, each 0.74 inches (19 mm) in width, are mounted on a 13" (0.33 m) long manifold. For illustrative purposes two end stations have been rendered inoperative using sealing plates 99A and 99B as has been described. The lines, instruments, and controls are connected and operation commenced. A hot melt adhesive is delivered to the die through line 97, hot air is delivered to the die through line 107, and instrument air or gas is delivered through lines 117 and 118.

Actuation of the control valves opens port 32 as described previously, causing polymer melt to flow though each module. The melt flows in parallel through manifold passages 87, through side ports 38, through passages 27, annular space, and through port 32 into the die tip via passage 67. The polymer melt is distributed laterally in passages 65 and 68 discharges through orifice 69 as side-by-side fibers 14. The air meanwhile flows from manifold passage 105 into port 39 through chamber 34, holes 57 and 58 discharging at air hole outlets 60. The converging air streams of air contact the fibers 14 discharging from the orifices 69 and by drag forces stretch them and deposit them onto an underlying substrate 15 in random pattern. This forms a generally uniform layer of meltblown material on the substrate 15. The center air holes 57A and 58A are perpendicular to the apex so the air streams therefrom carry the fibers 14 directly to the substrate with no or little lateral flaring. However, the air streams discharging from the flanking air holes 57B and 58B converge upon the fibers 14 therebetween at an angle β (see Figure 9). The angle β causes the fibers 14 to flare outwardly from the center of the die tip. The flaring is gradual from center to the outermost holes 57B depending on the value of angle β. As shown in Figure 4, the outermost fibers 14 of each module 16 exhibit the greatest degree of flaring, with the inner fibers gradually showing an increase in the degree of flaring from center to opposite ends. Preferably the die is constructed so the fibers 14 deposited by one module is uniformly spaced with the fibers 14 deposited by its adjacent module or modules, with no, or very little overlapping.

Typical operational parameters are as follows:

Polymer	Hot melt adhesive
Temperature of the Die and Polymer	270°F to 325°F (132-163°C), preferably at least 280°F (138°C)
Temperature of Air	280°F to 325°F (138-163°C)
Polymer Flow Rate	0.1 to 10 gms/hole/min.
Hot Air Flow Rate	0.1 to 2 SCFM/inch
Deposition	0.05 to 500 g/m2

As indicated above, the die assembly 10 may be used in meltblowing adhesives, spray coating resins, and web forming resins. The adhesives include EVA's (e.g. 20-40 wt% VA). These polymers generally have lower viscosities than those used in meltblown webs. Conventional hot melt adhesives useable include those disclosed in US-A-4,497,941, US-A-4,325,853, and US-A-4,315,842, the disclosures of which are incorporated herein by reference. The above melt adhesives are by way of illustration only; other melt adhesives may also be used.

The typical meltblowing web forming resins include a wide range of polyolefins such as propylene and ethylene homopolymers and copolymers. Specific thermoplastics include ethylene acrylic copolymers, nylon, polyamides, polyesters, polystyrene, poly(methyl methacrylate), polytrifluoro-chloroethylene, polyurethanes, polycarbonates, silicon sulfide, and poly(ethylene terephthalate), pitch and blends of the above. The preferred resin is polypropylene. The above list is not intended to be limiting, as new and improved meltblowing thermoplastic resins continue to be developed.

Polymers used in coating may be the same used in meltblowing webs but at somewhat lower viscosities. Meltblowing resins for a particular application can readily be selected by those skilled in the art.

In meltblowing resins to form webs and composites, the die assemble 10 is connected to a conventional extruder or polymer melt delivery system such as that disclosed in US-A-5,061,170, the disclosure of which is incorporated herein by reference.

Example

Two identical side-by-side modules were constructed having the following dimensions:

Die Tip Width	0.740 inches (18.3 mm)
Polymer Orifices	
Number	6
Diameter	0.02 inches (0.51 mm)
Center-to-Center	1.04 inches (26.4 mm)
Apex Length Between Orifices	0.100 inches (2.54 mm)
Air Holes	
Diameter	0.02 inches (0.51 mm)
Number Per Side	17
Angle: (α)	60°
Incremental Angle	1°
Spacing	27 per inch (1.1 per mm)
Nosepiece	
Apex Height From Base	0.088 inches (2.23 mm)

The two-module die was operated at the following conditions:

Polymer	Hot Melt Adhesive
Polymer Melt Temp.	270°F (132°C)

(continued)

Polymer	Hot Melt Adhesive
Air Temp.	280°F (138°C)
Polymer Flow Rate	1.66 g/hole/min.
Air Flow Rate	0.55 SCFM

The adhesive filaments were deposited on a substrate in a generally uniform sinusoidal wave pattern with very little overlapping. The width (TD) of the adhesive pattern produced by the side-by-side module was approximately 1.5 inches (38 mm) even through the total length of the row of orifices of the side-by-side modules was only 1.248 inches (31.70 mm). The pattern was uniform even across the space between the two modules. The lateral deposition of the adhesive from each module was 0.750 inches (19 mm) from a row of orifices 0.52 inches (13 mm) long.

Claims

1. A meltblowing system comprising

(a) a moving substrate or collector;
(b) a meltblowing die (10) having

(i) a die body (16); and
(ii) a die tip (13) mounted on the die body and having (a) a row of fiber forming means (65) formed therein, said row of fiber forming means being adapted to discharge a row of molten thermoplastic fibers (14) therefrom, and deposit the same on the moving substrate or collector (15) in a pattern thereon, and (b) two rows of air passages (57,58) flanking the fiber forming means, the rows of air passages being positioned to discharge air therefrom to contact opposite sides of the row of fibers and to cause at least some of the fibers to flare outwardly from the center of the row of fiber forming means, whereby the fiber pattern on the substrate or collector has a lateral dimension larger than the length of the row of fiber forming means.

2. The meltblowing system of claim 1 wherein the fibers are deposited on the substrate or collector in a random pattern which has a lateral dimension at least 10% larger than the length of the row of fiber forming means

3. The system of claim 1 or claim 2 wherein each of the rows of air passages comprise's a row of equally spaced air holes (57,58).

4. The meltblowing system of claim 3 wherein the fiber forming means are orifices (65) equally spaced in a row along the die tip which are disposed parallel to one another and are disposed in the same plane.

5. The meltblowing system of claim 4 wherein the row of orifices has a length in the range 0.25 to 3.00 inches (6.3 to 76 mm) and are equally spaced at a spacing between 5 to 50 orifices per inch (0.2 to 2 per mm).

6. The meltblowing system of claim 4 or claim 5 wherein

(a) the air holes (57) of one of the two rows of air holes lie in the same plane which forms an angle of 15° to 45° with the plane of the orifices, and
(b) the air holes (58) of the other of the two rows of air holes lie in the same plane and form an angle of 15° to 45° with the plane of the orifices, said air hole planes intersecting at the orifice outlets at an angle α between 30° and 90° whereby air discharging from the air holes convergingly contacts the fibers discharging from the orifices.

7. The meltblowing system of claim 6 wherein the ratio of the number of air holes per the number of orifices ranges from 3 to 8.

8. The meltblowing system of claim 6 or claim 7 wherein each row of air holes has at least one center air hole (57A) which lies in a plane perpendicular to and midway along the row of fiber forming means.

9. The meltblowing system of claim 8 wherein each row of the air holes (57B) positioned outwardly from the center air hole forms an angle β with the row of fiber forming means represented by the following equation

$\beta = 90° -ni$
where
n is the air hole position on each side of the center air hole, or holes (which is preferably in the range 4 to 15) and
i is the incremental angle and ranges from 0.5° and 4° and is preferably constant.

10. A meltblowing die (10) comprising

(a) a die body; and
(b) a die tip (13) secured to the die body and having

(i) a base (46) and
(ii) an outwardly converging triangular nosepiece (52) defined by first and second surfaces (53,54) that meet at an apex (56)
(iii) a plurality of fiber forming means (65) formed in the die body having their outlets (69) spaced along the apex
(iv) a first row of air holes (57) formed in the base and positioned to discharge along the first (53) of said surfaces at spaced intervals therealong, and parallel thereto; and
(v) a second row of air holes (58) formed in the base and positioned to discharge along the second (54) of said surfaces at spaced intervals therealone and parallel thereto.

11. The meltblowing die of claim 10 wherein the first and second row of air holes each have at least one center air hole (57A) positioned perpendicular to the apex, and flanking air holes (58B), each flanking air hole forms an angle β with respect to the apex based on the following equation:

$\beta = 90°-ni$
where
β is the angle,
n is the air hole position from the center air hole (and is preferably in the range 4 to 15), and
i is the constant angle increment which range from 0.5° to 4°, preferably 1° to 3.5°.

12. The meltblowing die of claim 11 wherein the fiber forming means are orifices spaced along the apex at a spacing of 10 to 20 per inch (0.4 - 0.8 per mm).

13. The meltblowing die of any of claims 10 to 12 wherein

(a) the air holes of the first row of air holes lie in the same plane which extends parallel to the first surface of the nosepiece and has a center air hole which extends perpendicular to the apex and the air holes on either side of the center air hole form an outwardly extending angle with respect to the apex, said angle differing from its inner adjacent air hole by a constant which ranges from -1/2° to -4°, and
(b) the air holes of the second row of air holes lie in the same plane which extends parallel to the second surface of the nosepiece and has a center air hole which extends perpendicular to the apex, and the air holes on either side of the center air hole form an outwardly extending angle with respect to the apex, said angle differing from its inner adjacent air hole by a constant which ranges from -1/2° to -4°.

14. A modular meltblowing die assembly (10) for the meltblowing system of claim 1 comprising

(a) first and second die modules (12), each having (i) a die body (16) and (ii) a die tip (13) having a row of fiber forming means (65) for discharging a row of fibers (14) therefrom, the die tip of the first and second modules being positioned in end-to-end relation whereby the fiber forming means of the modules and fibers discharged therefrom form a row, each module having air holes (57,58) on each side of its row of fiber forming means, said air holes being positioned and shaped to cause air discharging therefrom to contact fibers discharged from the fiber forming means and cause at least some of the fibers of each module to flare outwardly along the length of its fiber forming means.

15. A process in which molten thermoplastic material is meltblown using the system of any of claims 1 to 9, whereby fibres are collected on the moving belt.

16. A process according to claim 1 in which the die and the molten polymer are maintained at a temperature in the range 132 to 162°C and the air is at a temperature in the range 138 to 162°C.

17. A process according to claim 15 or claim 16 in which the polymer is selected from ethylene acrylic copolymers, nylon, polyamides, polyesters, polystyrene, poly(methyl methacrylate), polytrifluoro-chloroethylene, polyurethanes, polycarbonates, silicon sulfide, and poly(ethylene terephthalate), pitch and blends thereof.

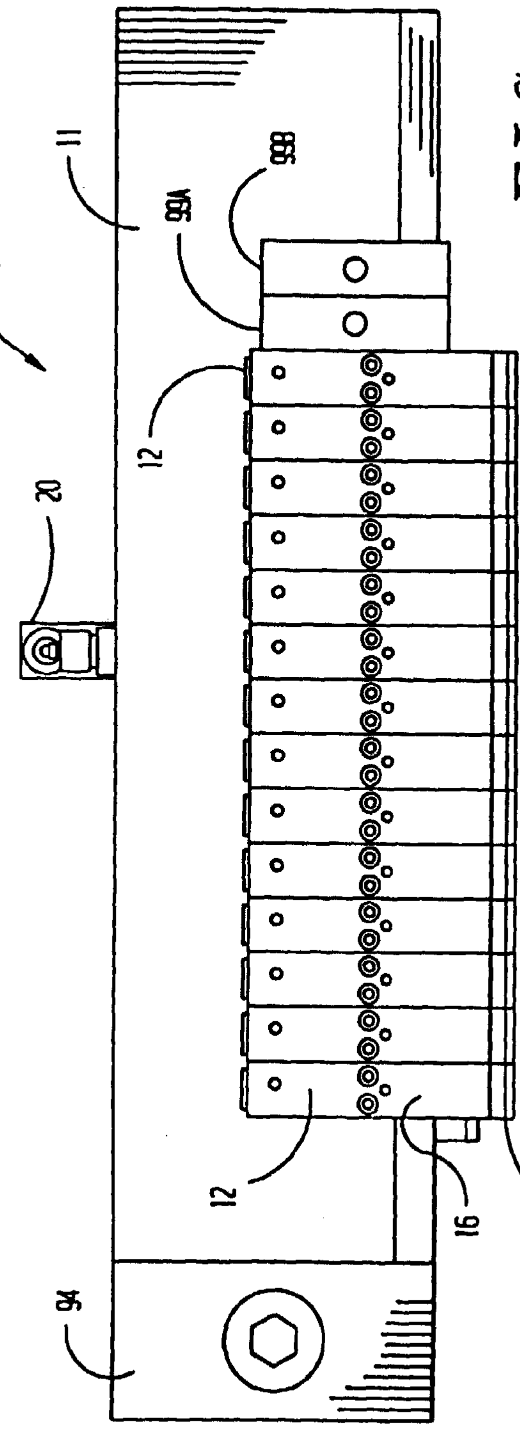


FIG-1

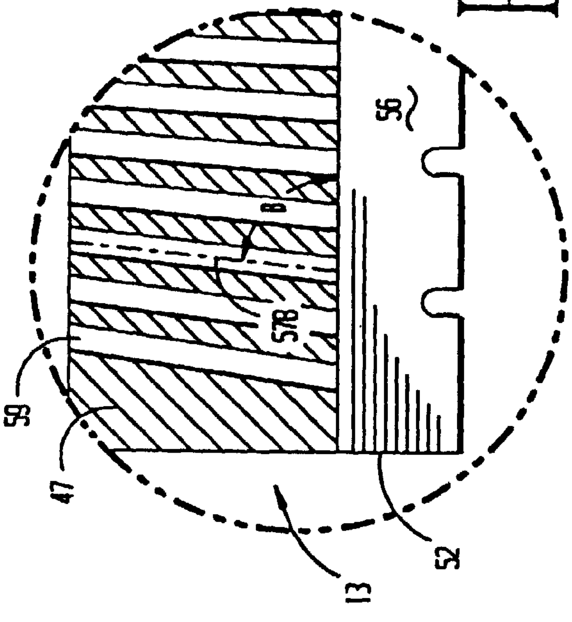
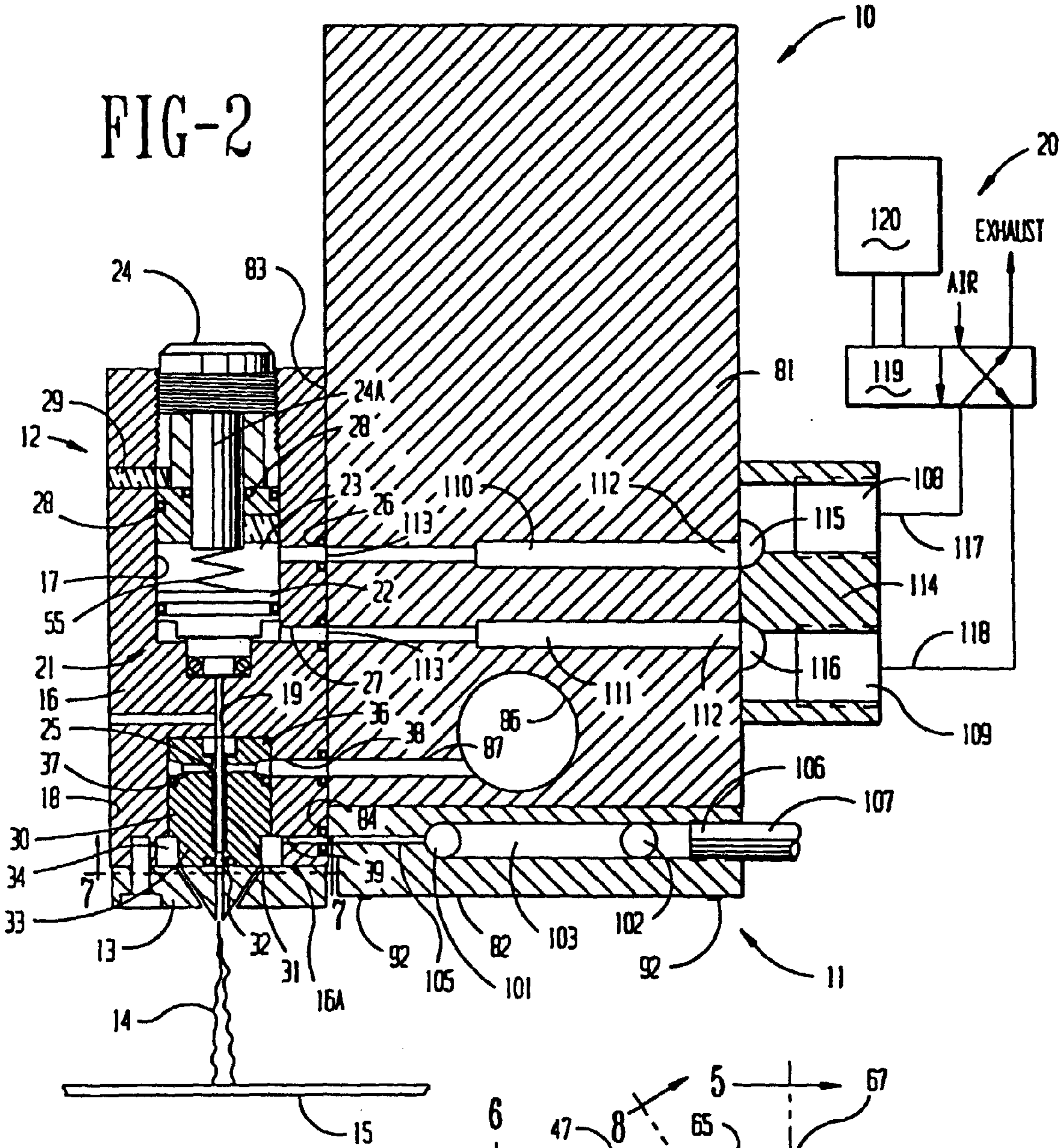


FIG-9

FIG-2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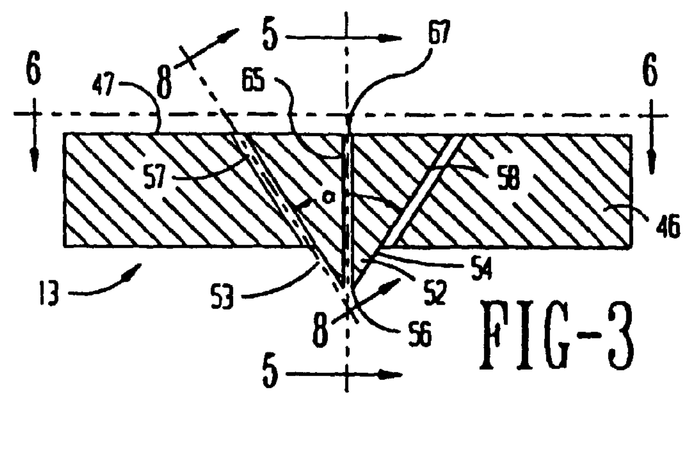
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FIG-3

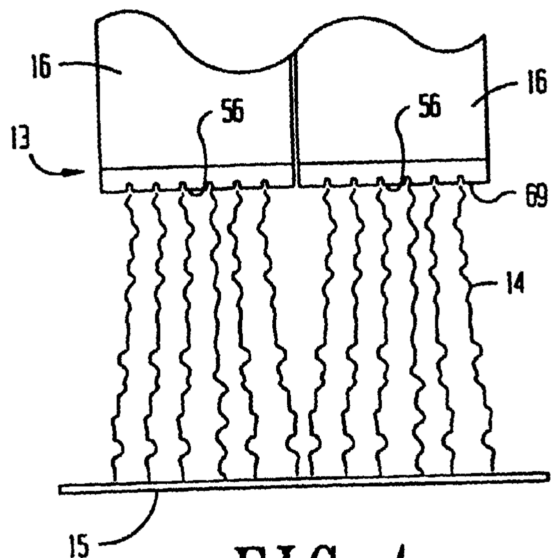

FIG-4

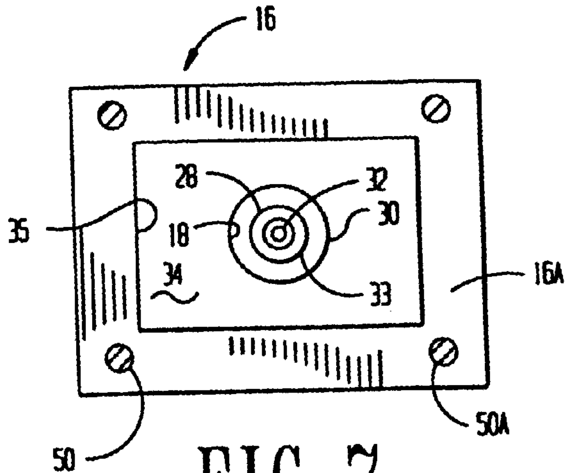

FIG-7

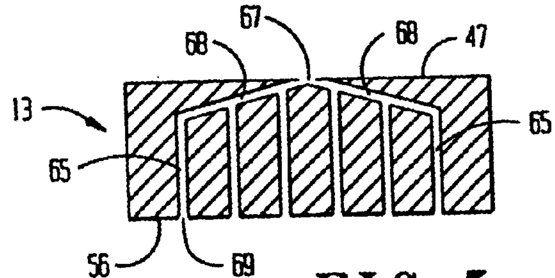

FIG-5

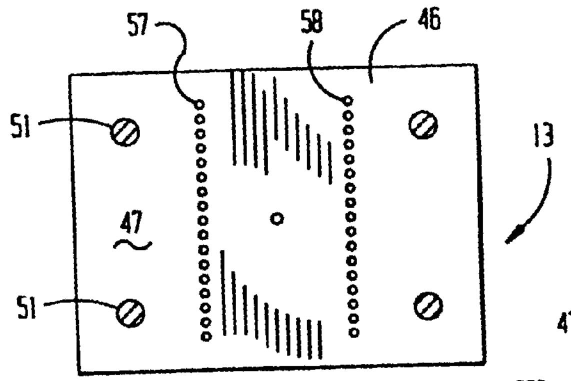

FIG-6

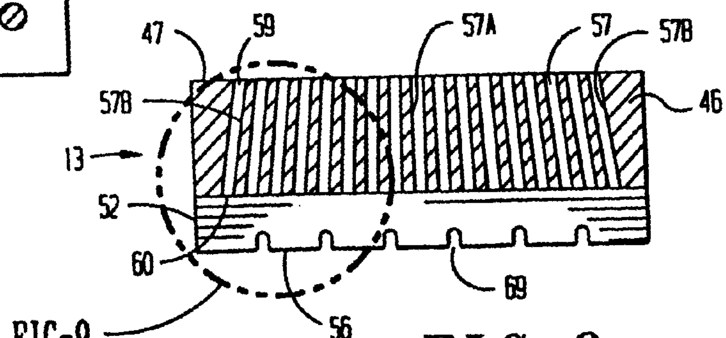

FIG-8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 2075

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 4 969 602 A (SCHOLL CHARLES H) 13 November 1990 * abstract * * column 5, line 19 - line 23 * * column 10, line 55 - line 57; figures 1-3 *	1,3,10, 14,15	D01D4/02
A	US 5 478 224 A (MCGUFFEY GRANT) 26 December 1995 * abstract * * column 2, line 3 - line 6; figures 2,4 *	1,3,14, 15	
D,A	WO 96 34132 A (EXXON CHEMICAL PATENTS INC) 31 October 1996 * abstract; figures 1,4 *	1-17	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
D01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	9 July 1998	Westermayer, W

CATEGORY OF CITED DOCUMENTS

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