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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
**F26B 19/00, A46D 1/00, B32B 31/08**

A1

(11) International Publication Number: **WO 97/06393**

(43) International Publication Date: 20 February 1997 (20.02.97)

(21) International Application Number: PCT/US96/12864

(22) International Filing Date: 8 August 1996 (08.08.96)

(30) Priority Data:
60/002,091 10 August 1995 (10.08.95) US

(60) Parent Application or Grant
(63) Related by Continuation
US 60/002,091 (CON)
Filed on 10 August 1995 (10.08.95)

(71) Applicant *(for all designated States except US)*: E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US).

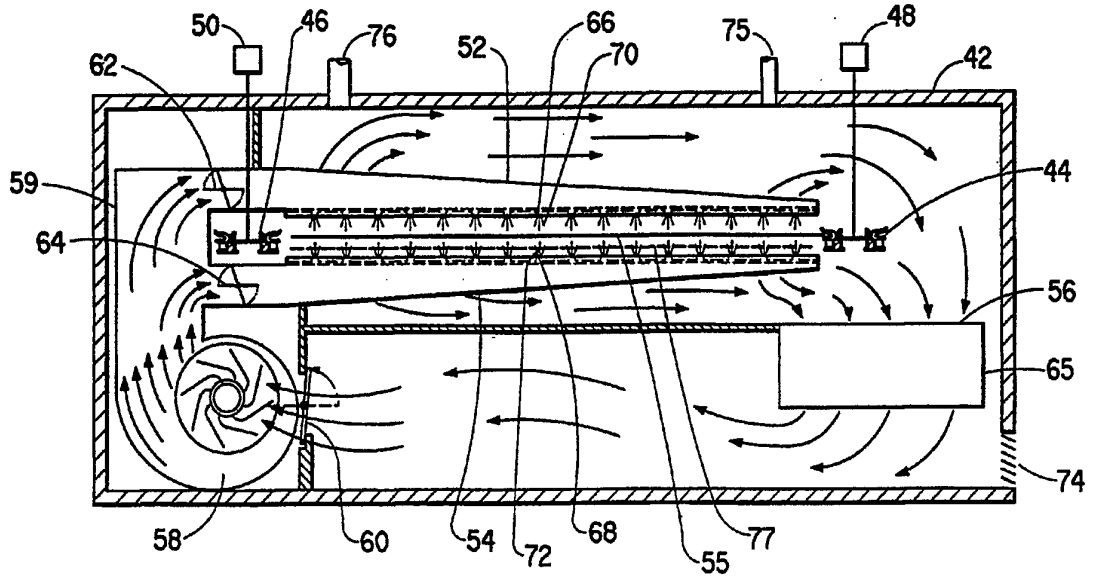
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: GUPTA, Mohinder, Kumar [US/US]; 423 East Ring Factory Road, Bel Air, MD 21014 (US). KENNARD, Jeffrey, Lee [US/US]; 103 Cheltenham Road, Hockessin, DE 19707-1807 (US). SAMANT, Kalika, Ranjan [IN/US]; 36 Nathalie Court, Hockessin, DE 19707-1145 (US). KUMAR, Vijayendra [US/US]; 53 The Strand, New Castle, DE 19720-4825 (US).

(74) Agent: MEDWICK, George, M.; E.I. du Pont de Nemours and Company, Legal Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).

(81) Designated States: AU, BR, CA, CN, CZ, JP, MX, PL, RU, TR, UA, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

**Published**
*With international search report.*

(54) Title: METHOD FOR BULKING TUFTSTRING CARPETS




(57) Abstract

Bulking unbulked nylon carpet (55) having a pile side and a backing side is accomplished by heating the carpet to between 90 and 150 °C, then cooling the carpet to a temperature below 60 °C. Heating is accomplished by directing heated fluid at the pile side, or both the pile side and the backing side. The heating oven comprises an enclosure (42); tenter clip loop (44) and opposed loop (46) driven by motors (48 and 50), respectively; a plurality of nozzles (52, 54); return inlet (56), blower (58) and a header (59) for circulating gaseous fluids through the nozzles; dampers (60, 62 and 64) and a heat exchanger (65) for heating or cooling the circulating fluid.

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# Method For Bulking Tuftstring Carpets

## Background of the Invention

This application is a continuation-in-part of copending application Serial No. 08/298,642 filed 8/31/94. This invention relates to bulking nylon carpet, and more particularly, it relates to bulking nylon carpet by directing heated air toward the carpet.

When forming a conventional nylon tufted carpet assembly, the pile yarn is inserted into a primary backing substrate by tufting needles to form an assembly having loops of yarn on the pile of the backing; the loops may be left as loops to form loop pile carpet, cut to form cut pile carpet, or only some of the loops cut to form a cut/loop pile carpet. The pile yarn in this assembly may already have the color in the yarn polymer (pre-dyed or solution dyed yarn), or the yarn must be treated in a dye bath or other liquid borne dyeing process that requires heating and drying of the carpet structure. The colored carpet must then have the tufts locked to the primary backing by an adhesive that impregnates the base of the tufts on the back side of the primary, and a secondary backing must be applied to protect the base of the tufts against abrasion and provide structural stiffness for handling the carpet. The adhesive is usually a water borne latex adhesive that must be dried to set the adhesive by passing the carpet assembly through a heated oven. During the tufted carpet process just described, the pile yarn will be heated at least once and may be heated twice; once to dry the dye fluid and once to dry the adhesive. These heating processes also activate the filament crimp that was inserted in the pile yarn during spinning and pulled out during tensioning in manufacturing. This recovery of latent crimp causes the yarn to bulk, which is beneficial to

achieve good area coverage with the minimum yarn and create a springy feel to the carpet.

It is known in some cases to use a predyed yarn in a tufted carpet structure useful in automobiles where the backing is a foamed material that is molded under heat while the pile yarn is cooled. In this case, the tufted carpet is bulked by treatment with steam after the carpet is assembled.

A process is disclosed in copending U.S. Application Serial No. 08/017,162, incorporated herein by reference, for making a nylon tuftstring carpet by bonding pile yarn to a support strand to form a tuftstring, and bonding the tuftstrings to a backing substrate to form a carpet structure. The bonding process does not require bulk heating of the pile yarn. There is no need for a secondary backing to protect the back of the tufts since they do not penetrate the primary backing. Such a process does not use latex or other water borne adhesives to bind the filaments in the tufts to each other or bind the tufts to the backing substrate or bind a secondary backing to the primary backing/tuft assembly. The process also uses a smaller creel of pile yarn to form a carpet than does the conventional tufting process. As a result, it is often advantageous to use a predyed yarn since a color change is easier to handle with a small creel. Use of predyed yarn eliminates the dyeing step requiring heated drying of the carpet assembly; this also eliminates the environmental problems often associated with liquid borne dyes.

As a result, the bonded tuftstring carpet, using pre-dyed pile yarn, never is exposed to heating of the carpet assembly. The pile yarn never is exposed to heat to bulk the yarn.

There is a need for a process to separately bulk the pile yarn on a nylon tuftstring carpet by heating the completed dry carpet. There is a need for a process to rapidly apply heat to the pile yarn from

the tip to the base of the tuft to recover the latent crimp in the pile yarn filaments. There is a need for a simple process to bulk the pile yarn at high line speeds with a minimum amount of heat energy.

## Summary of the Invention

The invention is a method of bulking an unbulked nylon carpet having a pile side and a backing side comprising the steps of: removing wrinkles and holding the carpet with a holding means in an extended wrinkle-free condition; heating the carpet to a temperature between 90-150°C; and cooling the carpet to a temperature below 60°C before removing the carpet from the holding means.

The means for accomplishing the method may particularly include a pin tenter for transporting an extended length of carpet through an oven, or a moveable frame for transporting a discrete piece of carpet through an oven, or a shroud covering a portion of a rotating cylinder used in forming the carpet for treating a portion of the carpet just after the portion is formed.

## Brief Description of the Drawings

Fig. 1 is a schematic view of a finishing line incorporating a bulking system.

Fig. 2 shows a section view of a bulking oven.

Fig. 3 is an isometric view of another bulking oven.

Fig. 4 is an isometric view of a means of bulking the carpet as it is being made.

## Detailed Description of the Invention

Fig. 1 shows a finishing line for a tuftstring carpet that requires bulking. It consists of an unwinder 20, a bulking heating oven 22, a cooling chamber 24, a conventional shearing device 26, an

inspection conveyor 28, and a windup 30. After winding, the rolls of finished carpet are strapped by strapper 32 and held for shipping at table 34. Conventional web accumulators are provided at 36, 38, and 40 to provide continuity of operations. Arrow 41 shows the path of the carpet through the line.

The heating oven is shown in more detail in Fig. 2. It comprises an enclosure 42; tenter clip loop 44 and opposed loop 46 driven by motors 48 and 50, respectively; a plurality of pile side nozzles, such as nozzle 52, and back side nozzles, such as nozzle 54, which extend across the path of the carpet 55; return inlet 56, blower 58, and header 59 for circulating gaseous fluids through the nozzles; main damper 60; trim dampers 62 and 64 for balancing flow to the pile side and back side of carpet 55, respectively; and heat exchanger 65 for heating or cooling the circulating fluid. The nozzles have a plurality of orifices, such as orifice 66 in nozzle 52 and orifice 68 in nozzle 54 for forming streams of gaseous fluid 70 and 72, respectively, directed at the carpet. The plurality of pile side and back side nozzles are spaced apart along the path of the carpet so the gases passing from the orifices can be redirected upwardly and downwardly without having to flow completely across the carpet to reach the return inlet. There may also be an external fluid inlet 74 and fluid exhaust outlet 76 for controlling the air flow and pressure in the oven; and a steam inlet 75 for controlling the moisture of the heated fluid. There may also be a porous support belt 77 between the nozzles to temporarily support the carpet, if it should sag during threadup or treatment. The belt would move at the same speed as the tenter clips so the carpet would not drag over the belt. If the belt is stiff enough to prevent longitudinal and lateral wrinkling of the carpet, the carpet may be attached to the belt instead of the tenter clips. Such an oven can be obtained from Krantz America, Inc.,

Charlotte, NC, and is known as a pin frame drying oven model Aeronot D74.

In operation, air may be selected as the treatment fluid, and the air is heated by heat exchanger 65 and is forced through header 59 by blower 58. The heater air passes along pile side nozzle 52 and through orifices, such as orifice 66, that extend across the width of the tuftstring carpet 55. The heated air is also passing along back side nozzle to heat the back side of the carpet. The carpet is placed with the pile yarn facing up and the backing substrate facing down. The carpet is placed on the pins on the tenter pin loops in a wrinkle-free condition by applying a slight tension in the longitudinal and lateral directions (machine direction and cross machine direction, MD and XD, respectively) as it is placed on the pins. The tension should be in a range of about 0.5 to 1.0 pounds per linear inch. The weight of the carpet causes sag that will add some tension in the lateral XD direction. The tenter pin loops may diverge over a portion of their path to further tension the carpet in the XD.

The hot air exiting the orifices impinges on the tuft tips and rapidly penetrates the pile yarn to heat the filaments making up the yarn. The hot air is then redirected from the pile of the carpet and drawn into the return air inlet 56 through the spaces between nozzles and at the lateral edges of the carpet. The return air then passed through damper 60 and to blower 58. The damper 60 is adjusted to ensure the total flow of air is appropriate for the particular pile yarn denier, density, and height so the velocity coming through the orifices will not deform the pile yarn causing bending of the tufts and matting. The heated air then passes to the pile side nozzle through trim damper 62, which is set to balance the flow to the two nozzles. It is desirable to provide slightly more flow to the pile side nozzle since it impinges directly on

the pile to more rapidly heat it. The back side flow helps support the carpet and supply some heating of the pile yarn adjacent the backing. Since the carpet is dry when it enters the oven and the air is used only to heat the carpet, the air can be recirculated and reused without exhausting part of the air and adding dry makeup air as is the case with dryers that must get rid of moist air and replace it with dry air. This permits high efficiency operation. A small amount of air may be exhausted through exhaust outlet 76 and makeup air added through external inlet 74 to minimize leakage of air from the oven into the surrounding room.

The tenter clip loops are driven at a speed to pass a given length of the tuftstring carpet through the oven in the number of seconds necessary to heat all the pile yarn to a temperature required to recover the latent crimp in the filaments. For a BCF nylon 6-6 pile yarn, it has been observed that the temperature of the filaments should be about 90-100°C to recover the latent crimp. The time for the nylon pile yarn to go from room temperature to at least 90°C throughout depends on the temperature of the air impinging on the carpet, the flow velocity of air impinging on the pile yarn, and the denier, density, and tuft height of the carpet. When hot air is applied to the pile side of the carpet, it must penetrate the entire pile height to also heat the base of the pile adjacent the backing to achieve the full bulk possible.

Some laboratory tests were run to determine some operating parameters to achieve heating of the entire pile yarn using hot air directed at the top of the pile. The samples tested were tuftstring carpets made with nylon 6-6 BCF pile yarn. Preferably, the carpet is a moisture stable nylon tuftstring carpet, as described in copending U.S. Application Serial No. 08/298,642, incorporated herein by reference. The samples were a particularly preferred embodiment wherein the pile yarn is nylon 6-6 BCF, the strand

comprises a core of fiberglass filaments coated with a sheath of nylon 6-6, and the backing substrate is a composite fabric of entangled non-bonded layers of nylon 6-6 filaments attached to the top and bottom of a fiberglass scrim layer by adhesive present on the scrim. The yarn is joined to the strand by fusion and the tuftstring is joined to the backing by fusion, both without the addition of a separate adhesive. It is important that the tuftstring, which includes the pile yarn, is mounted on a backing substrate that will not wrinkle during the heating required for bulking. The bulked carpet should lay flat under its own weight after cooling. The carpet samples were run through an oven just to test the temperature response. The carpet samples were not held in a wrinkle-free condition, but the samples were small enough that wrinkling was not evident. The orifices in the nozzle of the test oven were slots that spanned the width of the samples so the velocity distribution was very uniform across the width of the sample. The sample was a nylon 6-6 tuftstring carpet with 1/2 inch tuft length, 24 oz/sq yd density, and 1275 denier, 8 dpf pile yarn. The air temperature at the top of the pile was measured with a temperature indicator coupon stapled to the pile yarn; the temperature at the base of the pile was measured with a thermocouple attached to the backing at the base of the pile. In Case I, the air velocity was 1500 ft/min, and the temperature impinging on the top of the pile was 143°C. The temperature at the base of the pile was 92°C after about 80 seconds. In Case II, the air velocity was 2100 ft/min, and the temperature impinging on the top of the pile was 143°C. The temperature at the base of the pile was 93°C after about 60 seconds. In Case III, the air velocity was 2100 ft/min, and the temperature impinging on the top of the pile was 127°C. The temperature at the base of the pile was 92°C after about 90 seconds. Comparing Case I and II, an increase in velocity heated the base of the pile yarn more

quickly. Comparing Case II and Case III, decreasing the temperature at the same velocity took longer to heat the base of the pile yarn. It was discovered that if the temperature of the air impinging on the top of the pile yarn was above about 150°C, the tips of the pile yarn began to have a harsh feel. In another test, temperatures above 150°C also caused problems with lay-flat of the carpet.

It has been discovered that the tuftstring carpet must be cooled before releasing it from the tenter loops or some distortion of the backing substrate may occur that will prevent the bulked carpet from laying flat. The tenter loops, therefore, must extend beyond the oven 22 and through the cooling chamber 24 in Fig. 1. The cooling chamber can be designed similarly to the oven of Fig. 2, except the heat exchanger 64 will be removing heat from the return air instead of adding it. Alternatively, an external source of cool room air may be used instead of a heat exchanger. The tuftstring carpet should be cooled to a temperature of about 60°C, and preferably 50°C, before releasing it from the tenter loops. It may also be desirable to further cool the carpet to facilitate shearing. The carpet should be below about 40°C before winding into a roll to minimize roll set.

Fig. 3 shows an alternate embodiment for bulking a discrete piece of carpet that is a simpler, lower cost device than the system of Fig. 2. In this embodiment there is a frame 84 to hold the carpet in a wrinkle-free condition by pins 86 engaging the edges of the discrete carpet piece 88. A conveyor 90 extends from a loading position 92 to a cooling and unloading position 94, and passes through an oven 96 having nozzles 97 that may have orifices as in the oven of Fig. 2, or they may have a slot (not shown) for an orifice. The oven 96 has an entrance end 98 and an exit end 100. In operation, the carpet is placed in the frame in a wrinkle-free condition at the loading

position, and the conveyor transports the frame and carpet through the oven from the entrance end to the exit end at a speed to insure the pile yarn is heated throughout to a temperature exceeding 90°C. The carpet may be transported into the oven and stopped while the heated fluid is directed at the pile yarn. The velocity of fluid through the nozzles that impinges on the pile yarn is uniform and low enough so matting does not occur. The frame and carpet are then transported to the cooling and unloading position, and the carpet is allowed to cool in the room air while still held on the frame. The carpet is unloaded after the pile yarn is below about 50°C, and the frame is transported back through the oven to the loading position for loading the next carpet piece.

Fig. 4 shows an alternate embodiment for heating the carpet as the tuftstrings are being arranged and attached to the backing substrate to form the carpet. In this embodiment there is a drum 102 which holds the backing substrate 104 in a wrinkle-free condition by grasping the ends in a clamp 106 along the axis of the drum. The drum is rotated in the direction of arrow 107, and tuftstring 108 is guided onto the drum by traversing guide 110 driven in the direction of arrow 112 by a screw and nut assembly 114. For bonding the tuftstring to the backing substrate, the substrate includes a coating of a layer of thermoplastic adhesive which is softened by hot air jet 116 attached to guide 110. The jet heats a small portion of the coating just before the tuftstring comes into contact with the backing substrate. As the heated thermoplastic coating rotates away from the jet, it is cooled to bond the tuftstring to the backing substrate. Attached to the guide 110 is a shroud 118 which is supplied with heated fluid through flexible hose 120. The shroud has an entrance end 122 and an exit end 124. Within shroud 118 is a nozzle (not shown) to direct the heated fluid at the pile yarn on the carpet that has been formed.

The length of the shroud is such that the yarn passing from the entrance end to the exit end as the cylinder rotates beneath the shroud is heated for a time sufficient to bulk the yarn. Since the shroud is wider than a tuftstring, the same yarn is repeatedly heated as it passes under the shroud so complete bulking is assured. Eventually, the bonded tuftstring moves out from under the shroud and complete cooling of the pile yarn occurs while the assembled carpet is held on the drum. The thermoplastic adhesive used to attach the tuftstring to the backing substrate must have a bonding temperature that is higher than the bulking temperature required for the pile yarn so the tuftstring remains securely bonded during the bulking operation. The carpet may also be treated by first bonding all the tuftstring to the backing and then heating the carpet by traversing the shroud across the carpet at a speed so the yarn is only subjected to bulking heating once. This separates the bonding operation from the bulking operation, which may be desirable for some situations so bonding speed and bulking speed can be separately optimized. Other means to bond the yarn to the backing substrate are possible, such as using an ultrasonic horn as disclosed in the U.S. Serial No. 08/298,642 reference. After the tuftstring carpet is fully formed and bulked, the guide is moved away from the drum, the drum is stopped, the tuftstrings are cut along axial line 126 aligned with clamp 106, the clamps released, and the bulked tuftstring carpet removed from the drum.

Another fluid useful for heating the pile yarn and bulking it is steam at near atmospheric pressure. It has been observed that steam heating for bulking produces some slight fuzziness of a cut pile tuft tip compared to hot air, and the pile yarn has an additional springiness called "scroup" that may or may not be preferred in some applications.

What is Claimed is

1. A method of bulking an unbulked nylon carpet having a pile side and a backing side comprising the steps of: removing wrinkles and holding the carpet with a holding means in an extended wrinkle-free condition; heating the carpet to a temperature between 90-150°C; and cooling the carpet to a temperature below 60°C before removing the carpet from the holding means.

2. The method of claim 1, wherein heating the carpet is accomplished by directing heated fluid at both the pile side and the backing side of the carpet at a temperature between 90-150°C.

3. The method of claim 1, wherein heating the carpet is accomplished by directing heated fluid at the pile side of the carpet at a temperature of 90-150°C.

4. The method of claim 1, wherein holding the carpet comprises engaging the carpet with a plurality of pin clips traveling in opposed paths in a pair of loops of recirculating pin clips that grasp the edges of the carpet, and heating the carpet includes directing streams of heated fluid at the carpet in an oven and transporting the pin clips and the carpet engaged by the clips along the opposed paths from an entrance end to an exit end of the oven.

5. The method of claim 1, wherein holding the carpet comprises engaging the carpet with a plurality of pins arranged along the edges of a rectangular frame; and heating the carpet includes directing streams of heated fluid at the carpet in an oven and transporting the frame and the engaged carpet through the oven from an entrance end to an exit end of the oven.

6. The method of claim 1, wherein holding the carpet comprises attaching the carpet to a cylindrical drum, and heating the carpet includes placing a shroud containing a stream of heated fluid

over at least a portion of the carpet and transporting the carpet and drum under the shroud.

7. The method of claim 2 or claim 3 including the step of: recirculating at least 90% of the heated fluid to heat the carpet.

8. A method of bulking a nylon carpet, comprising: removing wrinkles in the transverse direction and the machine direction and holding the carpet with a holding means in an extended wrinkle-free condition; directing heated gaseous fluid at the pile side of the carpet to penetrate the pile yarn with the fluid at the surface of the pile at a temperature between 90-150 degrees C to heat the carpet; maintaining the directing of the fluid for a time sufficient to raise the temperature of the fluid throughout the pile yarn filaments to a temperature greater than 90 degrees C thereby raising the filaments to a temperature greater than 90 degrees C; and cooling the carpet to a temperature below 60 degrees C before removing the carpet from the holding means.

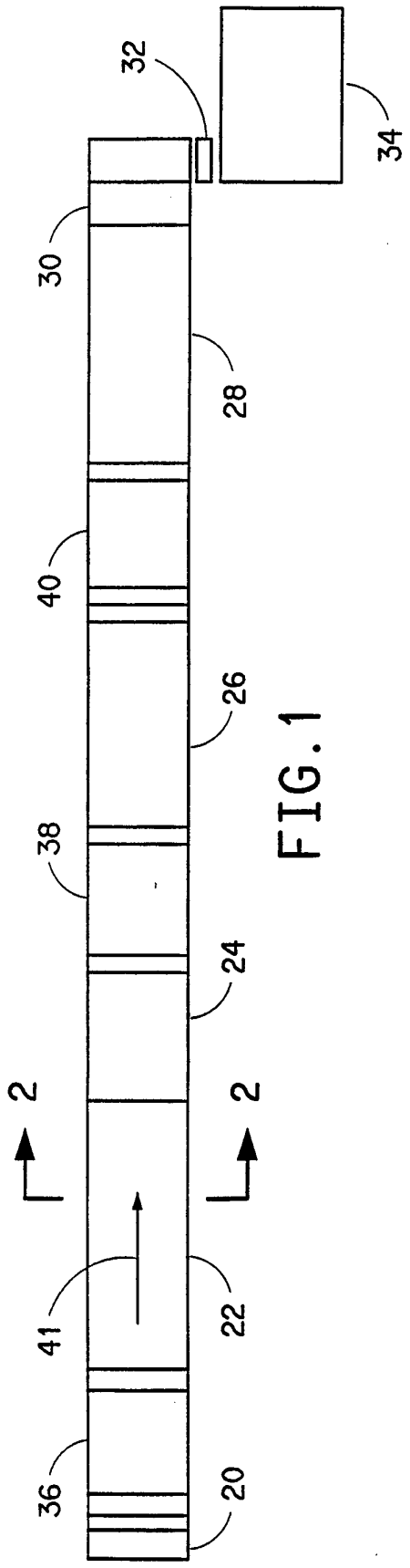
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FIG. 1

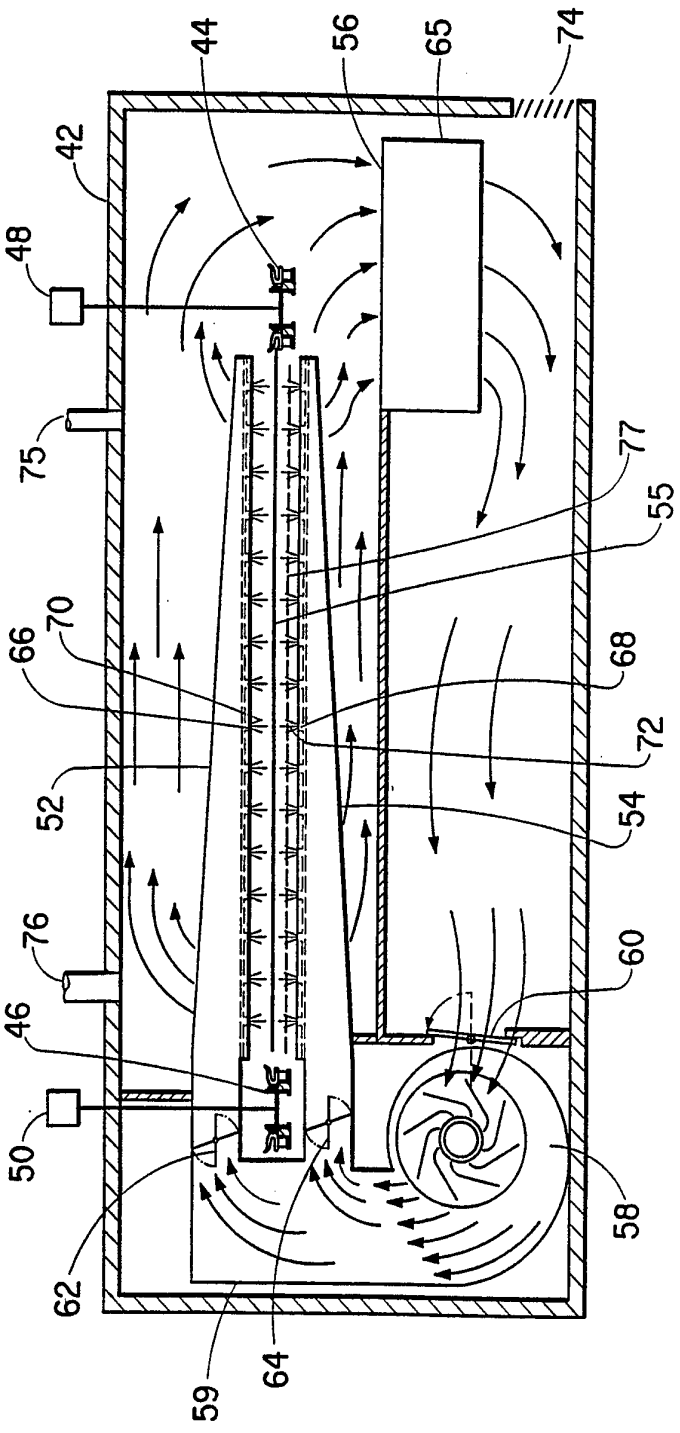
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FIG. 2

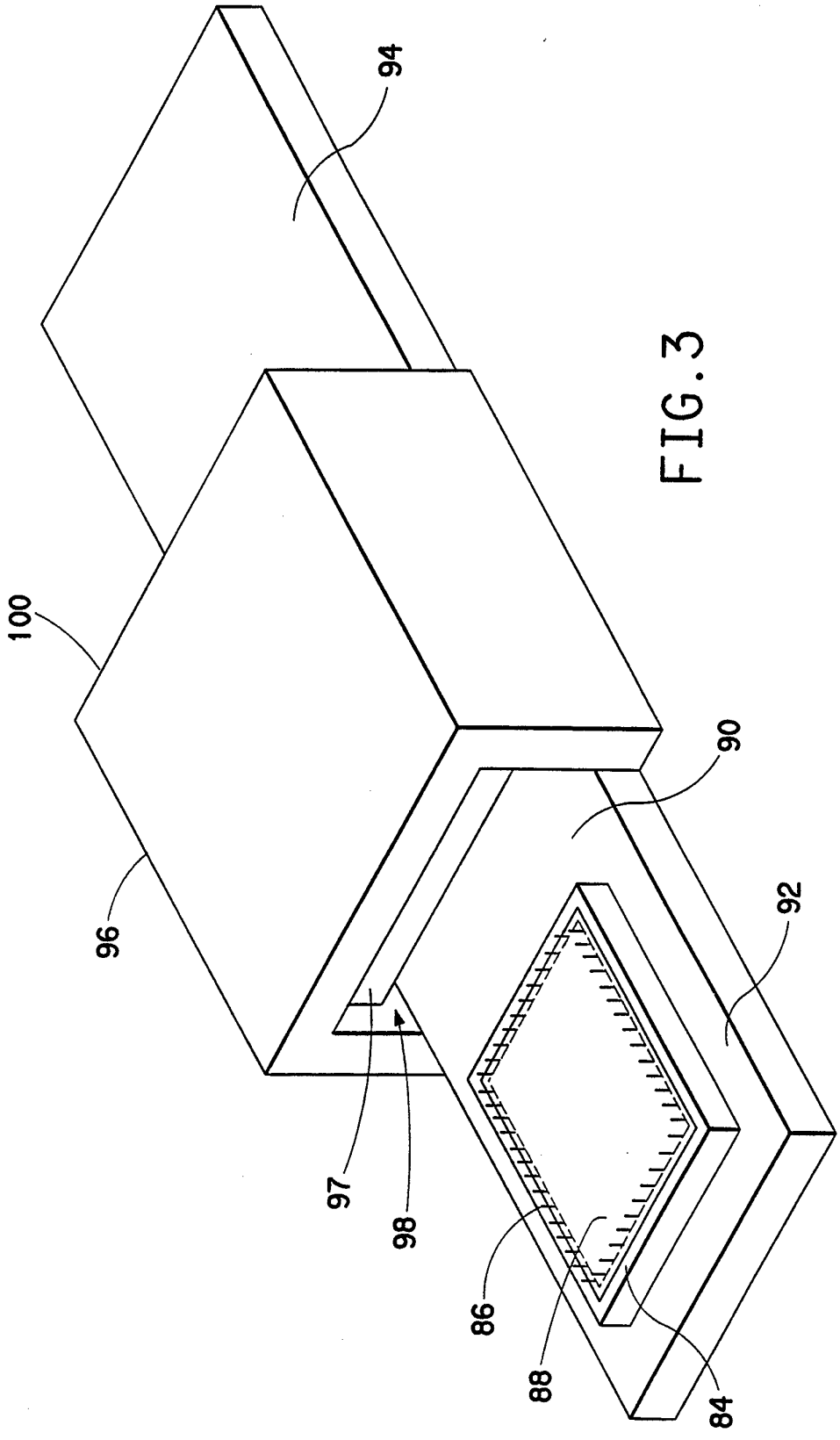
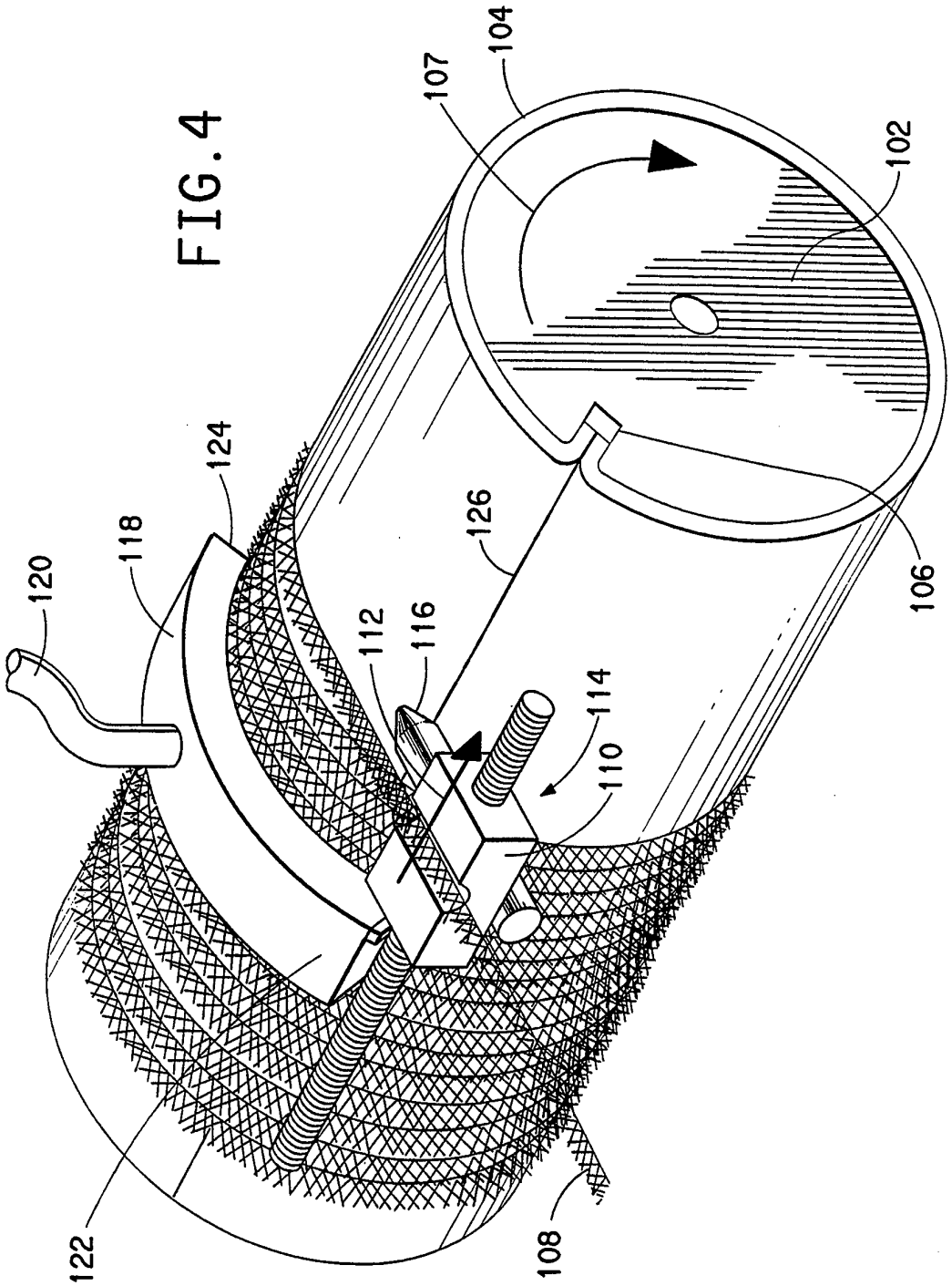



FIG. 3

FIG. 4



# INTERNATIONAL SEARCH REPORT

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| PCT/US96/12864 |

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :F26B 19/00; A46D 1/00; B32B 31/08
US CL :34/210, 212; 156/72, 164
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 34/210, 212; 156/72, 164

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US,A, 3,962,012 (SCHUMACHER) 08 JUNE 1976, see entire document. | 1-5, 7, 8 |
| Y | US,A, 4,578,132 (VAN UDEN ET AL.) 25 MARCH 1986, see entire document. | 1-5, 7, 8 |
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| A | US,A, 4,617,218 (CADENHEAD, SR.) 14 OCTOBER 1986, see entire document. | 1-3 |
| A | US,A, 3,921,308 (FREZE) 25 NOVEMBER 1975, see entire document. | 4, 7 |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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