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(54) **Method and apparatus for spreading fiber strands**

(57) The present invention provides a spreader assembly (2) suitable for opening and spreading a fiber strand into smaller strands or individual filaments. The spreader assembly (2) comprises at least one passageway (21) having an inlet opening (211) for receiving said fiber strand and having an outlet opening (232) through which said fiber strand exits said passageway (21), a divergent zone (23) within the passageway (21) having an entrance end (231) and an exit end (232), and at least one through hole (242) connected to the passageway (21) at an angle and suitable for introducing the air flow thereto. In order to increase the efficacy of opening a fiber strand, the angle of through hole (242) is substantially perpendicular with respect to the longitudinal direction of the passageway (21). In order to increase efficacy of spreading the opened fibers, the divergent zone has a flat cross-section and the area of said exit end (232) is larger than the one of the entrance end (231).

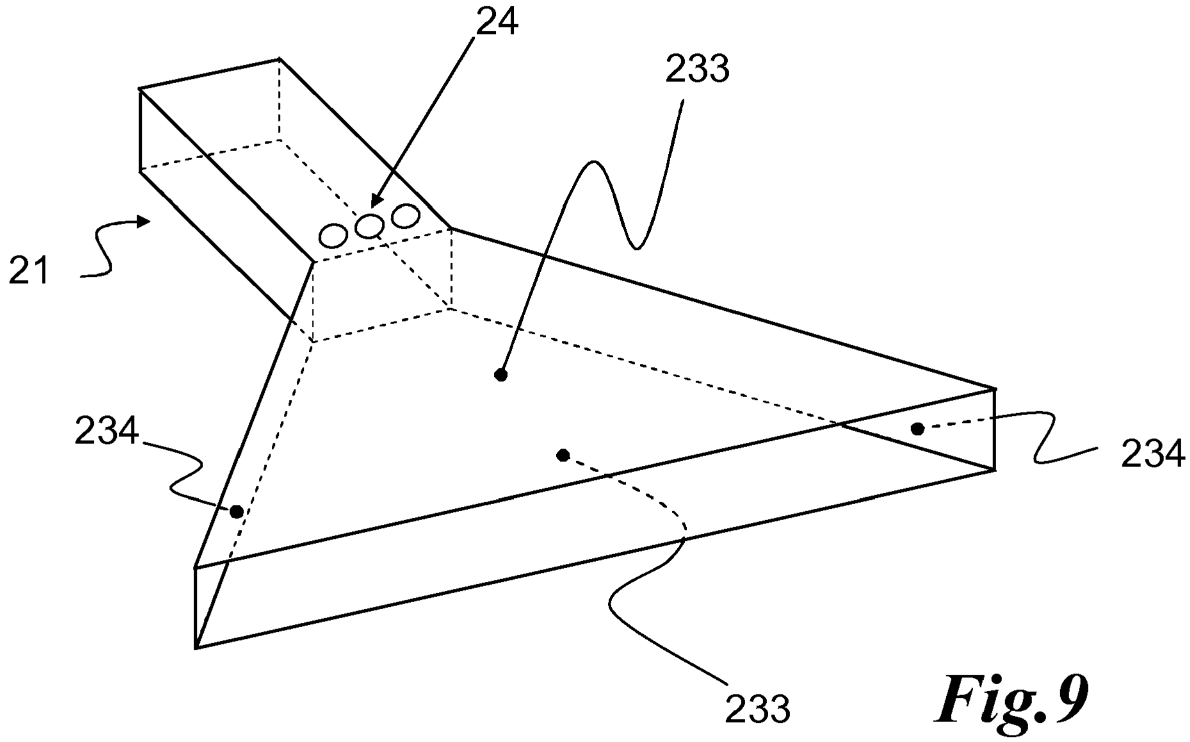

Fig.9

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Description

Technical Field

[0001] The present invention relates to an improved process and apparatus for opening and spreading a strand or bundle of fibers into smaller strands or individual filaments for various subsequent treatments and processes using a fluid stream, such as compressed air. The invention is particularly well suited for, but not limited to, various glass fiber applications, including the production of continuous reinforced polymer structure, more particularly.

Background for the Invention

[0002] Many types of filaments, fibers and strands (collectively "fibers") are sold as a "roving" in which a plurality of such fibers are collected, compacted, compressed or bound together, by methods known to those skilled in the art in order to maximize the content of roving or to facilitate the manufacturing, handling, transportation, storage and further processing thereof.

[0003] In many cases, maximum benefit is achieved, when strand or strands of such rovings are "open" or "spread" exposing the exterior surfaces of the individual fibers, so that the individual fibers can be subjected to various treatment, coating and further processing, for example to be impregnated with impregnating substances e.g. polymer matrix, in order to make high performance composites.

[0004] Numerous methods and devices have been developed for spreading fiber bundles into their constituent filaments or strands. Known methods typically involve vibration, pneumatics, the use of barrel-rollers, or electrostatic charging of the fiber bundle.

[0005] U.S. Pat. No. 4,799,985 describes a gas banding jet for spreading fiber tows. The banding jet consist of a gas box into which compressed air or another gas is fed through an adjustable gas metering means. One, or more than one, gas exit ports are provided to cause gas from within the gas box to impinge in a generally perpendicular fashion upon the fiber tow that passed across the exit ports. Because a flow channel of the banding jet has a rectilinear shape whose entrance and exit ends have same width, the tow requires to be squeezed and opened by a Godet roll under controlled tension prior to being subjected to the compressed air in order to obtain fibers well spread widthwise without wasting the compressed air. The whole system requires Godet rolls for controlling the tension to ensure an effective operation.

[0006] U.S. Pat. No. 6,032,342 describes a process and apparatus for spreading plural filaments combined together in such a manner that they are orderly disposed in parallel to each other. The multifilament bundle in a flexibly bent condition is subjected to suction air flowing crosswise with regard to the moving direction of the multifilament bundles. Prior to subjecting the filaments to the suction air flow, the process, however, requires a feeder, such as rolls, for squeezing the fiber bundle so as to disengage softly the filament stuck together by a sizing agent by tensile force provided with the feeder. The system requires a feeding control to work effectively. The speed of the process can be hindered or limited due to suction part of the process. Furthermore, the system requires a structure letting suction air go through between the individual filaments perpendicularly and letting the filaments bend in the direction of the suction air flow.

[0007] Additionally, the friction and tension created by rollers or bars on surface thereof to spread the fiber bundle into individual fibers in a flat shape without breakage of fibers permit production only at reduced processing rates. Accordingly, using rolls or bars to separate fiber bundle has limitations, and is not well suited for delicate fibers, particularly when operating at relatively high speeds.

[0008] U.S. Pat. No. 3,873,389 describes a process and apparatus for pneumatically spreading thin graphite or other carbon filaments from a tow bundle to form a sheet or tape in which the filaments are maintained parallel. The process includes a step of passing the tow through a slot venturi of preblower in which the tow is pulled through the preblower having a venturi in a direction along the primary air flow and subjected to the air flowing in parallel with the moving of the fibers. However such preblower requires for each unit at least a pair of plenum spaces which lie outwardly of and are partially defined by confronting plates. Thus, the stuck array of the single modules becomes much larger-in scale and more complicated in structure. The air stream is applied to the filaments initially along the direction of filament movement but not perpendicularly thereto.

[0009] In view of the inconveniences encountered with the prior art for spreading a fiber strand, the present invention proposes a frictionless solution to spread the fiber strand at higher speeds with a newly designed and simple apparatus.

Summary of the invention

[0010] The subject matter of the present invention is defined in the appended independent claims. Preferred embodiments are defined in the dependent claims.

[0011] In a first embodiment, the subject matter or the present invention is a spreader assembly suitable for opening and spreading a fiber strand into smaller strands or into individual filaments comprising (a) at least one passageway having an inlet opening for receiving said fiber strand and having an outlet opening through which said fiber strand exits said passageway, (b) a divergent zone within the passageway having an entrance end and an exit end wherein the area of said exit end is larger than the one of the entrance end and the divergent zone has a flat cross-section, preferably rectangular cross-section, and (c) at least one through hole connected to the passageway at an angle preferably substantially perpendicular with respect to the longitudinal direction of the passageway, and suitable for introducing the air flow thereto.

[0012] In particular, the passageway for fibers of the spreader comprises an inner channel of rectilinear shape disposed between the inlet opening of the passageway and the exit end of the divergent zone.

[0013] Preferably, the through hole of the spreader assembly is connected to the inner channel at an outlet having one or more holes smaller than the dimension of the through hole.

[0014] Advantageously, the through hole of the spreader assembly is located at a point immediately upstream from the entrance end of the divergent zone.

[0015] In particular, the divergent zone of the spreader assembly has a top wall, a bottom wall and sidewalls, wherein the sidewalls diverge outwardly at an angle greater than 0° and less than 90°, preferably between 5° and 85°, more preferably between 10° to 40°.

[0016] The subject matter of the present invention is also a method of spreading a fiber strand comprising the steps of (a) supplying the fiber strand from source of fiber strands, (b) pulling said fiber strand through a passageway having a divergent zone, and (c) subjecting said fiber strand to air flow at an angle, preferably substantially perpendicular, with respect to the moving direction of the filaments within said passageway.

[0017] Preferably, the filaments supplied the step (a) are coated by a sizing or binding agent.

[0018] Advantageously, in the step (c), the filaments is subjected to the air flow entering into a passage through at least one hole, the passageway having an inlet opening for receiving said fiber strand, an outlet opening through which the fiber strand exits said passageway and a divergent zone having an entrance end and an exit end, wherein the area of said exit end is larger than the one of the entrance end.

[0019] In particular, the step (c) is carried out within a inner channel having a rectilinear shape which is disposed between the inlet opening of the passage and the entrance end of the divergent zone, preferably at a point immediately upstream from the entrance end of the divergent zone.

[0020] These and other aspects of the present invention will become clear to those of ordinary skill in the art upon the reading and understanding of the specification.

Brief description of the Figures

[0021] This invention will be further described in connection with the attached drawing figures showing preferred embodiments of the invention including specific parts and arrangements of parts. It is intended that the drawing included as part of this specification be illustrative of the preferred embodiments of the invention and should in no way be considered as a limitation on the scope of the invention.

FIG.1 is a side elevation view of a preferable embodiment of the spreader assembly according to the present invention.

FIG.2 is an elevation view of the outlet opening of the spreader assembly shown in FIG.1.

FIG.3 is an elevation view of the inlet opening of the spreader assembly shown in FIG.1.

FIG.4 is a plan view of the spreader assembly shown in FIG.1.

FIG.5 is a bottom view of the spreader assembly shown in FIG.1.

FIG.5a is a perspective view of the spreader assembly shown in FIG.1.

FIG.6 is a longitudinal cross-section view of the spreader assembly shown in FIG. 1 according to a cutting plane VI-VI of FIG.4.

FIG.7 is a cross-section of the bottom part of the spreader assembly shown in FIG. 1 according to a cutting plane VII-VII of FIGs. 1 and 2.

FIG.8 is a cross-section of the top part of the spreader assembly shown in FIG. 1, according to a cutting plane VIII-VIII of FIGs. 1 and 2.

FIG.9 is a perspective view of a passageway in the spreader assembly according to the present invention.

FIG.10 is a cross-section similar to FIG.7, wherein a bundle of filaments is opening and spreading into individual filaments.

FIG.1 1 is a plan view of another preferable embodiment of the spreader assembly according to the present invention.

FIG.12 is an elevation side view of the spreader assembly shown in FIG.11.

FIG.13 is an elevation view illustrating the inlets of the spreader assembly shown in FIG.11.

FIG.14 is an elevation view illustrating the outlets of the spreader assembly shown in FIG.11.

FIG.1 5 is an elevation side view of another preferable embodiment of the spreader assembly according to the present invention.

FIG.16 is an elevation view illustrating the inlets of the spreader assembly shown in FIG.15.

FIG.1 7 is an elevation view illustrating the outlets of the spreader assembly shown in FIGs.15 and 16.

FIG.18 is a plan view of a spreader unit, which is an external element of the spreader assembly shown in FIGs.15 to 17, illustrating two inlets for air

FIG.19 is a bottom view (cross-section) of the top part of the spreader unit shown in FIG.15 to 18 according to a cutting plane XIX-XIX of FIGs. 15 and 16.

FIG.20 is a cross-section of the bottom part of the spreader unit shown in FIGS.15 to 18, according to a cutting plane XX-XX of FIGs. 1 5 and 16.

FIG.21 is a plan view of a spreader unit, which is an inner element of the spreader assembly shown in FIGs.15 to 17, illustrating an inlet for air.

FIG.22 is a bottom view (cross-section) of the top part of the spreader unit shown in FIGs. 15 to 17, and 21, according to a cutting plane XXII-XXII of FIGs. 1 5 and 16.

FIG.23 is a cross-section of the bottom part of the spreader unit shown in FIGs. 15 to 17, 21 and 22, according to a cutting plane XXII-XXII of FIGs. 1 5 and 16.

FIG.24 is a preferable configuration of holes disposed between a passageway for the filaments and an exit end of an air passage in the spreader assembly according to the present invention.

FIG.25 is a perspective view of an air passage in a preferable embodiment of spreader assembly according to the present invention.

FIG.26 is a schematic illustration of typical impregnation system for manufacturing a polymer structure reinforced with continuous fibers in which the spreader assembly of present invention may be used.

FIG. 27 is a stop action photo of opening and spreading four fiber strands into individual filaments which pass through the spreader assembly comprising four spreader units according to the present invention.

Detailed description of the invention

[0022] The present invention overcomes several of the problems experienced with the prior art means for opening and spreading a fiber strand (for example, a collection of hundreds or more of individual, small-diameter fibers gathered together to form a generally flat tape-like flexible bundle) into smaller strands or individual filaments and spreading the filaments widely.

[0023] In view of the inconveniences encountered with the prior art for producing a spread multifilament bundle, the aim of the present invention is to provide a method and apparatus for efficiently separating a fiber strand into smaller strands or individual filaments and spreading the smaller strands or the filaments so as to be aligned widthwise in parallel and distributed in a uniformed density.

[0024] Specially, the problems of the prior art include slow operation speeds. The present invention overcomes these problems by feeding a fiber strand to be spread through a specially designed spreader assembly. The general design of the spreader assembly avoids mechanical frictions and allows for operating at high speed without the breakage of fibers.

[0025] The term "fiber" as used herein means a filament or a fiber of any material, for example, inorganic, metallic, ceramic, polymeric, or refractory materials such as, but not limited to, carbon, graphite, glass, quartz, polyethylene, poly(paraphenylene terephthalamide), benzoxazole, cellulosic derivatives, silicon carbide, and boron nitride. The present invention is particularly suited to, but not limited to, glass fiber application with diameter ranging from, but not limited to, 6 μm to 32 μm for a given tex (g/km) strand.

[0026] The terms "strand", "tow", "bundle" or "roving" as used herein mean a plurality of individual fibers ranging from dozens to thousands in number, collected, compacted, compressed or bound together by means known to the skilled person in order to maximize the content thereof or to facilitate the manufacturing, handling, transportation, storage or further processing thereof.

[0027] Individual fiber having a variety of cross-section may be used in accordance with the invention. A bundle of fibers used in accordance with the invention preferably has an oblong cross-section, more preferably, a rectangular cross-section. Fiber strands used in practicing the invention are generally twist free strands.

[0028] A sizing or binding agent may have been applied to each fiber or some fibers in a strand to be spread so as to facilitate the manufacturing, handling, transportation, storage or further processing thereof, and a use of such fibers is included within the scope of the invention. Such sizing or binding agent may have been applied in an amount more than or equal to 0.01%, preferably from 0.01 % to 10 %, more preferably from 0.2 % to 1.00 % by weight of the fiber strand.

[0029] The terms "rectangular" and "substantially rectangular" as used herein, are to be understood as meaning a structure having a generally rectangular cross-section with possible slight defects, for example, rounded corners, and a slight bowing or indentation along side.

[0030] A spreader assembly according to the present invention includes at least one spreader unit. Preferably one strand is passed through one spreader unit, but more than one strands to be opened into individual filaments may be passed through one spreader unit. The spreader assembly may include two or more spreader units oriented vertically in order to provide enough amounts of spread smaller strands or individual filaments required for subsequent processing. A suitable configuration of plural spreader units enables to control the amount of fibers required or to adjust the width of the spread fibers as desired as per the process and application requirement.

[0031] FIGs. 1 to 9 illustrate a preferred embodiment of a spreader assembly 2 according to the present invention.

[0032] As shown in FIGs. 1 to 3, and 6, the spreader assembly 2 is provided with a cover 25 and a base 26 to be joined together so that a passageway 21 for the fibers is provided as illustrated in FIG.9. The spreader assembly comprises two side surfaces 201, a back surface 202, a front surface 203, a top surface 204 and a bottom surface 205 as illustrated in FIG. 5a.

[0033] The cover 25 is a rectangular plate having a certain thickness and comprises a through hole 242 passing through all thickness of the cover 25 as best shown in FIG.6. The through hole 242 corresponds to a passage for air as shown in details in FIG.25. One of the end of the through hole 242 corresponds to a air inlet 241 as shown in FIG 4, whish is disposed on the top surface 204 of the cover 25. The opposite end of the through hole 242 corresponds to an air outlet 24 having three small holes as shown FIGs.6 and 8. The bottom surface of the cover 25 forms a top wall for the passageway 21 (FIGs 1, 2, 3, 6 and 9).

[0034] The base 26 is a rectangular plate having a certain thickness and comprises a groove 21 in longitudinal direction, which corresponds to the passageway 21 for the fibers. The groove 21 comprises a rectilinear zone 22 and a divergent zone 23. The rectilinear zone 22 has constant width and depth from the one side of the base 26 to the point 231, which is the inter connection of the rectilinear zone 22 and the divergent zone 23 as shown FIGS. 6, 7 and 9. The divergent zone 23 has preferably a constant depth but may be varied over its length in order to get the best spread for the fibers. The zone 23 comprises sidewalls 234, which diverge outwardly at an angle $\alpha°$ from the point 231 to an exit end 232 on the back surfaces of the base 26 as shown FIGS. 6, 7 and 9.

[0035] The cover 25 and the base 26 are joined together by convenient joining means, such as screws or clamps (not shown). The groove 21 of the base 26 and the bottom surface of the cover 25 form a passageway 21 for filaments as shown in FIGS. 6, 8 and 9. The passageway 21 has an inlet opening 211, an outlet opening 232, a divergent zone 23 provided by the divergent zone 23 of the base 26 and the cover 25, and an inner channel 22 provided by the rectilinear zone 22 of the base 26 and the cover 25.

[0036] The air outlet 24 is preferably positioned so as to be within the inner channel 22 and immediately upstream from the divergent zone 23 so that the compressed air, applied to the fiber strand, breaks up links between the individual filaments without wasting the air. In case that the assembly does not comprise the rectilinear inner channel 22, the air outlet 24 may be adjacent to the entrance end 231 of the divergent zone 23.

[0037] The small holes disposed in the air outlet 24 may be one or more than one and the number of the holes may be varied as per input strand width and the requirement to achieve optimum opening of this strand into either smaller strands or individual fibers. The small holes may be aligned along lateral direction of the inner channel 22 as shown in FIGs.24 and 25.

[0038] As illustrated, through hole 242 corresponding to a passageway for air passes through the cover 25 at an angle, preferably substantially perpendicular with respect to the passage 21 for filaments. However, it is possible to orient the through hole 242 to practically desired angle to achieve the best separation.

[0039] The diverging angle $\alpha°$ of sidewall 234 of the divergent zone 23 is greater than 0° and less than 90°, preferably between 5° and 85°, more preferably 10° and 40°. It is to be mentioned, that the angle $\alpha°$ is selected in such way as to achieve the desired width for the spread fibers, which will depend upon the width requirement for subsequent processing. Thus, if wider spread is required, larger angles will need to be selected.

[0040] The length of the inner channel 22 is preferably, but not limited to, between 10 and 30 mm. The width and the depth of the inner channel 22 is selected as per input fiber strand width as well thickness so that the input fiber strand passes preferably easily through the channel 22, allowing efficient use of air for separating the strand into individual fibers. The passageway 21 for filament may comprise only a divergent zone 23 without any rectilinear channel. If only opening or separating of the bundled strand into smaller strands or into individual fibers is required, a smallest possible $\alpha°$ may be selected, preferably less than 2°.

[0041] The depth of the divergent zone 23 may be gradually varied. The width and the length of the divergent zone 23 may also be suitably altered to obtain desired dimensions or desired cross-section area for the spread fiber.

[0042] FIG. 10 shows as an example a opening and spreading process of a fiber strand within a passageway 21 comprising a divergent zone 23 having sidewalls 234 that diverge at an angle $\alpha°$ from the inner channel walls as the fiber strand moves in the direction represented with the arrow A and where the compressed air is applied perpendicularly to the fiber strand at a point immediately upstream from the divergent zone. The arrow represents the principal moving direction of the fibers.

[0043] A fiber strand may be supplied from a fiber strand source, such as commercial available spool or roving. The fiber strand is passing into the passageway 21 across the spread assembly 2 through an inlet opening 211. The fiber strand can move or pass freely through the rectilinear 22 and diverging 23 channels. The passing fiber strand attains the velocity according to the pulling force applied by the in-line subsequent process or by any suitable means. No special or separate pulling device is needed, in the case where the subsequent process is pulling the fibers. For example, a motorized rotating cylinder, tube or a mandrell can pull the fibers during winding process at a given winding speed. Also in another example, the impregnated fibers may be shaped into a rod and be pulled by a chopper to make the pellets of desired length. As it is understood, the speed will be determined by the speed requirement of the subsequent process such as pelletization. For example, the pelletization may be run at a speed of dozens to hundreds meter/min.

[0044] Compressed air flow supplied to the air passage through the air inlet 241 is applied to the fiber strand 5 at an angle, preferably perpendicularly, within the passage through small holes disposed at the air outlet 24. The air pressure is selected depending upon the strength of the links between individual fibers. The preferred pressure of air flow entering into the spreader assembly 2 is in the range of approximately 0.1 to 5 bras. For a commonly available commercial strand, air pressures of 0.5 to 3 bars may very well be suited to get good opening of fibers.

[0045] A pressure gradient is created across the divergent zone 23. Due to the pressure differential, the air entering the divergent zone 23 through its entrance end 231 flows through the entire width of the divergent zone 23 toward the outlet end 232 thereof.

[0046] Accordingly, at first the perpendicular air flow breaks up the links between individual filaments in the bundled fiber strand 5 created by, for example, a sizing or binding agent, physicochemical interactions, electrostatic force, mechanical, compaction or friction forces, and then, the divergent air stream created in the divergent zone forces the loosened and separated strands or filaments to spread widely and to disperse uniformly as shown in FIG.10.

[0047] An advantage of the invention is that it may be practiced upon two or more fiber strands at once that are spread widely and dispersed uniformly by using a spreader assembly comprising two or more spreader units disposed one above the other or side by side. It is suitable for manufacturing a composite structure comprising a large amount of reinforcing fiber. Thus, several separate spreader units may be combined together and placed in such a combination as to obtain either desired width for the spread fibers and/or desired amount of glass % by weight required for the in-line subsequent processing into a composite reinforced structure. Furthermore, by connecting each inlet for air of the spreader units to an air compressor by conventional means, all spreader units may share one air supply.

[0048] FIGs.11 to 14 illustrate an embodiment of a spreader assembly comprising four spreader units, two external units 2a, 2d and two inner units 2b, 2c, which are disposed one above the other.

[0049] Each spreader unit, although may have different structure to be used in combination, preferably has same structure as described above and illustrated in FIGS. 1 to 9. The base 26a of the upper external unit 2a is in contact with the cover 25b of the upper inner unit 2b which is just underneath. The upper external unit 2a mounted on the upper inner unit 2b is horizontally shifted toward the direction of fiber movement (represented with the arrow A in FIG.12) so that the air inlet 241b of the upper inner unit 2b is uncovered and can be connected to a compressed air supply. Each air inlet 241a, 241b may be connected to a compressed air supply by a conventional means (not shown). A second inner unit 2c is mounted under the upper inner unit 2b without any horizontal sift. And a second external unit 2d is mounted under the second inner unit 2c and shifted horizontally toward the direction of the fiber movement. According to other embodiments more than four spreader units can be stacked.

[0050] FIGs.15 to 23 illustrate another preferred embodiment of the spreader assembly 2 according to the present invention comprising four spreader units, 2e, 2f, 2g and 2h.

[0051] The upper spreader unit 2e comprises a cover 25e and a base 26e which are joined together by a conventional means such as screw or clamps (not shown).

[0052] The cover 25e of the spreader unit 2e comprises two through holes 242e and 242f corresponding to air passages as shown in FIGs.16, 17 and 19 to 21. One through hole 242e is connected the air outlet 24e of spreader unit 2e and the other 242f is connected to the through hole 242f disposed in the base 26e of unit 2e which has a structure similar to the structure of the base 26a as described above.

[0053] The hole 242e allowed the arrival of air into the passageway 21e of the upper spreader unit 2e and the hole 242f allowed the arrival of air into the passageway 21f of an inner unit 2f underneath. The hole 242f, therefore, passes through the cover 25e, the base 26e and the cover 25f.

[0054] The base 26f of the inner unit 2f comprises a groove 21f which has a structure similar to the structure of the groove 21e of the base 26e but is shifted into a lateral direction in order to avoid overlapping of the position of the through hole 242f with the one 242e of unit 2e.

[0055] The inner units 2f and 2g are joined together with their respective base 26f and 26g.

[0056] By the invention the fiber strand may be spread and separated into individual fibers so that it can be impregnated with impregnating substances e.g., solid such as powder or liquids such as solutions, emulsions, dispersions of polymers, molten polymers, waxes, to form a composite structure.

[0057] Referring now to FIG.26, there is schematically shown typical impregnation system for manufacturing a composite structure reinforced with continuous fibers in which the spreader assembly of the present invention may be used.

[0058] Fiber strands 5 may be supplied from spools holding fiber strand and fed through a spreader assembly 2 according to the present invention by a conventional pulling mechanism of subsequent process 13. The resulting fiber-opened strand 7 may be directed into an impregnation assembly 3 and subjected to an impregnation material brought from a source of impregnating material, e.g., an extruder 10. The resulting impregnated fiber strand 9 may be shaped to have a desired shape with a shaping die 11, such as a round strand, rod, ribbon, tape, plate, tube or any other special shape. The resulting product 9 may be cooled by a cooling means 12 or allowed to solidify or cure. The cooled, solidified or cured profiles may be cut to desired lengths. The resulting product 9 may be wound into a product such as pipe, cylinder, tube and panel, before cooling, solidification or curing. Also a readily formed rod may be cut to desired length using a pelletizer 14 to produce reinforced pellets which can be subsequently molded into composite parts. Such pellets with majority of fibers impregnated can lead to high performance composites even when molded at milder shear conditions. The obtained long fiber reinforced composite structure comprises reinforcing fibers which may be well impregnated with the impregnating material.

[0059] FIG. 27 shows a stop action photo of this spreading using the spreader assembly comprising four spreader units. It shows that four fiber strands are opening and widely spreading into individual filaments.

Claims

1. A spreader assembly (2) suitable for opening and spreading a fiber strand into individual filaments comprising:

   (a) at least one passageway (21) having an inlet opening (211) for receiving said fiber strand and having an outlet opening (232) through which said fiber strand exits said passageway (21);
   (b) a divergent zone (23) within the passageway (21) having an entrance end (231) and an exit end (232) wherein the area of said exit end (232) is larger than the one of the entrance end (231) and the divergent zone has a flat cross-section, preferably rectangular cross-section; and
   (c) at least one through hole (242) connected to the passageway (21) at an angle preferably substantially perpendicular with respect to the longitudinal direction of the passageway (21), and suitable for introducing the air flow thereto.

2. A spreader assembly according to claim 1 wherein said passageway (21) comprises an inner channel (22) of rectilinear shape disposed between the inlet opening (211) of the passageway (21) and the exit end (231) of the divergent zone (23).

3. A spreader assembly according to claim 2 wherein the through hole (242) is connected to the inner channel (22) through an outlet (24) having one or more holes smaller than the dimension of the through hole (242).

4. A spreader assembly according to claim 3 wherein the through hole (242) is located at a point immediately upstream from the entrance end (231) of the divergent zone (23).

5. A spreader assembly according to any of the preceding claims wherein the divergent zone (23) has a top wall (233), a bottom wall (233) and sidewalls (234), wherein the sidewalls (234) diverge outwardly at an angle greater than 0° and less than 90°, preferably between 5° and 85°, more preferably between 10° to 40°.

6. A method of spreading a fiber strand comprising the steps of:

   (a) supplying the fiber strand from source of fiber strands;
   (b) pulling said fiber strand horizontally through a passageway (21) having a divergent zone (23);
   (c) subjecting said fiber strand to air flow at an angle, preferably substantially perpendicular, with respect to the moving direction of the filaments within said passageway.

7. A method according to claim 6 wherein the filaments supplied by the step (a) are coated by a sizing or binding agent agent.

8. A method according to claim 6 or 7 wherein in the step (c), the filaments is subjected to the air blowing through at least one hole (24) suitable for introducing the air flow thereto within a passage (21), wherein the passageway (21) comprises an inlet opening (211) for receiving said fiber strand, an outlet opening (232) through which said fiber strand exits said passageway (21) and a divergent zone (23) having an entrance end (231) and an exit end (232) wherein the area of said exit end (232) of a divergent zone (23) is larger than the one of the entrance end (231) of the area of said exit end (232).

9. A method according to any of claims 6 to 8 wherein the step (c) is carried out within a inner channel (22) having a rectilinear shape which is disposed between the inlet opening (211) of the passage (21) and the entrance end (231) of the divergent zone (23), preferably at a point immediately upstream from the entrance end (231) of the divergent zone (23).

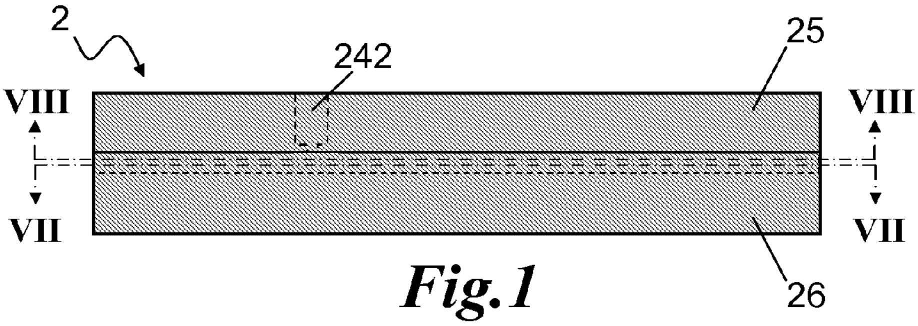


Fig.1

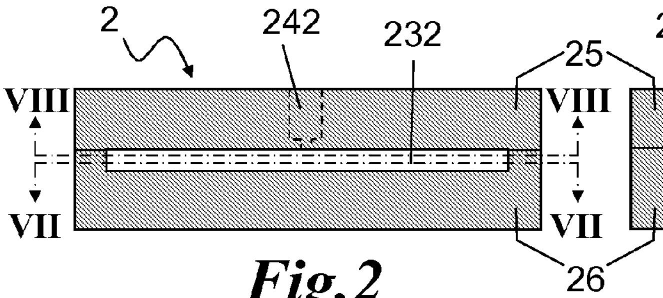


Fig.2

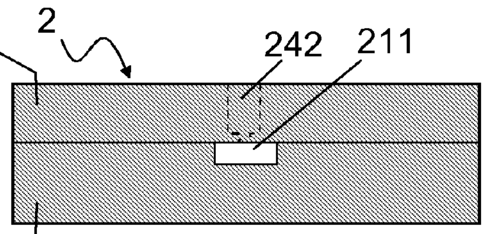


Fig.3

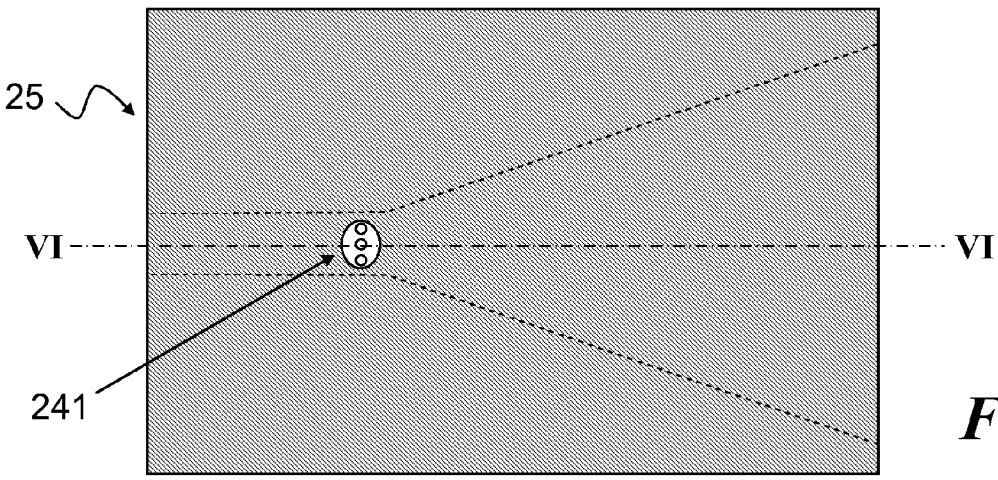


Fig.4

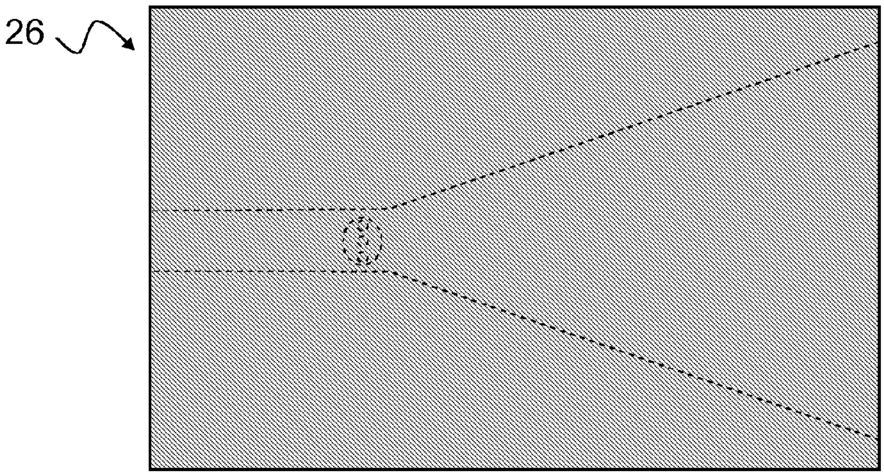


Fig.5

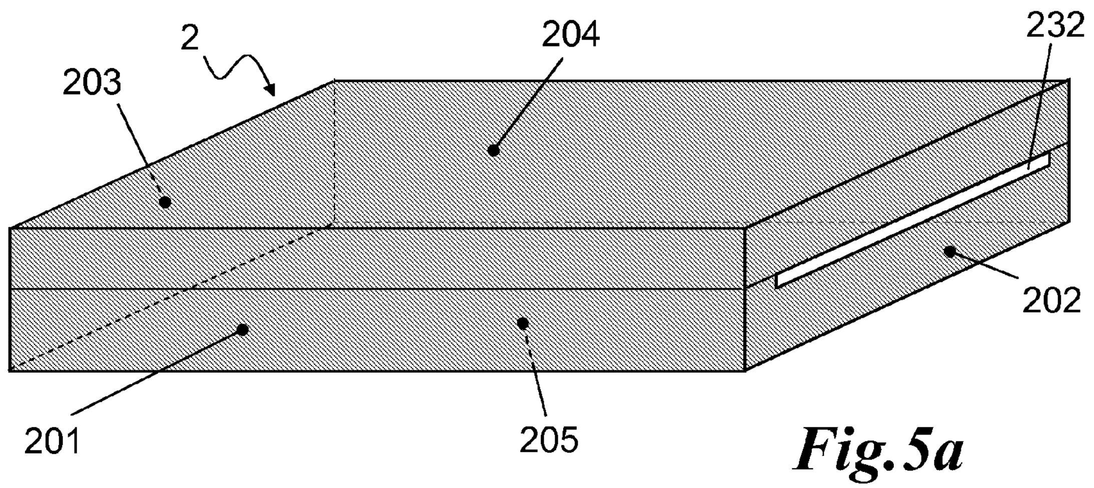


Fig.5a

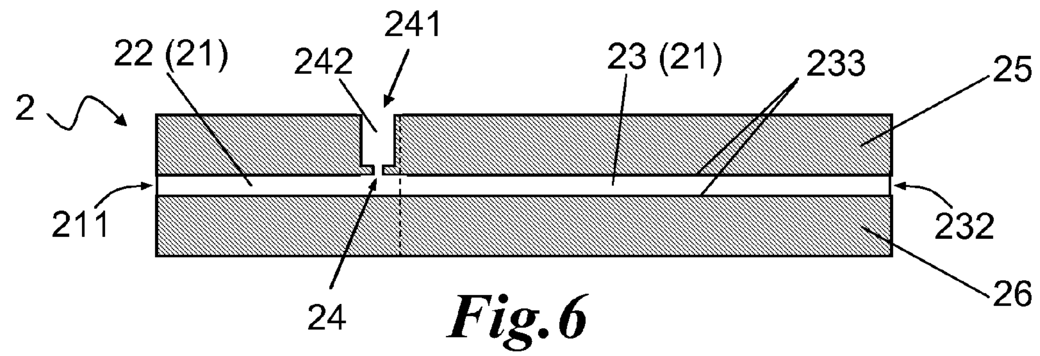


Fig.6

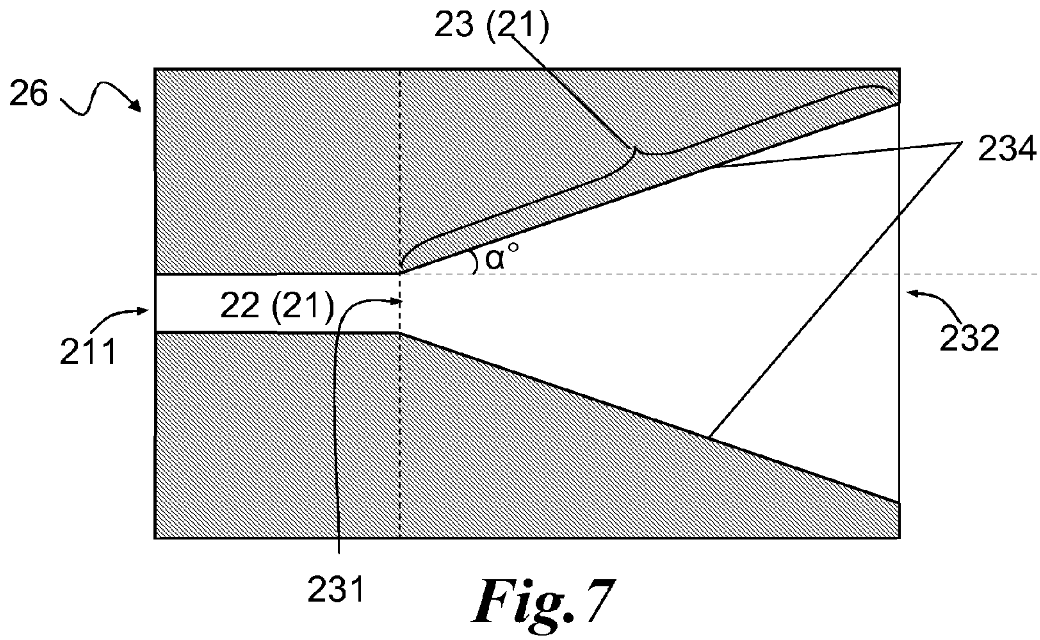


Fig.7

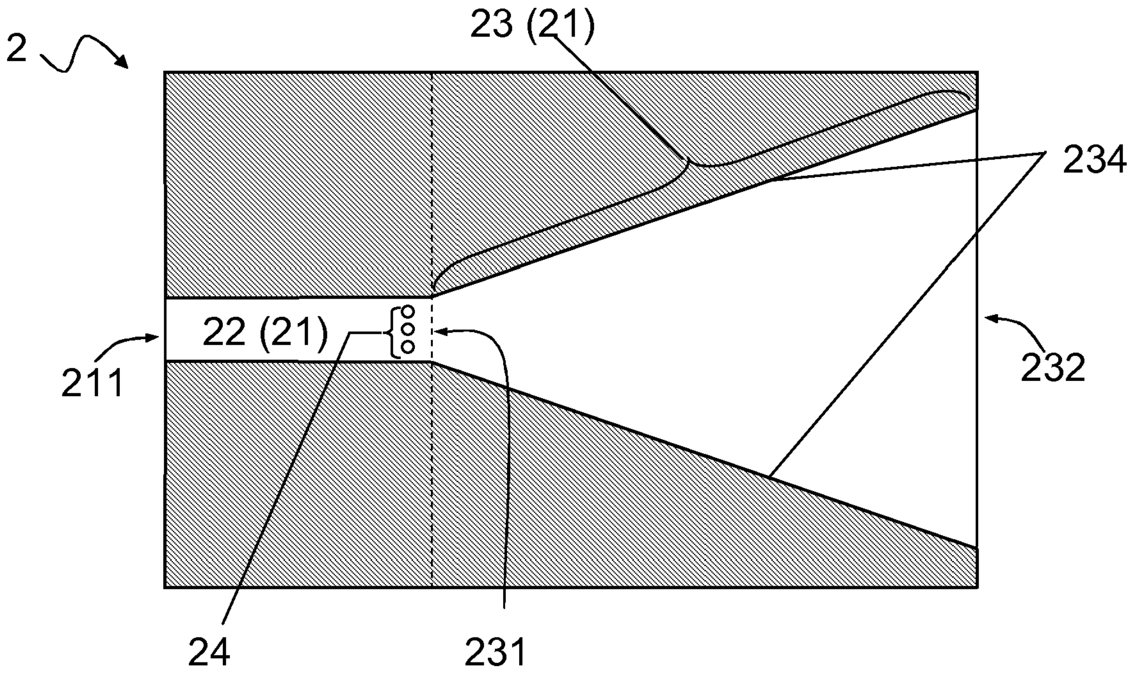


Fig.8

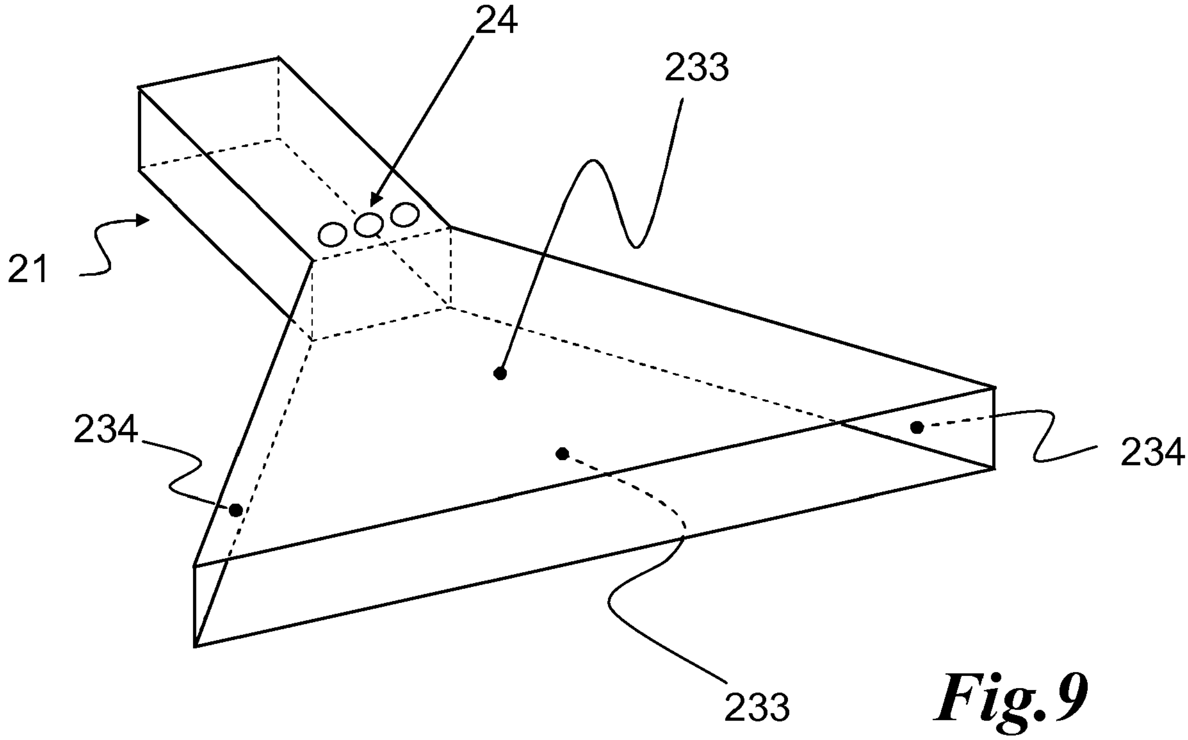


Fig.9

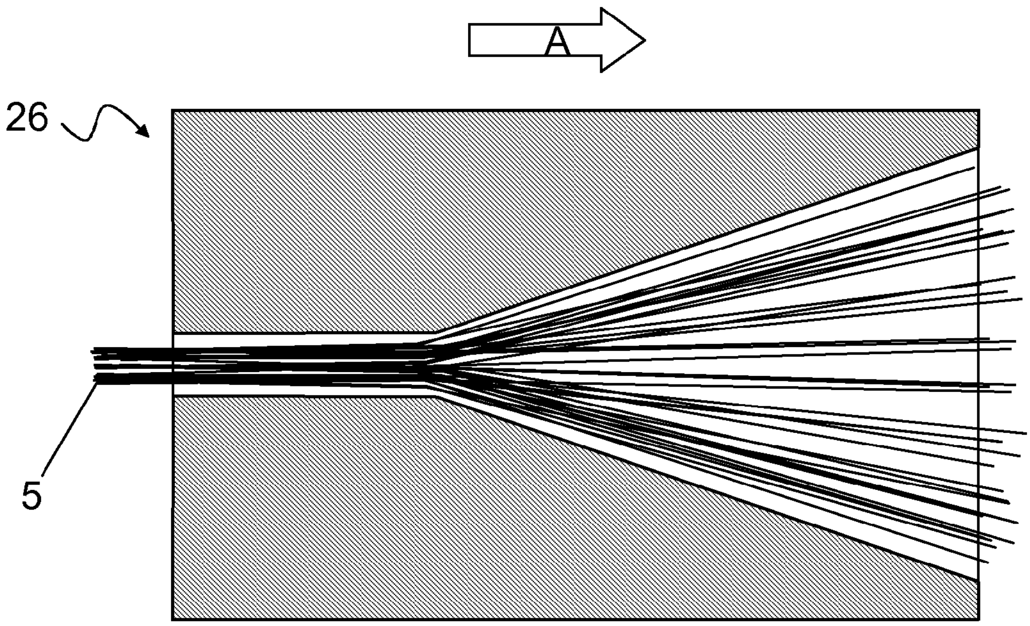


Fig.10

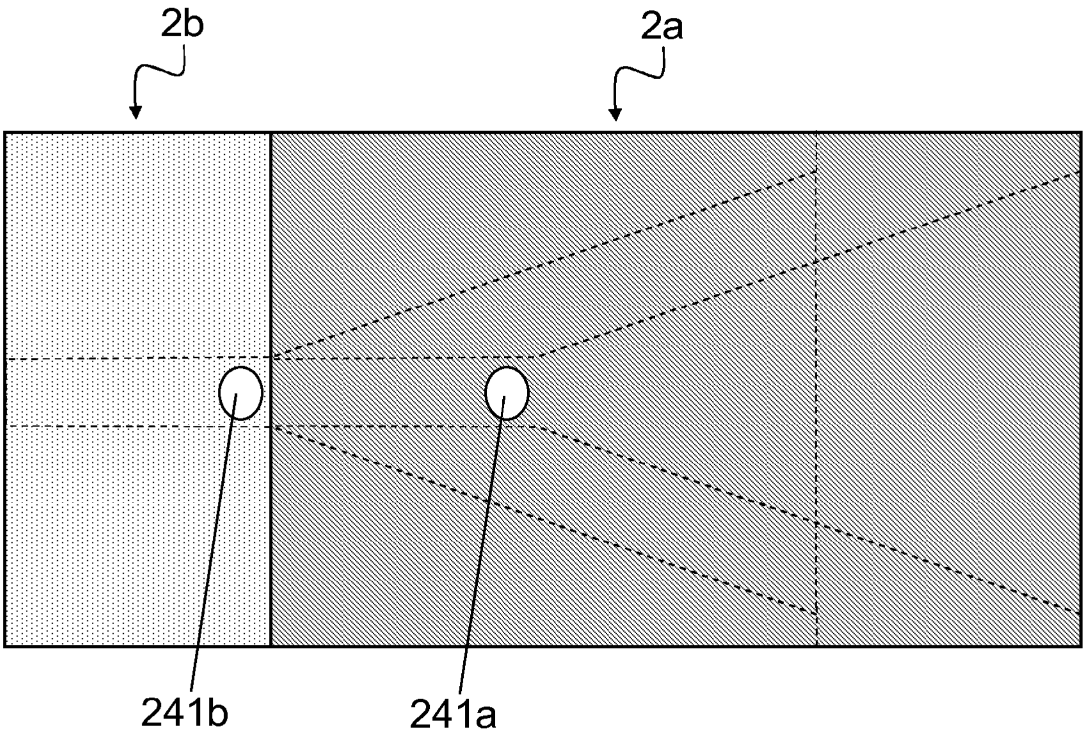
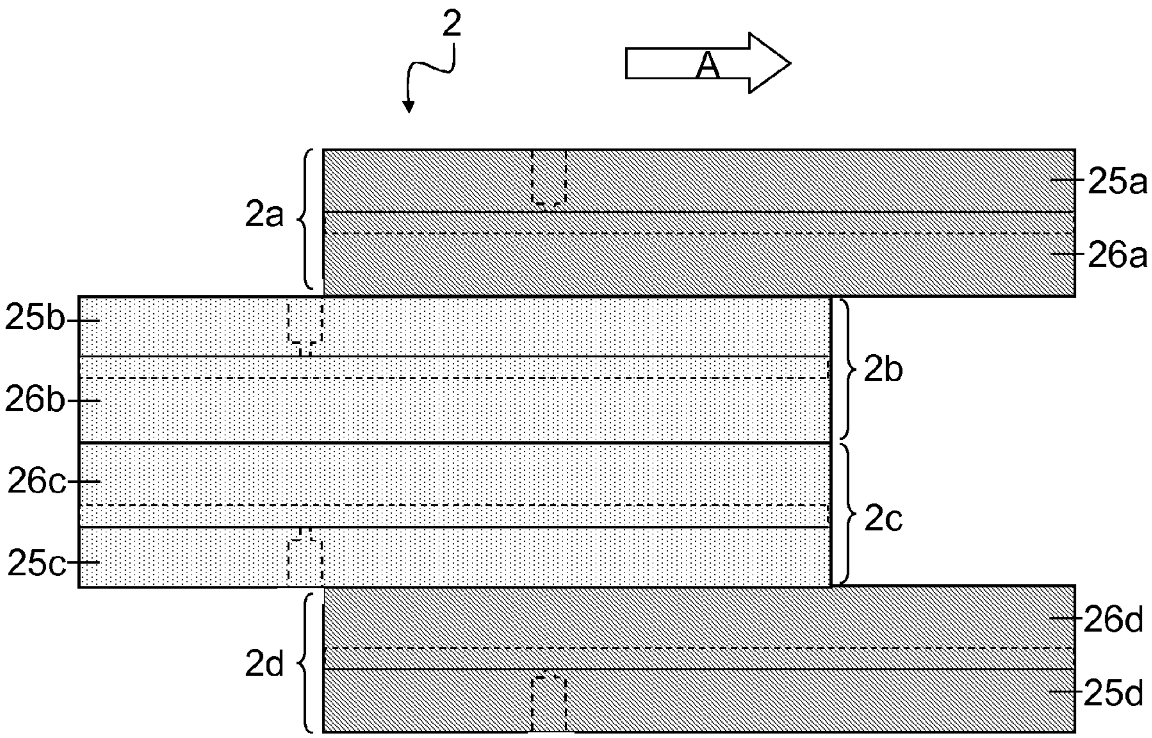


Fig.11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2d
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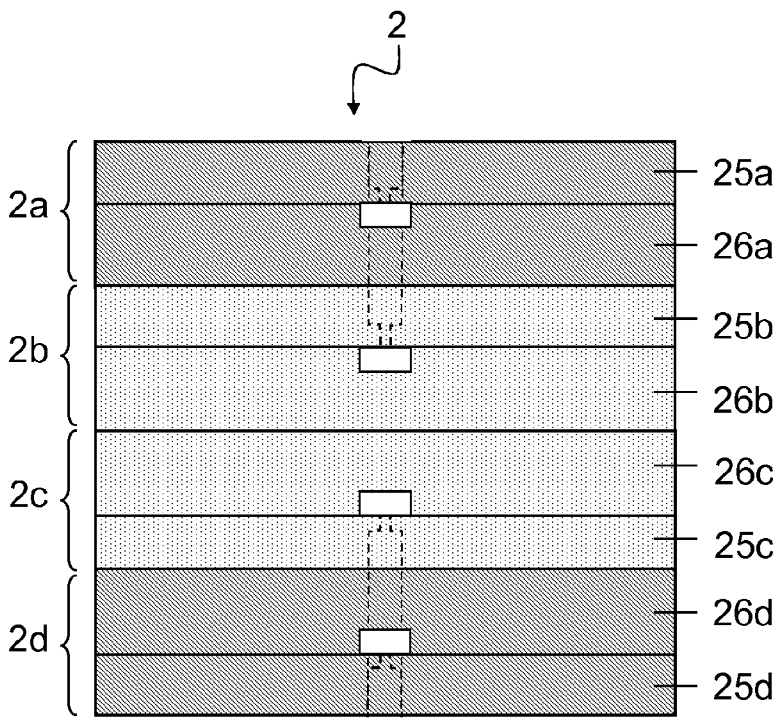
Fig.12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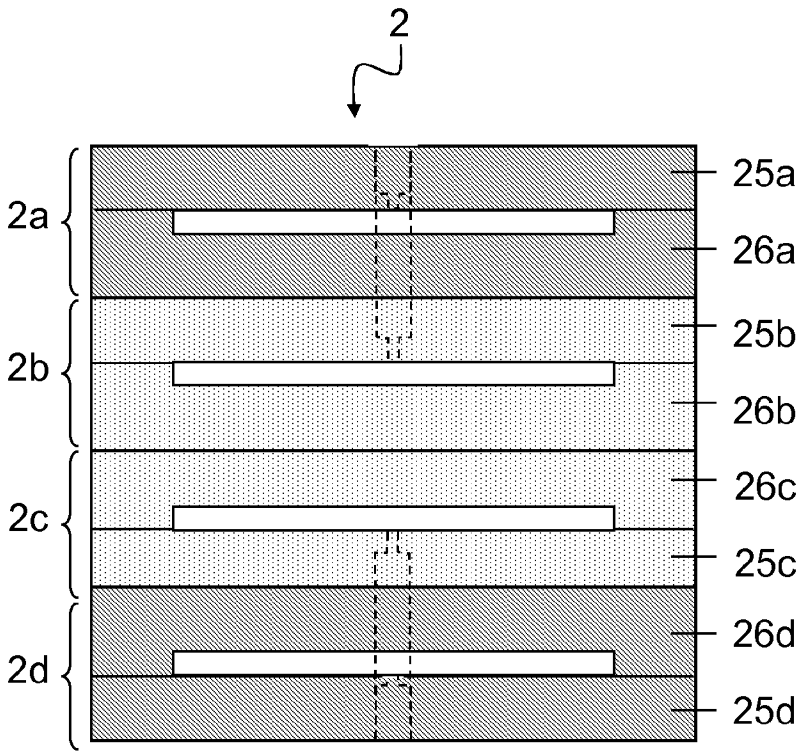
25d

Fig.13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26d
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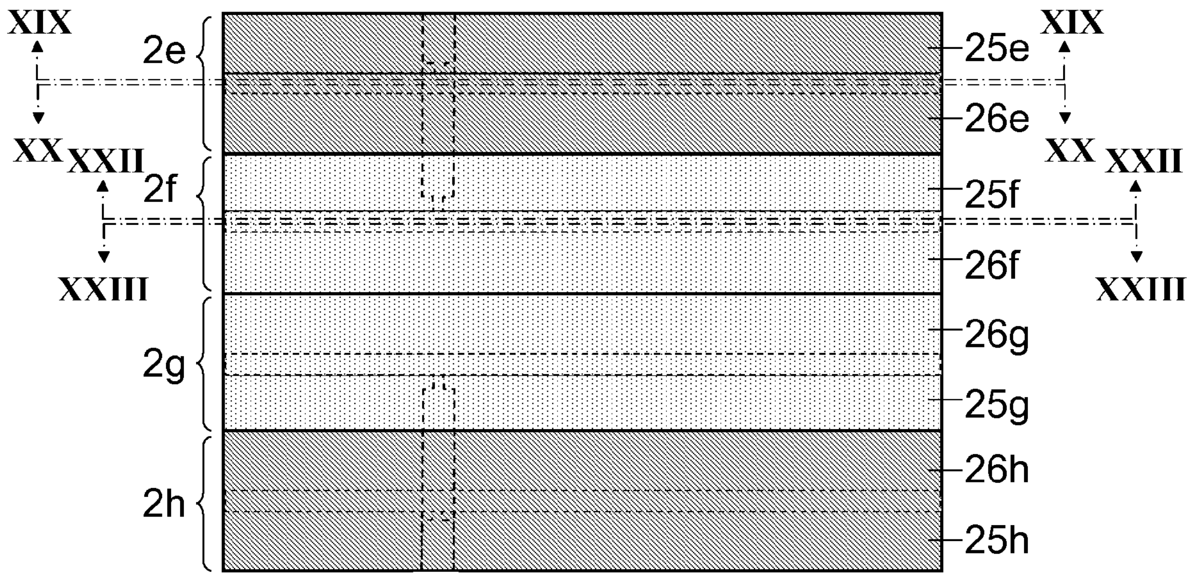
Fig.14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XXIII
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25h
XIX
XX
XXII
XXIII

Fig.15

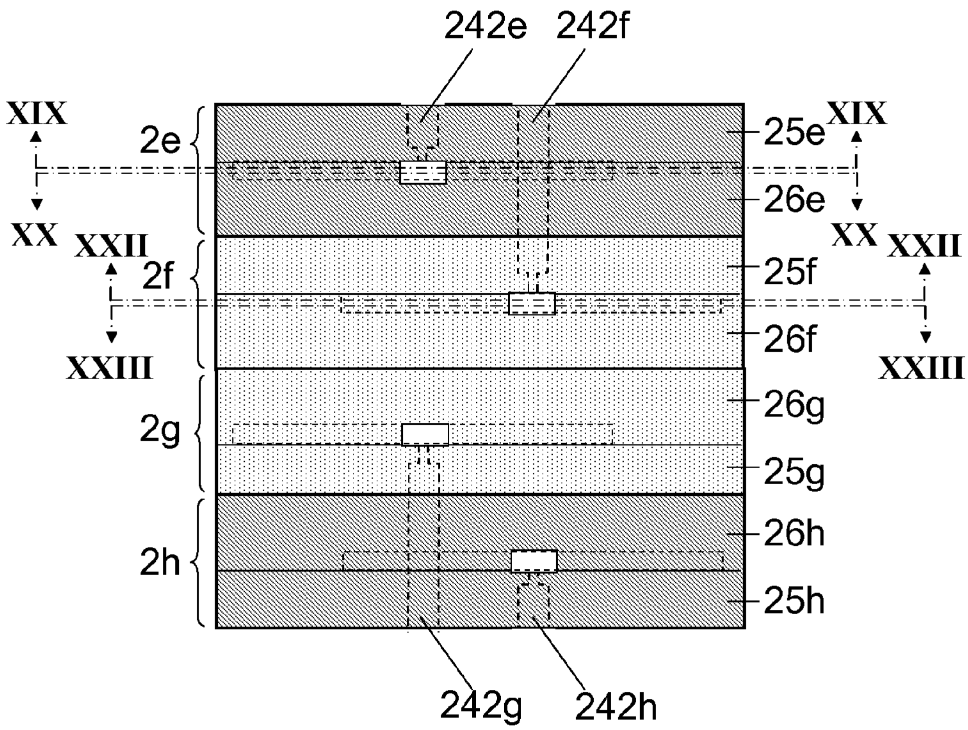
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Fig.16

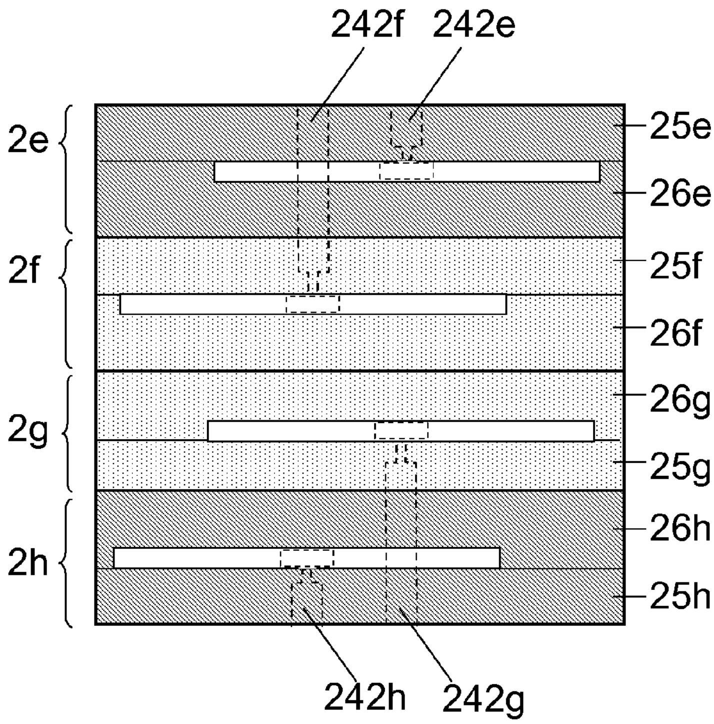
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Fig.17

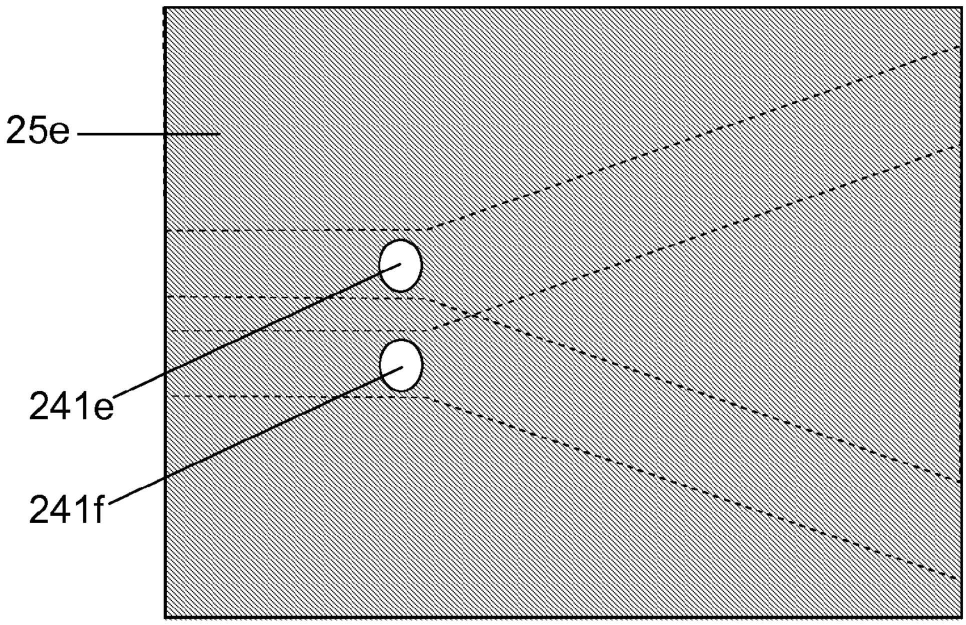

Fig.18

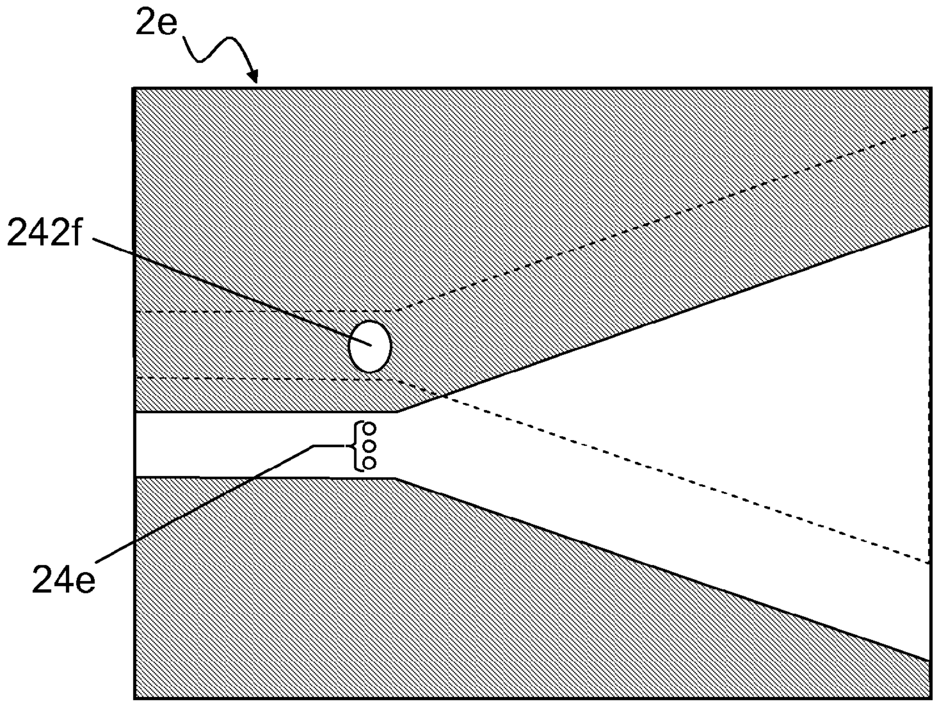

Fig.19

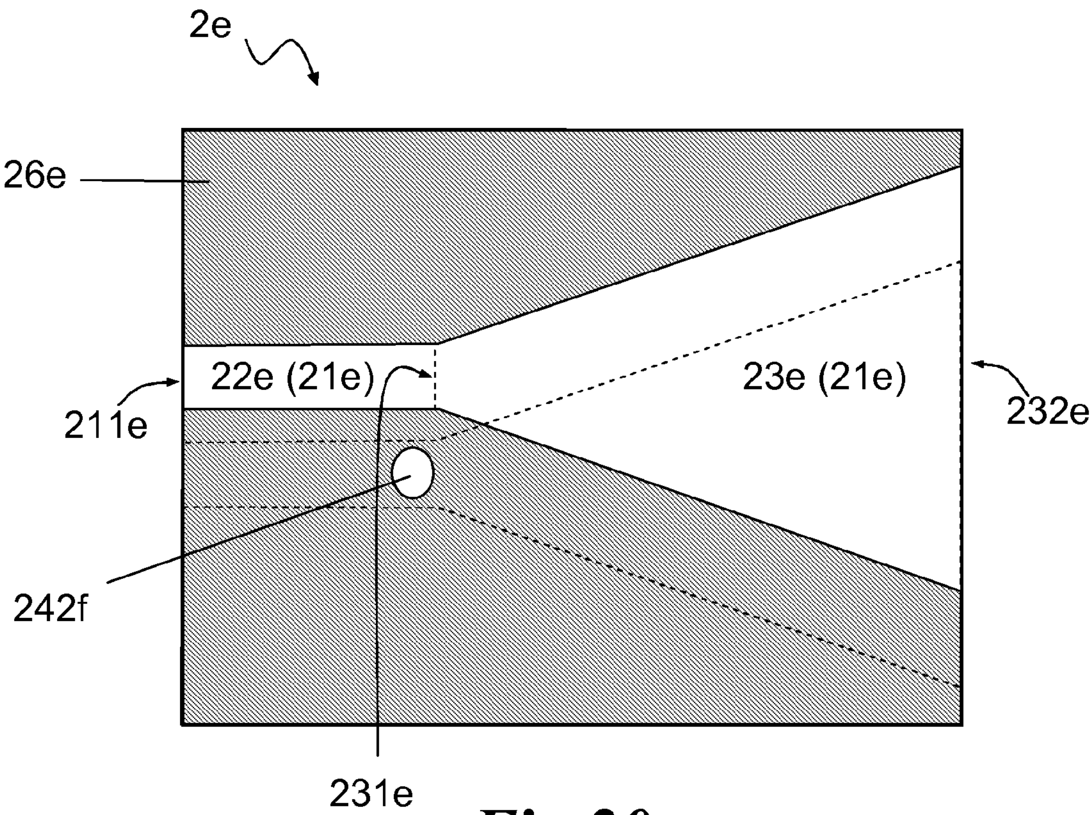

Fig.20

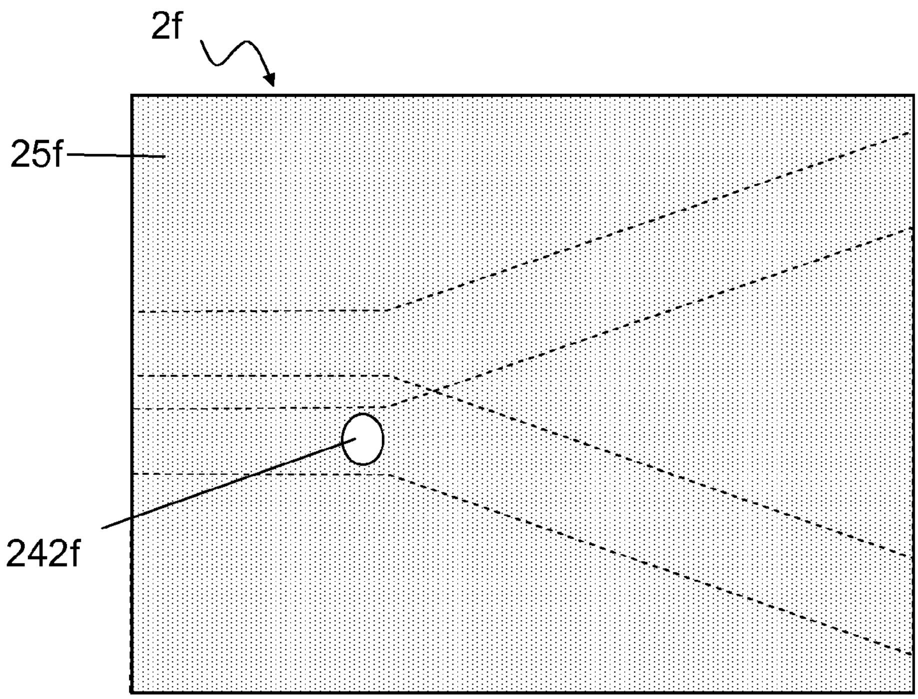

Fig.21

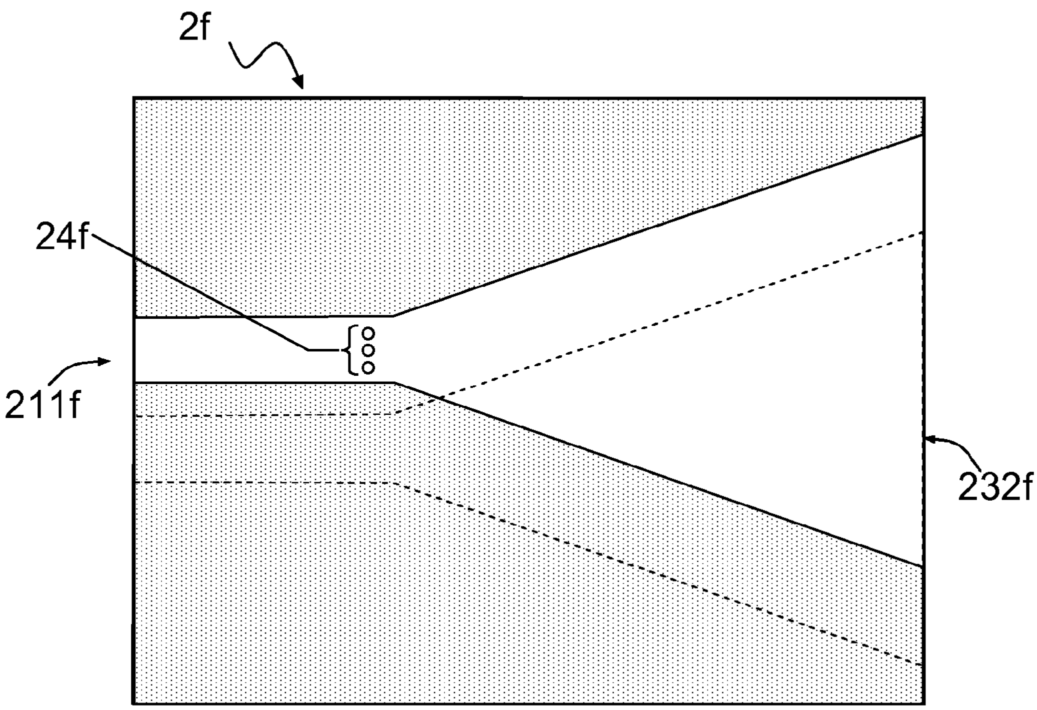

Fig.22

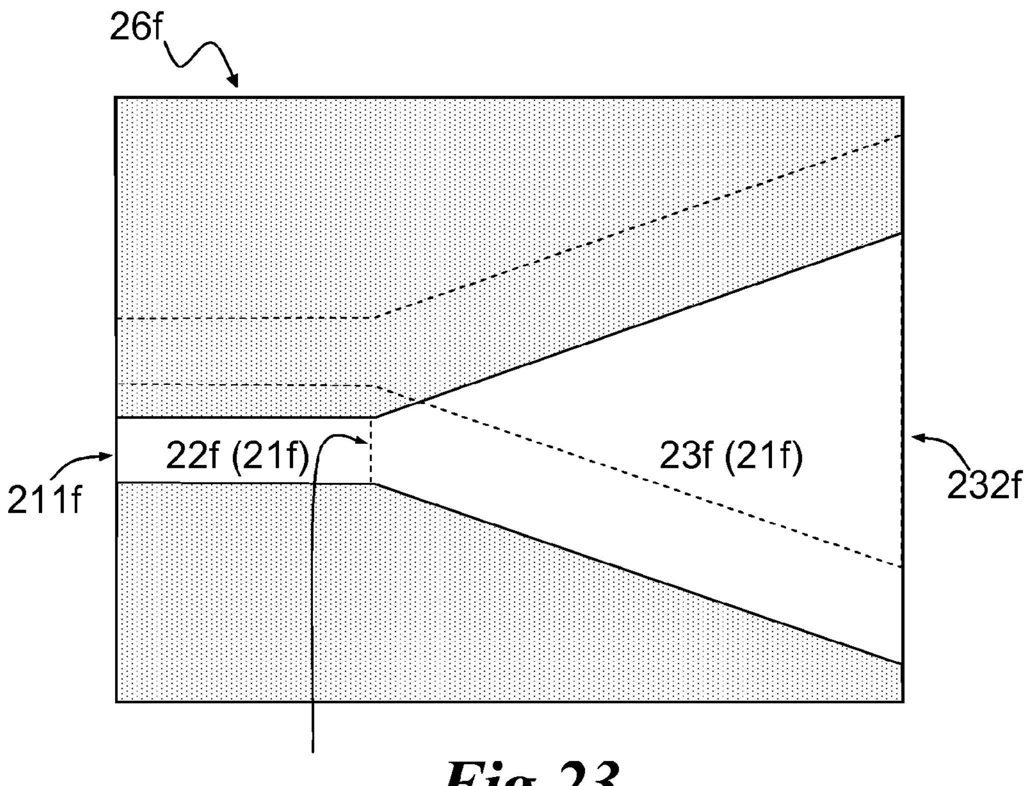

Fig.23

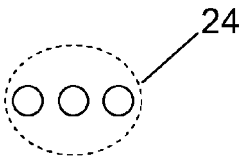

Fig.24

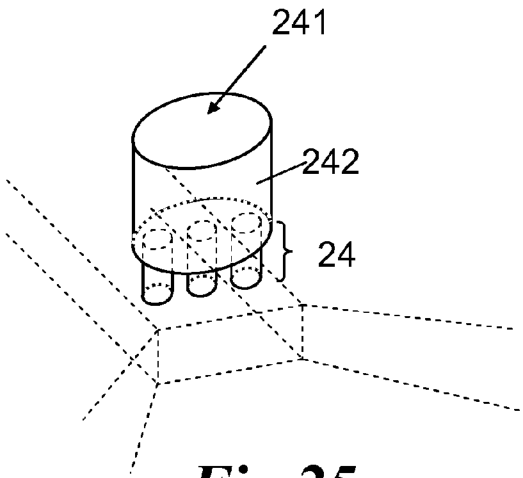

Fig.25

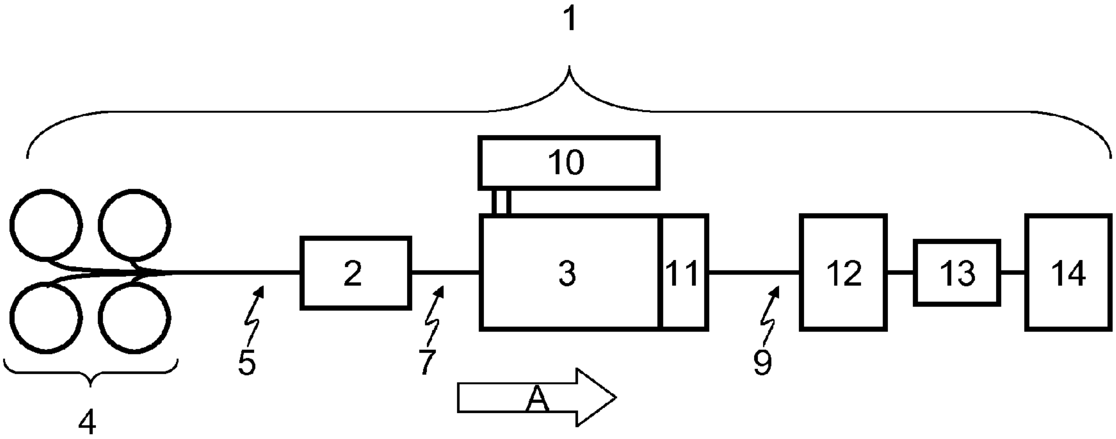

Fig.26

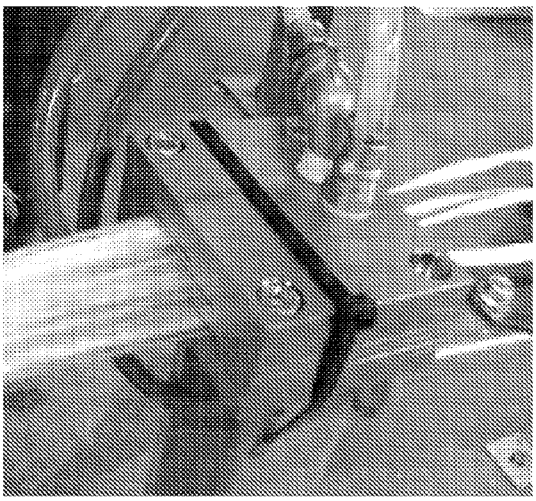

Fig.27

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 0270

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 August 2010	Verschuren, Johan

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Application Number
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The Hague	13 August 2010	Verschuren, Johan

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