(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 009 150 B2

(12) NEW EUROPEAN PATENT SPECIFICATION
After opposition procedure

(45) Date of publication and mention of the opposition decision:
10.01.2018 Bulletin 2018/02

(45) Mention of the grant of the patent:
05.03.2014 Bulletin 2014/10

(21) Application number: **08010201.5**

(22) Date of filing: **04.06.2008**

(51) Int Cl.:
D01H 1/115 *(2006.01)*

(54) Air-jet spinning machine

Luftdüsen Spinnmaschine

Machine à filer à jets d'air

(84) Designated Contracting States:
CH DE LI

(30) Priority: **04.06.2007 JP 2007148338**
04.06.2007 JP 2007148339
21.06.2007 JP 2007164202

(43) Date of publication of application:
31.12.2008 Bulletin 2009/01

(73) Proprietor: **Murata Machinery, Ltd.**
Kyoto 601 (JP)

(72) Inventors:
- **Yokota, Itaru**
Kyoto-shi
Kyoto 612-8686 (JP)
- **Toyoda, Takahiro**
Kyoto-shi
Kyoto 612-8686 (JP)
- **Morita, Akihiro**
Kyoto-shi
Kyoto 612-8686 (JP)

(74) Representative: **Weickmann & Weickmann PartmbB**
Postfach 860 820
81635 München (DE)

(56) References cited:
EP-A- 1 347 085
EP-A- 1 826 299
WO-A-03/014443
JP-A- 2003 193 337
US-A- 5 263 310

EP 2 009 150 B2

Description

[0001] The present invention relates to a spinning machine, and especially relates to a spinning machine for manufacturing a spun yarn by using swirling airflow.

[0002] A spinning machine for manufacturing a spun yarn by using swirling airflow includes a draft device and a spinning device along a yarn feeding direction in which a spun yarn is made of a fiber bundle. The spinning device includes a needle block having a needle, a nozzle block forming a space part into which a fiber bundle is introduced, and a spindle inserted into the space part. An air nozzle having an outlet opening at the space part is formed in the nozzle block. An inner periphery wall of the nozzle block that is a periphery wall of the space part is broad toward the end and inclined toward a down stream side of the yarn feeding direction. In the spindle, a hollow yarn passage hole is formed in its axis direction, and a tip of the spindle is formed in a truncated cone shape. A part of the outlet of the air nozzle is arranged at a position facing a reversal chamber that is a space between the needle block and the tip of the spindle. In such configured spinning machine, air is injected from the air nozzle to the tip of the spindle, a swirling airflow is generated in a swirling airflow generation chamber that is a space formed between the nozzle block and the spindle. Fibers in a part of the fiber bundle fed from the draft device and introduced into the swirling airflow generation chamber, twine fibers, are reversed and swirl along the inner periphery wall of the nozzle block due to the swirling airflow. The twine fibers twine around central fibers of the fiber bundle continuously introduced into the yarn passage hole, that is, the core fibers, and a spun yarn is manufactured via the thread passage hole (for example, refer to patent document 1).

[0003] Patent document 1: Japanese Unexamined Patent Publication No. 2003-193337

[0004] In a conventional spinning machine described above, there is a case where a swirling airflow generation chamber is constituted to be narrow in order to efficiently generate a swirling airflow by efficiently using energy of air and a diameter of the space part in the swirling airflow generation chamber is small with respect to fiber lengths of reversed twine fibers. In this case, the reversed fibers easily entwine each other during swirling in the swirling airflow generation chamber. When the reversed fibers have entwined each other, these fibers are disarranged in their twining configuration to be drawn into a yarn passage hole of a spindle. Unnecessary asperity is produced in a spun yarn manufactured in such manner, and physical property of the spun yarn such as feeling is deteriorated.

[0005] US 5263310 (A) discloses a spinning apparatus which imparts a turning air stream to an untwisted short fiber bundle drafted by a draft device to twist it to produce a spun yarn. A guide member supporting body having an extreme end projected conically is secured within a nozzle block for imparting a turning air stream to a fiber bundle moved out of a draft device, and the guide member supporting body having one side cut to form a gap adjacent to the nozzle block. Yarns can be manufactured by variously changing an angle of inclination alpha of the nozzle with respect to the moving direction of the fiber bundle in the range of 45 DEG to 90 DEG. In this case, however, a jet air stream is always blown out in the vicinity of the inlet of the spindle even if the angle of inclination alpha of the nozzle is changed. The diameter of the nozzle is 0.8 mm. It is found from the result that the angle of winding fibers of the yarn to be manufactured increases as the angle of inclination alpha of the nozzle increases. That is, the number of twists of the yarn increases. In order to obtain the yarn having the number of twists that is satisfactory, the angle of inclination alpha of the nozzle was 70 to 90 DEG.

[0006] The present invention is provided to solve the problems described above and intends to provide a spinning machine which can make it harder for reversed twine fibers in swirling to be entwined.

[0007] The present invention refers to a spinning machine according to claims 1 and 2.

[0008] To accomplish above described purpose, a first aspect of the present invention is a spinning machine which manufactures a spun yarn with swirling partial fibers in a fiber bundle by a swirling airflow comprising: a draft device having a front roller pair for feeding the fiber bundle while nipping the fiber bundle; and a spinning device installed at a downstream side of the yarn feeding direction with respect to the draft device, wherein the spinning device includes: a nozzle block having a cylindrical space part; a spindle arranged concentrically in the cylindrical space part of the nozzle block, a fiber bundle introduction block having an introduction path into which the fiber bundle is fed from the draft device and is introduced into a yarn passage hole of the spindle, a reversal chamber formed between the fiber bundle introduction block, the inner periphery wall of the nozzle block and the tip of the spindle, and air nozzles formed in the nozzle block and inclining to the downstream side of the yarn feeding direction toward the cylindrical space part.

[0009] In the configuration of the first aspect of the present invention, the spinning machine is characterized in that the relationship of

$$T \geq L\cos\theta/\pi$$

is satisfied where T is the diameter of the cylindrical space part of the nozzle block, θ is the inclination angle of the air nozzles with respect to a plane surface orthogonal to the axis direction of the cylindrical space part and L is the length from the nipping point of the front roller pair of the draft device to the center of the entrance of the yarn passage hole of the spindle.

[0010] With such configuration, since fibers to be twine fibers after reversing by a swirling airflow go around or less along a periphery wall of the space part in being reversed and in a planer view seen from the axis direction of the space part, a possibility of entwining of the fiber by itself is reduced.

[0011] In the conventional spinning device described above, in order to stably generate a swirling airflow, it is required to set a clearance between an inner periphery wall of the nozzle block and an outer periphery wall of the spindle to be an appropriate size with respect to a diameter of an outlet of the air nozzle on a plane surface orthogonal to an axis direction of the air nozzle. When the clearance is too large, air injected from the air nozzle will be dispersed, and by contraries, when the clearance is too small, the air will stagnate and counterflow. If a stable swirling airflow cannot be generated, the reversed twine fibers are hard to twine on a core fiber uniformly and a spun yarn with a weak yarn strength will be manufactured as a result.

[0012] The present invention is provided to solve the problems mentioned above, and intends to provide a spinning device which can stabilize the swirling airflow and manufacture a spun yarn with a predetermined yarn strength.

[0013] To accomplish above described purpose, a second aspect of the present invention is a spinning device which manufactures a spun yarn with swirling partial fibers in a fiber bundle by a swirling airflow comprising: a draft device having a front roller pair for feeding the fiber bundle while nipping the fiber bundle, and a spinning device installed at a downstream side of the yarn feeding direction with respect to the draft device, wherein the spinning device includes : a nozzle block having a space part, a spindle arranged in the space part of the nozzle block, wherein the clearance between the inner periphery wall of the nozzle block and the outer periphery wall of the spindle is constant within a range of a predetermined length along the axis direction of the spindle, a fiber bundle introduction block having an introduction path into which the fiber bundle is fed from the draft device and is introduced into a yarn passage hole of the spindle, the tip of the spindle having a plane surface, a reversal chamber formed between the fiber bundle introduction block, the inner periphery wall of the nozzle block and the plane surface of the tip of the spindle, and air nozzles formed in the nozzle block and inclining to the downstream side of the yarn feeding direction toward the space part, wherein the relation of

$$0.7D \leq S \leq 1.3D$$

is fulfilled,
where S is the constant clearance and D is the diameter of the outlet of the air nozzles on a plane surface orthogonal to the axis direction of the air nozzles.

[0014] With such configuration, a swirling airflow swirling between the inner periphery wall of the nozzle block and the outer periphery wall of the spindle hardly spreads, stagnates, and counterflows and is stabilized.

[0015] In a preferred embodiment of the present invention according to the second aspect the outlets of the air nozzles are formed on the inner periphery wall of the nozzle block within the range of the predetermined length.

[0016] With such configuration, air injected from the air nozzles does not rapidly spread.

[0017] Referring to the enclosed drawings, an embodiment of the present invention will be explained next.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a perspective view showing an outlined configuration of a spinning machine according to a first embodiment of the present invention.

Fig. 2 is a longitudinal cross-section view showing an outlined configuration of a part near a tip of a spindle of a spinning device shown in Fig. 1.

Fig. 3 is a horizontal cross-section view showing an outlined configuration near a part of an air nozzle of the spinning device shown in Fig. 2.

Fig. 4 is a view schematically showing a status where a twine fiber swirls along a periphery wall of a cylindrical space part of a nozzle block shown in Figs. 2 and 3.

Fig. 5(1) is a development view of the periphery wall of the cylindrical space part in the nozzle block shown in Figs. 2 and 3 within a range of a predetermined length, Fig. 5(2) is a schematic view showing a status where a plurality of the twine fibers continuously swirls on the development view of Fig. 5(1), and Fig. 5(3) is a schematic view showing a status where a plurality of the twine fibers continuously swirls on a development view with a smaller diameter of a cylindrical space part than that of Fig. 5(1).

Fig. 6 is a longitudinal cross-section view showing an outlined configuration of a part near a tip of a spindle of the spinning device shown in Fig. 1.

Fig. 7 is a view showing a relationship between the yarn strength ratio indicated by 100% at a maximum value and a clearance S/a diameter D of an air nozzle outlet.

Fig. 8 is a longitudinal cross-section view showing an outlined configuration of the part near the tip of the spindle of the spinning device shown in Fig. 1.

[0019] Fig. 1 is a perspective view showing an outlined configuration of a spinning machine according to a first embodiment of the present invention.

[0020] Referring to Fig. 1, a spinning machine 10 includes a can 11, a draft device 12, a spinning device 13, a yarn feeding device 14, a yarn defect detection device 15, and a winding device 16 along a yarn feeding direction in which a spun yarn 18 is made of a fiber bundle 17 from an upstream side. The can 11 houses the fiber bundle 17 produced by a drawing frame machine.

[0021] The draft device 12 is a device for nipping the fiber bundle 17 drawn from the can 11 to extend it, and includes four pairs of rollers, a back roller pair 19, a third roller pair 20, a second roller pair 21, and a front roller pair 22 from the upstream side in the yarn feeding direction. An apron belt 26 is installed in each roller of the second roller pair 21.

[0022] The spinning device 13 is a device for providing swirling airflow to the fiber bundle 17 fed from the front roller pair 22 of the draft device 12 to manufacture the spun yarn 18, and details thereof will be described below.

[0023] The yarn feeding device 14 is a device for feeding the spun yarn 18 manufactured by the spinning device 13 to the winding device 16 arranged in the downstream side of the yarn feeding direction. The yarn feeding device 14 includes a delivery roller 23 and a nip roller 24 being able to freely contact to and move away from the delivery roller 23, and the spun yarn 18 nipped between the delivery roller 23 and the nip roller 24 is fed to the winding device 16 by rotation drive of the delivery roller 23.

[0024] The yarn defect detection device 15 is a device for detecting a yarn defect of the spun yarn 18 at the middle of the feeding to the winding device 16. A defect part is removed based on yarn defect detection information produced by the yarn defect detection device 15, and defective yarn is prevented from being wound on a package 25. In addition, the yarn defect detection device 15 includes a cutoff device, which is not shown in the figure, for cutting the spun yarn 18 off depending on detection of a yarn defect, and the spinning machine 10 includes a piecing device for piecing both ends of the spun yarn 18 cut off once, which is not shown in the figure.

[0025] The winding device 16 is a device for winding the spun yarn 18 manufactured by the spinning device 13 on a bobbin 27 supported by a bobbin holder which is not shown in the figure to manufacture the package 25.

[0026] The spinning device 13 described above will be explained next.

[0027] Fig. 2 is a longitudinal cross-section view showing an outlined configuration of a part near a tip of a spindle of the spinning device shown in Fig. 1, and Fig. 3 is a cross-section view showing an outlined configuration of a part of an air nozzle of the spinning device shown in Fig. 2.

[0028] Referring to Figs. 2 and 3, the spinning device 13 includes a fiber bundle introduction block 30, a nozzle block 33 forming a space part 55, a spindle 38 inserted to the space part 55 at its tip 42 side from the downstream side of the yarn feeding direction along the yarn feeding direction in which the spun yarn 18 is made of the fiber bundle 17. Specifically, the space part 55 is composed of a cylindrical space part 43 formed in a cylindrical shape and a truncated cone space part 49 which is connected to a downstream side of the cylindrical space part 43 and where a diameter of a connected surface at an upstream side is the same as a diameter of the cylindrical space part 43 and enlarges toward a downstream side. The nozzle block 33 and the spindle 38 are arranged concentrically to each other. The spindle 38 is arranged with being separated from the fiber bundle introduction block 30 and the nozzle block 33 so as not to contact both of them. In the fiber bundle introduction block 30, an introduction path 32 into which the fiber bundle 17 fed from the draft device 12 is introduced is formed so as to pierce the fiber bundle introduction block 30 along the yarn feeding direction. In addition, a cylindrical space, that is, a reversal chamber 36 is formed between the fiber bundle introduction block 30 and the tip 42 of the spindle 38, and a cylindrical space, that is, a swirling airflow generation chamber 37 is formed between an inner periphery wall 44 of the nozzle block 33 and an outer periphery wall 45 of the spindle 38. A yarn passage hole 39 is formed with piercing the spindle 38 along an axis direction of the spindle 38 at a center core position of the axis. The aforementioned introduction path 32, the swirling airflow generation chamber 37, and the yarn passage hole 39 are communicated with each other via the reversal chamber 36.

[0029] The fiber bundle introduction block 30 includes a needle-shaped guide member 31 projecting its tip into the reversal chamber 36 that is a part of the cylindrical space part 43 so that the tip faces an entrance of the yarn passage hole 39. A part of the fiber bundle 17 introduced in the reversal chamber 36, that is, a core fiber positioning at the center of the fiber bundle 17 is inducted in the yarn passage hole 39 due to the guide member 31. In addition, a projection length toward a yarn passage hole 39 side of the guide member 31 can be freely adjusted.

[0030] A plurality of air nozzles 34 inclining to the downstream side of the yarn feeding direction toward the cylindrical space part 43, a cross section of which is circular, is formed in the nozzle block 33. Outlets 35 of the air nozzles 34 open on the inner periphery wall 44 of the nozzle block 33, that is, a periphery wall of the cylindrical space part 43. In addition, each of six air nozzles 34 is formed with being arranged at even interval along a direction of a tangent line of a circle formed by the inner periphery wall 44 of the nozzle block 33 as shown in Fig. 3. When air is equally injected from each of the air nozzles 34 by an air supply means which is not shown in the figure, a swirling airflow which swirls at a constant velocity toward an axis of rotation of the spindle 38 is generated in the reversal chamber 36 and the swirling airflow generation chamber 37. In addition, since the air nozzles 34 incline to the downstream side of the yarn feeding direction, the airflow includes not only a swirl component but also a component toward the yarn feeding direction.

[0031] The spindle 38 includes a cylindrical part 40 which is formed so as to have slightly smaller contour than that of the cylindrical space part 43 of the nozzle block 33 and where an edge of the tip 42 is rounded and includes a truncated cone part 41 where a diameter of a connected surface on the upstream side of the yarn feeding direction is the same as the diameter of the cylindrical part 40 and is enlarged toward the downstream side, and forms aforementioned yarn passage hole 39 in which the spun yarn 18 passes. A part from the tip 42 of the spindle to a middle portion of the truncated cone part 41 is inserted to the space part 55 of the nozzle block 33.

[0032] A manufacturing process of the spun yarn 18 will be explained next.

[0033] Fig. 4 is a view schematically showing a status where a twine fiber swirls along the periphery wall of the cylindrical space part of the nozzle block shown in Figs. 2 and 3.

[0034] At first, referring to Fig. 4, the fiber bundle 17 fed from the front roller pair 22 of the draft device 12 is introduced in the reversal chamber 36 via the introduction path 32 formed in the fiber bundle introduction block 30. The fiber bundle 17 is twined on the guide member 31 nearly halfway. A swirling airflow is generated in the swirling airflow generation chamber 37 connected to the reversal chamber 36 and to the downstream side of the yarn feeding direction of the reversal chamber 36 toward a direction indicated by arrowed lines in Figs. 2 and 3. Outside air is aspirated from the introduction path 32 because the swirling airflow has the component toward the yarn feeding direction as described above, thus the fiber bundle 17 is easily introduced to the reversal chamber 36.

[0035] Next, center fiber of the fiber bundle 17 introduced to the reversal chamber 36, that is, a core fiber is introduced to the yarn passage hole 39 with twining on the guide member 31. Other fibers in the fiber bundle 17, that is, twine fibers 46 are introduced to the yarn passage hole 39 with twining on the core fiber at its end part on the downstream side of the yarn feeding direction. And, the twine fibers 46 leave the front roller pair 22 at an end part on the upstream side of the yarn feeding direction, are reversed due to the component toward the yarn feeding direction of the swirling airflow as shown by a two-dot chain line in Fig. 2, and are introduced to the swirling airflow generation chamber 37. Since the end part of the twine fibers 46 on the downstream side of the yarn feeding direction are restrained and introduced to the yarn passage hole 39 with twining on the guide member 31, fibers to be loss without being used for manufacturing the spun yarn 18 can be reduced.

[0036] Next, the reversed twine fibers 46 swirl along the inner periphery wall 44 of the nozzle block 33 due to a swirl component of the swirling airflow as shown in Fig. 4, and twine on the core fiber which is continuously introduced to the yarn passage hole 39.

[0037] Next, the core fiber on which the twine fibers 46 are twined is fed from the spinning device 13 via the yarn passage hole 39. Thus, the spun yarn 18 is manufactured.

[0038] The diameter of the cylindrical space part 43 formed in the nozzle block 33 will be explained here.

[0039] Referring to Fig. 2, it is assumed that the diameter of the cylindrical space part 43 is T, the inclination angle of the air nozzle 34 with respect to a plane surface orthogonal to the axis direction of the cylindrical space part 43 is θ, and the length from the nipping point P at which the twine fibers 46 nipped by the front roller pair 22 are released to the center R of the entrance of the yarn passage hole 39 is L. Since the fiber bundle 17 has a predetermined width, the nipping point at which the twine fibers 46 nipped by the front roller pair 22 are released also has a predetermined width along the axis direction of the front roller pair 22. The nipping point P is a nipping point configuring the shortest path where the fiber bundle 17 can travel among some nipping points with a predetermined width. In addition, the length L is almost the same as a length of a path where the fiber bundle 17 travels from the nipping point P of the front roller pair 22 to the center R of the entrance of the yarn passage hole 39. Moreover, the length L is almost the same as a length of a portion projecting outward from the entrance of the yarn passage hole 39 of the twine fiber 46 in being reversed, that is, a length of the swirling portion in being reversed. And, when a relation of

$$T \geq L\cos\theta/\pi,$$

is assumed, the twine fibers 46 reversed by a swirling airflow almost go around along the periphery wall of the cylindrical space part 43, that is, the inner periphery wall 44 of the nozzle block 33 in being reversed and in a planer view seen from the axis direction of the cylindrical space part 43. In addition, since a fiber length of the twine fibers 46 are not constant, all the twine fibers 46 do not almost go around necessarily.

[0040] Fig. 5(1) is a development view of the periphery wall of the cylindrical space part in the nozzle block shown in Figs. 2 and 3 within a range of the predetermined length, Fig. 5(2) is a schematic view showing a status where a plurality of the twine fibers continuously swirls on the development view of Fig. 5(1), and Fig. 5(3) is a schematic view showing a status where a plurality of the twine fibers continuously swirls on a development view with a smaller diameter of a cylindrical space part than that of Fig. 5(1).

[0041] Referring to Fig. 5(1), in the spinning device 13 having a relation of the expression

$$T \geq L\cos\theta/\pi,$$

the length L goes around along the periphery wall 44 of the nozzle block 33 within a range of a predetermined length H in an axis direction on the cylindrical space part 43 and in the planer view seen from the axis direction of the cylindrical space part 43. The predetermined length H is a length along the axis direction of the cylindrical space part 43 in an area where the twine fibers 46 swirl. Referring to Fig. 5(2), a status where a plurality of twine fibers 50, 51, 52, and 53 corresponding to the length L in being reversed continuously swirls on the development view shown in Fig. 5(1) is schematically shown for example. The respective twine fibers 50, 51, 52, and 53 go around and along the periphery wall 44 of the nozzle block 33 in being reversed and in the planer view seen from the axis direction of the cylindrical space part 43. For example, there is no overlapping part in one piece of the twine fiber 50. Referring to Fig. 5(3), a status where a plurality of twine fibers 50, 51, 52, and 53 corresponding to the length L in being reversed continuously swirls on the development view with a smaller diameter of a cylindrical space part 43 than that of Fig. 5(1) is schematically shown similar to Fig. 5(2). In this case, since the diameter of the cylindrical space part 43 is smaller than that of Fig. 5(1), the respective twine fibers 50, 51, 52, and 53 go around and more in being reversed and in the planer view seen from the axis direction of the cylindrical space part 43. For example, there is an overlapping part a in one piece of the twine fiber 50.

[0042] Meanwhile, the reversed twine fibers 46 swirl along the periphery wall 44 of the nozzle block 33 and twine on the core fiber continuously introduced to the yarn passage hole 39 as described above, thus the spun yarn 18 is manufactured. The reversed twine fibers 46 are gradually introduced to the yarn passage hole 39 with swirling in the swirling airflow generation chamber 37 in this case. Accordingly, when the respective twine fibers 50, 51, 52, and 53 go around and more in being reversed and in the planer view seen from the axis direction of the cylindrical space part 43 as shown in Fig. 5(3), the respective twine fibers 50, 51, 52, and 53 can be easily entwined to each other when introduced to the yarn passage hole 39. On the other hand, when the respective twine fibers 50, 51, 52, and 53 go around in being reversed and in the planer view seen from the axis direction of the cylindrical space part 43 as shown in Fig. 5(2), the respective twine fibers 50, 51, 52, and 53 can be hardly entwined each other when introduced to the yarn passage hole 39. In addition, the twine fibers 46 cannot go around if a diameter T of the cylindrical space part 43 is enlarged, however, a trouble such as a lack of stability of the swirling airflow because of too much enlargement of the swirling airflow generation chamber 37 occurs, which results in an effect on a size of the entire spinning device 13. Therefore it is not appropriate to simply and indefinitely enlarge only the diameter T of the cylindrical space part 43.

[0043] In the spinning machine 10 including the spinning device 13 described above, the twine fibers 46 reversed by the swirling airflow almost go around and along the periphery wall of the cylindrical space part 43 with drawing a circle in being reversed and in a planer view seen from the axis direction of the cylindrical space part 43. That is to say, there is no overlapping part in one piece of the twine fiber 46. For this reason, the twine fibers 46 can smoothly swirl and the swirling twine fibers 46 can be hardly entwined to each other, thus a spun yarn 18 having good feeling can be manufactured.

[0044] Six air nozzles are formed in the above described embodiment. However, such configuration is not necessarily required and the number of the air nozzles may be varied.

[0045] Here, a relation of a clearance between the inner periphery wall 44 of the nozzle block 33 and the outer periphery wall 45 of the spindle 38 with diameters of the outlets 35 of the air nozzles 34 will be explained.

[0046] Referring to Figs. 3 and 6, it is assumed that the clearance between the inner periphery wall 44 of the nozzle block 33 and the outer periphery wall 45 of the spindle 38 within a range of the predetermined length H in the axis direction of the spindle 38 is S and that the diameters of the outlets 35 on a plane surface orthogonal to the axis direction of the air nozzles 34 are D. The length H is a length in the axis direction of the spindle 38 from a surface at an uppermost stream side in the yarn feeding direction of the cylindrical part 40 other than the rounded part of the spindle 38 to a surface at a lowermost stream side of the cylindrical space part 43 formed in the nozzle block 33. Within a range of the length H, the cylindrical space part 43 constituting the inner periphery wall 44 and the cylindrical part 40 of the spindle 38 are formed in a cylindrical shape having the same axis as a center. The clearance is accordingly constant at S within the range of the length H.

[0047] In addition, the length H is set to be longer than a length along the axis direction of the spindle 38 in an area where at least the twine fibers 46 swirl. That is, when it is assumed that a shortest path in which the fiber bundle 17 can travel from a nipping point of the front roller pair 22 to a center of the entrance of the yarn passage hole 39 of the spindle 38 is L, a radius of the cylindrical space part 43 is R, and an inclination angle of the air nozzles 34 with respect to a plane surface orthogonal to an axis direction of the cylindrical space part 43 is θ, the length H is set to be longer than a length of $(L-R)\sin\theta$. The length along the axis direction of the spindle 38 in an area where the twine fibers 46 swirl is almost the $(L-R)\sin\theta$. The shortest path L is shorter than an effective fiber length of fibers to be used. The effective fiber length is defined in pages 1093 to 1094 in section 10.1.2 "Fiber length" of chapter 10 "Standard test method" of "Seni binran-process part (2nd edition, 4th print)" MARUZEN Co., Ltd published in 20th January, 1986. Since the length H is set as described above, a stable swirling airflow is provided to the entire swirling twine fibers 46 and the swirling airflow can be effectively generated.

[0048] When the spinning device 13 is configured so as to have a relationship of $0.7D \leq S \leq 1.3D$, the spun yarn 18 having a predetermined yarn strength described next can be manufactured. An injection pressure of air injected from the respective air nozzles 34 is constant regardless of a size of the diameter D. That is, an injection volume per unit time of the air injected from the respective outlets 35 varies in proportion to the size of the diameter D.

[0049] Fig. 7 is a view showing a relationship between the yarn strength ratio indicated by 100% at a maximum value and the clearance S/the diameter D of the air nozzle outlet.

[0050] Referring to Fig. 7, a vertical axis indicates the yarn strength ratio indicated by 100% at a maximum value and a horizontal axis indicates the clearance S/the diameter D of the air nozzle outlet within a predetermined range. The figure shows a curved line formed by connecting the respective yarn strength ratios at 0.5, 0.7, 0.8, 1.0, 1.2, 1.3, and 1.5 of the clearance S/diameter D. The yarn strength ratio is approximately 78% when the clearance S/diameter D is 0.5, and similarly, approximately 87% when 0.7, approximately 95% when 0.8, approximately 100% when 1.0, approximately 92% when 1.2, approximately 87% when 1.3, and approximately 77% when 1.5.

[0051] Since air injected from the air nozzle stagnates and counterflows because the clearance S is too small at 0.5 of the clearance S/diameter D, a stable swirling airflow cannot be generated. For this reason, it can be considered that the reversed twine fibers 46 hardly twine on the core fiber uniformly and the yarn strength is considerably lowered. Meanwhile, since air injected from the air nozzle is spread because the clearance S is too large at 1.5 of the clearance S/diameter D, a stable swirling airflow cannot be generated. For this reason, it can be considered that the reversed twine fibers 46 hardly twine on the core fiber uniformly and the yarn strength is considerably lowered.

[0052] Acceptable lowering ratio of the yarn strength ratio indicated by 100% at a maximum value is approximately 15% in manufacturing the spun yarn 18. In addition, feeling, loss of fiber and the like have to be considered other than the yarn strength in the spun yarn 18, and the yarn strength is sometimes lowered slightly in order to give priority to the feeling and reduction of loss of fiber. When the lowering ratio of the yarn strength ratio is 15%, that is, the yarn strength is 85%, the clearance S/diameter D is approximately 0.67 and 1.33. Accordingly, when the clearance S/diameter D is set to be in a range from 0.7 to 1.3, the yarn strength ratio becomes 85% or more. That is, when the spinning device 13 is configured so as to have the relationship of $0.7D \leq S \leq 1.3D$, lowering of the thread strength of the spun yarn 18 manufactured by the spinning device 13 can be suppressed within a range of 15%.

[0053] In the spinning device 13 configured so as to have the relationship of $0.7D \leq S \leq 1.3D$, since the swirling airflow swirling between the inner periphery wall 44 of the nozzle block 33 and the outer periphery wall 45 of the spindle 38 hardly spreads, stagnates, and counterflows and is stabilized, the swirling of the twine fibers 46 which are fibers introduced to the swirling airflow generation chamber in the fiber bundle 17 is also stabilized. Consequently, the spun yarn having a predetermined yarn strength, that is, the yarn strength ratio of 85% or more in the yarn strength ratio indicated by 100% at a maximum value can be manufactured. In addition, since shapes of the spindle 38 and the cylindrical space part 43 are formed in a cylindrical shape within the range of the length H respectively, the swirling airflow can smoothly flow and can be efficiently generated.

[0054] The space part of the nozzle block and the spindle are formed in a cylindrical shape within a predetermined range in the above mentioned embodiment. However, they may be in other shapes such as a truncated cone shape if the clearance between the inner periphery wall of the nozzle block and the outer periphery wall of the spindle is constant.

[0055] In addition, in the above described embodiment a portion of the space part of the nozzle block is formed in a cylindrical shape. However, the entire space part may be formed in the cylindrical shape.

[0056] Moreover, six air nozzles are formed in the above described embodiment. However, such configuration is not necessarily required and the number of the air nozzles may be varied.

[0057] A cross-section area of the swirling airflow generation chamber 37 shown in Fig. 3 is constant within the range of the length H shown in Fig. 8 along the axis direction of the spindle 38 here. The cross-section area is a cross-section area of a circular area between the inner periphery wall 44 of the nozzle block 33 and the outer periphery wall 45 of the cylindrical part 40 in a plane surface orthogonal to the axis direction of the spindle 38. The length H is a length in the axis direction of the spindle 38 from a surface at an uppermost stream side in the yarn feeding direction of the cylindrical part 40 other than the rounded part of the spindle 38 to a surface at a lower most stream side of the cylindrical space part 43 formed in the nozzle block 33. Within a range of the length H, the cylindrical space part 43 constituting the inner periphery wall 44 and the cylindrical part 40 of the spindle 38 are formed in a cylindrical shape having the same axis as a center. Accordingly, the cross-section area is constant within the range of the length H.

[0058] In addition, the length H is set to be longer than a length along the axis direction of the spindle 38 in an area where at least the twine fibers 46 swirl. That is, when it is assumed that a shortest path in which the fiber bundle 17 can travel from a nipping point of the front roller pair 22 to a center R of the entrance of the yarn passage hole 39 of the spindle 38 is L, a radius of the cylindrical space part 43 is R, and an inclination angle of the air nozzles 34 with respect to a plane surface orthogonal to an axis direction of the cylindrical space part 43 is θ, the length H is set to be longer than a length of $(L-R)\sin\theta$. The length along the axis direction of the spindle 38 in an area where the twine fibers 46 swirl is almost the $(L-R)\sin\theta$. The shortest path L is shorter than an effective fiber length of fibers to be used. The effective fiber length is defined in pages 1093 to 1094 in section 10.1.2 "Fiber length" of chapter 10 "Standard test method" of "Seni binran-process part(2nd edition, 4th print)" MARUZEN Co., Ltd published in 20th January, 1986. Since the length H is set as described above, a stable swirling airflow is provided to the entire swirling twine fibers 46 and the swirling airflow can be effectively generated.

[0059] Each of outlets 35 of the air nozzles 34 is formed in the upstream side of the yarn feeding direction of the inner periphery wall 44 within the range of the length H. Not only a part of the outlets 35 but all of them are formed so as to be included within the range of the length H.

[0060] A manufacturing process of the spun yarn 18 will be explained next.

[0061] At first, referring to Fig. 2, the fiber bundle 17 fed from the front roller pair 22 of the draft device 12 is introduced in the reversal chamber 36 via the introduction path 32 formed in the fiber bundle introduction block 30. The fiber bundle 17 is twined on the guide member 31 nearly halfway. A swirling airflow is generated in the swirling airflow generation chamber 37 connected to the reversal chamber 36 and to the downstream side of the yarn feeding direction of the reversal chamber 36 toward a direction indicated by arrowed lines in Figs. 2 and 3. Outside air is aspirated from the introduction path 32 because the swirling airflow has a component toward the yarn feeding direction as described above, thus the fiber bundle 17 is easily introduced to the reversal chamber 36.

[0062] Next, center fiber of the fiber bundle 17 introduced to the reversal chamber 36, that is, a core fiber is introduced to the yarn passage hole 39 with twining on the guide member 31. Other fibers in the fiber bundle 17, that is, twine fibers 46 are introduced to the yarn passage hole 39 with twining on the core fiber at its end part on the downstream side of the yarn feeding direction. And, the twine fibers 46 leave the front roller pair 22 at an end part on the upstream side of the yarn feeding direction, are reversed due to the component toward the yarn feeding direction of the swirling airflow as shown by a two-dot chain line in Fig. 2, and are introduced to the swirling airflow generation chamber 37.

[0063] Next, the reversed twine fibers 46 swirl along the inner periphery wall 44 of the nozzle block 33 due to the swirl component of the swirling airflow, and twine on the core fiber which is continuously introduced to the yarn passage hole 39.

[0064] Next, the core fiber on which the twine fibers 46 are twined is fed from the spinning device 13 via the yarn passage hole 39. Thus, the spun yarn 18 is manufactured.

[0065] In such spinning device 13, respective outlets 35 of the air nozzles 34 do not face the reversal chamber 36 that is a large space. Air injected from the air nozzles 34 is consequently suppressed to rapidly spread. Since air is injected in the swirling airflow generation chamber 37, the area in a horizontal cross-section of which is constant, strength of the air sustains in long distance and turbulence of the swirling airflow is reduced. Furthermore, since the swirling airflow generation chamber 37 is formed in a cylindrical shape in a horizontal cross-section, the air smoothly flows. Accordingly, the swirling airflow can be stabilized and efficiently generated. When the swirling airflow can be efficiently generated, the twining of the twine fibers 46 on a core fiber in aforementioned manufacturing process is stabilized and yarn strength of the spun yarn 18 can be improved.

[0066] The space part of the nozzle block and the spindle is formed to be a cylindrical shape within a predetermined range in the above mentioned embodiment. However, they may be formed in other shapes if the area of the swirling airflow generation chamber in the cross-section area is constant within a predetermined range.

[0067] In addition, shapes of the inner periphery wall of the nozzle block and of the outer periphery wall of the spindle in a horizontal cross-section are formed in circular shapes with the same size at an arbitrary position within the range of the length H respectively. However, the respective shapes may be formed in circular shapes of different sizes if an area of the swirling airflow generation chamber in the horizontal cross-section is constant.

[0068] Moreover, each of outlets of the air nozzles is formed at an upstream side in the yarn feeding direction of the inner periphery wall, however, the outlets may be formed at any position if within the range of the length H.

[0069] Moreover, six air nozzles are formed in the above described embodiment. However, such configuration is not necessarily required and the number of the air nozzles may be varied.

Claims

1. Spinning machine (10) for manufacturing a spun yarn (18) with swirling partial fibers (46) in a fiber bundle (17) by a swirling airflow comprising:

a draft device (12) having a front roller pair (22) for feeding the fiber bundle (17) while nipping the fiber bundle (17), and
a spinning device (13) installed at a downstream side of the yarn feeding direction with respect to the draft device (12), wherein
the spinning device (13) includes:

a nozzle block (33) having a cylindrical space part (43),
a spindle (38) arranged concentrically in the cylindrical space part (43) of the nozzle block (33),
a fiber bundle introduction block (30) supporting a guide member (31) and having an introduction path (32) into which the fiber bundle (17) is fed from the draft device (12) and is introduced into a yarn passage hole (39) of the spindle (38),
a reversal chamber (36) formed between the fiber bundle introduction block (30), the inner periphery wall (44) of the nozzle block (33) and a tip (42) of the spindle (38), wherein the guide member (31) has a tip projecting to the space part so that the tip of the guide

member faces the entrance of the yarn passage hole (39) of the spindle (38), and
air nozzles (34) formed in the nozzle block (33) and inclining to the downstream side of the yarn feeding direction toward the cylindrical space part (43),

characterized in that
the relationship of

$$T \geq L\cos\theta/\pi$$

is satisfied, where
T is the diameter of the cylindrical space part (43) of the nozzle block (33), θ is the inclination angle of the air nozzles (34) with respect to a plane surface orthogonal to the axis direction of the cylindrical space part (43), and L is the length from the nipping point P of the front roller pair (22) of the draft device (12) to the center of the entrance of the yarn passage hole (39) of the spindle (38).

2. Spinning machine (10) for manufacturing a spun yarn (18) with swirling partial fibers (46) in a fiber bundle (17) by a swirling airflow comprising:

a draft device (12) having a front roller pair (22) for feeding the fiber bundle (17) while nipping the fiber bundle (17), and
a spinning device (13) installed at a downstream side of a yarn feeding direction with respect to the draft device (12), wherein
the spinning device (13) includes:

a nozzle block (33) having a space part (43),
a spindle (38) arranged in the space part (43) of the nozzle block (33), wherein the clearance between the inner periphery wall (44) of the nozzle block (33) and the outer periphery wall (45) of the spindle (38) is constant within a range of a predetermined length (H) along the axis direction of the spindle (38),
a fiber bundle introduction block (30) supporting a guide member (31) and having an introduction path (32) into which the fiber bundle (17) is fed from the draft device (12) and is introduced into a yarn passage hole (39) of the spindle (38),
the tip (42) of the spindle (38) having a plane surface,
a reversal chamber (36) formed between the fiber bundle introduction block (30), the inner periphery wall (44) of the nozzle block (33) and the plane surface of the tip (42) of the spindle (38), wherein the guide member (31) has a tip projecting to the space part so that the tip of the guide member faces the entrance of the yarn passage hole (39) of the spindle (38), and
air nozzles (34) formed in the nozzle block (33) and inclining to the downstream side of the yarn feeding direction toward the space part (43),

characterized in that

the relation of

$$0{,}7D \leq S \leq 1{,}3D$$

is fulfilled,
where S is the constant clearance and D is the diameter of the outlet (35) of the air nozzles (34) on a plane surface orthogonal to the axis direction of the air nozzles (34).

3. Spinning machine (10) according to claim 2, **characterized in that**
the outlets (35) of the air nozzles (34) are formed on the inner periphery wall (44) of the nozzle block (33) within the range of the predetermined length (H).

Patentansprüche

1. Spinnmaschine (10) zur Herstellung eines Spinngarns (18) mit verwirbeltem Faseranteil (46) in einem Faserband (17) durch einen verwirbelten Luftstrom, enthaltend:

eine Streckeinrichtung (12), die ein vorderes Walzenpaar (22) zum Zuliefern des Faserbandes (17) aufweist, während das Faserband (17) geklemmt wird, und
eine Spinneinrichtung (13), die in Bezug auf die Streckeinrichtung (12) auf einer stromabwärts liegenden Seite der Garnzulieferrichtung eingebaut ist, wobei
die Spinneinrichtung (13) enthält:

einen Düsenblock (33), der einen zylindrischen Raumteil (43) aufweist,
eine konzentrisch in dem zylindrischen Raumteil (43) des Düsenblocks (33) angeordnete Spindel (38),
einen Faserbandeinführblock (30), der ein Führungsglied (31) trägt und einen Einführweg (32) aufweist, in welchen das Faserband (17) von der Streckeinrichtung (12) eingespeist wird und in eine Garndurchtritt-

söffnung (39) der Spindel (38) eingeführt wird,

eine Umkehrkammer (36), die zwischen dem Faserbandeinführblock (30), der inneren Umfangswand (44) des Düsenblocks (33) und der Spitze (42) der Spindel (38) gebildet ist, wobei das Führungsglied (31) eine Spitze aufweist, die auf den Raumteil gerichtet ist, so dass die Spitze des Führungsglieds dem Eingang der Garndurchtrittsöffnung (39) der Spindel (38) gegenüber liegt und

in dem Düsenblock (33) gebildete Luftdüsen (34), die zu der stromabwärts liegenden Seite der Garnzulieferrichtung zu dem zylindrischen Raumteil (43) geneigt sind,

dadurch gekennzeichnet, dass
die Beziehung
$T \geq L\cos\theta/\pi$ erfüllt ist, wobei
T der Durchmesser des zylindrischen Raumteils (43) des Düsenblocks (33) ist, θ der Neigungswinkel der Luftdüsen (34) in Bezug auf eine zu der Achsenrichtung des zylindrischen Raumteils (43) ebene Oberfläche ist und L die Länge von dem Klemmpunkt P des vorderen Walzenpaars (22) der Streckeeinrichtung (12) zu der Mitte des Eingangs der Garndurchtrittsöffnung (39) der Spindel (38) ist.

2. Spinnmaschine (10) zur Herstellung eines Spinngarns (18) mit verwirbeltem Faseranteil (46) in einem Faserband (17) durch einen verwirbelten Luftstrom, enthaltend:

eine Streckeinrichtung (12), die ein vorderes Walzenpaar (22) zum Zuliefern des Faserbandes (17) aufweist, während das Faserband (17) geklemmt wird, und

eine Spinneinrichtung (13), die in Bezug auf die Streckeinrichtung (12) auf einer stromabwärts liegenden Seite der Garnzulieferrichtung eingebaut ist, wobei

die Spinneinrichtung (13) enthält:

einen Düsenblock (33), der einen Raumteil (43) aufweist,

eine in dem Raumteil (43) des Düsenblocks (33) angeordnete Spindel (38), wobei der Spalt zwischen der inneren Umfangswand (44) des Düsenblocks (33) und der äußeren Umfangswand (45) der Spindel (38) innerhalb eines Bereichs einer vorbestimmten Länge (H) entlang der Achsenrichtung der Spindel (38) konstant ist,

einen Faserbandeinführblock (30), der ein Führungsglied (31) trägt und einen Einführweg (32) aufweist, in welchen das Faserband (17) von der Streckeinrichtung (12) eingespeist wird und in eine Garndurchtrittsöffnung (39) der Spindel (38) eingeführt wird,

wobei die Spitze (42) der Spindel (38) eine ebene Oberfläche hat,

eine Umkehrkammer (36), die zwischen dem Faserbandeinführblock (30), der inneren Umfangswand (44) des Düsenblocks (33) und der ebenen Oberfläche der Spitze (42) der Spindel (38) gebildet ist, wobei das Führungsglied (31) eine Spitze aufweist, die auf den Raumteil gerichtet ist, so dass die Spitze des Führungsglieds dem Eingang der Garndurchtrittsöffnung (39) der Spindel (38) gegenüber liegt und

in dem Düsenblock (33) gebildete Luftdüsen (34), die zu der stromabwärts liegenden Seite der Garnzulieferrichtung zu dem Raumteil (43) geneigt sind,

dadurch gekennzeichnet, dass
die Beziehung

$$0{,}7D \leq S \leq 1{,}3D$$

erfüllt ist,
wobei S der konstante Spalt ist und D der Durchmesser der Auslassöffnung (35) der Luftdüsen (34) auf einer zu der Achsenrichtung der Luftdüsen (34) senkrechten ebenen Oberfläche ist.

3. Spinnmaschine (10) nach Anspruch 2, **dadurch gekennzeichnet, dass** die Auslassöffnungen (35) der Luftdüsen (34) an der inneren Umfangswand (44) des Düsenblocks (33) innerhalb des Bereichs der vorbestimmten Länge (H) gebildet sind.

Revendications

1. Machine à filer (10) pour fabriquer un fil filé (18) avec des fibres partielles tourbillonnantes (46) dans un faisceau de fibres (17) sous l'effet d'un écoulement d'air tourbillonnant, comprenant :

un dispositif de traction (12) ayant une paire de rouleaux avant (22) pour acheminer le faisceau de fibres (17) tout en pinçant le faisceau de fibres (17), et

un dispositif de filage (13) installé du côté aval du sens d'acheminement du fil par rapport au dispositif de traction (12), dans laquelle :

le dispositif de filage (13) comprend :

un bloc de buses (33) ayant une partie d'es-

pace cylindrique (43),
une broche (38) aménagée concentriquement dans la partie d'espace cylindrique (43) du bloc de buses (33),
un bloc d'introduction de faisceau de fibres (30) supportant un élément de guidage (31) et ayant un trajet d'introduction (32) dans lequel le faisceau de fibres (17) est acheminé depuis le dispositif de traction (12) et est introduit dans un trou de passage de fil (39) de la broche (38),
une chambre d'inflexion (36) formée entre le bloc d'introduction de faisceau de fibres (30), la paroi périphérique interne (44) du bloc de buses (33) et la pointe (42) de la broche (38), l'élément de guidage (31) ayant une pointe projetant vers la partie d'espace de sorte que la pointe de l'élément de guidage est tournée vers l'entrée du trou de passage de fil (39) de la broche (38), et
des buses d'air (34) formées dans le bloc de buses (33) et s'inclinant vers le côté aval du sens d'acheminement du fil vers la partie d'espace cylindrique (43),

caractérisée en ce que :

la relation suivante :

$$T \geq L\cos\theta/\pi$$

est satisfaite, où :

T est le diamètre de la partie d'espace cylindrique (43) du bloc de buses (33), θ est l'angle d'inclinaison des buses d'air (34) par rapport à une surface plane orthogonale à la direction axiale de la partie d'espace cylindrique (43) et L est la distance du point de pincement P de la paire de rouleaux avant (22) du dispositif de traction (12) au centre de l'entrée du trou de passage de fil (39) de la broche (38).

2. Machine à filer (10) pour la fabrication d'un fil filé (18) avec des fibres partielles tourbillonnantes (46) dans un faisceau de fibres (17) sous l'effet d'un écoulement d'air tourbillonnant, comprenant :

un dispositif de traction (12) ayant une paire de rouleaux avant (22) pour acheminer le faisceau de fibres (17) tout en pinçant le faisceau de fibres (17), et
un dispositif de filage (13) installé du côté aval du sens d'acheminement du fil par rapport au dispositif de traction (12), dans laquelle :

le dispositif de filage (13) comprend :

un bloc de buses (33) ayant une partie d'espace (43),
une broche (38) aménagée dans la partie d'espace (43) du bloc de buses (33), dans laquelle le jeu entre la paroi périphérique interne (44) du bloc de buses (33) et la paroi périphérique externe (45) de la broche (38) est constant dans une plage d'une longueur prédéterminée (H) le long de la direction axiale de la broche (38),
un bloc d'introduction de faisceau de fibres (30) supportant un élément de guidage (31) et ayant un trajet d'introduction (32) dans lequel le faisceau de fibres (17) est acheminé depuis le dispositif de traction (12) et est introduit dans un trou de passage de fil (39) de la broche (38),
la pointe (42) de la broche (38) ayant une surface plane,
une chambre d'inflexion (36) formée entre le bloc d'introduction de faisceau de fibres (30), la paroi périphérique interne (44) du bloc de buses (33) et la pointe (42) de la broche (38), l'élément de guidage (31) ayant une pointe projetant vers la partie d'espace de sorte que la pointe de l'élément de guidage est tournée vers l'entrée du trou de passage de fil (39) de la broche (38),et
des buses d'air (34) formées dans le bloc de buses (33) et s'inclinant vers le côté aval du sens d'acheminement du fil vers la partie d'espace (43),

caractérisée en ce que :

la relation suivante :

$$0{,}7D \leq S \leq 1{,}3D$$

est satisfaite, où :

S est le jeu constant et D est le diamètre de la sortie (35) des buses d'air (34) sur une surface plane orthogonale à la direction axiale des buses d'air (34).

3. Machine à filer (10) selon la revendication 2, **caractérisée en ce que**

les sorties (35) des buses d'air (34) sont formées sur la paroi périphérique interne (44) du bloc de buses (33) dans la plage de la longueur prédéterminée (H).

FIG. 1

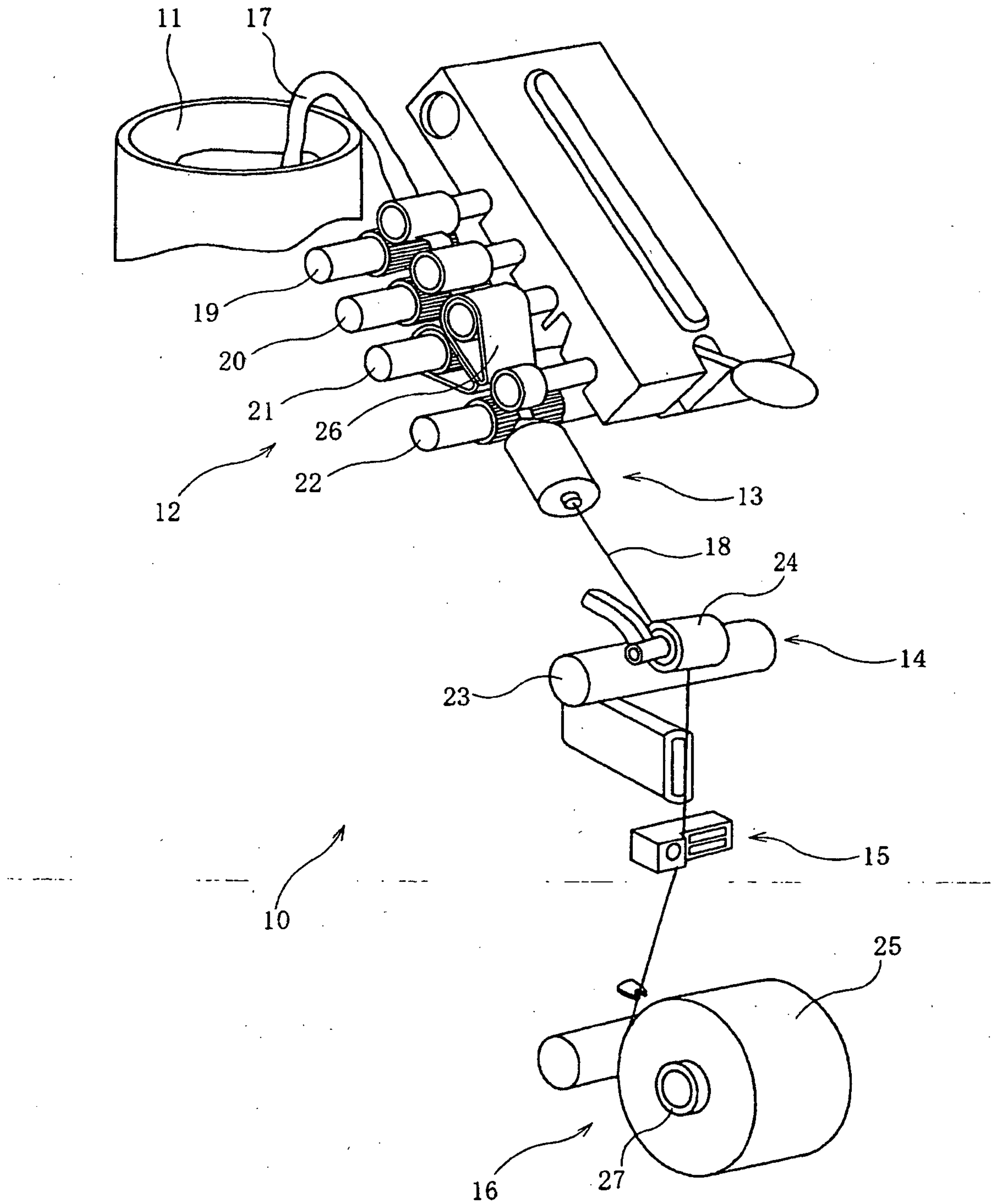


FIG. 2

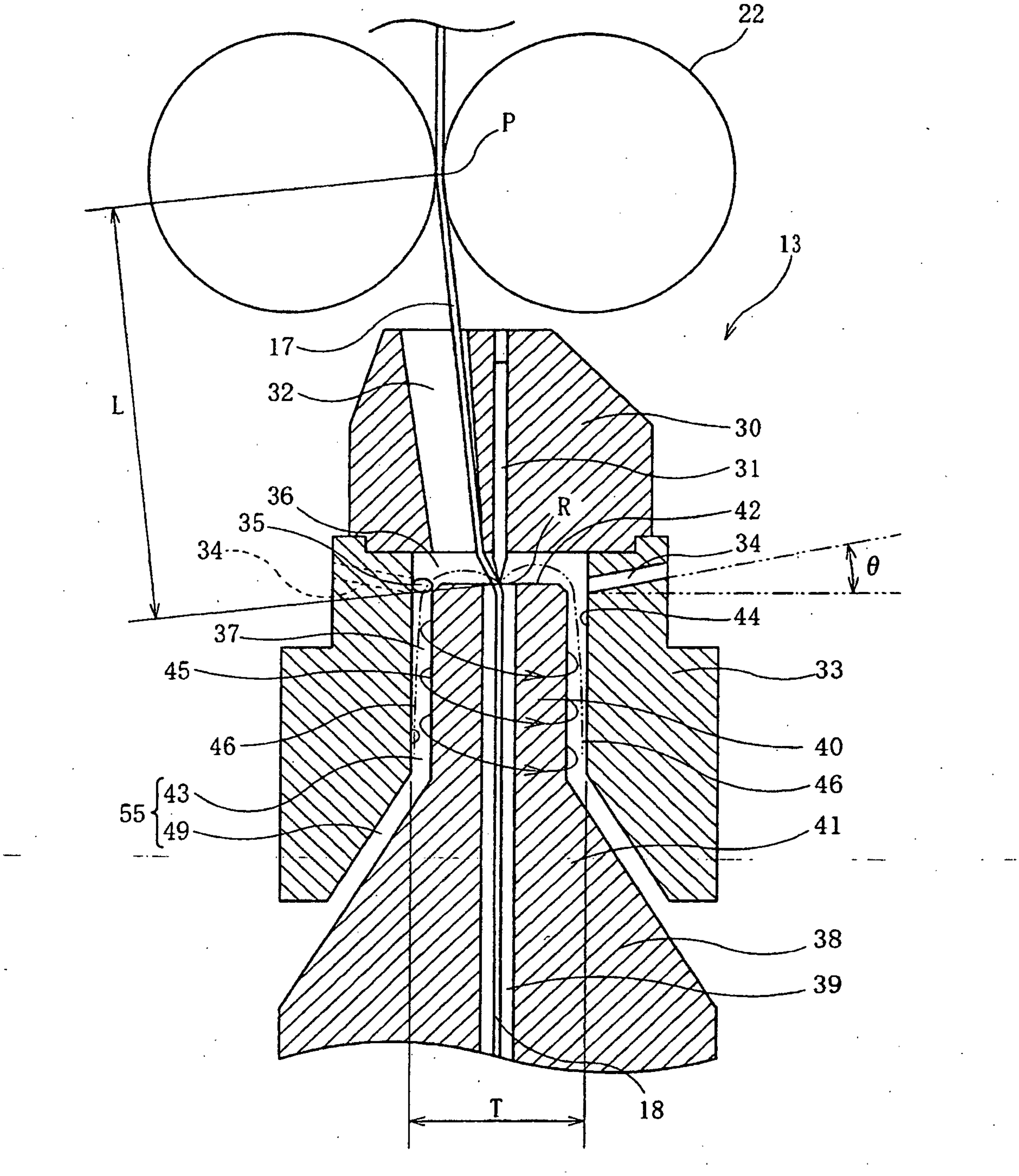

22
P
13
L
17
32
30
31
36
R
42
35
34
34
θ
44
37
33
45
40
46
46
55
43
49
41
38
39
18
T

FIG. 3

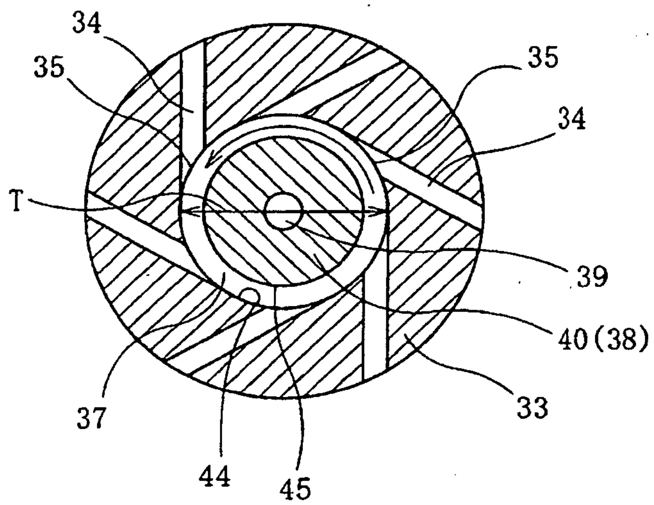


FIG. 4

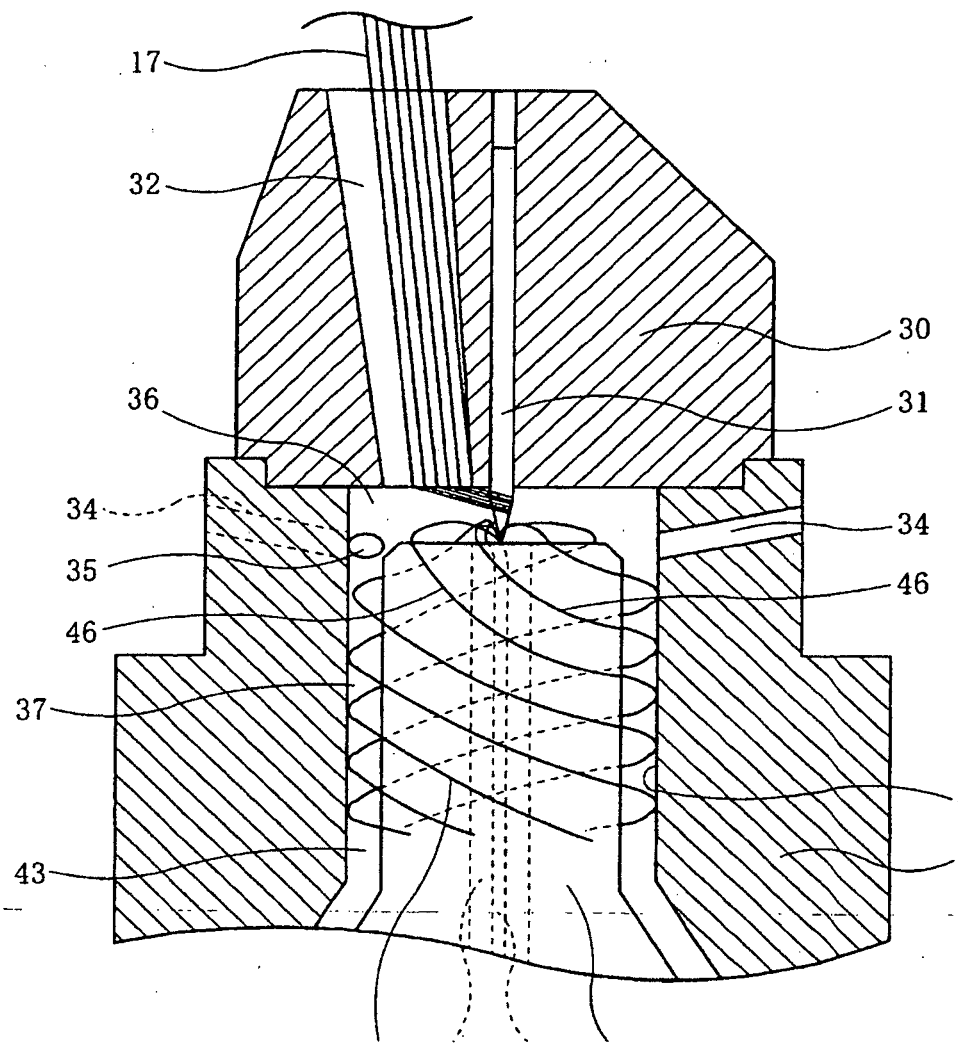


FIG. 5

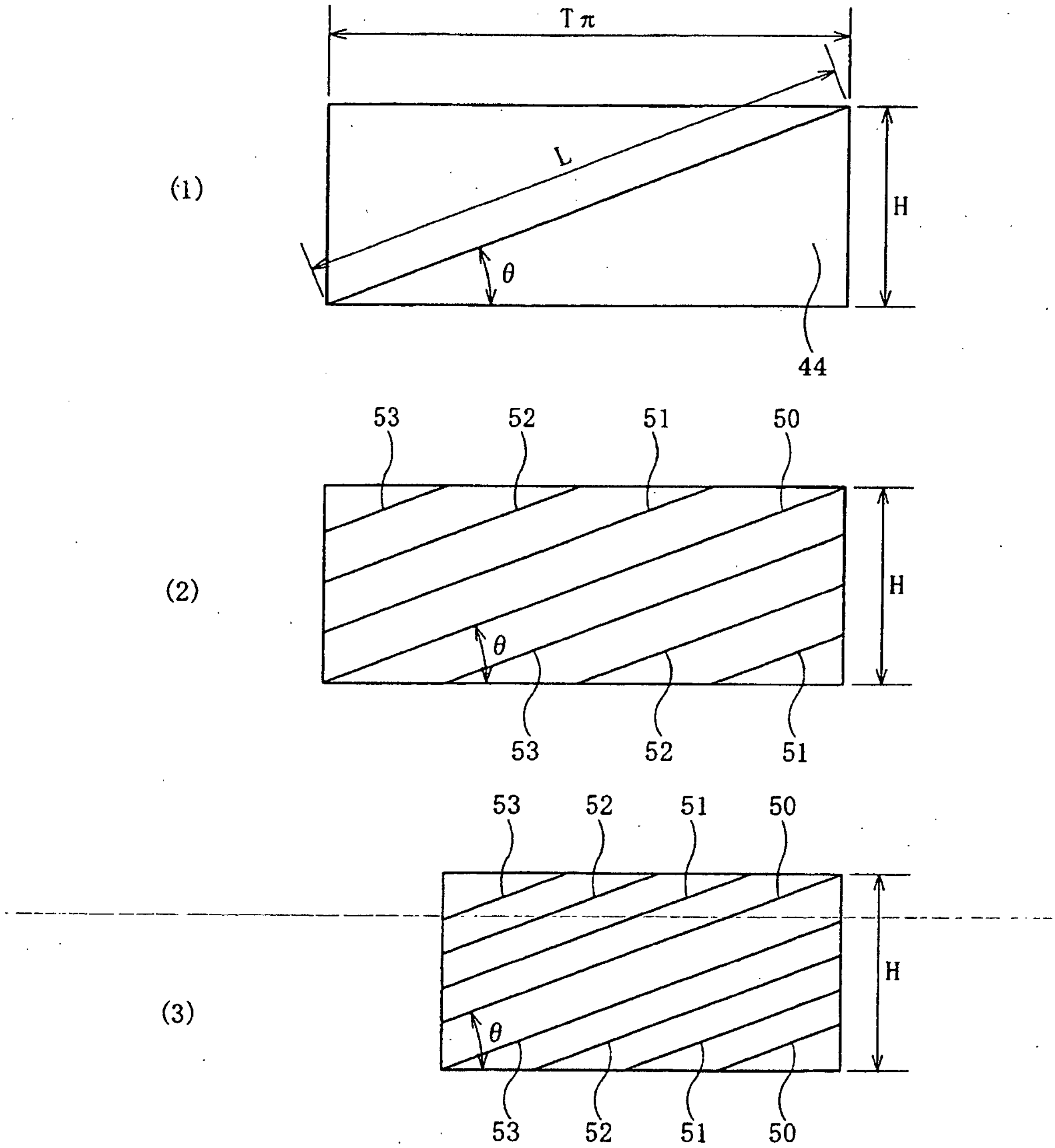


FIG. 6

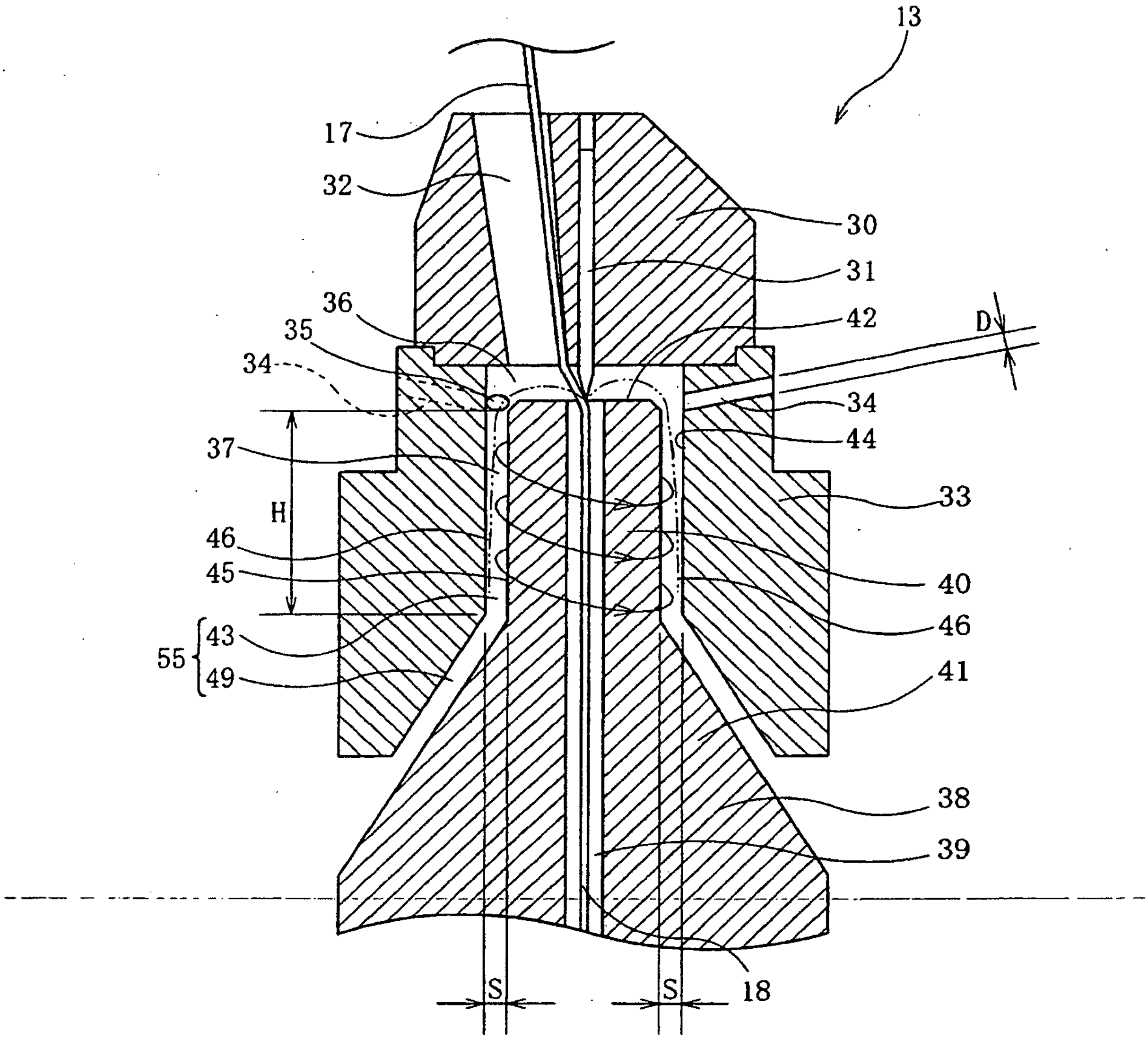

13
17
32
30
31
36
35
42
D
34
34
44
37
33
H
46
40
45
46
55
43
49
41
38
39
S
S
18

FIG. 7

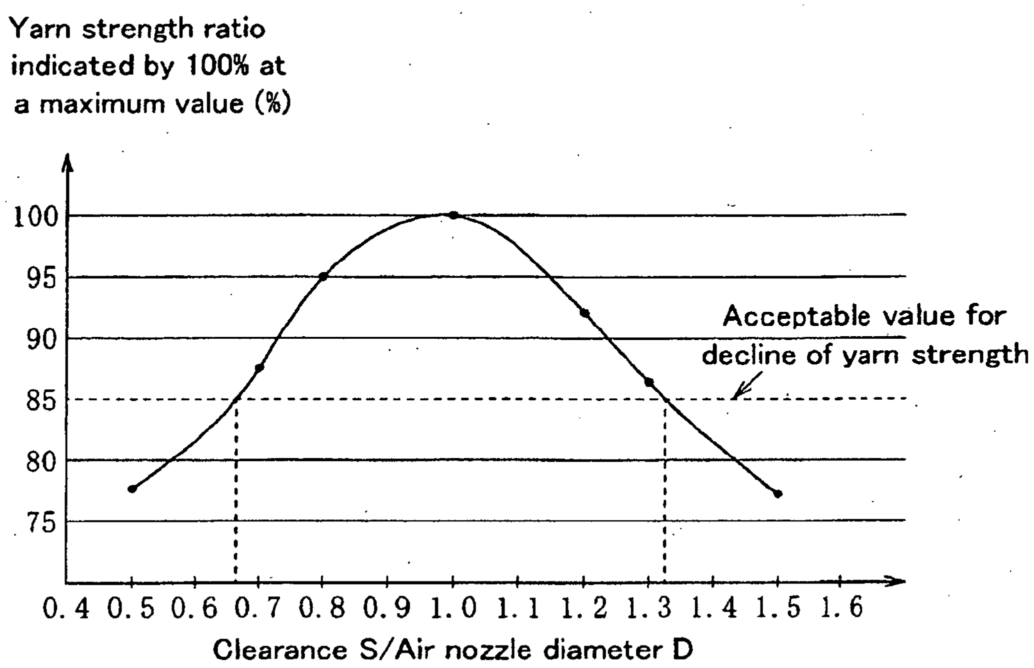
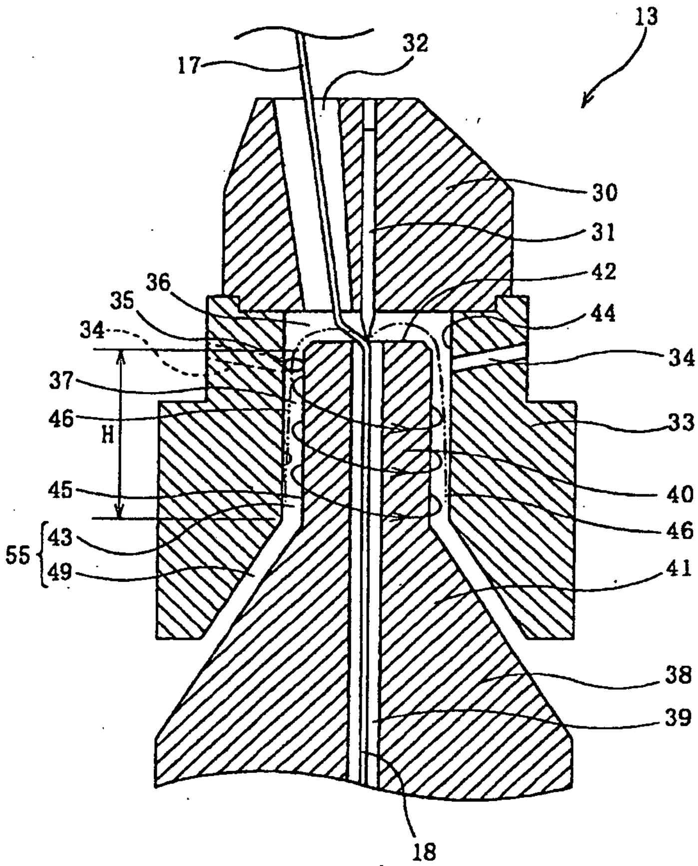

Yarn strength ratio
indicated by 100% at
a maximum value (%)
100
95
90
85
80
75
Acceptable value for
decline of yarn strength
0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
Clearance S/Air nozzle diameter D

FIG. 8



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003193337 A **[0003]**
- US 5263310 A **[0005]**

Non-patent literature cited in the description

- Standard test method. Seni binran-process. MARUZEN Co., Ltd, 20 January 1986 **[0047] [0058]**