Dec. 8, 1953 R. H. HELLE 2,661,619

APPARATUS FOR THE FLUID TREATMENT OF FIBERS AND THE LIKE

Filed Jan. 17, 1950

Fig. 1

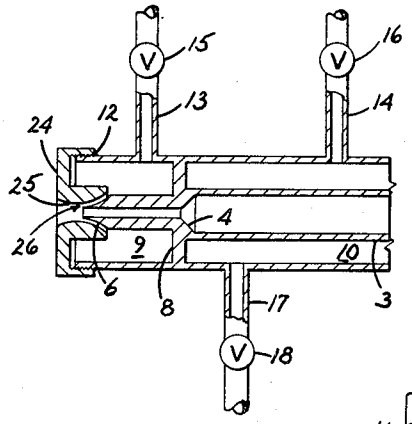
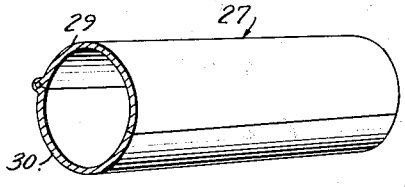


Fig. 2



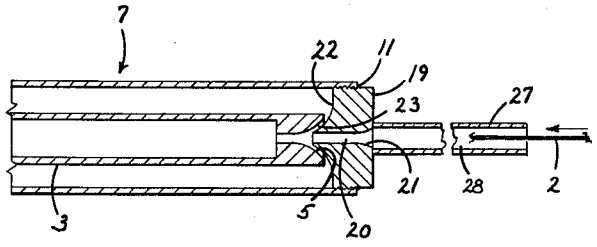


Fig. 3

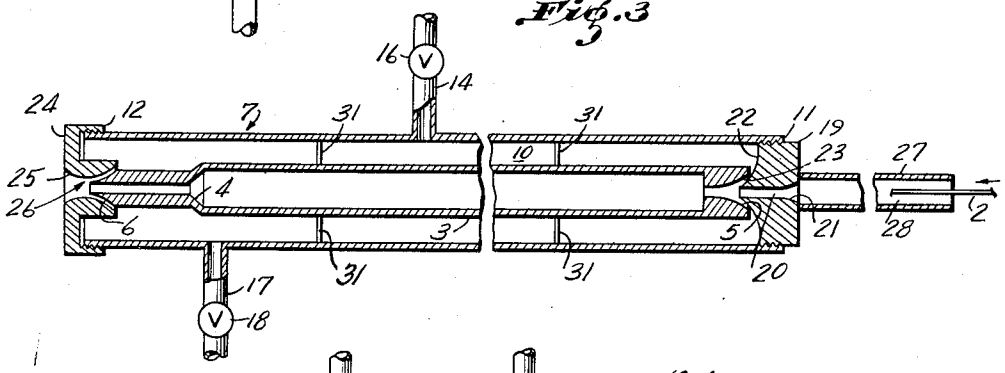
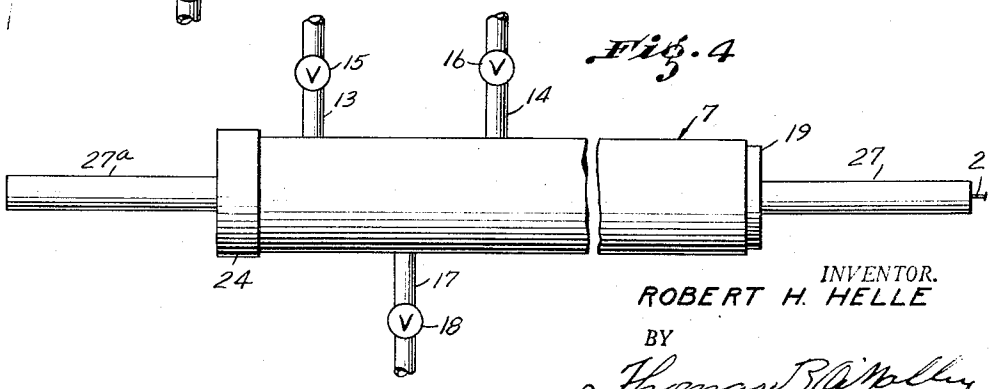


Fig. 4



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APPARATUS FOR THE FLUID TREATMENT OF FIBERS AND THE LIKE

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8 Claims. (Cl. 68—6)

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This invention relates to improved apparatus for treating fibers, yarns, and filamentary bundles generally, with fluid under pressure. More particularly the invention relates to improved apparatus for treating synthetic or artificial fibers with steam under pressure.

It is well known in the art to treat synthetic fibers or filaments with steam for the purpose of altering their properties, for example, by stretching the filaments in an atmosphere of steam under pressure or by permitting the filaments to shrink during the steam treatment. The apparatus used conventionally for contacting filaments with steam consists of an inclosure containing an atmosphere of steam into which the filaments are introduced and from which they are withdrawn through suitable openings in the inclosure. The openings for the passage of the filaments into and out of the inclosure are preferably as small as possible so as to minimize the escape of steam. Across these openings, there is a pressure drop and steam escaping exerts a friction effect on the filaments passing through the openings, which sets up a tension in the filaments additional to the tension exerted by any mechanical stretching devices. This tension resulting from the pressure drop at the openings has an adverse effect on the filaments, resulting in chafing or breaking thereof, especially at the entrance opening when the flow of steam from the inclosure is countercurrent to the direction of travel of the filaments.

It has been proposed to provide compressed air chambers at the openings of the inclosure for the purpose of reducing the tension exerted on the filaments by steam escaping from the openings. However, that arrangement has the disadvantage that unless the air is maintained under carefully controlled pressure lower than the pressure of the steam, some air will flow into the steam chamber, which is undesirable.

The primary purpose of this invention is to provide improved apparatus for the continuous treatment of synthetic or artificial fibers, filaments, yarns, or filamentary bundles, with fluid under pressure, in which damage to the fibers by escaping fluid is substantially eliminated, and treatment of the article forwarded to the steam-treating apparatus is facilitated, whether the article is in dry, wet or moist condition. Another object is to provide apparatus in which the fibers, filaments or filamentary or fibrous bundles may be treated with fluid under high pressures, without appreciable damage by escaping fluid.

In its broader aspects, apparatus in accordance with the invention comprises, in combination, a closed member for receiving fluid under pressure therein and having small-diameter strand entrance and exit openings in opposite ends thereof, in which fibers may be treated with the fluid during their travel from one point to another, means for supplying fluid under pressure to the member, and a tubular member having an axial strand passage the diameter of which is equal to or greater than the diameter of the strand openings in the member to which the fluid under pressure is supplied, the tubular member being arranged with one of its ends connected with the entrance end of the fluid-treating member and its other end open to the atmosphere, and with its axial passage aligned with the openings in the member to which the fluid under pressure is supplied. The axial passage of the tubular member comprises an elongated, enclosed introductory channel for the fibers or the like advancing to the member to which the fluid under pressure is supplied and functions to guide the fluid escaping from the strand openings thereof over an extended path to the atmosphere, so that the pressure drop is spread over an extended area and higher pressures than are ordinarily possible may be used to treat the fibers, without damage to the fibers entering the fluid-treating member. The diameter of the introductory channel is such that the fluid passing through it to the atmosphere, countercurrent to the fibers advancing to the member in which they are to be treated with the fluid under pressure, is confined and serves to pretreat the fibers. If the fibers or filaments are to be treated in an atmosphere of steam under pressure, they are preheated as they advance through the introductory channel by steam escaping from the entrance opening of the steam-treating member.

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The member to which the fluid under pressure is supplied may take various forms. For example, it may be an elongated straight tube to which fluid under pressure is supplied directly, or it may be such a tube to which the fluid under pressure is delivered indirectly from a jacket surrounding the tube, or both the jacket and the tube may be supplied directly with fluid under different pressures, the fluid in the jacket being utilized to superheat the fluid supplied to the tube. Alternatively, the member for receiving the fluid under pressure may be a chamber of any suitable cross-section, for example, tubular or rectangular.

In the attached drawing, Figure 1 shows a cross-sectional broken view of apparatus in accordance with one embodiment of the invention, Fig-

ure 2 is an isometric view of another type pretreating tube, Figure 3 is a cross-sectional broken view of another embodiment of the invention, and Figure 4 is a front elevation view of an apparatus as shown in Figure 1 having strand pretreating tubes attached at both the entrance and exit ends thereof. In Figure 1, the fiber or filamentary bundle 2 is passed through an elongated straight tube 3 the internal diameter of which is reduced at the opposite ends to permit pressure build-up, and which terminates in the convexly flared or curved face 5 and the concavely curved or flared face 6, respectively, the portion of reduced diameter adjacent the exit end of the tube being joined to the portion of greater diameter by the flared face 4. Suitable forwarding and take-up devices such as godets, thread-advancing reels, or the like (not shown), are provided for feeding the fibers to the tube 3 and drawing the fibers through the tube. The tube is surrounded by a steam jacket indicated generally by the reference numeral 7 and is supported centrally of the jacket by the partition 8 which divides the jacket into two separate compartments 9 and 10. One or more perforated partitions, spacers, or supports may be spaced axially along the length of compartment 10 for supporting tube 3 centrally of jacket 7, if desired. Jacket 7 is internally threaded at 11, and externally threaded at 12. The jacket is also provided with pipes 13 and 14 provided with valves 15 and 16 and connected to suitable sources of steam under pressure, and with a pipe 17 provided with valve 18 for the withdrawal of condensate or exhaust steam. An annular end-piece or closure 19, having an axial strand passage 20, which may terminate in a portion of gradually increasing diameter 21, is provided with external threads which engage the internal threads 11 of the steam jacket. The diameter of the passage in the end-piece other than the portion thereof having the gradually increasing diameter, if the passage comprises such a portion, may be the same as, less than, or greater than the internal diameter of tube 3. As shown, the internal diameter of the tube 3 between the end portions of reduced diameter is greater than the diameter of the strand passage in the end-piece. The end-piece comprises a central projection having a concavely curved or flared outer face 22. The convexly curved face 5 of the tube 3 and a portion of the concavely curved face 22 of the end-piece are more or less complementary and define an annular channel 23 therebetween through which steam in streamlined condition may be continuously delivered to tube 3 from the compartment 10 of the jacket. End-piece or closure 19 functions as a valve and is adjustable manually to vary the width of channel 23. The opposite or exit end of the assembly is provided with a cap 24 having internal threads which engage the threads 12 of the steam jacket. The cap has an axial strand passage defined by a curved face 25 which passage gradually narrows and then widens in a manner similar to a Venturi throat. A portion of the curved face 25 and the concavely curved face 6 of tube 3 are more or less complementary and define an annular channel 26 therebetween through which steam, air, or other fluid under pressure flows in a streamlined condition to the exterior of the apparatus, in the direction of travel of the fibers. Cap 24 functions as an ejector to assist in lacing the tube 3 and is adjustable manually to vary the width of channel 26.

In order simultaneously to prevent an abrupt drop in pressure on the steam emerging from channel 20, and to preheat the fibers, the escaping steam is guided from the strand entrance opening in the tube along an extended, confined path having a length of at least three inches, to the atmosphere. This may be accomplished by providing an end-piece 19 of the required length, or, as is shown, a relatively short end-piece, that is an end-piece having a length of one inch, for example, is used, and a tubular member 27 having an axial strand passage 28, is connected to the end-piece at the entrance end thereof, one end of tube 27 being connected with the end-piece and the opposite end being open to the atmosphere. Tube 27 has an internal diameter equal to or greater than the diameter of the strand entrance openings in the end-piece, and in tube 3, and is arranged with its axial passage 28 in alignment with the axial passage in the end piece and the bore of tube 3, to provide a straight line path for the fibers or filaments through the apparatus. The axial strand passage 28 of tube 27 may comprise a portion of gradually increasing diameter, at the entrance end thereof, which is open to the atmosphere, to facilitate lacing. The length of tube 27 depends on the length of tube 3 and the length of the end-piece, and is such that the length of the strand passage in the end-piece, plus the length of the strand passage in tube 27, is such as to provide an introductory channel for the fibers in advance of tube 3, having a length of at least three inches. The steam emerging from channel 23 travels through the strand passage in the end-piece 19, into tube 27, and through passage 28 of tube 27, to the atmosphere so that the drop in pressure is spread over an extended area and the escaping steam is confined to pretreat the filaments. Tube 27 may be a separate member which is welded or otherwise fixedly secured to the end-piece, or it may be formed integrally with the end-piece, and may comprise two semi-cylindrical sections 29 and 30 hinged or otherwise separably joined along their length and adapted to be temporarily separated for facilitating lacing of the device, as shown in Figure 2.

The apparatus of the invention comprising the long introductory channel for the fibers in advance of the fluid-treating tube or chamber proper is particularly advantageous when it is desired to treat wet fibers or filamentary bundles with steam as they proceed from the spinning bath or spinning cell, or from a liquid after-treating stage, without intermediate drying, since liquid carried by the fibers is at least partially volatilized in the introductory channel before the fibers enter tube 3.

To lace the apparatus illustrated, valve 15 is opened, valve 16 being closed, and steam is delivered to compartment or chamber 9 through the branched pipe 13. The fiber or filamentary bundle is introduced manually into the tube 27 and drawn through the end-piece 19 and tube 3 by the suction created by the steam flowing through channel 26. Instead of steam, air or other fluid may be introduced into compartment 9, for lacing the tube. After the device has been laced, valve 15 is closed, valve 16 is opened, and steam under pressure is delivered to chamber 10 of jacket 7 through the pipe 14. The steam flows in a streamlined condition along channel 23 to

the tube 3, end-piece 19 being adjusted manually to control the flow of steam into the tube. An advantage of the apparatus illustrated in the drawing resides in that the steam flows into the tube 3 in streamlined condition, and the fibers are not deflected from their straight-path course through the tube. Damage to the fibers by rubbing against the inner wall of the tube is avoided.

The apparatus shown may be modified in various respects. For example, as shown in Figure 3, partition 8 and branched pipe 13 may be omitted, the end-piece 19 being adjusted to close channel 23, channel 26 being open, and steam being delivered to the jacket through branched pipe 14. In this embodiment (Figure 3) it is necessary to support the tube 3 in the center of jacket 7 by means of brackets 31. As will be apparent to those skilled in the art, any type support or bracket may be employed, provided it is of such construction as not to interfere with the passage of steam through chamber 10. By adjusting cap 24 to close channel 26 and unscrewing end-piece 19 to open channel 23, after the device has been laced, the steam delivered to the jacket through branched pipe 14 will flow through channel 23 into the tube 3 to provide the steam atmosphere in which the fibers are to be treated.

The length of tube 3 will depend upon the speed of the fibers, the temperature to which the fibers must be heated taking into account the efficiency of the preheating by the steam escaping from channel 23, and whether the fiber is to be shrunk or stretched. In general, tube 3 may have a length of from 1 to 4 feet, and the introductory channel may have a length of from 3 inches to 2 feet, although large fibers which are to be given a very high stretch may require even longer tubes to provide steam preheating and heating zones of sufficient length.

Using the apparatus shown, in which tube 3 has a length of 2½ feet and tube 27 has a length of 15 inches, the end-piece having a length of about one inch, acrylonitrile polymer fibers, for example, may be heat-stretched in an atmosphere of steam under pressures up to 80 or 100 lbs. per square inch without noticeable damage to the entering yarn or fibers by steam escaping from channel 23, whereas, in the absence of tube 27 or an enclosed introductory channel having a length of at least three inches, pressures of that magnitude cannot be used without appreciable filament breakage and yarn damage.

Tube 3 may be of any suitable diameter, for example, from capillary dimensions to an inch or more, depending on the fiber denier and whether or not a single fiber or yarn, or a bundle comprising a multiplicity of fibers or yarns, such as a tow is to be treated. The diameter of the enclosed introductory channel in advance of tube 3 may be the same as or greater than the internal diameter of the tube 3 and/or end piece 22, the upper limit being determined by practicality and being, generally, not greater than 5 times the diameter of the strand entrance opening in the tube or end piece.

Although the apparatus has been described in detail in connection with the steam treatment of synthetic or artificial fibers, for which purpose either dry, wet, saturated, or superheated steam may be used, the device may be used for the treatment of fibers, filaments, or filamentary bundles generally with various fluids under pressure. For example, the fibers or filaments may be of regenerated cellulose, cellulose derivatives of the cellulose acetate type, vinyl resins, polyamides, polyethylenes, proteins, acrylonitrile polymers, including polyacrylonitrile and acrylonitrile copolymers, polyesters, etc. Any fluid under pressure may be used to treat the fibers or the like, for whatever purpose. For instance, regenerated cellulose fibers or yarns may be treated with steam or other gaseous fluid for setting them in a crimped, twisted, or otherwise distorted condition previously imparted thereto; or wet fibers, filaments or yarns may be treated to dry them; or synthetic resin or other fibers, filaments, or yarns may be treated with solvents or swelling agents for modification of the properties thereof; or the fibers, filaments or bundles may be stretched or shrunk during the fluid treatment.

Although the tube 27 for eliminating abrupt drop in the pressure is shown at the entrance end of the device only in Figure 1, a similar tube 27*a* may be associated with the cap 24, as shown in Figure 4, or the cap 24 may be elongated to provide a passage therein of the length required to prevent damage to the yarns or fibers emerging from the tube due to high velocity of the fluid escaping from channel 26.

Since variations and modifications may be made in the apparatus specifically illustrated without departing from the spirit and scope of the invention, it will be understood that the invention is not to be limited except as defined by the appended claims.

I claim:

1. An apparatus for treating continuously moving fibers and filamentary bundles with fluid under pressure comprising, an elongated, relatively narrow, straight tube having small diameter entrance and exit openings in opposite ends thereof, the inner wall of said tube, at the entrance end thereof, terminating in a gradually tapered portion and the outer wall of the tube, at the exit end thereof, terminating in a gradually tapered portion, an enclosed jacket surrounding the tube, means for supplying fluid under pressure to the jacket, an annular member having an axial strand passage threadedly secured to the jacket adjacent the entrance end of the tube with its passage in alignment with the bore of the tube, said annular member comprising a central projection which extends into the bore of the tube and terminating, at the end thereof adjacent the tube, in a gradually tapered outer face, the gradually tapered outer face of the annular member and the gradually tapered portion of the inner wall of the tube defining a channel which surrounds the central projection of the annular member and communicates with the bore of the tube and the interior of the jacket whereby the fluid under pressure can flow in a streamlined condition from the jacket into the tube, said annular member being movable toward and away from the tube to vary the width of the channel defined by the tapered portion of the tube and the tapered face of the annular member and capable of closing said channel, a strand pretreating and pressure drop tube arranged with one end thereof connected to the outer face of the annular member and the opposite end thereof opened to the atmosphere, said tube having an axial passage aligned with the passage of the annular member and the bore of the first tube, the axial strand passages of the annular member and of the strand pretreating tube constituting an elongated, enclosed introductory channel for the fibers or filamentary bundles advancing to the first tube which channel has a diameter at least as

large as the diameter of the strand entrance opening of the first tube and a length of at least 3 inches, and a second annular member threadedly secured to the jacket adjacent the exit end of the tube, said second annular member having an axial strand passage terminating, at the end thereof adjacent the tube, in a gradually tapered portion into which the exit end of the tube extends, the gradually tapered portion of the outer wall of the tube and the gradually tapered passage of the second annular member defining a channel which surrounds the exit end of the tube and communicates with the interior of the jacket and the passage in the second annular member whereby the fluid under pressure can flow in a streamlined condition from the jacket to the atmosphere through the passage in said annular member.

2. An apparatus as defined in claim 1 wherein there are fluid removal means attached to the jacket for removing fluid therefrom.

3. An apparatus as defined in claim 1 wherein the tube has reduced internal diameter along a portion of its opposite ends.

4. An apparatus for treating continuously moving fibers and filamentary bundles with fluid under pressure comprising, an elongated, relatively narrow, straight tube having small diameter entrance and exit openings in opposite ends thereof, the interior wall of said tube, at the entrance end thereof, terminating in a gradually tapered portion and the outer wall of the tube, at the exit end thereof, terminating in a gradually tapered portion, an enclosed jacket surrounding the tube, a partition separating the jacket into a shorter compartment surrounding the exit end of the tube and a longer compartment surrounding the entrance end of the tube, means for supplying fluid under pressure to the shorter compartment, means for supplying fluid fluid under pressure to the longer compartment, an annular member having an axial strand passage threadedly secured to the jacket adjacent the entrance end of the tube with its passage in alignment with the bore of the tube, said annular member comprising a central projection which extends into the bore of the tube and terminating, at the end thereof adjacent the tube, in a gradually tapered outer face, the gradually tapered outer face of the annular member and the tapered portion of the tube defining a channel which surrounds the central projection of the annular member and communicates with the bore of the tube and the interior of the longer compartment whereby the fluid under pressure can flow in a streamlined condition, from the longer compartment into the tube, said annular member being movable toward and away from the tube to vary the width of the channel defined by the tapered portion of the tube and the tapered face of the annular member and capable of closing said channel, a strand pretreating and pressure drop tube arranged with one end thereof connected to the outer face of the first annular member and the opposite end thereof opened to the atmosphere, said tube having an axial passage aligned with the passage of the annular member and the bore of the first tube, the axial strand passages of the annular member and of the strand pretreating tube constituting an elongated, enclosed introductory channel for the filamentary bundles advancing to the first tube which channel has a diameter at least as large as the diameter of the strand entrance opening of the first tube and a length of at least 3 inches, and a second annular member threadedly secured to the jacket adjacent the exit end of the tube, said second annular member having an axial strand passage terminating, at the end thereof adjacent the tube, in a gradually tapered portion into which the exit end of the tube extends, the gradually tapered portion of the outer wall of the tube and the gradually tapered passage of the second annular member defining a channel which surrounds the exit end of the tube and communicates with the interior of the shorter compartment and the passage in the second annular member whereby the fluid under pressure can flow in a streamlined condition from the jacket to the atmosphere through the passage in said annular member.

5. An apparatus as defined in claim 4 wherein the internal diameter of the tube extending through the shorter compartment is less than the internal diameter of the tube extending through the longer compartment.

6. An apparatus as defined in claim 4 wherein there are fluid removal means attached to the longer compartment.

7. An apparatus as defined in claim 4 wherein the tube has reduced internal diameter along a portion of its opposite ends.

8. An apparatus for treating continuously moving fibers and filamentary bundles with fluid under pressure comprising, an elongated, relatively narrow, straight tube having small diameter entrance and exit openings in opposite ends thereof, the interior wall of said tube, at the entrance end thereof, terminating in a gradually tapered portion and the outer wall of the tube, at the exit end thereof, terminating in a gradually tapered portion, an enclosed jacket surrounding the tube, a partition separating the jacket into a shorter compartment surrounding the exit end of the tube and a longer compartment surrounding the entrance end of the tube, means for supplying fluid under pressure to the shorter compartment, means for supplying fluid under pressure to the longer compartment, fluid removal means attached to the longer compartment, the internal diameter of the tube extending through the shorter compartment being less than the internal diameter of the tube extending through the longer compartment, and an annular member having an axial strand passage threadedly secured to the jacket adjacent the entrance end of the tube with its passage in alignment with the bore of the tube, said annular member comprising a central projection which extends into the bore of the tube and terminating, at the end thereof adjacent the tube, in a gradually tapered outer face, the gradually tapered outer face of the annular member and the tapered portion of the tube defining a channel which surrounds the central projection of the annular member and communicates with the bore of the tube and the interior of the longer compartment whereby the fluid under pressure can flow in a streamlined condition from the longer compartment into the tube, said annular member being movable toward and away from the tube to vary the width of the channel defined by the tapered portion of the tube and the tapered face of the annular member and capable of closing said channel, a strand pretreating and pressure drop tube arranged with one end thereof connected to the outer face of the annular member and the opposite end thereof opened to the atmosphere, said tube having an axial pas-

sage aligned with the passage of the annular member and the bore of the first tube, the axial strand passage of the annular member and of the strand pretreating tube constituting an elongated, enclosed introductory channel for the fibers or for the filamentary bundles advancing to the first tube which channel has a diameter at least as large as the diameter of the strand entrance opening of the first tube and a length of at least 3 inches, and a second annular member threadedly secured to the jacket adjacent the exit end of the tube, said second annular member having an axial strand passage comprising a Venturi throat into which the exit end of the tube extends, the gradually tapered portion of the outer wall of the tube and the gradually tapered Venturi throat of the second annular member defining a channel which surrounds the exit end of the tube and communicates with the

interior of the shorter compartment and the passage in the second annular member whereby the fluid under pressure can flow in a streamlined condition from the jacket to the atmosphere through the passage in said second annular member.

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