APPARATUS FOR SPINNING FIBERS OF GLASS OR THE LIKE

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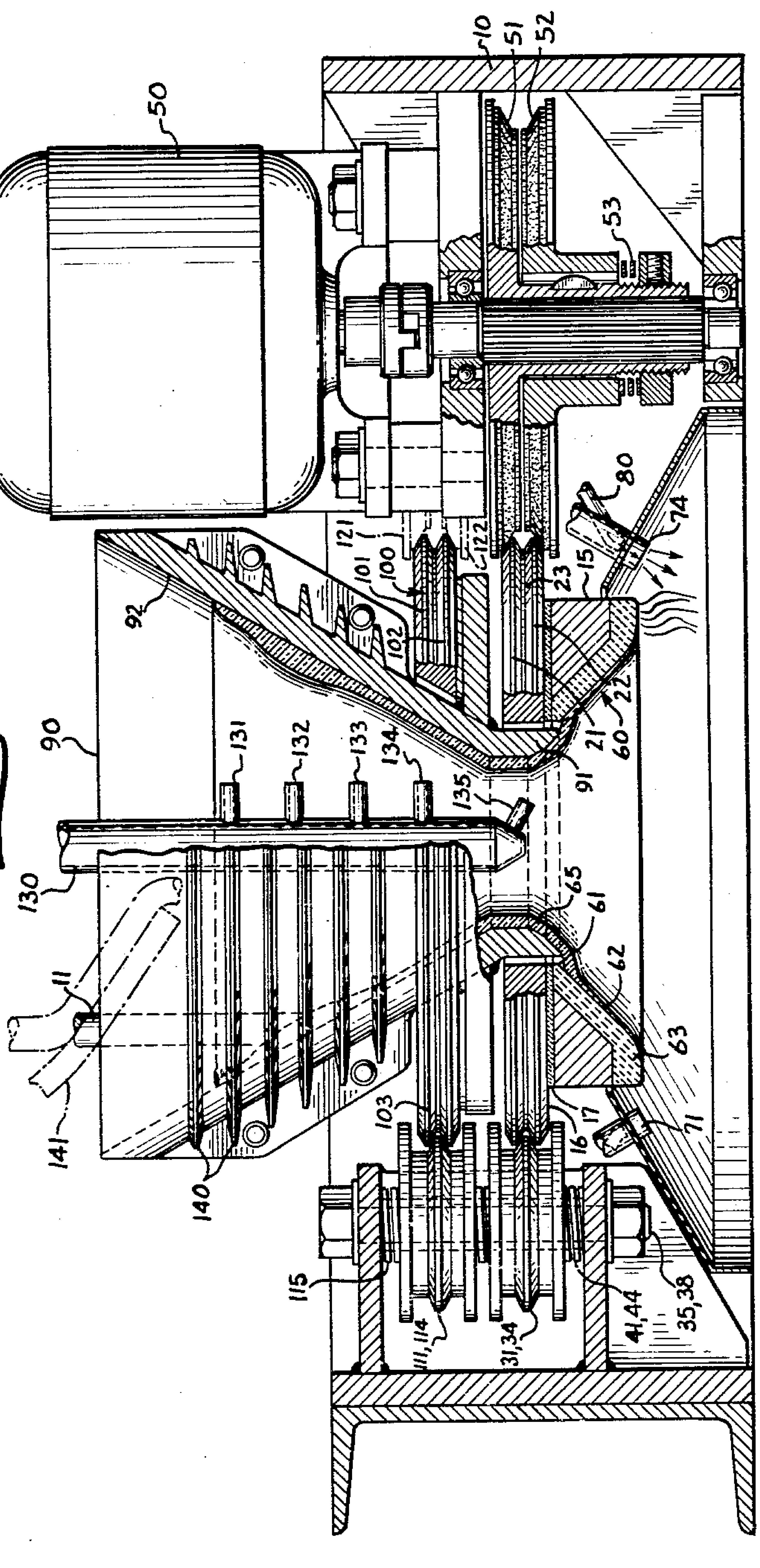

Fig. 1

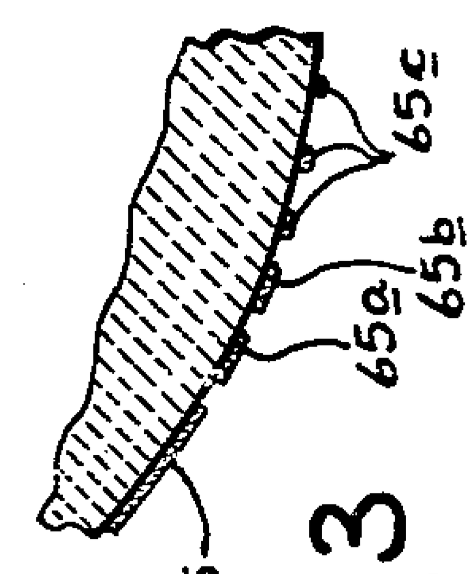

Fig. 3

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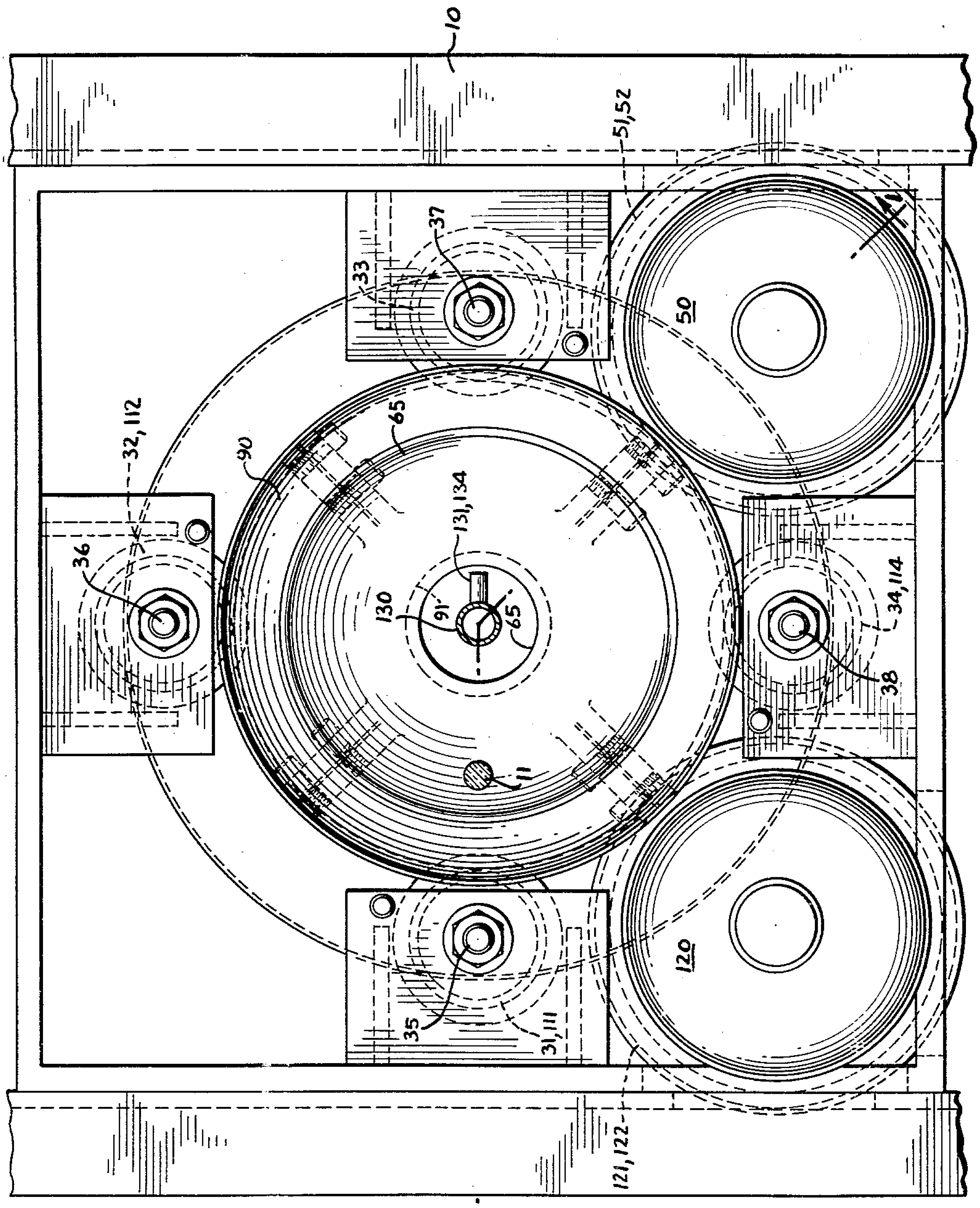

Fig. 2

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APPARATUS FOR SPINNING FIBERS OF GLASS OR THE LIKE

Filed May 5, 1958 5 Sheets-Sheet 3

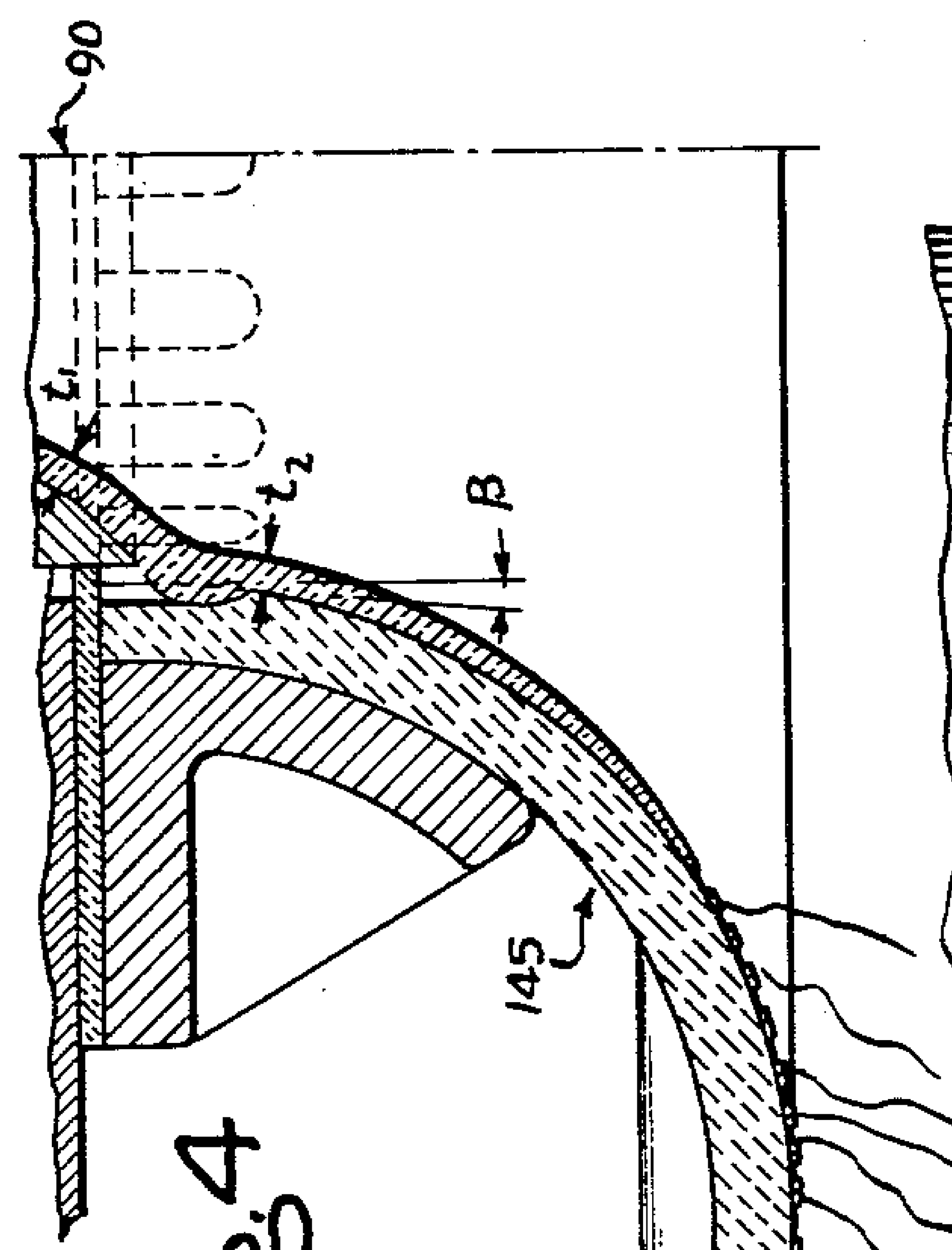

Fig. 4

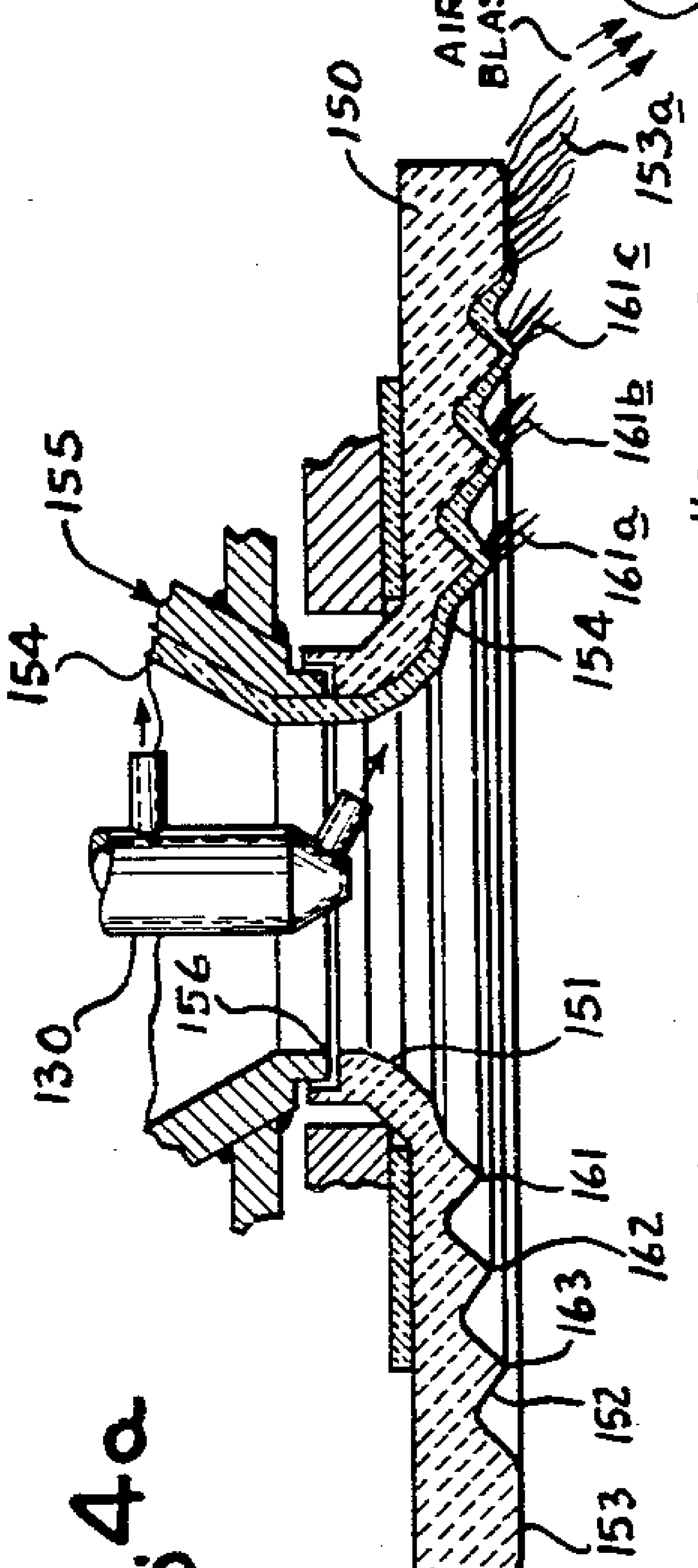

Fig. 4a

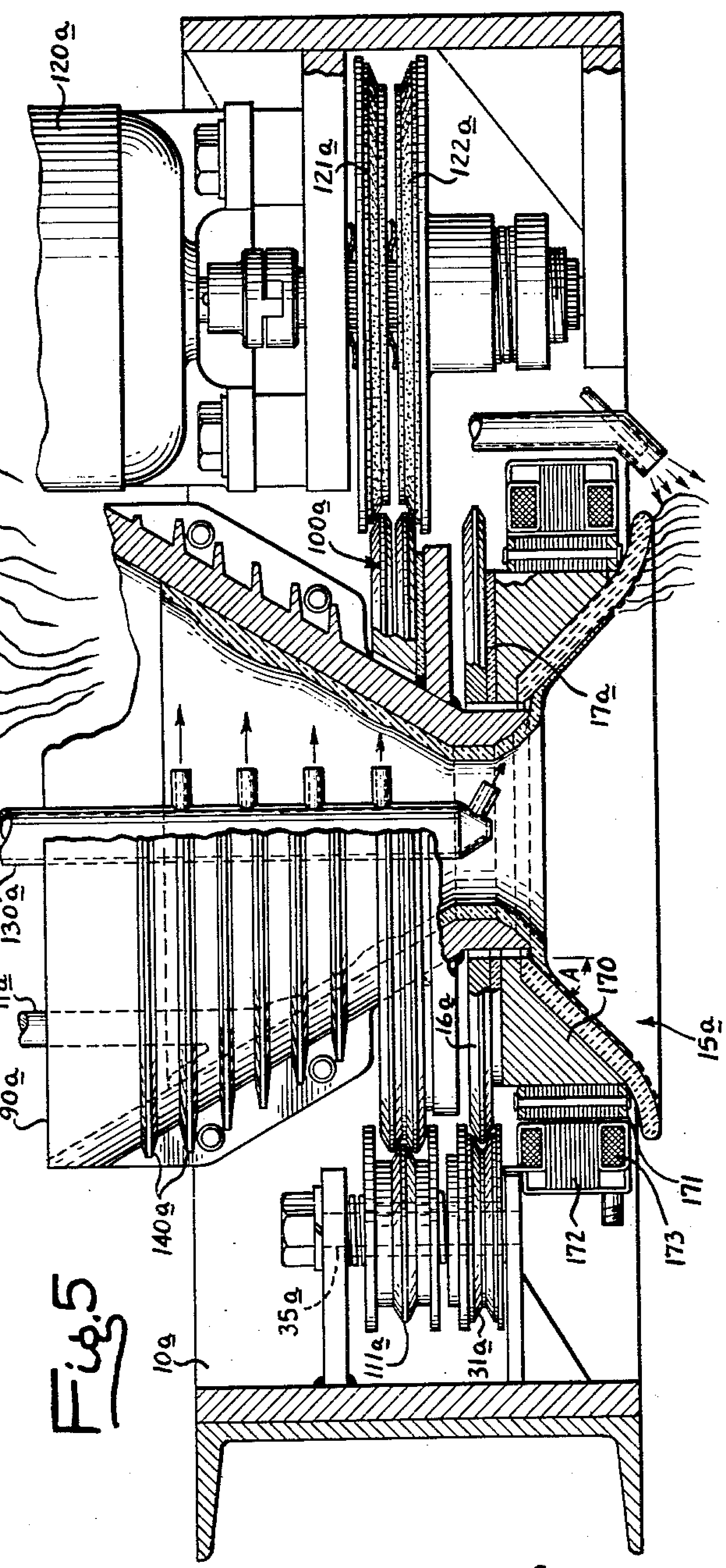

Fig. 5

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APPARATUS FOR SPINNING FIBERS OF GLASS OR THE LIKE

Filed May 5, 1958 5 Sheets-Sheet 4

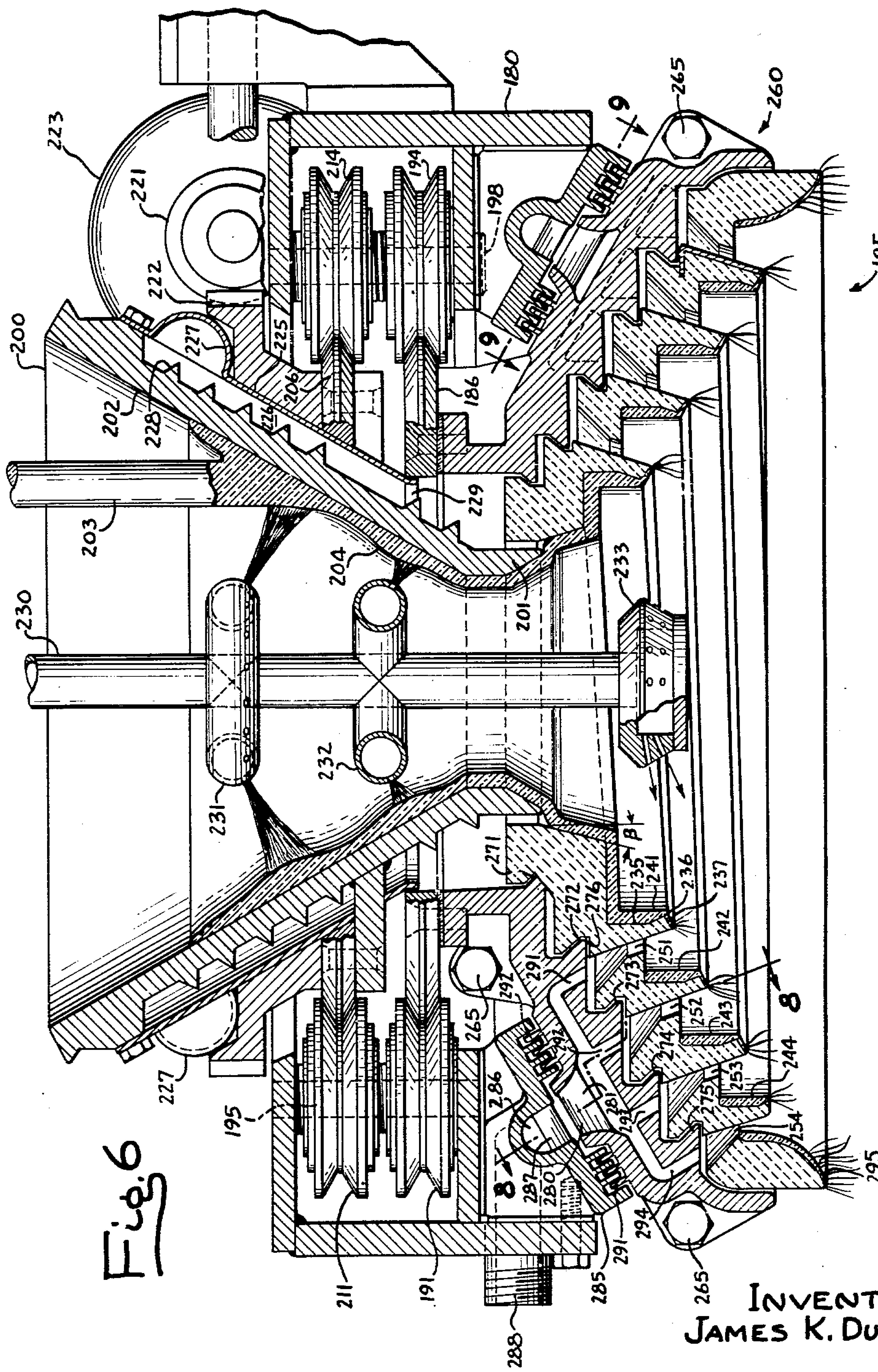

Fig. 6

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Aug. 8, 1961 J. K. DUNCAN 2,994,915

APPARATUS FOR SPINNING FIBERS OF GLASS OR THE LIKE

Filed May 5, 1958 5 Sheets-Sheet 5

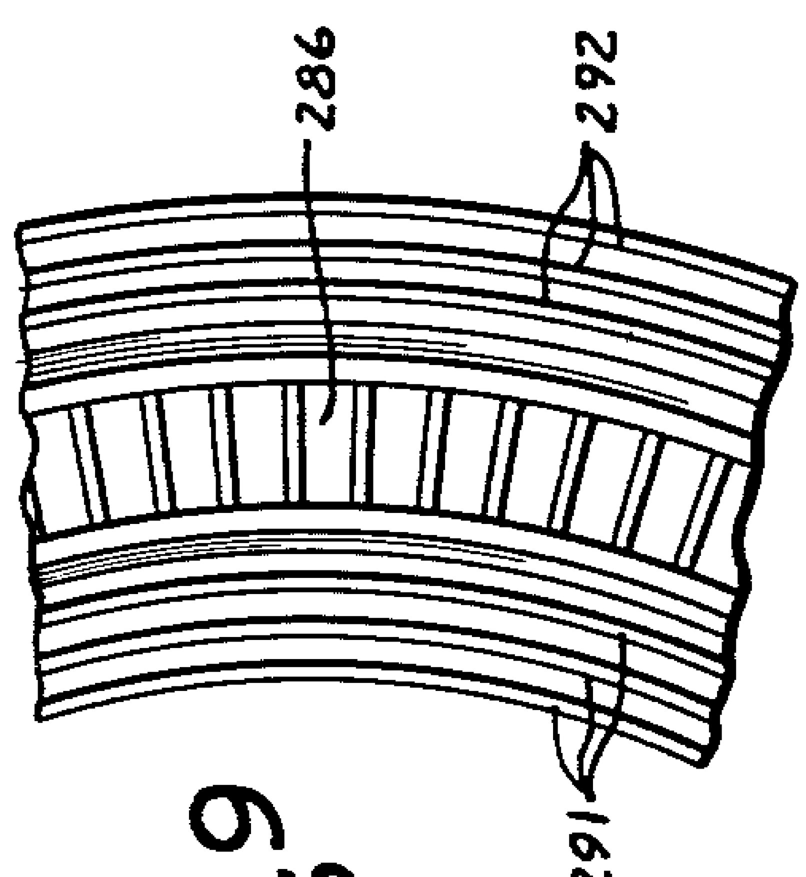

Fig. 9

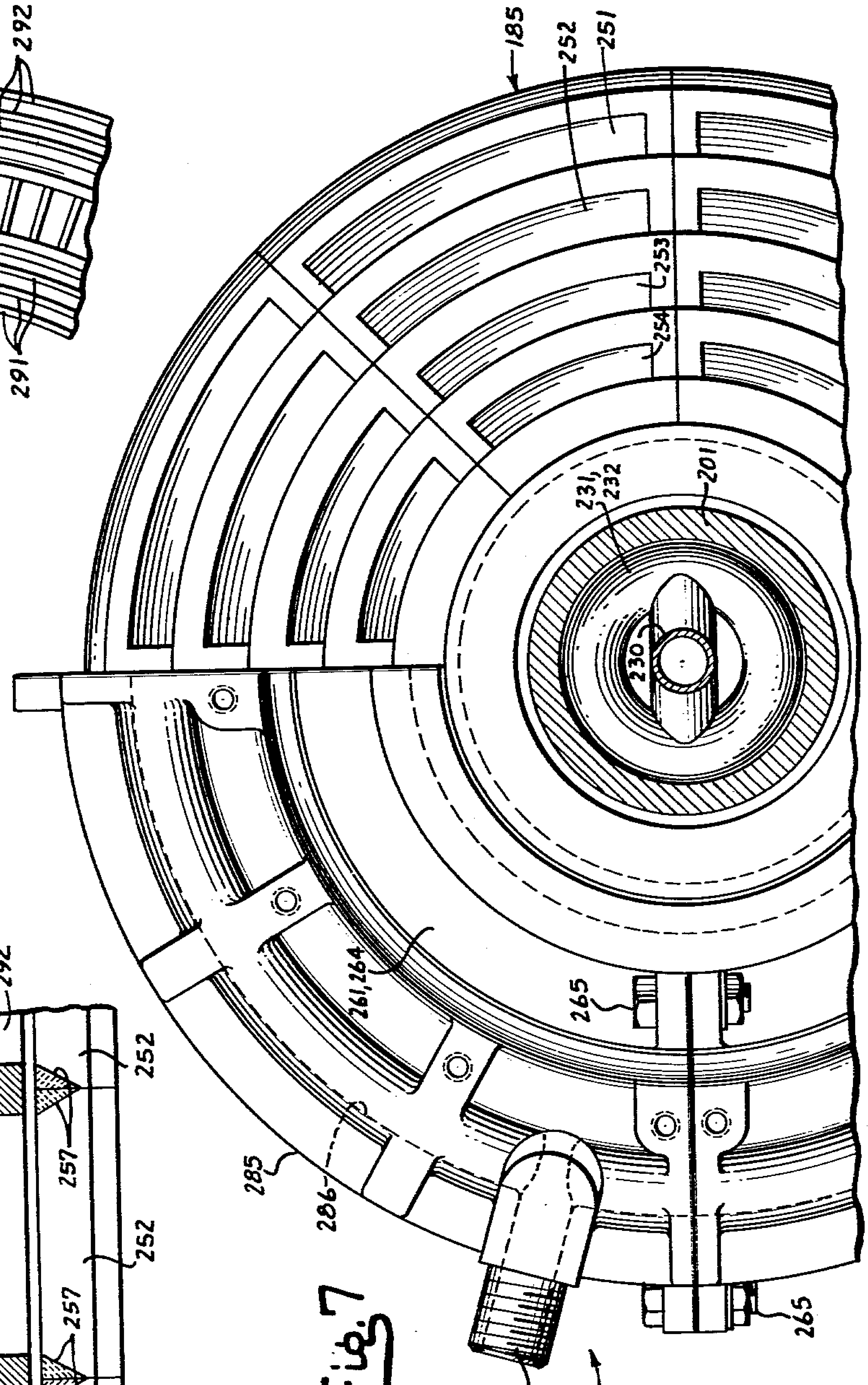

Fig. 7

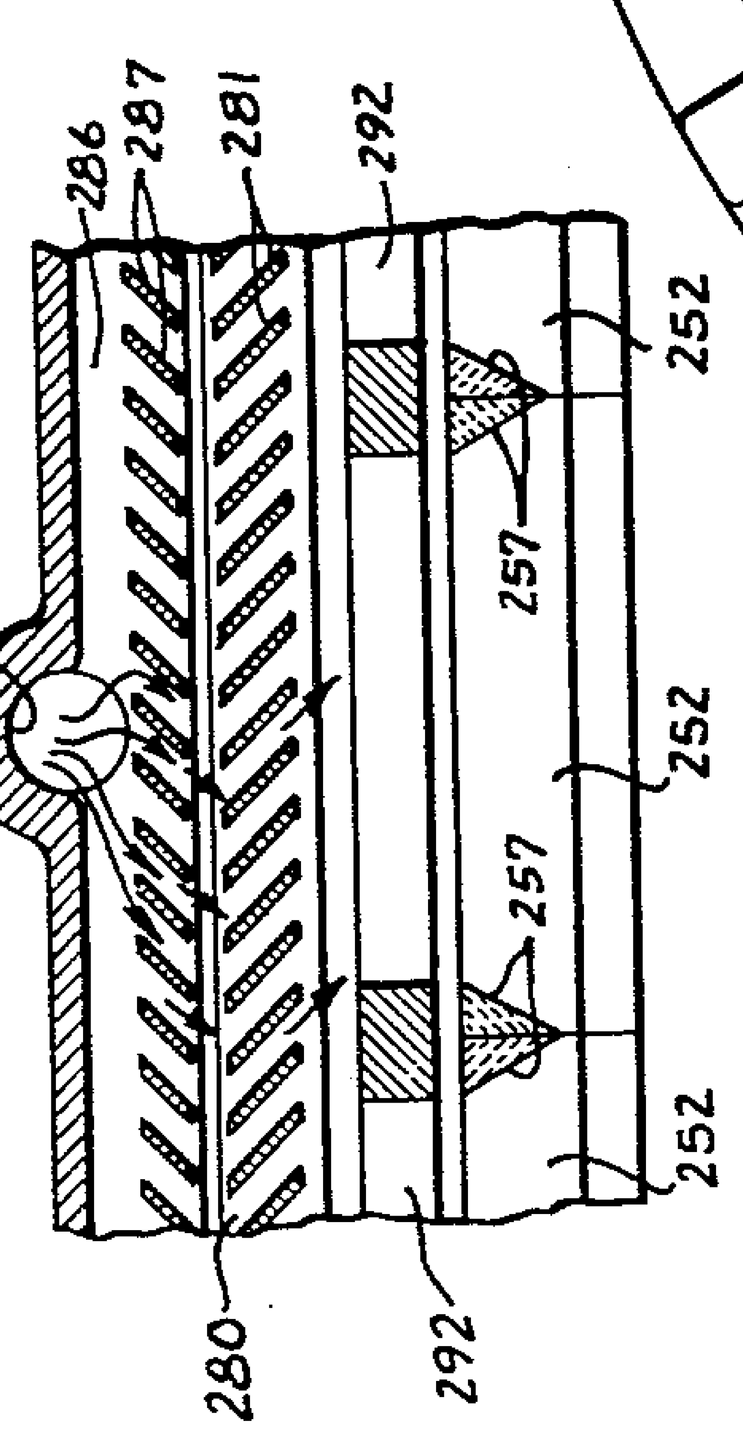

Fig. 8

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Patented Aug. 8, 1961

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APPARATUS FOR SPINNING FIBERS OF GLASS OR THE LIKE

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Filed May 5, 1958, Ser. No. 733,032

14 Claims. (Cl. 18—2.5)

The present invention relates to the spinning of molten material into elongated fibers and more particularly to the spinning of glass or slag into fibrous batts for use in insulation or as a material of construction.

It is the primary object of the present invention to provide a spinning apparatus which is capable of producing fibers or "wool" which has a high degree of consistency and uniformity. More specifically, it is an object to provide a spinning apparatus which produces fiber having a minimum percentage of "dust," "shot," "feathers," "lumps" and other non-fibrous forms of material which form a high percentage of the fibers produced by more conventional procedures. As will become clear as the description proceeds, it is an object to provide a spinning device in which the transition takes place from the molten form of the material to the fibrous form graduaally and with gradual acceleration of the material and without the violent blasting and spattering which characterizes the apparatus and schemes which have been used in the past. It is a related object to provide a spinning device which operates at high centrifugal speed and which maintains the material substantially captive for the building of high centrifugal pressure therein.

It is an object related to the foregoing to provide an apparatus for spinning fiber in which the temperature remains at a high level from the time that the molten material is received in the spinner to the time that fibers are formed therefrom, with any temperature change occurring gradually and free of the "thermal shock" which is characteristic of conventional spinners particularly those spinners intended for high quantity production.

It is another object of the present invention to provide a spinning apparatus in which the nature of the product is subject to more precise control, particularly as regards the diameter and length of the individual fibers. It is a correlative object to provide a spinning apparatus in which fibers may be "tailor-made" for particular applications ranging from long, thin fibers useful for making into fabric, to short, relatively stiff fibers suitable for use in air filters and the like.

It is another object of the present invention to provide a spinning apparatus which is capable of handling a wide range of raw material and in which the temperatures, spinning forces and other variables may be varied and controlled in accordance with the physical characteristics, such as viscosity and useful temperature range of the material being handled. Accordingly, the apparatus may be employed successfully with glass having a wide range of chemical composition as well as blast furnace slag or other by-product slag of different chemical composition and having a wide range of acid-base ratio.

It is a further object of the present invention to provide a spinning apparatus which has an inherently high production rate per spinning head. This is not only true, as compared to prior devices, in the spinning of fine fibers, but is particularly true in the spinning of wool for insulation or the like.

It is a related object to provide a spinning head which not only has a high individual tonnage output per unit time, but which is particularly suited for use in multiple with other spinning heads of the same type for the building up of fiber batts on a high speed conveyor belt or the like. In this connection it is an object of the present invention to provide a spinning head which makes novel and maximum use of the force of gravity to facilitate discharge of fiber from, and clear of, the spinning head for depositing of the same on a conveyor or receiving surface. It is a more detailed object in one of its aspects to provide a spinning head which is symmetrically arranged with respect to the force of gravity and in which such force acts uniformly and in the same direction upon all of the fibers being produced by the head. It is, moreover, an object to provide a symmetrical head arrangement in which auxiliary heat from gas burners may be applied evenly and in precisely controllable amounts, and in which liquid binder may be applied easily and uniformly as the fibers are being formed.

It is still another object to provide a spinning apparatus which is extremely compact and with only a few inches spacing between the incoming stream of molten raw material and the point at which the fibers are produced. Accordingly, it is an object to provide a spinning arrangement in which there is a minimum of loss of heat from inlet to outlet and in which the temperature at each point in the path of travel may be effectively controlled. It is a related object to provide a compact spinning head in which all of the engaging surfaces are covered with a layer of molten material with a minimum area subject to the action of atmospheric oxygen and with only limited access of atmospheric air to the oxidation-susceptible surfaces.

It is a further object to provide a spinning apparatus in which molten material is fed into the spinning element at a uniform and controlled rate. It is a related object to provide a spinning arrangement in which the uniformity of feed is accomplished in spite of variations in the inlet stream of material. More specifically, it is an object to provide a spinning arrangement in which there is maintained a reservoir of the raw molten material permitting variations in the rate of inlet but with a consistently maintained rate of discharge from the reservoir. In this connection it is an object to provide a spinning head having a reservoir in which there is a mixing and blending of the incoming material and which therefore is able to tolerate normal variations in the physical and chemical characteristics of the incoming material while nevertheless enabling the material which is spun to have highly uniform average characteristics contributing to the uniformity of the final product.

It is a still further object of the invention to provide a spinning head which is characterized by a long, useful life and a minimum of maintenance. As mentioned, this long life is brought about in part by minimizing the erosion and oxidation to which conventional devices are subjected. Moreover, as a result of the control which is afforded, a controlled crust may be formed on the spinning surfaces so that such surfaces are not subjected to the direct action of the hot molten raw material. Also contributing to long life is the gradual, non-violent nature of the spinning phenomena which are employed.

It is yet another object of the invention to provide a spinning head which is not only easily controlled but, as regards operating conditions, may be easily stopped and started and placed under "stand-by" conditions independently of the flow of incoming molten material. More specifically, it is an object to provide a spinning head which is of hollow vertical construction so that the incoming stream, when spinning is not desired, will be directed idly through the center of the head for collection in a pit or receptacle below. This enables the spinning operation to be turned on and off by moving the head relative to the stream only a few inches in one direction or the other. It is one of the objects of the device to provide a vertically oriented hollow spinning head which is acted upon uniformly by gravity so that the residual film on the spinning element upon shut-down is of uniform thickness without any tendency to produce unbalance when the spinning head is restored to operation. Moreover, it is an object to provide a spinning head which is automatically draining upon shut-down.

Turning to the mechanical aspects of the invention, it is an object to provide a novel high speed driving arrangement which is capable of operating at high temperature but without any of the problems usually associated with high temperature environments. More specifically, it is an object to provide a spinning arrangement in which lubrication does not present any problem in that certain of the driving elements are capable of operating without lubrication and in that the lubricated elements are safely removed from the region of high temperature. It is another object to provide a spinning arrangement having a spinning element which employs high centrifugal forces brought about by extremely high speed rotation, but in which unbalance and vibration are minimized to produce a smooth running, free spinning, element. It is yet another object to provide a spinning arrangement which operates at high speed but which nevertheless requires only a small amount of power, power much less than that required in conventional devices, and which may be constructed at low cost.

Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawing in which:

FIGURE 1 is a vertical section of a spinning head and associated drive mechanism constructed in accordance with the present invention, and taken along the section line **1—1** in FIG. 2.

FIG. 2 is a top view of the device shown in FIG. 1.

FIG. 3 is a fragmentary view of the extreme peripheral portion of the spinning member shown in FIG. 1.

FIG. 4 is a half-section of a modified spinning member or cone which may be used in the spinning head of FIG. 1.

FIG. 4*a* is a transverse section of a further modification of spinning member employing a thick film and plurality of circling ridges.

FIG. 5 shows an arrangement similar to that shown in FIG. 1 but including a novel driving arrangement for the spinning head.

FIG. 6 is a vertical section of a modified form of the present invention including channels in the surface of the spinning member and with additional fiberizing lip area.

FIG. 7 is a fragmentary view, a portion of which shows the top of the frame or housing which clamps together the spinning member and the remainder of which shows the fitting together of the segments of the spinning member.

FIG. 8 is a fragmentary section taken along the line **8—8** in FIG. 6.

FIG. 9 is a fragmentary section taken along the line **9—9** in FIG. 6.

While the invention has been described in connection with certain preferred embodiments, it will be understood that I do not intend to limit the invention to such embodiments but intend to cover such alternative and equivalent constructions as may be included within the scope and spirit of the appended claims.

Turning now to FIG. 1, there is shown a motor driven fiber spinning head constructed in accordance with the present invention. Mounted in a frame **10**, the device is intended to receive a stream of molten glass **11** and to convert the glass in such stream into the form of long thin fibers. For spinning the fiber, the device includes a conical spinning member **15** which includes a mounting and driving disc **16** which is rigid therewith but which is separated therefrom by means of a layer of insulation **17**. The edge of the disc **16** preferably has ridges **21, 22** defining a groove **23**. Spaced at equal increments about the disc **16** are guiding rollers or guides **31—34** mounted on shafts **35—38** respectively. For floatingly mounting the guiding rollers **31—34**, springs **41—44** are employed. Thus the disc **16** is not only centered for rotation but floatingly mounted, permitting rotation of the spinning head at a high rate of speed.

Driving of the spinning member is effected by a motor **50** which is splined to sheave elements **51, 52** which engage the ridges of the disc **16** between them being pressed together by a spring **53** as shown in FIG. 1. Preferably the faces of the sheave portions **51, 52** are covered with heat resisting material having qualities similar to brake lining so that a positive friction drive is assured.

In accordance with the present invention, the spinning member is in the form of an inverted cone **60** which includes a neck portion **61** and an outwardly and downwardly flaring wall **62** having a peripheral portion **63**, and means are provided for feeding a stream of glass within the neck and for discharging the stream radially outward against the inner surface of the spinning member. The spinning member is rotated at a sufficiently high rate of speed by the motor **50** so that the stream of glass **65** is flattened against the inner surface **62** and propelled along the surface in the form of a thin film for discharge at the peripheral portion **63** in the form of long fibers.

The peripheral portion **63** of the spinning member is preferably parabolic in profile, i.e., formed with a smooth bell-like flare that increases progressively as shown. Observations indicate that in employing a conical spinning member having a flared peripheral portion, it is possible to achieve, for a given viscosity of molten glass, a condition in which a thin film of glass is formed followed by separation of the film into discrete fibers which leave the surface of the spinning member. Because of the progressive thinning of the film which occurs as the same moves along the surface of the peripheral portion, surface tension tends to predominate over centrifugal force as well as the force of cohesion and the force of adhesion to the surface on which the film is supported, causing the leading edge of the film to separate initially into ribbons **65*a*, 65*b*** (FIG. 3). As the ribbons **65*a*, 65*b*** are propelled outwardly, surface tension causes them to change further from a ribbon-like cross section to a cylindrical cross section, i.e., causes them to change into incipient fibers as indicated at **65*c***. Since the glass at the time that the incipient fibers are formed is quite viscous, the nature of the surface at the peripheral portion of the spinning member, provided it is smooth seems to be non-critical. A typical material which may be used is a cast nickel-chromium-iron alloy known as "Nichrome." These incipient fibers are then projected, by the forces acting upon them, into the air where additional elongation and final cooling takes place.

The fibers as they are thrown clear of the spinning head are acted upon by gravity which tends to cause them to settle to a receiving area below the spinning head which may, in a practical case, be a conveyor belt. This settling is accelerated and controlled by providing, in the frame **10**, a plurality of air nozzles, which may be four in number and which have been designated **71–74**.

For the purpose of spraying the fiber with a plastic binder as it leaves the spinning head, jets **80** supplied from a reservoir of binder are included in the air nozzles **71–74** so that binder in the form of atomized droplets thoroughly coats the surfaces of the fibers causing them to adhere to one another for the formation of a random, yet integrated, mass. Where the spinning head is to be employed for making insulation, the coated fibers are gradually built up into a "batt" of a desired thickness. A plurality of units such as disclosed in FIG. 1 may be employed side by side and in staggered relation along a moving conveyor belt so that they cooperate with one another in laying down a batt at efficient production speed.

In accordance with a more detailed feature of the invention means are provided for imparting rotational movement to the stream of glass thereby causing the stream to be discharged radially outward against the inner surface of the spinning member. In the present embodiment this is accomplished by a conical receiving member superimposed above the conical spinning member **15** and telescoped into the neck of the latter. It will be noted that the lower edge of member **92** is positioned adjacent to and substantially contiguous with an edge of spinning member **15** so that the molten glass is smoothly fed from member **92** into spinning member **15**. The receiving member is arranged to receive a stream of molten glass and is rotated at a speed sufficient to form a reservoir and to convert such stream into a film **65** deposited within the neck of the spinning member. In the present instance the conical receiving member indicated at **90** is centered above the spinning member **15** and has a lower end portion **91** telescoped within the neck **61**. The receiving member **90** has a conical inner surface **92**, the incoming stream of molten material **11** being so positioned as to engage the surface **92** as shown.

In carrying out the present invention, means are provided for mounting the receiving member **90** for rotation and rotating it at a speed which is substantially less than the speed of the spinning member but which is nevertheless sufficient to maintain a reservoir of molten glass within the receiving member for feeding downwardly into the spinning member at a predetermined rate. The film leaving the lower end of the receiving member is flung outwardly by centrifugal force so that uniformly smooth contact with the inside of the spinning member is assured.

The double conical arrangement of spinning member **15** and receiving member **90** telescoped together at the neck, produces what may be termed for convenience an "hourglass," and the present spinning head may therefore be said to be of hourglass construction. Prior to discussing in detail the manner in which the two conical members cooperate with one another, and the advantages inherent in such construction, attention may be given to the means for mounting the receiving member. For this purpose a disc **100** is used having ridges **101**, **102** defining a groove or valley **103** between them. For engaging the disc four sheave rollers **111—114** are provided which are similar to the sheave rollers **31—34** previously mentioned. For convenience, the members **111—114** are mounted on the same shafts **35—38**, and springs **115** are used to achieve the same type of floating mounting. To drive the disc **100**, a motor **120** is used having opposed sheave members **121**, **122** which serve to drive the disc in the same fashion as the disc **16** discussed above. The motors **50**, **120** are both preferably of variable speed variety having well known means for controlling the speed. The only difference between them is that the motor **50** is preferably adjustable up to a speed of about 3000 r.p.m. whereas the motor **120** need be adjustable only up to approximately 600 r.p.m. In short, less speed is required for maintaining a reservoir of molten glass in the upper member than is required for centrifugal discharge of fibers in the lower or spinning member.

In order to control the temperature of the molten glass or melt being fed to the spinning member, a gas burner **130** extends axially into the receiving member and is provided with ports **131—134** which may be radially directed as well as a lower port **135** which may be directed into the neck of the spinning member. For cooling the receiving member, it may be formed with cooling ribs **140**. With the temperature of the receiving member thus lowered, a thin crust of glass is formed on the surface thereof and remains in a solid state under steady state operation, while the main body of the molten glass from the stream **11** flows over it.

Prior to putting the device shown in FIGS. 1–3 into operation, the stream **11** of molten glass may be started and directed down through the neck of the spinning head by a deflector **141** into a receptacle pit below. The burner **130** is turned on in order to pre-heat the surfaces of both the receiving member and the spinning member. When the surfaces are at a proper temperature, both of the members are brought up to appropriate rates of speed by their driving motors. It a practical case, the speed of the spinning member may be between 2000 and 3000 r.p.m. and that of the receiving member between 300 and 600 r.p.m.

The stream **11** is then directed so that it strikes the tapering side wall of the receiving member **90**, building up a reservoir of molten glass in the form of a thick film. The speed of the receiving member is gradually reduced so that gravity overcomes the centrifugal force acting upon the film thereby causing the film to feed at a controlled rate downwardly through the neck of the receiving member. Because of the centrifugal force acting upon the molten glass leaving the receiving member, the film of glass is flung radially outward striking the inside surface of the spinning member at a point just below the neck. At this point the glass film is accelerated to a substantially greater velocity. The additional centrifugal force acting upon the film in the spinning member causes the film to be impelled outwardly and downwardly along the wall **62** to the peripheral portion **63** where the phenomenon occurs which was previously discussed in connection with FIG. 3.

Where it is desired to maintain a larger reservoir of glass in a receiving member, the upper edge of the receiving member may be dished inwardly all around in order to form an annular retaining pocket. The steepness of the slope, the amount of the speed required to maintain the molten glass on such slope, and the depth of the pocket are matters which are within the scope of one skilled in this art.

Observations show that considerable centrifugal force is required to fling the fibers clear of the spinning member. Thus, referring to FIG. 3 the incipient fibers **65c** are of small cross section and light weight. While they have sufficient surface tension to adopt the fibrous shape, nevertheless there is still a large force of adhesion tending to hold the fiber on the spinning head. Stated in simple terms, the incipient fiber tends to be held "captive" at the peripheral region of the spinning member, and in order to dislodge it the speed must be brought to an extremely high value, say on the order of 2000 to 3000 r.p.m. or more. This high speed of rotation is found to be of great advantage since once the incipient fiber is flung clear of the surface of the spinning member it tends to elongate smoothly and there is no tendency to form the lumps, shot, dust, feathers and other unwanted forms of glass which characterize "wool" made by conventional means.

In the above discussion of FIGS. 1–3 mention was made of the fact that the molten glass, formed into a thick film in an upper or receiving member, passes into a spinning member just below the neck portion thereof and thence outwardly along the flared surface for discharge at the lower end of the spinning member. Attention is drawn to the fact that at the region where the glass film strikes the inner wall of the spinning member, such wall bears a rather large angle with respect to the axis. This angle has been indicated at "A" in FIG. 5. My observations show that where this angle is relatively large and the surface speed high, on the order of 10,000–25,000 inches or more per minute, an unusual effect takes place resulting in the almost immediate formation of a thin film, a film which needs to be additionally thinned by only a slight amount for fiberization to occur. This phenomenon may be referred to for convenience as "stripping." What happens is that the leading edge of the advancing thick film of glass from the receiving member, as it strikes the inner surface of the spinning member which is rotating at a higher rate of speed, is progressively "stripped off" or "shaved off" being changed abruptly from a thick film to a thin film at the region of contact and, because of centrifugal force, immediately transported away from such region of contact. For optimum stripping effect the angle A should preferably have a value which is greater than 30 degrees and which may be as high as 75 degrees.

By way of contrast to the stripping action, it is possible, in accordance with my teachings, to apply a different transfer phenomenon by constructing the neck portions of the two cones so that the thick film from the upper cone travels only a minimum distance radially outward incident to passage from one cone to the other and so that the surface which receives the film bears only a shallow angle with respect to the spin axis. This permits the film to be transferred from the upper member to the lower spinning member with a minimum change in the thickness of the film. An example of such construction is the spinning member **145** shown in FIG. 4. Here it will be noted that the angle, which is indicated at "B," is an extremely shallow angle preferably on the order of 5–10 degrees. This angle should be sufficient to preclude outward flow or leakage at the joint but in any event should be less than 30 degrees where it is desired to maintain the film thickness. As a result of the above, there is little or no change in thickness incident to the film transfer in FIG. 4, the thickness $t1$ of the film within the lower end of the upper cone substantially equaling the thickness $t2$ at the region where the film is deposited upon the surface of the lower cone. If desired the neck of the lower cone or receiving member may be vertically fluted so that the film is not stripped therefrom as a result of its acceleration. In order that the film may be subsequently thinned to a point suitable for the fiberizing phenomenon of FIG. 3 to occur, the spinning head is larger and has a longer path of travel for the film from neck to periphery than the spinning head shown in FIG. 1.

While the spinning heads shown in FIGS. 1 and 4 are distinguished by relatively high production of a high quality product, production can be further increased to produce a product which is satisfactory for most purposes by substituting the particular spinning head construction which is shown in transverse section in FIG. 4*a*. This head indicated at **150** employs what may be termed a "thick film" spinning phenomenon as contrasted with the "thin film" phenomenon as discussed in connection with FIG. 3. The spinning member **150** is more shallow than that previously discussed having a neck portion **151**, a generally conical internal surface **152** and a peripheral portion **153**. Formed on the internal surface of the spinning member **150** are a series of circling relatively sharp edged ridges **161**, **162**, **163**. Such ridges are spaced incrementally along the axis of the spinning member, but may be spiraled if desired. Thus the film **154** which is discharged into the spinning member from the receiving member must successively pass over the ridges as it is impelled by centrifugal force from the neck of the spinning member to the peripheral portion thereof. As the film of molten glass passes over the ridges, a certain amount thereof is stripped off, lost, or thrown clear of the spinning head as shown at **161***a*, **161***b*, and **161***c*. Since the spinning head is rotating at a high rate of speed, the fiber which is thrown off is elongated and falls, under the action of gravity, to a receiving conveying belt or the like. The portion of the glass film which remains on the head after passing the ridges is discharged in accordance with the "thin film" phenomenon as discussed in connection with FIG. 3, the fiber from the periphery of the spinning member being indicated at **153***a*.

It will be noted from what has been said thus far that the transition from the molten stream of glass **11** to the final product takes place smoothly and with gradual acceleration of the material without the violent blasting and spattering of more conventional devices, particularly those employed for producing insulating wool. Moreover, since the total travel of the material from point of entry to point of discharge is only a few inches, the temperature remains at a high level, and where it is necessary to supply additional heat, this is, in the present construction, conveniently accomplished by means of the burner **130**. The sustained high temperature maintained until the actual elongation of the fibers as they are thrown clear from the spinning head means that there is a total absence of thermal shock and its disadvantages.

By adjusting the relative speeds of the receiving and spinning members, the thickness and lengths of the fibers may be varied over wide limits. Thus by running the receiving member **90** at high speed so that it feeds only a limited amount of material to the spinning member, and by operating the spinning member at the upper portion of its range, long thin fibers may be produced. Conversely, by slowing down the receiving member to increase the material being fed to the spinning member, and by making a proportionate increase in the size of the incoming stream of molten glass **11**, the spinning member is more heavily loaded and consequently thicker fibers are produced. Also, as will be apparent to one skilled in the art in view of the present teachings, the character of the fibers may be controlled by the curvature and angling of the wall of the spinning member. Thus it is possible to produce fibers with the above arrangement which are suitable for a wide variety of insulating and structural purposes.

It is a further characteristic of the device described that it may be employed with a wide range of glass and slag having different physical properties and different chemical composition.

The vertical orientation of the "hourglass" arrangement is worthy of particular note since, combined with the various structural features, it brings about a number of important advantages. In the first place, although the spinning member is inverted, gravity, as far as the film is concerned, is successfully defied. Moreover, full use is made of gravity to pull the dislodged or ejected fibers downwardly and away from the head onto a conveyor belt or the like. Gravity acts uniformly on all the fibers which are produced. This is to be distinguished from horizontally arranged spinning devices in which gravity tends to add to centrifugal force in the case of some of the fibers and to subtract from centrifugal force in the case of others. Consequently, the present device is capable of laying down an even and homogeneous blanket of fibers. The vertical arrangement facilitates placing side by side in staggered relation for common discharge over a single delivery belt for high speed batt production. Also, because of the symmetry of the arrangement with respect to gravity, even heating is accomplished employing a single, centrally arranged gas burner. Finally, the vertical orientation permits the molten stream to be easily disposed of through the center of the neck under stand-by conditions.

One practical advantage of the present construction is the inherently long life and freedom of maintenance. Thus substantially all of the active surfaces remain coated with glass film and therefore protected from the effect of atmospheric oxygen. Moreover, high speed abrading or scuffing action is avoided so that the receiving and spinning members may be operated for long periods of time without requiring service or replacement. With regard to the materials of construction, both the receiving member and the spinning member may be made of the "Nichrome" alloy already mentioned.

With regard to the uniformity of the product produced, it must be kept in mind that the stream of molten material coming from a furnace normally includes variations in the material, particularly variations in chemical composition. Since the receiving member serves to temporarily maintain a reservoir of incoming material, it performs a mixing function so that the molten glass which is fed to the spinning member has more average and predictable characteristics than the incoming stream **11**.

With regard to the mechanical mounting, a number of advantages will be apparent to one skilled in the art. Not only does the mounting permit rotation of the spinning head at high speed with a minimum of vibration, but the parts requiring lubrication are all safely spaced away from the region of high heat so that the difficulties of lubrication normally encountered in high temperature devices are avoided.

One problem in conventional spinning arrangements is that of putting the device into and out of production. This is readily accomplished in the present device simply by providing means for moving the spinning head a few inches relative to the incoming stream so that the stream passes through the hollow center down into a pit or receiver. Thus there is no possibility that conditions will arise in which the molten material hardens in place on the receiver or spinning head in a condition which will set up unbalance when the operation is resumed.

In the device discussed in the foregoing figures, the spinning member is rotated at a high rate of speed by a separate driving motor **50**. In accordance with one of the aspects of the present invention, I propose that the driving motor be integrated with the spinning member as shown in FIG. 5. Aside from the driving means, the construction disclosed in this figure closely resembles that shown in FIG. 1 and the discussion will therefore not be repeated. Corresponding parts are indicated by corresponding reference numerals, where applicable, plus the subscript "*a*." In this figure, the spinning member **15*a*** is rigidly mounted with respect to a supporting disc **16*a***, supported on sheave rollers which are spaced about the periphery thereof and one of which is indicated at **31*a***. Arranged about the periphery of the spinning member **15*a*** and integral with it is a rotor **170** having a squirrel cage **171**. Surrounding the squirrel cage and separated therefrom by a small air gap is an armature **172** having the usual windings **173** as employed in an induction type motor. As will be appreciated by one skilled in the art, the windings **173** are still wired as to produce a rotating field which induces currents in the squirrel cage **171** causing high speed rotation of the rotor **170** and its associated spinning member **15a**. The synchronous speed of the rotating field may be on the order of 3600 r.p.m. and any conventional means used to control the speed of an induction motor may be employed to adjust the speed of the spinning head.

Alternate embodiment employing spiral channel

Certain aspects of the invention are embodied in a modified device shown in FIGS. 6–9, which device employs the same general vertical hourglass arrangement. The alternate form is intended for use where a higher production of fibers is required than may be obtained by using one of the receiving embodiments. As will be made clear as the discussion proceeds, greater production is brought about by providing a longer length of fiber-producing lip or "periphery." In the form of the invention shown in FIG. 1, fibers are produced about a single peripheral and curved edge whereas in the embodiment shown in FIG. 4*a*, production is augmented by passing the film, in the thicker form, over a series of concentric sharp ridges. In the form of the invention disclosed in FIG. 6, the molten glass, instead of flowing radially outward is constrained to follow a channel formed in the spinning member.

Prior to discussing the spinning member which distinguishes the device of FIG. 6, attention may first be given to the environmental portions of the mechanism. Thus the device is mounted in a frame **180**. The spinning member mounted therein and generally indicated at **185** is supported on a supporting disc **186** which rides in sheave rollers **191—194**. The latter are mounted for rotation on shafts or spindles **195—198**. Arranged concentrically above the spinning member **185** is a receiving member **200** which has a lower end **201**, which is telescoped within the upper end or neck of the spinning member **185**, and a surface **202** which receives a stream of molten glass **203** forming a film **204**. For mounting the receiving member **200** and for driving the same, a supporting disc **206** is provided which is engaged by sheave rollers **211—214** mounted on the same spindles **195—198** previously referred to.

For the purpose of driving the receiving member **200** a motor driven worm and worm gear are employed. Thus the worm indicated at **221** drives the worm gear **222** by torque received from motor **223**. The worm gear **222** is, in the present instance, in the shape of a circular rack which extends around the mid portion of the receiving member **200**.

In order to assist in keeping the receiving member **200** at a safe temperature, a cooling arrangement is employed which comprises a conical jacket **225** which surrounds the receiving member to define an air space **226**. For scooping air into the cooling air space, scoops are integrally formed in the jacket as indicated at **227**. Moreover, a helical or spiral rib **228** is integrally formed on the outer surface of the receiving member **200** so that the air scooped into the air space is progressively conducted along the surface of the receiving member for discharge at an annular vent **229** at the lower end of the receiving member.

In order to maintain the molten glass at a desired high temperature, a gas burner **230** extends axially through the device having annular burner elements **231, 232, 233** as shown.

In accordance with the present invention, a rotating conical spinning member is employed having a spiral channel formed in its wall for conducting the molten glass along a spiral path, with the channel being provided with a continuous edge or lip portion along which molten glass is ejected in the form of fibers by centrifugal force. Thus, turning to the illustrated embodiment, the spinning member **185** is formed on its inside surface with a continuous spiral channel **235** having a continuous, relatively sharp-edged lip **236**. The channel **235** has such radial depth that with the rated amount of molten glass coming into the spinning head, and when operated at production speed, the molten glass will tend to overflow around the sharp lip to form elongated fibers. In view of the successive loss of molten material along the length of the channel, the channel is made of successively smaller cross section so that the amount of overflow is substantially uniform along the entire lip **236**.

In accordance with one of the features of the present invention, the convolutions of the channel indicated at **241, 242, 243, 244** are made overlapping so that the lip portion of one convolution overlies the channel portion of the next. Preferably, the downward slope of the lip portion, indicated at **237**, is such that at operating speed the thin film phenomenon illustrated in FIG. 3 will occur, with ribbons and incipient fibers of molten glass being successively formed for discharge at the periphery of the lip into elongated fibers.

In accordance with one of the aspects of the invention and to insure downward discharge of the fibers thus formed even at high rotative speeds, an air blast is blown between the successive convolutions of the channel **235** in a downward direction. In the present instance this air blast occurs through openings **251, 252, 253** and **254**. In order to insure that air passes downwardly from the openings in the form of a continuous ring, the apertures are flaring as shown at **257** in FIG. 8, the mouths of such passages taking up substantially the entire periphery so that there are no "gaps" in the air blast.

To facilitate manufacture, the entire channel assembly is made up of a number of segments, eight in number (see FIG. 7), which are arranged end to end. In accordance with one of the more detailed aspects of the present invention, a supporting and clamping frame or enclosure **260** is provided for holding all of the segments together in one integrated unit and to define a single continuous melt-conducting channel. In the present instance this frame is made up of four separate pieces **261—264**, each of which occupies 90 degrees, and clamped together by suitable bolts **265**. For lockingly engaging the rear portions of each of the segments, the clamping frame **260** preferably has formed on its inner surface, a spiral ridge which extends radially inward and which has successive convolutions **271—275** which mate with corresponding grooves **276** formed on the back side of each of the individual segments.

Thus it will be apparent to one skilled in the art that when the clamping bolts **265** are tightened, the four sections **261—264** will be drawn inwardly, with the internal ridges in the sections lockingly engaging the grooves **276** formed in the respective segments, with the result that all segments are securely clamped together, one on the other, without any "play" and forming a solid integral unit. This permits operation at high rates of speed equivalent to that which would be possible if the assembly were formed of one piece.

Further in accordance with the present invention, the air which provides the air blast through the annular openings **251—254** is employed to rotate the spinning member. To accomplish this, the frame **260** provides a continuous, annular, air inlet **280** occupied by a set of inclined driving vanes **281** (FIG. 8) which are uniformly spaced from one another. For the purpose of directing air to the vanes **281**, a stationary hood member **285** is provided having an annular outlet **286** which is arranged directly opposite the inlet **280** and which has a set of directing vanes **287**. For supplying air through the vanes **287**, an air line **288** is provided which is connected to a suitable source of high pressure air. It will be apparent from what has been said thus far that the air discharged between the vanes **287** inwardly and downwardly, engages the driving vanes **281** on the spinning member thereby providing a constant driving force around the periphery of the spinning member and causing the latter to revolve at a high but controllable rate of speed.

For the purpose of preventing leakage between the hood **285** and the sections comprising the clamping arrangement **260**, two sets of labyrinth sealing members are employed. One labyrinth seal is indicated at **291** and the other at **292** (see FIGS. 6 and 9). Both comprise sets of registered fins which extend annularly about the spinning member and which run close to one another yet without touching. By this means it is possible to preserve sufficient pressure to provide efficient rotation of the spinning member. The exhaust air from the vanes **281** is passed through channelel orifices **291**, **292**, **293**, **294** and thence into the annular air outlets **251—254** previously referred to.

It is of interest to keep in mind that in addition to the efficient use of the exhaust air for transporting the fibers downwardly from their point of formation, the arrangement provides automatic correlation between the speed and air blast. Thus when the spinning head is rotating at a relatively low speed, the amount of air, i.e., the air velocity acting upon the fibers, will be relatively low. However, when the spinning head is operated at high speed, the air velocity is proportionately increased in order to overcome the effect of the greater centrifugal force effective at such higher speeds. Thus, regardless of the speed of operation there is always sufficient air blast to insure that the fibers produced along the continuous lip **236** are blown downwardly and clear of the spinning member, being received on a suitable conveyor belt or the like arranged below.

Any of the molten glass remaining in the channel **235** at the end of the channel, i.e., at the outer periphery is deposited on a curved surface **295** where fibers are formed by the "thin film" phenomenon discussed in connection with FIG. 3. It will be apparent that the device shown in FIG. 6 is effective to produce fiber along a fiber-producing edge or lip which is many times the length of the periphery of the spinning member, consequently, extremely high production rates may be achieved. And because of the novel arrangement for carrying the fiber downwardly by an air stream, high rotative speeds may be employed without risk that the fibers produced will be simply slung into the adjacent channel convolution. The speeds of the receiving member and spinning member may be coordinated by speed adjusting means associated with the motor **223** and pressure adjusting means associated with the air inlet **288**.

In the following claims, the term "glass" is intended to be generic to glass, slag, or any other material having the physical characteristics of molten glass and capable of being spun into thin fibers. Also the term "air" is intended to be generic to gas having physical qualities similar to air as regards capability for acting upon turbine blades. Also it will be understood that the term "cone" is not limited to a straight sided surface of revolution having a particular angle, but it is used in a more general sense to denote a surface of revolution in which one end is smaller than the other. The term "neck portion" means the portion in the general region of the neck of the cone, i.e., the portion of the cone of lesser diameter.

I claim as my invention:

1. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion at its upper end and defining an internal cavity which flares downwardly and radially outward from said neck portion to a peripheral portion at its lower end, means for feeding a thick film of molten glass to a region within the neck portion and for smoothly distributing the same on the wall of said cavity, the peripheral portion of said spinning member having generally parabolic curvature, and means for rotating said spinning member at a sufficiently high speed so that said film of glass separates into spiral incipient fibers at said peripheral portion for subsequent discharge therefrom.

2. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion and a peripheral portion, means positioned adjacent to and substantially contiguous with said neck portion for smoothly feeding into said neck portion an annular, rotating, relatively thick film of glass, and means for rotating the conical spinning member at a speed which greatly exceeds the speed of rotation of said film, the region at which the film strikes the spinning member being flared outwardly so that the leading edge of the advancing film is stripped therefrom and immediately re-formed into a film on said spinning member which has substantially reduced thickness for discharge in the form of fibers at the periphery of said spinning member.

3. A device for spinning glass fibers which comprises a first cone having a neck portion at its lower end, a second cone having a neck portion at its upper end mating with the neck portion of the first cone, means for feeding a stream of glass to said first cone, means for rotating said cones with the second cone being rotated at a speed which greatly exceeds the speed of rotation of the first cone, so that a film of glass fed from said first cone into said second cone is formed into an outwardly propelled film on said second cone for discharge of glass fibers from the peripheral portion of the latter.

4. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion at its upper end and defining an internal cavity which flares downwardly and outwardly from said neck portion to a peripheral portion at its lower end, means for feeding a thick annular film of molten glass to a region just below the neck of said spinning member, means for rotating the spinning member so that the glass flows down the wall of the cavity for discharge of glass fibers at said periphery, the angle of the wall of said cavity with respect to the spin axis at the region where the film strikes the wall being within the range of 30 to 75 degrees and said spinning member being rotated at a surface speed in excess of about 10,000 inches per minute so that the leading edge of the film is stripped off and the film thickness abruptly reduced.

5. A device for spinning glass fibers which comprises a spinning head of hourglass shape arranged for rotation about a vertical central axis, said head having an upper receiving portion, a lower spinning portion, and a neck portion in between, means for directing a stream of molten glass into said head so that it strikes the wall of said receiving portion, means for rotating said head so that the force of gravity exceeds the centrifugal force acting upon the glass in said receiving portion so that glass is fed downwardly through said neck into said spinning portion.

6. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck at its upper end and having an internal cavity which flares outwardly and downwardly from said neck to the lower peripheral portion of said member, a conical receiving member arranged above said conical spinning member and having a lower portion which is telescoped inside of the neck of said spinning member, said lower portion being positioned adjacent to and substantially contiguous with said neck, means for directing a stream of molten glass into said receiving member for depositing of a film on the internal wall thereof, means for rotating said receiving member at a speed which permits the molten glass to be fed in the form of said film down the wall of said receiving member with sufficient centrifugal force to cause said film smoothly to flow radially outward for formation of a film on the inside wall of said spinning member, and means for rotating the spinning member at high speed so that the film travels downwardly along the internal wall thereof for discharge at the peripheral portion of said spinning member in the form of glass fibers.

7. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck at its upper end and having an internal cavity which flares outwardly and downwardly from said neck to the lower peripheral portion of said member, a conical receiving member arranged above said conical spinning member and having a lower portion which is telescoped inside of the neck of said spinning member, said lower portion being positioned adjacent to and substantially contiguous with said neck, means for directing a stream of molten glass into said receiving member for depositing of a film on the internal wall thereof, means for rotating said receiving member at a speed which permits the molten glass to be fed in the form of said film down the wall of said receiving member with sufficient centrifugal force to cause said film smoothly to flow radially outward for formation of a film on the inside wall of said spinning member, and means for rotating the spinning member at high speed so that the film travels downwardly along the internal wall thereof for discharge at the peripheral portion of said spinning member in the form of glass fibers, said rotating means including annular discs surrounding said members respectively and having sheave rollers supporting the same.

8. A device for spinning glass fibers which comprises a hollow conical spinning member, a spiral channel formed in the wall thereof and having a lip portion extending along its edge, means for feeding molten glass to the inner end of said channel, means for rotating said spinner member at a rate of speed which is sufficiently high as to cause the glass to be propelled along said channel with a portion thereof escaping over said lip and ejected therefrom in the form of glass fibers, means defining a substantially continuous annular air passage between the convolutions of said channel, and means for propelling air through the latter during rotation of the member.

9. A device for spinning glass fibers which comprises a conical spinning member having a neck at its upper end and flaring outwardly and downwardly, the conical surface of said spinning member being channeled out to define a spiral channel having a lip running along the edge thereof, with the lip of one convolution of said channel overlying the adjacent convolution, means for rotating said spinning member at a sufficiently high rate of speed so that the molten glass is propelled along the channel with a portion thereof escaping over the lip of said channel and ejected from said lip in the form of fibers, and means providing an air blast between the convolutions of said channel for engaging the fibers being ejected from the lips thereof and for blowing said fibers downwardly from said spinning member.

10. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion at its upper end and having a cavity which flares outwardly and downwardly, means for supplying a film of glass to the wall of said cavity adjacent said neck portion, said conical spinning member having a ring of vanes formed on its outside wall, means for directing pressurized air upon said vanes for producing high speed rotation of said conical spinning member so that the film of glass is forced along the wall of said cavity and ejected from said spinning member in the form of fibers, and channel means for directing the exhaust air from said vanes against said fibers for blowing the same clear of said spinning member.

11. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion at its upper end and an internal cavity which flares outwardly and downwardly therefrom, means for feeding a film of molten glass to the wall of said cavity in the region of said neck portion, means for rotating a spinning member at a sufficiently high rate of speed so that the film of glass tends to flow downwardly and outwardly along the wall of said cavity for discharge in the form of fibers, said wall in cross section having a flared contour, and air nozzles spaced about the periphery of said member for directing the fibers downwardly, said air nozzles including means for coating the fibers with a binder.

12. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion and having an internal wall defining a cavity which flares outwardly from said neck portion, said wall having a plurality of upstanding annular ridges thereon, means for feeding molten glass into said spinning member so that a film of glass is deposited on the inside wall thereof, means for rotating said spinning member at a sufficiently high rate of speed so that a film of glass is forced outwardly from said neck portion by centrifugal force and over said ridges, said ridges having sharply defined outwardly facing edges, means for adjusting the speed of rotation so that the surface tension of the molten glass is overcome at the ridges so that a portion of the glass separates from the main body of the film and is propelled from the ridges in the form of glass fibers, said spinner member having a flared edge portion for ejecting in the form of glass fibers any of the glass film which remains on the wall of said spinning member following discharge of a portion thereof by said ridges.

13. A device for spinning glass fibers which comprises a hollow conical spinning member having a neck portion at its upper end and defining an internal cavity which flares downwardly and radially outward from said neck portion to a peripheral portion at its lower end, means for feeding a stream of molten glass to a region within the neck portion and for depositing the same on the wall of said cavity, means for heating the spinning member, means for rotating the conical spinning member so that the glass flows down the wall of the cavity in the form of a film for discharge of glass fibers at said periphery, receiving means for waste glass centered below said spinnig member, and diverter means interposable in the path of said stream for causing said stream to be directed idly through said neck portion free of contact with the wall of said cavity for depositing of the glass in said receiving means prior to the time that the spinning member comes up to the desired speed and temperature.

14. A device for spinning glass fibers which comprises a first cone having a neck portion at its lower end, a second cone having a neck portion at its upper end mating with the neck portion of the first cone, means for feeding a stream of glass to said first cone, means for rotating said cones with the second cone being rotated at a speed which greatly exceeds the speed of rotation of the first cone, so that a film of glass fed from said first cone into said second cone is formed into an outwardly propelled film on said second cone for discharge of glass fibers from the peripheral portion of the latter, and means providing a current of air at said peripheral

portion for blowing the fiber downwardly away from said second cone.

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