March 23, 1965 J. K. DUNCAN 3,174,182

SPINNING ARRANGEMENT FOR SPINNING FIBERS FROM MOLTEN PLASTIC OR THE LIKE

Filed June 22, 1962 2 Sheets-Sheet 1

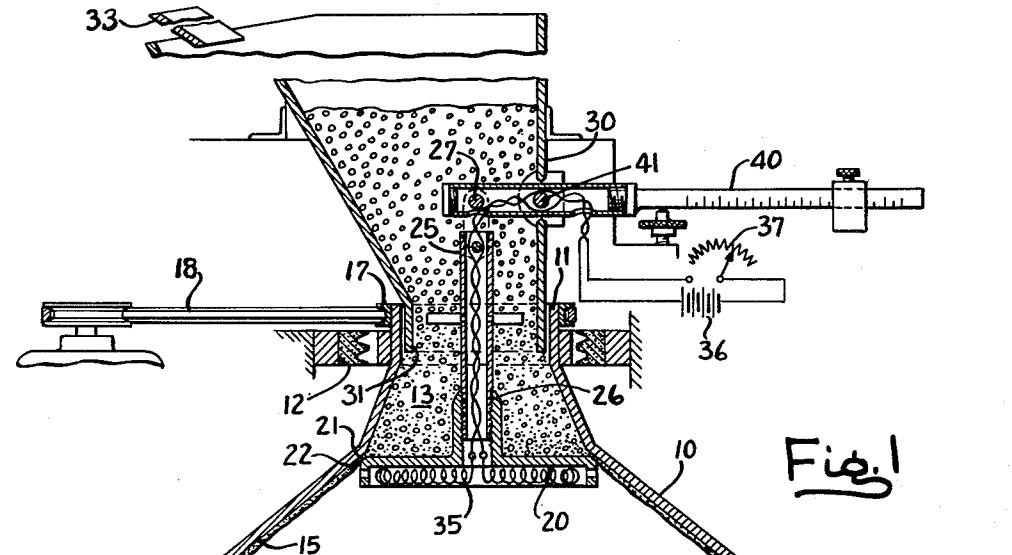


Fig. 1

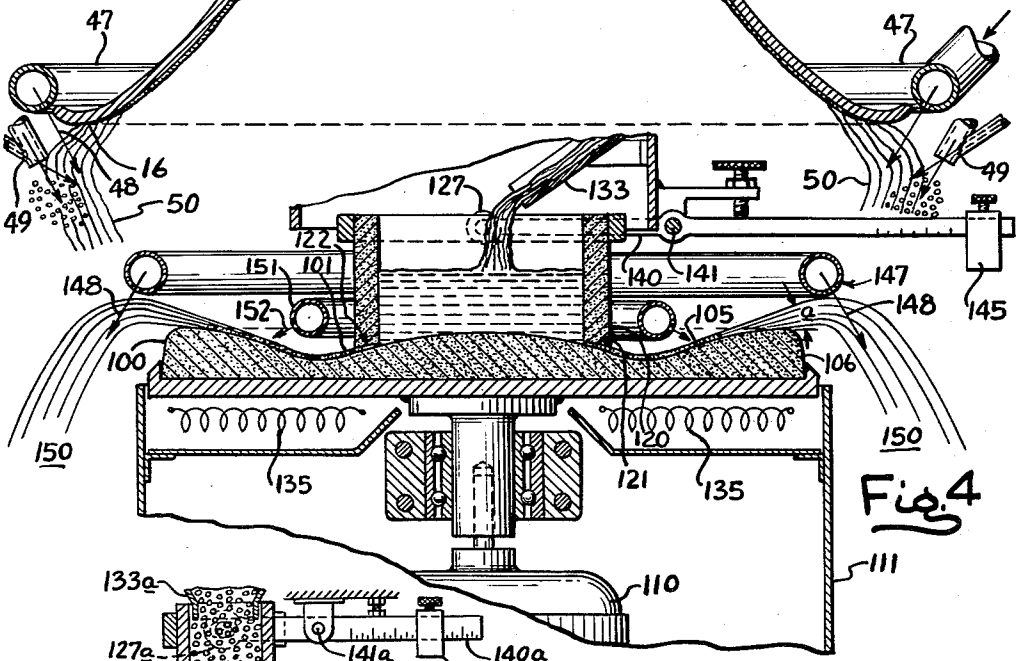


Fig. 4

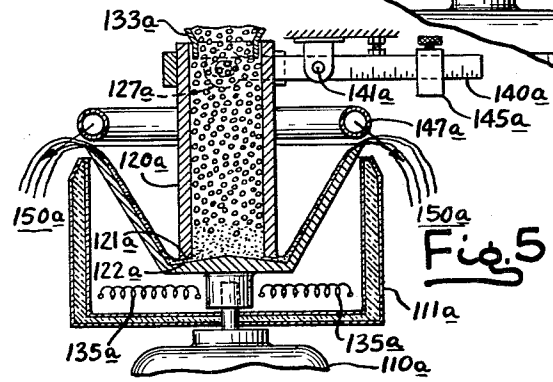


Fig. 5

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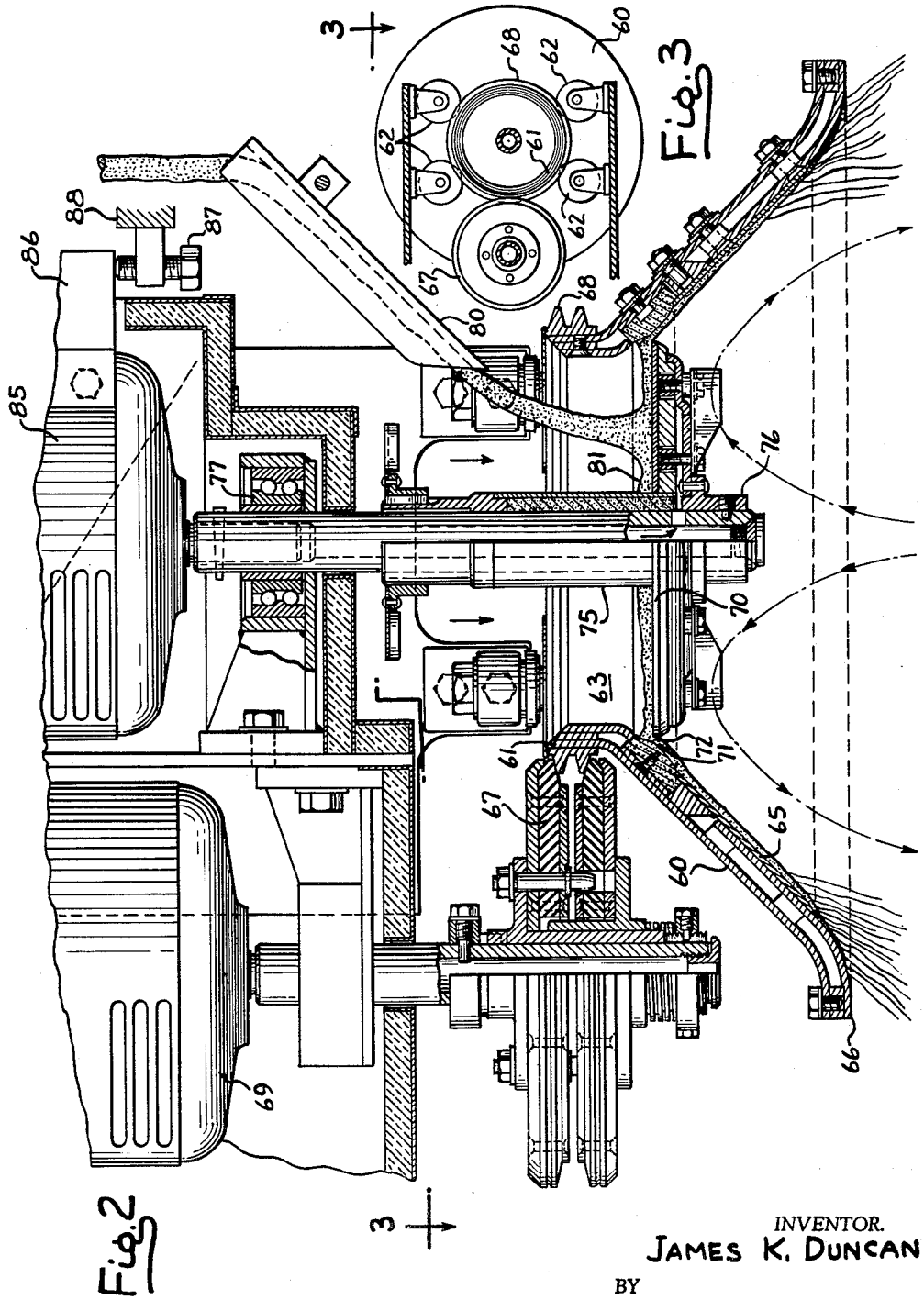


Fig. 3

Fig. 2

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SPINNING ARRANGEMENT FOR SPINNING FIBERS FROM MOLTEN PLASTIC OR THE LIKE

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8 Claims. (Cl. 18—2.5)

The present invention relates to spinning apparatus, and more particularly to centrifugal apparatus for spinning fibers of molten plastic and similar materials.

In order to make high quality fiber from fluid or molten thermal plastic materials, glass and the like, conventional practice has been to extrude the material through fine holes in spinnerettes which may, for example, be located at the periphery of a spinning element rotated at high speed. However, the cost of fiber formed in this manner is high since production is limited to the amount of material which can be forced through the spinnerettes per unit time, the production in a typical case being measured in terms of pounds per hour instead of hundreds or thousands of pounds per hour. Moreover, great difficulty has been experienced in forcing viscous plastic material through the fine openings in the spinnerettes. In the case of polypropylene, for example, the material remains quite thick even when heated to high temperatures so that extruding through small holes has not been satisfactory, at least in the finer gauges. Where attempts have been made to produce fiber at a higher tonnage rate using techniques employed in the manufacture of "glass wool" of commercial grade, as, for example, by slinging the fibers from a rapidly rotating element or by action of a steam or air blast, the quality has been poor with the fibers being accompanied by a high percentage of "shot" and "feathers," precluding use of the fiber for weaving, quilting or the like.

Accordingly, it is an object of the present invention to provide a fiber spinning arrangement particularly well suited for use with molten polypropylene or the like, which is capable of producing fibers or high quality and having a gauge or thickness falling within a desired range. It is a related object to provide a spinning arrangement which is capable of producing fibers of plastic or the like which have a negligible amount of shot and feathers and which are of "long staple" suitable for spinning into thread and for numerous other uses. It is another object to provide a spinning arrangement in which the average thickness of the fibers may be conveniently varied by a simple adjustment of the operating conditions and depending upon the uses to which the fibers are to be put.

It is a more specific object to provide a spinning arrangement utilizing molten plastic or the like in which the flow of the molten material may be adjusted to the optimum point. It is one of the objects to provide a spinning arrangement in which novel means are provided for automatic regulation of the flow so that the spinning device is capable of producing a consistent product over long periods of time without necessity for constant supervision or adjustment by the operator. In carrying out the automatic adjustment use is made of the inherent viscosity of the material being spun and with variations in such viscosity being employed to bring about a compensatory change in the rate of flow. It is still another object to provide a spinning arrangement which provides for easy control of temperature and hence the viscosity of the material immediately adjacent the region where the material is converted from the fluid to fibrous form. In this connection it is an object of the present invention, in one of its aspects, to create a film for fiberization at the lowest possible temperature thereby avoiding the decomposition or change in color which may occur where the material is molded remotely at a high temperature to compensate for heat loss in transit to the spinner. It is yet another object related to the foregoing to provide a spinning arrangement which may be conveniently fed with solid pellets of the material to be fiberized with means for causing the pellets to be transformed to molten condition on a continuous basis coordinated with the rate of discharge.

It is an important object of the present invention to provide a spinning arrangement having an inherently high rate of production, a rate which greatly exceeds that attainable where other means are employed. Consequently, high production can be achieved with a relatively minor investment in equipment and resulting in an extremely low cost per pound of production. The cost of the resulting product is sufficiently low so as to multiply the uses to which the fiber may be put enabling the high quality fiber to be substituted for the coarser low quality materials formerly used.

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

FIGURE 1 is a vertical section taken through a spinning arrangement employing the present invention.

FIG. 2 is a vertical section taken through a modified form of the present invention especially suited to the spinning of molten materials, such as glass, at high temperatures.

FIG. 3 is a transverse section, somewhat simplified, taken along the line 3—3 in FIG. 2 to show the cone mounting means.

FIG. 4 is a vertical section showing another modified form of the present device.

FIG. 5 is a vertical section of a device similar to that shown in FIG. 4.

While the invention has been described in connection with certain preferred embodiments, it will be understood that the invention is not limited thereto but I intend, on the contrary, to cover modified or equivalent devices falling within the spirit and scope of the appended claims.

Turning now to the drawings there is disclosed in FIG. 1, in simplified, partially diagrammatic form for ready understanding, a spinning arrangement constructed in accordance with the present invention. Mounted for rotation about a vertical axis is a conical spinning member 10 having a neck portion 11 at its upper end supported in an anti-friction bearing 12 preferably comprising a combination of a polished stainless steel ring of the cross section shown enclosed by adjustable carbon graphite segments or gibs to form a high temperature oil-less bearing. Formed within the neck portion is an opening 13. The conical inner surface 15, as shown, flares outwardly and downwardly from the neck terminating in a peripheral edge 16. As will later be discussed in detail, the spinning member is rotated at a sufficiently high rate of speed so that molten plastic, applied as a film to the inside surface of the spinning member is converted to a multiplicity of threads or fibers for downward discharge onto a conveyor or the like. The spinning member may be rotated by a sheave 17 about which is trained a belt 18 driven by a suitable high speed motor (not shown).

In accordance with the present invention a feed member with circular discharge is provided at the neck of the conical spinning member and having a metering member with an annular presented edge portion which extends to within a short distance of the surface of the spinning member to define a uniform clearance space for the feeding of molten plastic material to the surface of the spinning member. In the present embodiment the feed member is in the form of a feed or metering disc 20 which is axially centered within the spinning member and which

has an annular edge surface 21 defining a uniform clearance space 22. The metering disc 20 is mounted on a plunger 25 which extends downwardly through the neck opening and which has a connection 26 at its lower end and a connection 27 at its upper end.

Means are provided for feeding plastic material to the feed member and for maintaining the same in a molten condition for discharge through the annular clearance or metering space 22. In the present instance the plastic material is supplied in the form of pellets which are retained in a hopper and converted to molten condition just prior to being fed through the metering space. Thus I provide a hopper 30 having a neck 31 which registers with the neck 11 of the spinning member and which flares outwardly and upwardly to accommodate a reasonable amount of the pelleted material. Such material may be supplied from a feed chute 33 having automatic feeding means (not shown) so that a number of units may be run by one operator. For the purpose of converting the plastic material from the solid or pellet form to the molten form, I provide a heater in the form of a heating element 35 which is in close thermal coupling with the metering disc 20. Conveniently, the leads which energize the heating element may be accommodated within the plunger 25 which is, as shown, of hollow construction. Externally the leads are connected to a source of current 36 and a suitable controller, as, for example, a rheostat 37. It will be apparent, then, that as the device operates the pelleted material gradually settles down into the heated region immediately above the metering disc where it is converted to molten form for metering through the annular space 22. The material may "dam up" and fill the annular space like a reservoir, but be moved outwardly towards and downwardly along the cone surface 15 by centrifugal action and gravity.

In accordance with one of the aspects of the invention, means are provided for axially adjusting the feed member 20 with respect to the spinning member thereby to vary the width of the metering space 22 and hence the amount of material which passes to the spinning member. In the present instance this is accomplished by connecting the upper end 27 of the plunger 25 to a control member 40 in the form of a lever having a pivot connection 41. It is one of the features of the device that the metering disc 22 is biased in the direction of the spinning member so that the molten plastic material must overcome the force of bias in order to escape to the surface of the spinning member. It is found that such bias is advantageous since it tends to provide for automatic regulation of the amount of material which is passed through the metering space per unit time. Thus in the event of minor changes in the viscosity of the plastic material the disc 20 correctively moves either upwardly or downwardly. When the plastic material is particularly thin the feed member tends to close so that the flow does not increase to a point which is greater than that which can be accommodated by the spinning member. When the material is thicker than normal the metering or feed member is automatically opened to reduce the amount of friction and to let the material by. Since the member 20 is stationary while the spinning member 10 rotates at a high rate of speed, it is found that the relative movement tends to "walk" the plastic material through the metering opening at an even rate and over a wide range of viscosity. For convenience in adjustment, the biasing means in the present instance is in the form of a weight on the member 40.

With the plastic material present above the feed member 20 and with the heat applied, it will be apparent that the plastic material will become fluid to a certain depth so that a small pressure head will exist at the feed member tending to urge the material through the metering space.

It will be apparent that instead of employing the weight 45 means may be provided simply for fixing the adjusting member 40 in position for manual control of the rate of flow.

The plastic material which passes through the annular metering space forms a film on the inside surface of the spinning member. Because of the high speed of rotation which, in a practical case, may be from 2000 to 40,000 r.p.m. depending upon the material and fiber size desired, the film is, by centrifugal force, forced outwardly and downwardly and spread over a large area so that it becomes thinner as it flows. My observations show that a point of thickness is reached where the force of cohesion predominates over the force of adhesion so that the film separates into a multiplicity of thin threads or fibers formed on a helical locus on the lower inside surface of the spinning member. The spinning member is preferably made of a material which is non-wetted, or only poorly wetted, by the molten plastic so that the threads or fibers thus formed are, by action of centrifugal force and windage, swept clear of the conical surface for discharge downwardly as an airborne mass upon a suitable conveyor. In order to control the discharged fibers and to insure positive downward movement, an air ring 47 may be provided surrounding the periphery of the spinning member for directing jets of air 48 inwardly and downwardly as shown. If desired, a coating or binding material may be admixed with the air from the tube 47 by spray nozzles 49 so that the fibers 50 are coated prior to being gathered by a suitable collecting means (not shown) from which they may be passed to an oven so that the coating is cured.

The particular spinning member 10 has a conical surface in the present instance which is of reduced flare as the periphery is approached. However, it will be apparent that the precise shape of the spinning member depends upon the temperature-viscosity characteristics as well as the inherent cohesion of a molten plastic being acted upon. Consequently the shape of the spinning member may depart from that shown and, if desired, the periphery of the spinning member may flare outwardly with a bell-like curve.

In accordance with one of the aspects of the invention the feed member may be separately rotated for effecting transfer of the molten plastic from the feed member to the inside surface of a spinning member and a physical gap may be provided between the two members. Thus, as shown in FIG. 2, a spinning arrangement is provided which includes a conical spinning member 60 having a neck 61 and rotatably mounted upon idler wheels 62 (see FIG. 3). Centered within the neck 61 is an opening 63 which leads to a conical discharge surface 65 formed on the inside surface of the member and terminating in a peripheral edge 66. For the purpose of rotating the spinning member 60 at a high rate of speed, a wheel 67 engages a sheave 68 formed on the neck of the spinning member, the wheel 67 being direct coupled to a high speed drive motor 69. In this embodiment the feed member is in the form of a disc 70 having an outer peripheral edge 71 which defines an annular clearance space 72 with respect to the surface of the spinning member. The disc 70 is mounted on a central supporting member 75, with the disc being secured to its lower end at 76. The supporting member in the embodiment of FIG. 2 is in the form of a rotatable spindle having a bearing 77 at its upper end.

For the purpose of supplying molten plastic material to the feed member 70, it is convenient to apply the material directly in molten form from a conduit 80, with the material being deposited on the feed member as indicated at 81. In order to insure transfer of the molten plastic material from the feed member to the inside surface of the spinning member in the form of an evenly distributed film, means are provided for rotating the feed member at a sufficiently high rate of speed so that the molten material thereon is conveyed across the gap 72 by centrifugal force. For this purpose I provide

a motor 85 at the upper end of the shaft 75. Adjustment of the width of the gap 72 is achieved in the present instance by making the motor and shaft axially movable with respect to the bearing 77 and the remainder of the device. This is accomplished by mounting the motor upon a bracket 86 having a threaded adjusting member 87 which is screwed into a stationary threaded member 88 as shown. It will be apparent, then, that by turning the member 87 the disc 70 at the lower end of the shaft will be moved upwardly or downwardly with a corresponding change in the clearance space. It will be apparent, as a limiting case, that the disc 70 may be brought into rather close proximity with the inside surface of the spinning member so that the space 72 becomes a true metering space and so that no dependence need by placed upon centrifugal transfer.

In accordance with another aspect of the invention the spinning member may be inverted without departing from the invention and the feed member may depart from the disc shape discussed in the preceding embodiments. Thus referring to FIG. 4 there is provided a spinning member 100 having a neck portion 101 and a surface 105 having a periphery 106. It will be apparent from FIG. 4 that the cone angle indicated at "A" is rather shallow and the angle may be increased depending upon the temperature-viscosity characteristics of the material being handled as well as its inherent cohesion. For the purpose of rotating the spinning member and for supporting it on a vertical axis, a motor 110 is provided which may, if desired, be mounted within an enclosure 111.

In order to feed a film of molten material to the central or neck portion of the spinning member, a circular feed member is provided in the form of an upright cylinder 120 having an annular downwardly facing edge 121 defining an annular metering space 122. The metering member 120 is supported by a connection 127 at its upper end. Molten plastic material is supplied from a suitable nozzle or conduit 133 and a spinning member is maintained at the desired spinning temperature by means of heating elements 135 which are energized as in FIG. 1. For the purpose of varying the axial adjustment of the feed member 120, and hence the width of the metering space 122, an adjusting member 140 is provided in the form of a lever pivoted at 141 and having a counterweight 145. An air tube 147 provides air jets 148 for controlling the discharged fibers indicated at 150.

Where it is desired to increase the conical angle from the angle "*a*" shown in FIG. 4, the construction of FIG. 5 may be utilized. In this figure corresponding parts carry the same reference numeral with the addition of a subscript "*a*." Also in this figure it will be understood that the plastic material is supplied in dry or pellet form from a spout 133*a* fed by a suitable source.

I have found that production may be substantially increased by providing an additional air tube 151 producing high velocity air jets 152 which impinge directly upon the film formed on the surface 105, tending to urge the film radially and to strip and sweep fibers therefrom.

While a number of different embodiments of the invention have been disclosed herein, it will be apparent that they possess a number of significant features and advantages in common. The present invention enables high quality fiber to be formed of molten plastic material having a desired range of thickness and free of extraneous shot or feathers. The fiber gauge may be varied through relatively wide limits simply by varying the operating conditions, a matter within the skill of the art. The arrangement described above is particularly advantageous since it is capable of handling such viscous and difficult to work with materials as polypropylene or the like which is viscous even at relatively high temperatures and which cannot be handled by conventional

types of spinning machines. Vertical arrangement of the equipment with downward flow of fibers is preferred because this promotes uniformity of diameter, elongation, and molecular orientation, particularly for fine fibers of polypropylene or the like down to one micron or less in thickness.

Each unit of the type described is capable of producing fiber at a rate (lbs. per hour) which exceeds that attainable using conventional techniques. Operation is convenient and, because of the automatic control features, little attention is required on the part of the operator.

Plastic material may be added either in molten form or in dry pellet form with assurance of proper temperature and viscosity at the metering point.

While polypropylene has been mentioned as a typical plastic material, it will be apparent that the invention is not limited thereto and the term "plastic" will be understood to include various materials, including glass, which are thermo plastic and which are converter to a viscous fluid when heated. And while the invention has been described in connection with a plastic material rendered fluid by heat, material of desired viscosity may be formed by addition of a solvent.

I claim as my invention:

1. In a spinning arrangement the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, a metering feed member having an annular presented edge portion extending to within a short distance of the surface of the spinning member to define an annular metering space, means for establishing a body of molten plastic material above the metering member, means for rotating the spinning member at a high rate of speed so that molten material is discharged through the metering space and onto the surface of the spinning member to form a film which is of decreasing thickness as the material moves toward the periphery of the spinning member for formation of a multiplicity of fibers at the surface of the spinning member, and means for biasing the metering member toward said spinning member to limit the metering space depending upon the viscosity of the material flowing therethrough.

2. In a spinning arrangement the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, a metering member having an annular presented edge portion extending to within a short distance of the surface of the spinning member to define an annular metering space, means for establishing a body of molten plastic material above the metering member, means for rotating the spinning member at a high rate of speed so that molten material is discharged through the metering space and onto the surface of the spinning member to form a film which is of decreasing thickness as the material moves toward the periphery of the spinning member for formation of a multiplicity of fibers at the surface of the spinning member, means for biasing the metering member relatively toward said spinning member for corrective adjustment of the metering space depending upon the viscosity of the material flowing therethrough, and means for varying the biasing force.

3. In a spinning arrangement for spinning fibers from molten plastic or the like the combination comprising a conical spinning member having a neck providing an opening at its upper end and having an internal discharge surface which flares outwardly and downwardly therefrom, a metering disc centered within said spinning member and having a periphery which extends into close proximity with the surface of the spinning member to define an annular metering space, means for adjustably supporting the disc so as to determine the width of the metering space, a hopper arranged above the spinning member and communicating therewith, means for supplying plastic material to the hopper, means for heating the metering disc so that molten plastic material may

flow through the metering space, and means for rotating the conical spinning member at a sufficiently high rate of speed so that the plastic material is formed into a film on the surface of the spinning member and converted to a multiplicity of fibers as the material is acted upon by centrifugal force and windage.

4. In a spinning arrangement for spinning fibers from molten plastic or the like the combination comprising a conical spinning member having a neck providing an opening at its upper end and having an internal discharge surface which flares outwardly and downwardly therefrom, a metering disc centered within said spinning member and having a periphery which extends into close proximity with the surface of the spinning member to define an annular metering space, a plunger extending through the opening in said neck for supporting the disc so as to determine the width of the metering space, means for supplying molten plastic material to the metering disc for flowing through the metering space, and means for rotating the conical spinning member at a sufficiently high rate of speed so that the plastic material is formed into a film on the surface of the spinning member and converted by surface tension to a multiplicity of fibers.

5. In a device for spinning molten plastic and the like into fibers the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, means for rotating the spinning member at a high rate of speed, means defining an upstanding hopper and including a feed member at the bottom of the hopper providing a circular edge which extends to within a short distance of the spinning member to define an annular metering space, means for feeding plastic material into the top of said hopper, heating means at the vicinity of the bottom of said hopper for causing the plastic material in the hopper to be maintained at a temperature above the melting point and suitable for spinning so that the material in the molten state passes in the form of a relatively thick film through the metering space and onto the surface of the spinning member for acting upon by centrifugal force as the spinning member rotates for formation of a multiplicity of air-borne fibers at the surface of the spinning member adjacent the periphery thereof.

6. In a device for spinning molten plastic and the like into fibers the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, means for rotating the spinning member at a high rate of speed, a hopper in the form of a vertical generally cylindrical container centered with respect to the neck portion of the spinning member having a feed element at the bottom thereof providing a circular edge which extends to within a short distance of the spinning member to define an annular metering space therewith, means for feeding plastic material into the top of said hopper, means at the vicinity of the bottom of said hopper for causing the plastic material in the hopper to be maintained at a temperature above the melting point and suitable for spinning so that the material in the molten state passes in the form of a relatively thick film through the metering space and onto the surface of the spinning member for acting upon by centrifugal force as the spinning member rotates thereby producing an outwardly flowing film of decreasing thickness for formation of a multiplicity of air-borne fibers at the surface of the spinning member adjacent the periphery thereof, said hopper being fixed against rotation and said feed element being vertically movable to control the width of the metering space in the face of variations in the viscosity of the molten plastic material.

7. In a device for spinning molten plastic and the like into fibers the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, means for rotating the spinning member at a high rate of speed, an upstanding hopper centered with respect to the neck portion of the spinning member and including a feed element at the bottom of the hopper providing a circular edge which extends to within a short distance of the spinning member to define with the latter an annular metering space, means for feeding unmelted granular plastic material into the top of said hopper, heating means at the vicinity of the bottom of said hopper for causing the plastic material in the hopper to be melted to a sufficient depth to create a fluid head adequate to force a relatively thick film through the metering space and onto the surface of the spinning member for acting upon by centrifugal force as the spinning member rotates thereby producing an outwardly flowing film of decreasing thickness for formation of a multiplicity of fibers at the surface of the spinning member adjacent the periphery thereof.

8. In a device for spinning molten plastic and the like into fibers the combination comprising a spinning member having a neck portion and a conical discharge surface flaring outwardly therefrom, means for rotating the spinning member at a high rate of speed, means defining an upstanding hopper and including a feed element at the bottom of the hopper having a circular edge which extends to within a short distance of the spinning member to define with the latter an annular metering space, means for feeding plastic material into the top of said hopper, means at the vicinity of the bottom of said hopper for causing the plastic material in the hopper to be maintained at a temperature above the melting point and suitable for spinning so that the material in the molten state passes in the form of a relatively thick film through the metering space and onto the surface of the spinning member for acting upon by centrifugal force as the spinning member rotates thereby producing an outwardly flowing film of decreasing thickness for formation of a multiplicity of air-borne fibers at the surface of the spinning member adjacent the periphery thereof, and means providing a gas blast for acting upon the film to expedite the formation of fibers therefrom.

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