United States Patent [19]

Eriksen

[11] **3,709,670**

[45] **Jan. 9, 1973**

[54] **METHOD, APPARATUS AND SYSTEM FOR FIBERIZING MOLTEN MINERAL MATERIAL**

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[22] Filed: **Sept. 10, 1970**

[21] Appl. No.: **71,148**

[52] **U.S. Cl.** ....**65/8,** 65/15, 209/144, 264/176 F

[51] **Int. Cl.** **C03b 19/04**

[58] **Field of Search**..................65/2, 10, 6, 8, 14, 15; 209/144, 141; 264/176 F

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[57] **ABSTRACT**

A method for converting molten material into filamentous form of fibers consisting of discharging the molten material to at least one spinner assembly disposed in the region of a pickup chamber, circulating a conveying medium through a duct work system including a pickup chamber in the region of the spinner assembly and controlling the temperature and velocity of the conveying medium in a manner to produce fibers having a minimum shot content and good strength and resiliency characteristics, an apparatus and system for converting molten material into filamentous form of fibers including a cupola for the molten material having a discharge spout, a duct work system, means for circulating the conveying medium through the duct work system, at least one pair of spinner assemblies in the region of a pickup chamber in the duct work system, feed means for directing the molten material to each of the spinner assemblies and means for maintaining the quantity discharged to each spinner assembly substantially uniform.

10 Claims, 15 Drawing Figures

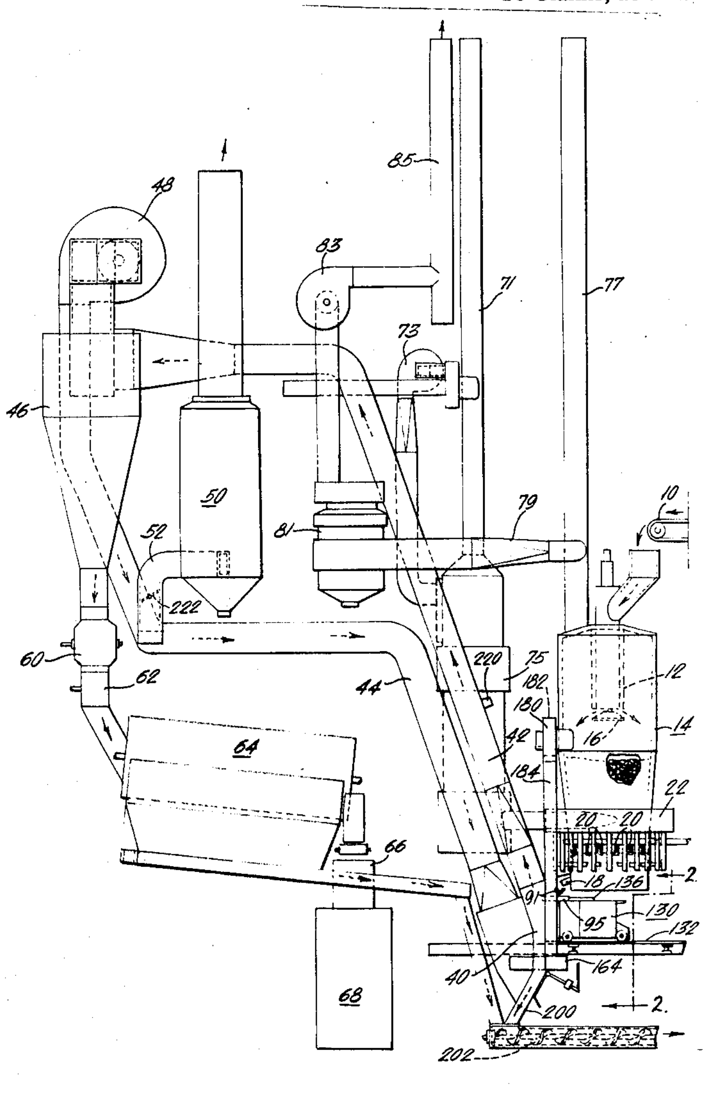

FIG.1.

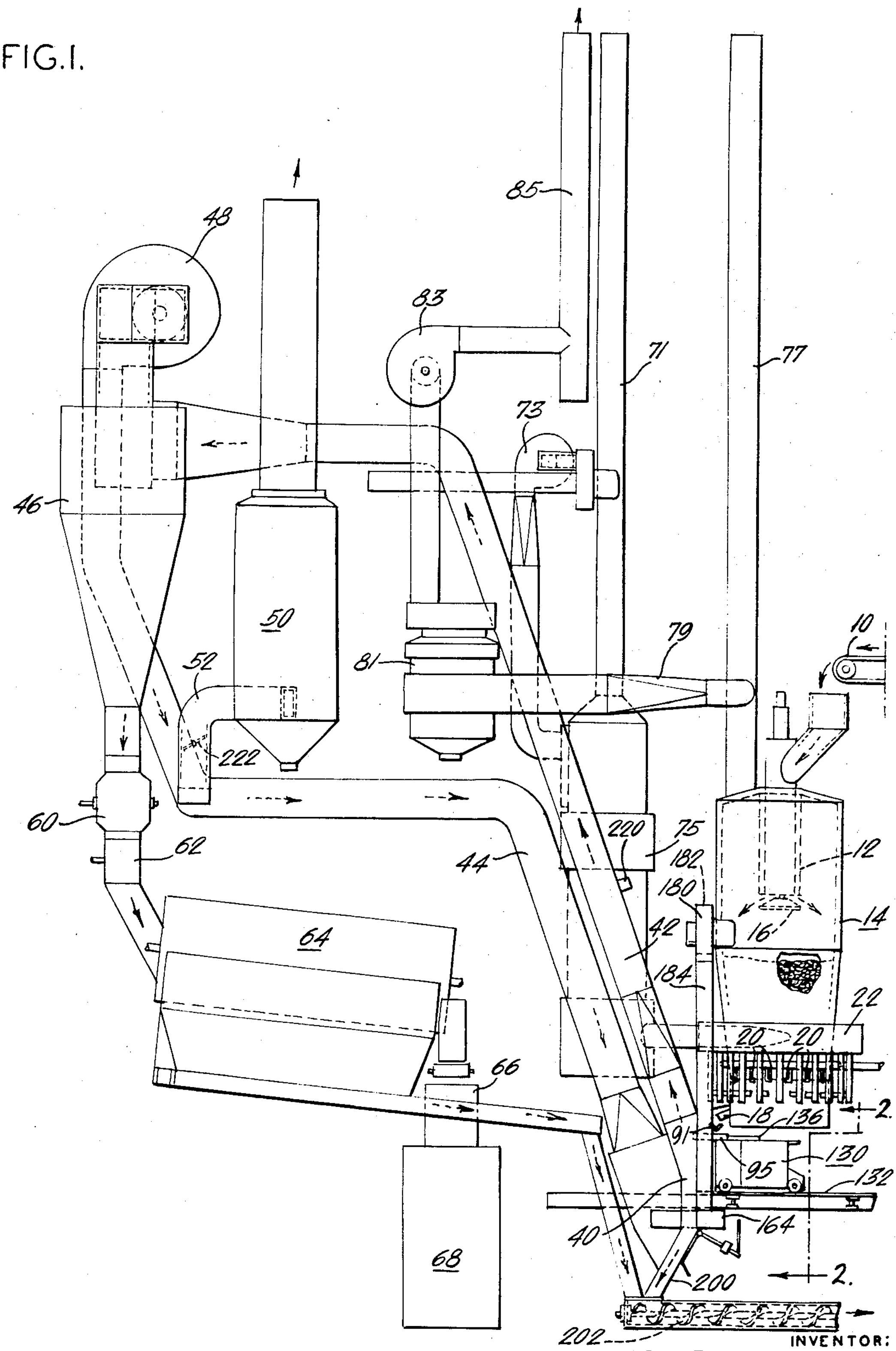

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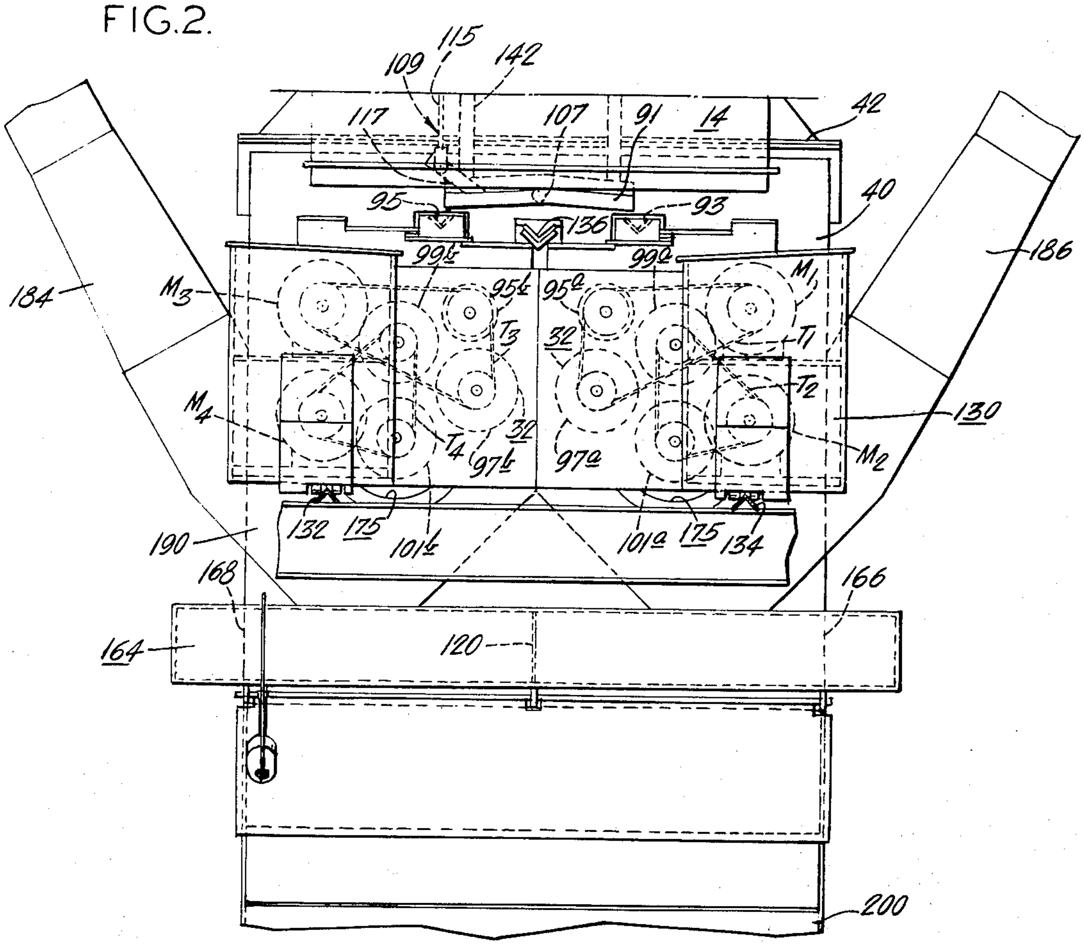
FIG.2.



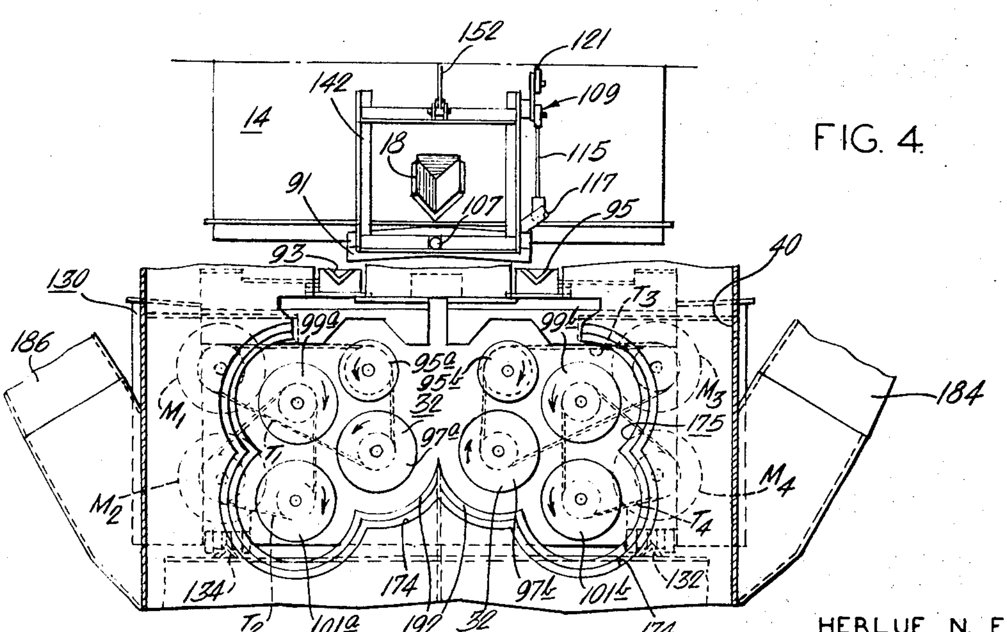


FIG. 4.

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FIG. 3.

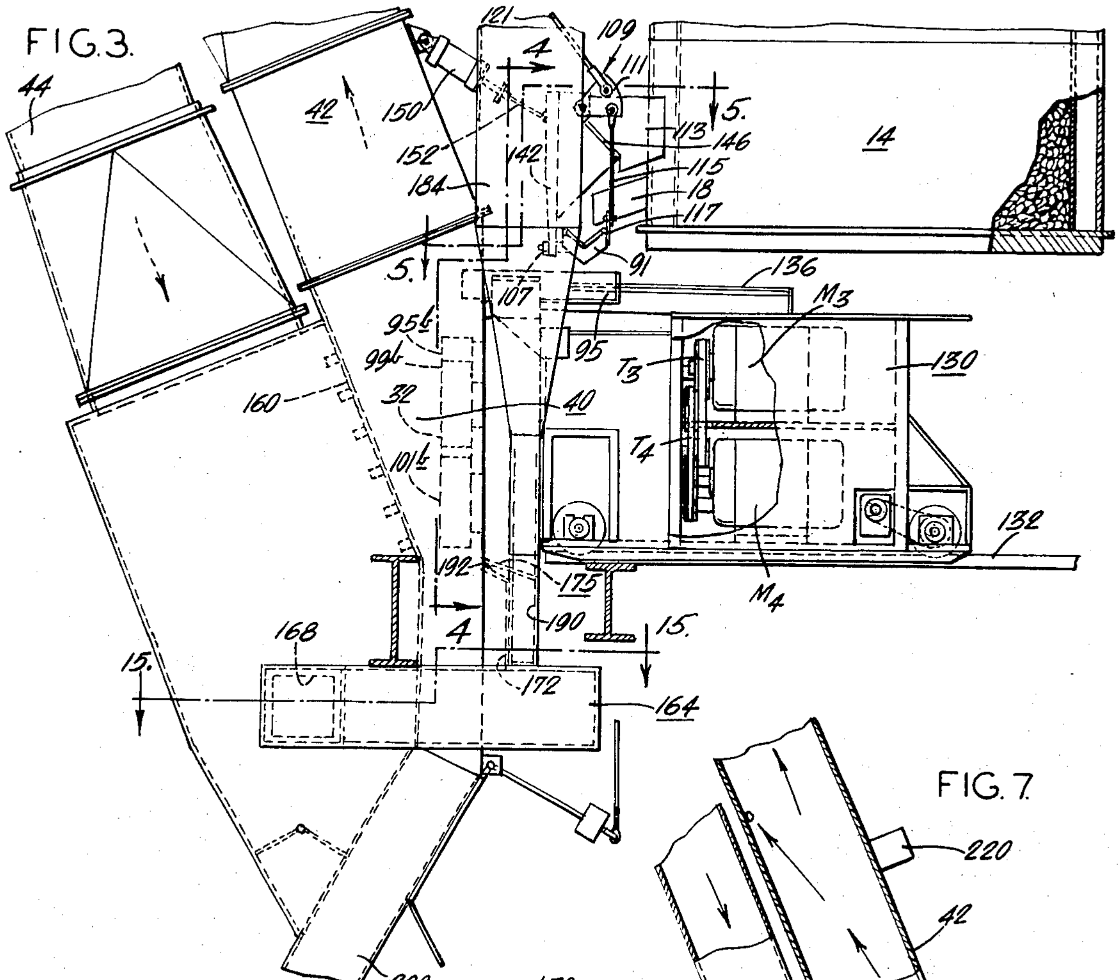

FIG. 7.

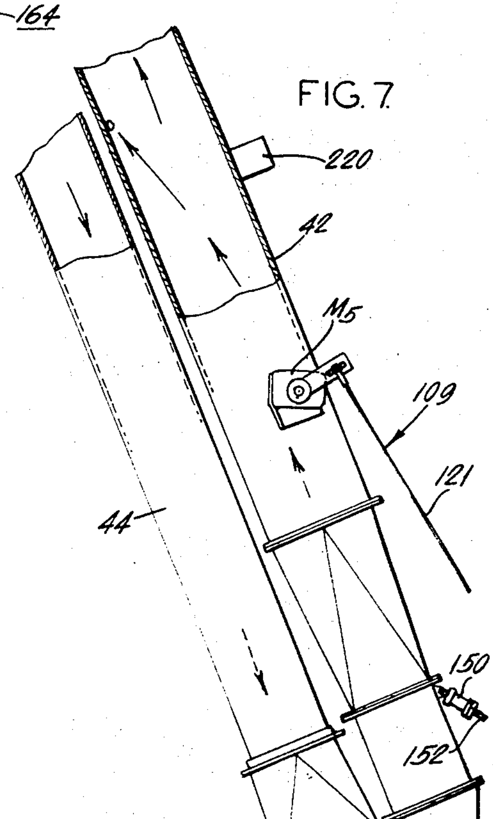

FIG. 5.

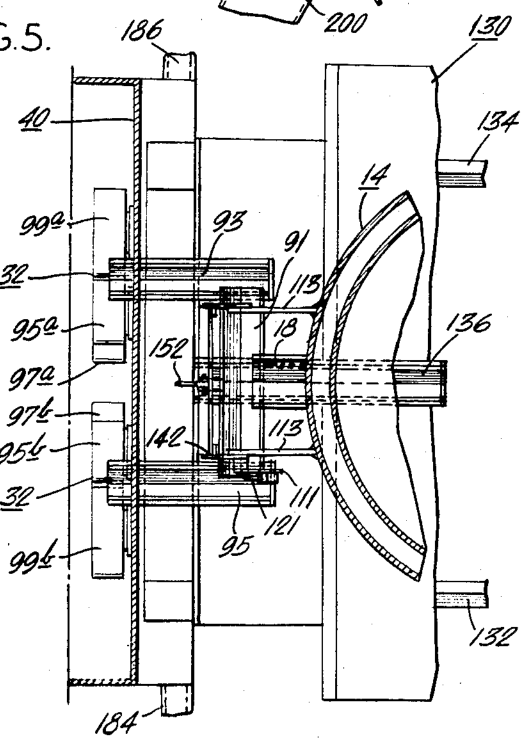

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FIG. 6.

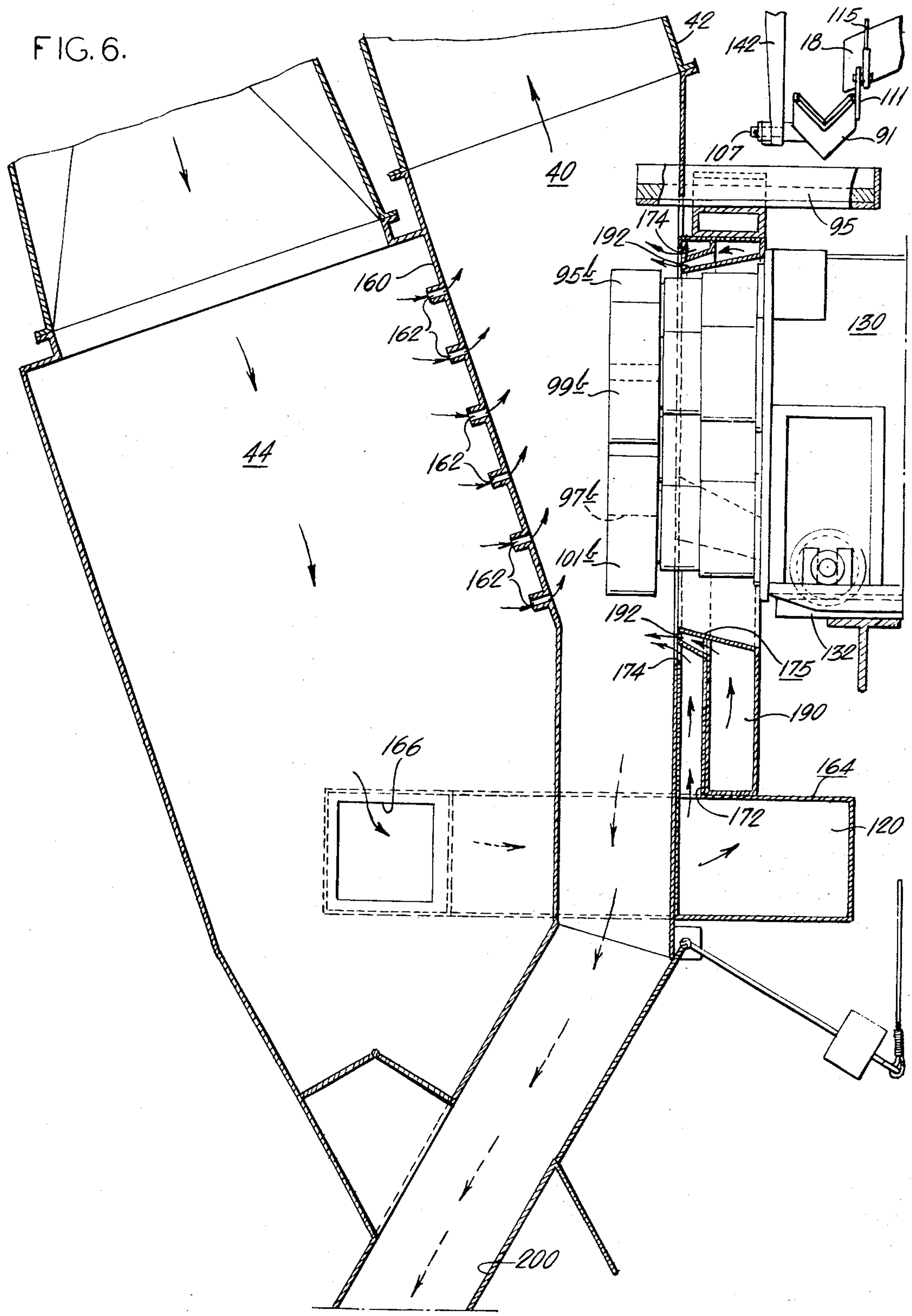

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FIG. 8.

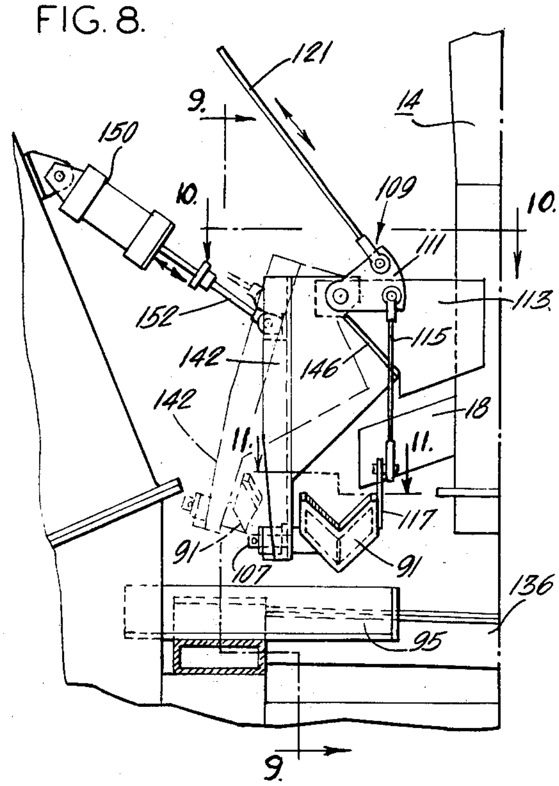


FIG. 9.

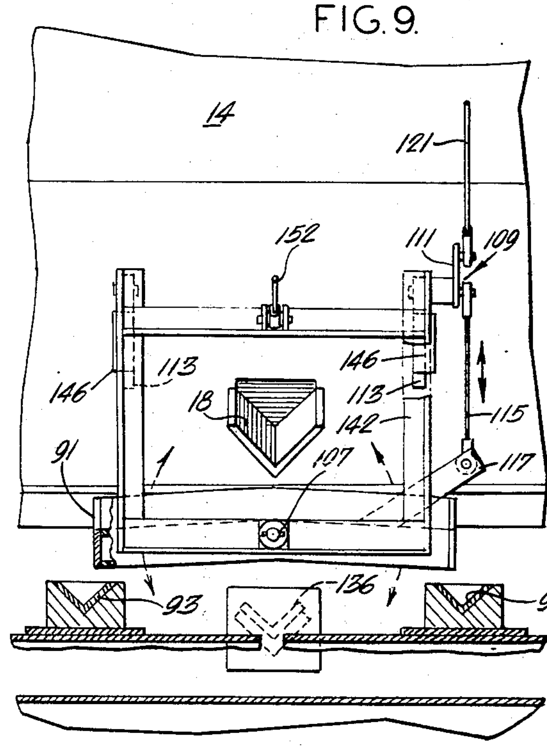


FIG. 10.

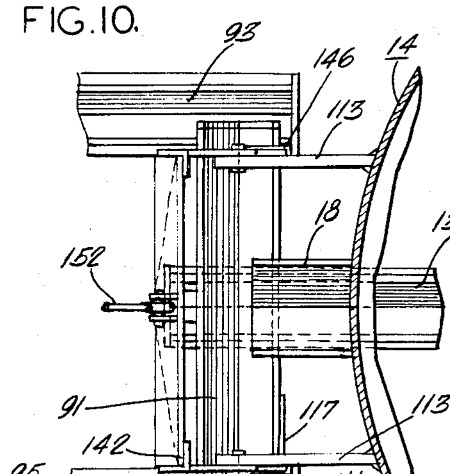


FIG. 11.

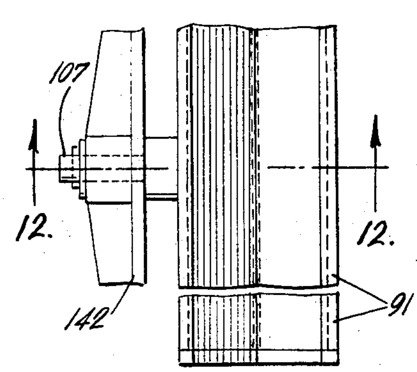
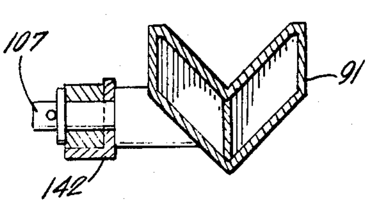


FIG. 12.



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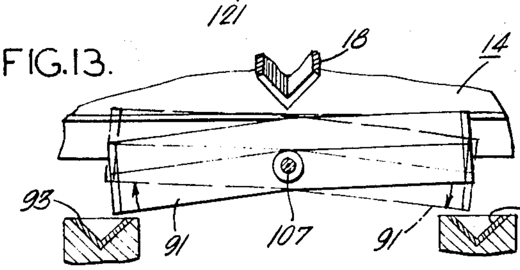

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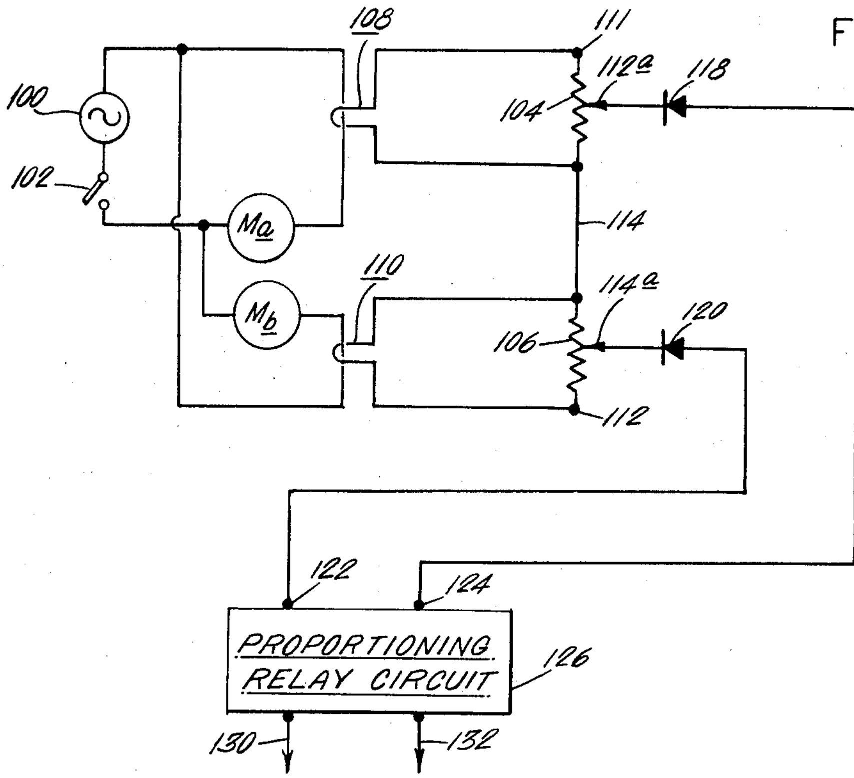

FIG. 14.

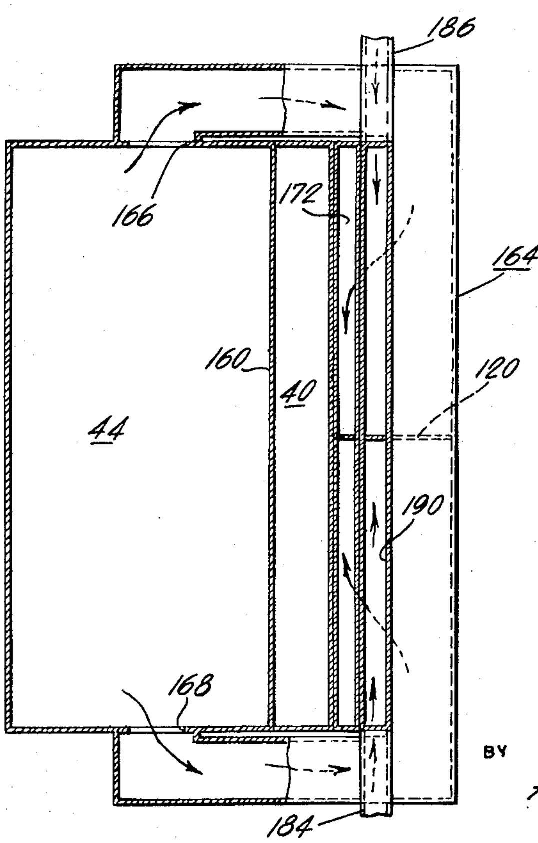

FIG. 15.

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METHOD, APPARATUS AND SYSTEM FOR FIBERIZING MOLTEN MINERAL MATERIAL

The present invention relates to improved system and apparatus for fiberizing bulk material.

The invention is directed to an improved system and apparatus for converting molten material, such as slag, glass or fusible rock into filamentous form of fibers such as are generally known as slag wool, glass wool, or mineral wool and the like.

There are many known processes presently used for this purpose including, for example, the process wherein a powerful blast of gas, usually air, is directed against the molten slag to fiberize the same. In other instances, the molten slag is directed onto the periphery of a plurality of spinner heads which are rotating at rapid speed, again to cause the desired fiberization of the peripherally discharged droplets.

Even though these processes are generally satisfactory, they are not as effective in producing fibers having a comparatively low "shot" content and also the desired characteristics such as good strength and resiliency. The shot is formed during the fiberization and is usually in the form of a small globule formed on the end of the fiber which, in some instances, is discharged from the fiber during processing. For example, in the production of wet felt, a high "shot" content can jam the screen in the forming machines thereby resulting in down time for repair and replacement. Additionally, it has been found that board produced from fibers having a high shot content are non-uniform in cross section, presenting handling problems, and also resulting in damage to the boards when they are in face-to-back relation.

With the foregoing in mind, an object of the present invention is to provide an improved system and apparatus for converting molten vitreous material into fibers which is of comparatively simplified construction and incorporates novel features whereby the shot content is maintained at a minimum and the fibers produced are of a superior quality. To this end, the system includes a pair of spinner assemblies which receive the molten vitreous material from a discharge spout of a cupola and fiberize the molten material in a pickup chamber where the velocity and temperature of the conveying medium, air, is controlled in such a manner to produce fibers having a minimum shot content and good strength and resiliency characteristics. Another important feature of the present invention in producing fibers of this type is the feed arrangement for the spinner heads which broadly includes a tiltable trough communicating with the discharge spout of the cupola which is arranged to supply substantially equal quantities of the molten vitreous material to each of the spinner head assemblies. The spinner heads of each assembly are motor driven and, in accordance with the present invention, load sensing means is provided for sensing load of the motors for each assembly and selectively and automatically regulating the feed flow to each spinner head assembly when the load on one exceeds the other.

These and other objects of the present invention and the various features and details of the operation and construction of the system and apparatus of the present invention are hereinafter more fully set forth with reference to the accompanying drawings.

FIG. 1 is a view showing the system and apparatus for manufacturing mineral wool incorporating the present invention;

FIG. 2 is a view taken along lines 2—2 of FIG. 1 showing the discharge end of the cupola and the spinner assembly;

FIG. 3 is a fragmentary side elevation view showing the pickup chamber and the details of the system for controlling discharge of the molten material to the spinner assembly;

FIGS. 4 and 5 are enlarged sectional views taken on lines 4—4 and 5—5 respectively of FIG. 3;

FIG. 6 is an enlarged sectional view taken through the pickup chamber and spinner assembly showing the flow of conducting air through the pickup chamber;

FIG. 7 is a side view partly in section showing a portion of the pickup duct and return air duct;

FIG. 8 is a fragmentary view of the tilt control mechanism for the slag discharge trough;

FIGS. 9, 10 and 11 are enlarged sectional views taken on lines 9—9, 10—10 and 11—11 respectively of FIG. 8;

FIG. 12 is an enlarged sectional view of the tilting discharge trough taken on lines 12—12 OF FIG. 11;

FIG. 13 is a view showing extreme tilt positions of the discharge trough; and

FIG. 14 is an electrical schematic of the control system for the tilting discharge trough assembly;

FIG. 15 is a sectional view taken on lines 15—15 of FIG. 3.

Considering now the principal elements and broad details of the system of the present invention and with particular reference to FIG. 1 of the drawings, a system and apparatus for making fibers from a fiberizable molten material in accordance with the present invention includes means such as a conveyor **10** for delivering the fiberizable material to the charging sleeve **12** of a cupola **14**. The cupola is of conventional construction and includes a charging valve **16** whereby the cupola may be filled to a predetermined level, and a discharge spout **18** at its lower end. Conventional heating means in the form of a series of gas nozzles **20** and a bustle pipe **22** circumscribe the lower end of the cupola to provide means for selectively controlling the temperature of the fiberizable material at the discharge end of the cupola.

The molten material discharged from the cupola is directed to a pair of spinner assemblies **32** which cause fiberization thereof. The spinner assembly heads are disposed in the region of a pickup chamber **40**, which is at the juncture of an upwardly extending pickup duct **42** through which the fibers are conveyed in a stream of air, and a return air duct **44**. Means, described in more detail hereinafter, is provided for controlling the temperature and velocity of the conveying medium through the pickup chamber **40** to facilitate production of fibers having a desired small shot content and superior characteristics.

The pickup duct **42** discharges into a separator **46** which separates the fibers from the entrainment air. The entrainment air is then passed through a blower **48** whereupon part of the entrainment air is directed to a wet scrubber **50** through duct work **52** and part is directed to the recirculating or air return duct **44**.

The fibers from the separator pass through a rotary discharge gate **60** to a granulator **62** and rotary screen **64**. In the rotary screen **64** the finer shot and foreign particles are separated from the fibers and the fibers are discharged at the end of the screen to a weighting hopper **66** for bailing in a conventional bailer **68**.

There is shown in FIG. **1** a conventional system for supplying the heated gases for the bustle pipe **22** and gas nozzles **20**. This system includes a stack **71** communicating with outside air, a blower **73** and a preheater **75**. There is also a discharge stack **77** which may discharge directly from the cupola to the atmosphere. There is also provided a duct work **79** communicating with the discharge stack **77** which vents into a venturi scrubber **81**, the discharge air being withdrawn through the scrubber by a blower **83** to a secondary discharge stack **85**.

Considering now the specific details and arrangement of the system and apparatus and with reference to FIGS. **8** and **9**, the molten material discharged from the discharge spout **18** of the cupola is directed to a tilt trough **91**, the outer terminal ends of which overlie a pair of feed troughs **93** and **95** which direct the molten material to a pair of spinner assemblies **32**. Each of these spinner assemblies comprise four spinner wheels **95***a*, **97***a*, **99***a* and **101***a*. The other group of spinner wheels are designated by the same numeral with a *b* subscript. In each group, pairs of the spinner wheels are actuated from a motor source through suitable transmission means. Thus, the spinner wheels **95***a* and **97***a* are driven by motor M_1 through transmission T_1, wheels **99***a* and **101***a* are driven through motor M_2 and transmission T_2. Motors M_3 and M_4 drive the wheels **95***b*, **97***b* and **99***b*, **101***b* through transmissions T_3 and T_4.

An important feature of the present invention for controlling the shot content and the characteristics of the fibers is the provision of means for maintaining substantially equal flow of molten material to each of the spinner assemblies. To this end, the tilt trough **91** is pivotally mounted on an axis **107** and a linkage system broadly designated **109** connects the tilt trough to a motor actuator M_5. More specifically, the linkage system includes a triangular pivot arm **111** pivotally mounted on the trough support brace **113**, a first tilt rod **115** connecting a lever arm **117** mounted on the tilt trough to the pivot arm **111** and a second tilt rod **121** connecting the pivot arm **111** to the motor M_5.

Referring now to FIG. **14** by way of example of one type of electrical circuitry which may be utilized to adjust automatically the angle of the discharge trough so as to maintain the loading on the two sets of spinner heads substantially equal, motor bank M_a represents the one or more parallel-connected motors which drive one set of spinner heads, and motor bank M_b represents the one or more parallel-connected motors which drive the other set of spinner heads; for example, motor bank M_a may comprise motors M_1 and M_2 parallel to each other, and motor bank M_b may comprise motors M_3 and M_4 connected in parallel with each other. Alternating line current source **100**, which may be the usual **115** volt AC line, is connected across the motor banks M_a and M_b in parallel, and typically a switch **102**, which may be manually or automatically operable, is connected in series with one lead from the power source **100** to permit turning on and off of the two motor banks. A pair of variably-tapped resistors **104** and **106** are supplied with currents proportional to the currents operating motor banks M_a and M_b respectively, by means of respective current-sensing transformers **108** and **110**. The latter transformers may each comprise a conventional so-called " doughnut" transformer, or a simple single turn of wire around the lead to the corresponding motor bank. The polarity of the connections and of the transformer couplings is such that the upper terminal **111** of resistor **104** and the lower terminal **112** of resistor **106** are at any instant of time of the same polarity with respect to the opposite ends of the resistors, which are directly interconnected by means of the lead **114**. The variable taps **112** and **114** of resistors **104** and **106** are connected respectively through rectifiers **118** and **120** to separate input terminals **122** and **124** of the proportioning relay circuit **126**.

Referring now to the operation of the portion of the circuit thus far described, when switch **102** is closed, alternating current from source **100** flows through both of the motor banks M_a and M_b to operate the corresponding spinner heads, The currents in the leads **130** and **132**, supplying motor banks M_a and M_b respectively, increase as the load on the corresponding motor bank increases and, in general, these two will be substantially equal when the loads are equal. Accordingly, when the delivery of molten material to the two sets of spinner heads is substantially equal, the loads on the corresponding motor banks are equal as are the currents in leads **130** and **132**. Under these conditions the voltage at the top terminal **111** of resistor **104** will be equal to the voltage at the lower terminal **112** of resistor **106** with respect to their mutual connecting line **114**, and accordingly, with taps **112***a* and **114***a* similarly positioned, there will be no difference in voltage between the cathode elements of the rectifiers **118** and **120**. The latter rectifiers serve to rectify the applied alternating current and to produce, at terminals **122** and **124** uni-directional negative voltages which are equal when the loads on the two motor banks M_a and M_b are equal. The taps **112**a and **114**a are provided for calibration purposes, i.e. so that should there by any difference in the current characteristics of the two motors which would tend to result in a difference in voltage between terminals **111** and **112** when the loads on the motors are equal, the taps **112***a* and **114***a* can be adjusted to assure that the voltage applied to the rectifiers **118** and **120** is exactly equal at such times. The proportioning relay circuit **126** responds to the voltages applied to its input terminals **122** and **124** to supply current through its output leads **130** and **132** to tilt motor M_5 of a direction and magnitude dependent upon the polarity of the voltage between input terminals **122** and **124**. The connections of leads **130** and **132** to the tilt motor M_5 are such that if the voltage at input terminal **124** becomes more negative than that at input terminal **122**, indicating that the load on motor bank M_a is larger than that on motor bank M_b, the tilt motor M_5 will be operated to tilt the discharge trough in the direction to deliver less slag to the spinner heads operated by motor bank M_a and more slag to the spinner heads rotated by motor bank M_b. When the delivery of slag to the two sets of spinner heads is thereby equalized, the loads on the two sets of motor banks will become equal, there will be no substantial difference in voltage at the input terminals 122 and 124, and current from output leads 130 and 132 to tilt motor M_5 will be terminated, arresting the tilting of the discharge trough. A similar operation will occur for an opposite unbalanced loading of the spinner heads.

The proportioning relay circuit 126 may take any of a large variety of conventional forms. To avoid continuous angular motion of the discharge trough and "-hunting" by the servo loop provided by the apparatus of FIG. 14, circuit 126 preferably has a relatively slow time constant, and includes an appropriate thresholding circuit such that the tilt motor M_5 will not be operated until the difference in voltage between input terminals 122 and 124 become substantial. Preferably, also, the circuit 126 is of a nature such that when the input voltage at terminals 122 and 124 exceeds said threshold value, the tilt motor M_5 will be operated only for a predetermined time interval less than that which can cause overcorrection of the angle of tilt, after which time interval the circuit 126 will again sense any remaining difference in the input voltage between terminals 122 and 124 and again operate the motor M_5 for a predetermined time, if further correction is required. Circuitry is well known in the art for providing the above-described functions, and it will be understood that circuit 126 may in fact take any of a large variety of different forms in different applications so long as it serves to provide an output current for operating the tilt motor M_5 in the direction to reduce the difference in loading on the two motor banks M_a and M_b.

In the present instance, the spinner assemblies are mounted in a carriage 130 having wheels which ride on stationary trackways 132 and 134 so that the spinner assemblies may be retracted from the opening to the pickup chamber when desired to provide means for gaining access to the spinner heads, for example for replacement or repair purposes. Additionally, the carriage 130 may be retracted when shutting down the system. In the event the cupola is still discharging molten material, the tilt trough 84 is mounted for pivotal movement relative to the discharge chute of the cupola and a center discharge trough 136 is provided between the main feed troughs 93 and 95 which discharges rearwardly to a suitable accumulation area. To this end, the tilt trough is carried by a bracket 142 pivotally connected to the support brace. The bracket 142 as illustrated is generally rectagular, the opposing sides of which abut angularly disposed bumpers 146 of the brace in the down or operative position of the tilt trough. The bracket and trough are actuatable to an outer position [shown in broken lines in FIG. 8] by means of a piston-cylinder actuator 150, the piston connected to the bracket by means of a link arm extension 152.

Considering now the specific details and arrangement of the pickup chamber and with specific reference to FIGS. 1 and 6, the lower end of the air return duct is separated from the pickup chamber by a dividing wall 160 which as illustrated has a plurality of openings 162 therein for circulation of some of the return air to the pickup chamber. Additionally, a doughnut-shaped manifold 164 is provided which communicates at opposite ends as at 166 and 168 with the two compartments of the lower end of the air return chamber. This manifold as illustrated has center dividing wall 120 which in turn is in fluid communication with return air inlet chamber 172 extending for a major portion about the periphery of the spinner head assembly opening 175 to the pickup chamber. This air inlet manifold has a discharge opening 174 to direct the air around the spinner heads in the manner shown in FIG. 6.

Means are also provided for selectively adding new air to the return air at the pickup chamber. To this end, in the present instance a pair of blowers 180 and 182 are provided which communicate through duct work 184 and 186 with a fresh air manifold 190 having a discharge outlet 192 closely adjacent the opening 174 and circumscribing the periphery of the spinner head opening in the manner shown in FIG. 4. By this arrangement the velocity and temperature of the air flowing in the system, particularly in the region of the pickup chamber, may be selectively controlled.

Considering now briefly the operation of the apparatus and system described above, the spinner head assemblies are simply moved into the operative position wherein the spinner heads are disposed in the pickup chamber as illustrated in FIG. 6. The cupola is then charged in the cknventional manner. The molten material then discharges continuously from the cupola discharge spout and engages the tiltable trough, which is normally in a level position, so that substantially the same quantities of molten material flow to the feed troughs for the two spinner head assemblies. Of course, as the material discharges to the spinner heads, it is fiberized by the action of the spinner heads and the flow of air through the pickup chamber. During the course of operation, if the quantity of molten material discharged to either spinner head assembly is not substantially uniform, the imbalance in the load on the spinner head assemblies is sensed and the circuit described above effects a tilting movement of the trough to correct the imbalance. It is noted that buildup on either the tilt trough or the feed troughs may result in the imbalance situation. This is an important feature of the present invention, since it has been found that overload of the spinner head assemblies results in a substantially increased shot content in the fibers.

As the fibers are formed in the pickup chamber and are conveyed upwardly in the pickup duct, some of the shot separated from the fibers discharges downwardly through the shot discharge cute 200 to a screw type conveyor 202 where it is accumulated at a suitable source. Another important feature of the present invention is the control of the velocity and temperature of the circulating medium, in the present instance air, through the pickup chamber and in the pickup duct. This is controlled in part by the system and specific arrangement of the fresh air additive system and the specific configuration and arrangement of the return air system including the distribution manifolds providing communication between the air chamber and the pickup chamber. More specifically, it has been found that when the temperature of the circulating medium is maintained between 330°–400° F and the velocity is maintained at about 2500 feet per minute in the pickup chamber and about 4000 feet per minute in the pickup duct 42 and return air duct 44, fibers having a minimum shot content and good strength and resiliency characteristics are produced. In order to maintain these conditions, a conventional temperature sensing device **220** may be provided in the pickup duct **42** (see FIGS. 1 and 7) which may be operatively connected to a damper **222** in the duct **52**. This provides a means for selectively controlling the amount of air recirculated through the return air duct **44** in a balanced system. In other words, as the damper **22** discharges more of the circulating air to the atmosphere, fresh air is drawn into the system through the duct work **184** and **186** and also through the spinner head opening **175**. Additionally, the speed of the blower **48** may be selectively varied to provide for velocity control of the air circulated through the pickup chamber.

I claim:

1. A method for converting molten mineral material into vitreous fiber consisting of the steps of discharging the molten mineral material to at least one spinner assembly comprising a plurality of rotating spinner wheels and disposed in the region of a pickup chamber located at the juncture of a pickup and return duct of a continuous duct work system, circulating a heated gaseous conveying medium through the duct work system, controlling velocity of the gaseous conveying medium in a manner to quickly convey fibers formed in the pickup chamber on discharge from the spinner assembly and effect passage through the pickup duct thereby to produce fibers having a minimum shot content and controlling temperature of the gaseous conveying medium by recirculating at least a portion thereof thereby producing fibers having good strength and resiliency characteristics.

2. A method as claimed in claim 1 wherein the temperature of the conveying medium is maintained in the range between about 300°–400° F.

3. A method as claimed in claim 1 wherein the velocity of the conveying medium is in the vicinity of about 2500 feet per minute at the pickup chamber, and about 4000 feet per minute in the duct work system.

4. An apparatus for converting molten mineral material into vitreous fibers comprising a continuous duct work system, means for circulating a gaseous conveying medium through the duck work system, said duct work system including in series a non-horizontal pickup duct, a separator for separating fibers from the conveying medium and a conveying medium return duct, a juncture of the pickup duct and return duct defining a pickup chamber, at lease one spinner assembly in the region of the pickup chamber, said spinner assembly including a plurality of spinner wheels operable to effect conversion of the molten mineral material and random dispersion of fibers, means for directing the molten mineral material to the wheels of the spinner assembly, means for controlling the velocity of the gaseous conveying medium in a manner to quickly convey fibers formed in the pickup chamber and effect passage through the pickup duct thereby to produce fibers having a minimun shot content and means for controlling temperature of the gaseous conveying medium by recirculating at least a portion thereof thereby producing fibers having good strength and resiliency characteristics.

5. An apparatus as claimed in claim 4 including a manifold system adjacent the spinner assembly, said manifold system including means for receiving low pressure gaseous conveying medium from the return duct and high pressure gaseous conveying medium and discharge means circumscribing the periphery of said spinner assembly.

6. An apparatus as claimed in claim 5 including valve means for selectively controlling the quantity of high pressure gaseous conveying medium introduced to said manifold system.

7. An apparatus as claimed in claim 4 including temperature sensing means in said pickup duct operatively connected to a valve control means in the return duct for selectively controlling the amount of gaseous conveying medium recirculated through the return duct.

8. An apparatus as claimed in claim 4 including classifying means to receive and classify fibers discharged from said separator.

9. A system for converting molten mineral material into vitreous fibers including a container means for the molten mineral material having at least one discharge spout, at least one pair of spinner assemblies adjacent said discharge spout, each spinner assembly comprising a plurality of rotatable spinner wheels operable to disperse the molten material from the cupola to form the fibers, a feed trough for each of the spinner assemblies, an inclined distributor trough to receive molten material from the discharge spout and direct the same to the feed troughs, control means responsive to load on spinner wheels to actuate said inclined distributor trough and maintain the distribution of molten mineral material discharged to each spinner assembly substantially uniform.

10. A system as claimed in claim 9 including motor actuating means for each of the spinner assemblies, an actuator for the distributor trough and load sensing means for the spinner assembly, said motor actuator means operable in response to load variations to effect operation of said distributor trough actuator to vary distribution of molten material to said spinner assemblies to maintain a substantially uniform distribution.

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