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W. R. SCHLEHR

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METHOD FOR DRAWING FIBERS

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FIG. 1

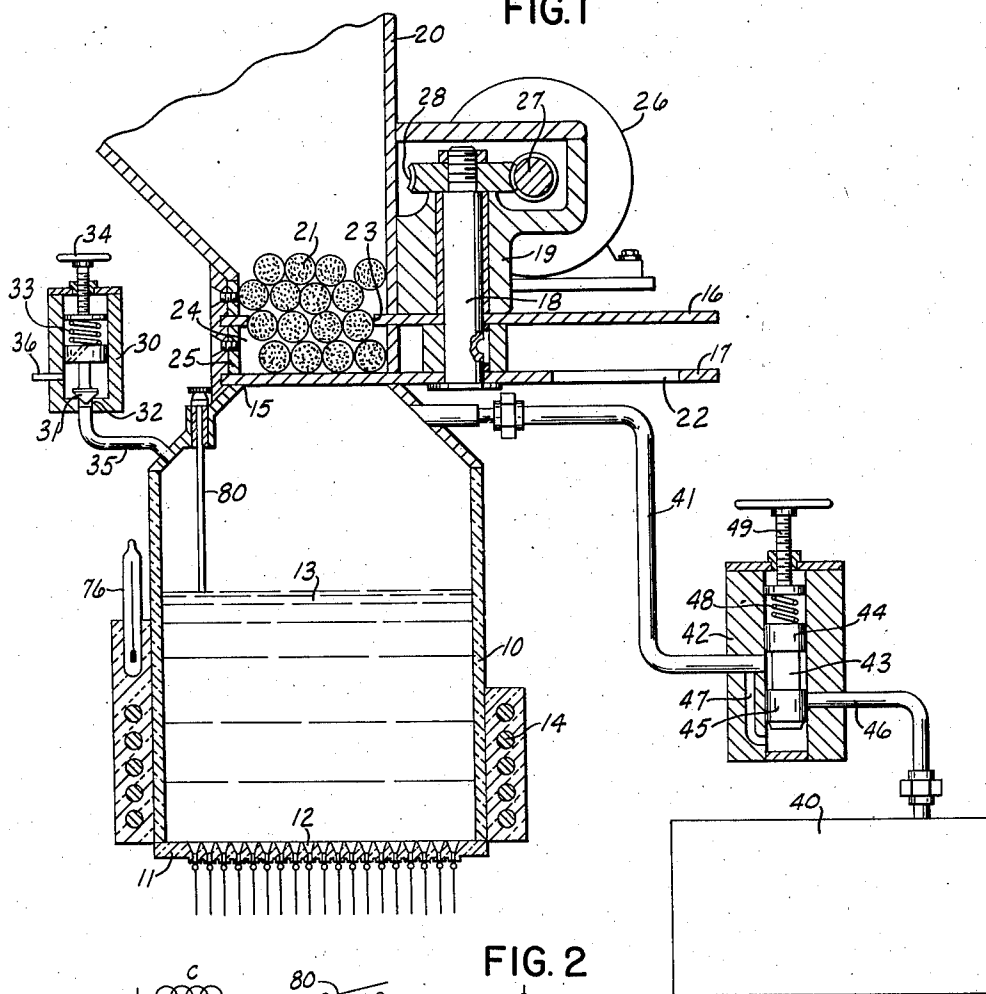
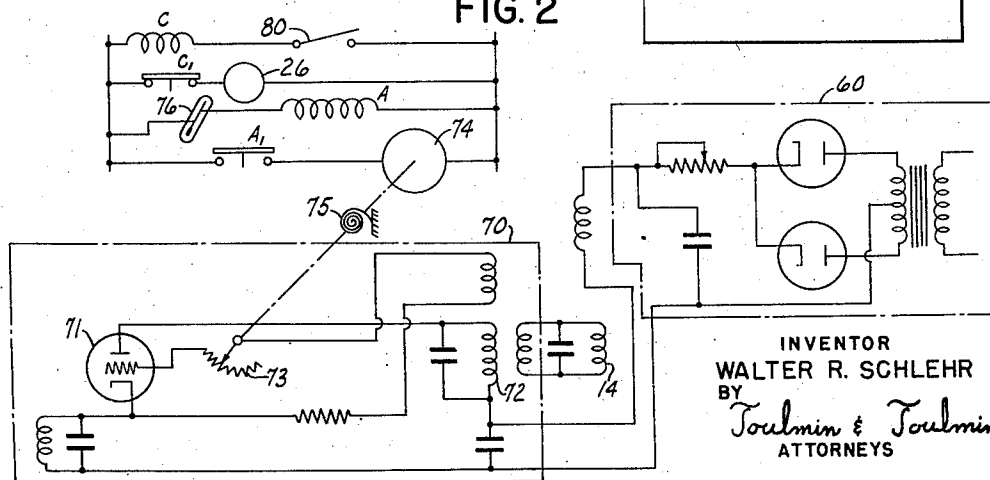


FIG. 2



INVENTOR
WALTER R. SCHLEHR
BY
Toulmin & Toulmin
ATTORNEYS

UNITED STATES PATENT OFFICE

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METHOD FOR DRAWING FIBERS

Walter R. Schlehr, Toledo, Ohio, assignor, by
mesne assignments, to Glass Fibers, Inc.,
Waterville, Ohio

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9 Claims. (Cl. 49—77.5)

1

This invention relates to a method for drawing fine filaments from molten or semi-molten materials, and particularly directed to the drawing of fine filaments from molten glass. The invention is particularly directed to a process wherein the fine filaments are mechanically drawn from a supply or body of molten material, such as glass, and the filaments, as drawn, are wound upon a suitable reel or collected in any desired manner.

It has been found that semi-molten materials have a tendency to develop more satisfactory drawing characteristics when the material is worked at a temperature somewhat below the actual melting temperature of the material, but wherein the material is still in a highly viscous state so that it can be exuded through small orifices. This peculiar quality is particularly noticeable when drawing filaments from a body of molten glass. The major characteristic of the material that is improved is the tensile strength of the fibers or filaments which is increased substantially as the temperature at which the material is drawn is reduced.

However, as the drawing temperature of the material is reduced in an endeavor to obtain the higher tensile strength of the material, the molten material becomes more difficult to pass through small orifices. Therefore, to overcome the difficulty of mechanically drawing the fibers or filaments from the body of molten material, such as glass, it has been proposed to utilize pressure upon the body of the glass of a sufficient degree to cause the material to exude through small orifices at a lower working temperature. Such a method is disclosed in the copending application of Everett J. Cook, Serial No. 628,056 that is assigned to the same assignee as this instant patent application.

It is, therefore, an object of this invention to provide an improved method for drawing fine fibers or filaments of material mechanically wherein the pressure that is applied upon the body of the material to cause it to exude through small orifices is at least partially obtained from gases evolved from the body of material when the same passes from a solid to a molten condition.

It is still another object of the invention to provide an improved method in accordance with the foregoing object wherein the pressure of the gas upon the body of material is accurately controlled so that the material will be caused to exude through small orifices at a regular and constant rate.

It is still another object of the invention to provide an improved method for mechanically drawing fine fibers or filaments from a body of molten material wherein the gases that are evolved from the material are trapped above the

2

body of the material and the pressure developed thereby is directly applied upon the body of material for causing the material to exude through small orifice openings.

5 It is still another object of the invention to provide an improved method in accordance with the foregoing object wherein the pressure applied upon the body of material is automatically controlled at a relatively constant value, and also
10 wherein an auxiliary source of gas under pressure can supplement the pressure of the gas developed by that evolved from the body of material in transforming from the solid to the molten condition.

15 Further objects and advantages will become apparent from the drawings and the following description.

In the drawings:

Figure 1 is a cross-sectional view of an apparatus, shown somewhat schematically, for carrying forward the method of drawing fibers of this invention and of an apparatus for the same.

Figure 2 is a schematic electrical wiring diagram of a rectifier and oscillator for applying
25 high frequency current upon the crucible in which the material is heated and rendered into a molten condition.

In Figure 1 there is illustrated an apparatus wherein a material can be heated to render it
30 into a molten condition, and wherein gaseous pressure can be confined for application upon the body of molten material therein to cause the material to exude through small orifices provided in the bottom wall of the heating device.
35 To obtain the gaseous pressure confined within the heating chamber for application upon the body of molten material therein, two sources of gas are provided. One of the sources is from the body of material that is of a composition
40 that a gas is evolved therefrom when it passes from a solid to a molten condition, and the second source of pressure may be an external source for aiding or supplementing the first source of pressure.

45 The subject matter of this invention will be particularly described with reference to the manufacture of glass fibers or filaments from a body of molten glass, but it will be understood that the principles of the invention disclosed
50 herein are applicable to the production of fibers or filaments from materials other than glass including the ferrous or non-ferrous metals or alloys.

In the apparatus illustrated in Figure 1 there
55 is provided a heating crucible 10 having a bottom wall 11 provided with a plurality of small openings 12 therein. The heating crucible 10 is adapted to contain a body of molten material 13, such as glass.

60 A high frequency induction coil 14 may be

disposed around the lower end of the heating crucible 10 for the purpose of heating the crucible and thereby melting the glass therein. The heating crucible 10 is preferably constructed of platinum or a platinum alloy to withstand the temperature at which the glass is melted and the erosive action of the glass. The high frequency induction coil 14 is adapted to be connected to a source of high frequency energy, such as that illustrated in Figure 2, hereinafter described.

The heating crucible 10 is provided with an opening 15 in the top wall thereof. A pair of metal discs 16 and 17 are positioned in parallel relationship and are carried upon a shaft 18 suitably journaled within a bearing boss 19 secured to the feed hopper 20.

The metal discs 16 and 17 pass over the opening 15 in the heating crucible 10 to control the feeding of pellets 21 of glass-making materials into the crucible 10 and to seal off the interior of the crucible 10 from the atmosphere.

The lower disc 17 may be provided with an opening 22 therein and a corresponding opening 23 may be provided in the upper disc 16, the opening 23 being displaced 180° from the opening 22. The spaced parallel relationship of the discs 16 and 17 provides a chamber 24 within the mouth 25 of the hopper 20 to allow the pellets 21 of glass-making materials to be received therein when the opening 23 is disposed within the mouth 25 of the hopper.

The rotation of the discs 16 and 17 concurrently will cause the opening 23 to seal off the chamber 24 from the hopper 20 so that when the opening 22 aligns with the opening 15 of the heating crucible 10, the pellets contained within the chamber 24 may pass through the opening 22 into the heating crucible 10 without allowing any substantial discharge of gas from within the heating crucible.

The discs 16 and 17 carried upon the shaft 18 are rotated by means of an electric motor 26 driving the shaft 18 through a worm 27 and a worm wheel 28.

The heating crucible 10 is provided with a pressure relief valve 30 for allowing exhaust of pressure above a predetermined value from within the interior of the crucible 10. The relief valve 30 is provided with a valve member 31 retained normally in closed position upon the valve seat of the inlet opening 32 by means of a spring 33 that is adjustable by means of the adjusting screw 34 to set the pressure at which the valve member will open to allow passage of gas through the conduit 35 for exhaust through the exhaust pipe 36. The conduit 35 communicates with the interior of the heating crucible 10 above the level of the body 13 of molten material therein.

There are four principal factors which govern the diameter of a fiber or filament during drawing thereof, and which factors can be correlated to obtain a desired filament diameter. After correlation of the factors they must remain constant during the drawing of the filament to maintain the diameter of the filament constant. These four main factors are (1) establishing a predetermined temperature of the molten material, in this instance glass, from which the fibers are drawn and maintaining the temperature constant, (2) establishing a pressure upon the body of molten material, or a pressure differential upon opposite sides of the body of molten material, correlated with the temperature of the material to exude it through the openings in the wall of the heating crucible at a predetermined rate and to

maintain the pressure constant during the drawing operation, (3) establishing a rate of drawing the fibers from the molten material at the discharge ends of the openings in the heating crucible that is correlated with the temperature of the material to mechanically draw the fibers to a predetermined degree of fineness as established by the rate of drawing and holding the rate of drawing constant during the drawing operation, and (4) establishing a predetermined size orifice in the wall of the heating crucible through which the material is exuded that is correlated to the temperature of the molten glass or material in the crucible and the pressure differential established upon the body of material to allow passage of the molten material through the orifice at a rate to allow drawing of the fibers from the molten material as it exudes through the orifice and yet retain a reservoir of molten material at the discharge side of the orifices from which the fibers can be drawn.

It has been found that to obtain a filament diameter of .00025", when manufacturing glass filaments, the most favorable conditions are to hold the temperature of the molten glass in the crucible 10 at 2250° F. plus or minus 10° F. with the size of the orifices 12 at .040" plus or minus .006". The pressure maintained upon the body of the glass in the heating crucible 10 is equal to 10" of water in a water column gauge plus or minus 5" of water with a rate of draw of the filaments at approximately 10,000 feet per minute. The above conditions will maintain filament diameters of the desired size plus or minus .00002".

To obtain the desired pressure of approximately 10" of water upon the body 13 of molten glass, the materials that go into the composition of the glass may be such that the melting of the materials causes gas to evolve or be liberated therefrom. The choice of the gas that will be evolved or liberated must be made considering the composition of the glass and its relative solubility for various gases. In drawing glass fibers it is preferable that the glass shall be substantially seed-free, hence the volume of gas that can be dissolved by the molten glass shall be relatively small. Thus, when using any ordinary soda-lime glass, oxygen and nitrogen would be preferable gases to use as the atmosphere within the heating crucible because they are relatively insoluble in the molten glass. In a boro-silicate glass, particularly where little or no alkali oxides are present, carbon dioxide is comparatively insoluble. Therefore, in developing a furnace atmosphere and a pressure within the heating crucible 10 by the gas liberated from the composition, the nature of the constituents of the glass will vary depending upon the gas that is to be liberated.

As for example, a batch composition for glass that would satisfactorily evolve or liberate sufficient quantities of carbon dioxide gas to develop pressure within the heating crucible 10 may consist of

Per cent parts by weight	
Raw dolomite	CaMg(CO ₃) ₂ ----- 22.4
Raw limestone	CaCO ₃ ----- 17.4
Calcined borax	Na ₂ B ₄ O ₇ ----- 5 1/3
Boric acid	H ₃ BO ₃ ----- 5 1/3
Kyanite	(AlO) ₂ SiO ₃ ----- 23 3/4
Sand	SiO ₂ ----- 48 1/4

The above materials may be pressed into the forms of pellets, after mixing of the materials, and introduced into the hopper 20 of the apparatus.

5

When the pellets 21 are melted within the crucible 19, carbon dioxide gas will be liberated to produce pressure within the furnace or heating crucible 10.

The pressure relief valve 30 is suitably adjusted to allow excess carbon dioxide gas to exhaust from the interior of the crucible 10 should the pressure rise above the desired value, such as 10" of water as hereinbefore set forth.

To supplement, or augment, the pressure developed by the gas liberated from the molten material within the crucible 10, should insufficient gas be liberated, an auxiliary pressure supply 40 may be provided. The gas preferably would be the same as that evolved from the body of molten material. However, other gases could be used so long as they did not dissolve readily in the molten material. The source of gas under pressure 40 may be connected with the interior of the furnace or heating crucible 10 by means of a conduit 41 in which there is placed a pressure control valve 42.

As long as the pressure within the crucible 10 is at the value for which the valve 30 is set, thus indicating that sufficient gas is liberated from the materials melting within the furnace, the valve 42 will not allow gas from the auxiliary source 40 to enter the interior of the crucible 10. However, should insufficient gas be liberated from the glass materials melting within the furnace 10, the valve 42 will open to allow pressure from the source 40 to be delivered through the conduit 41 into the interior of the crucible 10.

The valve 42 consists of a spring-pressed plunger 43 having the heads 44 and 45 thereon. The head 45 controls the inlet port 46 so that when pressure in the conduit 41 is sufficiently high and engages the lower face of the head 45 through the control passage 47, the port 46 will be closed. However, when the pressure within the pipe 41 reduces, the spring 48 will force the head 45 downwardly to open the port 46 in proportion to the drop in pressure until the pressure in the pipe 41 has been restored to its normal value. The spring 48 is adjustable by the adjustment member 49 so that the valve 42 can be adjusted to cooperate with the valve 30.

The pressure within the heating crucible 10 may thus be maintained at a constant level with the gas liberated from the melting materials being used as the primary source of pressure and the external source of pressure as an auxiliary or augmenting source of pressure.

In Figure 2 there is illustrated a schematic wiring diagram for operating the apparatus illustrated in Figure 1. In general, the electrical system consists of a full wave rectifier 60 having the output thereof connected with an oscillator unit 70. The oscillator 70 may consist of an oscillator tube 71 that connects with the transformer 72 which in turn is connected to the high frequency coil 14.

The output of the oscillator may be controlled by varying the voltage in the grid circuit of the oscillator tube 71 by means of a variable resistor 73 which is operated in one direction to decrease the output of the oscillator by means of a motor 74, and is operated in the opposite direction by means of a torsion spring or motor 75 that is connected to the common shaft of the motor 74 to increase the output of the oscillator 70. The spring motor 75 is normally active to increase the output of the oscillator 70 except when the motor 74 is energized in response to a thermal control

6

element 76 which is sensitive to the temperature of the heating crucible 10.

A relay coil A is connected in series with the temperature-sensitive device 76 so that when circuit is made through the relay coil A indicating a high temperature of the crucible 10, or temperature satisfaction thereof, the contacts A₁ will be closed to energize the motor 74 and thereby reduce the output of the oscillator 70. When circuit is broken through the relay A the contacts A₁ will open to de-energize the motor 74 and allow the spring motor 75 to operate the resistance member 73 to increase the output of the oscillator 70. Constant temperature control of the crucible 10 is thereby obtained.

The motor 26 for feeding pellets of material to be melted is operated in response to the level of the body of material 13 within the crucible 10. A contactor 80 is placed in circuit with a relay coil C, an electric circuit being adapted to be completed through the contactor 80, the body of molten glass 13 and the crucible 10 for making or breaking circuit through the relay coil C.

When the level of molten glass is such as to engage the bottom of the contactor 80, electric circuit is completed through the relay C to open the relay contactor C₁ thereby stopping operation of the motor 26, and halting the feeding of pellets into the crucible 10. However, when the body of molten glass falls below the end of the contactor 80, electric circuit will be broken through the relay C to allow the contactor C₁ to close and thereby energize the motor 26 for again feeding pellets of material into the crucible 10.

The feeding of the pellets 21 into the crucible 10 will thus replenish the supply of material as used therefrom and will provide for replenishment of gas that may escape from the furnace or crucible.

While the method and apparatus disclosed herein constitute a preferred form of the invention, yet it will be understood that the apparatus and the method of operating the same is capable of alteration without departing from the spirit of the invention, and that all modifications that fall within the scope of the appended claims are intended to be included herein.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. The method of producing fibers or filaments which includes, feeding glass stock capable of evolving a gas having a low solubility in molten glass into a heating chamber having a plurality of apertures in one wall thereof, heating the glass stock within the chamber to melt the same with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the glass free of seeds, retaining at least a portion of the liberated gas within the heating chamber to establish a pressure above atmosphere upon the body of material therein to exude the melted material through the apertures, and attenuating the material as exuded into fine fibers.

2. The method of producing fibers or filaments that includes, introducing glass-making materials capable of liberating a gas having a low solubility in molten glass into a heating chamber having a plurality of apertures in one wall thereof, melting the materials in the chamber with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the glass free of seeds, retaining the liber-

ated gas within the chamber to establish a pressure above atmosphere within the chamber to exude the melted material from the chamber through said apertures, and attenuating the material exuded into fine fibers.

3. The method of producing fibers or filaments which includes, feeding glass stock capable of evolving a gas having a low solubility in molten glass into a heating chamber having a plurality of apertures in one wall thereof, heating the glass stock within the chamber to melt the same with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the glass free of seeds, retaining at least a portion of the liberated gas within the heating chamber to establish and maintain a predetermined pressure above atmosphere upon the body of material therein to exude the melted material through the apertures, and attenuating the material as exuded into fine fibers.

4. The method of producing fibers or filaments which includes, feeding material capable of evolving a gas having low solubility in the material into a heating chamber having a plurality of apertures in one wall thereof, heating the material within the chamber to melt the same with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, retaining at least a portion of the liberated gas within the heating chamber to establish a pressure above atmosphere upon the body of material therein to exude the melted material through the apertures, and attenuating the material as exuded into fine fibers.

5. The method of producing fibers or filaments which includes, feeding material capable of evolving a gas having low solubility in the material into a heating chamber having a plurality of apertures in one wall thereof, heating the material within the chamber to melt the same with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, retaining at least a portion of the liberated gas within the heating chamber to establish and maintain a predetermined pressure above atmosphere upon the body of material therein to exude the melted material through the apertures, and attenuating the material as exuded into fine fibers.

6. The method of producing fibers or filaments that includes, introducing materials from which the fibers or filaments are produced into a heating chamber having a plurality of orifices in one wall thereof, which materials are capable of liberating gas having low solubility in the molten material upon heating thereof, heating the materials within the heating chamber to render them viscous with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, confining the liberated gas within the heating chamber to establish and maintain a gas pressure above atmosphere upon the body of viscous material therein to exude the material through the orifices, and attenuating the viscous material into fibers as exuded from the orifices.

7. The method of producing fibers or filaments that includes, introducing materials from which the fibers or filaments are produced into a heating chamber having a plurality of orifices in one wall thereof, which materials are capable of lib-

erating gas having low solubility in the molten material upon heating thereof, heating the materials within the heating chamber to render them viscous with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, confining the liberated gas within the heating chamber to establish and maintain a gas pressure above atmosphere upon the body of viscous material therein to exude the material through the orifices, exhausting a part of the liberated gases from the heating chamber in response to the pressure in the heating chamber to maintain the pressure therein constant, and attenuating the viscous material into fibers as exuded from the orifices.

8. The method of producing fibers or filaments that includes, introducing materials from which the fibers or filaments are produced into a heating chamber having a plurality of orifices in one wall thereof, which materials are capable of liberating gas having low solubility in the molten material upon heating thereof, heating the materials within the heating chamber to render them viscous with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, confining the liberated gas within the heating chamber to establish and maintain a gas pressure above atmosphere upon the body of viscous material therein to exude the material through the orifices, introducing a like gas into the heating chamber from an external source of supply to augment the supply of gases liberated within the heating chamber, and attenuating the viscous material into fibers as exuded from the orifices.

9. The method of producing fibers or filaments that includes, introducing materials from which the fibers or filaments are produced into a heating chamber having a plurality of orifices in one wall thereof, which materials are capable of liberating gas having low solubility in the molten material upon heating thereof, heating the materials within the heating chamber to render them viscous with consequent liberation of gas therefrom to control the atmosphere in the chamber thereby and render the material free of gas bubbles, confining the liberated gas within the heating chamber to establish and maintain a gas pressure above atmosphere upon the body of viscous material therein to exude the material through the orifices, exhausting a part of the liberated gases from the heating chamber to maintain the pressure therein constant, introducing a like gas into the heating chamber from an external source of supply to augment the supply of gases liberated within the heating chamber, and attenuating the viscous material into fibers as exuded from the orifices.

WALTER R. SCHLEHR.

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