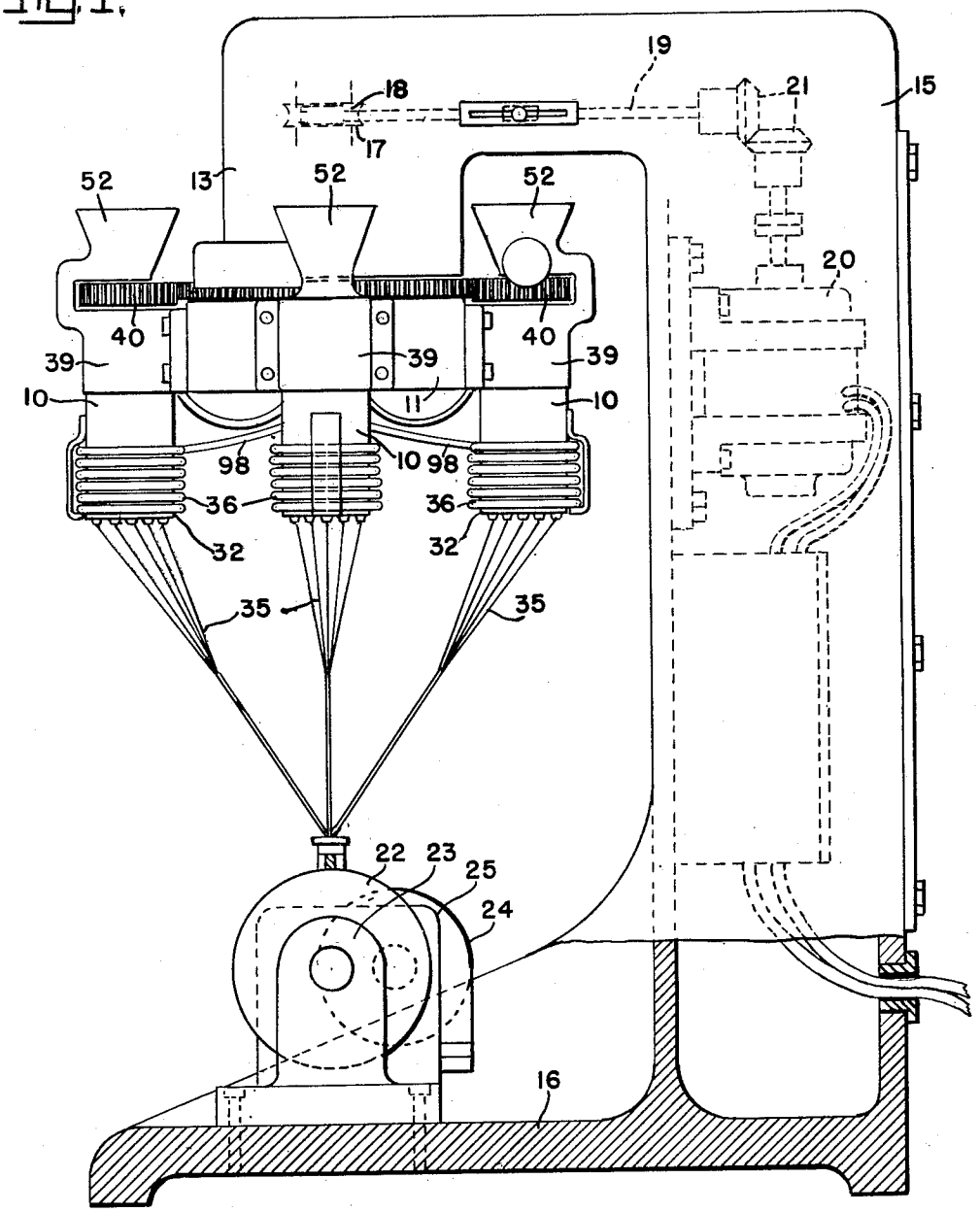
July 11, 1950 E. J. COOK 2,514,627

APPARATUS FOR PRODUCING GLASS FIBERS

Filed Dec. 11, 1945 3 Sheets-Sheet 1

FIG. 1.



INVENTOR
EVERETT J. COOK,
BY Toulmin & Toulmin
ATTORNEYS

July 11, 1950 E. J. COOK 2,514,627

APPARATUS FOR PRODUCING GLASS FIBERS

Filed Dec. 11, 1945 3 Sheets-Sheet 2

FIG 2.

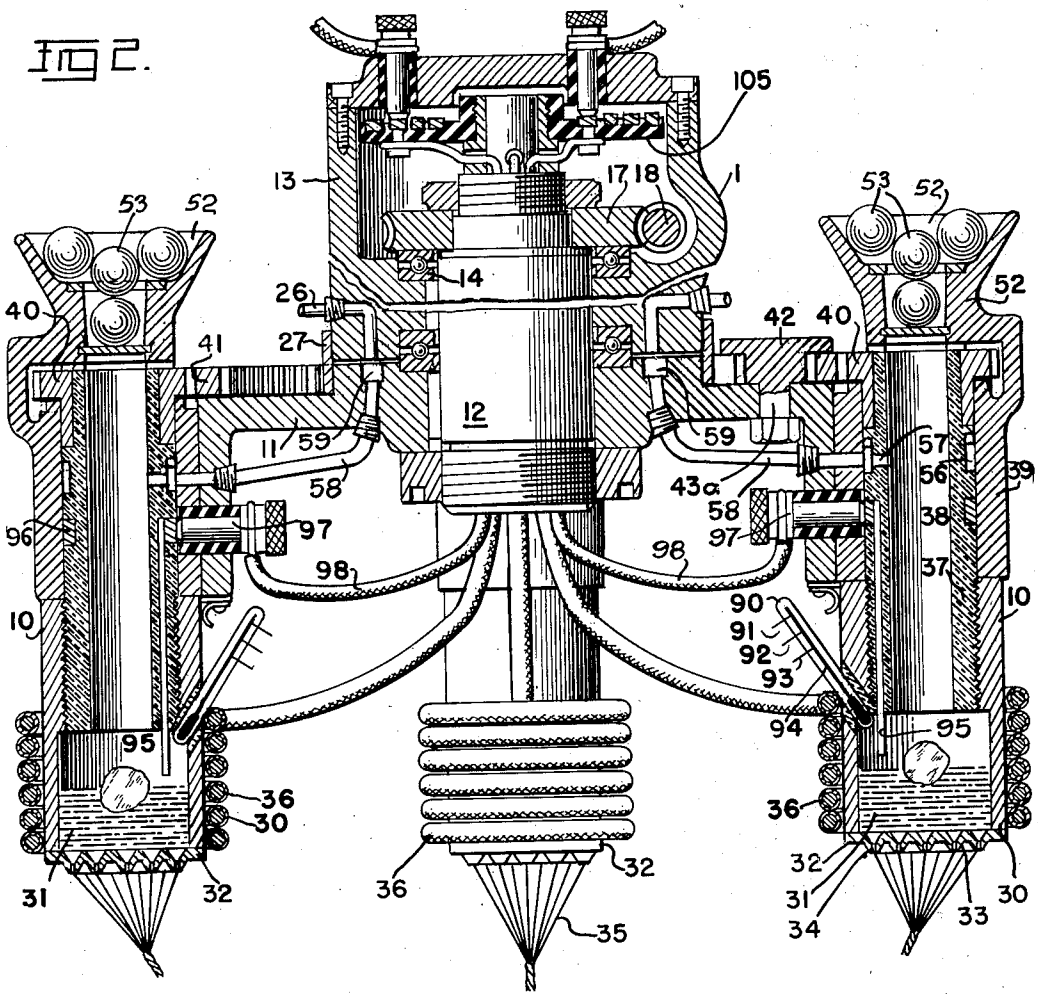
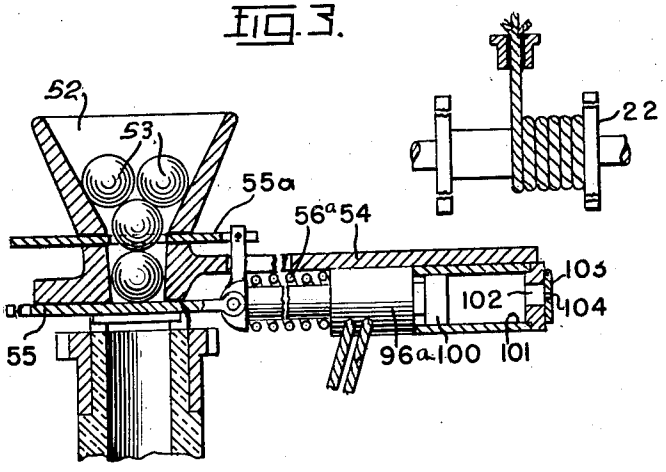


FIG. 3.



INVENTOR
EVERETT J. COOK,
By
Toulmin & Toulmin
ATTORNEYS

July 11, 1950 E. J. COOK 2,514,627

APPARATUS FOR PRODUCING GLASS FIBERS

Filed Dec. 11, 1945 3 Sheets-Sheet 3

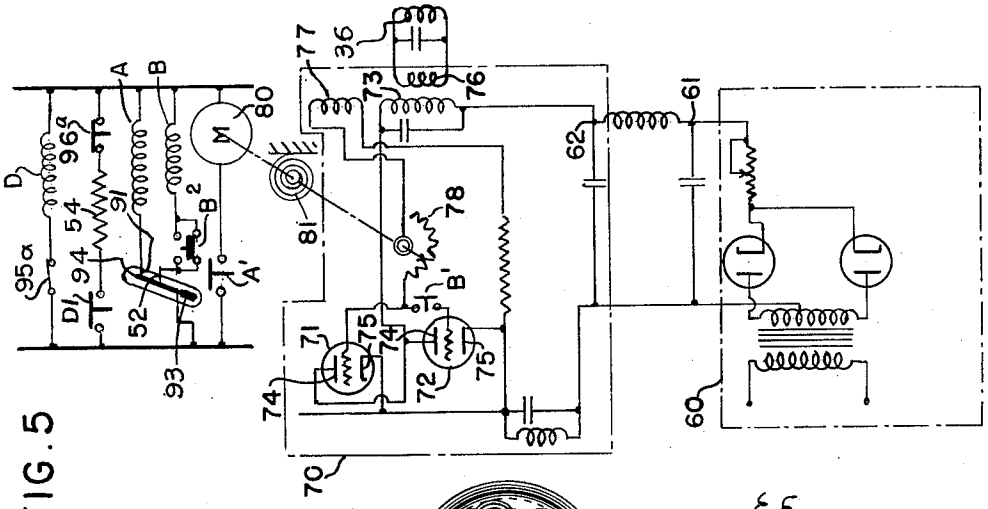


FIG. 5

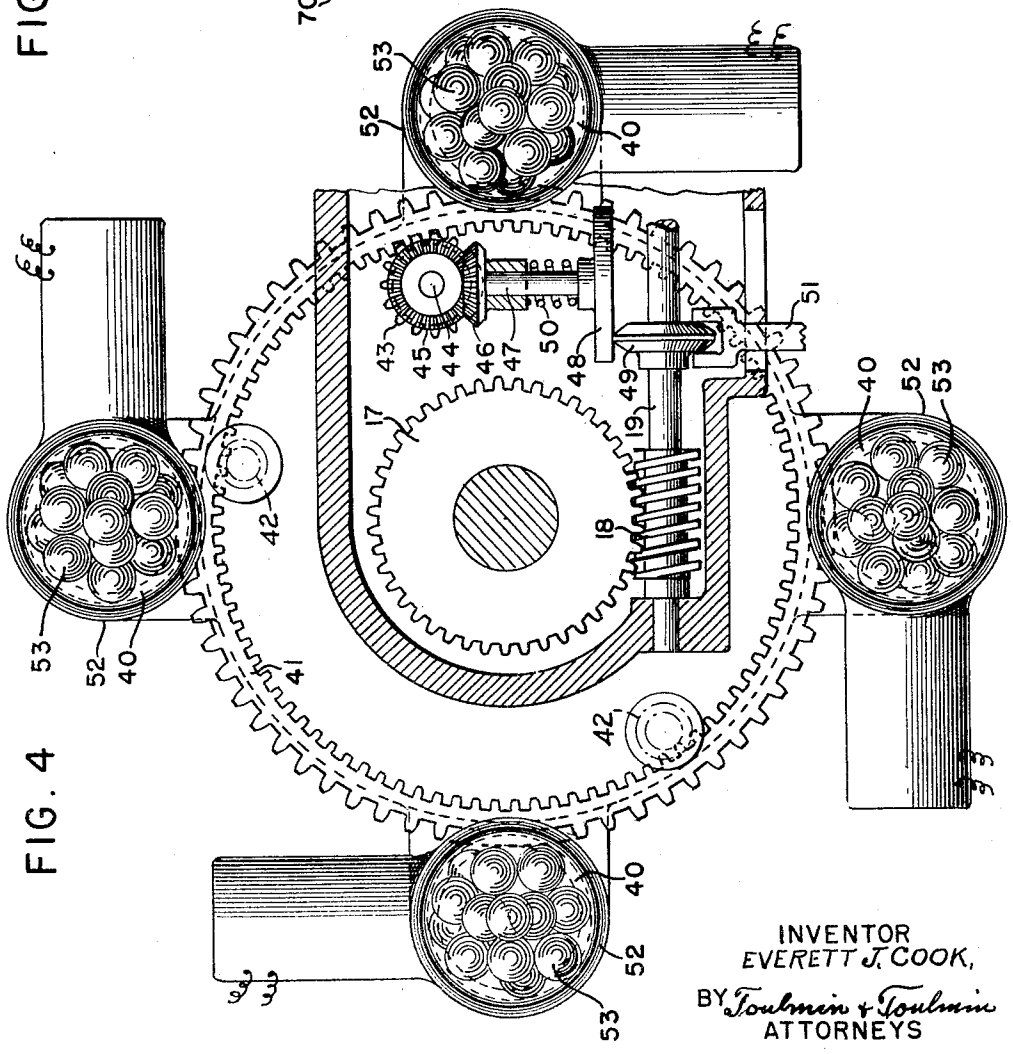


FIG. 4

INVENTOR
EVERETT J. COOK,
BY Toulmin & Toulmin
ATTORNEYS

Patented July 11, 1950 2,514,627

UNITED STATES PATENT OFFICE

2,514,627

APPARATUS FOR PRODUCING GLASS FIBERS

Everett J. Cook, Toledo, Ohio, assignor, by mesne assignments, to Glass Fibers, Inc., Waterville, Ohio

Application December 11, 1945, Serial No. 634,285

2 Claims. (Cl. 49—17)

1

This invention relates to an apparatus for producing glass fibers, and specifically to apparatus for spinning or twisting the glass fibers into a thread or yarn immediately following the drawing of the glass fibers.

An object of the invention is to provide an apparatus wherein glas fibers or filaments are continuously drawn and immediately upon cooling or solidification thereof the fibers are twisted or spun into a thread, the drawing of the glass fibers and the subsequent spinning of the thread being accomplished in a continuous operation so that the finished thread can be wound directly upon a reel or spool.

Another object of the invention is to provide an apparatus wherein fibers or filaments are drawn mechanically from a molten or semi-solid substance, and wherein the fibers or filaments are drawn in independent groups so that each group of fibers may be spun into a small thread separately, which threads are subsequently brought together for spinning into a heavier thread.

Still another object of the invention is to provide an apparatus wherein there is provided a plurality of individual heating crucibles or furnaces for heating glass and from each of which a group of glass fibers is mechanically drawn, and wherein the furnaces, or crucibles, are adapted to be rotated upon their own axes for the purpose of spinning the fibers as drawn therefrom into a thread, and also which furnaces are adapted to be rotated in a planetary arrangement around a central axis so that the threads spun by the individual furnace mechanisms will be further spun into a composit thread for collecting upon a reel or spool.

Still another object of the invention is to provide an apparatus for spinning threads from glass fibers as a continuous process during the drawing of the fibers wherein the type of thread produced can be changed by varying the spinning operation.

Still another object of the invention is to provide an apparatus for spinning threads from glass fibers wherein the manufacture of the thread can be carried forward as a continuous process and without interruption to give an indeterminate length of thread.

Still another object of the invention is to provide an apparatus for spinning threads from glass fibers wherein the controlled conditions under which the glass fibers are drawn can be changed to regulate the size of the drawn fibers and thereby regulate the size and strength of the thread produced therefrom.

2

Still another object of the invention is to provide an apparatus wherein a pressure differential is established on a body of molten glass and the temperature of the molten glass as well as the rate at which the fibers are mechanically drawn is maintained relatively constant after these conditions are correlated to obtain a predetermined size filament, and thereafter immediately spin or twist the fibers into a finished thread product.

Another object of the invention is to provide an apparatus for accomplishing any of the foregoing objectives wherein glass stock is fed into the heating crucible in response to the volume of molten glass therein to maintain a substantially constant volume of glass available from which the glass fibers can be drawn.

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

In the drawings:

Figure 1 is a side elevational view of an apparatus for drawing and spinning glass fibers.

Figure 2 is a vertical cross-sectional view, somewhat diagrammatic in form, of the machine illustrated in Figure 1, showing the principal constructional features of the machine.

Figure 3 is a vertical cross-sectional view of one of the feeding mechanisms for feeding the glass stock into the heating chambers of the machine.

Figure 4 is a plan view, somewhat diagrammatic in form, of the apparatus illustrated in Figure 1.

Figure 5 is a schematic wiring diagram of a power source and electrical mechanism for operating the apparatus illustrated herein.

In this invention the glass fibers or filaments are drawn mechanically from a supply or body of molten glass in such a manner that the diameter of the filaments is accurately controlled by the drawing operation. As soon as the drawn fibers have cooled sufficiently that there is no further drawing thereof, they are brought together and spun into a thread, string or yarn, as a continuing operation of the drawing process. The spun thread, string or yarn is then wound upon a spool or reel.

The term fiber or filament as used in this application refers to fibers that are of a diameter on the order of .000325" and variations therefrom such as from .0001" to .0004".

There is a peculiar quality in glass in the manufacture of glass fibers or filaments, in that the tensile strength of the glass fibers is increased as

the temperature at which the glass fibers are drawn is reduced. However, as the temperature of the glass is reduced in an endeavor to obtain the higher tensile strength in the glass fibers, many difficulties have been encountered in properly controlling the diameter of the fibers or filaments to obtain absolute uniformity thereof. In this invention, however, the glass fibers or filaments are mechanically drawn under controlled conditions under which the lowest possible temperature of the glass consistent with good drawing qualities, is used. Preferably, the body of glass is heated within a metal furnace by conduction and radiation from the walls thereof, which walls are heated inductively by the use of high frequency energy. The temperature of the furnace is accurately controlled to maintain a predetermined condition of fluidity of the molten glass in the furnace so that a predetermined pressure differential applied upon the body of molten glass will cause the molten glass to exude through a plurality of orifices in one wall of the furnace at a predetermined rate and thereby allow fibers or filaments to be drawn from globule-like reservoirs established at the outlet of each of the orifices at a predetermined rate to establish a predetermined size filament.

By controlling the temperature of the furnace, and thus the fluidity of the molten glass therein, the pressure differential upon the molten body of glass, the size of the orifices in the wall of the furnace and the rate at which the fibers are drawn, the diameter of the drawn filaments can be controlled and varied to meet any requirement.

After the fibers or filaments have been drawn a sufficient distance from the furnace, they have cooled sufficiently to allow them to be brought together and spun into a thread. The groups of filaments that are drawn from each of the furnaces of the apparatus described herein are first brought together to form a primary thread. This operation is produced by causing rotation of the individual furnaces and through a spinning of the filaments issuing therefrom. The primary threads spun from each of the furnaces are then brought together so that a rotation of the furnaces in a planetary arrangement around a common axis will cause a second spinning of the primary threads into a major thread or finished product.

The apparatus of this invention for drawing and spinning glass fibers consists of a plurality of furnaces 10, that are secured to a rotating frame 11. The rotating frame 11 is carried upon a shaft 12 suspended from a stationary head 13 by means of the bearings 14.

The stationary head 13 is a part of the main frame 15 of the machine that includes the base portion 16 thereof.

The rotatable frame 11 is driven by the shaft 12 which in turn carries a gear 17 engaged by the worm 18 carried upon the shaft 19. The shaft 19 is in turn driven by the electric motor 20, preferably of the variable speed type, through means of a pair of beveled gears 21. Thus, whenever the motor 20 is operating, the frame 11 will rotate the furnaces 10 in a planetary arrangement about the axis of the shaft 12.

The base portion 16, of the machine supports a receiving reel or spool 22 upon suitable bearings 23. The receiving spool, which receives the finished thread product, is driven by means of an electric motor 24 that drives the same through a variable speed mechanism 25 whereby the speed of rotation of the spool 22 may be regulated and

controlled at any predetermined value. The winding of the finished thread product upon the reel or spool 22 provides the source of power or energy required to mechanically draw the fibers or filaments from the furnaces 10 in a manner hereinafter more specifically described. Thus, the speed of rotation of the winding spool 22 will regulate the speed of drawing of the glass fibers or filaments and becomes one of the factors entering into the control of the diameter of the filaments.

Each of the furnaces 10 consists of a crucible 30 that contains a body of molten glass 31. The crucible 30 is constructed of a metal, preferably of a non-oxidizable nature, at the high temperatures at which the metal is worked, which in this invention will be from 2200° F. to 2300° F. Such a metal is found in platinum or in platinum rhodium alloys. The crucible 30 is provided with an aperture plate 32 that forms the bottom wall thereof. The operture plate has a plurality of aperture 33 therein, which apertures are formed in protrusions 34 that extend downward from the aperture plate 32. The molten glass within the crucible 30 exudes from the apertures 33 under controlled conditions, hereinafter referred to and forms globule-like reservoirs of molten glass at the discharge end of each of the apertures 33. The glass filaments or fibers 35 have their genesis in the globules and are drawn therefrom by the mechanical means consisting of the spool or reel 22 hereinbefore referred to.

The crucible 30 is of relatively small size and has a high frequency coil 36 positioned around the same. The coil 36 is preferably constructed from a small patinum tube to avoid deterioration of the same at the high temperature involved in its use adjacent the crucible 30. The high frequency coil is adapted to be connected to the output of a high frequency generator or oscillating unit, such as the simplified form of such unit illustrated in Figure 5, hereinafter more fully described, for impressing a frequency of 1.5 megacycles on the coil 36, which frequency has been found most favorable for heating the platinum crucible 30.

The crucible 30 is secured upon the end of a ceramic tube 37 that has an opening 38 therein through which the glass stock is fed into the crucible 30.

The ceramic tube 37 is carried within the upper metal body 39 of the furnace 10 and is adapted to rotate therein. The upper end of the ceramic tube 37 carries a gear 40 secured thereto, which gear 40 may also suspend the ceramic tube 37 within the body 39 of the furnace.

Each of the furnaces 10 is provided with a gear 40 that meshes with a ring gear 41 carried upon the upper face of the frame 11 and held in position by means of suitable guide gears 42, carried upon the pinion shafts 43a and spaced substantially equidistantly about the ring gear 41.

The ring gear 41 rotates the furnaces 10 within the body portion 39 thereof for the purpose of spinning the filaments issuing from the aperture plates 32. The ring gear 41 is driven by means of pinion gear 43 carried upon the shaft 44 secured to the frame 11. The shaft 44 also carries a bevel gear 45 that engages a companion bevel gear 46 carried upon the shaft 47. A friction plate 48 is caried upon the opposite end of the shaft 47 and is spring pressed against the beveled drive member 49 by means of a spring 50. The beveled drive member 49 is keyed to be slidable upon the drive shaft 19 to allow the fork 51

to move the same over the face of the plate 48 and thus change the speed at which the ring gear 41 is driven to change the speed of axial rotation of the furnaces 10 and thus the speed of spinning the filaments issuing therefrom to either wind the same tighter or more loosely, depending upon the nature of the thread desired.

The body member 39 of the furnace 10, supports a hopper 52 adapted to receive the glass balls or marbles 53 that are fed into the heating crucible 30 through the opening 38 in the ceramic tube 37. The glass balls 53 are fed into the crucible 30 one at a time by means of an electric solenoid 54 actuating a gate 55 that is normally held in closed position by means of a spring 56a. The operation of the feeding mechanism will be more clearly set forth in the description of the electric circuit disclosed in Figure 5.

The ceramic tube 37 has an annular recess 56 therein that communicates through an opening 57 with a passage 38. The recess 56 also communicates with a gaseous pressure line 58 that extends from an annular recess 59 in the upper face of the rotating frame 11, this latter recess 59 communicating with a gaseous pressure line 26 connected to a suitable source of gaseous pressure, whereby gas under pressure is supplied to and maintained in the crucible 30 to slowly exude the molten glass through the apertures 33 in the aperture plate 32. A sealing ring 27 is carried upon the stationary head 13 and engages the rotating frame 11 to seal the joint therebetween and prevent loss of gaseous pressure. The double gate arrangement consisting of the gate 55 and the gate 55a, in the feeding device prevents loss of pressure from the crucible 32 when a ball is being fed thereinto. The gaseous pressure supplied to the crucible 30 is suitably controlled by any conventional well known means to maintain the pressure in the crucible at any desired value and to allow for change of pressure in the crucible when operating conditions require such a change in pressure.

The furnace 10 is provided with a temperature sensitive device 90 for controlling the output of the high frequency oscillator to the coil 36 and thus control the temperature of the crucible 30. The temperature sensitive device 90 is in effect a mercury thermometer having the three terminals 91, 92 and 93 passing thereinto into engagement with the mercury column 94.

The terminal 93 is a common terminal or ground connection. The upper terminal 91 controls the output of the oscillator in a manner hereinafter described to maintain the temperature of the crucible 30 substantially constant. The terminal 92 also controls the oscillator and is adapted to cut in a stand-by tube in case the temperature of the crucible 30 should drop below a predetermined value for some accidental or unusual reason.

The electrical system for controlling the temperature of the crucible 30, and for controlling the feeding of the glass balls 53 is more particularly illustrated in Figure 5 wherein there is shown a simplified form of high frequency oscillator.

In the electrical wiring diagram shown in Figure 5, there is illustrated a full wave rectifier 60 having the output terminals 61 and 62 thereof. An oscillator or high frequency generator 70 is connected to the output terminals 61 and 62 of the rectifier 60. The high frequency generator may consist of a conventional oscillating circuit to obtain the desired frequency on the output side thereof for delivery to the high frequency coil 36. As illustrated in Figure 5, the high frequency generator may consist of an oscillator tube 71 and a stand-by oscillator tube 72 that is supplied with current from the rectifier 60. One side of the transformer 73 is connected to the anode 74 of the oscillator tubes 71 and 72, and the other side of the transformer 73 is connected with the cathodes 75 of the oscillator tubes 71 and 72 in conventional manner in cooperation with the rectifier 60. The secondary coil 76 of the transformer 73 has the opposite terminals thereof connected with the opposite terminals of the high frequency coil 36 for thereby transmitting the energy of the high frequency generator to the high frequency coil. The grid-exciting coil 77, that may be a compound winding in the transformer 73, supplies the grid circuit of the oscillator tubes 71 and 72, and by varying the voltage in the grid circuit of the oscillator tubes 71 and 72, the output of the oscillator 70 is thereby controlled. Such a control of the grid circuit may be had through the potentiometer 78.

The grid circuit of the oscillator tube 71 is continuously in circuit while the grid circuit of the oscillator tube 72 is provided with the contacts B_1 that are operated by the relay coil B that is placed in circuit with the terminal 92 of the temperature-sensitive device 90. The contacts B_1 are opened when the relay B is energized, which is a normal condition, thereby allowing the tube 72 to act as a stand-by tube.

The potentiometer 78 of the high frequency generator 70 is adapted to float over the resistance element thereof to control the output of the generator as this potentiometer is caused to operate by the electric motor 80. The electric motor 80 is adapted to cause the potentiometer to move in one direction and a torsion spring 81 connected to the shaft between the motor 80 and the potentiometer 78 is adapted to cause the potentiometer to move in an opposite direction. The direction of movement of the potentiometer to vary its resistance is controlled by the position of the mercury column 94 in the temperature-sensitive device 90 with relation to the terminal 91 thereof. When the mercury column 94 engages the terminal 91 or is above the same, an electric circuit will be made through the relay coil A which closes the contacts A_1 and thereby energizes the motor 80 to actuate the potentiometer 78 and reduce the output of the high frequency generator 70. Conversely, when the mercury column 94 is below the upper terminal 91 of the temperature-sensitive device 90, the relay coil A will be de-energized, thereby de-energizing the electric motor 80 and allowing the torsion spring 81 to actuate the potentiometer 78 in the opposite direction and thereby increase the output of the high frequency generator 70. It will thus be seen that the temperature-sensitive device 90 will thus control the output of the high frequency generator 70 with sufficiently close accuracy as to maintain the temperature of the crucible 30 at a substantially constant value. The preferable temperature conditions involved are approximately 2250° F. plus or minus 10° F.

As previously mentioned, the oscillator tube 72 acts as a stand-by tube, and assuming the apparatus is in operation, the mercury column 94 of the temperature-sensitive device 90 will be above the terminal 93 thereof, thus maintaining energized the relay coil B through the holding circuit contacts B_2 that are closed, thus holding

the contacts B_1 open to render the grid circuit of the tube 72 ineffective. Should the temperature of the crucible 36 fall sufficiently low that the mercury column of the temperature-sensitive element 90 disconnects with the terminal 93, the relay coil B will be deenergized, thus allowing contacts B_1 to close to cut in the second oscillator tube 72 and thus quickly and substantially increase the output of the high frequency generator 70 to overcome the abnormal condition.

The solenoid 54 for feeding the glass marbles 53 in the crucible 30 is normally inactive as long as the molten glass engages the bottom end of the contact rod 95 that is connected to a contact ring 96 engaged by a contact pin 97 for conducting current thereto through the line 98, the spring 56*a* holding the gates 55 and 55*a* in the position illustrated in Figure 3. The contact switch 95*a* representing the end of the contact rod 95 will retain the relay coil D energized as long as the volume of glass is sufficiently high to hold the contacts D1 open thus retaining the solenoid 54 de-energized. When the level of the glass falls below the bottom end of the contact rod 95, the relay D will be de-energized, thus allowing the contacts D1 to close de-energizing the solenoid 54, thus causing the gates 55 and 55*a* to move in a rightward direction to allow the marble on the gate 55 to drop into the crucible 30.

A delayed action switch 96*a* is provided in series with the solenoid 54 which is opened when the solenoid armature reaches the extreme limit of its rightward movement, thereby de-energizing the solenoid to allow the same to return to its previous position. However, the delayed action switch 96*a* is arranged so that the glass marble 53 will have fallen into the molten glass in crucible 30 before the solenoid reaches its initial starting position to prevent a reactuation of the solenoid if the one glass ball is sufficient to raise the volume of the glass to a point to engage the bottom end of the contact rod 95.

If the level of the glass is sufficiently high to engage the bottom of the contact rod 95, the relay D will be re-energized to open contacts D1 and thereby prevent any further actuation of the solenoid 54. However, if the single ball 53 is insufficient to raise the level of the molten glass to the end of the contact rod 95, closing of the delayed action switch 96*a* will again energize the solenoid 54 because at this time the relay D will be de-energized and the contacts D1 will be closed. It will thus be seen that the feeding device is capable of feeding a single glass ball upon each operation thereof and sensing the level of the molten glass before feeding another glass ball.

The delayed action switch 96*a* may be any conventional type but as shown in the drawing, the delayed action device consists of a piston 100 operating within a closed chamber 101 that has a port 102 therein closed by a flapper valve 103 having a leak port 104 therein. The flapper valve 103 allows for a rapid exhaust of air from the chamber 101 but a slow intake of air into the chamber to obtain the desired delayed action in the closing of the switch 96*a*.

All of the electric lines connecting the various electrical members on the furnaces 10 may be carried through the center shaft 12 and suitably connected to a connecting ring 105, having various annularly arranged contact members thereon from which and to which various electrical connections can be made for suitably connecting the electrical elements of the system. Such slip ring arrangements are well known in the art and it is not deemed necessary to specifically describe the same.

There are four principal factors which govern the diameter of a fiber or filament during the drawing thereof, and which factors must be correlated to obtain a desired filament diameter, and after correlation of the factors they must remain constant thereafter 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 glass from which the fibers are drawn and maintaining the temperature constant thereafter, (2) establishing a pressure differential upon opposite sides of the body of molten glass in the furnace correlated with the temperature of the glass to exude the molten glass through the orifices in the orifice plate at a predetermined rate and maintain the pressure differential constant during the drawing operation, (3) establishing a rate of drawing the fibers from the molten glass at the ends of the orifices that is correlated with the temperature of the glass to mechanically draw the fibers to a predetermined degree of fineness as established by the rate of draw and thereafter hold the rate of draw constant during the drawing operation, and (4) establishing a predetermined size orifice in the orifice plate correlated to the temperature of the molten glass in the crucible and the pressure differential established upon that body of glass to permit passage of the molten glass through the orifice at just a sufficient rate to allow drawing of the fibers from the molten glass as it exudes through the orifice at the predetermined rate established by the mechanical drawing means and still retain a reservoir of molten glass at the orifices from which the fibers can be drawn, all of which variable features and a more complete discussion thereof is fully described and disclosed in my Patent 2,495,596 dated January 31, 1950.

From the foregoing description, it will therefore be apparent that the apparatus of this invention is capable of drawing glass fibers or filaments of a predetermined controlled diameter in individul groups from individually controlled heating crucibles. Also, that the individual fibers or filaments can be spun or twisted into a primary thread as the fibers are drawn from the furnaces, allowing of course, sufficient time for their delivery from the furnace to permit satisfactory solidification to avoid adherence of the fibers to one another. Thereafter, the primary threads are further spun or twisted together by a planetary rotation of the furnaces about a common axis to produce the major product or thread of the desired size. Also, by controlling the variable factors referred to hereinabove, it will be appreciated that the size of the filaments drawn from the furnaces can be readily changed to thereby effect a change in the diameter of the thread being produced and the strength thereof. Again, by changing the speed of rotation of the individual furnaces as well as the speed of rotation of the primary rotating frame 11, either a loosely wound or tightly wound thread can be produced.

While in this description the manufacture of glass fibers has been specifically referred to, yet it will be understood that the process is applicable to the manufacture of fibers or filaments from other substances including metals and metal alloys, without any major change from the general arrangement of the apparatus.

While the apparatus disclosed and described herein constitutes a preferred form of the invention, yet it will be understood that the apparatus is capable of operation without departing from the spirit of the invention, with reference to the manufacture of threads from drawn filaments, 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. An apparatus for spinning a thread from a plurality of fine filaments that includes, a heating crucible having a plurality of apertures in one wall thereof and adapted to contain a body of molten substance, means for establishing and maintaining a controlled constant pressure differential upon opposite sides of the body of molten substance to cause the substance to exude slowly through said apertures, a first means of independently variable controllable speed of operation for mechanically drawing the molten substance from adjacent the apertures into controlled diameter fine filaments, a second independent means of independently variable controllable speed of operation rotating said crucible on its own axis concurrently with the drawing of said filaments to twist the drawn filaments to controlled tightness, and a third means of independently variable controllable speed of operation for moving a plurality of said crucibles radially around a common axis to twist the twisted filaments into a thread of controlled tightness.

2. An apparatus for spinning a glass thread from a plurality of fine filaments that includes, a heating crucible having a plurality of apertures in one wall thereof of larger diameter than filaments to be produced and adapted to contain a body of molten glass, a high frequency heating coil encircling said crucible at the level thereof

at which the molten glass is located therein, means for establishing and maintaining a controlled constant pressure differential upon opposite sides of the body of molten glass to cause the same to exude slowly through said apertures in streams of at least the diameter of the apertures, a first means of independently variable controllable speed of operation for mechanically drawing and attenuating the glass from said streams into controlled diameter fine filaments, a second independently controllable means for rotating said crucible on its own axis concurrently with the drawing of said filaments to twist the drawn filaments to controlled tightness, means drivingly connected with said second independent means for effecting a change in the speed of rotation of said crucible and effect a change in the tightness of twisting of said filaments, a third independently controllable means for moving a plurality of said crucibles radially around a common axis to twist said twisted filaments into a thread of controlled tightness, and means drivingly connected with said third independent means for effecting a change in the speed of movement of said plurality of crucibles about said common axis and effect a change in the tightness of twisting of the thread.

EVERETT J. COOK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
702,163	Strehlenert	June 10, 1902
2,187,094	Pink	Jan. 16, 1940
2,229,489	Barnard	Jan. 21, 1941
2,234,986	Slayter et al.	Mar. 18, 1941
2,294,266	Barnard	Aug. 25, 1942
2,369,506	Weibel	Feb. 13, 1945