April 23, 1957 C. J. STALEGO 2,790,019

APPARATUS FOR HANDLING AND PROCESSING MINERAL MATERIALS HAVING HIGH FUSING TEMPERATURES

Filed June 19, 1952 3 Sheets-Sheet 1

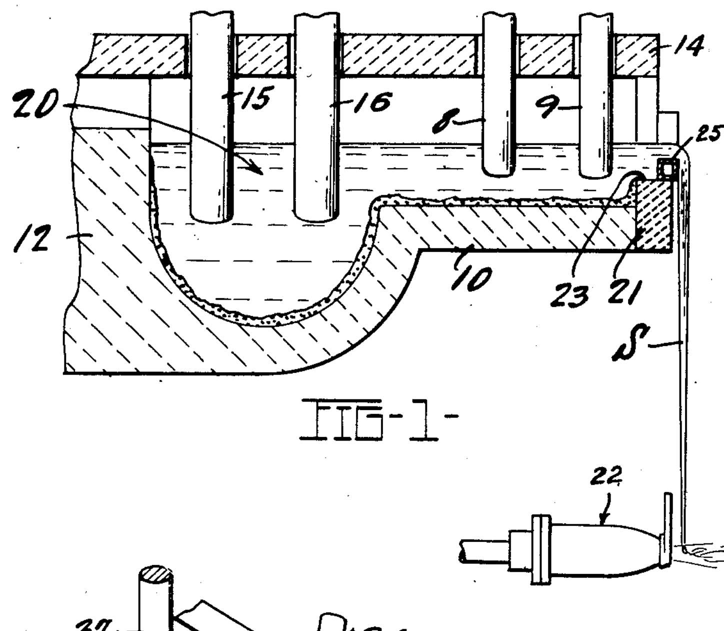

FIG-1-

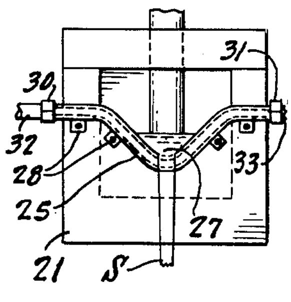

FIG-2-

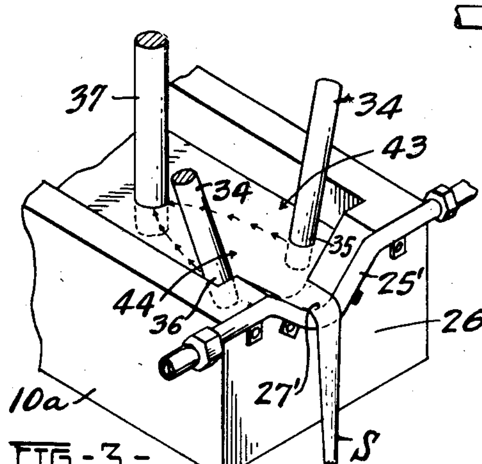

FIG-3-

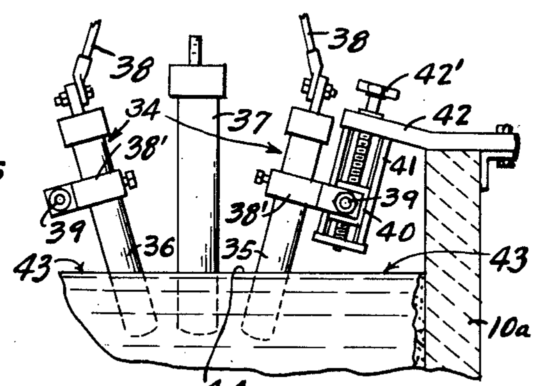

FIG-4-

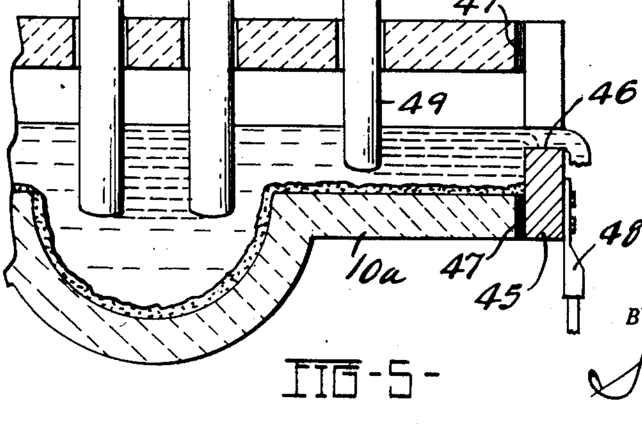

FIG-5-

INVENTOR:
CHARLES J. STALEGO.
BY
Staelin & Overman
ATTYS.

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Filed June 19, 1952 3 Sheets-Sheet 2

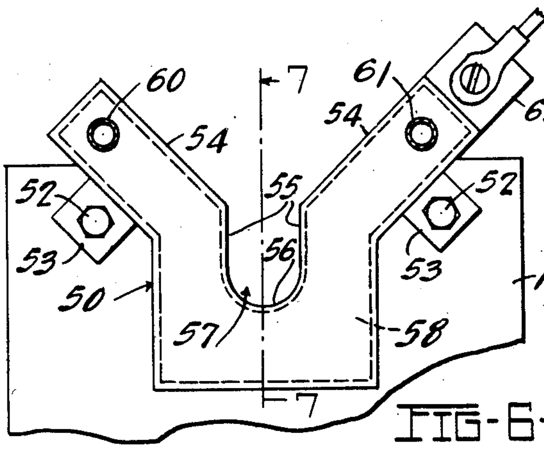

FIG-6-

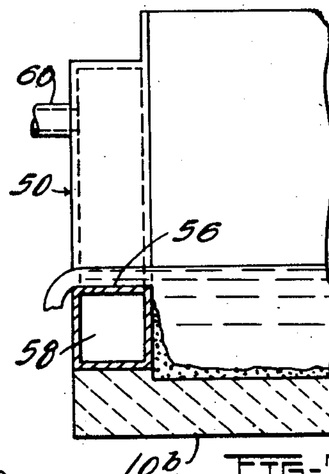

FIG-7-

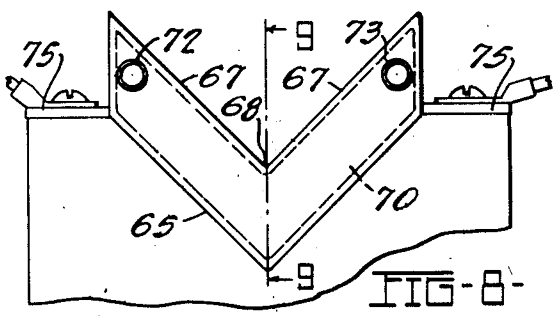

FIG-8-

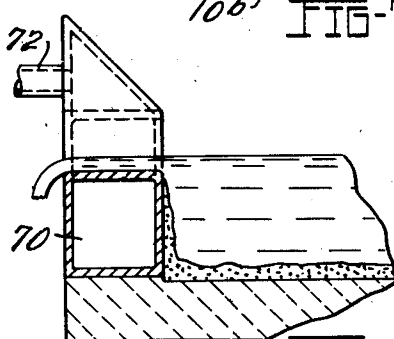

FIG-9-

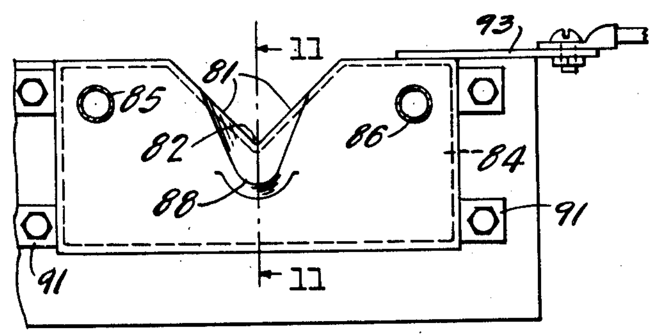

FIG-10-

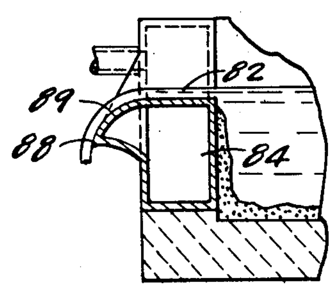

FIG-11-

INVENTOR:
CHARLES J. STALEGO.
BY
Staelin & Overman
ATTYS.

April 23, 1957 C. J. STALEGO 2,790,019

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Filed June 19, 1952 3 Sheets-Sheet 3

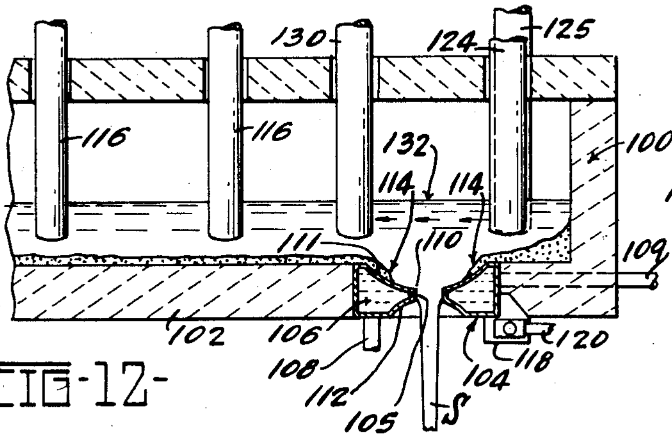

FIG-12-

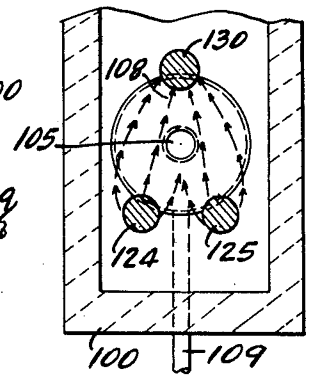

FIG-13-

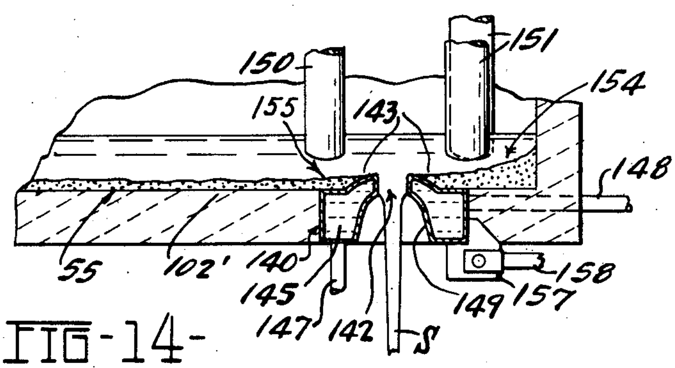

FIG-14-

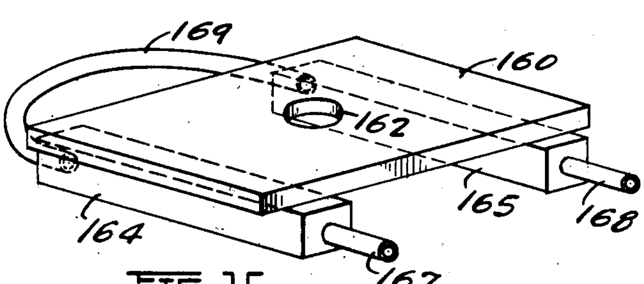

FIG-15-

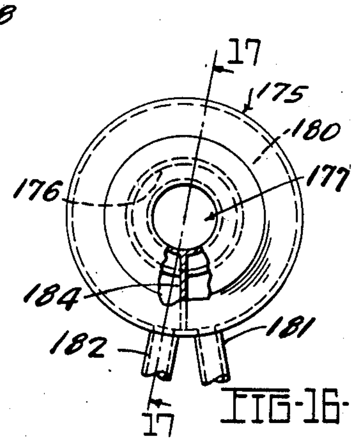

FIG-16-

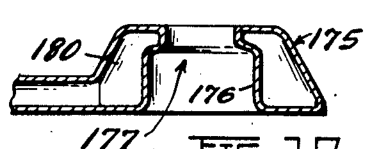

FIG-17-

INVENTOR:
CHARLES J. STALEGO.
BY Staelin & Overman
ATTYS.

United States Patent Office 2,790,019 Patented Apr. 23, 1957

2,790,019

APPARATUS FOR HANDLING AND PROCESSING MINERAL MATERIALS HAVING HIGH FUSING TEMPERATURES

Charles J. Stalego, Newark, Ohio, assignor to Owens-Corning Fiberglas Corporation, a corporation of Delaware

Application June 19, 1952, Serial No. 294,522

6 Claims. (Cl. 13—33)

This invention relates to method and apparatus for handling and processing mineral materials fusible at high temperatures and for controlling and maintaining the material in a flowable state, the method and apparatus being especially usable in providing for the continuous flow of one or more streams of material delivered to a zone where the stream or streams may be acted upon by suitably directed forces for producing fibers from the material.

It has been conventional practice to produce fibers in commercial quantities from mineral materials such as glass, slag and certain types of fusible rock where such materials may be softened or reduced to a flowable state at temperatures under 2800° Fahrenheit. Considerable difficulties have been encountered, however, in attempts to control and maintain materials that are rendered heat-softenable or flowable at temperatures in excess of 2800° Fahrenheit in a satisfactorily flowable state or condition.

Certain glass compositions and other mineral materials such, for example, as aluminum silicate from which fibers may be formed are rendered flowable at extremely high temperatures. Aluminum silicate may be fused or melted at a temperature of about 3500° Fahrenheit and at such temperature has a relatively low viscosity and hence is readily flowable. At a high temperature the material may be highly fluid and readily flowable, but by reason of the low viscosity of the fluid material, attenuation of the material to fibers cannot be satisfactorily attained. It is found that at a temperature of about 3100° Fahrenheit the viscosity characteristic of aluminum silicate is extremely critical and changes markedly within a temperature range of about 25° Fahrenheit. At comparatively high temperatures, such an extremely critical temperature range of 25° Fahrenheit is difficult to maintain, and it has been found that satisfactory attenuation of the material to fibers is attainable only when the material is within the critical temperature range.

In fusing materials such as aluminum silicate, resistance to the flow of electric current between electrodes immersed in the material is utilized to soften or melt the material so that it may be discharged from the melting furnace through a trough or pouring spout. Heretofore it has not been possible to maintain or stabilize the temperature of the material adjacent the pouring spout so as to prevent "freezing" of the material, a condition which impairs or obstructs the continued flow of the material through the spout. The accretion of congealed material in the trough or spout, even if not wholly interrupting the flow of the stream, causes an unstable or sporadic flow of the material and unsatisfactory attenuation of the softened material to fibers.

Heretofore flow blocks formed with pouring spouts have been fashioned of graphite or ceramic materials having high fusion temperatures but these have been unsatisfactory. Flow blocks formed of such materials

absorb and conduct heat from the molten material so rapidly that the viscosity of the molten material is increased causing a reduction in the flow rate and congelation or freezing of the material eventually interrupts the flow or discharge of the material. Ceramic compositions suitable for flow block constructions are readily subject to corrosion at high temperatures and disintegrate within a short period of time.

The present invention embraces a method of heating and controlling the condition of material fusible at high temperatures in a manner providing for uninterrupted flow of the material and delivery thereof to a fiber-forming zone under conditions wherein attenuation will occur while the fiber-forming material is within a viscosity range necessary to satisfactorily form fibers.

An object of the invention involves a method of flowing mineral material from a supply through a passage arranged to foster a continuity of movement of the material and avoid or minimize conditions which would otherwise tend to retard or interrupt the flow of the material.

Another object of the invention resides in a method of heating fiber-forming materials which fuse at high temperatures and controlling the temperature of the fused material in a manner rendering the material flowable from a supply under conditions avoiding the dissipation of heat from the material at the zone of discharge of the material from the supply.

Another object of the invention resides in the provision of apparatus for handling mineral material having a high-temperature fusing point, the apparatus including a discharge means for the material arranged so that the molten material may be conveyed from the supply without appreciable temperature variation thereby avoiding liability of the molten material to chill or congeal in the discharge zone.

Another object of the invention resides in an apparatus for conveying or discharging a stream of mineral material at a high temperature wherein the wall of a material-conveying or discharging passage or orifice is maintained at a temperature whereby adherence of the molten mineral material to the conveying or discharging means is substantially minimized or avoided.

Another object of the invention resides in the provision of a discharge orifice or passage construction formed of metal and cooled through the medium of a circulating fluid to maintain a reduced temperature for the orifice or passage construction below the point at which the molten material will adhere to the metallic surfaces to avoid a congealing of the material in the orifice or passage and without appreciable transfer or conduction of heat away from the material.

Another object of the invention resides in an apparatus for melting fiber-forming material and maintaining the material in a flowable state through the utilization of electrical energy applied to the material in a manner to avoid congealing of the molten material in zones which would interfere with the facile discharge or flow of the molten material from a forehearth or melting receptacle.

Still a further object resides in the provision of apparatus for maintaining material having a high fusion point in a molten state wherein a flow block or orifice construction forms an electrode connected to a source of electrical energy and disposed to facilitate flow of current through the material adjacent a zone of discharge of the material from a supply for controlling the temperature of the material at said zone.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawing of a form of the invention, which may be preferred, in which:

Figure 1 is an elevational view illustrating a form of apparatus for carrying out the method of the invention;

Figure 2 is an end view of an end of the apparatus shown in Figure 1;

Figure 3 is an isometric semidiagrammatic view of the construction illustrated in Figure 1 embodying an electrode arrangement for controlling the temperature of the molten material;

Figure 4 is a transverse sectional view of the arrangement shown in Figure 3;

Figure 5 is a view similar to Figure 1 illustrating a flow block or material-discharge means arranged to function as an electrode;

Figure 6 is an elevational view of another form of flow block construction;

Figure 7 is a vertical sectional view taken upon the line **7—7** of Figure 6;

Figure 8 is an elevational view of a modified form of flow block;

Figure 9 is a vertical sectional view taken substantially on the line **9—9** of Figure 8;

Figure 10 is an elevational view showing a further form of flow block;

Figure 11 is a vertical sectional view taken substantially on the line **11—11** of Figure 10;

Figure 12 is a longitudinal sectional view of a forehearth or receptacle embodying a modified form of means for flowing a stream of molten material;

Figure 13 is a top plan view of a portion of the construction shown in Figure 12;

Figure 14 is a view similar to Figure 12 illustrating another form of orifice construction;

Figure 15 is an isometric view illustrating another form of fluid-cooled orifice plate;

Figure 16 is a plan view of an annularly shaped fluid-cooled orifice construction, and

Figure 17 is a sectional view taken substantially on the line **17—17** of Figure 16.

The method and apparatus of the invention are especially usable for flowing a stream of material which fuses at comparatively high temperatures, such for example as aluminum silicate, and other mineral materials such as compositions of glass or vitreous materials which may be softened or rendered molten or flowable at temperatures of 2800° Fahrenheit or more.

The apparatus of the present invention involves a control of the condition of the fused or molten material effective to avoid congealing or freezing of the material so as to assure continuity of flow of the material without interruptions otherwise necessary to remove congealed material from the orifice or flow passage constructions.

One form of apparatus utilizing the principles of the present invention in carrying out the method is illustrated in Figures 1 and 2. Figure 1 illustrates in longitudinal vertical section a forehearth **10** which is connected to or forms a part of a receptacle or melting furnace illustrated at **12**, the forehearth and furnace being provided with a suitable ceramic or refractory lining capable of withstanding the comparatively high temperatures of the molten material. The ceramic or refractory is not directly in contact with the molten material as the material adjacent the walls of the forehearth and furnace consists of solid unmelted batch or partially fused batch forming a protective coating for the surfaces. The forehearth may be provided with a cover member **14** through which electrodes **15** and **16** extend for the purpose of melting or aiding in melting the glass **20** contained in the furnace and forehearth. The cover member **14** may be formed with openings to accommodate additional electrodes **18** and **19** usable for controlling the temperature of the material at the discharge orifice or passage.

The forehearth or receptacle is formed with a block or member **21** fabricated or formed of material such as graphite capable of withstanding the temperature of the molten fiber-forming material. Secured to the block **21** is a member **25** formed of metal which may be of tubular or hollow formation through which may be circulated a cooling medium such as water, steam, air or other fluid suitable for the purpose. The member **25** is formed with a V-shaped configuration **27** to fit the similarly shaped upper surface of the block **21**, the apex of the V-shaped configuration forming a passage, channel or spout through which the molten material **20** from the receptacle is discharged in the form of a stream S which may be attenuated to fibers by a gaseous blast from a blast-producing means **22** or by other attenuating forces.

The member **25** may be provided with projecting lugs or extensions **28** adapted to receive lag bolts or other securing means for retaining the member **25** in fixed relation with respect to the member **21**. The member **25** may be connected by means of fittings **30** and **31** with fluid inlet and outlet tubes **32** and **33** for conveying or circulating the cooling medium through the hollow interior of the member.

The member **25** is preferably disposed above the block **21** in order to avoid direct contact of the molten material with the block **21** at the discharge zone so as to minimize the conduction of heat away from the molten material by or through the block **21**. The member **25** may be advantageously formed of metal and through the use of a cooling medium, the temperature of the passage or channel wall may be controlled and reduced below a temperature at which the molten material tends to adhere or cling to the metal surface as the material flows over the surface.

Heretofore a material-discharge passage or channel has been provided in a flow block formed of graphite and of substantial thickness. As the molten material moved through the channel in the graphite flow block, heat was conducted away from the stream at such a rapid rate as to cause an instant increase in the viscosity of the material with the result that the material congealed or froze in the passage thus obstructing or interrupting further flow or discharge through the passage. By means of the arrangement disclosed in Figures 1 and 2, the flowing stream substantially contacts only the metal of member **25** at the apex **27** and while the temperature of the metal member is maintained considerably below that of the molten stream, the stream moves over the molten member at a rapid rate so that there is insufficient time for substantial loss of heat from the stream and hence a continuity of stream flow is assured without liability of congealing or freezing of the stream.

Different metals may be employed for the member **25**, the metal selected being dependent in a large measure upon the characteristics of the material being handled and the temperature at which the molten stream is to be maintained. For example, cast iron or cold rolled steel may be utilized if cooled so as to maintain their temperatures at about 800° Fahrenheit to 1000° Fahrenheit. Stainless steels may be employed for fabricating the member **25** and such materials are capable of withstanding temperatures of from 2200° Fahrenheit to 2400° Fahrenheit. The flow block or member **25** may be made of metal alloys such as platinum rhodium or the like capable of use at temperatures of about 2800° Fahrenheit.

In practice, the member **25** may be cooled to a temperature considerably below its critical or melting temperature and even though the temperature differential between the molten material and the member **25** is comparatively large, the stream moves through the passage so rapidly that there is comparatively little heat loss and no appreciable change in viscosity. The temperature of the molten material at the discharge zone may be further controlled by the use of electric current flowing between electrodes 18 and 19 disposed in the forehearth 10 in proximity to the flow passage.

Figures 3 and 4 illustrate a flow block construction similar to that shown in Figures 1 and 2 in conjuction with a temperature-regulating electrode arrangement facilitating control of the flowability or viscosity of the material through the exercise of accurate control of the temperature of the molten material adjacent the flow passage. In this form of construction, the forehearth **10*a*** is provided with a member **25′** of a configuration similar to member **25** shown in Figure 2. The member **25′** is disposed adjacent and above the end wall **26** of the forehearth and is configurated with converging portions forming an apex **27′**, the latter providing a passage or channel through which the molten material is discharged in the form of a stream S. The member **25′** is cooled in the same manner as the member **25** shown in Figures 1 and 2.

It has been herein pointed out that in order to provide for a constant stream flow of material from the forehearth, it is imperative to control the viscosity or flowability of the material adjacent the discharge passage. In the form of apparatus shown in Figures 3 and 4 this may be accomplished by a special electrode arrangement. Disposed adjacent the discharge zone of the forehearth or receptacle is an electrode **34** of a dipolar construction with poles **35** and **36** thereof disposed in transverse spaced relation and projecting into the fusible material in the forehearth and in proximity to the flow block or member **25′**. Another electrode **37** which may be of a single-pole type projects into the fusible material and cooperates with the electrode **34**. Conductors **38** and **39** are connected to the respective electrodes to establish current flow thereto.

Through the dipolar electrode arrangement adjacent the discharge zone of the material in the forehearth, current passes through the fusible material from each of the poles **35** and **36** of the electrode **34** to the electrode **37** as indicated by the arrows in Figure 3. Through this arrangement the material in the zone between the poles **35** and **36** of the electrode **34** is maintained at a controlled temperature by regulating the current flow through the mtaerial. Temperature regulation may be effected by adjusting the distance between the poles **35** and **36** in the fusible material.

One form of adjustable support for the dipolar arrangement is illustrated in Figures 3 and 4. The poles **35** and **36** of the dipolar electrode arrangement **34** are respectively supported upon clips or brackets **38′**, each bracket being pivotally connected by a pin **39** to an element **40** slidably mounted in a guide portion **41** formed upon a supporting bar or member **42**. The pole-supporting element **40** may be slidably adjusted in the guide **41** by an adjusting screw **42′**.

Through an arrangement of this character, each of the poles **35** and **36** may be adjusted to a desired angle and immersed in the molten material to a proper depth. Under certain operating conditions, one of the poles may be disintegrated or burned away at a faster rate than the other and the above-described construction also affords a facile means of compensating for an irregularity of this nature.

By providing dual paths for current flow through the material from poles **35** and **36** of electrode **34** to the electrode **37**, the material at the zone **44** between the poles **35** and **36** adjacent the material-discharge passage **27′** may be held to a substantially constant temperature whereby the material in said zone will remain in a flowable condition. It may be that the material may freeze or congeal in the zones indicated at **43** between the side walls of the forehearth **10*a*** and the poles **35** and **36**, but the congealing of the material in these zones has no material effect upon the flowability of the material in the zone **44**. The temperature of the member **25′** is maintained sufficiently below the fusing temperature of the material by the circulation of a coolant through the member in order to eliminate the tendency of the flowing material to stick or adhere to the metal surfaces of the member **25′**.

Thus through an effective control of the temperature of molten material adjacent the discharge zone and the avoidance of appreciable conduction of heat from the material in the flow passage, a continuity of flow of the material from the forehearth is assured whereby efficient fiber-forming operations may be carried on without interruption.

Figure 5 illustrates a modified arrangement of apparatus for maintaining a material of high fusing temperature in a molten or flowable state. In this form the forehearth or receptacle **10*a*** is formed with a flow block **45** as an end wall of the receptacle and having a V-shaped passage or channel at **46** through which the molten material flows or is discharged. Disposed between the flow block **45** and the forehearth **10*a*** is a layer of electrical insulating material **47** which may be of a suitable ceramic or vitreous material having noncurrent-conducting characteristics so as to insulate the block **45** from the receptacle. A composition of clay, asbestos and sodium silicate has been found suitable for the purpose.

In this form of the invention the block **45** may be fabricated of compressed graphite, granular carbon or other current-conducting materials that are resistant to the corrosive action of the molten material. The block **45** is connected by means of a current conductor **48** with a source of electrical energy, the graphite block **45** forming an electrode. Another electrode **49** extends into the glass, aluminum silicate or other material in the forehearth and is spaced from the end wall or electrode block **45** so that current flows between the electrodes **45** and **49** through the molten glass.

By reason of the current flow between the electrodes **45** and **49**, the material in the forehearth is maintained well above the fusing temperature through the heat generated by the resistance to the passage of the current through the material. As the flow block **45** also serves as an electrode in the arrangement shown in Figure 5, the graphite block is heated to a high temperature and hence there is substantially no transfer of heat from the molten material to the electrode-flow block **45** and the molten material may flow in a continuous stream through the passage in the block **45** without interruption or obstruction, such as might be caused by congealing or freezing of the material in the passage.

Figures 6 and 7 illustrate another form of flow block or means for discharging molten material from a receptacle. In this form the flow block or member **50** is secured to an end of a forehearth **10*b*** by securing bolts **52** passing through openings formed in lugs **53** extending from the member **50**. The member **50** is formed with converging walls **54** joining vertical wall portions **55** which are connected by an arcuate portion **56**. The vertical walls **55** and the arcuate or semicylindrical wall **56** form a passage or channel **57** through which molten material may flow from the forehearth **10*b***.

The member **50** is of hollow configuration providing a chamber or duct **58**, the member **50** being provided with inlet and outlet tubes or pipes **60** and **61** in communication with the chamber **58** to convey fluid such as water, air or other suitable heat-absorbing and conducting medium into and away from chamber **58**. The member **50** forming a flow block may be made of any of the metals hereinbefore mentioned, the choice of metal being dependent upon the temperature at which the glass, aluminum silicate or other mineral material is delivered through the flow passage **57** formed by the walls **55** and **56**.

The member **50** may be utilized as an electrode in the manner hereinbefore described in respect of the form of construction shown in Figure 5 for controlling the temperature of the material to maintain the same in a flowable or molten state so that the material at the time of its delivery to a fiber-forming zone is at a viscosity suitable for forming fibers. An extension **63** may be formed on the member to which a terminal of a current conductor may be secured for conducting current to the member **50**. As the temperature of the flow block or member **50** is reduced by the cooling medium in the chamber **53** below a point at which the molten fiber-forming material will stick or adhere to the member, the molten material readily flows through the orifice or passage **57** and freezing or congealing of fiber-forming material in the passage is substantially eliminated.

Figures 8 and 9 illustrate another form of flow block construction. In this form of the invention, the flow block **65** is fashioned with a V-shaped configuration, the walls **67** converging at **68**, the apex and adjacent converging wall portions presenting a trough-like passage through which molten material may flow from a forehearth. This construction of flow block is made of metal and is formed with a chamber **70** through which a cooling fluid may be circulated through inlet and outlet pipes **72** and **73**.

When it is desired to utilize the flow block **65** as one electrode of an arrangement for heating and controlling the temperature of molten fiber-forming material in the forehearth or receptacle, the flow block may be provided with projections or terminal plates **75** to one or both of which may be secured suitable current conductors. It is to be understood that when the member **65** is utilized as an electrode, one or more additional electrodes are immersed in the molten material in the forehearth. The resistance offered by the material in the forehearth to the passage of current heats the material, and by regulating the current or the spacing of the electrodes, an effective control may be exercised over the temperature and viscosity of the material.

Figures 10 and 11 illustrate another form of orifice or flow block construction fashioned of metal. As illustrated, the flow block is of substantially rectangular shape provided at its upper central zone with downwardly extending, converging walls **81** forming a V-shaped trough or channel **82** through which molten material may flow from a forehearth. The flow block is of hollow configuration providing a chamber **84** through which a cooling medium may be circulated through inlet and outlet pipes **85** and **86**.

One wall of the flow block is formed with a pouring or material-discharging lip **88** to facilitate a smooth flow of molten material from the forehearth, the upper zone of the pouring lip being curved in the manner indicated at **89** in Figure 11, the lip serving to accurately direct the path of the stream to fiber-forming forces. Projections **91** may be provided for securing the orifice or flow block construction to the end of a forehearth. Welded or otherwise secured to the orifice construction is a terminal plate **93** which is adapted to be connected with a current conductor when it is desired to utilize the flow block as an electrode of a material-heating system or arrangement of the character shown in Figure 5.

The lip or spout portion **88** is of thin-walled construction to accommodate the flow of cooling medium in the proximity of the spout surface in order to reduce the temperature of the portions of the flow block engaged by the stream of molten material so as to prevent the molten material from sticking to the surfaces of the passage and thus eliminating freezing or congealing of material in the passage.

Figure 12 illustrates another arrangement for flowing high temperature fusing material from a receptacle or forehearth. In this arrangement the forehearth **100** is provided with a floor or bottom wall **102** having an opening formed therein to receive a member or flow block

104 provided with a suitable orifice or pasasge **105** through which molten material may flow in the form of a stream S. The member **104** may be advantageously shaped of circular configuration and is formed with a chamber **106** to facilitate the circulation of fluid for cooling the member.

The cooling fluid may be conducted to and away from the chamber **106** through inlet and outlet pipes **108** and **109**. It should be noted that the vertical dimension of wall **110** bounding or defining the passage **105** is very short and the portions of the member **111** and **112** adjacent the bounding wall **110** are curved and extend away from the wall **110** both above and below the passage as portrayed in Figure 12.

Such construction provides for a substantially large chamber **106** to accommodate an adequate quantity of cooling fluid and provides a flow passage or orifice, the wall of which is comparatively short so that a minimum of surface contact of the molten material with the wall of the passage is obtained. It has been found that the molten material, under certain temperature conditions and due to the conduction of heat by the cooling fluid, may tend to congeal in the zones indicated at **114**. However, the comparatively rapid flow of the stream S away from the supply in the forehearth through the passage does not result in any appreciable cooling of the stream, and hence the liability of the material to freeze or congeal in the passage **105** or above the passage is substantially eliminated thereby assuring a smooth, continuous flow of fiber-forming material from the forehearth.

In some installations it may be desirable to employ the metal member or flow block **104** as an electrode for establishing current flow through the molten material in the forehearth to one or more electrodes **116** projecting into the material in the forehearth. When this method of heating and controlling the temperature of the material is employed, a connecting block or terminal **118** may be welded or otherwise secured to the member **104** to which a current-conducting member **120** may be connected in utilizing member **104** as an electrode.

The temperature of the fusible material in the forehearth may be controlled by an electrode arrangement of the character shown in Figures 3 and 4. The electrode construction in proximity to the end wall of the forehearth preferably includes a dipolar arrangement having poles **124** and **125** spaced apart as illustrated in Figure 13. The other electrode **130** for completing a current path through the material may be disposed in the position shown in Figure 13, the two paths of current flow from the poles **124** and **125** and the electrode **130** being indicated by arrows. By means of the electrode arrangement, the zone **132** of the material in the forehearth adjacent or immediately above the orifice or passage **105** may be heated to the temperature required to maintain the fusible material at a desired viscosity to insure the flow of molten material through the orifice and avoid or eliminate congealing of the material adjacent or in the orifice.

The fusible material, under certain conditions, may have a tendency to congeal at zones **114** spaced from the orifice, but the congealed material is out of the path of flow of the material from the zone **132** and, hence, such congealed material does not interfere with a continuous flow of material through the orifice.

The metal orifice member **104** may be employed as an electrode and for this purpose is provided with a projection **118** to which a current conductor **120** may be connected. When the orifice member is used as one electrode, the current flow through the fusible material may be between the member **104** and the electrode **130**. If desired, the poles **124** and **125** of the dipolar electrode may be connected directly to electrode **130** to facilitate current flow from member **104** to poles **124, 125** and electrode **130**.

Figure 14 illustrates another form of orifice or passage construction providing a means for flowing a stream of fusible material from a supply. In this form, the floor 102' of a forehearth or receptacle is formed with an opening in which is disposed a member or flow block 140. The member 140 is shaped to provide a flow orifice or passage 142. At the upper portion of member 140 the walls 143 extend upwardly so that the entrance to the passage 142 is above the floor surface 102' of the forehearth.

The member 140 is preferably of annular configuration and of hollow construction providing an annular chamber 145 through which a coolant fluid or medium may be circulated, the fluid being conveyed to and from the chamber through inlet and outlet pipes 147 and 148. It should be noted that the passage wall which is determinative of the size of the material stream is comparatively short to minimize the area of contact with the material and hence avoid excessive cooling of the stream. The interior wall portion 149 of the member 140 is flared outwardly and downwardly as illustrated to eliminate contact of this portion of the member with the stream of molten material.

An effective control of the temperature and hence the viscosity or flowability of the material may be had through the use of an electrode arrangement of the character shown in Figures 3 and 12 comprising electrodes 150 and 151. The electrode 151 may be of dipolar construction similar to the electrode 34 illustrated in Figure 3, while the electrode 150 may be of the single pole type.

As shown in Figure 14, the electrodes are disposed in the receptacle in relation to the orifice 142 so that the temperature of the material in the zone immediately adjacent the orifice may be controlled so that the material is maintained in flowable condition for discharge through the orifice. Through this method, the material may be maintained at a requisite high temperature so that heat that may be transferred from the moving material to the wall of the orifice 142 is insufficient to raise the viscosity of the material to a point at which it tends to congeal or freeze to the walls of the orifice. During the operation of the apparatus some of the material may congeal or freeze in the zones indicated at 154 and 155, but such congealed material does not interrupt or obstruct free flow of the molten material through the passage or orifice.

The orifice member 140 may be utilized as an electrode in the same manner illustrated in the arrangement shown in Figure 12. Thus the orifice member may be provided with a metallic terminal or projection 157 to which a current conductor 158 may be connected. Other electrodes may be disposed within the forehearth or receptacle adapted for cooperation with the orifice member 140 so that electric current may be caused to flow in paths adjacent the orifice plate or flow block so as to maintain the material adjacent the orifice member in a flowable state.

The orifice member being formed of metal may be cooled below a temperature at which the molten material will tend to cling or adhere to the metal. As the molten material is in contact with the orifice wall for a relatively short distance, the temperature of the molten material is not reduced through conduction of heat to the walls of the orifice to a point at which the material tends to congeal or freeze in the orifice or passage.

Figure 15 illustrates another form of orifice plate or flow block adapted to fit into an opening in the floor of a forehearth. The plate 160 is formed with an orifice or passage 162 through which molten material may flow from the forehearth. Means is provided for maintaining the temperature of the plate 160 sufficiently low to prevent the molten material from wetting and adhering to the plate. As illustrated, members 164 and 165 are arranged at each side of the orifice 162 and are in heat-transferring or conducting relation with the plate 160, each of the members being of hollow configuration to form fluid-receiving chambers.

The chambers formed in members 164 and 165 are respectively provided with inlet and outlet pipes 167 and 168 connected to adjacent ends of the chambers while the opposite ends are connected together by means of a tube or pipe 169. Through this arrangement a coolant or temperature-control fluid may be circulated through the chambers 164 and 165 to conduct heat away from and thus regulate and control the temperature of the orifice plate 160. The plate 160 and the chambers 164 and 165 may be formed of metal, and through the use of a coolant or cooling medium circulating through the chambers, the temperature of the zones of the plate adjacent the orifice is reduced below the point at which the molten material will cling or adhere to the surface defining the orifice 162. The arrangement shown in Figure 15 may be embodied in the forehearth construction illustrated in association with other forms of the invention and the material in the forehearth may be heated by one of the arrangements disclosed herein. Gases or liquids, as, for example, water, steam, air or any suitable heat-absorptive fluid, may be used as cooling mediums for circulation through chambers 164 and 165.

Figures 16 and 17 illustrate still another form of orifice or flow block construction for flowing a stream of material having a high fusing temperature from a receptacle or forehearth. In this form of construction, an annular member 175 is shaped to provide an interior circular wall 176 forming or defining an orifice or passage 177 through which the molten material may be discharged. The member 175 is formed with an annularly shaped chamber 180, the latter being in communication with inlet and outlet pipes 181 and 182 which may be disposed in close relation as shown in Figure 16. In order to insure a satisfactory circulation of cooling fluid through the chamber 180, a baffle plate or abutment 184 may be disposed in the chamber 180 in the position shown in Figure 16. The baffle serves the purpose of directing the flow of cooling fluid in one direction through the chamber 180 in order to control the temperature of the orifice or passage wall 176. It is to be understood that the member 175 may be formed of metal and the temperature thereof reduced sufficiently through the circulation of cooling fluid through the chamber 180 to avoid or substantially eliminate the tendency of the molten material to adhere to the wall 176 of the passage.

In carrying out the method of the invention through the novel forms of apparatus disclosed herein, it will be apparent that an effective control may be had of the temperature of the wall of a passage or orifice. The method of heating the material adjacent the orifice or passage provides a control of the temperature of the material assuring a continuous flow of molten material. The utilization of the method and apparatus for handling such material is particularly advantageous in feeding or flowing the material to a fiber-forming station as interruptions of the process or operation are avoided through the elimination of conditions fostering a freezing or congealing of the material in the passage or orifice of a flow block. Thus a continuous stream of molten material of a controlled viscosity may be delivered from a receptacle or forehearth through the use of the method and apparatus of this invention for carrying on continuous fiber-forming processes or for other purposes.

It is apparent that, within the scope of the invention, modifications and different arrangements may be made other than is herein disclosed, and the present disclosure is illustrative merely, the invention comprehending all variations thereof.

What I claim is:

1. Apparatus for handling material having a high fusing temperature including, in combination, a melting furnace adapted to contain the material; said furnace being formed with a forehearth; a member formed of metal associated with said forehearth formed with a passage through which molten material may be discharged from the forehearth; means for passing an elec-

tric current between the member and an electrode immersed in the material for maintaining the material in the forehearth adjacent the passage in a flowable state, said member having a chamber formed therein adapted to receive a cooling fluid for maintaining the wall of the passage at a temperature below that of the molten material.

2. Apparatus of the character disclosed, in combination, a forehearth adapted to contain a supply of molten mineral material; a flow block supported by the forehearth provided with a passage through which molten material may flow from the forehearth; said flow block being formed with a chamber adapted to receive a coolant fluid for maintaining the temperature of the portion of the flow block defining the passage at a lower temperature than that of the molten material; an electrode extending into the material in the forehearth, and means for establishing flow of electric current between the flow block and the electrode for maintaining the material adjacent the passage in a flowable condition.

3. In an apparatus of the character disclosed, in combination, a receptacle adapted to contain molten material fusible at comparatively high temperatures; a flow block associated with a wall of the receptacle; said flow block being of hollow configuration to receive coolant fluid for circulation through the flow block; said flow block being formed with converging walls providing a V-shaped channel through which the material may flow in a stream from the receptacle; and means for passing an electric current through said flow block and the material adjacent thereto for maintaining the material in the receptacle adjacent the channel in a flowable state.

4. Apparatus of the character disclosed, in combination, a furnace adapted to contain material having a high fusing temperature and critical viscosity characteristics, a pair of electrodes extending into the furnace, means for flowing electrical energy between the electrodes and through the material in the furnace to render the material molten, a forehearth extending from the furnace and adapted to receive molten material from the furnace, a flow block supported by the forehearth provided with a passage through which the molten material is discharged from the forehearth, said flow block being formed with a chamber adapted to receive a coolant fluid for maintaining the temperature of the portion of the flow block defining the passage at a lower temperature than that of the molten material, an electrode extending into the molten material in the forehearth, and means for establishing flow of electrical energy between the flow block and the electrode in the forehearth for maintaining the material adjacent the discharge passage in a flowable state.

5. Apparatus of the character disclosed, in combination, a furnace adapted to contain material having a high fusing temperature and critical viscosity characteristics, a pair of electrodes extending into the furnace, means for flowing electrical energy between the electrodes and through the material in the furnace to render the material molten, a forehearth extending from the furnace and adapted to receive molten material from the furnace, a flow block supported by the forehearth formed with converging walls providing a V-shaped passage through which the molten material is discharged from the forehearth, said flow block being formed with a chamber adapted to receive a coolant fluid for maintaining the temperature of the portion of the flow block defining the passage at a lower temperature than that of the molten material, an electrode extending into the molten material in the forehearth and means for establishing flow of electrical energy between the flow block and the electrode in the forehearth for maintaining the material adjacent the discharge passage in a flowable state.

6. The method of handling material having a high fusing temperature and critical viscosity characteristics including melting the material in a furnace by flowing electrical energy through the material in the furnace, flowing the molten material into a forehearth and through a passage in the wall of the forehearth, flowing electrical energy from the wall of the passage through the material in the forehearth adjacent the passage, and circulating a fluid through a chamber formed in the wall of the passage for maintaining the passage wall within a temperature range facilitating flow of the material at a viscosity to avoid congealing of the material in the passage.

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