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(54) **MANUFACTURING APPARATUS AND METHOD FOR PRODUCING A PREFORM**

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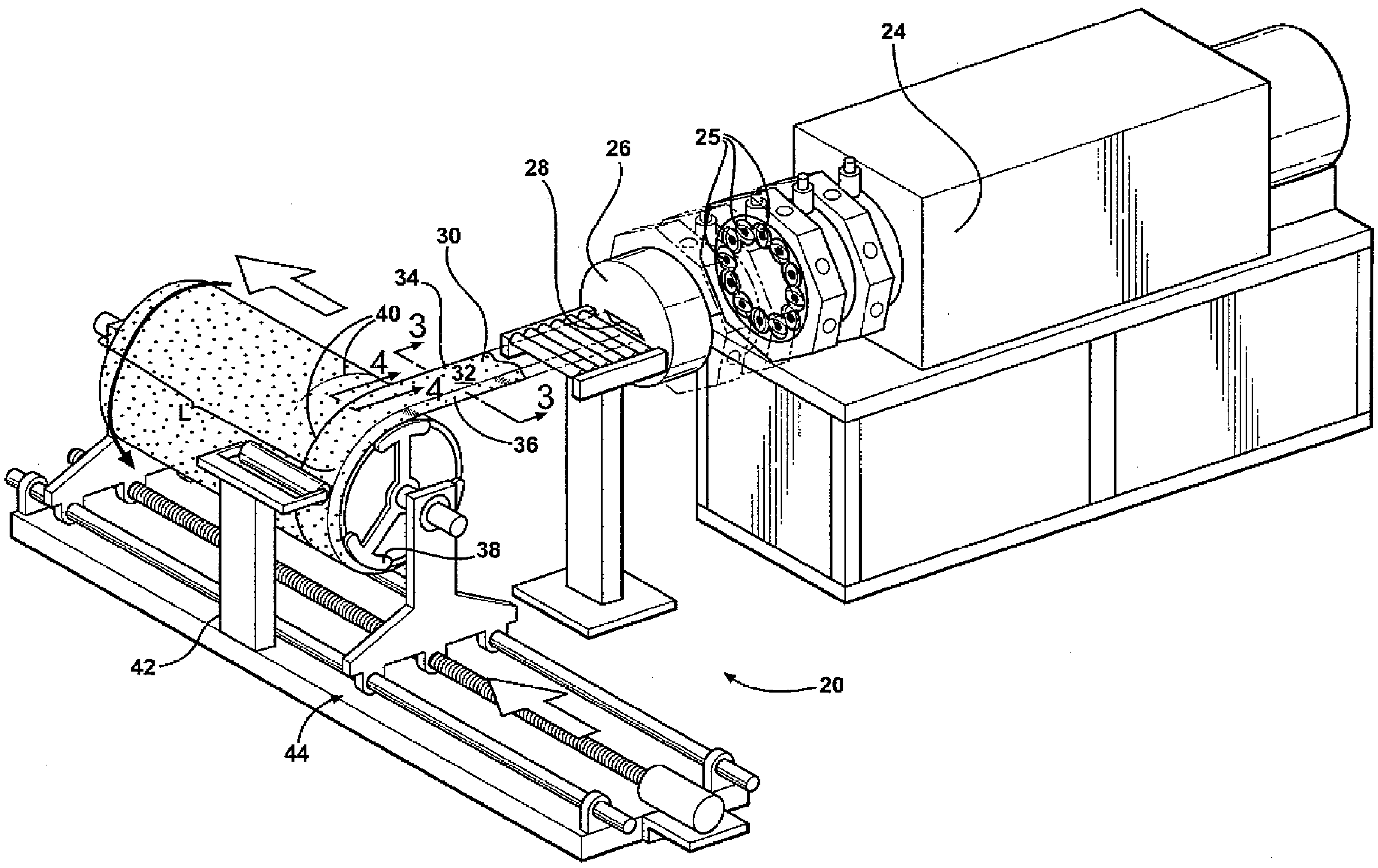
(57) **ABSTRACT**

The present invention relates to a method of forming a preform from a material having a first edge and a second edge utilizing a mandrel. The method comprises the step of extruding the material through an extruder to form an extrudate. The first edge of the extrudate has a configuration complementary to a configuration of the second edge of the extrudate. The method also includes wrapping the material around the mandrel by abutting the first edge and the second edge to form a spiral joint.

The invention uses a manufacturing apparatus comprising a multi-screw extruder having at least three intermeshing screws for forming the extrudate. The mandrel receives the extrudate and a pressure-applying device adjacent to the mandrel engages the extrudate and applies pressure to the spiral joint to create a smooth exterior surface of the extrudate and to define the preform.



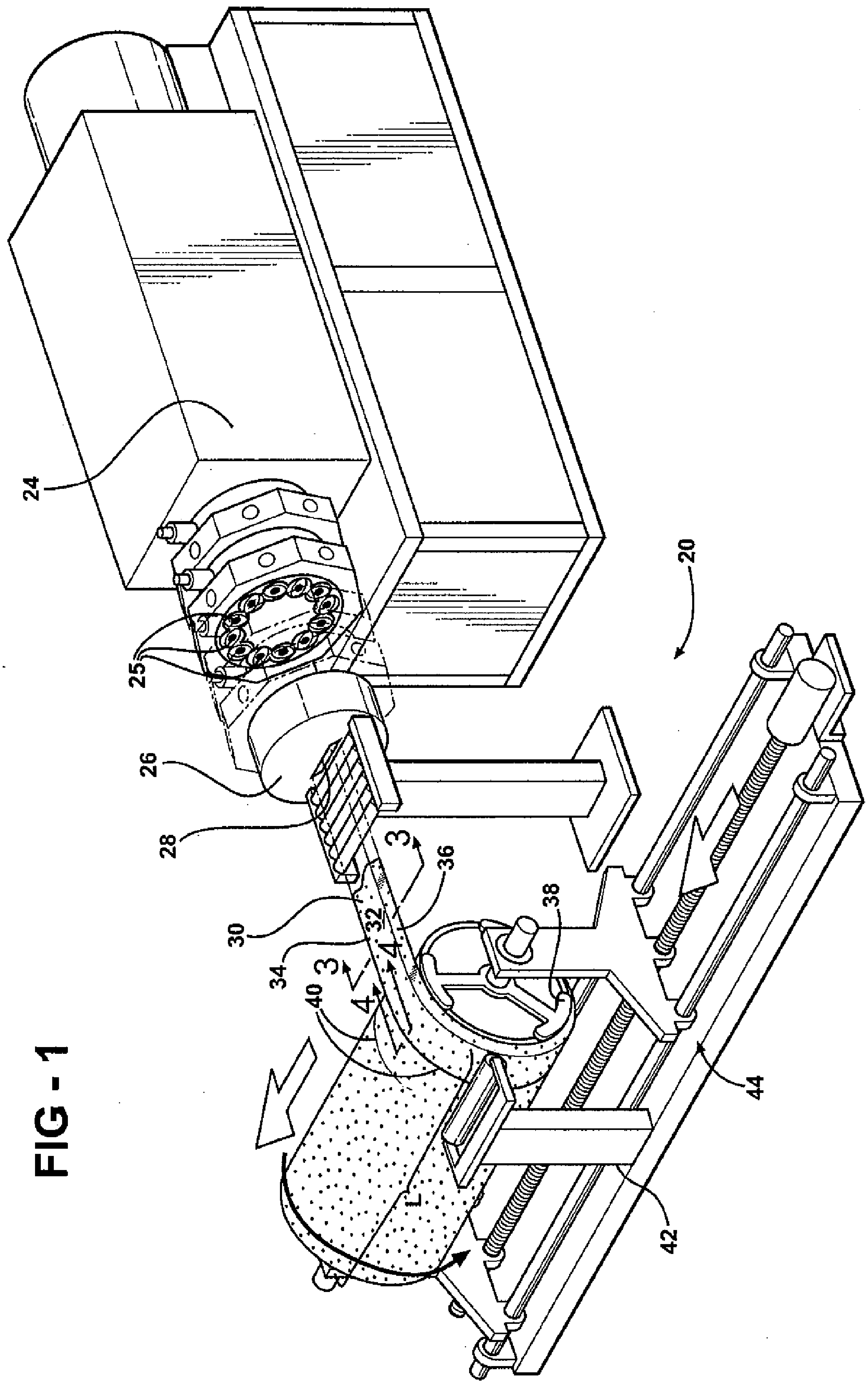


FIG - 1

FIG - 2

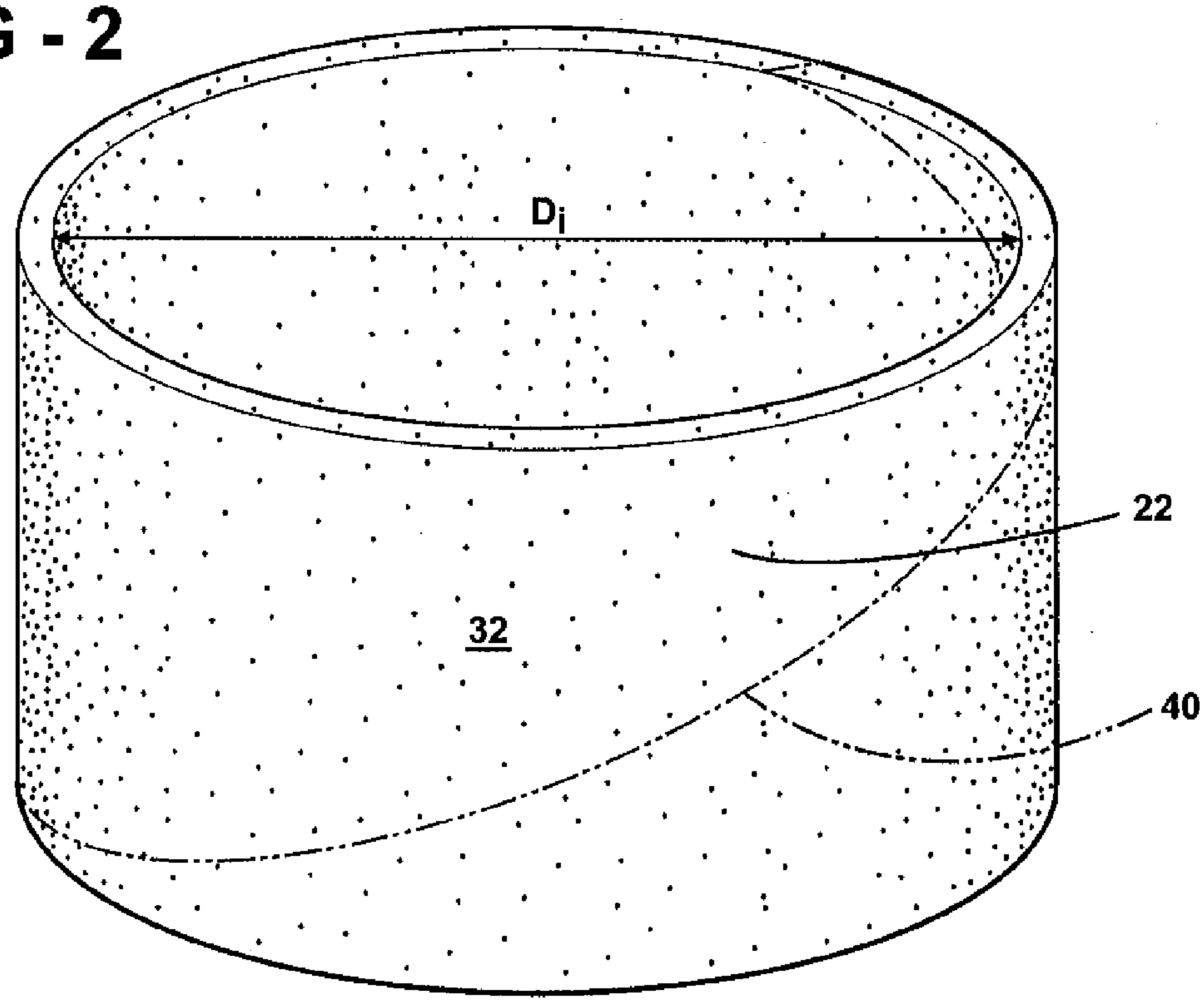


FIG - 3

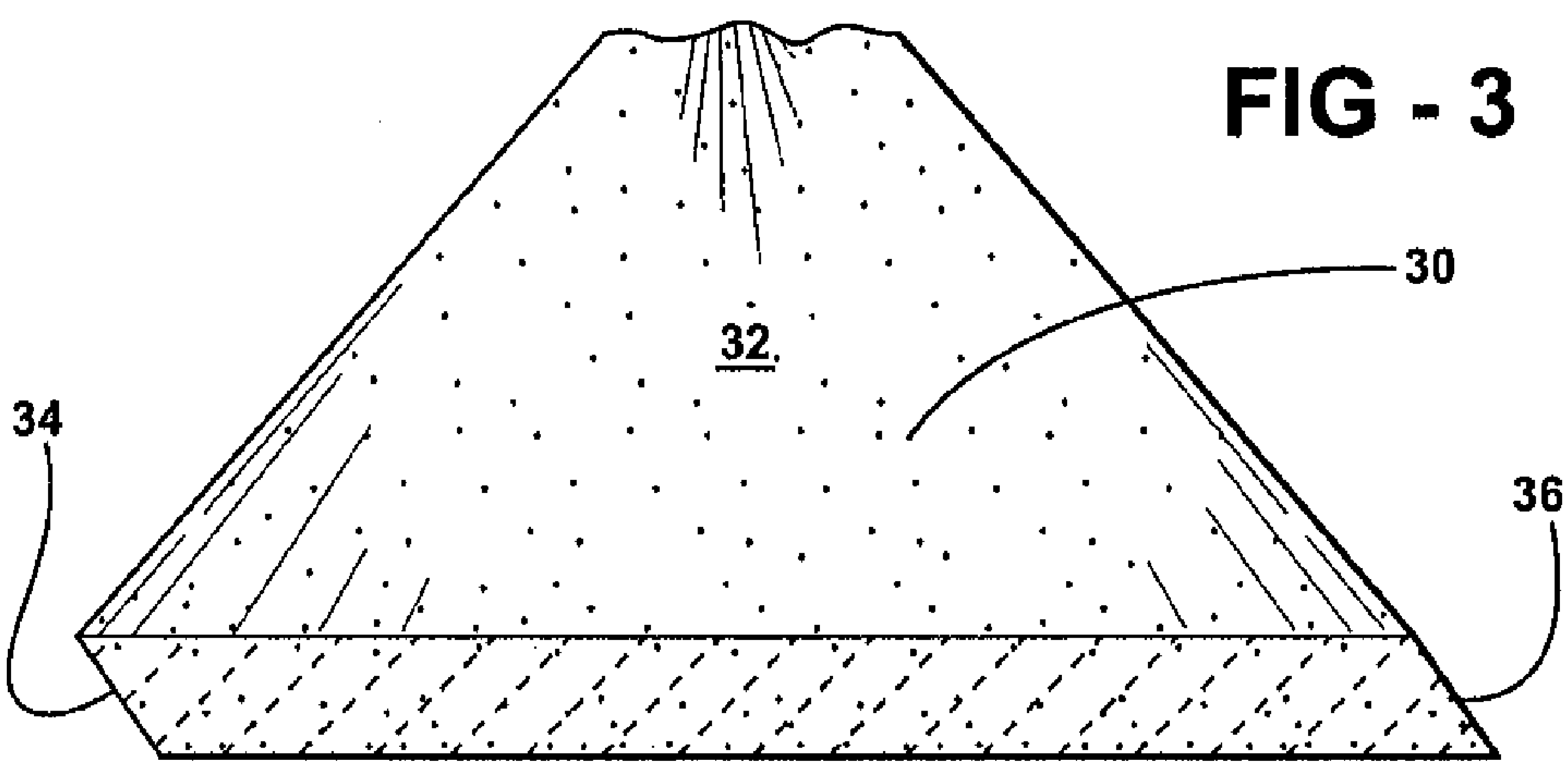


FIG - 4

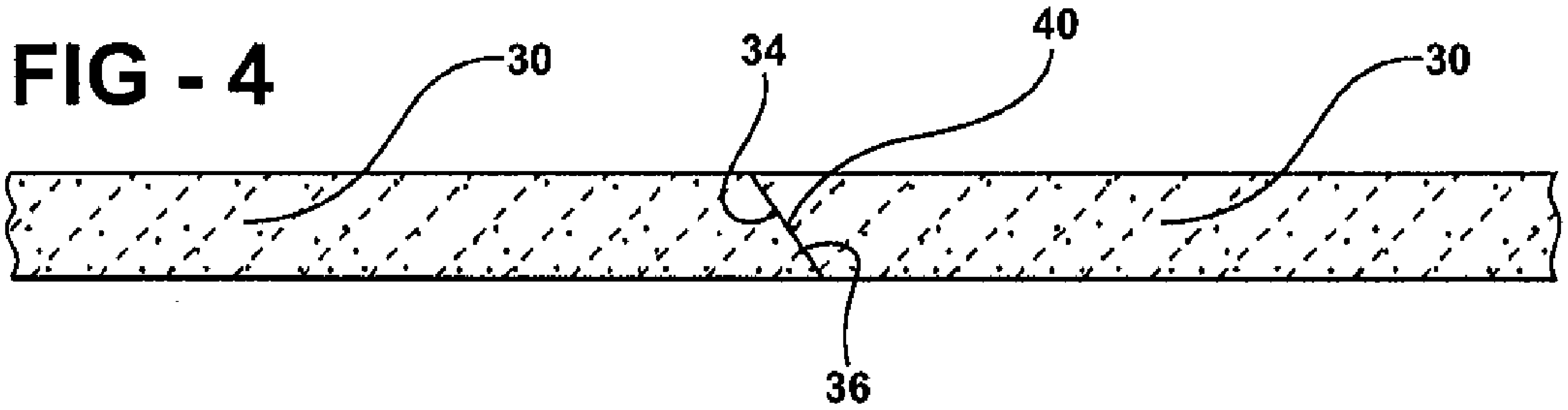


FIG - 5

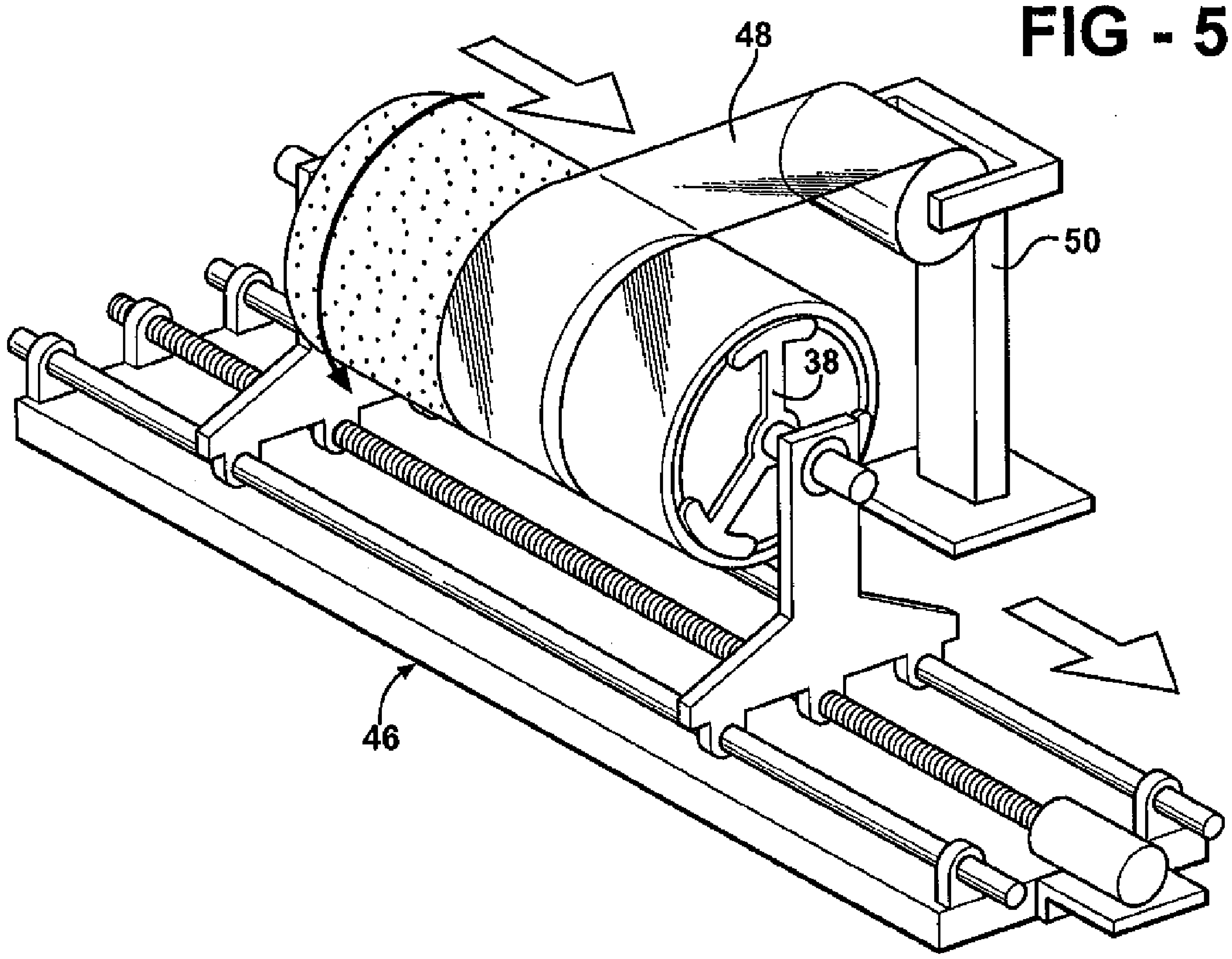
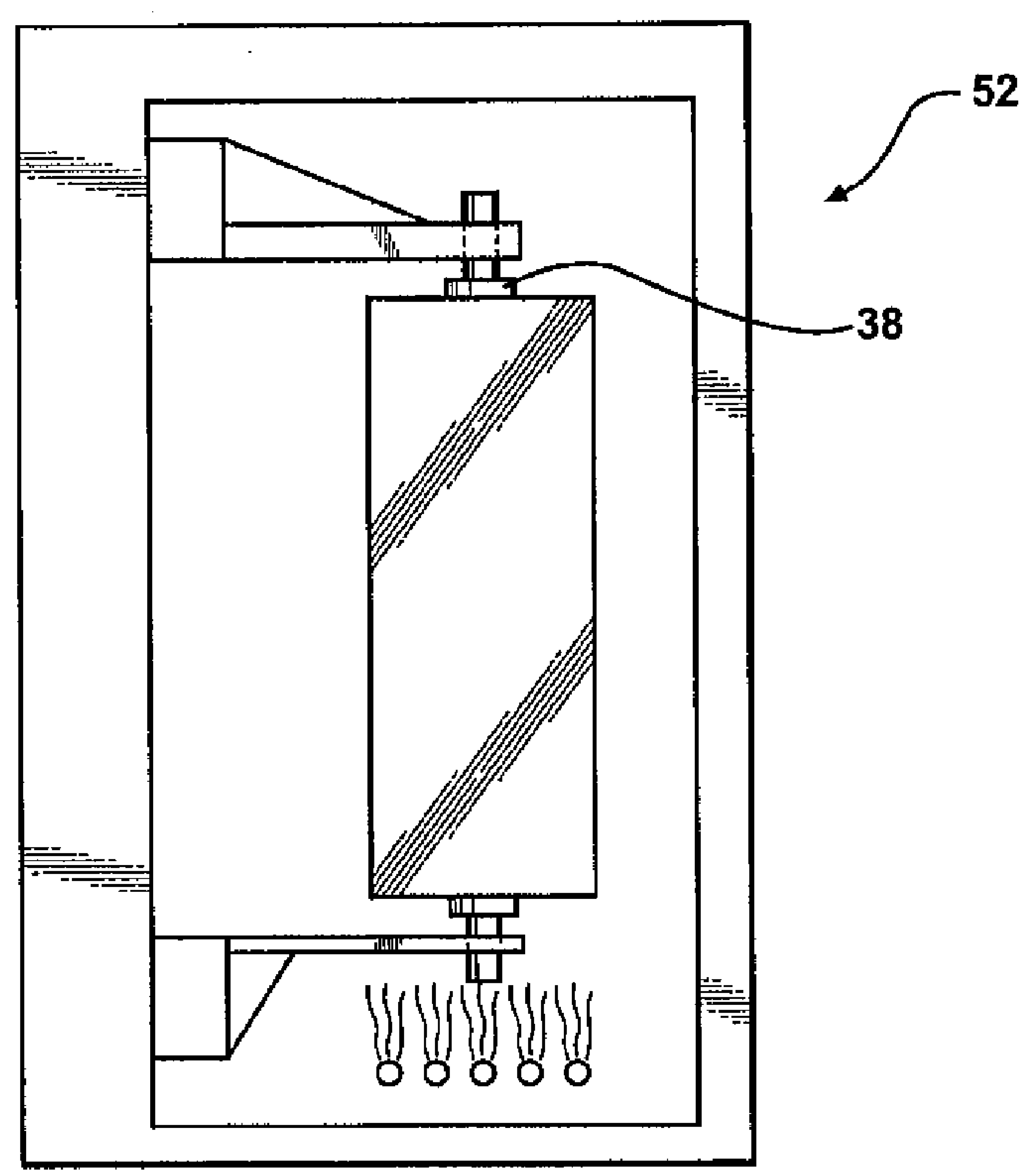


FIG - 6



MANUFACTURING APPARATUS AND METHOD FOR PRODUCING A PREFORM

RELATED APPLICATIONS

[0001] This application claims priority to and all advantages of U.S. Provisional Patent Application No. 61/132,281, which was filed on Jun. 17, 2008.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a manufacturing apparatus and a method of producing a preform.

[0004] 2. Description of the Related Art

[0005] Manufacturing preforms, such as ceramic preforms, are known in the industry. However, the current methods of manufacturing ceramic preforms are accomplished through a manual batch mixing process and then a manual formation of the design configuration. Traditionally, preforms in the shape of a cylinder are hand formed from a material. A metal wire is disposed about the preform for strengthening the preform. More specifically, the material used for the production of preforms does not meet the strength requirements for the final preform. As such, the metal wire is required to add strength to the final preform. A preform having the metal wire as discussed above is disclosed in U.S. Pat. No. 6,530,458.

[0006] During the manual forming process, the material is generally rolled out onto a flat surface. The material has a first edge and a second edge. The first edge and the second edge are abutted to form the cylinder configuration of the preform. Several different joint concepts have been attempted including butt joints, dovetail joints and several variations of these concepts. However, these joint types are weak and tend to separate during subsequent processing of the preform. Further, these joint types are complicated and unlikely to be formed in an automation process.

[0007] Therefore, there exists a need for a joint that is strong enough not to separate during processing and that is efficient to manufacture thereby allowing for the automation of the process to decrease production time and production costs.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0008] The present invention relates to a manufacturing apparatus for producing a preform. In one embodiment, the manufacturing apparatus comprises a multi-screw extruder having at least three intermeshing screws for producing an extrudate. The extrudate has a first edge and a second edge. The manufacturing apparatus also includes a mandrel for receiving the extrudate by wrapping the extrudate around the mandrel to form a spiral joint by overlapping and abutting the first edge with the second edge. The manufacturing apparatus further includes a pressure-applying device adjacent to the mandrel for engaging the extrudate and applying pressure to the spiral to level an exterior surface of the extrudate and to define the preform.

[0009] The present invention also includes a method of forming the preform from the material utilizing the mandrel. The method comprises the step of forming the first edge and the second edge of the material with the first edge having a configuration complementary to a configuration of the second edge. The method also includes the steps of wrapping the material around the mandrel and abutting the first edge and the second edge to define a spiral joint. Pressure is applied to the spiral joint to level the exterior surface of the material and to define the preform.

[0010] In another embodiment of the method, the preform comprises ceramic particles and ceramic fibers with an aspect ratio of greater than 3:1 and the ceramic fibers substantially randomly orientated in three dimensions. The method can also include the step of extruding the ceramic particles and the ceramic fibers through the extruder to form the extrudate having the first and second edges.

[0011] The spiral joint, and the manner in which the preform is manufactured, creates a consistently strong joint that does not separate during subsequent processing of the preform. The spiral joint eliminates any sharp discontinuities that may arise due to a gap in the preform. Additionally, utilization of the spiral joint lends itself to an automated production setting thereby decreasing production time and increasing efficiencies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0013] FIG. **1** is a perspective view of a manufacturing apparatus for producing a preform in accordance with the subject invention;

[0014] FIG. **2** is a perspective view of a preform;

[0015] FIG. **3** is a cross-sectional perspective view of an extrudate having a first edge and a second edge;

[0016] FIG. **4** is a cross-sectional side view of the extrudate with the first edge and the second edge abutting each other;

[0017] FIG. **5** is a perspective view of a wrapping device; and

[0018] FIG. **6** is a schematic side view of an oven.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a manufacturing apparatus **20** for producing a ceramic article or preform **22** from a material (not shown) is generally shown in FIG. **1**. The preform **22** has a width and a final configuration defining an internal diameter Di as shown in FIG. **2**.

[0020] The manufacturing apparatus **20** includes a multi-screw extruder **24** for processing the material and producing an extrudate **30**. The material preferably includes ceramic particles and ceramic fibers with an aspect ratio of greater than 3:1 with the ceramic fibers being substantially randomly orientated in three dimensions. However, it is to be appreciated that the material can be manufactured from components other than ceramic particles and ceramic fibers without deviating from the broadest scope of the subject invention.

[0021] The multi-screw extruder **24** preferably has at least three intermeshing screws **25**. The at least three intermeshing screws **25** are typically arranged in a fixed ring configuration and are typically geared to a common motor. The screws **25** also typically rotate at a common speed as is known in the industry. The at least three intermeshing screws **25** may be co-rotating or counter-rotating. The multi-screw extruder **24** typically has a modular design and comprises solid barrels and/or combination barrels. The combination barrels typically include ports for injecting components or for venting volatile gases. One skilled in the art typically selects a combination of solid barrels and combination barrels to provide desired mixing characteristics of the multi-screw extruder **24** and desired physical properties of the extrudate **30**.

[0022] The multi-screw extruder **24** may also include flow blocking flights for providing separate mixing processes in the multi-screw extruder **24**. The flow blocking flights may be flighted, and typically impede passing of the material between sections of the multi-screw extruder **24**. It is to be appreciated that certain flow blocking flights can be removed for increasing the feeding capability of the multi-screw extruder **24**.

[0023] The multi-screw extruder **24** typically has about 2 to 8 mixing zones and more typically about 4 to 6 mixing zones. The multi-screw extruder **24** also typically has an L/D ratio of about 18 to 56, and more typically of about 20 to 44. A suitable multi-screw extruder **24** is the 3+ RingExtruder commercially available from Century, Inc. of Traverse City, Mich.

[0024] The process of forming or extruding the extrudate **30** may be further defined as rotating the at least three intermeshing screws **25** at about 20 to 1,200 rpm and more typically about 100 to 400 rpm. As the at least three intermeshing screws **25** rotate, the material is conveyed, mixed, and advanced through the multi-screw extruder **24** until the material exits the multi-screw extruder **24**.

[0025] The multi-screw extruder **24** typically elongates and shears the material to provide distributive and dispersive mixing to both substantially randomly orient the ceramic fibers in three dimensions and substantially homogeneously distribute dispersed ceramic fiber. The step of extruding typically includes arranging adjacent ceramic fibers in different dimensions so that adjacent ceramic fibers arranged in different dimensions are present in the extrudate **30** in an amount of greater than 85 parts by volume based on 100 parts by volume of the extrudate **30**. That is, the multi-screw extruder **24** typically provides excellent elongational and low-intensity shear mixing that results in adjacent ceramic fibers oriented in different dimensions in the extrudate **30**.

[0026] The multi-screw extruder **24** typically also mixes an organic binder into the material. The organic binder typically comprises a cellulose ether. The cellulose ether typically exhibits reverse thermal gelation and provides lubricity during formation of the preform **22**. Without intending to be limited by theory, it is believed that the cellulose ether also typically provides surface activity, plasticity, uniform rheology, strength, and uniform distribution of air during formation of the preform **22**. The cellulose ether is typically selected from the group of methyl cellulose, hydroxypropylmethylcellulose, hydroxybutylmethylcellulose, and combinations thereof. A suitable methyl cellulose is hydroxypropylmethylcellulose, commercially available under the trade name Methocel™ A4M from The Dow Chemical Company of Midland, Mich. The specific features and characteristics of the material are set forth in copending U.S. patent application Ser. No. ______, filed concurrently herewith (H&H Docket No. 65109.038).

[0027] The multi-screw extruder **24** typically also mixes a filler into the material. One skilled in the art typically selects the filler to control the density of the extrudate **30**. That is, the filler is typically included in the material according to the weight percent of ceramic particles and ceramic fibers in the material. The filler typically spaces out the ceramic particles and ceramic fibers to provide the extrudate **30** and the preform **22** with desired density and to allow effective metal infiltration during any secondary processing of the preform **22**, such as infiltrating the preform **22** with a metal. The filler may be any filler known in the art. The filler is typically selected to burn off during heating of the extrudate **30**. The filler is typically selected from walnut shell flour, cellulose fiber, air, and combinations thereof.

[0028] A suitable filler is walnut shell flour, commercially available under from Ecoshell of Corning, Calif. The specific features and characteristics of the material are set forth in copending U.S. patent application Ser. No. ______, filed concurrently herewith (H&H Docket No. 65109.038).

[0029] The multi-screw extruder **24** typically also mixes an inorganic binder into the material. The inorganic binder is typically silica. Without intending to be limited by theory, it is believed that the inorganic binder provides the preform **22** with strength. A suitable inorganic binder is silica, commercially available under the trade name Bindzil 1440 Colloidal Silica from Wesbond Corporation of Wilmington, Del. The specific features and characteristics of the material are set forth in copending U.S. patent application Ser. No. ______, filed concurrently herewith (H&H Docket No. 65109.038).

[0030] A die **26** is disposed on the multi-screw extruder **24** for forming the material as the material exits the multi-screw extruder **24**. The die **26** defines a bore **28** through the die **26** for allowing the material to pass through the die **26**. The material is forced through the bore **28** of the die **26** by the multi-screw extruder **24**. The material defines the extrudate **30** once the material has been processed by the multi-screw extruder **24** and has been shaped by the die **26**. It is to be appreciated that the material may be formed either manually or automatically without deviating from the subject invention. It is to be further appreciated that the manufacturing apparatus **20** may forego the multi-screw extruder **24** and the material may be mixed and formed by other methods known in the art, such as by manual processing, without deviating from the broadest scope of the subject invention.

[0031] Referring to FIGS. **3** and **4**, the extrudate **30** in the most preferred embodiment has a rectangular cross section with an exterior surface **32** disposed between a first edge **34** and a second edge **36**. The first edge **34** and the second edge **36** of the extrudate **30** define a first configuration and a second configuration, respectfully, with the first configuration being complementary to the second configuration. In one embodiment, the first configuration and the second configuration are substantially planar and angled relative to the exterior surface **32**. Typically, the first edge **34** and the second edge **36** are cut at about a **45**-degree angle such that each edge **34**, **36** is parallel with each other. It is to be appreciated that the edges **34**, **36** may be cut at any angle without deviating from the subject invention. Additionally, it is to be appreciated that the edges **34**, **36** can define configurations other than angles, such as a dovetail or a notch, without deviating from the subject invention.

[0032] Referring back to FIG. **1**, the manufacturing apparatus **20** also includes a mandrel **38** having a length L disposed adjacent to the multi-screw extruder **24**. The mandrel **38** has a diameter that is substantially equal to the internal diameter Di of the preform **22** that is desired. It is to be appreciated that the diameter of the mandrel **38** may vary without deviating from the subject invention. Typically, the mandrel **38** is formed of a polymeric material and is heated to an elevated temperature. More specifically, the elevated temperature is a first temperature of from about 100 to 180 degrees Fahrenheit, more typically of from about 120 to 160 degrees Fahrenheit and most typically of from about 130 to 150 degrees Fahrenheit. It is to be appreciated that the mandrel **38** can comprise other materials of which would not require heating the mandrel **38** without deviating from the subject invention. The extrudate **30** is wrapped around the mandrel **38** so that the first edge **34** and the second edge **36** of the extrudate **30** overlap and abut each other to define a spiral joint **40**.

[0033] The mandrel **38** is preferably disposed on a translation device **44** such that the mandrel **38** may move relative to the multi-screw extruder **24** and the die **26** for providing an unwrapped portion of the mandrel **38** adjacent to the multi-screw extruder **24** for receiving the extrudate **30**. As shown, the translation device **44** incrementally moves the mandrel **38** transverse to the extruder **24** and simultaneously provides rotation of the mandrel **38** as the extrudate **30** is wrapped around the mandrel **38**. It should be appreciated that the translation device **44** may be of any suitable configuration.

[0034] A substance can be applied to the first edge **34** and the second edge **36** for increasing adhesion of the extrudate **30** prior to the step of wrapping the extrudate **30** around the mandrel **38**. The substance may be of any composition, including water, to increase adhesion without deviating from the subject invention.

[0035] The manufacturing apparatus **20** further includes a pressure-applying device **42** disposed adjacent to the mandrel **38**. The pressure-applying device **42** engages the extrudate **30** for applying pressure to the spiral joint **40** to level the exterior surface **32** of the extrudate **30**. The pressure-applying device **42** is shown schematically and may be of any suitable configuration. A second substance can be applied to the spiral joint **40** prior to or simultaneously with applying pressure to the spiral joint **40** for assisting with the leveling of the extrudate **30**. It is appreciated that the second substance can also be of any composition, including water, to increase adhesion without deviating from the subject invention.

[0036] The extrudate **30** is disposed on the mandrel **38** such that a majority of the length L of the mandrel **38** is covered by the extrudate **30**. It is to be appreciated that once the majority of the length L of the mandrel **38** has been wrapped with the extrudate **30** the mandrel **38** can be removed from the manufacturing apparatus **20** and replaced by a second mandrel (not shown) for repeating the process of wrapping the mandrel **38** with the extrudate **30**. Preferably, the length L of the mandrel **38** is longer than the width of several of the preforms **22** such that the extrudate **30** wrapped on the mandrel **38** can be cut into the individual preforms **22** before removing the preforms **22** from the mandrel **38**. The extrudate **30** defines the preform **22** once the exterior surface **32** of the extrudate **30** has been leveled and the preform **22** has been cut to size.

[0037] Turning to FIG. **5**, the manufacturing apparatus **20** further includes a wrapping device **46** for disposing a film **48** about the extrudate **30** or preform **22**. As shown, the wrapping device **46** preferably disposes the film **48** about the extrudate **30** while still on the mandrel **38**. The film **48** is extracted from a dispenser **50**, which is schematically shown in FIG. **5**. The film **48** encapsulates the extrudate **30** or preform **22** to control an evaporation rate of moisture within the extrudate **30** or preform **22**. In one embodiment, the film **48** is a polymeric film, such as a polyethylene film. As with the translation device **44**, the wrapping device **46** incrementally moves the mandrel **38** transverse to the extruder **24** and simultaneously provides rotation of the mandrel **38** as the film **48** is wrapped around the mandrel **38**. It should be appreciated that the wrapping device **46** may be of any suitable configuration. The specific features and characteristics of the film and the method of controlling the evaporation are set forth in copending U.S. patent application Ser. No. ______, filed concurrently herewith (H&H Docket No. 65109.043).

[0038] Referring to FIG. **6**, the manufacturing apparatus **20** includes a heating apparatus **52**, such as an oven or a kiln. The heating apparatus **52** is shown schematically in FIG. **6** and it should be appreciated that the extrudate **30** or preform **22** may be heated by other methods, such as an open heat source. The heating apparatus **52** heats the extrudate **30** or preform **22** to a plurality of elevated temperatures as discussed in greater detail below. Typically, the heating is utilized for evaporating water, burning off any organic binder and filler from the extrudate **30** or preform **22**, and setting the inorganic binder to strengthen the preform **22**, which defines void space in the preform **22**. As shown, the mandrel **38** with the wrapped extrudate **30** or preform **22** is disposed within the oven as a single unit. It should be appreciated that the heating of the extrudate **30** or preform **22** can be accomplished through a variety of different methods.

[0039] The invention further provides an associated method for producing the preform **22** from the material. It is to be appreciated that the method herein described can be accomplished utilizing the manufacturing apparatus **20** described above or by other methods known in the art, such as by manual processing, without deviating from the broadest scope of subject invention. The method includes the step of forming the first edge **34** and the second edge **36** of the material. The forming of the material can be accomplished either by utilizing the multi-screw extruder **24** and the die **26** discussed above or by manual processing without deviating from the subject invention. Further, it is to be appreciated that if the multi-screw extruder **24** of the manufacturing apparatus **20** discussed above is utilized then the material referenced in the following discussion would be the extrudate **30**.

[0040] Generally, the extrudate **30** is heated to a temperature of from about 50 to 100 degrees Fahrenheit as it exits the multi-screw extruder **24**. The method also includes heating the mandrel **38** to the first temperature. Typically, the first substance is applied to the first edge **34** and the second edge **36** and the material is wrapped around the mandrel **38**. It is to be appreciated that the step of forming the first edge **34** and the second edge **36** of the material and applying the first substance to the first edge **34** and the second edge **36** occurs prior to the step of wrapping the material around the mandrel **38**.

[0041] The wrapping of the material on the mandrel **38** occurs by abutting the first edge **34** and the second edge **36** of the material to define the spiral joint **40**. The abutting of the edges **34**, **36** is further defined as overlapping the planar first edge **34** with the planar second edge **36** in the preferred embodiment. The overlapping of the first edge **34** and the second edge **36** of the material occurs simultaneously with the step of abutting the first edge **34** and the second edge **36**.

[0042] A pressure is applied to the spiral joint **40** for leveling the spiral joint **40** to form a smooth exterior surface **32** of the preform **22**. The process of leveling the spiral joint **40** can consist of rolling the spiral joint **40** such that the exterior surface **32** of successive revolutions of the wrapped material are level with each other. Typically, the application of the pressure to level the spiral joint **40** ensures a strong bond between the first edge **34** and the second edge **36** when abutting each other. It is to be appreciated that the first edge **34** and the second edge **36** can overlap each other and application of the pressure forces the overlap edge into the material resulting in the exterior surface **32** of successive revolutions of the wrapped material being level with each other. The material defines the preform **22** once the exterior surface **32** of the material is leveled and the extrudate **30** is cut. The second substance can be applied to the exterior surface **32** of the material for assisting the pressure-applying device **42** to level the exterior surface **32**. The pressure is applied to the spiral joint **40** after abutting the first edge **34** and the second edge **36** to form the spiral joint **40**.

[0043] Typically, the method further includes the step of encapsulating the extrudate **30** or preform **22** with the film **48** while the extrudate **30** or preform **22** remains disposed on the mandrel **38** for controlling an evaporation rate of moisture from within the extrudate **30** or preform **22**. It is to be appreciated that the encapsulation of the extrudate **30** or preform **22** can be accomplished by a variety of methods. The extrudate **30** or preform **22** is placed within the heating apparatus **52** and heated to a second temperature while the extrudate **30** or preform **22** is disposed on the mandrel **38** and encapsulated by the film **48**. It is to be appreciated that the extrudate **30** or preform **22** may be heated to the second temperature by alternative methods without deviating from the subject invention.

[0044] The material or extrudate **30** has a temperature as the extrudate **30** exits the multi-screw extruder **24** of from about 50 to 100 degrees Fahrenheit. Preferably, the mandrel **38** is heated to the first temperature prior to wrapping the material or extrudate **30** on the mandrel **38** for preventing the material from cracking as a result of thermal expansion of the mandrel **38**. Additionally, heating the mandrel **38** to the first temperature provides improved adhesion between the mandrel **38** and the extrudate **30** for improving the wrapping of the extrudate **30** on the mandrel **38**.

[0045] Generally, the extrudate **30** or preform **22** is heated to the second temperature to effect drying of the extrudate **30** or preform **22**. At this point, the extrudate **30** or preform **22** is known as an uncured ceramic article. Specific parameters and processes for heating uncured ceramic article are set forth in copending U.S. patent application Ser. No. ______, filed concurrently herewith (H&H Docket No. 65109.043).

[0046] The second temperature is from about 70 to 200 degrees Fahrenheit and more typically from about 110 to 130 degrees Fahrenheit. The extrudate **30** or preform **22** is held at the second temperature until a gel point of the organic binder is reached which occurs after about 90 to 240 minutes. It is to be appreciated that the extrudate **30** or preform **22** is maintained on the mandrel **38** during the steps of abutting, applying pressure and heating the extrudate **30** or preform **22** to the second temperature. The extrudate **30** or preform **22** is then removed from the heating apparatus **52** and the mandrel **38**. It is to be appreciated that the several preforms **22** are disposed on the mandrel **38** up to this step and the removal of the preforms **22** requires removing the file **48** from the extrudate **30**, cutting of the extrudate **30** to the desired width of the preform **22** and removing the preform **22** from the mandrel **38**.

[0047] Once removed from the mandrel **38**, the extrudate **30** defines the preform **22** and the preform **22** is placed into the heating apparatus **52** and again heated to the second temperature until the moisture content of the preform **22** is from about 0% to 18%, and more typically from about 5% to 10%.

[0048] The preform **22** is subsequently heated to a third temperature for about 30 to 90 minutes and more typically for about 60 minutes for burning off organic binders and fillers within the material. The third temperature is typically from about 450 to 700 degrees Fahrenheit and more typically from about 475 to 525 degrees Fahrenheit.

[0049] The preform **22** is then heated to a fourth temperature for about 90 to 150 minutes and more typically for about 105 to 135 minutes to set the inorganic binder and provide the ceramic article **10** with excellent strength at high temperatures. The fourth temperature is from about 1,600 to 2,000 degrees Fahrenheit and more typically from about 1,700 to 1,900 degrees Fahrenheit. After the step of heating the preform **22** to the fourth temperature, the preform **22** can be referred to as a cured or sintered ceramic article. The method of producing the preform **22** is completed by machining the preform **22** to a final configuration.

[0050] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The foregoing invention has been described in accordance with the relevant legal standards; thus, the description is exemplary rather than limiting in nature. Variations and modifications to the disclosed embodiment may become apparent to those skilled in the art and do come within the scope of the invention. Accordingly, the scope of legal protection afforded this invention may only be determined by studying the following claims.

What is claimed is:

1. A method of forming a preform from a material having a first edge and a second edge utilizing a mandrel, the method comprising the steps of:

forming the first edge and the second edge of the material with the first edge having a configuration complementary to a configuration of the second edge;

wrapping the material around the mandrel;

abutting the first edge and the second edge to form a spiral joint; and

applying pressure to the spiral joint to create a smooth exterior surface of the material and to define the preform.

2. The method of claim **1** further including the step of overlapping the first edge and the second edge of the material.

3. The method of claim **2** wherein the step of overlapping the first edge and the second edge of the material occurs simultaneously with the step of abutting the first edge and the second edge to form a spiral joint.

4. The method of claim **1** wherein the step of forming the first edge and the second edge of the material is performed before the step of wrapping the material around the mandrel.

5. The method of claim **1** wherein the configuration of the edges is substantially planar and angled relative to an exterior surface and wherein the step of abutting is further defined as overlapping the planar first edge with the planar second edge.

6. The method of claim **1** further including the step of applying a substance to the first edge and the second edge for increasing adhesion of the material prior to the step of wrapping the material around the mandrel.

7. The method of claim **1** further including the step of applying a second substance to the spiral joint prior to applying pressure to the spiral joint.

8. The method of claim **1** wherein the step of applying pressure to the spiral joint is performed after the step of abutting the first edge and the second edge to form a spiral joint.

9. The method of claim **1** further including the step of heating the mandrel to an elevated temperature before the step of wrapping the material around the mandrel.

10. The method of claim **1** wherein the step of abutting the first edge and the second edge to form a spiral joint is performed simultaneously with the step of wrapping the material around the mandrel.

11. The method of claim **1** further including the steps of maintaining the preform on the mandrel during the steps of abutting and applying pressure and subsequently removing the preform from the mandrel.

12. The method of claim **1** further including the step of encapsulating the preform with a film while the preform remains disposed on the mandrel for controlling an evaporation rate of moisture within the preform.

13. The method of claim **12** further including the step of heating the preform to an elevated temperature while disposed on the mandrel.

14. The method of claim **13** further including the steps of removing the film from the preform and drying the preform.

15. The method of claim **1** further including the steps of heating the mandrel to a first temperature, heating the preform to a second temperature which is equal to or lower than the first temperature while on the mandrel, and heating the preform to a third temperature greater than the first and second temperatures for burning off organic binders and fillers within the material and heating the preform to a fourth temperature greater than the first, second and third temperatures for setting an inorganic binder and providing the preform with excellent strength at high temperatures.

16. The method of claim **1** further including the step of machining the preform to a final configuration.

17. A method of forming a ceramic preform having ceramic particles and ceramic fibers with an aspect ratio of greater than **3**:**1** and the ceramic fibers substantially randomly orientated in three dimensions utilizing a mandrel and an extruder, the method comprising the steps of:

extruding the ceramic particles and ceramic fibers through the extruder to form an extrudate having a first edge and a second edge;

forming the first edge and the second edge of the extrudate with the first edge having a configuration complementary to a configuration of the second edge;

wrapping the extrudate around the mandrel;

abutting the first edge and the second edge to form a spiral joint; and

applying pressure to the spiral joint to create a smooth exterior surface of the extrudate and to define the preform.

18. The method of claim **17** wherein the step of forming the first edge and the second edge of the extrudate is performed simultaneously with the step of extruding the ceramic particles and ceramic fibers through the extruder.

19. The method of claim **17** further including the step of overlapping the first edge and the second edge of the extrudate.

20. The method of claim **19** wherein the step of overlapping the first edge and the second edge of the extrudate occurs simultaneously with the step of abutting the first edge and the second edge to form a spiral joint.

21. The method of claim **17** wherein the step of forming the first edge and the second edge of the extrudate is performed before the step of wrapping the extrudate around the mandrel.

22. The method of claim **17** wherein the configuration of the edges is substantially planar and angled relative to an exterior surface and wherein the step of abutting is further defined as overlapping the planar first edge with the planar second edge.

23. The method of claim **17** further including the step of applying a substance to the first edge and the second edge for increasing adhesion of the extrudate prior to the step of wrapping the extrudate around the mandrel.

24. The method of claim **17** further including the step of applying a second substance to the spiral joint prior to applying pressure to the spiral joint.

25. The method of claim **17** further including the step of heating the mandrel to an elevated temperature before the step of wrapping the extrudate around the mandrel.

26. The method of claim **17** wherein the step of abutting the first edge and the second edge to form a spiral joint is performed simultaneously with the step of wrapping the extrudate around the mandrel.

27. The method of claim **17** further including the steps of maintaining the preform on the mandrel during the step of abutting and subsequently removing the preform from the mandrel.

28. The method of claim **17** further including the step of encapsulating the preform with a film while the preform remains disposed on the mandrel for controlling an evaporation rate of moisture within the preform.

29. The method of claim **28** further including the step of heating the preform to an elevated temperature while disposed on the mandrel.

30. The method of claim **29** further including the steps of removing the film from the preform and drying the perform.

31. The method of claim **30** further including the steps of heating the mandrel to a first temperature, heating the preform to a second temperature which is equal to or lower than the first temperature while on the mandrel, baking the preform at a third temperature which is greater than the first and second temperatures and subsequently firing the preform to a fourth temperature with is greater than the first, second and third temperatures for increasing a strength of the preform.

32. A manufacturing apparatus for forming a ceramic preform from an extrudate having a first edge and a second edge, said apparatus comprising:

a multi-screw extruder having at least three intermeshing screws for forming the extrudate;

a mandrel having a diameter for receiving the extrudate with the extrudate wrapping around said mandrel to form a spiral joint by overlapping and abutting the first edge with the second edge;

a pressure-applying device adjacent to said mandrel for engaging the extrudate and applying pressure to the spiral joint to create a smooth exterior surface of the extrudate and to define a preform.

33. An apparatus as set forth in claim **32** wherein the multi-screw extruder has at least three intermeshing screws rotating at 20 to 1,200 rpm.

34. An apparatus as set forth in claim **32** wherein the multi-screw extruder includes at least three screws formed in a ring configuration.

35. An apparatus as set forth in claim **32** wherein the multi-screw extruder has 2 to 8 mixing zones.

36. An apparatus as set forth in claim **32** wherein the multi-screw extruder has an L/D ratio of about 18 to 56.

37. The apparatus as set for in claim **32** wherein the mandrel is heated to an elevated temperature.

38. The apparatus as set forth in claim **32** further including a wrapping device for encapsulating the preform with a film to control the evaporation rate of moisture within the preform.

39. The apparatus as set forth in claim **32** further including a heating apparatus for heating the preform to an elevated temperature and for baking and firing the preform after the film has been removed for increasing a strength of the preform.

40. The apparatus as set forth in claim **32** further including a die mounted to said extruder for shaping the extrudate.

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