Sept. 3, 1968 K. F. NACKE 3,400,189

PROCESS FOR CENTRIFUGALLY SPINNING HOLLOW OR FILLED FILAMENTS

Filed Sept. 14, 1964

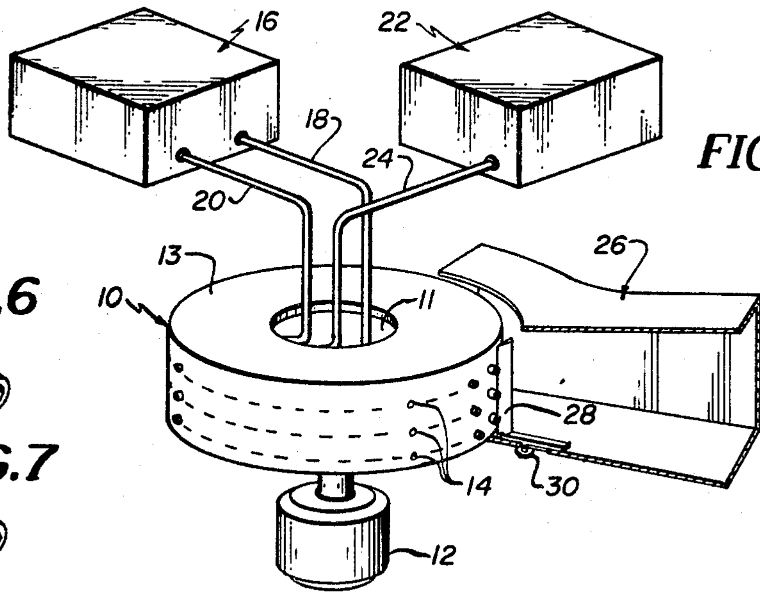


FIG. 1

FIG.6

FIG.7

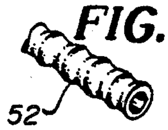


FIG. 2

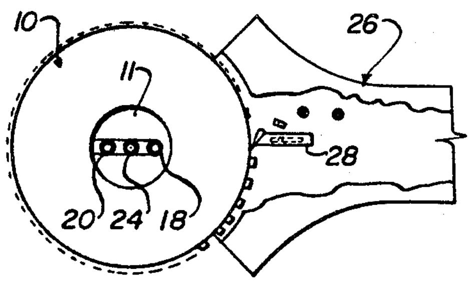


FIG.3

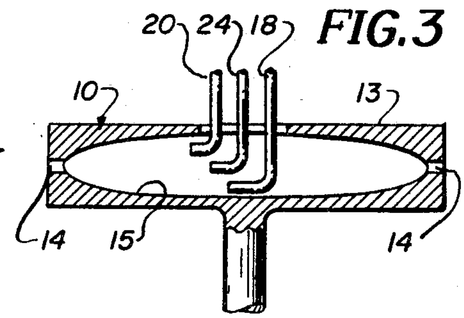
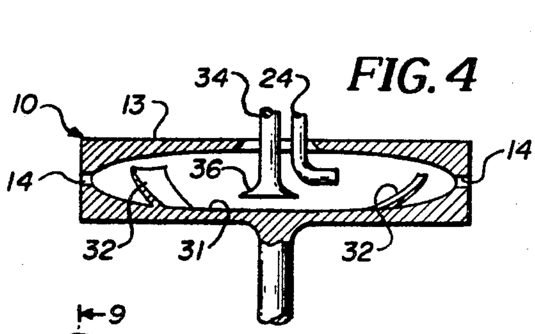


FIG. 4



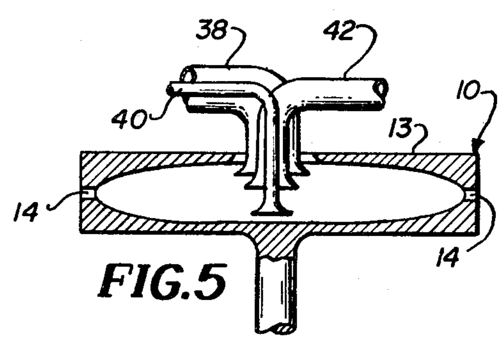


FIG.5

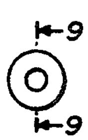


FIG. 8

FIG. 9

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PROCESS FOR CENTRIFUGALLY SPINNING HOLLOW OR FILLED FILAMENTS

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ABSTRACT OF THE DISCLOSURE

Method for making novel hollow filaments with nodules thereon. The orifices of the spinneret are starve-fed to effect the hollow aspect while the rate of feed of molten plastic is varied to accomplish the nodule aspect of the filament.

This invention relates to the method for preparing hollow or filled plastic filaments in the form of strands or toroidal shaped wafers, or platelets.

Processes which have been proposed previously for preparing hollow or filled plastic filaments have involved complicated techniques and apparatus. For example, in the past, special spinnerets capable of supplying a gas to the center of each filament cross section as it is extruded from the spinneret, or of forming a cluster of small filaments which coalesce immediately below the face of the spinneret into a larger hollow filament, have been used. The method which involves positively supplying a gas to the center of the filament suffers from the disadvantage of the high cost of preparing such complicated spinnerets, as well as the difficulty of maintaining such spinnerets in good condition through the frequent cleaning operations which must be performed. The method of preparing hollow filaments by coalescence, or the other hand, suffers from the disadvantage of the frequent occurrence of failure of coalescence at some point, especially when spinning lower viscosity polymer. If, in order to insure coalescence, the holes in each cluster producing a hollow filament are closely spaced so that the individual streams coalesce before leaving the face of the spinneret, then there is no opening for air to enter the hollow cavity and the filament immediately collapses so that no hollow cavity, or only a very small one, is present in the final filament.

The above mentioned processes are discussed, and the disadvantages of the same acknowledged, in U.S. Patent No. 3,095,258, which patent discloses still another process for preparing hollow plastic filaments which is purportedly superior to these previously used processes. The process of this patent involves melt-spinning synthetic super polymers directly into hollow textile filaments. According to the patent, with this process, a gaseous or gas-forming material must be present in the molten polymer at the moment of extrusion, and the center portion of the orifice in the spinneret which is used, must be obstructed in some fashion. In a preferred embodiment of the subject patent, a low boiling inert fluid is pumped under pressure into the molten polymer before extrusion. Upon extrusion, the fluid vaporizes and undergoes a rapid increase in volume as the pressure on the polymer falls to atmospheric pressure at the exit end of the spinneret orifice. In a less preferred method, ground or otherwise finely divided polymer is melted while under pressure of an inert gas, or polymer is first melted and then mixed with the gas under pressure. Pressure is adjusted so that the desired amount of gas is dissolved in the polymer. And, in still another embodiment of the subject patent, the polymer is mixed with a relatively stable solid material which is capable of decomposing to produce a gas at

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the temperature of polymer extrusion. Such materials may be added during the formation of the polymer itself, or mixed with polymer flake before it is melted for the spinning operation.

It will be apparent from the detailed description hereinafter, that this process is also far more complex, and the apparatus far more costly, then need be. Accordingly, it is an object of this invention to provide improved methods for preparing hollow or filled plastic filaments, and in particular, hollow or filled plastic filaments in the form of strands or toroidal shaped wafers, or platelets.

It is a still further object to provide improved methods for preparing hollow or filled plastic filaments, whereby a wide range of polymers and copolymers of viscous nature may be used.

It is a still further object to provide improved methods for producing filled plastic filaments, whereby a wide range of filler material may be used.

Other objects of the invention will be obvious and will in part appear hereinafter.

These objects are accomplished by the present invention which provides for the production of hollow or filled filaments in the form of strands or toroidal shaped wafers or platelets, by a process comprising feeding a plastic material into a rotating centrifugal die at a rate and under conditions which starve the individual die orifices formed therein, until a filler is fed into the die to force the plastic material out of the orifices.

Upon feeding the filler to the die, the plastic material is extruded through the individual die orifices and radiates outwardly from the periphery of the die in the form of strands. An appropriate filler in the case of hollow strands may be air or an inert gas, whereas in the case of filled strands clays, binders, inert materials, sand or asbestos may be used.

Hollow or filled toroidal shaped wafers, or platelets, may be produced by positioning cutting means adjacent the periphery of the die to cut the extruded strands as the individual orifices, or row of orifices, rotate past the cutting means.

The process, as will be more apparent from the detailed description which follows, is extremely versatile in that a wide range of plastic materials may be used. For example, plastic materials suitable for use in this process include polyethylene, polypropylene, polystyrene, saran, polyvinylchloride and other polymers and copolymers of a viscous nature.

The die comprises a cylindrical shaped spinneret having a plurality of unobstructed extrusion orifices formed about its periphery. Plastic material and filler material are fed to the interior of the spinneret from supply tanks adapted to supply the same thereto through feeder tubes, under predetermined rates of flow and conditions. The feeder tubes are arranged to expel the plastic material and the filler material within the spinneret in a fashion such that the spinneret need not be sealed.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others and the apparatus embodying features of construction, combinations of elements and arrangements of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing in which:

FIGURE 1 is a view of a spinneret and its associated apparatus, exemplary of the present invention, the orifices and the filaments shown being greatly exaggerated;

FIGURE 2 is a partial top view of the apparatus of FIG. 1;

FIGURES 3, 4 and 5 are sectional views of various modified forms of spinnerets exemplary of the present invention, which views also illustrate various modified feeder tube arrangements;

FIGURES 6 and 7 are greatly enlarged views of a smooth strand and a strand having nodules thereon, respectively, obtained in accordance with this invention when using the apparatus of FIG. 1; and

FIGURES 8 and 9 are side and cross-sectional views, respectively, of a toroidal shaped wafer, or platelet, obtained in accordance with this invention when using the apparatus of FIG. 1.

Similar reference characters refer to similar parts throughout the several views of the drawing.

Referring now to FIG. 1 which shows apparatus exemplary of the present invention, a spinneret **10** which is adapted to be heated, in any suitable fashion, is driven, either in a clockwise or counter-clockwise direction, by means of a motivating means, such as the electric motor **12**, at a speed which is dependent upon the fluidity of the plastic material used, the attenuation required and the driving force required to extrude the plastic material through the orifices **14** formed about its periphery. The rotational speed, as will be explained more fully hereinafter, depending on the above mentioned factors, may vary from 1000 r.p.m. to 25,000 r.p.m. Electric motor **12** is accordingly of the type which is adjustable to provide a predetermined constant speed of rotation.

The spinneret **10** may have a diameter of a few inches up to 18 or 24 inches, depending upon the rotational speed required and the material from which it is constructed. Also, the orifices **14** can be formed about the periphery in a number of rows, with the orifices either in line, as shown, or staggered, and can be of various sizes, ranging from .010 to .100 inch in diameter. The orifices can also assume various shapes, for example, circular, rectangular, triangular, or irregular shapes. It may be further noted that the orifices are not obstructed, as taught by the above mentioned patent. The orifices **14** may therefore be easily and much less expensively formed in the spinneret **10**, hence the manufacturing cost of the spinneret is relatively low. Furthermore, there is less likelihood that the orifices will become clogged from material sticking to the center obstruction in the orifices.

The spinneret **10** is cylindrical in shape and has closed ends, except for the opening **11** formed in the top wall **13** thereof. A pair of feeder tubes **18** and **20** extend from a heated supply tank **16** into the interior of the spinneret, through the opening **11**. Any suitable means may be provided for heating and for forcing the plastic material out of the supply tank **16** and through the feeder tubes **18** and **20** to the interior of the spinneret **10**.

A filler supply tank **22** has a feeder tube **24** which likewise extends into the interior of the spinneret **10**. The filler supply tank **22** may also be provided with any suitable means for forcing the filler material out of it and through the feeder tube **24** in to the spinneret **10**.

The feeder tubes **18**, **20** and **24**, as may be best seen in FIG. 3, terminate at different heights within the interior of the spinneret **10**. The terminal end of feeder tube **24** which feeds the filler material to the spinneret is preferably positioned between the plastic feeder tubes **18** and **20**. Also, the ends of the feeder tubes **18**, **20** and **24** are angled so that the plastic material and the filler material are expelled, in the same direction, towards the interior periphery of the spinneret. It may be further noted that the top and bottom walls **13** and **15** of the spinneret **10** are curved, in opposite directions, towards the orifices **14**. In FIG. 3, only a single row of orifices **14** are shown, but in actual practice numerous rows of orifices may be formed about the periphery of the spinneret **10**.

In operation, the plastic material which is directed to

the interior of the spinneret **10** through the feeder tube **20** impinges on the top wall **13** and flows outwardly and downwardly about the orifices **14**, while the plastic material fed to the spinneret **10** through the feeder tube **18** impinges on the bottom wall **15** and flows outwardly and upwardly about the orifices **14**. The spinneret **10** is rotated at a speed such that the centrifugal force of the spinneret will cause the plastic material to flow to its interior periphery and about the individual orifices **14**, but not out of the individual orifices. In other words, the individual orifices **14** are starved so that the plastic material is not extruded from the spinneret.

Filler material fed to the interior of the spinneret **10** through the feeder tube **24** is expelled between the layers of plastic material fed to the spinneret through the feeder tubes **18** and **20**. The filler material is therefore immediately enveloped, or surrounded, by the plastic material and is carried, by the centrifugal force, to the interior periphery of the spinneret **10**. Since the spinneret is rotated at a speed which is on the verge of forcing the plastic material through the orifices **14**, the added impact of the filler material upsets the established equilibrium and the plastic material is forced through the orifices **14**. Continuous filaments in the form of strands are extruded through the individual orifices **14**, as long as the plastic material and the filler material is supplied to the spinneret at the established rate and conditions. Post heating and subsequent treatment can be used to adjust the properties of the filaments, as desired for various applications. Also, the centrifugal force of the spinneret **10** attenuates the strands, and they can be further attenuated before being post treated, cut and wound up, as desired.

As previously indicated, a wide range of plastic materials may be used in this process. The plastic material is heated within the supply tank **16** to a desired fluidity, the driving force required to extrude the plastic material through the spinneret orifices determined, and the rotational speed of the spinneret accordingly adjusted so that the centrifugal force of the rotating spinneret is on the verge of, but not sufficient to, force the plastic material through the orifices. In essence, an equilibrium condition is established within the spinneret. The rotational speed of the spinneret therefore varies depending upon the type of plastic material used. It has been found in using the previously mentioned types of plastic materials that the rotational speed may vary between 1000 r.p.m. and 25,000 r.p.m.

In FIGS. 4 and 5 are shown 2 modifications of the spinneret **10** and the feeder tubes **18**, **20** and **24**. In FIG. 4, the spinneret **10** has deflectors **32** projecting upwardly at a slight curvature from the bottom surface **31** of the interior of the spinneret. The deflectors **32** are positioned in spaced relation about the interior of the spinneret **10** and function to deflect the plastic material upwardly to its top wall **33**. The deflectors **32** are positioned in a spaced relation so that a portion of the plastic material can flow between the deflectors **32**, along the bottom wall of the spinneret, to the orifices **14**, while the remaining plastic material is deflected upwardly by the deflectors **32** to the top wall **33**, from whence it flows to the orifices **14**. In this case, a single feeder tube **34** may be substituted for the two feeder tubes **18** and **20**. The feeder tube **34** has an outwardly flared end **36** and is arranged so that the plastic material is directed downwardly upon the lower wall **31** of the spinneret. The plastic material is then disbursed in the manner described above. The feeder tube **24** for the filler material extends into the interior of the spinneret **10** and its end is angularly bent so as to expel the filler material toward the interior periphery of the spinneret **10**, in the same manner as the feeder tube **24** of FIG. 3.

In FIG. 5, the spinneret **10** is of the type shown in FIG. 3 and the feeder tubes **38**, **40** and **42** have outwardly flared ends which are directed downwardly toward the bottom wall **41** of the spinneret. The feeder tube **42** for feeding the filler material to the spinneret has its end positioned between the ends of the plastic feeder tubes 38 and 40. In the case of the embodiment of FIG. 5, the plastic material flows through the feeder tube 40 to the bottom wall 41 of the spinneret 10 and flows outwardly and upwardly about the orifices 14 formed in the periphery of the spinneret, due to centrifugal force. The plastic material which flows through the feeder tube 38 is discharged on top of the plastic material which flows through the feeder tube 40 and flows outwardly and downwardly about the orifices 14. As described above, the plastic material is not extruded through the orifices 14, until filler material is fed to the interior of the spinneret, through the feeder tube 42. The filler material is discharged between two layers of plastic material and is completely enveloped by this material and flows outwardly to the interior periphery of the spinneret 10.

It may be noted that in each of the above described cases, the arrangement of the feeder tubes is such that the plastic material substantially immediately envelopes, or surrounds, the filler material as it is expelled into the spinneret. Also, the rate of flow of the plastic material and the filler material to the spinneret is adjusted such that the centrifugal force of the rotating spinneret maintains the material within its interior. The previously mentioned disadvantages of the prior apparatus of this type is virtually eliminated and, furthermore, the spinneret need not be sealed, i.e., completely closed. The process and apparatus both are therefore greatly simplified.

Referring now again to FIG. 1, in operation, the spinneret 10 is rotated by means of the electric motor 12 at a constant speed which, as previously indicated, is dependent upon the fluidity of the plastic material, the attenuation required and the driving force required to extrude it through the orifices. Plastic material is fed from the supply tank 16 through the feeder tubes 18 and 20 to the interior of the spinneret. The temperature of the material may vary from 150° F. up to 800° F., depending upon the plastic material used and the desired fluidity. The plastic material will flow about the interior periphery of the spinneret 10, due to centrifugal force, until a filler material is supplied to the spinneret to upset the established equilibrium condition, as described above.

Continuous filaments in the form of hollow or filled strands, such as the strand 50 partially shown in FIG. 6, are produced by supplying an appropriate filler material to the spinneret 10. In the case of a hollow strand, the filler material supplied to the spinneret 10 may be air or inert gases of various types. The air or inert gas is fed through the feeder tube 24 under a pressure sufficient to upset the equilibrium condition, to force the plastic material through the orifices 14 formed about the periphery of the spinneret.

In the case of filled strands, appropriate filler material may be clays, binders, inert materials, sand and asbestos, to mention but a few of the various types of fillers which may be used. In this case, the filler material is fed from the filler supply tank 22 through the feeder tube 24 at a rate such that the centrifugal force imparted to it will carry it to the interior periphery of the spinneret and upset the equilibrium condition so that the plastic material flows through the orifices 14.

The strands radiate outwardly as wheel spokes as the spinneret 10 rotates and are attenuated due to the centrifugal force of the rotating spinneret. The strands may be further attenuated, post treated and gathered in any convenient manner, as for example, by hand or providing equipment which will automatically gather them.

Continuous strands or fibers with nodules, such as the strand 52 partially shown in FIG. 7, or strands having a rough surface, may be produced using the apparatus shown in FIG. 1 by varying the rate of flow of filler material to the spinneret 10, or by varying the extrusion conditions so that melt fracture is obtained. Surface roughness is dependent on the orifice through-put, as well as

orifice condition and configuration, and varying degrees of surface roughness may be provided by changing one or more of the above conditions. Filaments having surface roughness are desirable for a number of applications, since the rought surfaces provide, for example, more surface to improve adhesion and more sites for dry blending colors.

Toroidal shaped wafers, or platelets, of the type shown in FIGS. 8 and 9 may also be produced using the apparatus of FIG. 1. In this case, cutting means, such as a knife blade 28, is positioned adjacent the periphery of the spinneret 10 so that the extruded strands are cut as they rotate to and are engaged by the knife blade 28. A chute 26 may be provided to collect and to transport the wafers, or platelets, to any suitable collection means. Alternatively, the cutting means, or knife blade 28, may be adjustably mounted adjacent the periphery of the spinneret by means of a fastener, such as the nut and bolt assembly 30 secured within the elongated slot 31 formed in the chute 26, so that it may be spaced from the periphery of the spinneret, in accordance with the size of the toroidal shaped wafers, or platelets, desired.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above method and in the construction set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall therebetween.

Now that the invention has been described, what is claimed as new and desired to be secured by Letters Patent is:

1. A method for producing hollow or filled plastic filaments in the form of strands by means of a hollow spinneret having a plurality of unobstructed extrusion orifices formed about its periphery comprising the steps of rotating said spinneret at a predetermined speed while supplying plastic material to the interior of said spinneret such that said plastic material flows to the interior periphery and about said orifices, but not out of the individual orifices, and supplying a filler material to said spinneret under conditions to upset the established equilibrium and force said plastic material through said orifices.

2. The method of claim 1 for producing hollow plastic filaments wherein said filler material supplied to said spinneret comprises air.

3. The method of claim 1 for producing hollow plastic filaments wherein said filler material supplied to said spinneret comprises an inert gas.

4. The method of claim 1 for producing filled plastic filaments in the form of toroidal shaped wafers, or platelets wherein said filler material is solid filler material, and cutting said filaments as said spinneret is rotated.

5. The method of claim 1 for producing hollow or filled plastic filaments having a plurality of nodules formed on its surface wherein the supply of said filler material is at a continuously varying rate to cause nodule formation on said filaments.

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