

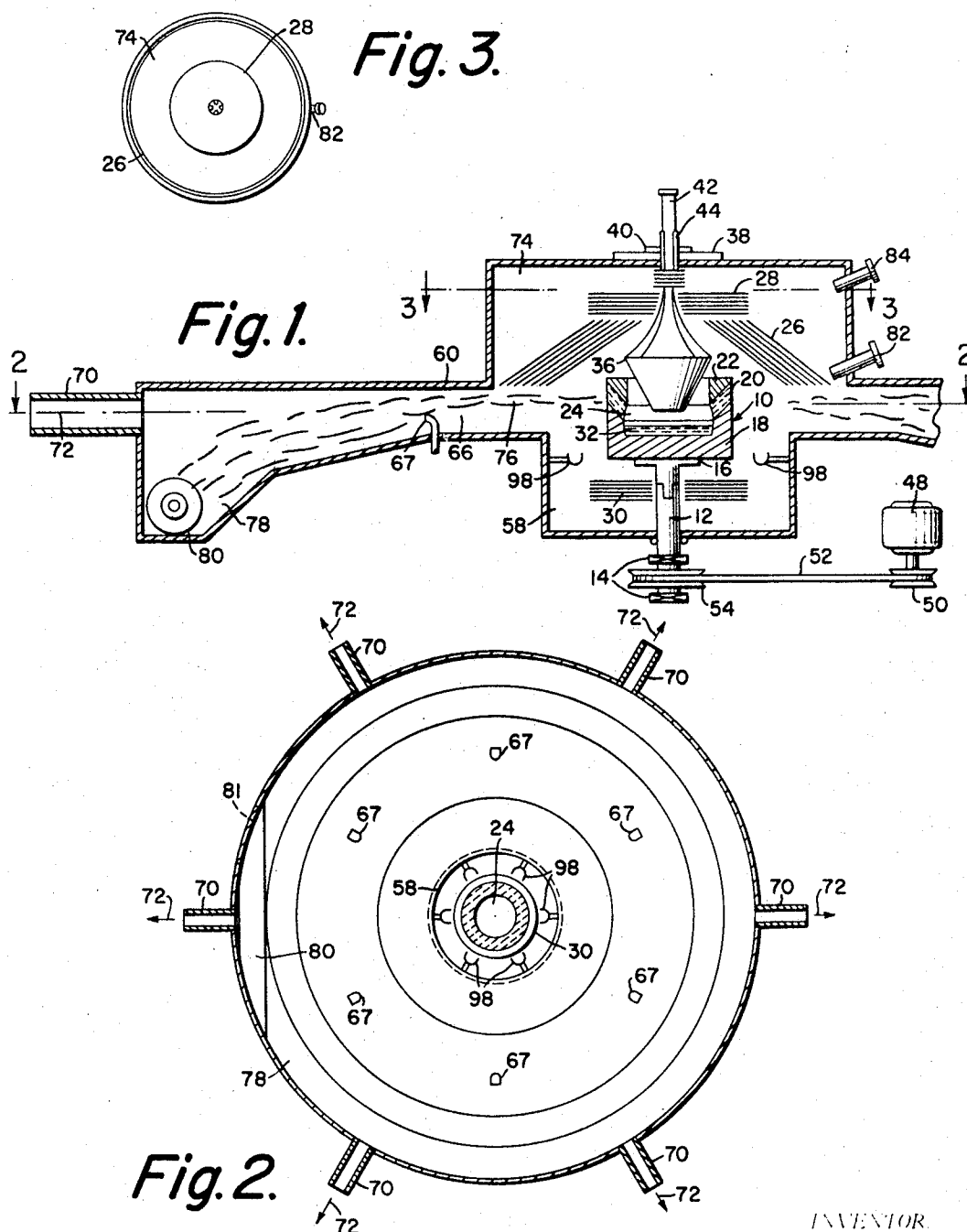
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PROCESS FOR PRODUCING FIBERS

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3,466,352

## PROCESS FOR PRODUCING FIBERS

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6 Claims

### ABSTRACT OF THE DISCLOSURE

This invention proposes a new and improved method for making attenuated fibers by melting the starting material to convert such material to an extrudible state and then spinning the melted material within a container having a porous, annular sintered section, including interstices through which the extrudible material can be ejected under centrifugal force. As the attenuated fibers emerge through the porous layer they are of a preferred cross-sectional size and shape and are then projected through a chamber which can be either evacuated or include a preferred composition for modifying the fiber. The process may be continuous and it is especially noted for its ability to produce a very small cross-section fiber exhibiting many of the unexpected properties of fibers.

This application is a continuation application of my copending application filed June 21, 1965, entitled "Process for Producing Fibers," Ser. No. 465,463.

This invention relates to an improved process for producing fibers, and more particularly, attenuated fibers having a relatively thin cross section of either uniform or modified composition and elongated configuration. In the process of producing attenuated fibers, there have been proposed numerous apparatus wherein fiber-forming material is forced outwardly from a container means. The shortcoming of such apparatus and the method which it follows has been the inability of the apparatus and method to produce a uniform product and one which consists of relatively stable, uniform fibers of small cross section. It was previously the practice to form small apertures or orifices within a spinning chamber and to cause the plastic material to issue out of the orifices under centrifugal inertial load effected by rotating the chamber at high rotational speeds depending upon the diameter of the rotated chamber. The prior art does not make an attempt to control the composition of a resulting fiber by modifying or completely changing it in order to produce superior and desirable properties. No practical controls were understood or even attempted in the process of producing fibers from a melt of extrudible material. In the present invention, there is first comprehended the relationship between spinning off the fiber from an extrudible starting material and providing controlled parameters for producing a finished fiber of the desired composition, size and rate.

In order for the apparatus of the character described to be operable, the plastic material must be maintained at a substantially constant temperature and viscosity (viscosity being directly related to temperature) in order that the plastic material which forms the fiber will be extruded at a substantially constant rate. Uniformity of product produced requires that the plastic material be substantially constant in physical condition of viscosity and temperature.

It is likewise important in the production of fibers to maintain the orifices through which the fibers are forced, in a substantially unclogged or free condition allowing the filaments which are spun out of the orifices to issue without interruption.

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It is one of the principal objects of the present invention to provide an improved process for producing filaments of plastically extrudible material of controllable composition.

It is a further object of the present invention to provide an improved process for producing attenuated fibers in which the fibers are forced outwardly through the interstices of a refractory body and which are less prone to be clogged and otherwise impeding the flow of plastic material outwardly through the body under centrifugal force. By the term "plastic" is meant any composition material which can be rendered extrudible for effecting its transition through a porous body and be thereby drawn into fine filament form.

Other objects and features of the present invention will become apparent from a consideration of the following description, which proceeds with reference to the accompanying drawings, wherein:

FIGURE 1 is a partial diametral section view of the apparatus showing the rotatable container or spinner and the associated structure;

FIGURE 2 is a section view taken on line 2—2 of FIGURE 1; and

FIGURE 3 is a section view taken on line 3—3 of FIGURE 1.

Referring now to the drawings, there is shown in FIGURE 1, a rotor 10 which is mounted on a shaft 12 having bearing supports 14 to provide for driving of the rotor by the shaft 12 through a heat resistant support member 16 which may be comprised of tungsten or other such heat resistant material. The rotor 10 includes a refractory bottom pan section 18 which is sufficiently heat resistant and inert to the fiber forming material that it will contain such material without deteriorating and without allowing any of such material to leak or become lost to the system. Above the refractory pan section 18 is an annular layer section 20 of porous refractory material which has sufficient porosity to permit passage of liquid-phase or plastic-phase material through its pores or interstices, when the plastic material is heated up and spun within the rotor 10. The density of the fibers can be varied by changing the particle size, compact pressure and relative density of annular layer section 20, and also the porosity of the annular layer section 20, which is determined by the sintering temperature at which the particles forming the annular layer section 20 are coalesced.

The porous annular layer section 20 is sandwiched between pan section 18 and an uppermost layer 22 of heat resistant material such as tungsten or the like. Layer section 20 provides a transition means for the plastic material moving outwardly through the interstices within layer 20. Chamber 24 for containing the plastic material is defined by the pan section 18, porous annular layer section 20 and tungsten uppermost layer 22. These materials of construction are mentioned by way of example and not limitation, and such other materials which are heat resistant, refractory and have the necessary degree of strength to withstand centrifugal loading are intended to be included within the teaching of the present invention as equivalents of the materials described.

Above, and surrounding the rotor 10 are a plurality of radiation shields 26, 28, and below and surrounding the rotor are heat shields 30; the shields 26 are of conical construction, and shields 28, 30 are disc shaped.

The chamber 24 is filled to a suitable level with melt 32 which partially fills the chamber 24 and a suitable degree of viscosity for the melt is maintained by means of 3-phase tungsten heating elements 36 which are suspended on an exit plate 38, having a seal 40 and a shaft 42 with a fluted shank 44 which facilitates gripping the shaft and suspending the heating elements 36 so that the heating elements will extend into the chamber 24 and

produce a radiating effect upon the melt 32 within the pan section 18. The heating effect is relatively constant and being in close proximity with the melt, causes a substantially constant heating effect on the melt, whereby its viscosity remains unchanged. The heating elements radiantly heat the melt 32 but are not in contact with the rotor; and, therefore, relative rotation can occur between the rotor and heating elements so that the melt is constantly being heated during rotation of the rotor. Such rotation is accomplished by means of a drive motor 48 having a take-off pulley 50 and belt 52 which is passed over pulley 54 on the shaft 12 so that the drive motor 48 will produce a positive driving action on the rotor 10 causing centrifugal force to be developed on the melt 32. The rotor 10, with its associated drive members are located generally within a dropped section 58 of enclosure 60 which also defines an annular chamber 66 having a conduit 70 which connects with a vacuum-producing source to exhaust the air or gas from the annular chamber 66 and the other areas enclosed by enclosure 60. The vacuum-producing action is indicated by arrows 72. The heat shields 26, 28, 30 and heating elements 36 together with its associated mounting structure is disposed generally within a raised section 74 of the enclosure structure 60 in order to leave the annular chamber 66 unobstructed and thereby permitting radially outward movement of fibers which are formed by transition of the plastic material through the pores of the porous refractory porous annular layer section 20, the spin off of fibers being indicated generally by reference numeral 76.

The vacuum permits the light fibers to move radially outwardly under inertial force without interference either by atmosphere or by mechanical interference. The porous annular layer section 20 is inclined slightly upwardly at its outer radius so that the general spin-off flow of plastic fibers is in an upward and outward direction. As the fibers 76 move radially outwardly through chamber 66 they can be combined with other material which will tend to coat the outer surface of the fibers. A complete vacuum or partial vacuum can be developed in the chamber in order to (1) reduce interference of movement of the fibers by the presence of atmosphere or (2) prevent attack of the fibers by the atmosphere. The fibers 76 are spun outwardly and they tend to fall downwardly and into trough 78 where they are displaced by a conveyor 80 to a discharge opening 81 and are thereby withdrawn from the system. The operation can take place either continuously or semi-continuously, the chamber 24 being either constantly or intermittently driven.

In order to observe the interior conditions of the apparatus, there can be used sight glasses 82 and 84.

In operation, the motor 48 is energized when the chamber 24 is loaded sufficiently with fiber-forming material such as glass, metals, alloys, non-metals, organic and inorganic materials or the like, combinations of such materials, or any other suitable plastic material, and after the heating elements 36 have been energized to heat the material to the desired temperature.

The chamber 66 defines a zone surrounding the rotor 10, and through which the light fibers move radially outwardly under inertial force, and which can have a prepared atmosphere, meaning either sub-atmospheric pressure in the form of a partial vacuum, in order that the fibers can move outwardly without impedance or without attack by the atmosphere or a protective atmosphere can be introduced through inlet 67 to prevent deterioration of the fibers. In this case, such gases as helium, argon, hydrogen, etc., are usable depending upon the composition of the material of the fibers. For example, fibers which are manufacturable within the scope of the invention include metal fibers, glass fibers, etc., and the composition of the fibers will dictate the composition of the atmosphere.

In the event that the composition of the fibers 76 is to be modified, a gas for this purpose may be introduced

through inlet line 67. For example, if aluminum fibers were being formed, the introduction of an oxidizing gas would cause the formation of aluminum oxide and the resulting fiber could be either coated with this oxide or completely transformed into an aluminum oxide fiber. If a gas containing a metallic ion were added, this gas would disassociate and the metal atoms would attach themselves to the fiber 76 causing growth of the fiber 76 and modifying the composition of the fiber if the metal atoms were unlike those of the melt 32 producing the fiber. If the metal atoms were the same as the metal being formed into fiber, the adhering atoms would tend to fill any lattice voids thus reducing the number of voids or dislocations and thus producing a stronger fiber. In some cases, the gas introduced may serve to only coat the fibers with a second medium such as a bonding agent that is desired for further processing reasons. The inlets 67 may also be used for a second purpose. If a gas is introduced so that its flow is parallel with the flow of the fibers, its action will elongate or stretch the fibers thus reducing their cross section and thereby strengthening the fiber.

The charge 32 may be either molten or may be heated to melt, depending upon the composition of the material.

#### Examples

As specific examples of products and materials which can be used with the described apparatus, there are the following, being understood that these are set forth by way of illustration and not limitation:

|    | Extrudible material          | Environment                | Product                             |
|----|------------------------------|----------------------------|-------------------------------------|
| 1  | Iron                         | Vacuum                     | Iron fibers.                        |
| 2  | do                           | Hydrogen, helium           | Do.                                 |
| 3  | do                           | Chromium, nickel vapor.    | Coated fiber.                       |
| 4  | do                           | Aluminum, zinc, tin vapor. | Do.                                 |
| 5  | do                           | Epoxy resin vapor          | Do.                                 |
| 6  | do                           | Blast of hydrogen          | Elongated fiber.                    |
| 7  | Aluminum                     | Vacuum                     | Aluminum fibers.                    |
| 8  | do                           | Oxidizing                  | Aluminum fibers with oxide coating. |
| 9  | do                           | do                         | Aluminum oxide fiber.               |
| 10 | do                           | Aluminum vapor             | Superior aluminum fiber.            |
| 11 | Boron                        | Vacuum                     | Boron fibers.                       |
| 12 | do                           | Oxidizing                  | Boron oxide fiber.                  |
| 13 | Boron+percent O <sub>2</sub> | Deoxidizing.               | Boron without any oxygen.           |
| 14 | Copper                       | Tin or zinc vapor          | Bronze or brass fiber.              |
| 15 | Glass                        | Air blast                  | Fibrous glass.                      |
| 16 | Stainless steel              | Vacuum                     | Stainless steel fiber.              |
| 17 | Molybdenum oxide             | Hydrogen                   | Pure molybdenum fiber.              |
| 18 | Iron oxide                   | do                         | Pure iron fiber.                    |

After the rotor 10 is started to spin by the motor 48 and the revolutions per minute developed by the rotor has reached sufficient speed to produce fiber formation, the charge material is forced through the porous annular layer section 20. The exact speed of rotation is a function of the material being spun, the porosity of the porous annular layer section 20 and the diameter of the rotor 10. After the rotor has started spinning, the melt will be forced radially outwardly through the porous annular layer section 20 and it is ejected from the outer surface under centrifugal force, emerging as relatively thin attenuated fibers. Inertia throws off the thin fibers which move outwardly without impedance by either structure or by atmosphere and the momentum of the fibers is sufficient to carry them outwardly to the point where conveyor 80 can pick up the fibers and remove them from the apparatus.

The heat shields 26, 28, 30, confine the heat to the zone of the rotor 10 where the heating effect must be maximized and the operation produces spun fibers at the optimum condition of temperature which determines the viscosity of the plastic fiber-forming material.

During operation, the rotor 10, being made of heat-resistant material, will not deteriorate and will not disintegrate under the centrifugal force developed by spin. The centrifugal force will, however, continuously eject

the fiber-forming material through the porous annular layer section 20. This material may consist of sintered powdered metals or the desired metal oxide composition. The layer section 20 has considerable adherence in order not to disintegrate under centrifugal force. The layer section 20 also provides interstitial pores for the plastic material to pass through and form fibers.

A plurality of vaporizer units 98, the exact number of which can be made a matter of design preference, are also provided. I prefer approximately six units 98 equidistantly spaced about 60 degrees apart, and generally in radial line with the six vacuum ports 70. These vaporizer units 98 are used to vaporize a second material so that the fibers 76 are coated with the second material. For instance, an iron fiber might be coated with chromium or aluminum to improve its properties or to impart corrosion resistance.

I claim:

1. A process for producing extruded fibers comprising the steps of:

- (a) filling with metal material a container having a porous wall section;
- (b) heating the metal material sufficiently to render it extrudible;
- (c) rotating the container about an axis to spin the metal material within the container and force said metal material by the resulting centrifugal force radially outwardly through the porous wall section to extrude such material therethrough and thereby attenuating such material into fibers;
- (d) passing said fibers by centrifugal force through a surrounding atmosphere composed of the vapor of a further material to cause deposition of the further material as a coating over the surface of the formed fibers passing therein; and
- (e) collecting the resulting coated fibers.

2. The process in accordance with claim 1 wherein said surrounding atmosphere is composed of a vapor of different metal thereby causing deposition of the different metal as a coating over the surface of the formed fibers passing therein.

3. A process for producing strengthened fibers, the steps comprising:

- (a) filling with an extrudible plastic material a container having a porous wall section;
- (b) heating the plastic material to render it extrudible;

(c) rotating said container about an axis to spin said plastic material within said container and force said material by the resulting centrifugal force radially outwardly through a porous wall section of the container to extrude the material therethrough and thereby forming the plastic material into fibers;

(d) passing said extruded fibers by centrifugal force through a surrounding zone into which streams of flowing gas, inert to the fibers, are directed against the extruded fibers to carry said fibers outwardly from said rotating container and to thereby elongate and strengthen said fibers by such action; and

(e) collecting the fibers thus produced.

4. The process in accordance with claim 3 including the step of cooling the fibers after extrusion thereof into fiber form.

5. A process for extruding plastic material through a continuous solid phase container having an annular wall section of porous refractory material interstices which provide for extruding said plastic material through the porous wall section, comprising the steps of:

- (a) filling said container with said plastic material;
- (b) heating the plastic material to render it extrudible through the interstices of said wall section;
- (c) rotating said container about an axis under a centrifugal force to extrude said plastic extrudible material outwardly through the interstices of the wall section of the container to form fibrous particles which are thrown beyond the outer surface of said wall as they emerge therefrom; and
- (d) collecting said fibrous particles thus produced.

6. The process in accordance with claim 5 wherein said plastic material is selected from the group consisting of metals, metal alloys, glass fibers, and metal oxides.

#### References Cited

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45 18—26, 47; 264—8

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,466,352

September 9, 19

Robert B. Corbett

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 43, after "of" insert -- the --. Column 5, line 3, after "desired" insert -- metal or --.

Signed and sealed this 14th day of April 1970.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR

Commissioner of Patents