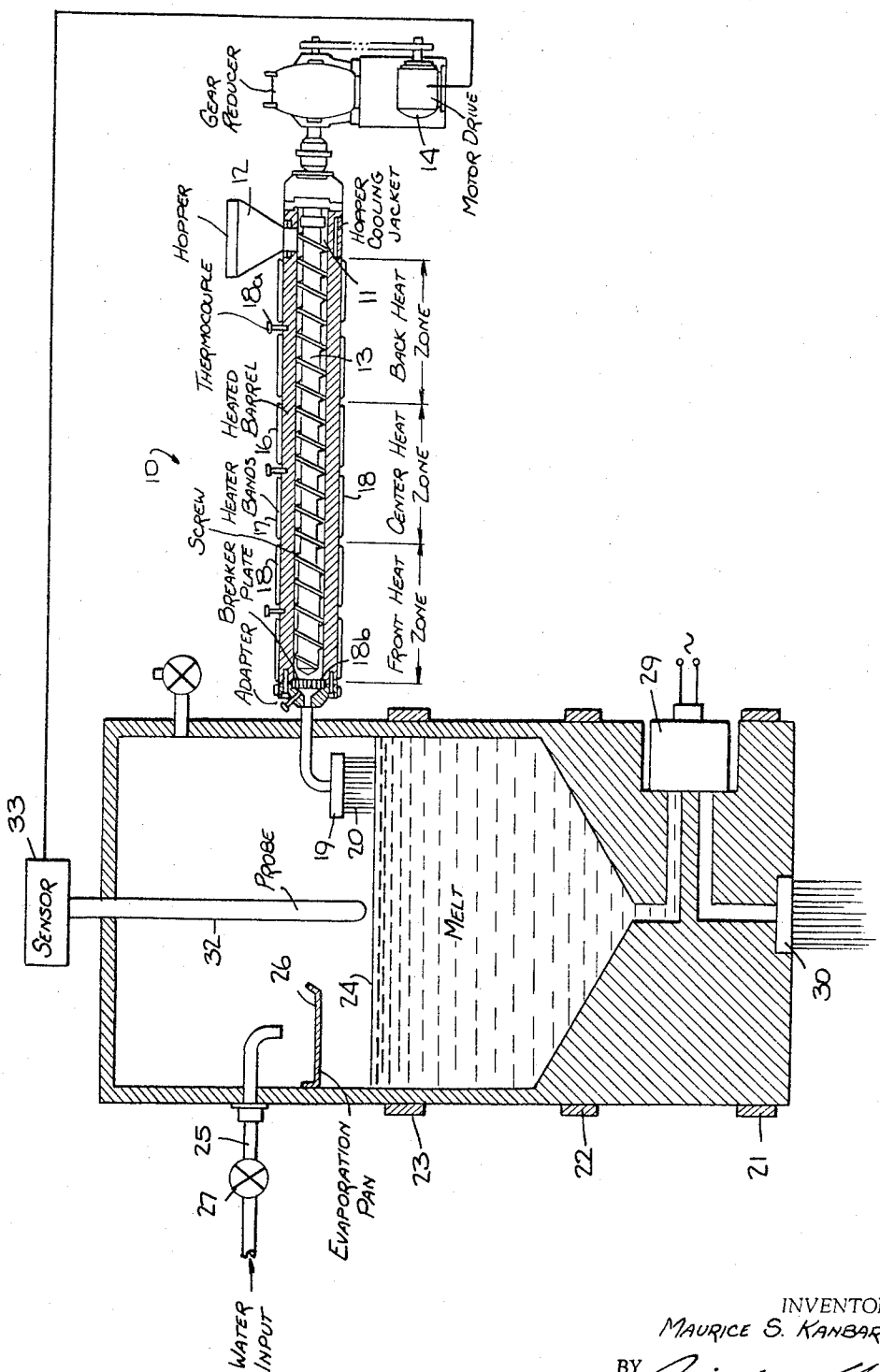
Sept. 13, 1966 M. S. KANBAR 3,271,817

NYLON MELT-SPINNING APPARATUS

Filed May 27, 1963



INVENTOR.
MAURICE S. KANBAR
BY Richard Clark
ATTORNEY

United States Patent Office 3,271,817
Patented Sept. 13, 1966

3,271,817

NYLON MELT-SPINNING APPARATUS

Maurice S. Kanbar, 105 E. 15th St., New York, N.Y.

Filed May 27, 1963, Ser. No. 283,236
6 Claims. (Cl. 18—8)

This invention relates generally to the melt-spinning of nylon, and more particularly to an improved technique and apparatus for the melt-spinning of nylon in an atmosphere of steam to produce nylon fiber and yarn of superior quality.

For the most part, polyamide fiber and yarn of the type commercially available, is based either on nylon 66 derived from hexamethylenediamine and adipic acid, or or nylon 6, derived from caprolactam. The conversion of nylon chips or flakes into fiber is effected by the melt-spinning process wherein the melt is extruded through a spinneret to form filaments which are then cooled and solidified. These filaments are subsequently drawn to orient their molecular structure, with a resultant increase in tensile strength.

The nylon flakes used in melt-spinning have a water content determined by the amount of water remaining after polymer production, as well as the amount thereafter absorbed from the atmosphere. Since at elevated temperatures, the degree of depolymerization of polyamides in a function of the amount of water present, it has generally been the practice to dry the nylon flakes so as to reduce the water content before melt-spinning. Also, in the course of melt-spinning, dry nitrogen has been used to sweep away some of the water present during spinning. The need to pre-dry the flakes and the equipment entailed when melt-spinning under a positive pressure of nitrogen, contributes substantially to processing costs.

To avoid the necessity of pre-drying nylon flakes and melting them in nitrogen atmosphere, it has been known to introduce steam into the melting chamber, the steam serving to control the polymerization-depolymerization equilibrium, whereby yarn of good uniformity may be obtained. In apparatus heretofore employed for this purpose, steam from an external boiler is introduced into a melt chamber having a heater grid, the steam serving to blanket the polymer and to adjust the viscosity of the melt in relation to the water vapor pressure of the steam. The advantage of the steam process is that it becomes possible to use an untreated polymer flake having a moisture content as high as 6.5%, no special equipment being necessary either to precondition the flake or to melt it in an inert atmosphere. Thus substantial economies are effected in the melt-spinning process.

The difficulty with steam-operated melt processing apparatus of the prior-art type is that the steam is intermingled with the unmelted flake, thereby slowing down the reaction time and delaying the establishment of the desired equilibrium. Moreover, since the steam is derived from an external source, this calls for a relatively elaborate system of pipes, thermal insulation and pressure control means.

Accordingly, it is the main object of this invention to provide a melt-spinning process and apparatus wherein steam is generated within the chamber rather than in an external source, the steam pressure being maintained at a desired level.

Also an object of the invention is to provide an apparatus of the above type wherein the nylon is introduced into the steam chamber in molten form to accelerate its interaction with steam and to attain equilibrium more quickly.

Another object of the invention is to provide an apparatus of the above type wherein the melt pool in the chamber is maintained at a constant level by regulating the melt input thereto. Since the nylon is introduced into the chamber in molten form, it is not necessary to heat the pool to as high a temperature as would be required in grid systems wherein the nylon enters in flake form.

A significant advantage of the invention is that spinning is carried out under a positive water vapor pressure, the melt being spun under unvarying conditions of temperature, moisture and pressure to produce a yarn having uniform and optimum properties. It is important to bear in mind that if polymerization and de-polymerization is not in equilibrium, the resultant yarn varies in molecular weight and hence is non-uniform in tenacity and elongation. With the present invention, the various factors involved in the melt process are stabilized, and variations in the quality of the output are obviated.

Briefly stated, these objects are attained in an apparatus comprising a heated chamber wherein water is introduced into an evaporation pan, the water being vaporized to form steam whose pressure is maintained at a predetermined level by a relief valve which discharges steam from the chamber when the pressure level therein is exceeded, the steam reacting with the incoming stream of molten nylon which is fed into the chamber through a melt extruder, thereby forming a melt pool in the chamber, from which pool the molten nylon passes through a metering pump into a spinneret which extrudes the nylon in filamentary form. The operation of the melt extruder is controlled as a function of the melt pool level whereby the supply of molten nylon into the chamber is regulated to maintain a substantially constant pool level.

Another drawback in existing steam-operated melt processing apparatus, is that it is difficult to maintain the melt pool at a desired level relative to the steam in the chamber. The level of the pool in such steam systems is to some degree controlled by the metering pump which governs the depletion rate at which the melt is forced through the spinneret, and hence the rate at which the level of the pool is lowered. The pool level may be raised by elevating the temperature of the grid, thereby melting more polymer. However, a rise in temperature will also bring about an increase in degradation of polymer. Generally the grid is designed to melt only enough to feed the amount of polymer that the pump is metering. This imposes a practical limitation on the system.

For example, if the grid is melting enough to make 70 denier yarn and 140 denier yarn is desired, one of two changes must be made to accomplish this result. Either the speed of take-up must be cut in half or the capacity of the grid to melt must be doubled. (The pump can be run at twice the speed, or a larger pump can be used.) Since changing the take-up speed presents difficulties and raising the grid temperture in order to melt at a faster rate will degrade the polymer, the usual solution is to employ a grid of larger capacity.

In the present invention, the switch-over from 70 denier to 140 denier may be carried out more easily. Let us, for example, assume that the extruder used has a maximum capacity of 30 pounds per hour. If therefore 70 denier yarn is being made and taken up at a constant speed of say 1800 feet per minute, about 5 pounds per hour will

be needed; hence the extruder will be run at its slowest speed. If now we wish to make 140 denier, all that need be done is to increase the extruder screw speed to produce 10 pounds per hour and also double the speed of the metering pump or use a larger pump.

Obviously the screw melt system is much more flexible than the grid melt arrangement and carries out melting of the polymer at a much faster rate.

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawing, wherein the single figure schematically shows an apparatus in accordance with the invention.

Referring now to the drawing, the apparatus is constituted by two main components, namely a melt extruder, generally designated by numeral **10**, and a melt spinning chamber generally designated by numeral **11**. In the extruder **10**, the polymer in chip or flake form is supplied to a hopper **12**, from which it passes through the feed throat into the channel of the rotary screw conveyor **13** driven by a motor **14** through a gear reducer **14***a*. The barrel **15** of the conveyor is surrounded by suitable heating coils or bands **16**, **17** and **18** which are preferably operated electrically and serve to raise the temperature within the barrel to a degree sufficient to melt the nylon flakes. The temperature is measured by a thermocouple **18***a*. As the granules are conveyed along the screw channel they are melted, the melt being forced through a melter plate **18***b*.

The output of the screw conveyor communicates with the chamber **11** and terminates in a spinneret **19**. The direction of screw rotation is such as to convey the molten nylon in the direction of the spinneret, from which it is extruded in the form of a mono- or multi-filament stream **20**.

Chamber **11** is surrounded by heater bands **21**, **22** and **23** which serve to heat the space therein to a degree maintaining the stream of nylon fed therein in the molten state, the stream collecting within the chamber to form a melt pool **24**. Since the heat of the chamber is only that necessary to maintain the pool in a molten condition rather than to melt dry flakes as in prior arrangements, the chamber may be operated at a lower heat level with less degradation to polymer.

Also flowing into the chamber through a pipe **25** is a stream of water, preferably distilled, which is discharged within the chamber into a spreader-pan **26** positioned above the melt pool. The flow of water is adjusted by a valve **27** in the pipe line. The water received in the pan is quickly vaporized, the temperature in the chamber being well above 212° F. Thus steam is generated within the chamber, whereby the molten polymer in the pool is blanketed with an atmosphere of steam.

The amount of steam pressure within the chamber is regulated by a relief valve **28** of conventional design, which is set to discharge steam from the chamber when a predetermined pressure is exceeded. In practice, the pressure may be set at between 7 to 30 pounds per square inch gauge. The pressure setting depends on such factors as the nature of the polyamide being spun and the type of yarn being formed, the higher the steam pressure the higher the amount of water in the melt in equilibrium with the steam, and the lower the viscosity of the melt.

In general, the invention is operable with any polyamide which includes the polyesteramides. The polymer flakes used may have a relatively high moisture content, in the order of 4 to 7 percent, there being no need to precondition the flakes before spinning.

Since the nylon enters the chamber in a molten stream and is immediately exposed to the steam atmosphere, the desired condition of equilibrium is rapidly attained. The molten polymer is metered out of the chamber through a metering pump **29** of any known construction, which passes the melt continuously and at a constant rate to the spinneret assembly **30**, from which the nylon is extruded in the usual filamentary form.

To prevent decomposition, the inventory of polymer in the melt should be as small as possible, but the amount should be sufficiently large so that the melt is exposed to the steam before being metered out to establish equilibrium. The height of the melt pool in the chamber is maintained substantially constant by means of a suitable probe **32** whose tip is slightly above the desired level of the pool, such that if the pool touches the probe, a response is produced by electrical, mechanical or optical means to operate a sensing relay **33** connected to the control circuit of motor **14**. In this way the motor may be cut off or its speed reduced when the pool goes above the desired level, to arrest or slow down the operation of the screw conveyor until such time as the pool is lowered by operation of the metering pump **29**. Thus a closed feedback loop is formed between the motor-controlled extruder and the melt pool, to stabilize the level of the pool.

Thus molten nylon is fed in the chamber and is withdrawn therefrom at relative rates maintaining a desired pool level while the pool is subjected to steam pressure at a controlled level.

While there has been shown a preferred embodiment of nylon melt-spinning apparatus in accordance with the invention, it will be appreciated that many changes and modifications may be made therein without, however, departing from the essential spirit of the invention as defined in the annexed claims.

What is claimed is:

1. Apparatus for spinning polyamides, comprising:

(a) a melt extruder having a predetermined maximum capacity and including variable speed means to operate said extruder in a range extending from a minimum rate to a rate in accordance with said predetermined maximum capacity, an input and an output,

(b) means to feed polyamide flake into the input of said extruder,

(c) means to heat the flake within said extruder to a temperature level sufficient to melt same whereby said polyamide emerges from the output of said extruder in molten form,

(d) a steam treatment chamber,

(e) means coupling the output of said extruder to said chamber to introduce a stream of molten polyamide therein which collects as a melt pool,

(f) means to feed water into said chamber above said pool,

(g) means to apply heat to said chamber at a temperature level maintaining the molten condition of said pool and vaporizing said water to form steam subjecting said pool to steam pressure,

(h) means to regulate said steam pressure in said chamber to maintain a predetermined steam pressure level therein,

(i) a spinneret, and

(j) a metering pump intercoupling said chamber with said spinneret to pass said molten polyamide therethrough to form polyamide filaments, said pump being operable at different rates, the highest of which removes less of said molten polyamide from said chamber than said melt extruder is capable of introducing therein at its maximum capacity.

2. Apparatus as set forth in claim **1**, further including means to vary the feed of molten polymer into said chamber to maintain the pool at a desired level.

3. Apparatus as set forth in claim **1**, wherein said vaporization means includes an evaporation pan to receive water fed into said chamber.

4. Apparatus as set forth in claim **1**, wherein said means to maintain steam pressure at a desired level is constituted by a relief valve.

5. Apparatus as set forth in claim **1**, wherein said conveyor is operated by a motor which is controlled as a function of the level of the pool in said chamber.

6. Apparatus as set forth in claim 5, further including a probe to sense the level of the pool and means coupled to said probe to control motor operation.

References Cited by the Examiner

UNITED STATES PATENTS

2,437,703	3/1948	Moncrueff	18—8
2,571,975	10/1951	Waltz	18—8
2,692,405	10/1954	Gayler	18—8
2,747,224	5/1956	Koch et al.	264—176
3,010,147	11/1961	Davies et al.	264—176
3,093,445	6/1963	Freeman	264—176
3,110,930	11/1963	Beck	18—8

FOREIGN PATENTS

628,935	10/1961	Canada.
752,665	7/1956	Great Britain.

WILLIAM J. STEPHENSON, *Primary Examiner.*

ALEXANDER H. BRODMERKEL, *Examiner.*

K. W. VERNON, L. S. SQUIRES, *Assistant Examiners.*