May 30, 1967 J. D. HARNDEN, JR., ETAL 3,322,933

SYNTHETIC FIBER PROCESSING MACHINE

Filed Jan. 16, 1964 2 Sheets-Sheet 1

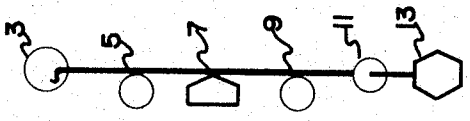


FIG. 1

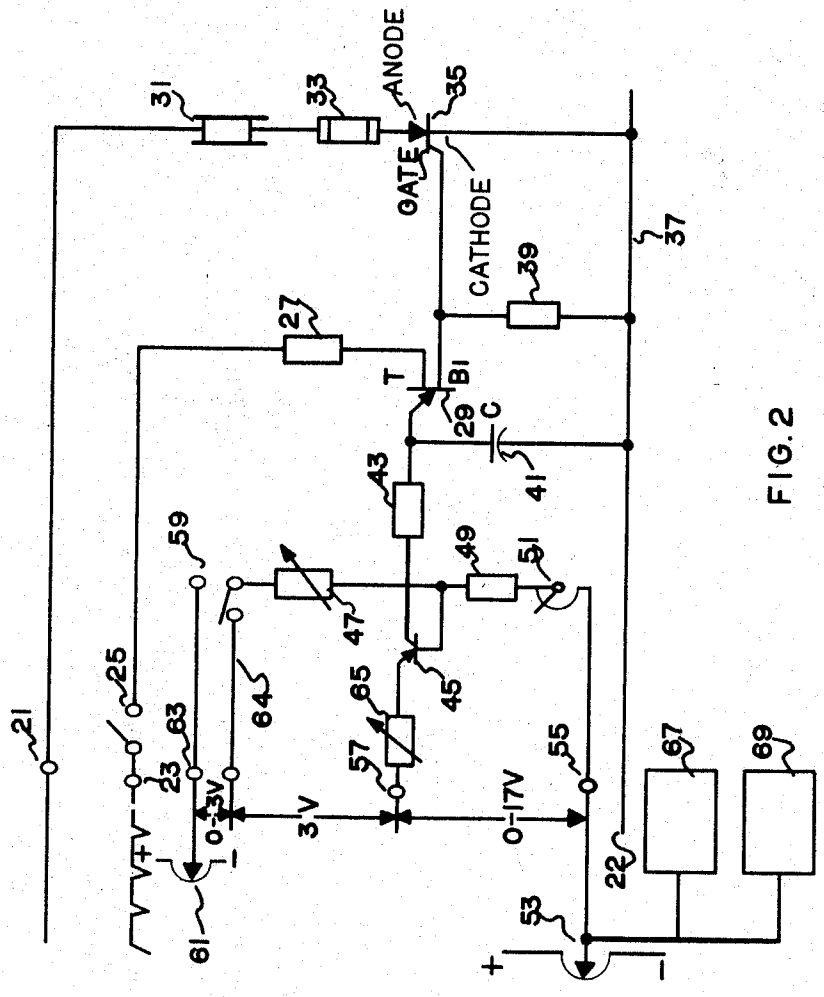


FIG. 2

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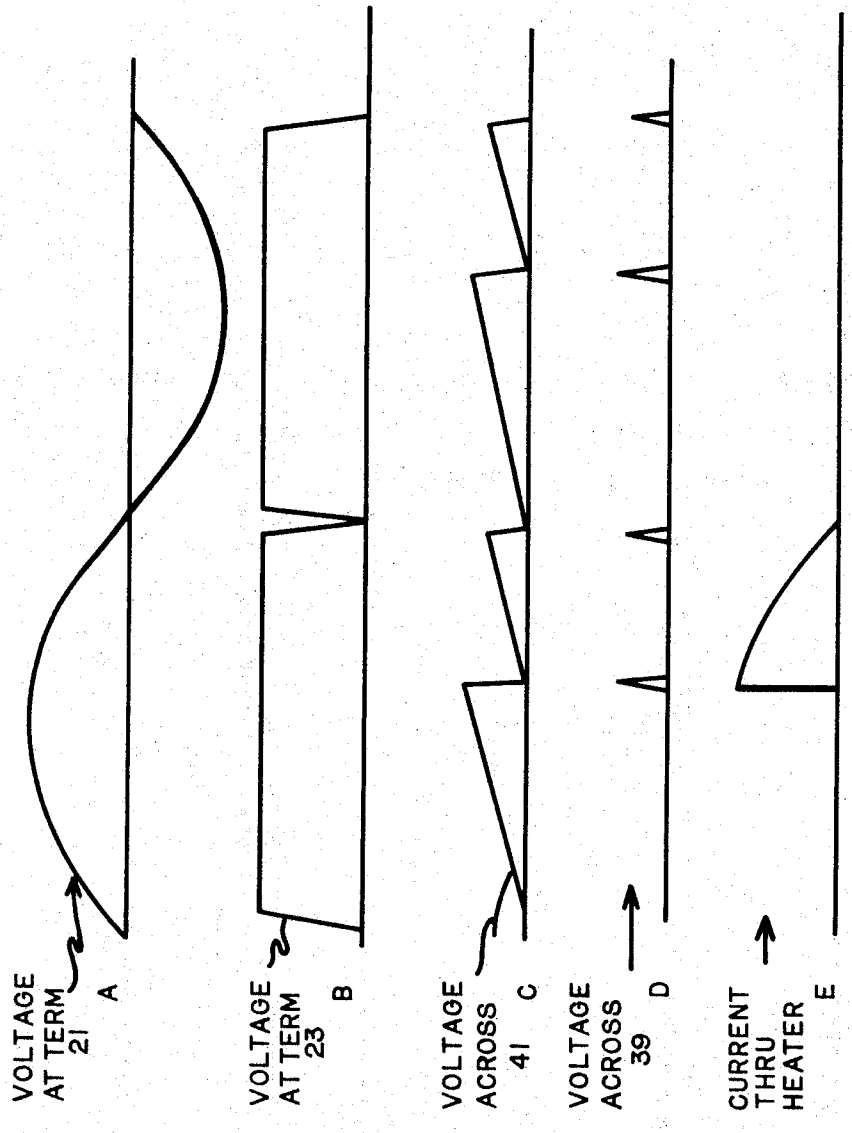


FIG.3

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United States Patent Office 3,322,933 Patented May 30, 1967

3,322,933

SYNTHETIC FIBER PROCESSING MACHINE

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Filed Jan. 16, 1964, Ser. No. 338,209
1 Claim. (Cl. 219—501)

This invention is directed to a synthetic fiber processing machine and more particularly to a synthetic fiber processing machine for closely controlling the temperature of fibers during the draw process.

Fine synthetic fibers obtained directly from spinning or extrusion processes require further processing to obtain the desired smaller deniers. This further processing is usually carried out on a draw twist machine where the fiber is heated to raise the fiber to a temperature just below its melting point, while the fiber is under tension. Due to the tension while it is heated the fiber is reduced by a drawing process to a smaller diameter or denier. The fiber may be heated prior to being drawn to prepare it for the draw process, and may also be heated after being drawn for annealing.

The temperature of synthetic fibers has been controlled during the draw process in the past in a number of ways. The most common way has been to put a series rheostat in the power supply to each heater to control the power supplied to each heater, and thus the temperature of the fiber being drawn. There is no temperature feedback in such a machine so that it is responsive to fiber loading and changing ambient conditions. Another way has been to apply power to each heater, and provide a temperature feedback to turn the power off when the temperature rises above a predetermined value, and to turn the power on when the temperature falls below a predetermined value. It is impossible to maintain a straight line temperature function, with such control, and the temperature varies widely. It has not been possible to keep close control of the temperature of the fiber, nor of the surface temperature of the various rolls, plates and pins used in heating the fibers during the draw process. It has also been difficult to reproduce the temperature settings during subsequent draw, and subsequently there have been variations in the quality of the fibers produced. It has also been difficult to maintain low long term drift and reliability.

It is therefore an object of this invention to provide a new and improved synthetic fiber processing machine which provides a straight line temperature function during the draw process.

It is another object of this invention to provide a new and improved synthetic fiber processing machine which will closely control the surface temperature of the various rolls, plates and pins used in the heating of fibers during the draw process.

Another object of this invention is to provide a new and improved synthetic fiber processing machine for controlling the temperature of fibers during the draw process which is responsive to fiber loading and changing ambient conditions.

Yet another object of this invention is to provide a new and improved synthetic fiber processing machine which will control the temperature of fibers during the draw process by providing reproductibility of temperature setting.

Still another object of this invention is to provide a new and improved synthetic fiber processing machine which will control the temperature of fibers during the draw process by maintaining low long term drift and reliability.

Synthetic fiber processing machines have several positions so that several fibers are drawn at the same time,

and then twisted together to make the finished thread. The temperature of the heating elements for the different positions has tended to vary from position to position, resulting in variations in the thread quality.

It is therefore an object of this invention to provide a new and improved synthetic fiber processing machine which will maintain the same temperature at the different positions of the machine during the draw process.

In brief then the temperature of the fiber heated by a heating element is sensed during the draw process. The application of constant power to the heating element is controlled to maintain the temperature of the fiber at a predetermined value, in response to the sensing of the temperature. Where there are a plurality of fibers being drawn the predetermined values of each position may be controlled simultaneously to insure that the temperature at each position is the same.

The invention is set forth with particularity in the appended claims. The principles and characteristics of the invention, as well as other objects and advantages are revealed and discussed through the medium of the illustrative embodiments appearing in the specification and drawings which follow.

In the drawings:

FIGURE 1 is a diagrammatic representation of a synthetic processing machine.

FIGURE 2 is a schematic of the synthetic fiber processing machine constructed according to this invention.

FIGURE 3 shows the waveforms used in controlling the machine shown in FIGURE 2.

Referring first to FIGURE 1 for a brief description of the operation of a typical synthetic fiber processing machine, the fiber to be processed is taken directly from the spinning process of a raw fiber package **3**. The fiber may then pass through one or more tension devices and takes several wraps about the feed roll **5**. The feed roll **5** may or may not be heated, depending on the specific process involved. If heated, the purpose is to bring the fiber up to a temperature close to the "drawing" temperature. The thread is then passed over a heated flat plate **7** to raise the fiber to a temperature just below its melting point. The draw roll **9** runs at a surface speed higher than that of the feed roll to put the fiber under a tension. Due to the tension, the diameter or denier of the heated fiber is reduced between the draw roll and the feed roll. The ratio between the surface speed of the feed roll and the draw roll is called the draw ratio and varies from 1.5 to 8 depending on the desired denier. The draw roll **9** may also be heated to perform annealing and shrinking functions. The fiber then passes onto a twisting ring **11** where fibers from several draw rolls are twisted together, and put into the finished package **13**.

Three elements of the machine may be heated—the feed roll **5**, the plate heater **7**, and the draw roll **9**. The temperature of each must be regulated to a predetermined value and corresponding identical value. The heaters used for heating the elements are usually electrical resistance heaters such as the heater **31** in FIGURE 2. The application of the heaters to the rolls, pins, and plates varies. Some rolls are heated from stationary cylinderical heaters mounted inside the rolls, while others have the heaters imbeded in the rolls with power supplied by slip rings. The flat plate heaters and the pin heaters vary from simple tube heaters attached to a metal base to "calrod" type elements cast into aluminum, copper or steel shells. The manner in which the electrical heater is applied to the heated element may be carried out in any suitable manner.

The temperature of the heater is sensed by a suitable electrical detector such as thermocouples, resistance temperature detectors, or thermistors. A thermistor is employed in the embodiment described herein. The embodiment described herein senses the heater temperature but

the temperature of the roll, plate, pin or fiber itself may also be sensed. The thermistor is placed in a position to sense the temperature of the heated element such as imbedding the thermistor in the heater block. The thermistor provides a signal which is a function of the temperature of the heated element.

Referring now to FIGURE 2, a 60 cycle A.C. power supply is applied to terminals **21** and **22**. The waveform applied to terminal **21** is shown as waveform A in FIGURE 3. A square wave in synchronism with the 60 cycle A.C. waveform A is applied to terminal **23**, as shown in FIGURE 3, waveform B. Terminal **23** is connected through an on-off switch **25** and resistor **27** to base **2** of unijunction transistor **29**. Terminal **21** is connected through electrical heater **31** and fuse **33** to the anode of silicon controlled rectifier **35**. The cathode of the silicon controlled rectifier **35** is connected to common buss **37**, which is in turn connected to terminal **22**. The gate of the silicon controlled rectifier **35** is connected to base **1** of unijunction transistor **29** and through resistor **39** to common buss **37**. The emitter of unijunction transistor **29** is connected through capacitor **41** to common buss **37** and through resistor **43** to the collector of PNP transistor **45**. The base of transistor **45** is connected to thermistor **47** and through a 1100 ohm resistor **49** to a trim rheostat **51**. Trim rheostat **51** is connected to a potentiometer **53** which may be adjusted to provide a variable 0 to 17 volts between terminals **55** and **57**. Potentiometer **53** is connected to a D.C. power source. Thermistor **47** is connected through a fiber break switch **59** to a buss **64**. When the fiber at that specific position breaks the fiber break switch **59** is connected to terminal **63**. A variable 0 to 3 volt supply is connected between terminals **63** and buss **64**. A fixed 3 volt supply is connected between terminals **57** and **64**. Rheostat **61** is connected to terminal **63** and to a D.C. power source. Terminal **57** is connected through variable resistor **65** to the emitter of transistor **45**.

The thermistor **47**, the sum of the 1100 ohm resistor **49** and the trim rheostat **51**, the 3 volt power supply between terminals **64** and **57**, and the 0–17 volt variable power supply between terminals **55** and **57** form four legs of a bridge circuit.

A plurality of heater controls identical to the heater control just described may be connected in parallel at the terminals **23**, **63**, **64**, **57**, **55** and **22**. When so connected the group control potentiometer **53** simultaneously adjusts the 1–17 volt leg of the bridge circuit in each heater control. Two heater controls **67** and **69** are shown in block form connected in this manner.

The desired temperature is set by adjusting the trim rheostat **51** and the group control potentiometer **53** to adjust the 0–17 volt leg of the bridge. The bridge is balanced when the ratio of the thermistor's 47 ohms divided by the ohms of the 1100 ohm resistor **49** and the trim rheostat **51** is equal to the ratio of the 3 volt power supply to the actual voltage on the 1–17 volt power supply.

After the fiber has been placed in position for the draw process the on-off switch **25** is closed. The bridge circuit is unbalanced as the temperature of the fiber is below the desired temperature. The error signal from the bridge circuit turns transistor **45** on, providing a current to charge capacitor **41** to a positive potential as shown in waveform C, FIGURE 3, if the waveform applied to base **2** of unijunction transistor **29** is positive as shown in waveform B, FIGURE 3. When the voltage across capacitor **41** reaches the proper value, unijunction transistor **29** fires, generating a voltage pulse across resistor **39** as shown in waveform D, FIGURE 3. The voltage pulse across resistor **39** is applied to the gate electrode of silicon controlled rectifier **35** to trigger the silicon controlled rectifier **35** on if a positive signal is applied to terminal **21** as shown in waveform A, FIGURE 3. Line voltage is then applied to the heater **31** for the rest of that half cycle, as shown in waveform E, FIGURE 3, to raise the temperature of the heater **31**. At the end of the half cycle the voltage at terminal **23** momentarily goes to zero, as shown in waveform B, FIGURE 3, causing unijunction transistor **35** to fire, discharging capacitor **41**.

At the end of the half cycle, the silicon controlled rectifier **35** turns off as the anode becomes negative with respect to the cathode, as the current falls below the holding current value.

The signal applied to the silicon controlled rectifier **35** is a 60 cycle A.C. signal. Thus, for half of each cycle a negative signal is applied to the anode and a positive signal applied to the cathode of the silicon controlled rectifier **35**. For the other half cycle a positive signal is applied to the anode and a negative signal applied to the cathode of the silicon controlled rectifier **35**. During the half cycle that a positive signal is applied to the anode, the silicon controlled rectifier **35** is forward biased so that when a trigger pulse is applied to the gate electrode from base **1** of the unijunction transistor the silicon controlled rectifier is turned on.

During the first half cycle of each cycle the error signal from the bridge circuit causes the silicon controlled rectifier to be turned on to apply power to the heater **31**. As the actual temperature approaches the desired temperature the silicon controlled rectifier is turned on later in the half cycle to apply less power to the heater **31**. When the actual temperature reaches the desired temperature, the system will stabilize with the silicon controlled rectifier turned on for a small portion of each half cycle only to apply constant power to the heater **31** to maintain the temperature constant. As the heat load changes due to fiber loading, or ambient changes, the silicon controlled rectifier will be turned on at different times in the half cycle due to changes in the error signal from the bridge circuit to keep the temperature of the heater **31** constant.

Potentiometer **53** may be changed to change the 0–17 volt power supply leg of the bridge circuit of each of the heater controls to change the desired temperature of the heaters.

During normal operation a temperature gradient exists between the sensing point and the fiber. If the fiber breaks removing the heat load, the surface of the heating element will rise to an undesirably high temperature. Thus when the fiber breaks the fiber break switch **59** will connect terminal **23** instead of buss **64**, applying a bias signal into the bridge circuit forcing it to balance at a lower temperature. The magnitude of the bias signal is selected with potentiometer **61**. The amount of temperature cut back required is a function of the operating temperature.

The silicon controlled rectifier **35** may also be supplied from fullwave rectified A.C., and it will then conduct on each half cycle.

In summary, a new and improved synthetic fiber processing machine has been described. Any change in temperature is immediately sensed, and the heater changed accordingly. The temperature of the heaters of several heater controls may be changed at a central location to maintain a constant and equal temperature on several heaters.

While the invention has been explained and described with the aid of particular embodiments thereof, it will be understood that the invention is not limited thereby and that many modifications retaining and utilizing the spirit thereof without departing essentially therefrom will occur to those skilled in the art in applying the invention to specific operating environments and conditions. It is therefore contemplated by the appended claim to cover all such modifications as fall within the scope and spirit of the invention.

What is claimed is:

In a synthetic fiber processing machine for closely controlling the temperature of fibers during the draw process, means for heating a fiber, an A.C. power supply for said heating means, a silicon controlled rectifier connected between said A.C. power supply and said heating means, a bridge circuit having a thermistor in one leg

therein for sensing the temperature of the fiber heated by said heating means and a variable resistance in another leg for indicating a desired predetermined value, said bridge circuit producing an error signal varying according to the difference between the sensed temperature and a predetermined value, a transistor tuned in by an error signal from said bridge circuit, a capacitor charged to a positive potential through said transistor, a unijunction transistor fired to produce a voltage pulse when the potential across said capacitor reaches a predetermined value, means for applying the voltage pulse from said unijunction transistor to the gate electrode of said silicon controlled rectifier to fire said silicon controlled rectifier so that power from said A.C. source is applied to said heating means during a portion of a half cycle to maintain the temperature of said predetermined value, means for indicating if a fiber breaks, and means responsive to an indication of a broken fiber for applying a bias signal into said bridge circuit so that said bridge circuit balances at a lower indicated temperature.

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