Feb. 24, 1953 H. E. PECK 2,629,162

METHOD AND APPARATUS FOR HEAT-TREATING TEXTILE FABRICS

Filed Oct. 27, 1949 3 Sheets-Sheet 1

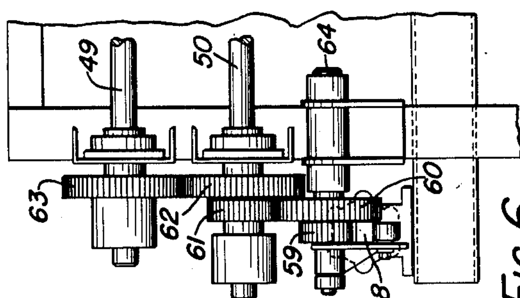

FIG. 6.

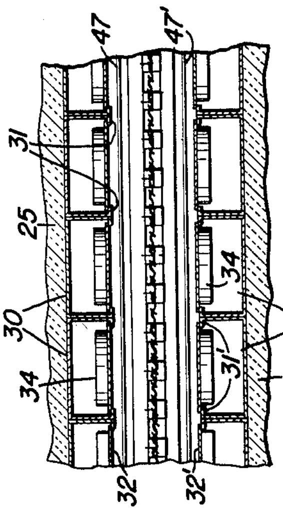

FIG. 3.

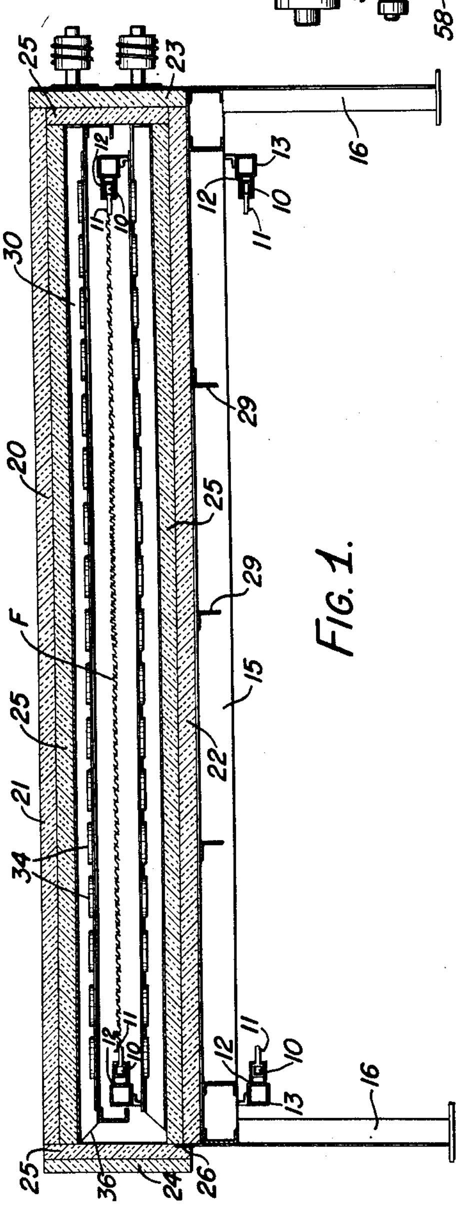

FIG. 1.

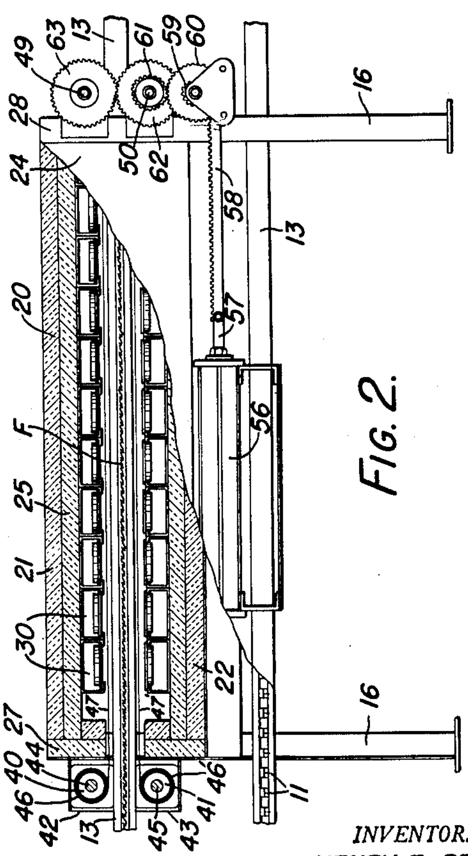

FIG. 2.

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METHOD AND APPARATUS FOR HEAT-TREATING TEXTILE FABRICS

Filed Oct. 27, 1949 3 Sheets-Sheet 2

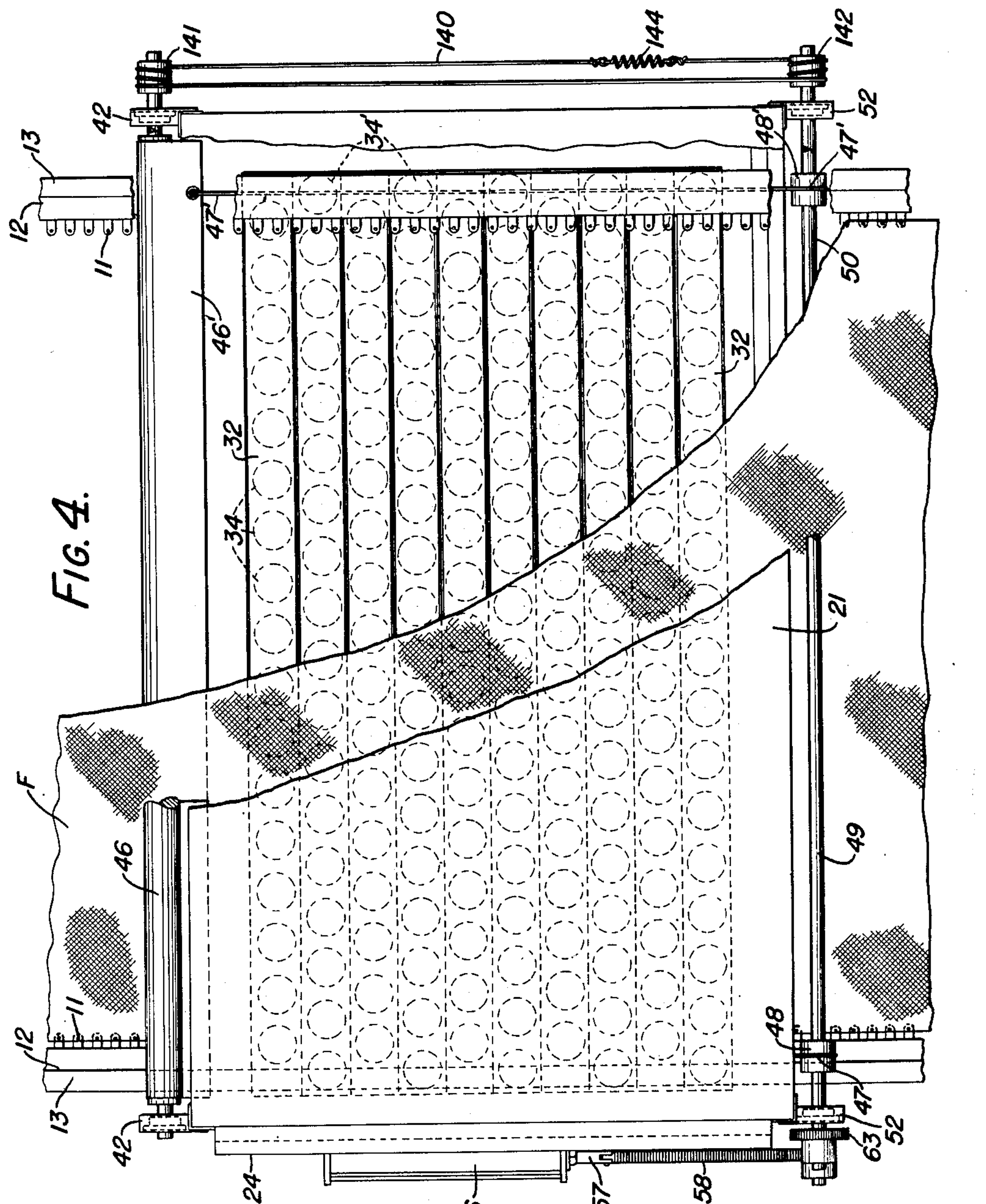

FIG. 4.

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METHOD AND APPARATUS FOR HEAT-TREATING TEXTILE FABRICS

Filed Oct. 27, 1949 3 Sheets-Sheet 3

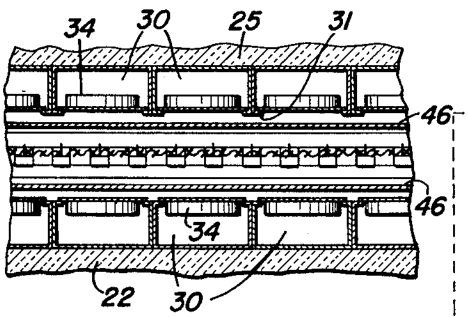

FIG. 5.

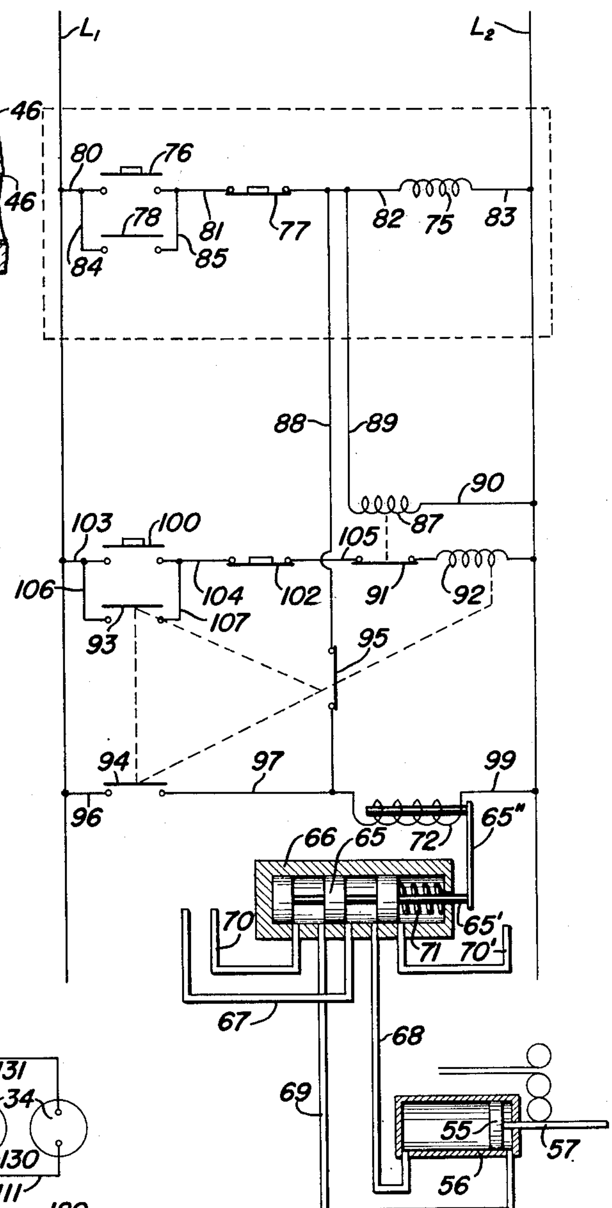

FIG. 7.

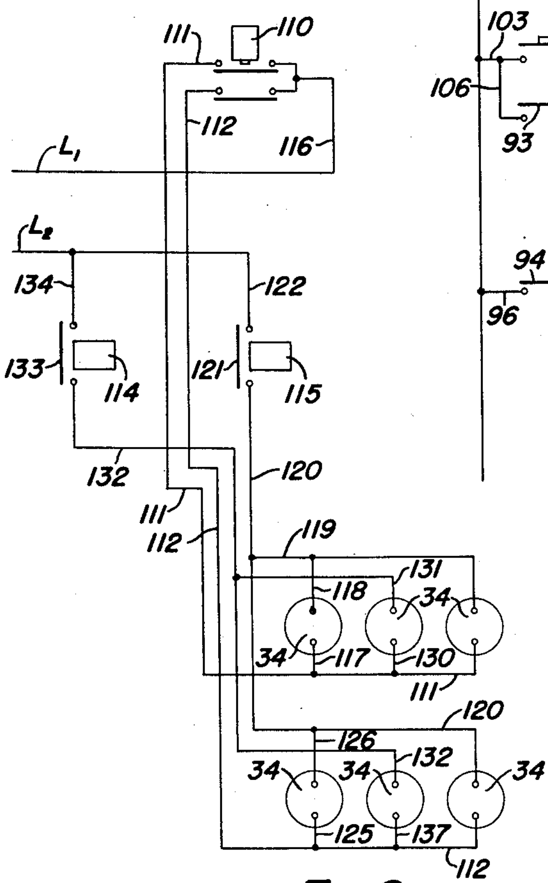

FIG. 8.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR HEAT-TREATING TEXTILE FABRICS

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Application October 27, 1949, Serial No. 123,925

8 Claims. (Cl. 26—1)

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The present invention relates to a method and apparatus for heat-treating textile fabrics and more particularly to a method and apparatus for heat-treating thermoplastic fabrics, such as "nylon," to bring about the physical changes required to give the fabric a dimensional stability or "set," and to give the fabric such other desirable physical characteristics as will result from proper heat-treating.

So far as I know the conventional method of heat-treating or setting nylon is to wind the fabric loosely on a core or roll and to place the core or roll in an autoclave to which steam at 5 lbs. to 25 lbs. per square inch pressure is admitted. The material is held in this steam atmosphere for a period of a few minutes to half an hour. This method of heat-treating the fabric produces satisfactory results but is slow because only one batch of the fabric can be heated at a time; it is not continuous.

Efforts have been made, therefore, to develop a process and a machine for continuously heat-treating or setting nylon and similar fabrics. According to one idea, the fabric is made to make a 180° wrap around a roll, which is run at the speed of travel of the fabric, and which is heated by a liquid or vapor medium inside the roll. The temperature is controlled by a potentiometer controller actuated by a thermocouple in the roll surface. Difficulties have been experienced, however, in controlling the heat in this machine; and, moreover, this machine has the disadvantage that the material cannot be stretched or tensioned crosswise as it moves over the roll.

Another idea involves running the fabric through an oven on a pin tenter-frame conveyor. A fuel gas burner is fired directly into the upper chamber of this oven; and the products of combustion combined with air are blown by means of fans down onto the fabric as it is carried on the tenter-frame conveyor through the oven. Again, however, difficulty has been experienced in controlling the heat. Stratification of high temperature streaks in the atmosphere of the oven is bound to take place in spite of the mixing action of the fans. Since it is necessary, in order to effect setting, to bring the fabric temperature up to a temperature close to that at which it may be damaged by oxidation or melting, this lack of temperature uniformity is very detrimental. The entire oven temperature must be held below the temperature at which nylon melts so that if it becomes necessary to stop the fabric in the oven it will not burn up. However, when the oven temperature is held at this

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level, a relatively long period of exposure is required to bring the fabric up close to this level with the result that the fabric is exposed to high temperature for so long that oxidation, evident by yellowing, begins to occur.

The primary object of the present invention is to provide a method and machine for heat-treating fabrics in which the fabric can be treated continuously and brought up rapidly to the desired temperature without danger of burning.

Another object of the invention is to provide a method and machine for heat-treating fabrics in which the fabric is heated by radiant heat applied over a large area and at such a relatively low temperature that burning will be prevented.

Another object of the invention is to provide a machine for heat-treating nylon and similar fabrics in which the fabric will be protected from burning, even if the mechanism for conveying the fabric through the heat-chamber is stopped for any reason.

Further objects of the invention are to provide a machine for heat-treating fabrics which will be simple in construction and which may be operated at a relatively low cost.

Other objects of the invention will be apparent hereinafter from the specification and from the recital of the appended claims.

In the process and machine of the present invention, the fabric is carried by a standard pin tenter-frame conveyor through a heating chamber while heat is transmitted to the fabric by direct radiation. Instead of using infra-red lamps or the like for heating the fabric, however, I employ heated metal plates, which are located parallel to the fabric and positioned a few inches above and below it. The metal plates may be heated by disc heaters or in any other suitable manner. The temperature level of the plates may range from 600° to 900° F. for nylon. Other temperatures may be employed for other materials but in such range that the peak of the radiation emission at the temperatures employed substantially coincides with the highest absorption wave-length band for the material being treated.

One result of this relatively low temperature heat source is that the rate of heat transfer drops off rapidly as the fabric approaches the temperature of the plates. This is because the rate of transfer of radiant heat is proportional to the difference in the fourth power of the absolute temperatures. The rapid diminution of heat transfer, as the desired temperature is approached, provides a self-regulating effect which greatly diminishes the harmful effects of irregularity in temperature. Another benefit of use of low-temperature plates is that heat distribution is more or less independent of the distance from the heat source to the fabric, instead of being proportional to the square of the distance, as in the case of heat lamps, so that uniform distribution of temperature is easily achieved. Since the fabric is held by the tenter-frame conveyor under tension in all directions, with the method and machine of the present invention, then, the desired set can be achieved easily without danger of harming the fabric.

In the drawings:

Fig. 1 is a transverse sectional view taken through the heat chamber of a machine built according to one embodiment of the invention;

Fig. 2 is a view at right angles to the section of Fig. 1, parts being broken away to show a partial longitudinal sectional view through the heating chamber;

Fig. 3 is a fragmentary longitudinal sectional view on a greatly enlarged scale;

Fig. 4 is a plan view of the heating chamber and adjacent parts of the machine, part of the upper heating plates, and upper curtain rods being broken away to show the fabric and tenter-frame conveyor, and part of the fabric and conveyor being broken away to show the lower plates and lower curtain and rods;

Fig. 5 is a fragmentary longitudinal sectional view, similar to Fig. 3, but showing the curtains drawn over the heating plates;

Fig. 6 is a fragmentary detail view showing the drive to the curtain rollers;

Fig. 7 is an electrical diagram showing the interlock between the main motor of the machine and the curtain-actuating mechanism; and

Fig. 8 is a fragmentary electrical diagram showing the controls for certain of the heaters and the connections between these controls and the heaters.

Referring now to the drawings by numerals of reference, 10 denotes a conventional tenter-frame conveyor comprising two parallel endless chains whose links are provided with tenter pins or hooks 11. The chains are adapted to travel in channels 12 (Fig. 1) which are supported by rails 13 that may be secured in any suitable manner to the frame 15 of the machine. The frame is supported by legs or uprights 16.

The nylon or other fabric F, which is to be heat-treated, is fastened to the hooks of the tenter frame so that it may be stretched both transversely and lengthwise to the desired degree by the tenter frame which is shown only fragmentarily in the drawings.

Between the ends of the machine there is provided a heating chamber 20. This comprises the upper and lower walls 21 and 22, a side wall 23, and a door 24 which closes the side of the chamber opposite to side wall 23. These constitute an outer jacket. Each of the walls 21, 22 and 23 and the door 24 is lined with suitable insulating material 25. The door 24 and its lining is hinged at 26 to the chamber. The chamber itself is supported by the longitudinal beams 29 of the machine.

Secured to the upper wall of the heating chamber are a plurality of identical, inverted U-shaped channel members 30. The depending legs of these channel members have inturned flanges 31 (Fig. 3) at their lower ends. The flanges 31 of each channel member provide rests and guides for a heating plate 32 to the back of which is secured a plurality of standard disc heaters 34.

Secured to the lower wall 22 of the heating chamber are plurality of other identical U-shaped channel members 30′, which may be identical to the channel members 30, but which are mounted in the reverse relation to the channel members 30, that is, with their open ends at the top. These channel members are provided with inturned flanges 31′ on which rest the lower heating plates 32′. To the back of each of these plates is secured also, a plurality of standard heating discs 34.

Each plate 32 or 32′ is adapted to be slid into and out of a channel member through the door 24 of the chamber. To this end, each channel member is open at one end, as shown at the left in Fig. 1, and beveled off as denoted at 36 so that the plates 32 or 32′ can easily be slid into or out of it.

The upper plates 32 are disposed to be spaced a few inches above the fabric traveling through the heating chamber and the lower plates are disposed to be spaced a few inches below the material. The disc heaters 34 heat the plates by conduction and the plates transfer their heat to the material by radiation. The several plates 32 and 32′ provide relatively large heating areas above and below the fabric being conveyed through the heating chamber. The plates are heated by the heaters 34 to a temperature preferably between 600° and 900° F., as already stated. Because of the large area of the plates, the heat is transmitted evenly to the fabric as it travels between the plates; and because of the low temperature of the plates the rate of heat transfer drops off rapidly as the fabric approaches the temperature of the plates. This is because the rate of transfer of radiant heat is proportional to the difference in the fourth power of the absolute temperature. These two factors protect the fabric against burning in normal operation.

It sometimes happens, however, that a breakdown occurs or that the machine must be shut down with fabric between the upper and lower plates. To protect the fabric in the heating chamber during shut-down, two curtains 46, 46′ (Figs. 2, 4 and 5) are provided that are made of very thin brass, aluminum or a similar reflecting metallic material. These curtains are adapted to be drawn between the upper and lower heating plates and the upper and lower sides, respectively, of the fabric. They are normally wound on the rolls 40 and 41 which are secured to shafts 44 and 45, respectively, that are journaled in brackets 42 and 43, respectively, that are secured to the front end wall 27 of the heating chamber. A pair of parallel cables 47 connect the upper curtain 46 with rolls 48 that are secured adjacent opposite ends of a shaft 49 that is suitably journaled in brackets 52 (Fig. 4) that are secured to the side wall 28 of the heating chamber. A pair of similar parallel cables 47′ are connected at one end to the lower curtain 46′ and at their opposite end to rollers 48′ to wrap around said rollers. Rollers 48′ are secure adjacent opposite ends of a shaft 50 which is journaled in brackets 52′ also secured to side wall 28 of the heating chamber. Shafts 44, 45, 49 and 50 are parallel.

The curtains are normally rolled up on rollers 40 and 41 but may be unrolled by actuation of a piston 55 (Fig. 7) that is reciprocable in a cylinder 56 (Figs. 2 and 7) which is suitably mounted on the frame of the machine. There is a piston rod 57 secured to the piston which is connected to a rack 58. This rack meshes with a spur pinion 59. This pinion is secured to a stub shaft 64 to which is fastened spur gear 60. This gear meshes with a pinion 61 which is secured to shaft 50. There is also a spur gear 62 secured to this shaft. The spur gear 62 meshes with a spur gear 63 on shaft 49. When the piston 55 is moved in one direction, therefore, the curtains are drawn and when it is moved in the other direction the curtains are rolled up.

The direction of movement of the piston 55 is controlled by a reciprocable valve 65 (Fig. 7) which reciprocates in a valve head 66. In the position shown in Fig. 7 compressed air is supplied from the duct 67 through the duct 68 to the left hand end of the cylinder 56, and air is exhausted from the right hand end of the cylinder 56 through the duct 69 and the exhaust duct 70. The numeral 70′ denotes a second exhaust duct leading from the valve chamber. Compressed air may be supplied to duct 67 from a main line in the shop or from any other suitable source. The valve 65 is spring pressed in one direction by coil spring 71 and is adapted to be moved in the opposite direction by energizing the coil 72 to which the valve stem 65′ is connected by any suitable connection 65″.

The machine may be wired as illustrated diagrammatically in Fig. 7 to insure shifting of the valve 65 and drawing of the curtains should the main motor of the machine stop for any reason.

75 denotes the starter coil of the main motor, that is, the motor which drives the tenter frame. The numeral 76 denotes the start button; and 77 is the stop button for this motor. The numeral 78 denotes the hold-in switch for the hold-in circuit to the motor when the start button is released. L_1 and L_2 are the main lines. When the start button is pushed in, a circuit is made from the main line L_1 through line 80, start button 76, line 81, normally-closed stop button 77, line 82, starter coil 75, and line 83 to main line L_2. This starts the motor. The circuit to the motor is maintained after starting through a conventional controller which comprises the hold-in contact 78 that bridges the lines 84 and 85. When the start button 76 is closed, a circuit is also made from the main line L_1 through line 80, button 76, line 81, button 77, line 88, normally-closed switch 95, coil 72, and line 99 to main line L_2. This energizes coil 72 to hold the valve 65 in the position shown in Fig. 7 with the curtains rolled up. If for any reason the main motor stops, the circuit to coil 72 is broken; and the spring 71 shifts the valve 60, causing the curtains to be unwound and disposed in front of the heating plates.

When the main motor is stopped, the curtains can be drawn by pushing in button 100. This establishes a circuit from main line L_1, through line 103, button 100, line 104, normally-closed stop button 102, line 105, normally-closed switch 91 and coil 92 to main line L_2. This causes coil 92 to be energized, opening normally-closed switch 95 and closing normally-open switches 93 and 94. This establishes a circuit from main line L_1 through line 96, now-closed switch 94, line 97, coil 72 and line 99 to main line L_2, energizing coil 72 and causing the curtains to be rolled up. The switch 93 operates, when closed, to maintain this circuit. This circuit may be broken by pushing stop button 102.

If the main motor is started with the curtains drawn, the circuit to coil 72 is broken, deenergizing coil 72 and permitting spring 71 to shift valve 65 to the right from the position shown in Fig. 7 so that the curtains are rolled up. This happens because on starting of the main motor, coil 87 is energized from main line L_1 through start button 76, line 81, stop button 77, line 89, coil 87, and the line 90 to main line L_2. Energizing of coil 87 causes normally-closed switch 91 to be opened, breaking the circuit to coil 92, allowing switches 93 and 94 to open and switch 95 to close. Opening of switch 94 opens the circuit to coil 72. Therefore, the curtains are rolled up.

Tension on the curtains is provided all times by cables 140 which are wrapped around rollers 141 and 142 and whose ends are secured to a coil spring 144 (Fig. 4).

To achieve uniform setting of the fabric out to its edges, it has been found that higher temperatures should be provided at the sides of the fabric than in the center of the fabric. The higher temperature at the edges of the fabric can be achieved in various ways. For instance, the heaters 34 which are close to the edges of the tenter-frame conveyor may be constructed to have greater wattage than the other heaters, or all of the heaters may be wired to provide multiple stages of heat and those, which lie above and below the edges of the fabric may be set to maximum temperature while the others are adjusted to a lower temperature.

As illustrated, there are ten plates 32 in the upper portion and ten plates 32′ in the lower portion of the heating chamber; and seventeen or eighteen heaters 34 secured to each plate.

Fig. 8 shows one way in which the heaters may be wired so that they may be manually controlled. The numeral 110 denotes a manually-operated double-bladed switch controlling lines 111 and 112, which lead to the upper and lower rows of heaters, respectively. The main lines are designated L_1 and L_2. The numerals 114 and 115 denote single-bladed switches for controlling, respectively, different heaters in a particular row of heaters, that is, different heaters attached to a single plate 32 or 32′. The switch 114 controls the heaters in the center of the row or plate; the switch 115 controls the heaters at the edges of the row. When the switch 110 is pressed in and the switch 115, which controls the heating discs 34 at the sides of the row, is closed, a circuit is made from the main line L_1 through the line 116, the double-bladed switch 110, line 111, line 117, two outside heating discs 34 of an upper plate 32, the line 118, line 119, line 120, the blade 121 of switch 115, the line 122 to the main line L_2. Simultaneously a circuit is made from the line 112, through the line 125, two outside discs 34 of the opposed lower plate 32′, line 126, to the line 120. Likewise, when the switch 114 is closed, circuits are made from the main line L_1 through the line 116 switch 110, line 111, line 130, central heating disc 34, line 131, line 132, switch blade 133, and line 134 to the main line L_2, and simultaneously from the line 132 through the opposed lower disc 34, line 137, and line 112, push button 110 and line 116 to the main line L_1.

This diagram illustrates how three discs in the same row or plate are interconnected for control. Obviously the discs of other rows or plates can be similarly wired.

If desired, thermostatic control switches may be used to control the temperatures of the various rows of heaters, once the rows have been connected to the source of electrical energy by the manually-operated start buttons 110, 114 and 115, the thermostatic control switches being interposed in the lines to the heaters. The thermostatic switches then insure maintenance of the desired temperatures at the heaters.

For fabrics of different widths, different numbers of heaters will be used on each plate. For a narrower fabric, for instance, not all the heaters of a row or plate need be employed. For different types of fabrics, various numbers of heating plates will be used. One fabric may be heat-treated faster than another and so only part of the plates in the heat chamber need be heated for the fabric which is subject to faster heat-treatment.

The temperature of upper and lower heating surfaces can be varied by varying the numbers of heaters turned on. Moreover, the position of the curtain can be changed so that by drawing it part way into place, certain of the plates **32** and **32'** may be shielded to affect the heat radiated to the fabric. Furthermore, the rate of travel of the fabric can be varied. For nylon a rate of travel of 20 to 25 yds. per minute is quite satisfactory although the fabric can be run faster by increasing the length of the heating chamber which means, in the structure shown, increasing the number of heating plates, that is, increasing the distance over which the fabric is exposed to heat. The heating elements are located and connected in such fashion that the required additional temperature at the sides of the fabric can be produced by any one of a number of locations at will, and the length of effective heating plates in the direction of travel of the fabric can be changed by turning off entire rows of heaters so that different weights of fabrics can be accommodated without varying the plate temperatures.

While the controls for the heating elements are described as manually operated, obviously they might be made automatic. Obviously, also, a standard low temperature radiation pyrometer may be used if desired to control the number of plates **32**, which are energized and thereby the effective length of the heating chamber. It will further be understood that instead of heating the plates by electric disc heaters, they can be heated by other means, such as vapor or liquid, or by burning fuel gas. In the embodiment shown, the plates are heated by conduction and operate as shields to prevent transmission to the fabric of the higher wave lengths of the heating elements.

Unlike most industrial applications of radiant heat, the apparatus of the present invention does not use infra-red lamps, glowing refractory surfaces, or other small high-temperature heat sources to transmit heat to the fabric, but uses relatively large heating areas operating at low heat, these areas being interposed between the heat source and the fabric. As pointed out above, one result of this is that the rate of heat transfer drops off rapidly as the fabric approaches the temperature of the plates. This rapid diminution of heat transfer has a self-regulating effect which greatly diminishes the harmful effects of irregularity in temperature or of "hot spots." The transfer of heat from the plates is essentially uniform all across the plates, dropping off only at the edges where it may be maintained uniform by employing additional heating elements or using higher temperatures as described.

As the material being heated approaches the temperature of the plates, the rate of heat transfer drops off at a rapid rate. Therefore, there is very little tendency for spots of the fabric to overheat. This prevents burning of the seams of the fabric particularly. The air between the plates and the fabric is transparent to radiant heat and is cooler than the fabric. The use of the plates permits, moreover, of employing a heating temperature which will generate wave lengths which substantially coincide with the highest heat-absorption wave-length band for the material being treated.

With the present invention, the surface of heating has to have high emissivity as opposed to high reflectivity. The plates employed may be made of oxidized iron.

The curtains are made of highly polished aluminum or other reflecting material and are very thin. Since the curtains reflect the radiant energy from the plates, the curtains are heated only by convection from the atmosphere in the heat chamber, and, therefore, they block off the transmission of heat from the plates to the fabric when the curtains are unwound.

While the invention has been described particularly in connection with the heat treatment of nylon it will be understood that it can be used to set resin-impregnated rayon fabrics and any fabric where temperature must be raised to a predetermined level to heat-treat it. By heat-treatment the nylon or other fabric will retain its shape and shrinkage of the fabric in a subsequent dyeing operation will be prevented. If a nylon fabric is not set evenly, the dye will not take evenly and one part will be darker than another.

Among the advantages of the present method is that the heat transfer is extremely rapid as compared to hot atmosphere heating which means that a very short time of exposure may be employed and, therefore, there is less danger of damage to the fabric. With the process of the present invention nylon, for instance, may be heat-treated with the temperature of the plates approximately 700° F. in about six seconds of exposure. A better job of heat treatment can be done due to the rapid penetration of heat supplied in this manner. The process can be accomplished while the fabric is on a tenter-frame conveyor which allows the heat treatment to be effected while the material is held under tension in both directions. The apparatus is relatively small and compact and less in overall costs than the elaborate hot atmosphere ovens previously required. The energy curve of the heat source and the curve of maximum absorption of heat by the fabric substantially coincide. By using a plate as a radiating surface, the plate temperature may be that most favorable to absorption of heat by the material being treated.

The method of the present invention not only sets the fabric, reducing residual shrinkage to a negligible amount but produces a superior "hand" in the fabric, and the characteristic of not retaining wrinkles as a result of any type of handling is greatly improved.

While the invention has been described in connection with a specific embodiment thereof, it is capable of further modification and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth and as fall within the scope of the invention or the limits of the appended claims.

Having thus described my invention, what I claim is:

1. The method of heat-treating a textile fabric which comprises passing the fabric between two continuous, uninterrupted, surfaces which are spaced above and below the fabric, while heating said surfaces to cause the surfaces to heat the fabric by radiant heat from said surfaces, the surfaces being equal in width at least to the width of the fabric and being heated to a higher temperature at their edges than in their centers.

2. A machine for heat-treating textile fabrics comprising a heating chamber having a pair of parallel, spaced, uninterrupted heating surfaces therein which are at least as wide as the fabric which is to be treated, means for conveying the fabric between said surfaces while holding it under tension both lengthwise and cross-wise, said surfaces being disposed to be spaced above and below the fabric as it passes through the heating chamber, and means for heating the portions of said surfaces, which lie above and below the edges of the fabric to a higher temperature than the portions of the surfaces which register with the central portion of the fabric.

3. A machine for heat-treating textile fabrics comprising a heating chamber having a pair of spaced heating surfaces therein which are at least as wide as the fabric which is to be treated, means for heating said surfaces, means for conveying the fabric between the surfaces in spaced relation thereto, and heat-blocking means interposable between the surfaces and the fabric for protecting the fabric from the heat of the surfaces.

4. A machine for heat-treating textile fabrics comprising a heating chamber having a pair of spaced heating surfaces therein, means for heating said surfaces, means for conveying the fabric between the surfaces in spaced relation thereto, heat-blocking means interposable between each surface and the adjacent side of the fabric, means for moving the heat-blocking means to said interposed position, and means for interlocking the operations of said last-named means and the conveying means so that, on stoppage of the conveying means, the blocking means is moved to operative position.

5. A machine for heat-treating textile fabrics comprising a heating chamber having a pair of spaced heating surfaces therein, means for heating said surfaces, means for conveying the fabric between the surfaces in spaced relation thereto, heat-blocking means interposable between each surface and the adjacent side of the fabric, means for moving the heat-blocking means to said interposed position, and means for interlocking the operations of said last-named means and the conveying means so that, on stoppage of the conveying means, the blocking means is moved to operative position, and vice versa, on starting of the conveying means, the blocking means is moved to inoperative position.

6. A machine for heat-treating textile fabrics comprising a heating chamber having a pair of spaced heating surfaces therein, a tenter-frame conveyor for moving the textile fabric through said heating chamber between said surfaces, means for driving said conveyor, a pair of curtain rolls journaled at one end of said chamber, heat-blocking curtains wrapped therearound, means for drawing one curtain between each heating surface and the fabric in the chamber, and means for interlocking the operations of the last-named means and the drive means so that on stoppage of the drive means the curtains are drawn between the surfaces and the fabric.

7. A machine for heat-treating textile fabrics comprising a heating chamber, a plurality of supports mounted in the upper part of said chamber, a plurality of plates removably secured to said supports, a plurality of supports mounted in the lower part of the chamber, a plurality of plates removably secured to the latter supports in parallelism to the first plates, a tenter-frame conveyor for conveying the fabric between the upper and lower plates in spaced relation thereto, said plates extending at least over the full width of the fabric, a plurality of electrical heater secured to the back of each plate, and means for controlling said heaters.

8. A machine for heat-treating textile fabrics comprising a heating chamber, means in said chamber for emitting heat, means for conveying the fabric, which is to be treated through said chamber, and a pair of continuous, uninterrupted heating plates mounted in the chamber, respectively, to be above and below the fabric being conveyed through the chamber and to be spaced from opposite sides of the fabric, respectively, and to be interposed between the opposite sides of the fabric and the heat-emitting means, whereby the plates are heated by the heat-emitting means and the plates, in turn, heat the fabric by radiation.

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