Sept. 24, 1957 G. V. KULLGREN ET AL 2,807,096

APPARATUS FOR HEATING AND STRETCHING FABRICS

Filed Aug. 16, 1954 8 Sheets-Sheet 1

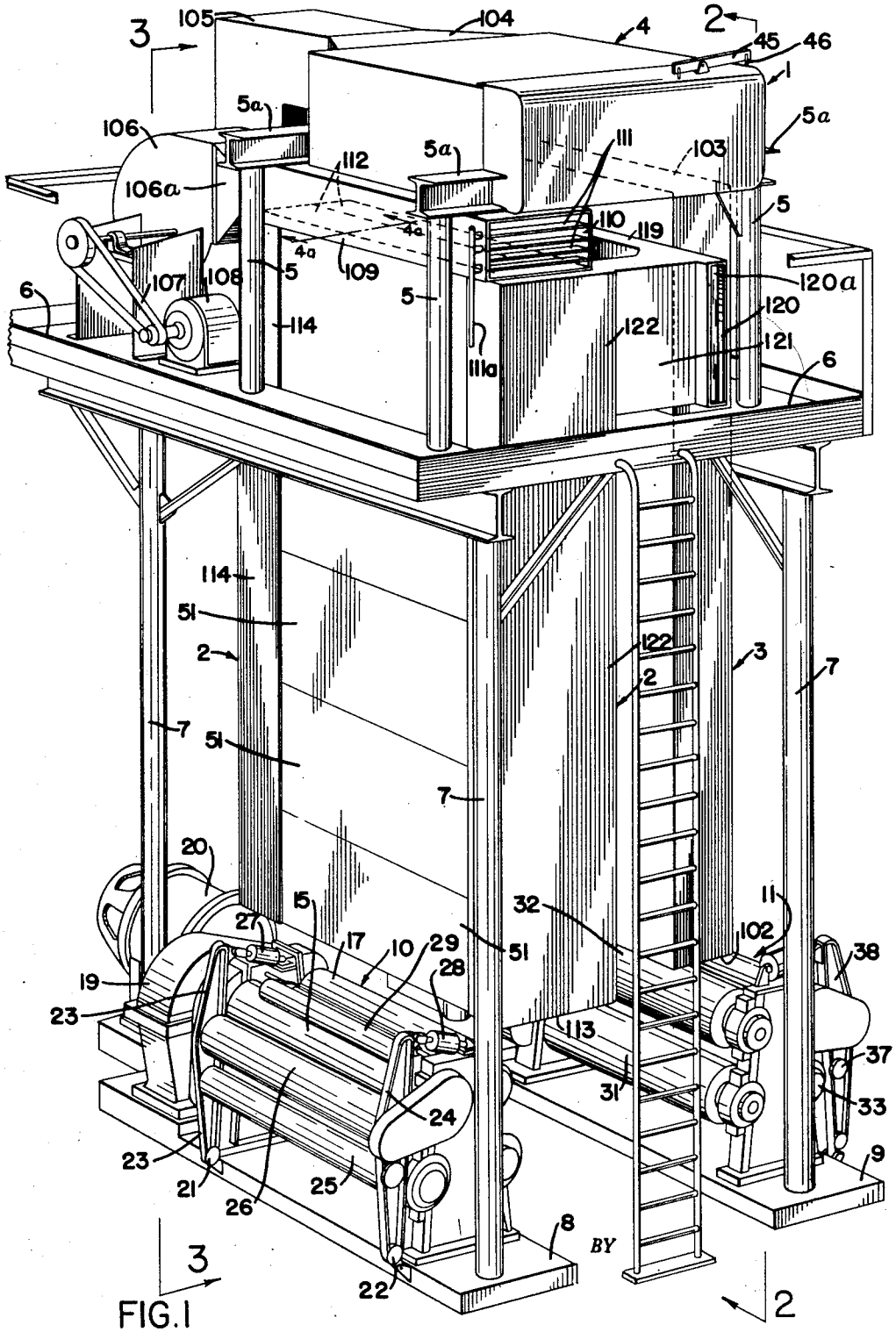

FIG. 1

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APPARATUS FOR HEATING AND STRETCHING FABRICS

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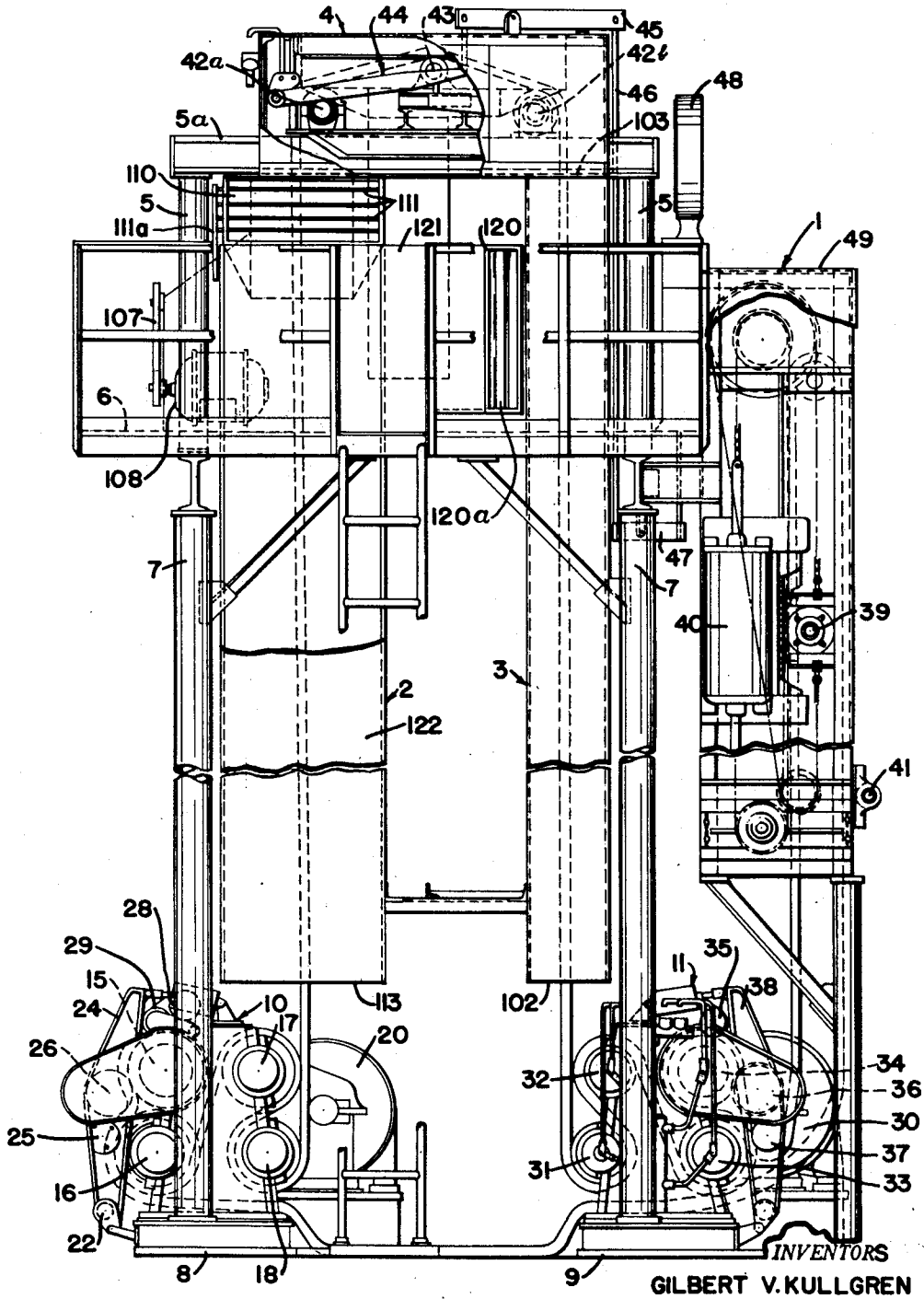

FIG. 2

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APPARATUS FOR HEATING AND STRETCHING FABRICS

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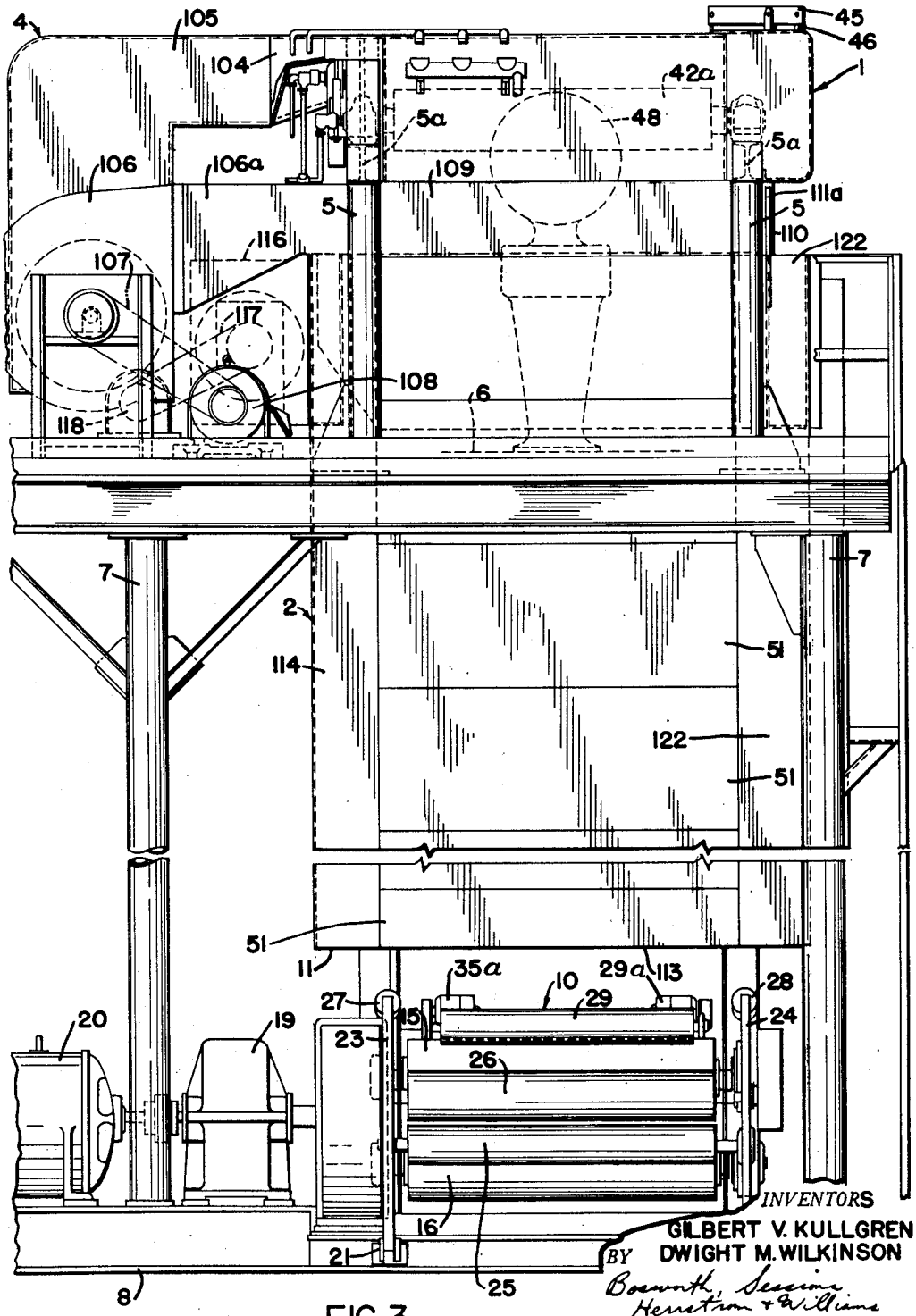

FIG. 3

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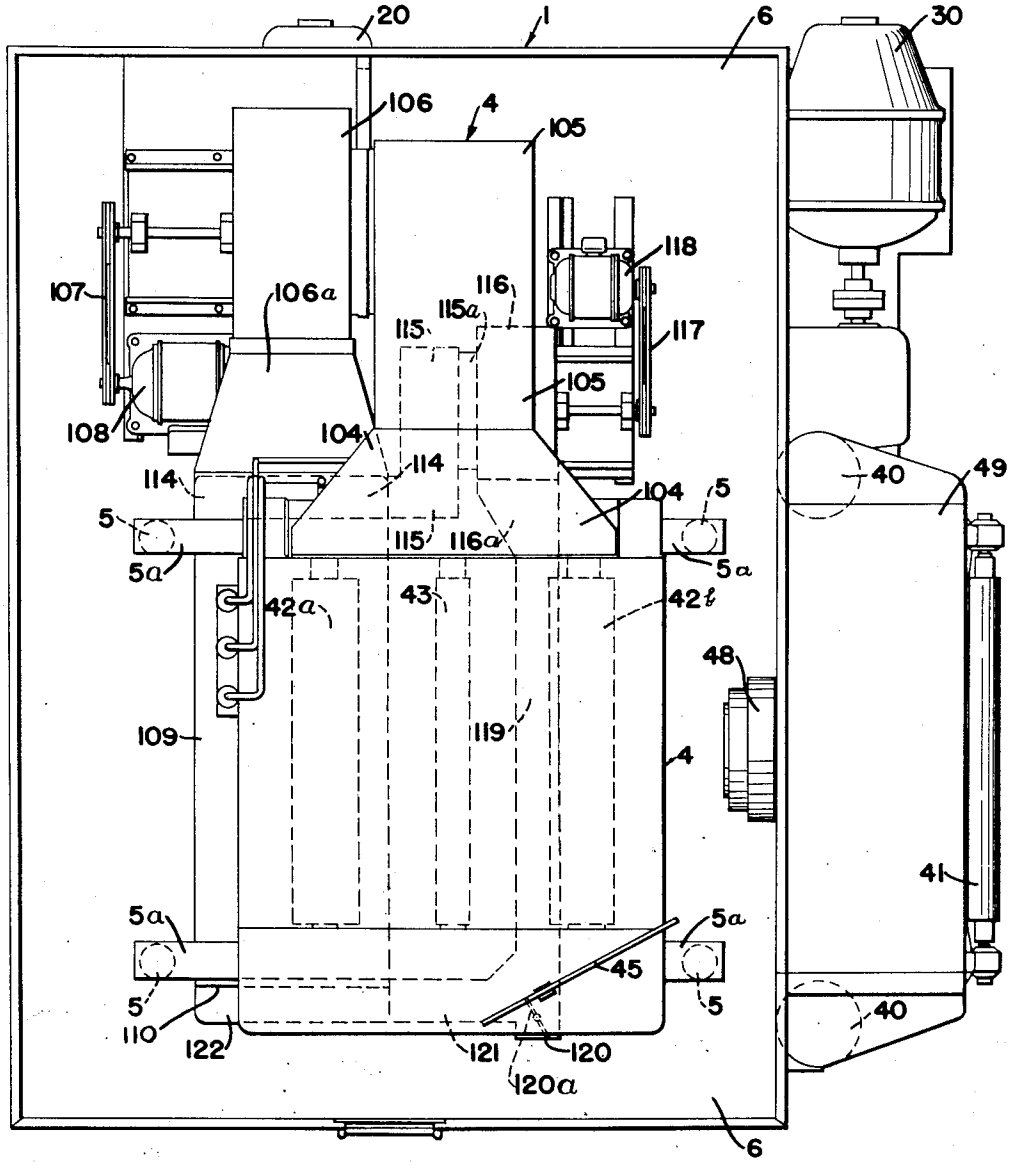
FIG. 4



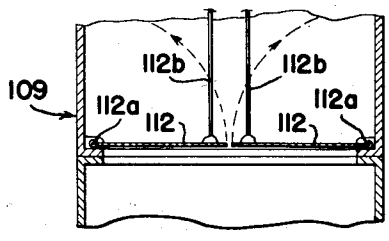


FIG. 4a

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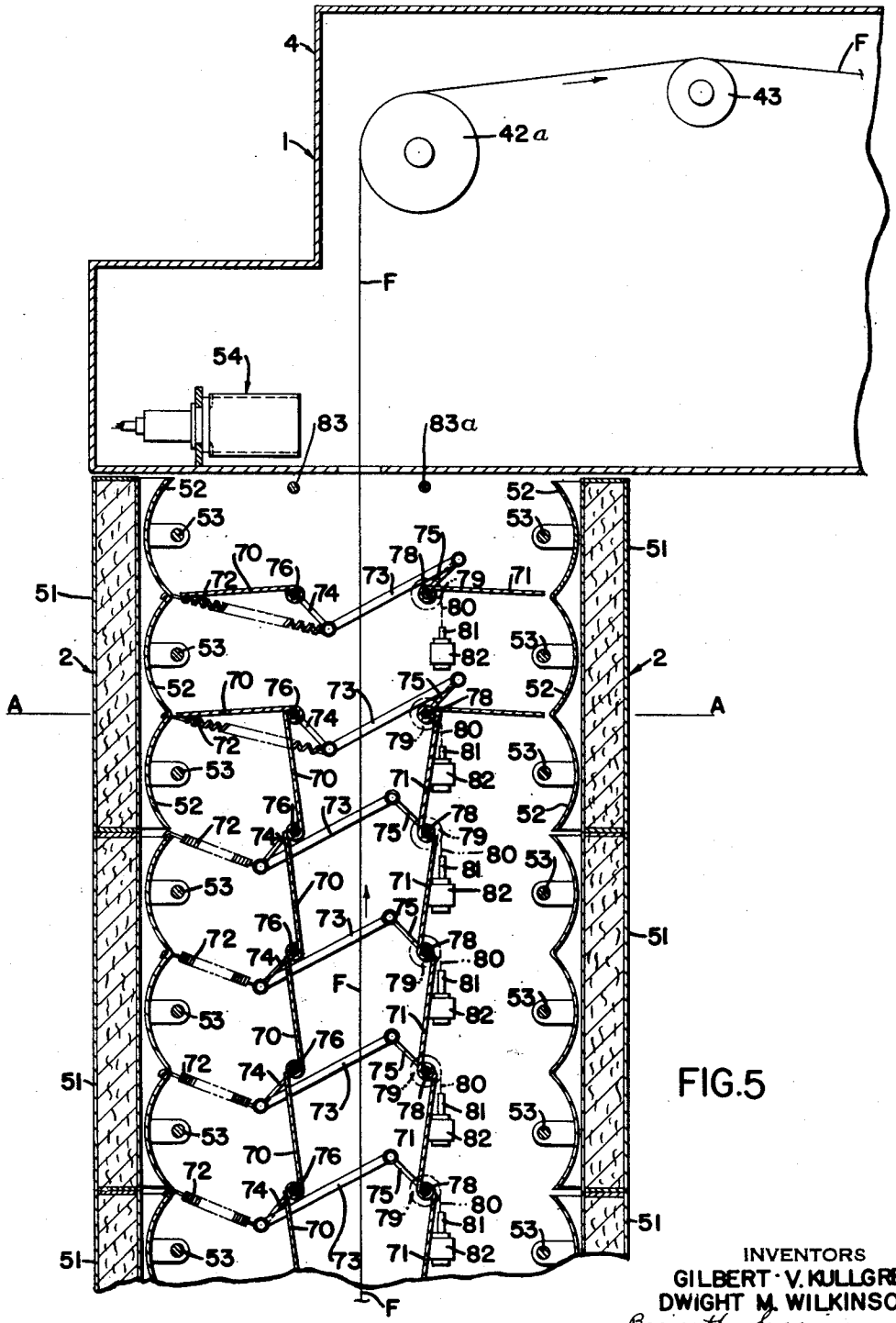

FIG.5

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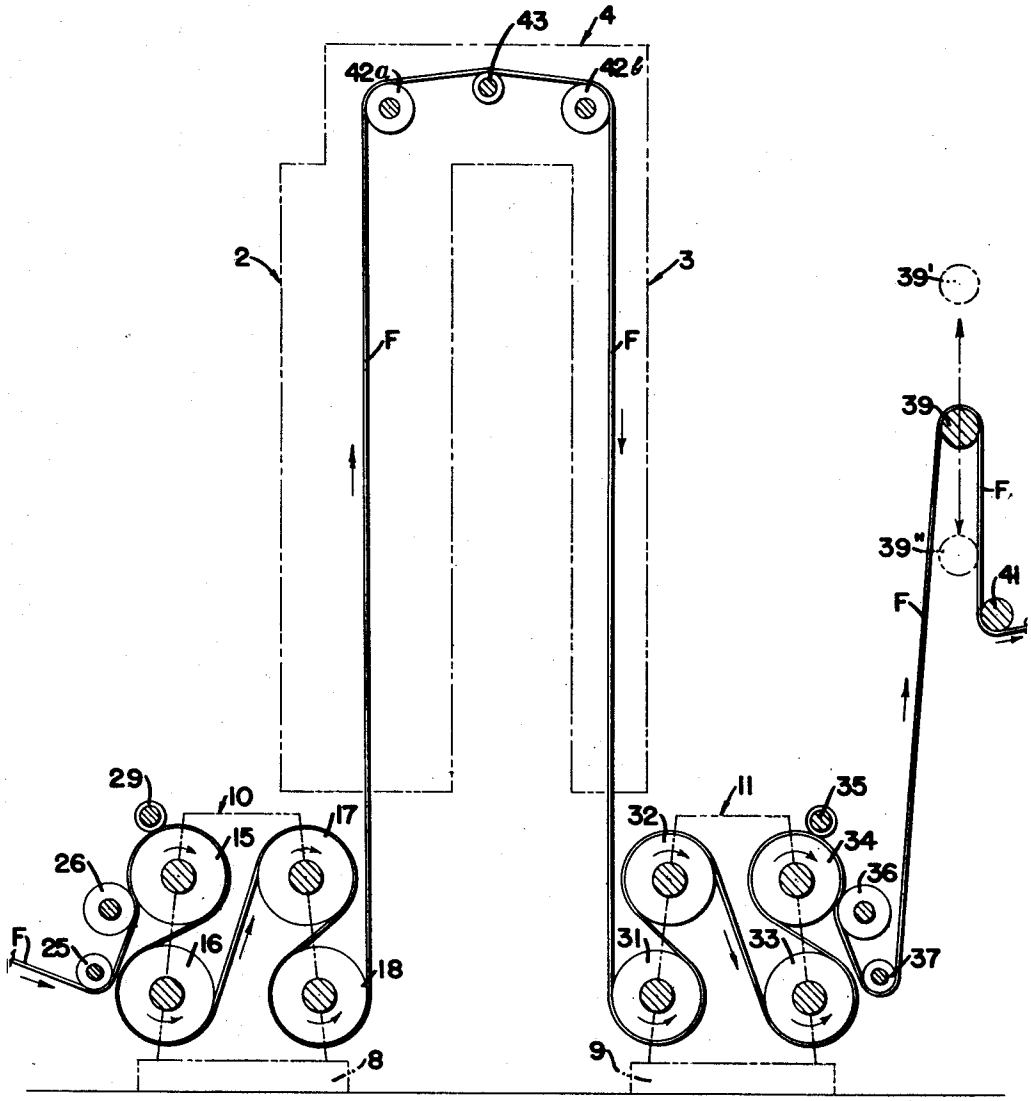

FIG. 6

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APPARATUS FOR HEATING AND STRETCHING FABRICS

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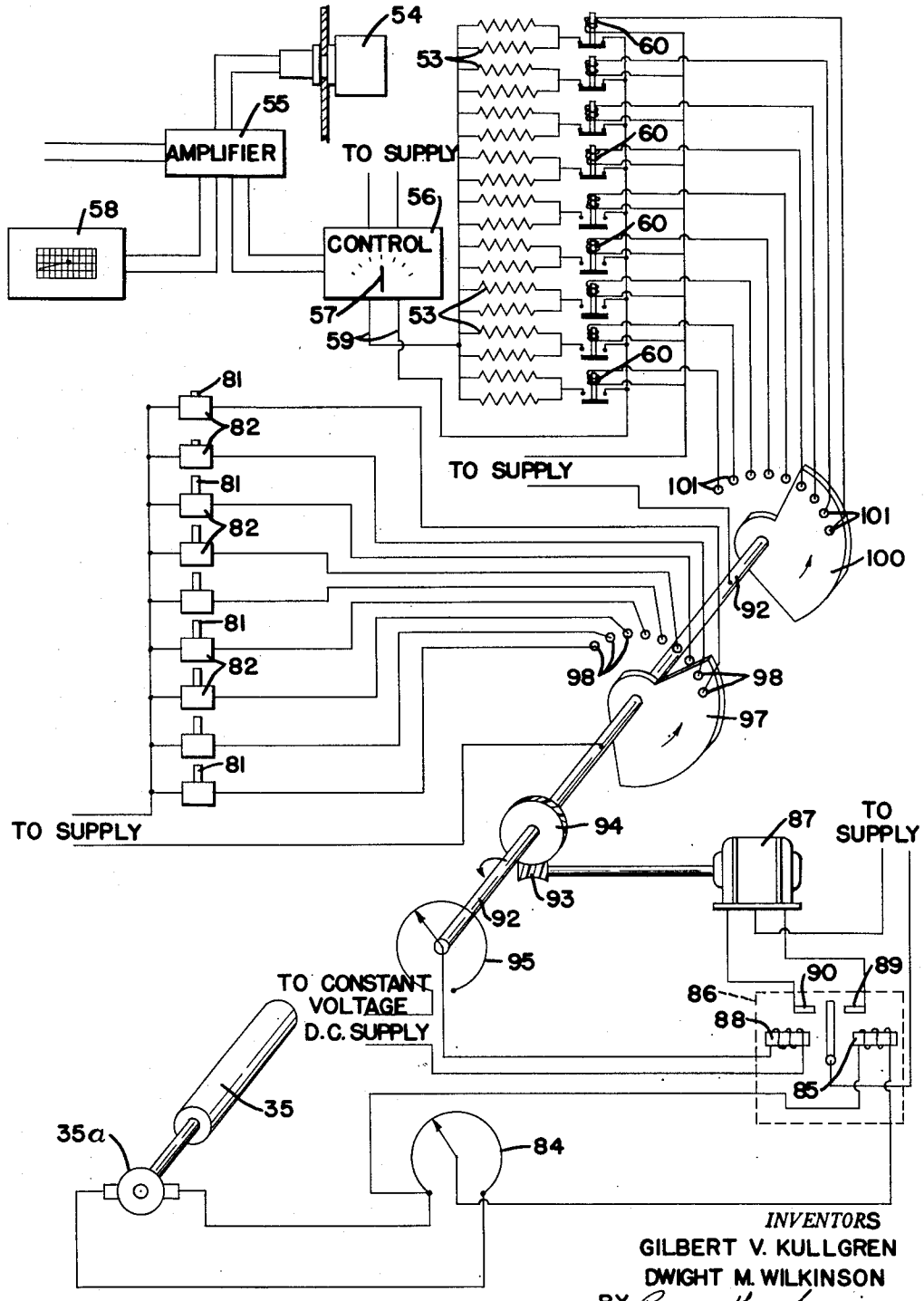

FIG. 7

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APPARATUS FOR HEATING AND STRETCHING FABRICS

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FIG. 9

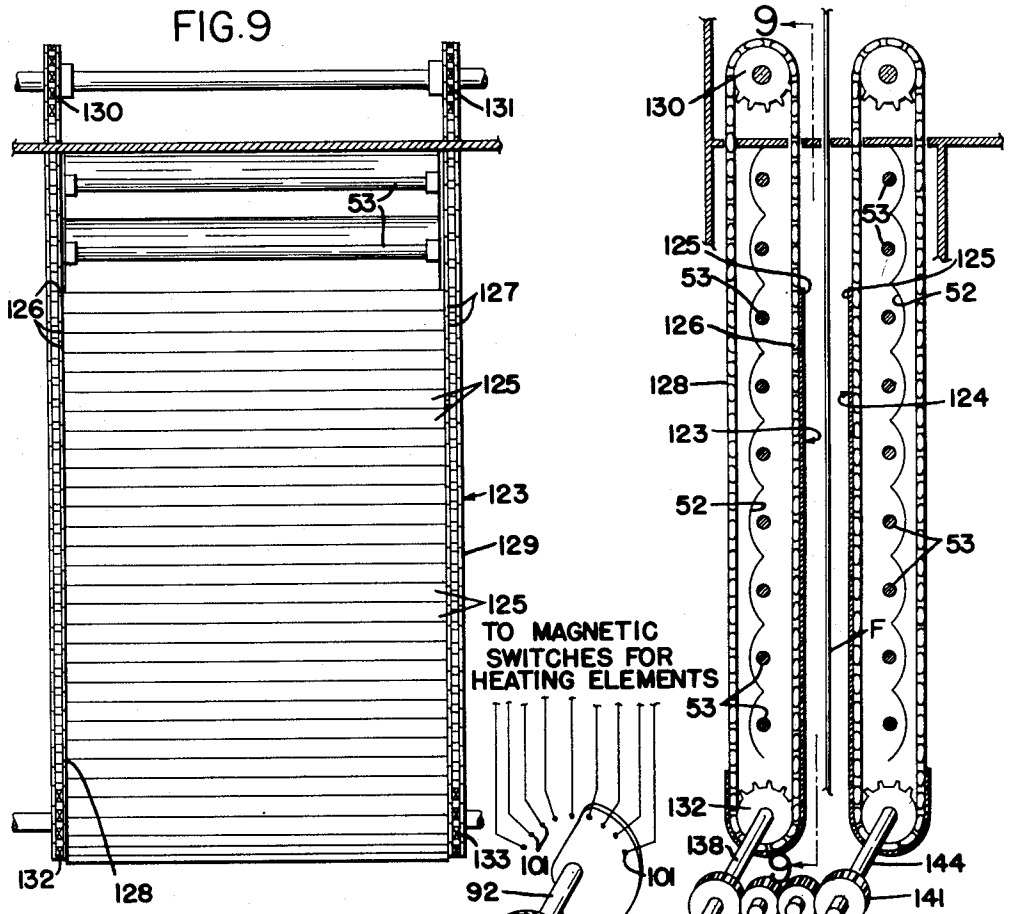
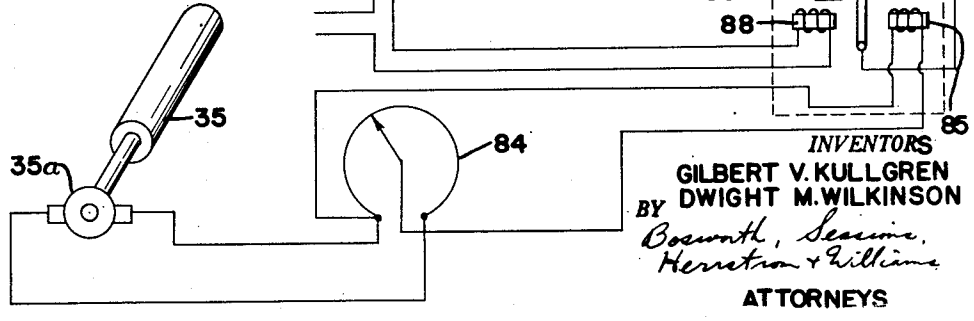


FIG. 8



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Patented Sept. 24, 1957

2,807,096

APPARATUS FOR HEATING AND STRETCHING FABRICS

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Application August 16, 1954, Serial No. 449,946

19 Claims. (Cl. 34—45)

This invention relates to apparatus and processes for hot-stretching textile fabrics and particularly to fabrics made of synthetic thread such as nylon, Dacron, Terylene and the like.

In readying fabrics of these kinds for industrial uses as, for example, in the manufacture of tires and mechanical rubber goods, it is sometimes desirable to subject the fabric to drastic stretching, meanwhile heating and cooling it in rapid success. However, because certain fabrics, such, for example, as those made of nylon, tend to melt or at least to undergo extensive degradation at elevated temperatures, it is necessary that the heating and cooling steps be carefully controlled. Since degradation is proportional to the time at elevated temperatures, it is advantageous to provide a heating method for rapid temperature rise in combination with proper control to minimize exposure time. The heating time in particular should not be permitted to last for more than a few seconds. Therefore, means must be provided to heat and cool the fabric to the proper extent at the proper time and, if the operation of the apparatus as a whole comes to a halt, to protect the fabric from over-long exposure to heat within the apparatus itself.

These problems are recognized as such in the art to which the invention relates. In efforts to solve such problems in the past, others have proposed the use of tunnel-like ovens through which the fabric is passed in the form of a traveling web and in which it is brought into contact with heated platens or the like, usually followed by a cooling roll. However, such installations have not as a rule been sufficiently adaptable to varying conditions imposed by extraneous factors, such as changes in the rate of travel of fabric through the oven; in addition, they have lacked effective means for purging the apparatus of hot air in the event that the fabric ceased to travel into, through and out of the oven. The desired high degree of control over the heating and cooling of the fabric has not heretofore been achieved, largely because the heating means could not respond quickly enough to achieve control.

It is an object of the present invention to provide an oven in which the fabric, which is in the form of a web made up of a large number of warp threads, cords or the like with or without weft threads, may be passed at speeds answering the requirements of the calender or other take-up device to which the fabric proceeds from the oven. Particularly it is an object of the invention to provide an oven equipped with means for varying, in relation to the speed of the fabric, the distance over which the fabric is subjected to the action of the heat. It is highly desirable that, as the speed of the fabric increases, the distance over which the fabric is subjected to the action of heat shall be increased; similarly, as the speed of the fabric decreases, the distance over which the fabric is subjected to such heat should be correspondingly decreased. These ends the apparatus and processes of the present invention are well adapted to meet.

Another object of the invention is to provide an installation in which the intensity of the heat is controlled by means responsive to temperature so that if the temperature of the fabric happens to decrease, the intensity of the heat increases and vice versa.

Still another object of the invention is to provide apparatus and processes in which there can be a recirculation of hot air within the system which can be interrupted if the apparatus comes to a halt. The apparatus and processes of the present invention contemplate such interruption of the recirculation of the hot air, the exhausting of the air which surrounds the fabric, and the introduction in lieu thereof of air at temperatures more nearly corresponding to room temperatures. Thus the fabric can be cooled almost immediately even though, as a result of circumstances, it may have to remain stationary in the apparatus for a prolonged period of time.

Other objects and advantages of the invention will be apparent from the description which follows and from the accompanying drawings, in which:

Fig. 1 is an isometric view of a tower-type oven incorporating the features of the invention.

Figure 2 is a side elevation of the oven as seen from view line **2—2** of Figure 1.

Figure 3 is an end elevation on a somewhat larger scale of the oven as seen from view line **3—3** of Figure 1.

Figure 4 is a top plan of the oven of Figures 1, 2 and 3.

Fig. 4*a* is a section on line **4*a*—4*a*** of Figure 1.

Figure 5 is a vertical section, with certain parts omitted, through the upper portion of the oven of Figures 1 to 4, the section being parallel to the sides of the oven.

Figure 6 is a schematic representation showing in a general way the path of travel of the fabric through the oven.

Figure 7 is a diagram showing electrical control circuits for the heating means incorporated in the oven.

Figure 8 illustrates a modified and in some respects preferred form of heating control; and

Figure 9 is a section taken as indicated by line **9—9** of Figure 8.

In Figure 1, the oven generally is designated **1**. It comprises a heating leg **2**, the same appearing at the left in Figure 1, and a cooling leg **3**, laterally spaced therefrom. A superstructure made up in part of top structure **4**, which constitutes part of the cooling section, interconnects heating leg **2** and cooling leg **3** toward the upper ends thereof. The superstructure also includes such structural members as the four posts **5**, the two horizontally extending H-beams **5*a***, and the platform **6** which surrounds the oven at the base of posts **5**. Platform **6** and other parts of the superstructure are supported by four posts **7**, two of which, shown toward the left in Figure 1, have their bases in a concrete footing **8**. The two posts **7** at the opposite end of the oven have their bases in a similar footing **9**.

Footings **8** and **9** also serve to mount and support the roll stands **10** and **11**, respectively. The former is located in juxtaposition to the bottom of heating leg **2**; the latter, in juxtaposition to the bottom of cooling leg **3**. As indicated in Figure 6, fabric F passes seriatim over the various rolls of roll stand **10**, proceeds upwardly through heating leg **2**, laterally across the top of the oven within the top structure **4**, and downwardly through cooling leg **3**, and, on leaving the latter, is taken up by roll stand **11**, over the various rolls of which it proceeds seriatim. Fabric F is tensioned between roll stands **10** and **11**, and stretched as a result of a substantial differential between the linear speed at the point where the fabric leaves roll stand **10** and the linear speed at the point where the fabric is taken up by roll stand **11**.

As further appears from Figure 6, roll stand **10** is made up of four parallel tensioning rolls **15**, **16**, **17** and **18**. These four rolls are positively driven through a con-

ventional reduction gear unit **19** from an electric motor **20** (Figures 1 and 2). Fabric F enters roll stand **10** as indicated in Figure 6. It proceeds over roll **15** in clockwise direction, counterclockwise over roll **16**, clockwise over roll **17**, and counterclockwise over roll **18**. Leaving roll **18**, fabric F is drawn vertically upward through heating leg **2**.

Pivoted at **21** and **22** to the supporting structure for roll stand **10** are the two laterally spaced arms **23** and **24** appearing in Figure 1. Along with an accessory idler **25**, arms **23** and **24** carry a movable pinch roll **26** mounted for rotation approximately midway between the upper and lower ends of arms **23** and **24**. Two fluid-pressure power cylinders **27** and **28** are mounted on the supporting structure in such manner that they operate transversely to the upper ends of arms **23** and **24**. If the attendant actuates the power cylinders so as to urge the upper ends of arms **23** and **24** away from roll stand **10**, movable pinch roll **26** will be urged away from the driven roll **15**. If, on the other hand, the attendant actuates the power cylinders in a manner such as to cause them to pull the upper ends of arms **23** and **24** toward roll stand **10**, pinch roll **26** will be urged toward roll **15** holding the fabric against roll **15** as shown in Figure 6 to prevent slipping of the fabric on the roll.

For reasons which will appear hereinafter, a tachometer roll **29** is mounted as shown in Figures 1 and 3 in contact with fabric F where the latter passes through roll stand **10**. Tachometer roll **29** drives tachometer generator **29***a* (see Figure 3).

Roll stand **11** at the opposite end of oven **1** includes four driven rolls **31**, **32**, **33** and **34**. After leaving cooling leg **3**, fabric F travels in sequence over these four rolls, proceeding counterclockwise over roll **31**, clockwise over roll **32**, counterclockwise over roll **33**, and clockwise over roll **34**. These rolls are operated by a gear reduction unit and electric motor **30** similar to gear reduction unit **19** and motor **20** for roll stand **10**. The peripheral speed of roll **31** is greater than that of roll **18** of roll stand **10**, the degree of speed difference being adjustable; thus the fabric can be stretched to the desired extent between the two roll stands. Also forming part of roll stand **11** is the tachometer roll **35** (Figure 6).

In one form of the apparatus motor **20** and motor **30** are supplied with power through any convenient means such as a variable voltage drive so that the speed of these motors can be controlled through a relatively wide range. The two motors are interconnected electrically by an appropriate adjustable control so that the tension in the fabric between the roll stands **10** and **11** can be maintained substantially constant and at a desired value. With this arrangement, motor **20** acts as a tensioning device during normal operation of the apparatus; the motor functions as a generator and the power generated is put back into the circuit including the motor **30**.

The tachometer roll **35** drives a tachometer generator **35***a* and the output of this generator may be used, if desired, with a suitable control apparatus to control the speed of the fabric leaving the apparatus. If desired, the outputs of tachometers **35***a* and **29***a* may be used to operate a stretch indicator or to control the degree of stretch.

Roll stand **11**, like roll stand **10**, is provided with a movable pinch roll **36** and accessory idler **37**. Pinch roll **36** and idler **37** are mounted in two laterally spaced arms similar to arms **23** and **24** of roll stand **10**. Arm **38**, one of the two arms of roll stand **11**, is shown in Figures 1 and 2. These two arms are actuated by fluid pressure power cylinders which are in all respects similar to power cylinders **27** and **28** on roll stand **10**. Therefore, the attendant can increase or relax the nip-pressure on fabric F as it leaves roll stand **11** by moving pinch roll **36** toward or from the driven roll **34** with which it cooperates.

A sub-assembly incorporating a vertically movable idler **39** of the kind commonly known as a dancer roll is provided to take up slack in fabric F as the latter travels from roll stand **11** to the calender or other take-up unit. This sub-assembly, which is enclosed within a housing **49**, is largely conventional. It includes two air cylinders **40**, one at each end of the dancer roll, one of which appears in Figure 2, and a fixed idler **41** over which fabric F passes on its way to the calender or other take-up unit. The ends of dancer roll **39** are mounted in blocks adapted to slide in the vertical guide-ways which appear in Figure 2. At each of the ends of dancer roll **39** there is one such block, two vertical guideways, an air cylinder, and a suitable system of pulleys.

Under the influence of air cylinders **40** and the tension of the fabric, dancer roll **39** can move from the solid line position shown in Figure 6 to any one of a variety of other positions represented by dotted-line positions **39′** and **39″**. If, for example, the calender or other take-up unit to which fabric F proceeds from roll stand **11** is momentarily operating at a speed greater than the speed of roll **34**, dancer roll **39** moves downward to a position such as **39″**. If, on the other hand, the calender or other take-up unit is momentarily operating more slowly than roll **34**, dancer roll **39** moves upward to a position such as **39′**. The dancer roll **39** thus prevents the development of slack in the fabric. The movements of the dancer roll may be utilized to control the speed of the entire apparatus, including both roll stands, to coordinate the speed of the apparatus with speed of preceding or succeeding processing equipment, or the position of the dancer roll may be utilized to coordinate the speed of succeeding or preceding equipment with the speed of the apparatus.

In top structure **4** are mounted the idlers **42***a* and **42***b* illustrated in Figure 6. After leaving roll stand **10**, the fabric F passes first over idler **42***a* and thence over idler **42***b*, from the latter of which it proceeds to roll stand **11**. Between idlers **42***a* and **42***b* is a roll **43** forming part of a scale mechanism of conventional construction which includes, among other things, a pivoted arm **44** to which roll **43** is connected, a first scale beam **45**, a depending link **46**, and a second scale beam **47**. The latter in turn is coupled by a short upwardly extending link to a direct-reading scale **48**. As indicated in Figure 2, scale **48** is mounted in abutting relation to the housing **49** enclosing the sub-assembly including dancer roll **39**. By means of it, it becomes possible to read off in pounds the tension on fabric F as the latter proceeds through top structure **4**. The scale can also be utilized to control the amount of tension in the web by control of the electrical system for the drive motors **20** and **30**. It will be understood that other force-responsive means may be substituted for the scale **48**; for example, pressure cells may be employed.

By operating roll stands **10** and **11** in the manner described, it is possible to place on fabric F a tension of from something less than 10,000 to something more than 20,000 pounds, which in most cases serves to stretch fabric F sufficiently to eliminate any excessive residual stretch ("elongation") remaining after removal of the tension.

Referring now to Figure 5, it will be observed that the sides of heating leg **2** are constructed of a series of superimposed panels **51** of insulating material, there being several such panels in vertical alignment with each other on each side of the path of travel of the fabric. Associated with each panel **51** is a group of three reflectors **52**, such reflectors being of a suitable metal of one of the kinds conventionally used for radiant heating. An electric resistance heating element **53** is mounted in front of each of the reflectors; accordingly, heat radiated from heating elements **53** is reflected onto fabric F. In passing it should be noted that near the top of Figure 5 certain of the heating elements **53** on each side of heating leg **2** are illustrated as operating directly on fabric F without interference by intervening shutters or other barriers.

Located in the superstructure beyond the point where

the fabric leaves heating leg **2** but in juxtaposition to the fabric itself is a heat-sensitive unit **54** for controlling the voltage on heating elements **53**. Such unit, which preferably comprises a thermopile and a focusing lens, is responsive to heat radiated from the fabric. The circuit employed in conjunction therewith is illustrated in the upper part of Figure 7 and comprises an amplifier **55** which receives and amplifies the output voltage of the thermopile in unit **54**. The output of the amplifier operates the control **56** which controls the voltage supplied to the heating elements **53** in such a manner as to maintain the temperature of the fabric as it passes the unit **54** approximately constant and at a point determined by the setting of the control knob **57** of control **56**. The output of the amplifier, if desired, may also be fed to a recording instrument **58** that indicates and records the temperature of the fabric as it passes unit **54**. The unit **54**, amplifier **55**, control **56**, and recorder **58** may all be of commercially available construction and per se form no part of the present invention.

It will be noted that oppositely disposed heating elements **53** are connected in pairs across the power lines **59**, each pair being controlled by a magnetic switch **60**. The purpose of this connection is to provide for energization of varying numbers of heating elements in accordance with variations in the speed of the fabric passing through the apparatus, as will appear more fully below. If the temperature of the fabric emerging from heating leg **2** tends to increase unduly, unit **54** operates to decrease the voltage on heating elements **53**; conversely, if the temperature of the fabric tends to decrease unduly, it operates to increase the voltage on the heating elements. Thus the temperature is maintained at approximately the desired level, which is usually not more than about 400° or 450° F.

In order to provide for additional control of the heating of the fabric F by the heating elements **53**, the number of heating elements that are operative, and correspondingly the length of the active heating zone through which the fabric passes, is varied in accordance with the speed of the fabric. If the fabric is traveling at a high rate of speed, a large number of heating elements **53** must be operative in order to heat the fabric to the desired temperature; similarily, if the fabric is traveling at a low rate of speed, only a relatively few heating elements **53** need to be operative to effect the desired result. In the condition shown in Figure 5, the radiation of heat from heating elements **53** onto fabric F cannot take place until the last few heating elements are reached. The line of demarcation is indicated by line A—A. The distance above this line, a distance over which fabric F is subjected to radiant heating by the elements **53**, is a variable distance; in other words, the distance over which heat is allowed to radiate onto fabric F may be greater or less than the distance exemplified by line A—A in Figure 5. Such line merely illustrates the beginning of a heating zone at a given time. As hereinafter explained, line A—A may occupy a position that is either higher or lower than that shown in Figure 5.

To control the effective length of the heating zone, each heating element **53** is provided with a suitable barrier which may be moved between one position in which the heat radiated by the heating element is permitted to reach and another position in which it is precluded from reaching the fabric. In the form of the invention shown in Figures 5 and 7, the heating elements **53** in each opposed pair of elements are equipped with shutters **70** and **71**, which are biased toward closed position by a coil spring **72**. One end of spring **72** is fixed to the reflector **52** at the left in Figure 5 and the other end is connected to link **73** and lever **74** at their point of pivotal connection. Lever **74** is rigidly connected to shutter **70**, which is mounted on pivot **76**. Thus, spring **72**, acting on the end of link **74**, tends to move shutter **70** from the open position shown above line A—A in Figure 5 to the closed position shown in the portion of Figure 5 below line A—A. In order to operate shutter **71**, link **73** extends from lever **74** to lever **75** which is rigidly attached to shutter **71**. Shutter **71** is pivotally mounted on pivot **78** and moves between open and closed positions simultaneously with shutter **70**.

As noted above, the springs urge the several shutters to closed position in which they block the radiation from the elements **53** to the fabric F. In order to move the shutters to open position and thus to permit heat to be radiated from heating elements **53** onto fabric F, a metal drum **79** of small diameter is mounted on one end of pivot pin **78**. A short flexible wire or chain **80** is connected to the drum and the free end of wire **80** is attached to the armature **81** of a fixedly mounted solenoid **82**. Each pivot pin **78** is provided with such an assembly, and when any given solenoid **82** is energized, its armature **81** is drawn downwardly pulling wire **80** and rotating the corresponding drum **79**, pivot pin **78** and shutter **71** in a clockwise direction as shown in Figure 5.

Energization of the solenoid causes shutter **71** to rotate through an angle of about 90° from the closed position shown toward the bottom of Figure 5 to the open position shown near the top of Figure 5. Shutter **70** is simultaneously moved to open position through the linkage made up of lever **75**, link **73** and lever **74**, against the force exerted by spring **72**.

So long as solenoid **82** is energized, shutters **70** and **71** remain in the open positions shown near the top of Figure 5. When, however, solenoid **82** is de-energized, spring **72** returns these parts to closed positions to block radiation of heat from heating elements **53** onto fabric F. The open position of the shutters is determined by the stroke of the solenoids; in closed position the upper edge of each shutter engages the pivot **76** or **78** of the shutter immediately above it as a stop, except for the topmost shutters which engage stops **83** and **83***a*. The solenoid springs and associated mechanisms are disposed at the ends of the shutters beyond the ends of heating elements **53**.

As previously stated, the zone in which intensive heating of fabric F is accomplished may be longer or shorter than that indicated in Figure 5. Thus in a typical instance in which fabric F is traveling more slowly than usual, a relatively small number of heating elements will be required to bring the fabric to the proper temperature; in such case, the beginning of the heating zone will be at some higher level than that represented by line A—A. If fabric F is traveling rapidly the beginning of the heating zone will be at a lower level than the level A—A at which it is shown in Figure 5; in such case, a relatively large number of heating elements will be operative. As the speed of the web increases, the shutters are opened successively, preferably in a direction opposite to the direction of travel of the web. In circumstances in which the fabric is traveling at its maximum rate of speed, all of the various heating elements below the line A—A may be operative. In this situation, the beginning of the heating zone will coincide with the bottom of heating leg **2**. In every position of adjustment the top of the heating zone is at the top of the heating leg **2**, and the strip travels only a short distance before passing the heat-responsive unit **54**.

In order to control the length of the heating zone, the energization of the solenoids **82** is controlled in accordance with the speed of the fabric entering the apparatus. A suitable circuit for accomplishing this control is shown in Figure 7 and particularly the lower part thereof where it will be seen that the output of the tachometer generator **35***a*, which is driven by the fabric by means of the tachometer roll **35**, is supplied through rheostat **84** to coil **85** of a differential relay **86**. Relay **86** controls the operation of a reversible control motor **87**. When coil **85** is energized to a sufficiently greater extent than coil **88** of relay **86**, the circuit to the motor is closed through contact **89** and the motor operates in a forward direction. When the coils **85** and **88** are approximately balanced the cur-

rent to the motor is cut off, and when the energization of coil **88** is sufficiently greater than the energization of coil **85** the circuit to the motor is closed through the contact **90** and the motor is operated in reverse direction.

Motor **87** drives control shaft **92** through worm **93** and worm wheel **94**. Control shaft **92** operates a balancing rheostat **95** that is supplied with a constant voltage direct current and controls the energization of coil **88** of differential relay **86**. With this arrangement motor **87** operates to position shaft **92** and rheostat **95** so that the output of the tachometer generator **35***a*, as modified by rheostat **84**, is balanced by the voltage supplied to coil **88** through the rheostat **95**. Thus, as the speed of tachometer generator **35***a* increases, its output correspondingly increases, and upon such an increase motor **87** operates to increase the voltage supplied to coil **88** until a state of balance is reached; upon a decrease in the speed of the tachometer generator **35***a*, the motor **87** will operate in the reverse direction to again bring the relay **86** into a state of balance.

For a given setting of rheostat **84**, therefore, the shaft **92** takes a particular angular position for a given speed of the fabric. The shaft **92** is utilized to control the operation of the solenoids **82** which actuate the shutters **70** and **71**. This is accomplished through a contact plate **97** secured to shaft **92** and adapted successively to engage contacts **98**, each of which controls one of solenoids **82**. The arrangement is such that as the speed of the web increases the shaft rotates in the direction of the arrow and successively cuts in the circuits to the solenoids starting with the uppermost one. In the embodiment shown in the drawing, contact plate **97** has rotated sufficiently to energize the two uppermost solenoids opening the shutters **70** and **71** associated therewith, while the remaining solenoids are not energized, as indicated by the position of their plungers **81**. By this arrangement the length of the zone in which the fabric is exposed to heat is varied directly in accordance with the speed of the web passing through the apparatus and the control preferably is arranged so that the time of exposure to heat remains substantially constant regardless of variations in speed.

Preferably the same control mechanism is utilized to control the magnetic switches **60** for the heating elements **53**. This is accomplished through a contact plate **100** also mounted on shaft **92** and adapted to make engagement successively with contacts **101** leading to the several magnetic switches **60**. In order to provide for quick response it is preferable that the heating elements **53** be turned on in advance of the opening of the shutters associated therewith. In the embodiment of the invention shown in Figure 7 two sets of shutters have been opened and four pairs of heating elements **53** have been energized. As the fabric web continues to accelerate, requiring the opening of additional sets of shutters, the heating elements **53** associated with such shutters will have been turned on sufficiently far in advance of the opening of the shutters to preheat the elements. This is accomplished simply by positioning the contact plate **100** on shaft **92** in a position angularly in advance of contact plate **97**. By varying the amount of the advance, the length of time provided for warming up the heating elements can be correlated with the normal rate of acceleration of the web. To this end contact plates **97** or **100**, or both of them, can be adjustably mounted on shaft **92**.

From heating leg **2**, fabric F proceeds over idlers **42***a* and **42***b* in top cooling structure **4** to cooling leg **3**, wherein it is subjected to rapid cooling by air at room temperatures drawn upwardly through cooling leg **3**. The latter preferably takes the form of a sheet metal duct of rectangular cross section that is somewhat wider than the maximum width of fabric F. Cooling leg **3** is open at its lower end, indicated at **102** in Figures 1 and 2, to admit air at room temperatures.

The cooling air travels upwardly in cooling leg **3** on both sides of fabric F until it reaches the point where top structure **4** overlies cooling leg **3**. An open connection between cooling leg **3** and top structure **4** permits the air to be drawn into top structure **4** from the top end **103** of the cooling leg (Figure 1). Air so reaching the top structure is drawn laterally therethrough into a tapering connection duct **104**, shown in Figures 1 and 4, whence it is drawn into the angled duct **105**, best seen in Figure 1. The latter is in communication with a fan housing **106** containing a fan (not shown) operated by a belt **107** from a motor **108** mounted on platform **6**. The fan operates to pull cold air into cooling leg **3** through the open bottom **102** thereof.

In the event that movement of the fabric web ceases for any reason, it is desirable not only that the heating element be rendered ineffective, but also that the hot air in heating leg **2** be exhausted therefrom as rapidly as possible. Such action is usually necessary in order to avoid damaging fabric F. Exposure of the fabric to high temperatures, sometimes of the order of magnitude of 400° or 450° F., for more than a few seconds would melt a fabric such as nylon. Therefore a system for effectively purging the heating leg of hot air, such system to become operative in the event of stoppage of travel of fabric F, is a feature of the present invention.

Normally, air drawn into the apparatus by the fan in fan housing **106** is discharged through a tapering connecting duct **106***a* into the horizontally extending duct **109**, best shown in Figure 1. In ordinary circumstances, air so blown into duct **109** is precluded from entering heating leg **2**. It is returned to the room through the louvred exit **110**. The vanes **111** in the louvred exit **110**, which are actuated in conventional manner by means of pinions and a depending rack **111***a*, are allowed to remain in horizontal position as long as the operation of the apparatus as a whole is progressing properly. If, however, travel of fabric F ceases for any reason, vanes **111** are caused to move from the horizontal position which they normally occupy into a vertical position, thereby blocking the further discharge of air into the room.

At the same time, the two halves of a normally closed damper **112** (Figure 4*a*) that is hinged along its sides as at **112***a* so as to permit it to open along its center line are pulled in conventional manner by chains **112***b* out of horizontal position into vertical position, thus opening the way for the discharge of cooling air directly into heating leg **2**. Figure 1 illustrates in dotted lines the two halves of damper **112** in their normal position, this position being that which damper **112** occupies when vanes **111** in exit **110** are in horizontal position.

The means by which vanes **111** and damper **112**, through rack **111***a* and chains **112***b*, are caused to move from their horizontal to their vertical positions and vice versa may take any convenient form such as solenoids connected into the system in a manner such as to produce the necessary movement. Accordingly, the electrical circuit for actuating and deactuating solenoids **82** (Figure 5) may be elaborated so as to include means for energizing and de-energizing the solenoids for controlling the positions of vanes **111** and damper **112**. This can be accomplished, for example, by connecting the solenoids for operating vanes **111** and damper **112** in parallel with the uppermost solenoids **82** in such manner that the vanes will be closed and the damper open whenever the uppermost shutters are closed to prevent radiation of heat from the uppermost heating elements **53** from reaching the web. When the latter are to be moved from horizontal to vertical positions, all shutters **70** and **71** that are in horizontal position are likewise to be moved to vertical positions.

When fabric F stops, the output of tachometer generators **29***a* and **35***a* drops to zero, the power supply to the heating elements **53** is shut off, the shutters **70** and **71** close, and air previously at room temperatures that has been drawn into cooling leg **3** through the lower end of **102** thereof, instead of being allowed to discharge into the room through louvred exit **110** at the end of

horizontal extending duct **109**, is diverted downward into heating leg **2**. Thus air at temperatures not too far above ordinary room temperatures is forced through heating leg **2**, whence it is discharged to the room at the open lower end **113** thereof (Figure 1). In proceeding downward through heating leg **2**, it blankets fabric F on both sides thereof. With this arrangement, the system may be purged of hot air in a matter of a few seconds.

Under normal conditions; i. e., when the air drawn through cooling leg **3** is being discharged into the room through louvred exit **110**, it is possible and is usually desirable to circulate air in heating leg **2** to prevent the ambient temperature from becoming too high and to prevent overheating of the reflectors, shutters and other elements associated with or disposed near the heating elements **53**. For this reason, a second air circulation system is included in the apparatus. The more important elements forming part of such second air circulation system can be seen in Figures 1 and 4. Except as hereinafter explained, it is largely independent of the system heretofore described.

Along that side of heating leg **2** which appears at the left in Figures 1 and 3, there is a vertically extending sheet metal duct **114**. Hot air that is in contact with fabric F can be drawn upward through duct **114** into a communicating duct **115** (Figure 4) which communicates by means of an extension **115***a* with a fan housing **116** located on platform **6** beneath top structure **4**. In fan housing **116** is a fan (not shown) driven by a belt **117** from a fan motor **118** which likewise is mounted on platform **6**. The fan in fan housing **116** draws the hot air from duct **114** and discharges it through an extension **116***a* on fan housing **116** (Figure 4) into a horizontal extending sheet metal duct **119** (Figures 1 and 4). Hot air in the duct may be discharged into the room through a vertical exit **120** (Figure 1) which is controlled by an appropriate damper **120***a*. When vertical exit **120** is closed by the damper **120***a*, the hot air flowing in duct **119** is diverted laterally into a second sheet metal duct **121**. Duct **121** is in open communication with the upper end of a downwardly extending sheet metal duct **122** at the right hand side of heating leg **2** as seen in Figures 1 and 3. Thus hot air drawn by the fan in fan housing **116** out of duct **114** at one side of heating leg **2** is forced back into heating leg **2** through the duct **122** at the opposite side of heating leg **2**. Between the two ducts the air travels laterally across fabric F on both sides thereof, and along the heating elements, shutters, reflectors and associated parts. When the exit **120** is partially or entirely open, hot air is discharged therefrom and a corresponding volume of cool air is drawn into the system through the open bottom end **113** of leg **2**.

In ordinary circumstances the exit **120** is controlled, either manually or thermostatically, so that there is a partial recirculation of the hot air in the heating leg **2**, sufficient hot air being bled out of opening **120** to maintain the ambient temperature within the heating leg **2** at a desired level. In the event that the fabric stops, it is possible to circulate the cooling air in leg **2**. In such circumstances, cooling air is supplied to the upper end of heating leg **2** through damper **112**. If the exit **120** remains closed, the cooling air supplied through damper **112** will ultimately be discharged from the open bottom **113** of leg **2**.

A modified apparatus for controlling the distance through which the fabric is exposed to the action of the heating elements in accordance with the speed of the fabric is shown in Figures 8 and 9. Here the heating elements **53** and reflectors **52** are constructed and supported as before, but instead of utilizing pivoted shutters, movable curtains **123** and **124** are employed. Each curtain consists of a series of metal strips or slats **125**, each of which is secured at its ends to links **126** and **127** of chains **128** and **129**; the strips extend throughout a sufficient length of the chains to form curtains long enough to be interposed between all of the heating elements **53** and the fabric web, and can be moved to expose the web to all of the heating elements. The parallel chains **128** and **129** are carried by sprockets **130** and **131** adjacent the top of the apparatus and sprockets **132** and **133** at the bottom of the apparatus. It will be evident that by rotation of the sprockets the chains can be made to carry the curtains **123** and **124** up or down in front of the resistance heating elements **53**, thereby decreasing or increasing the exposure of the strips to the heating elements. As the curtains are moved downwardly more heating elements become effective, as they are moved upwardly the heat from more of the heating elements is prevented from reaching the web.

This apparatus is in some respects advantageous as compared to the apparatus of Figure 5 for the reason that it provides a continuously variable, and thus finer, adjustment of the exposure of the strip to the heat radiated by the heating elements than the step-by-step adjustment obtained with the shutters of the previous form. It is also simpler in some respects inasmuch as the solenoids and springs of the previous modification are eliminated.

Control is effected in substantially the same manner as before. Thus, the tachometer roll **35** drives the tachometer generator **35***a* in accordance with the speed of the fabric. The output of the generator, modified by the rheostat **84**, is supplied to the coil **85** of the differential relay **86**, as before, and the relay is utilized to control the adjusting motor **87** which drives control shaft **92** through worm **93** and worm wheel **94** as before. Control shaft **92** operates the balancing rheostat **95** which furnishes a balancing voltage to relay **86** and also drives contact plate **100** which controls the contacts **101** leading to the magnetic switches **60** which control the heating elements **53** as illustrated in Figure 7.

In the previous modification, shaft **92** also had mounted upon it a contact plate **97** for controlling the several solenoids **82** that control the shutters **72**. In the form shown in Figure 8, contact plate **97** is eliminated; instead, the motor shaft **135** is provided with a bevel pinion **136** which drives bevel gear **137** on shaft **138** upon which the sprockets **132** and **133** for the chains **126** and **127** of curtain **123** are mounted. Shaft **138** is also provided with a spur gear **140** which drives spur gear **141** through idlers **142** so that the direction of rotation of spur gear **141** is opposite to that of spur gear **140**. Gears **140** and **141** are of the same diameter and hence rotate at the same speed.

Gear **141** is mounted on shaft **144** which carries the sprockets **132** and **133** of curtain **124**. Thus, rotation of the motor shaft results in rotation of the shafts **138** and **144** and corresponding upward or downward movement of the curtains **123** and **124**. At the same time, rotation of the motor shaft **135** causes rotation of the control shaft **92** which controls the balancing rheostat **95** and the energization of the heating elements **53**. The ratios of the worm and worm wheel and the bevel gears are selected so that the curtain will travel from fully closed to fully open position as the contact plate **100** travels a distance sufficient to make contact with all of the contacts **101**. As before, the contact plate **100** is preferably adjusted on the shaft **92** so that the heating elements are given an opportunity to preheat as the fabric web accelerates in its passage through the apparatus in advance of the exposure of the web to them. Thus in the embodiment shown the curtains **123** and **124** have exposed only two of the heating elements **53**, but the contact plate has closed the circuits through four of the contactors **101** so that four of the heating elements on each side are energized, the strip being shielded from the two lower heating elements on each side by the curtains **123** and **124**.

In this modification, as in the previous modification, the higher the speed of the web, the greater the distance

of exposure to heat. The increase in distance with increase in speed preferably is arranged to maintain substantially constant the time of exposure of the fabric to the radiant heating elements. Thus, for a given temperature of the heating elements, the heating effect on the fabric web remains substantially constant regardless of variation in speed of the web. Also, in this modification, as in the previous modification, when the web stops, the output of the tachometer generator goes down to zero and the adjusting motor operates immediately to cut off the exposure of the web to all of resistance elements 53 and to open all of the circuits leading to the resistance elements.

Although the above described embodiment of the invention represents the preferred embodiment, it is also possible to employ the apparatus and processes of the invention in an installation in which high-velocity jets supplying heated air are used in lieu of heating elements 53 in heating leg 2. In such case, reflectors are unnecessary, but the shutters, links, pivot pins and other parts of the system for operating the shutters can be retained substantially as already described.

Thus the invention contemplates apparatus and processes for stretching textile fabrics in which a high degree of control is exercised over the fabric in its travel into, through and out of the oven. One of the important features of the invention is the system by which the variable length of the heating zone; i. e., the distance above line A—A in Figure 5, may be varied to take into account and to respond to variations in the speed of travel of the fabric. This system is obviously one of general application, regardless of whether the oven is or is not of the tower type.

It is intended that the patent shall cover, by the summarization in the appended claims, all features of patentable novelty residing in the invention.

What is claimed is:

1. In an oven for heating a fabric traveling in the form of a web, a series of radiant heating elements; radiation-opaque means interposed between the web and the heating elements, said radiation-opaque means being adapted to cut the heating elements into or out of operation on a progressive basis in consequence of progressive movement of such radiation-opaque means; and, operating on said radiation-opaque means, speed-sensitive control means functioning to move said radiation-opaque means automatically in continuous response to variations in the speed of travel of the web, said radiation-opaque means being coupled to and actuated by said speed-sensitive control means.

2. Apparatus according to claim 1 wherein said radiation-opaque means comprises a series of shutters extending along the direction of travel of said web.

3. Apparatus according to claim 1 wherein said radiation-opaque means comprises an articulated curtain movable between said heating elements and said web.

4. Apparatus according to claim 1 embodying a temperature responsive unit for sensing the temperature of the web and means connected thereto for decreasing the power supplied to said heating elements when the temperature of said web increases and increasing the power supplied to said heating elements when the temperature of said web decreases.

5. In an oven for heating a traveling web, means for driving the web, a series of heating elements in apposition to the web, means for activating and de-activating said heating elements, means responsive to the temperature of the web controlling said activating and de-activating means, and other means responsive to the speed of the web controlling said activating and de-activating means in a manner such as to progressively activate said heating elements as the speed of said web increases and to progressively de-activate said heating elements as the speed of said web decreases.

6. In an oven for heating a fabric traveling in the form of a web, the combination comprising two opposed series of heating units each of which series parallels the direction of travel of the web, shutters for the heating units, said shutters being movable between shut positions in which they render the heating units ineffective and open positions in which they permit heat from said heating units to reach said web, means for biasing the shutters toward one of said positions, means sensing variations in the speed of travel of the web, and, coupled to and actuated by the sensing means, over-riding means capable of overcoming the biasing means to move the shutters toward the other of said positions.

7. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material adapted to be interposed progressively between the web and the heating elements of said series, means responsive to variations in the temperature of the web for varying the amount of heat radiated by said heating elements, and means responsive to variations in the speed of the web for controlling said movable means and successively turning on and off said heating elements in accordance with the movement of said movable means.

8. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material adapted to be interposed progressively between the web and the heating elements of said series, means responsive to the speed of the web for controlling said movable means and successively turning on and off said heating elements in accordance with the movement of said movable means, and means for circulating heated air over said web and said heating elements.

9. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material adapted to be interposed progresssively between the web and the heating elements of said series, means responsive to the speed of the web for controlling said movable means and successively turning on and off said heating elements in accordance with the movement of said movable means, means for circulating heated air over said web and said heating elements, and means for circulating cooling air over said web.

10. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material adapted to be interposed progressively between the web and the heating elements of said series, means responsive to variations in the speed of the web for controlling said movable means, and means responsive to variations in the speed and temperature of the web for controlling the power supplied to said heating elements.

11. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material to prevent radiation from said heating elements from falling on said web, means for moving said movable means progressively between a closed position in which radiation from all of said heating elements is prevented from falling on said web and an open position in which radiation from all of said heating elements falls on said web, whereby said web may be exposed to heat over varying distances, and means responsive to the speed of the web for controlling said means for moving said movable means and for successively turning on and off said heating elements in accordance with the movement of said movable means.

12. An apparatus according to claim 11 wherein said heating elements are turned on in advance of the opening of said movable means.

13. In an oven for heating fabric traveling in the form

of a web, the combination comprising a series of radiant heating elements in apposition to the web, movable means of radiation-opaque material to prevent radiation from said elements from falling on said web, means for moving said movable means progressively between a closed position in which radiation from all of said heating elements is prevented from falling on said web and an open position in which radiation from all of said heating elements falls on said web, whereby said web may be exposed to heat over varying distances, said movable means operating in a direction opposite the direction of movement of said web to increase the distance through which said web is exposed to heat and in the same direction as said web to decrease the distance through which said web is exposed to heat, and means responsive to the speed of the web for controlling said means for moving said movable means and for successively turning on and off said heating elements in accordance with the movement of said movable means.

14. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, a movable flexible curtain of radiation-opaque material adapted to be interposed between said series and said web, means for moving said curtain between a position in which it is interposed between all of said heating elements and said web and a position in which it is entirely removed from the space between said heating elements and said web whereby said web may be exposed to heat over a varying distance depending upon the position of said curtain, means responsive to the speed of the web for controlling said means for moving said curtain, means for circulating heated air over said web and said heating elements, and means for circulating cooling air over said web.

15. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, a movable flexible curtain of radiation-opaque material adapted to be interposed between said series and said web, means for moving said curtain between a position in which it is interposed between all of said heating elements and said web and a position in which it is entirely removed from the space between said heating elements and said web whereby said web may be exposed to heat over a varying distance depending upon the position of said curtain, means responsive to the speed of the web for controlling said means for moving said curtain and for successively turning on and off said heating elements in accordance with the movement of said curtain, means responsive to the temperature of said web for controlling the energization of said heating elements to maintain said temperature substantially at a predetermined value, means for circulating air over said web and said heating elements, and means for circulating cooling air over said web after said web has passed said series.

16. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, a movable flexible curtain of radiation-opaque material adapted to be interposed between said series and said web, means for moving said curtain between a position in which it is interposed between all of said heating elements and said web and a position in which it is entirely removed from the space between said heating elements and said web whereby said web may be exposed to heat over varying distances depending upon the position of said curtain, said curtain moving in a direction opposite the direction of movement of said web to increase the distance through which said web is exposed to heat and in the same direction as said web to decrease the distance through which said web is exposed to heat, and means responsive to the speed of the web for controlling said means for moving said curtain and for successively turning on and off said heating elements in accordance with the movement of said curtain.

17. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating elements in apposition to the web, a movable flexible curtain of radiation-opaque material adapted to be interposed between said series and said web, means for moving said curtain between a position in which it is interposed between all of said heating elements and said web and a position in which it is entirely removed from the space between said heating elements and said web whereby said web may be exposed to heat over varying distances depending upon the position of said curtain, said curtain moving in a direction opposite the direction of movement of said web to increase the distance through which said web is exposed to heat and in the same direction as said web to decrease the distance through which said web is exposed to heat, means responsive to the speed of the web for controlling said means for moving said curtain and for successively turning on and off said heating elements in accordance with the movement of said curtain, means responsive to the temperature of said web for controlling the power supplied to said heating elements to maintain said temperature substantially at a predetermined value, means for circulating air over said web and said heating elements, and means for circulating cooling air over said web after said web has passed said series.

18. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating units extending transversely of the direction of travel of said web, movable means of radiation-opaque material adapted to be interposed progressively between the units of said series and said web, and means responsive to the speed of the web for controlling said movable means and successively turning on and off said heating units in accordance with the movement of said movable means, said speed responsive means being adapted to turn off all said heating units and to interpose said movable means between all said heating units and said web upon stopping of said web.

19. In an oven for heating fabric traveling in the form of a web, the combination comprising a series of radiant heating units extending transversely of the direction of travel of said web, movable means of radiation-opaque material adapted to be interposed progressively between the units of said series and said web, means for circulating heated air over said web and said heating units, means for circulating cooling air over said web after said web has passed said series, and means for interposing said movable means between said units and said web and for causing cooling air to circulate over said web in the zone of said heating units in the event of stoppage of said web.

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