

[54] **APPARATUS FOR HEAT TREATMENT
OF SYNTHETIC YARN**[76] Inventor: **Nobuhisa Kodaira**, 7-1, 2-chome,
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Japan[22] Filed: **Sept. 15, 1971**[21] Appl. No.: **180,708**[52] U.S. Cl. **219/326, 28/62, 57/34 HS,**
165/105, 219/388, 219/530, 34/155[51] Int. Cl. **H05b 1/02**[58] Field of Search 219/325, 388, 530,
219/540; 28/62; 57/34 HS; 105/32, 105;
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[57] **ABSTRACT**

In heat treatment apparatus for the treatment of synthetic yarns and the like, a plurality of heat-transfer jackets having replaceable heating plates thereon are connected to a common liquid heating chamber and a common header or condenser to form a closed heating system. The jacket and header are connected through a restricted orifice to provide a fluid-pressure resistance so that the heated liquid in the chamber when vaporized flows into the upper portion of the heating jacket, through the orifice and into the header where it condenses. The restricted orifice increases the velocity of the vapor flowing into the header preventing the condensation of the vapor at the upper portion of the jackets to thereby eliminate non-uniform temperature areas on the external surfaces of the heater plates. A pressure sensor is connected to at least one of the jackets and includes switching means to control a heating element to maintain a constant temperature and pressure.

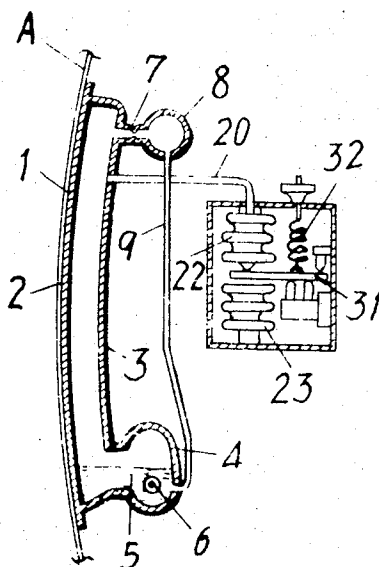
6 Claims, 8 Drawing Figures

Fig. 1.

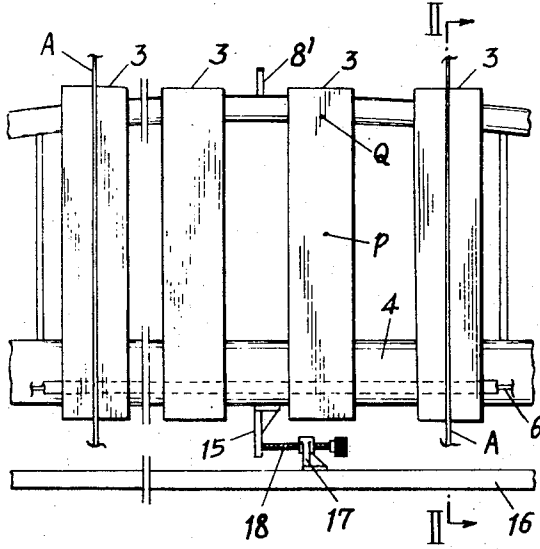


Fig. 2.

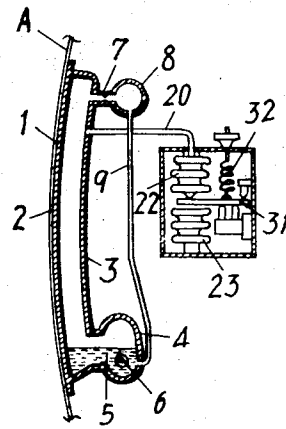


Fig. 4.

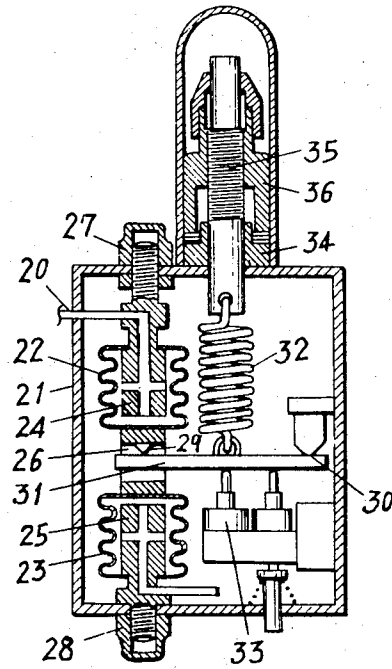


Fig. 3.

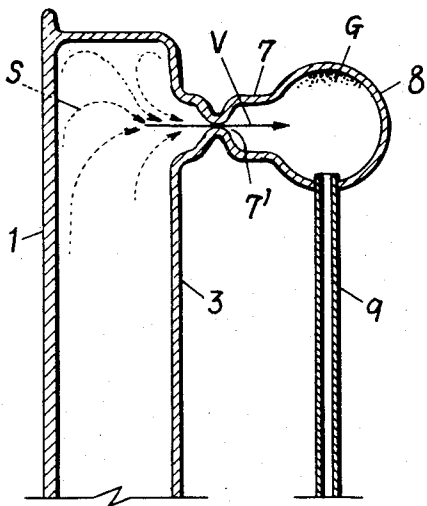


Fig. 5.

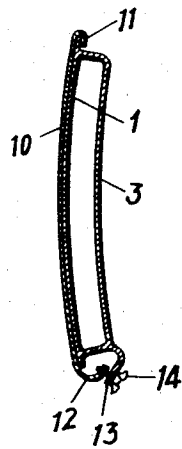


Fig. 6.

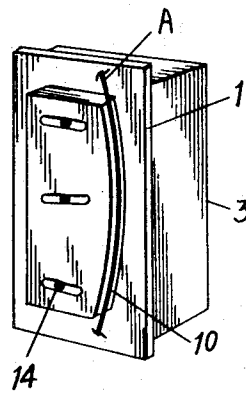


Fig. 7.

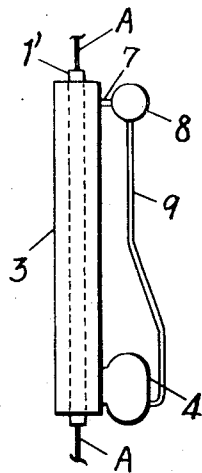
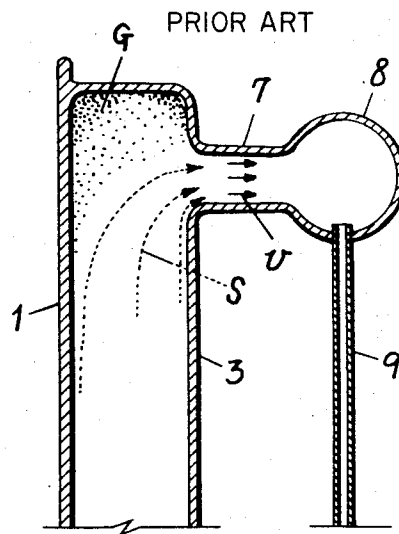


Fig. 8.



APPARATUS FOR HEAT TREATMENT OF SYNTHETIC YARN

BACKGROUND OF THE INVENTION

In a conventional heat treating apparatus for synthetic yarns and the like having a single heating jacket, uniform temperatures will be maintained on the surface of the heater only so long as the substances in the vapor produced from the heat transfer medium is uniformly pure. If low-boiling point materials or inactive gas is entrained in the vapor, the impurities will condense on the upper portions of the jacket resulting in a non-uniform surface temperature distribution. If fibrous yarn is subjected to heat treatment with an apparatus having a non-uniform temperature distribution, it will not be finished to a uniform quality.

In an early attempt to solve the problem outlined above, the heater jacket is provided with a header or condenser which communicates through a pipe to the upper portion of the jacket. A pressure differential exists between the header and jacket such that the impurities contained in the vapor pass with the vapor through the pipe into the header rather than remaining within the heater. While this met with some success, the vapor flowing through the pipe into the header is generally of a small volume and somewhat low velocity so that some of the vapor remained in the upper portion of the jacket condensing therein causing temperature variations.

SUMMARY OF THE INVENTION

The present invention relates to an improved apparatus for heat treatment of synthetic fibrous yarns in the provision of a plurality of longitudinally positioned spaced-apart heating jackets for heating the yarn passing thereover. Each jacket includes a yarn contacting face or heater plate and an internal chamber to contain a heat-transfer media vapor. The upper portion of each jacket is connected to a common header or condenser through a restricted orifice. The lower portions of each jacket are connected to a common heating chamber where the liquid heat-transfer medium is heated. The header, heating chamber, and jacket are interconnected such that the internal surfaces of the apparatus communicate with each other to form a closed heating system.

Since a relationship exists between the saturation pressure and saturation temperature of the heat-transfer media and the vapor in the jackets, a pressure sensing apparatus including a balanced bellows and switching means is connected to at least one of the jackets to detect the pressure in the jacket and to control the heat source to maintain a constant pressure.

Accordingly, it is an object of the present invention to provide a closed heating system for treatment of synthetic yarns and like materials.

It is another object of the present invention to provide a heat treatment apparatus having a uniform surface temperature distribution over the heater face.

Another object of the present invention is to provide a closed heat treating apparatus having means communicating therewith to prevent condensation of vapor within said heating surface.

It is a further object of the present invention to provide a heat treatment apparatus having a condensation chamber wherein low-boiling point materials and un-

desirable gases may be separated from the heated vapor.

It is another object of the present invention to provide a pressure sensor and switching means for controlling the pressure and temperature in a heat treatment apparatus.

Another object of the present invention is to provide a heat treatment apparatus for synthetic yarn having replaceable heater plates.

Basically, the present invention provides a plurality of longitudinal heating jackets arranged in rows each jacket having a yarn-contacting heater face and an inner vapor chamber. The upper portion of each jacket is connected to a common header or condenser through a pipe having a restricted opening or orifice therein which provides a resistance to the flow of fluid pressure to thereby increase the velocity of fluid flow as it passes into the header. The lower portion of each jacket is connected to a common heating chamber having an electrically controlled heating element therein. The header and heating chamber are connected to each other through a return pipe. The jackets, heating chamber, and condenser are interconnected and form a completely closed system in which the fluid heat transfer medium may be heated, vaporized, and condensed. At least one of the jackets is connected to a pressure detector which includes a pressure-responsive bellows and an evacuated bellows to compensate for changes in atmospheric pressure and to control the pressure and temperature of the heat transfer medium contained in the closed system.

The invention will now be more fully described with reference to the accompanying drawings in which:

FIG. 1 is a front plan view of a heat treatment apparatus of the present invention;

FIG. 2 is a cross-sectional view taken along the plane II—II in FIG. 1;

FIG. 3 is an enlarged cross-sectional view of the heating jacket and condenser chamber illustrated in FIG. 2;

FIG. 4 is an enlarged cross-sectional view of the pressure detector assembly illustrated in FIG. 2;

FIG. 5 is a cross-sectional view of a heating jacket showing a modified yarn-contacting plate;

FIG. 6 is a perspective view of another type of yarn-contacting plate provided on the heating jacket;

FIG. 7 is a side view of another embodiment of the present invention; and

FIG. 8 is a cross-sectional view similar to that shown in FIG. 3 illustrating a prior art structure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and in particular, to FIGS. 1 and 2, the apparatus of the present invention will be described in detail. A plurality of longitudinally positioned jackets 3 are arranged in a row. Each jacket has at its front face an arcuately curved heating plate 1 for contacting and heating a fibrous yarn A. The lower portion of each jacket is connected to a laterally extending common heating chamber 4 in which an electrical heater 6 is provided. The upper portion of each jacket 3 is connected through a pipe 7 extending to a common header or condenser assembly 8. The pipe 7 is throttled to provide a reduced diameter orifice 7' (FIG. 3) forming a resistance to the flow of fluids therein

which will be more fully described hereinafter. The header 8 has a circular or polygonal cross section and extends at the back of the jackets in an arc, that is, as seen in FIG. 1, from its intermediate portion it bends downwardly towards its opposite ends. A sealed drain pipe 8' extends upwardly from the center of the header.

A plurality of pipes 9 extending from the lower portion of the header to the heating chamber form a return path for the condensed fluid. The jackets 4 and pipes 7 and 9 are welded or soldered together to form a completely closed chamber. The bottom of the heater chamber 4 is filled with a suitable heat transfer medium such as Dowtherm, commercially available from the Dow Chemical Co., Midland, Michigan. The liquid 5 is heated by the heater 6 in the chamber 4 to produce a vapor. The heated vapor enters the jacket 3 through its lower inlet and fills the jacket with the heated vapor to thereby heat the heater plate 1. Most of the vapor is heat exchanged with the heating plate 1 and condenses on the inner wall surfaces of the jacket 4 where it flows down the inner wall into the liquid where it is again heated. The header 8 also radiates heat and the vapor therein is cooled and condenses creating a pressure differential between the jackets and the header. Since the vapor pressure within the header is lower than that in the jacket, the vapor flows through the pipe 7 through the restriction 7' and into the header.

Referring briefly to FIG. 8, in the conventional apparatus shown, the header 8 and the jacket 3 are connected through a pipe 7. The volume of vapor flowing into the header is relatively small and the velocity of the flowing vapor as represented by the vector v is small. Therefore, vapor in the upper portion of the jacket 3 flows slowly along the dotted lines S whereby low-boiling point materials or inactive gases or other impurities are separated from the vapor and deposited on the upper portion of the jacket 3. This deposition or condensation causes non-uniform temperature distribution on the heating plate 1.

In the present invention as shown in FIG. 3, the pipe 7 connecting the jacket 3 and header 8 is throttled or is provided with a reduced diameter orifice 7' to provide a resistance to the flow of the vapor. As the heated vapor flows through this narrow cross-sectional passage because of the pressure differential between the jacket 3 and header 8, the velocity of the vapor passing through this portion increases as shown by the vector V . Accordingly, the heated vapor in the upper portion of the jacket is induced by the high speed flow and guided along the dotted lines S into the header. Thus, the vapor is not retained in or on the inner surfaces of the jacket 3 but rather flows into the header together with the low-boiling point materials, inactive gases, and other impurities. Accordingly, the surfaces of the jackets and the heating plates are uniformly heated, and the temperature distribution is uniform throughout its surface.

The relationship between the fluid resistance, gas volume, and temperature in the jacket 4 is shown in the following example. With reference to FIG. 3, the inside diameter of pipe 7 is 6 mm, and the inside diameter of the orifice is m . Dowtherm A is used in the jacket as a heat transfer medium and the gas volume n is mixed in its vapor. The heating plate 2 shown in FIG. 1 is heated at its center point P to 120° C. The difference in tem-

perature between point P and its upper point Q is as follows:

throttle m	gas volume n				
	10cc	20cc	30cc	40cc	50cc
1 mm	0	0	0	0	-4°c
2 mm	0	0	0	0	-4°c
3 mm	0	0	0	-4°c	
4 mm	-4°c	-4°c or lower			

From the above table, it is readily apparent that in the case of a gas volume of 40cc with the inside diameter of the orifice 2 mm or less or in the case of a gas volume of 30cc with a throttle diameter of 3 mm or less, there will be no difference in temperature on the heating plate 2.

The heated vapor, having passed with high speed through the orifice 7', is retained in the condenser for a time while the impurities and inactive gases are separated into a gaseous state. The impurities thus separated are collected and retained in the upper of the center portion of the condenser. The amount of gas thus collected is of a very small volume and may periodically be drained by opening the drain pipe 8' (FIG. 1) draining and then resealing. The condensed vapor produced by the heat discharge from the header returns through the pipe 9 to the chamber 4 where it is again reheated. The pipe has a relatively small diameter and provides a resistance to the volume of returning heated medium. Thus, the liquid heated in the chamber 4 becomes a vapor flowing upwardly through the jacket 3 into the header 8 where it is condensed and returns to the liquid chamber thereby forming a closed system.

The temperature within the jackets is controlled by means of the pressure-sensing apparatus illustrated in detail in FIG. 4. The pressure sensor basically comprises a pair of balanced, sealed bellows members 22 and 23 one of which is responsive to variations in pressure within the jacket while the other is responsive to changes in atmospheric pressure. The two bellows members are interconnected and serve to operate a switching member 33 which in turn controls the application of power to the heater 6.

The pressure-sensing bellows 24 is connected to a housing 21 by means of a bushing 24 having an outwardly extending threaded end which is fixed to the housing 21 by means of a nut 27. The bushing is provided with a plurality of communicating passageways which are connected by means of a pipe 20 to one of the jackets 3. An increase in pressure in the jacket 3 transmitted through pipe 20 will enter into the bellows 23 and cause a corresponding increase in its length.

The atmospheric pressure responsive bellows 23 is similar in construction to the bellows 22. A bushing 25 therein having a plurality of communicating passages has an extended threaded end by which it is fixed on the housing 21 by means of a nut 28. The bellows 23 is evacuated to not less than 1×10^{-4} Torr and is sealed. The bellows members 22 and 23 are connected to each other by means of a U-shaped metal connector 26. The metal connector is provided with a projection 29 which presses against one end of a lever arm 31 pivotable about a fulcrum 30. The lever 31 is urged upwardly against the pressure responsive bellows by a coil spring 32 connected along its length. The opposite end of the

coil spring 32 is fixed to a screw member 35 which passes through a bushing 34 at the upper surface of the housing 21. The screw member is vertically movable by adjusting nut 36 which is threadably engaged therewith. The tension on the coil spring 32 and on the lever arm 31 is adjusted by turning the nut 36. An electrical switching means 33 is provided adjacent the lever arm 31 for actuation thereby. The switching means serves to control the application of suitable electric power to the heater 6 located within the liquid chamber 4. Since the bellows members 22 and 23 are connected, their connecting point at 29 on lever arm 31 will indicate the absolute vapor pressure in the jackets since the atmospheric pressure on the two bellows is balanced. Therefore, by using this joining point as the control point for the lever 31 which is balanced by adjustment of the spring force, the lever will remain at a predetermined position. The switching means is arranged to act with only a slight movement of the lever arm 31 so that even a minute pressure variation in the jacket will serve to operate the switching means to control the power of the heater 6 immersed in the heating chamber 3. In this manner, the vapor pressure and accordingly, its temperature will be controlled.

Since each of the bellows members 22 and 23 are equally subjected to outer atmospheric pressure, there will be no error in the fluctuations caused by outer pressure changes. Since the inside of the lower bellows 23 is evacuated to an extent of not less than 10^{-4} Torr, outside temperature changes will have no effect on the bellows.

The bellows arrangement previously described also serves as an extremely effective safety device for this system. If, for example, extremely high pressures should develop within the system, the bellows will act as a safety valve and be destroyed allowing the pressure within the system to vent through the pipe 20 into the housing 21.

The yarn contacting surface 2 of the heating plate 1 may be provided with a chemical or ceramic coating of metal oxide to increase its life. Alternately, as shown in FIG. 5, a second yarn contacting plate 10 may be removably fixed over the heating plate 1 by means of an upper hook 11 and a lower hook 12. Plate 10 is secured by a screw 14 passing through a fixed plate member 13 which, in turn, contacts the lower hook 12. By simply releasing the screw 14, the yarn contacting plate 10 may be easily removed and replaced.

Another embodiment of a relatively thick yarn-contacting plate 10 is shown in FIG. 6 in which the sides of the plate rather than the face are adapted for contacting and treating the yarn. The plate 10 is secured to the heating plate 1 with a plurality of screws 14. The openings in the plate 10 through which the screws 14 pass may be elongated so that the relative position of the plate may be varied.

FIG. 7 illustrates another embodiment of a yarn treatment means wherein the yarn is passed through a heating pipe 1' placed within the jacket 3.

Referring again to FIG. 1, an arm member 15 may be fixed to the body of the heating device and an arm 17 fixed to the frame 16. A screw means 18 is provided between the body arm 15 and fixed arm 17. By turning the threaded bar, the position of the heating apparatus may be varied. If necessary, the heating plate 1 may be provided at the side face of the jacket.

Other modifications will become obvious to those skilled in the art. For example, it may be advantageous to provide a wide surface yarn contacting heater plate over which a plurality of yarn strands may be taken.

Other variations and the many advantages of the present invention will be suggested to those skilled in the art without departing from the scope of the invention which is defined by the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. Heat treatment apparatus for synthetic fibrous yarn comprising:

a plurality of heat exchangers;

a heating chamber tube means connecting said heating chamber to each of said heat exchangers; heating surface means for receiving a yarn in heat exchange relationship to said heat exchangers;

a liquid heat transfer medium in said heating chamber;

a condensing chamber;

pipe means connecting said condensing chamber to each of said heat exchangers

conduit means connecting said condensing chamber to said heating chamber;

heating means for heating said heat transfer medium in said heating chamber to cause said medium to vaporize, said vapor passing through said heat exchangers and into said condensing chamber through said pipe connecting means; and

venturi means in said pipe connecting means, said venturi means increasing the velocity of said vapor passing from said heat exchanger into said condenser to thereby prevent said vapor from condensing and remaining within said heat exchanger.

2. Heat treatment apparatus as defined in claim 1 and further including means responsive to pressure changes in at least one of said heat exchangers and switch means operatively connecting said pressure responsive means to said heating means for controlling said heating means in response to changes of pressure in said heat exchanger.

3. The heat treatment apparatus as defined in claim 2 wherein said heating means is an electrical heating element, said pressure-responsive means comprising a pair of cooperable bellows elements, one of said bellows being connected to said exchanger and responsive to pressure changes therein, the other of said bellows being responsive to changes in atmospheric pressure, said switch means for controlling said heating means including electrical switch means for controlling said heating element and means connecting said bellows to said electrical switch means for switching same in response to changes in sensed pressure.

4. The heat treatment apparatus as defined in claim 1 and further including plate means removably attached to said heat exchanger, said plate means having means formed therein for guiding the yarn during the treatment thereof.

5. The heat treatment apparatus as defined in claim 4 and further including means adjustably mounting said plate means with respect to said heat exchanger.

6. Heat treatment apparatus for synthetic fibrous yarn comprising:

a heating chamber;

a low boiling point liquid heat transfer medium in said chamber;

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a heating element in said heating chamber;
a vertically elongated heat exchange chamber communicating with said heating chamber for receiving said liquid after heating to the gaseous phase;
heating surface means for receiving a yarn in heat exchange relationship to said heat exchange chamber;
a condensing chamber;
pipe means connecting the upper end of said heat exchange chamber to said condensing chamber;
said pipe means having a venturi having a throat

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diameter in proportion to the quantity of said liquid heat transfer medium such that the acceleration of the movement of gas will prevent the high boiling point components of said gas from condensing on the walls of the upper portion of said heat exchange chamber; and
conduit means connecting said condensing chamber to said heating chamber below the surface of the liquid in said latter chamber under normal working conditions.

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