Jan. 11, 1938. T. LYDON ET AL 2,105,088

APPARATUS FOR HUMIDIFYING TEXTILE YARNS

Filed July 23, 1936 3 Sheets-Sheet 1

Fig. 1

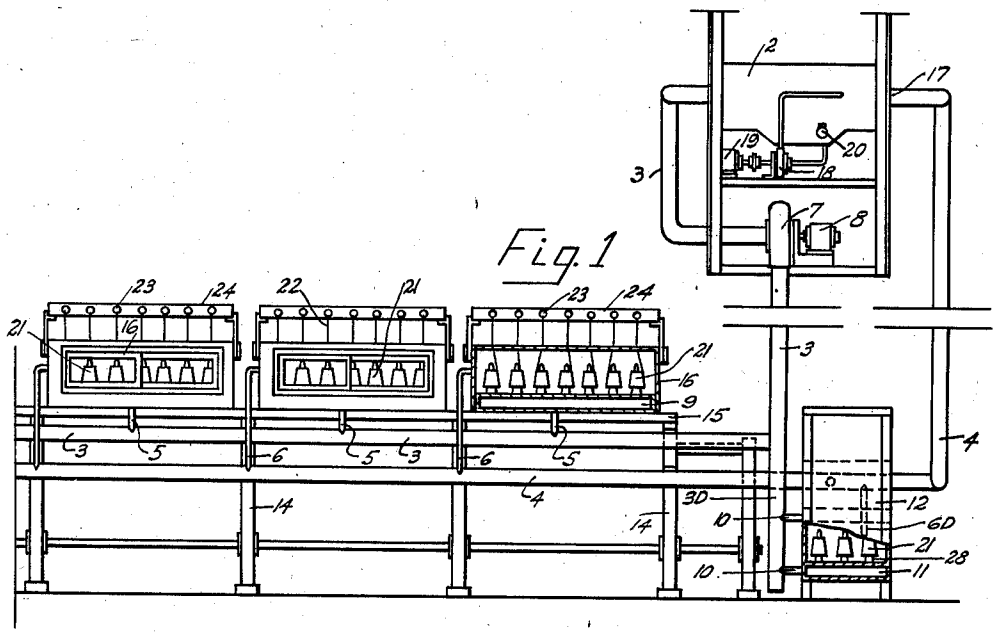


Fig. 2

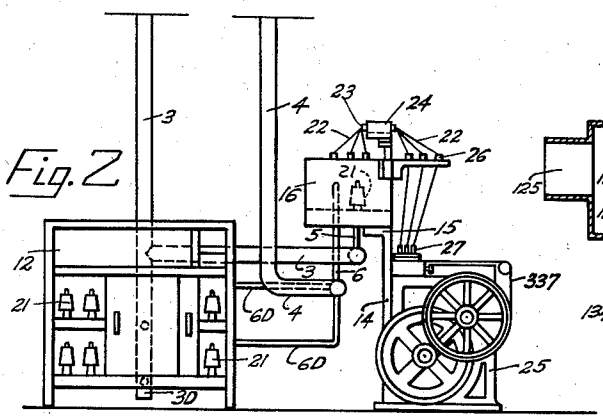


Fig. 5

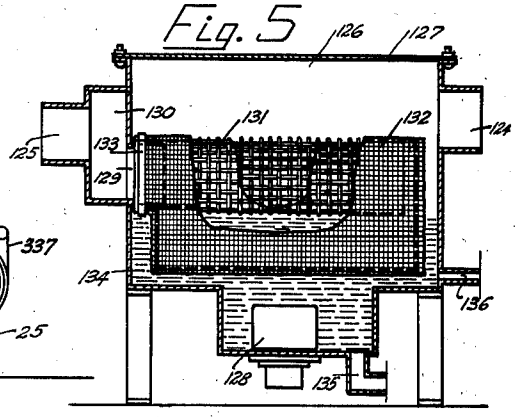


Fig. 3

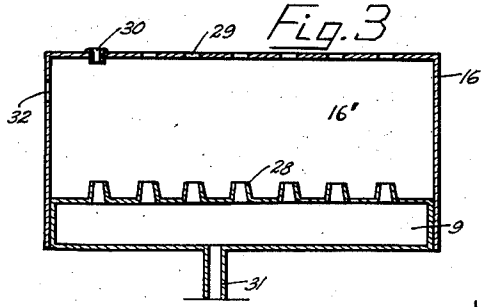
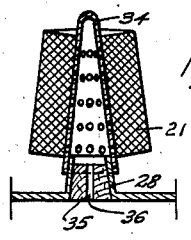


Fig. 4



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APPARATUS FOR HUMIDIFYING TEXTILE YARNS

Filed July 23, 1936 3 Sheets-Sheet 2

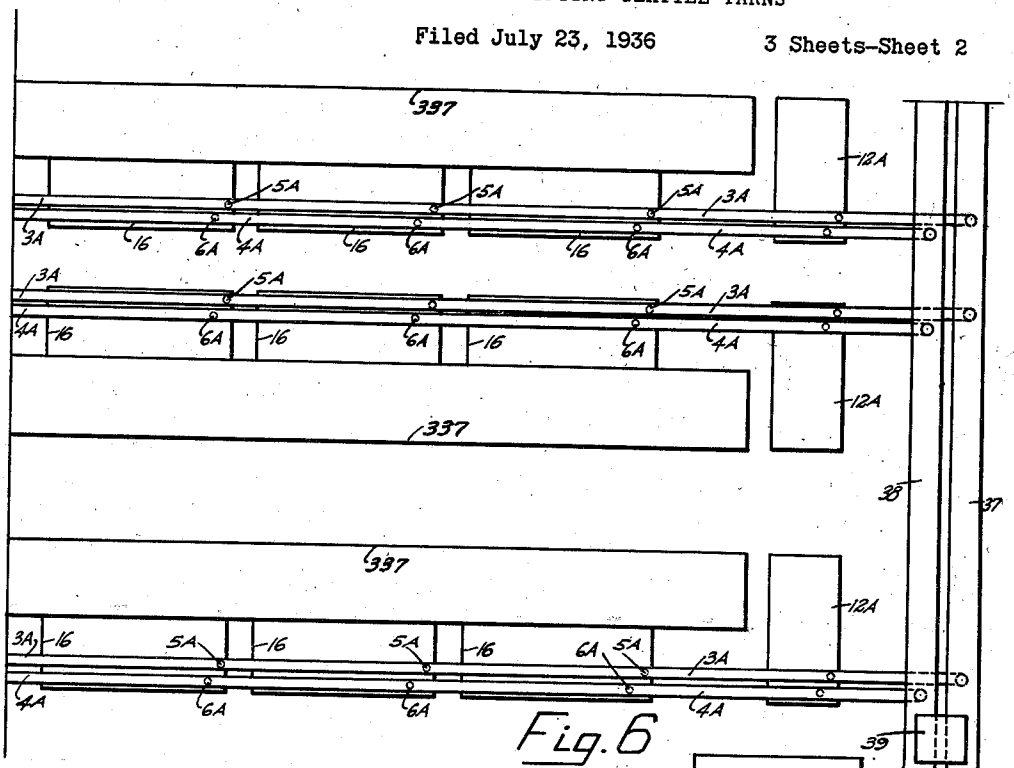


Fig. 6

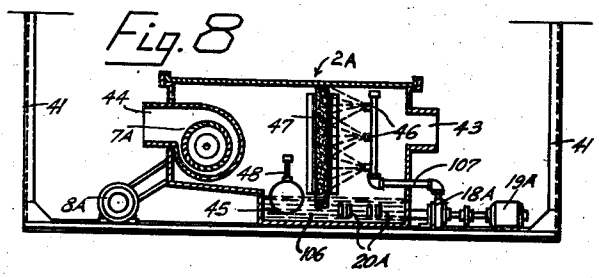


Fig. 8

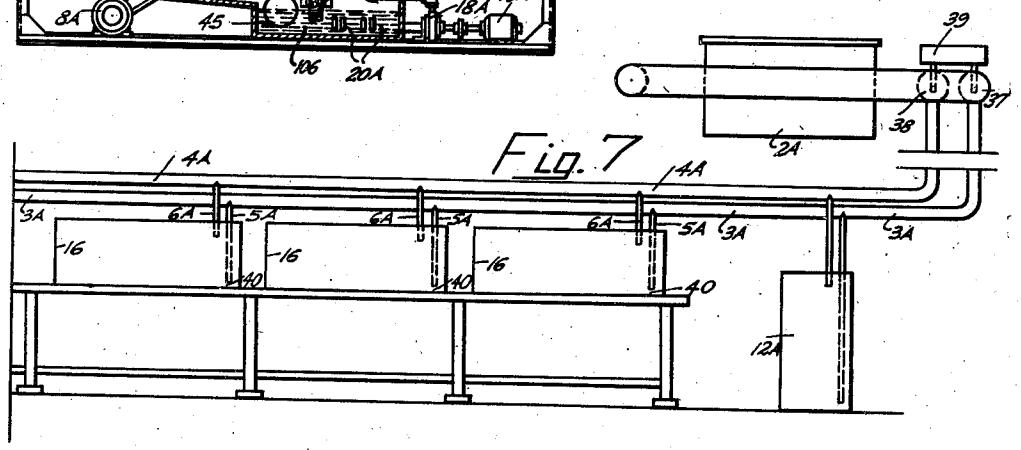


Fig. 7

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APPARATUS FOR HUMIDIFYING TEXTILE YARNS

Filed July 23, 1936 3 Sheets-Sheet 3

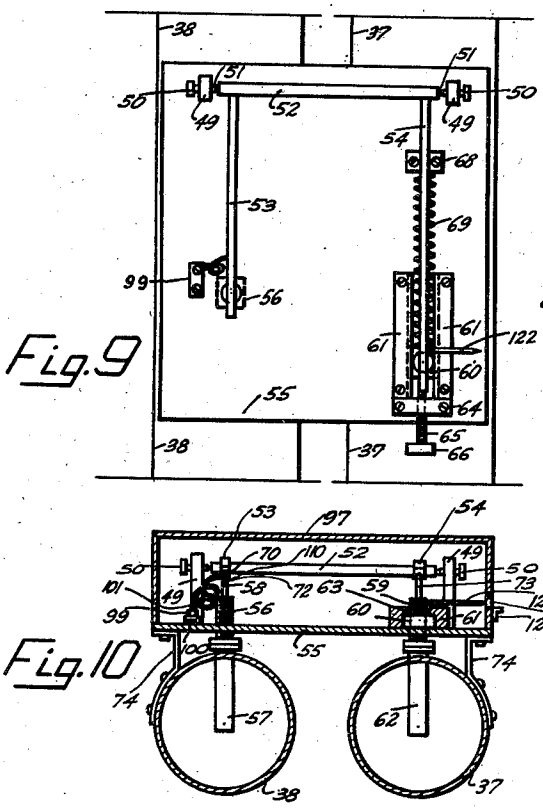


Fig. 9

Fig. 10

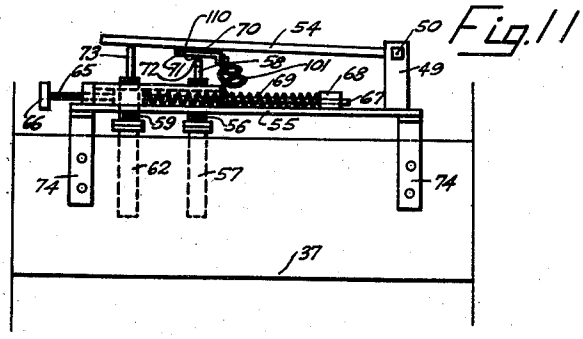


Fig. 11

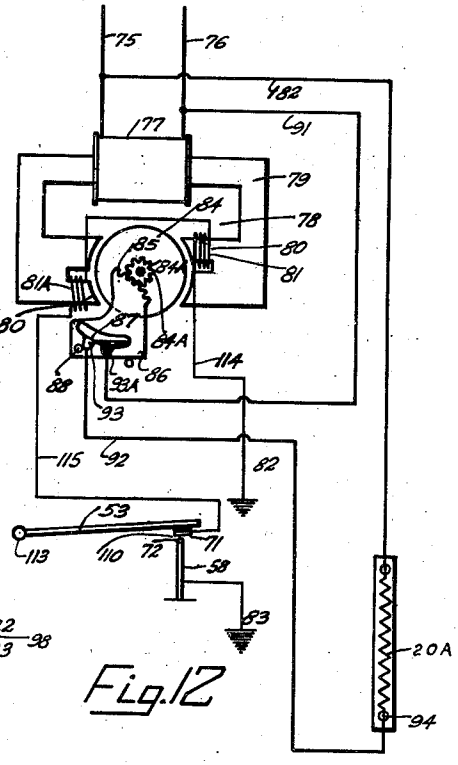


Fig. 12

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UNITED STATES PATENT OFFICE

2,105,088

APPARATUS FOR HUMIDIFYING TEXTILE YARNS

Timothy Lydon, Tenafly, and Patrick J. Lydon, Jersey City, N. J.

Application July 23, 1936, Serial No. 92,136

5 Claims. (Cl. 28—57)

This invention relates to improvements in methods of conditioning textile yarns prior to and during the knitting or weaving processes.

Before yarn is knitted into hosiery or other products it is placed on cones which are used on the knitting machine. In the process of weaving the yarn is carried on small slender shafts known as cops or quills.

Several different kinds of knitting machines are in use in the manufacture of hosiery, one of the most common of which is known as the full fashion hosiery knitting machine. While the applicants' invention can be applied to the several different kinds of hosiery machines as well as to looms for weaving cloth, the applicants for the sake of clearness herein only show the application of their invention to full fashion hosiery machines.

It is a well established fact in the textile industry that humidification is essential to the yarn to bring about the most perfect handling of the yarn in the knitting or weaving machines. Dry yarn kinks or snarls, so that, breakage, knotting, or curling occurs. The occurrence of these irregularities create very visible defects in the finished knitted or woven goods. Textile knitting and weaving machinery is highly developed to operate at a high speed. Irregularities which occur during the knitting or weaving process, may greatly hinder production by frequent stoppage of the machines, or may affect very seriously the quality and value of the product due to consequent defects in the finished product.

In recent years the need for more perfect methods for the humidification and conditioning of yarn during the process of textile manufacture has been more keenly felt than previously. Knitting and weaving machines have been improved to operate at faster speeds. These machines represent large investments in capital. Their efficient and economical operation depends on a very well coordinated and balanced system of mechanical parts.

It is found that in the knitting of full fashioned hosiery that when the yarn is properly humidified, it bends uniformly and easily about the needles. Every loop is uniform and regular. The yarn, as it were, hugs the needle when it is looped about it, when the yarn is not properly humidified, the loops are not so uniform and the yarn does not hug the needle, but irregular loops are formed. These irregularities are very distinct in the finished stocking. It is also found that yarns humidified to different degrees or extent stretch or extend under tension and working to varying degrees. To keep the amount of stretch or extension of the yarn uniform it is important to maintain the humidity of the yarn uniform. Lack of uniformity in the yarn has the effect of producing stockings of varying lengths and sizes other than those intended by the manufacturer.

The demands of style and fashion as well as quality has made it more and more necessary in the past few years to produce yarns of very high twist. These yarns may consist of one or more threads twisted together. The high twist yarns are twisted very many more turns per inch than are the low twist yarns. A high twist yarn is much more lively than a low twist yarn, under the same conditions. In other words it is much more likely to snarl or kink than a low twist yarn and if the twist has been set, it is much more likely to become lively again due to a tension being applied to it or due to drying out. It follows therefore that troubles which might not occur on low twist yarns might cause considerable loss of time and money when high twist yarns were used.

It has furthermore been found that troubles from kinks, snarls and so forth can be avoided to a great extent if after the twist is properly set, the yarn is kept in a conditioned state and not allowed to dry out. Dry yarn resembles wire of a springy nature. This same yarn when conditioned so that its moisture regain is high, loses its wire like nature, and its tendency to curl and snarl.

Many textile mills are humidified in order to facilitate manufacture and to overcome the above mentioned difficulties. It is, however, found in all mills which are not humidified and often in mills which are humidified that as the weather outside changes from a humid condition to a dry condition, the amount of trouble and loss from poor quality increases. Variable weather conditions result in a varied quality of finished products and a complete lack of control by the manufacturer over the quality of his product.

While some of the difficulty can be avoided by a thorough humidification of the textile plant, complete room conditioning seems to be not the answer. With the advent of the higher twists, such high degrees of humidity are being found necessary, that it becomes impractical to carry such high humidities in the rooms. Very high humidities in the knitting or weaving rooms are impractical for the following reasons:—(1) They are very difficult to maintain particularly during the cold seasons. (2) They create uncomfortable working conditions for the labour. (3) They cause rusting and serious damage to the delicate

parts of the machinery. (4) During the cold seasons high humidity inside the rooms causes copious condensation and sweating on windows and walls unless double windows are provided and all the walls are insulated.

Another rather serious objection to general room humidification especially in connection with the knitting of silk hosiery on full fashion hosiery machines has been experienced. The silk stocking when in the process of being knitted is kept under a tension so that as it develops in length it is drawn away. The tension required is such that if the stocking is too wet the threads will stretch. It has been found that although it is desirable to humidify the thread to a high degree in order to obtain satisfactory knitting, at the same time the knitted stocking should be comparatively dry at a distance of approximately three inches from the needles. In other words conditions should be such that the humidified yarn after being knitted will dry out by the time this yarn in the knitted stocking reaches a point three inches away from the needles or place at which it was knitted. If not dry at this point stretching due to tension may take place. It is obvious therefore that in a highly humidified room the yarn could not dry out and the yarn in the stocking would remain high in moisture content for such a time as would make it impossible to prevent stretching of the partly knitted stocking due to the tension applied to it on the knitting machine. In our invention the high humidity is confined to the cone boxes where its effects on the yarn are beneficial only.

Our invention can be adapted to weaving machines by placing the quills or cops which are to be used on the looms, in boxes or containers on the looms, and humidifying these boxes by means of our herein described controlled humidifying equipment. We can also adapt our equipment to other textile machines, such as spinners, by placing a container on the machine in which the bobbins are stored previous to being placed on the spindle. In this manner the yarn can be kept at the desired regain at all times up to the moment it is placed on the spindle and this can be done without the installation of highly expensive equipment necessary to humidify the whole spinning room.

In the forms of our invention at present in actual use it has been found that materials such as cones of silk can remain in one location under the influence of our system for a long time without developing signs of fungus growth. Constant washing of the air and filtration of same effects this result. Our system is adapted therefore to not only humidify the air but to purify it. To increase the effectiveness of our system as a means of preventing injurious bacterial or fungus growth on the material being treated, a chemical or suitable disinfectant such as cresylic acid, para chlora meta zylenol or para chlora meta cresol may be introduced into the circulation water, or a gas such as zone may be released from time to time within the humidifying system. Either one or both of these methods may be employed periodically or constantly as may be thought most desirable. A neutral mineral or animal oil may also be introduced into the system for providing a penetrating agent to soften or otherwise improve the working quality of the yarn.

An object of the present invention is therefore to provide a practical method of humidifying textile yarn during the process of manufacture into spun, knitted, or woven goods.

A further object of the present invention is to provide a comparatively inexpensive method of humidification for yarns on machines during the process of manufacture, which method may be easily applied to old machines without necessitating expensive changes in existing equipment.

A further object of the present invention is to provide a method of maintaining textile yarns during the knitting or weaving processes at a high humidity without adversely affecting comfort conditions for the workers in the knitting or weaving room.

A further object of the present invention is to provide a method for maintaining textile yarns at a high humidity during manufacture, said method being relatively inexpensive in first cost and in cost of operation.

A further object of the present invention is to provide a method for maintaining a high humidity on textile yarns during manufacture, said method being such that it can be applied to either one or several machines in a room.

A further object of the present invention is to provide a method for maintaining a uniform humidity on textile yarns during manufacture into knitted or woven material.

A further object of the present invention is to provide equipment which will maintain textile yarns at uniform humidities during the knitting or weaving processes and without the formation of condensation on the yarn.

A further object of the present invention is to provide a method of humidifying yarn during weaving or knitting, said method being responsive to accurate automatic control.

A further object of the present invention is to provide a humidifying method for textile yarns, in which by constant circulation of the air and by constant washing and filtration of said air, the growth of bacteria, fungi and other yarn damaging micro organisms is prevented.

A further object of the present invention is to provide an apparatus for humidifying yarn, by means of which the humidifying medium is constantly cleaned and washed of deleterious organisms, and into which may be introduced a disinfecting medium in the form of a gas or a fluid to further aid the cleansing effect of passing the circulated air through finely divided water sprays.

A further object of the present invention is to provide a yarn humidifying system, into the humidifying medium of which may be introduced a chemical by means of which air rectification is effected so as to diminish or entirely prevent the passage and growth of injurious organisms throughout the apparatus and on the materials so humidified.

A further object of the present invention is to provide a gas circulating apparatus for use in connection with the fabrication of textiles and of such a nature that such apparatus can, when so desired, be used to convey gases of beneficial value to said textiles in such proportions or concentrations as are thought most desirable.

A further object of the present invention is to provide a method of maintaining yarn on textile machines under automatically controlled humidity which automatic control can be changed to result in a desired humidity.

Thus, objects of the present inventions are to provide a method and apparatus for humidifying

yarn on knitting and weaving machinery such as will be practical, automatic in operation, inexpensive to install and operate, and such as will make it possible to maintain the yarn at high humidities without affecting the comfort of workers in the room and such as will effect large savings, by elimination of lost time and general improvement in the quality of the finished product.

Other objects and advantages of our invention will hereinafter appear.

We may attain these objects by the humidifying equipment and the appurtenances thereof, two forms of which are shown in the drawings, or by any mechanical equivalents or obvious modifications of the same, or by other devices which will accomplish the method of the herein method claims.

In the drawings:

Fig. 1 is a view in elevation of one form of our humidifying system as applied to a full fashion hosiery knitting machine;

Fig. 2 is a side elevation showing our system and its relationship to a full fashion knitting machine and the cone storage box;

Fig. 3 shows a view in longitudinal vertical section of one of the cone storage boxes as used in the forms of our invention shown in Figs. 1 and 2;

Fig. 4 is an axial section of a cone of yarn showing the cone tube and cone tube holder also in section;

Fig. 5 is a view in vertical section of another form of humidifying unit such as can be used in our system as applied to a single machine;

Fig. 6 is a plan diagrammatically showing another form of our invention as applied to several full fashion hosiery knitting machines;

Fig. 7 is an elevation of the form shown in Fig. 6 showing the relationship of our system to the cone boxes;

Fig. 8 is a view in longitudinal vertical section of our humidification unit, by means of which the air is humidified, and circulated through our system;

Fig. 9 is a plan of our automatic control instrument which controls the humidity of the air delivered to the system;

Fig. 10 is a vertical sectional view of our automatic control instruments showing its relationship to the circulating ducts;

Fig. 11 is a side elevation of the control instrument showing its relation to the adjoining air circulating ducts; and

Fig. 12 is a wiring diagram of the electric circuit used in conjunction with our automatic control.

Like characters of reference refer to like parts throughout the different views.

The arrangement and principal feature of our apparatus will first be briefly indicated, with reference to the species of Fig. 6, after which the several species and features will be described in detail.

Briefly diagrammatically indicated, the apparatus of Fig. 6 is shown in combination with a plurality of textile machines **337** (Figs. 1 and 2) and include yarn supply boxes **16** at the respective machines.

A humidifying unit **2A** (Figs. 6 and 8) has inlet and discharge openings **43, 44** (Fig. 8) a water reservoir **106**, means **18A, 46**; for substantially saturating air passing through the unit **2A** with water from said reservoir **106**, whereby the wet and dry bulb temperatures of the humidified air at the discharge opening **44** are substantially the same. Pressure ducts **37, 3A, 5A** conduct air from the discharge opening **44** into the yarn supply boxes **16**, from which boxes ducts **6A, 4A, 38** conduct the air from the yarn chamber to said inlet opening **43** of the unit, thereby completing the air circuit. A blower **7A**, is the means for thus causing the air to circulate from said discharge opening **44** through the ducts and chambers back to the inlet opening **43** of the unit.

An electric heater **20A** (Fig. 8) in said reservoir **106** is controlled by heat sensitive means **57** and **62** (Fig. 10) in said ducts respectively. This control is effected, as will be explained, through means shown in Figs. 10 and 11 cooperating with said sensitive means for closing contacts **71, 72** to cause a relay motor shown in Fig. 12 to supply current to the heater **20A** to heat only whenever the wet bulb temperature in the pressure duct **37** is more than a few degrees lower than the dry bulb temperature in the suction duct **38**, as will be explained.

Now the arrangement, features and means of the different species will be described in detail.

In Fig. 1 is shown one form of our invention in its relation to the cones being used on a full fashion hosiery knitting machine. For the sake of clearness the many complicated mechanical features of the knitting machine are omitted. Parts of the machine which are shown in this view include the rear supports **14** and the cone box shelf **15**.

A humidifying unit **2** suspended from the roof or ceiling is provided with a pressure duct **3** in which is interposed a pressure blower **7** driven by a motor **8**. This duct **3** conducts air taken from the humidification unit and distributes it through cone box pressure tubes **5** to pressure chambers **9** in the bottom of the cone boxes **16** and through branch tubes **10** to pressure chambers **11** contained in the storage cabinet **12** (right of Fig. 1). A suction return duct **4**, connected to branch suction tubes **6**, is in turn connected to the suction inlet **17** of the humidification unit **2**.

The humidifying unit **2A** may be used in the apparatus of Fig. 1 or we may provide the unit (Fig. 1) which is provided with a pressure blower **7** direct connected to a motor **8**. A water circulating pump **18** direct connected to a motor **19** is used to circulate water inside the humidifying unit **2**. An electric immersion heater **20** is used to heat the water when increased humidity is desired.

The cone chambers **16'** of the boxes **16** are shown containing cones **21** of silk from which the silk threads **22** are unwound and drawn through small openings **23** (Fig. 2) through troughs **24** in which the thread is finally treated before being knitted into hosiery. Additional cones are shown in storage in the storage cabinet **12**.

In Fig. 2 is shown a side view of the knitting machine **25** and its relation to parts of our humidifying system. Supports **14** and shelf **15** are shown supporting the cone box **16**. The pressure duct **3** and the suction duct **4** are shown together with the pressure tubes **5** and the suction tubes **6**. The silk threads **22** pass through the trough **24** and are led through eyes **26**, whence they go to the carriers **27** which play an important part in knitting the hosiery.

At the base of the cone box **16** (Figs. 1 and 3) is shown the pressure chamber **9**, at the top of which are openings surrounded by cone tube holders **28**. Hollow perforated cone supports, **34** (Fig. 4) for cones of yarn **21** in the yarn chamber,

communicate through openings 36 with the pressure chamber 9. The threads of yarn 22 pass from the cones to the machines as shown. At the top of the cone chamber 16' are shown openings 29 into which may be placed eyelets 30 to protect the silk thread which is drawn from the box through these openings. Attached to the base of the pressure chamber is the nipple 31 which forms an attachment for the pressure tube 5. On the left hand side is indicated an opening 32 to accommodate a suction tube 6.

In Fig. 4 we show in axial section a cone of yarn 21 contained upon a perforated cone tube or support 34 which is held in place on the cone tube holder 28. Inside the cone tube holder is a filler block 35 provided with a small axial orifice 36 to limit the air flow to a cone holder where the yarn is exhausted therefrom.

Instead of the humidifying unit shown in Fig. 1 or 8 we may use that of Fig. 5 which is of a simple nature; and by the elimination of a pump and sprays we have provided an inexpensive unit which can be used where it is desired to use one humidifying unit for each full fashion hosiery machine. Air is drawn into the unit through the inlet 124 by a fan such as the blower 7 or 7A attached to the outlet 125. The humidifier casing 126 is airtight, being furnished with a tight cover 127. An electric percolator heater unit 128 is provided in the bottom of the casing. The casing is provided with one or more collars 129 on the inside, these collars communicating with the collection chamber 130 on the outside. The outlet 125 provides communication from the outside with the collection chamber 130. A wire fabric cylinder 131 is placed over and supported by the collar 129, and spread over this wire fabric cylinder is a sack shaped cloth fabric 132 of high hygroscopic nature, the sack being open only enough at one end to allow it to slip over the wire fabric cylinder 131. This is held in place around the cylinder by a rubber band 133. This cloth fabric 132 hangs loosely, and extends into the water reservoir 134 having therein water maintained at a level up to about the bottom of the wire fabric cylinder. A drain connection 135 is provided at the bottom; and a water supply connection 136 is provided at the side.

Water is soaked up by the hygroscopic cloth fabric 132 from the water reservoir 134 and this material is kept constantly moist by virtue of capillary attraction. Air drawn through the inlet 124 must pass through the wetted fabric 132 to leave through the outlet 125. In passing through the wetted fabric the air becomes humidified. The electric percolator heater unit 128 is provided to heat the water when high humidity is desired. By providing several wire fabric cylinders to each unit and a corresponding number of cloth fabric covers, the area of cloth can be increased so that the air passes through the cloth at a relatively slow speed creating little resistance and allowing efficient humidification of the air.

In Fig. 6 we show diagrammatically an arrangement of our invention as now being used with great success on full fashioned hosiery knitting machines. The front of the machines are indicated at 337 (Fig. 6), the cone boxes 16 being at the rear of each machine. Some machines have ten of these boxes, other machines have as many as twelve cone boxes. At the end of each machine is located a cone storage cabinet 12A. The humidifying unit is indicated at 2A in outline. To this humidifying unit is connected the main pressure duct 37 and the main suction duct 38. From the main pressure duct the subsidiary pressure ducts 3A branch out to convey air to each group of cone boxes on each machine. In a similar manner a system of subsidiary suction ducts 4A are shown branching out from the main suction duct 38 to the cone boxes. Pressure tubes 5A convey air from the subsidiary pressure ducts 3A to the cone boxes, and suction tubes 6A are used to convey the return air from the cone boxes to the subsidiary suction duct 4A. At 39 is indicated the location in plan of our control.

Fig. 7 shows a rear elevation of the parts of the arrangement of our invention shown in Fig. 6. The humidifying unit 2A is shown connected to the main pressure duct 37. The main suction duct 38 is shown dotted. The control is indicated at 39. The subsidiary pressure duct 3A is shown connected to the main pressure duct 37 on one end and running above the cone boxes. A pressure tube 5A is taken off as indicated from the subsidiary pressure duct 3A for each cone box. Each pressure tube is brought to a point close to the bottom of the cone box as indicated at 40. In a similar manner the subsidiary suction duct 4A is located above the cone boxes and is connected to the main suction duct 38. A suction tube 6A is connected from near the top of each box to the subsidiary suction duct 4A. Suction and pressure tubes are connected to the cone storage cabinet 12A in a similar manner.

In Fig. 8 we show a humidification unit which may be used in the form of invention of Figs. 1 and 2, or in the form shown in Figs. 6 and 7. The humidifying unit is suspended from the ceiling or roof by angle irons 41. A blower 7A belt driven from a motor 8A, draws air through the opening 43 communicating with the suction duct 38, and expels it from the blower discharge 44 communicating with the pressure duct 37. The pump 18A driven by the motor 19A draws water from the water reservoir 45, and discharges it through the pipe 107 and spray nozzles 46, against the glass wool filter screen 47. A constant water level is maintained in the water reservoir by the automatic flat valve 48. Electric water heaters 20A increase the temperature of the water when high humidity is called for by the automatic control. The blower 7A used in this form of our invention is not of the high pressure type. High air pressure is not required in this form of the invention.

Figs. 9, 10 and 11 show the automatic control and its relation to the main pressure and suction ducts. Vertical posts 49 carry adjustable pivot points 50 with pointed ends 51 (Fig. 9) on which is freely pivotally supported the main shaft 52 carrying fast thereon the arms 53 and 54 lying in the same plane and free to move about the axis of the shaft 52. The posts 49 are screwed to a main plate 55.

Immediately under the arm 53 near the outer end thereof threaded to the main plate 55 is the bushing piece 56, to the bottom of which is attached a thermostatic expansion element 57 disposed in the suction duct 38. Extending down through and fitting loosely into the bushing piece 56 and the expansion element 57 is the rod 58 adapted to be raised by a thermostatic bellows element (not shown) in the element 57. Immediately under the arm 54 near its outer end is located the bushing piece 59 threaded into a movable rectangular slide block 60 guided between undercut guide pieces 61. Attached to the bottom of the bushing piece 59 is the expansion element 62 disposed in the pressure duct 37. A

slot (not shown) is provided in the main plate 55 to allow the piece 59 and with it the block 60 to be moved for about two inches back or forth longitudinally of the arm 54. The pieces 61 are screwed down fast to the main plate 55 and hold in place the block 60 by means of the shoulders which are indicated at 63 in Fig. 10. Secured across the end of the pieces 61 is an end piece 64 into which is threaded the screw 65 to which is affixed the knob 66. The screw 65 bears against the block 60 and is for the purpose of adjustably moving the block 60. Attached to the block 60 is a rod 67 (Fig. 11) which loosely passes through an opening in the saddle piece 68. Surrounding the slender shaft 67 and compressed between the block 60 and the saddle piece 68 is the spring 69 to hold the block 60 against the screw 65.

The expansion elements 57 and 62 respectively extend completely into the ducts 38 and 37. Immediately above the rod 58 and on the bottom side of the arm 53 is attached a strip of insulation to the bottom of which is fastened a silver contact member 71. Immediately below this contact member 71 and attached to the end of the rod 58 is the small silver contact 72. Attached to the block 60 is the reference pointer 122 the position of which may be referred to a scale 123 attached to the cover 97. A slotted opening 98 is provided in the cover to accommodate the reference pointer 122.

The bushing piece 56 is provided with a central opening into which fits loosely the rod 58. This rod rests at the bottom, on the top of an expansion bellows, not shown, inside the expansion element 57. In a similar manner the rod 73 rests on an expansion bellows, not shown, inside the expansion element 62. The expansion elements 57 and 62 are both provided with a fluid with a high coefficient of temperature expansion. The rod 73 is not provided with a silver contact and touches the arm 54 at all times. The brackets 74 fastened to the ducts 37 and 38 form a platform on which is supported the plate 55. Attached to the plate 55 below the arm 53 is the terminal 99. This terminal is insulated from the plate by the insulation piece 100. A pigtail lead 101 connects the silver contact 71 with the insulated terminal 99. The pigtail lead 101 is flexible to allow easy movement of the arm 53.

In Fig. 12 we show a wiring diagram of a simplified control circuit such as we use in conjunction with our control instrument and the forms of our invention above indicated. The power lines 75 and 76 are the source of electrical energy and are connected to the field coil 77, of the shaded pole motor 78 of which 79 represents the magnetic core. The shaded pole motor is provided with two shaded poles 80 which are provided with shading coils 81, and 81A. These coils 81 and 81A are in series with one another being connected at one end to the silver contact, 71, and on the other end to ground at 82. Below the contact 71 is indicated the rod 58 with the silver contact 72 and this rod is indicated connected to ground at 83. The armature 84 of the shaded pole motor is free to rotate and is provided on its shaft with a gear 84A which engages the geared segment 85 of a pivoted member 86. Attached to the member 86 is a mercury switch 87. The member 86 is pivoted to and free to turn about the axis 88. A lead 182 is taken from the line 75 to one terminal of an electric water heating element 20A and another lead 91 is taken from the line 76 to one terminal on the mercury switch 87. A lead 92 connects the other terminal 93 of the mercury switch to the terminal 94 of the electric water heating element 90.

We have shown two forms of our invention. The second form of which is shown in Figs. 6, 7 and 8 is at present in actual use and is proving very successful in connection with the knitting of full fashioned silk hosiery for women.

The operation of the form of our invention shown in Figs. 1, 2, 3 and 4 is as follows: The cones of silk which are to be used in knitting are contained on perforated cone tubes 34 and these tubes are placed tightly in place on the cone tube holders 28.

By means of the pressure blower 7 driven by the motor 8 air is drawn through the humidifying unit 2. The air drawn through the humidifying unit is humidified by a water spray which is provided by the water circulating pump 18. The air drawn through the pressure blower 7 is blown into the pressure duct 3 and conveyed through this duct to the pressure tubes 5 and to the pressure chambers 9. The pressure blower 7 is of a size capable of generating a pressure equal to a water gauge pressure of about 10 inches. By virtue of the pressure the air is forced through the openings in the perforated cone tubes 34 (Fig. 4) and out through the porous mass of yarn of the cone 21. In passing through the yarn mass the air loses some of its humidity to the yarn and the yarn assumes a more perfect condition for knitting.

The air which passes through the yarn escapes into the upper part of the cone box 16. Return or suction tubes 6 are attached to the cone boxes at openings 32 and air is drawn by suction from the blower through these openings 32 into said suction tubes 6 into the suction duct 4 and back to the humidification unit 2 where it is again humidified.

The cone storage cabinet 12 in which cones are stored prior to being placed in the cone boxes, are also provided with pressure chambers 11 and cone tube holders 28. Air is conveyed to the pressure chambers 11 by a branch duct 3D and returned from the cone cabinet by the suction tubes 6D.

The filler block 35 with the small orifice 36 is provided in each cone tube holder in order to prevent an excessive proportion of the air from escaping through one or more cone holders when all the yarn becomes unwound therefrom.

When high humidity is required the heater 20 (Fig. 1) is utilized to heat the water which is circulated in the sprays inside the humidifier. An explanation of the method of controlling this heater is given hereinafter in our description of the second form of our invention.

The second form of our invention is indicated in Figs. 6, 7 and 8. This is the form which is being used with great success at the present time on machines for knitting full fashioned silk hosiery. In this form of our invention the operation is as follows:

Each knitting machine is provided with cone boxes 16 in which are placed the cones which are being used in the knitting of the hosiery. A cone box may contain the cones from which one, two or more stockings are being knitted. Some machines are capable of knitting 9 stockings at the same time, while others may be large enough ti knit 20, 24 or 28 stockings. The number of cone boxes on a machine depends on the type of the machine or in other words on the number

of stockings which the machine will knit. In Fig. 6 we have shown in plan a partial view of several machines and cone storage cabinets to which our himidifying system has been applied. While each machine may contain 12 cone boxes only three have been shown. Each machine is also provided with a cone storage cabinet 12A on one end.

Air is drawn through the suction inlet 43 (Fig. 8) of the humidifying unit 2A by the blower 7A. The water circulating pump 18A driven by the motor 19A takes water from the water reservoir 106 and forces it through the piping 107 to the spray nozzles 46 and against a glass wool air washing filter 47. The air drawn through the humidifying unit is humidified by contact with the water sprays and by its intimate contact with the wetted surfaces of the glass wool air washing filter 47. Water is supplied to the water reservoir and the water level regulated therein by the float valve 48. The electric water heaters 20A are provided to heat the water when this is found necessary to increase the humidity of the air passing through the unit.

The humidified air drawn through the humidifying unit if forced by the blower 7A into the main pressure duct 37 from which it passes to the several subsidiary pressure ducts 3A, and to the pressure tubes 5A. The pressure tubes convey the air as indicated in Fig. 7 to a point near the bottom of each of the cone boxes 16 and similarly to a point near the bottom of each of the storage cabinets 12A. Return air from the cone boxes 16 and the storage cabinets 12 is drawn through the suction tubes 6A near the top of each box to the subsidiary suction ducts 4A and thence is drawn by suction to the main suction duct 38 through which it returns back to the suction opening 43 of the humidifying unit, thence through the unit to the blower 7A. From the blower it is again discharged to make another circuit of the system as above described.

As the air is circulated in the humidifier and through the water spray and wetted interstices of the filter it becomes humidified. If no heat is applied to the water which is being circulated an adiabatic exchange of heat between the air and the water will take place. This adiabatic exchange of heat between the air and the water results in a lowering of the dry bulb temperature of the air passing through the water spray. If the humidification is efficient the dry bulb temperature and the wet bulb temperature of the humidified air may be the same, or in other words the air may be 100% saturated after passage through the spray. However in passing through the water spray which is normally at a lower temperature than the air, the dry bulb temperature of the air is reduced to a temperature which is the same as the wet bulb temperature of the air previous to its passage through the humidifying unit. Now although the air which passed through the humidifying unit has become humidified 100%, this has been done by reducing the dry bulb temperature of the air. As this air is circulated through the ducts and cone boxes it expands by absorbing heat through the walls of the ducts and tubes from the outside air of the room, which is at a higher temperature. This expansion of the air during its travel through the duct lowers its relative humidity by increasing its dry bulb temperature to a greater extent than its wet bulb temperature. If the air circulation system were perfect and no infiltration of air occurred from the outside, an exchange of heat would occur ultimately so that the air inside the duct would become saturated at room temperatures by virtue of conduction of heat through the duct from the outside room air to the air inside the duct, and by the gradual exchange of this heat to the water from the circulated air inside the duct. The duct circulation system however can hardly be perfect and leakage occurs. Moreover such an exchange of heat would be very gradual because of the low temperature ordinarily maintained in textile plants. Comfortable conditions call for temperatures between approximately 70° F. and 90° F.

To overcome the reduction in humidity of the recirculated air due to expansion, we have provided the electric water heaters 20A by which the water can be heated. The amount of heat applied to the water is controlled by our special controller shown in Figs. 9, 10 and 11. We will explain the operation of this control in conjunction with the other parts of our humidifying system as follows:

It has been found that a high relative humidity is desirable in the cone boxes but this high relative humidity must not be accompanied by condensation of moisture on the yarn. Other methods were unsuccessful because of such condensation. If the air delivered to these boxes had a wet bulb temperature in excess of the dry bulb temperature of the air in the room outside the boxes, conduction of heat away from the air inside the ducts and cone boxes would cause the vapor in said inside air to condense inside the ducts, cone boxes, etc. We therefore have devised our control so that the controlled wet bulb temperature it sets up is dependent on the room temperature. Referring to Figs. 9, 10 and 11, the control is placed in a position above the two main ducts 37 and 38. The expansion element 62 extending into the main pressure duct 37 is affected by the temperature of the air circulating through said duct whereas the expansion element 57 is affected by the temperature of the air circulating in the main suction duct 38. Due to heat transfer through the duct and to leakage of outside air into the system on the suction side the dry bulb temperature of the air in the main suction duct 38 is about the same as that of the room. In the main pressure duct 37 at a point very near the humidifying unit the wet bulb temperature of the air leaving the unit and the dry bulb temperature of said air are approximately the same because of the high humidifying efficiency of the humidifying unit 2A. We therefore consider that the expansion unit 57 is being affected by the room dry bulb temperature while the expansion unit 62 is being affected by the wet bulb temperature of the air as it leaves the humidifying unit.

When the expansion unit 57 is affected by increasing temperatures the rod 58 is lifted up slightly due to the action of the bellows (not shown) inside the element. When the expansion unit 62 is affected by increased temperature the rod 73 is raised slightly. The arm 54 rests upon the rod 73 and is raised by the rod 73 when heat is applied to the element 62. The rod 58 does not touch the silver contact 71 on the arm 53 but is separated from it by a small air gap 110. This air gap can be increased by moving the whole assembly consisting of the element 62, block 60, bushing piece 59 and rod 73 in a direction towards the main arm 52 under the sloping arm 54. This movement may be accomplished by turning the knob 66 and the threaded shaft 65.

When the temperature of the air passing the element 62 decreases the rod 73 allows the arm 54 to drop slightly and as the arm 54 is connected solidly to the arm 53 through the main arm 52, the arm 53 drops down also and in so doing the silver contact 71 comes in contact with the silver contact 72 on top of the rod 58. When this connection is made an electrical circuit (Fig. 12) is closed, as will be explained, causing heating current to flow in the electric water heater 20A of the humidifying unit 2A. The application of heat to the water which is being circulated through the water sprays immediately increases the wet and dry bulb temperatures of the air passing through the humidifier and as humidifying efficiency is high these two temperatures are approximately the same. The increased temperature of the air as it leaves the humidifying unit 2A affects the expansion unit 62 and the rod 73 is elevated, this rod elevates the arm 54 which causes the main arm 52 to turn and elevate the arm 53. The elevation of the arm 53 eventually causes the separation of the silver contact 71 from the silver contact 72 on top of the rod 58. This separation interrupts the electrical circuit through which heat is applied to the water and the temperature of the air in the pressure duct 37 begins to diminish.

In order not to risk any chance of condensation in the air circulating system or in the cone boxes a small difference in temperature of one or two degrees Fahrenheit is maintained between the wet bulb temperature of the air in the main pressure duct 37 and the dry bulb temperature of the air in the suction duct 38. This difference in temperature is known as the differential and it is dependant on the size of the air gap allowed between the contact 71 and the contact 72 on the rod 58. The air gap and the differential is regulated by turning the knob 66 and the threaded shaft 65 as above described. If a high relative humidity is desired in the system a small differential is set and if a low humidity is desired a wide differential is set. A slot (not shown) provided with an air tight cover is provided in the duct 37 to allow the expansion element 62 to be moved. If the temperature of the air returning to the humidifying unit through the main suction duct increases, the element 57 is affected thereby and the rod 58 is elevated so that the arm 53 comes in contact with the rod 58 at a higher elevation during the downward movement of the arm 53. This contact again completes the electrical circuit and heat is again applied to the water through the electric heater. In this manner the temperature of the air in the main suction duct 38 determines the wet bulb temperature of the air delivered to the main pressure duct 37. The difference between these two temperatures being the differential. As the return air in the main suction duct 38 is taken from a large group of cone boxes on the knitting machines, and since it has been circulated through these boxes and the extensive subsidiary ducts, its temperature will be representative of an average of the room. This is the temperature which affects the expansion element 57 and which controls the wet bulb temperature of the air delivered from the humidifying unit to the humidifying system. It can therefore be seen that this control maintains a high humidity in the cone boxes at all times but that the humidity is maintained at room temperature and not above it and that condensation is avoided in this manner. Several means of adjusting the parts of this control are provided. It can be seen that the slope of the arm 54 has a direct bearing on the adjustment of the control. If the arm 54 is horizontal or parallel with the main plate 55 then no movement however great in a horizontal direction of the element 62, block 60, bushing pieces 59 and rod 73 will change the position of the arm 54. The smaller the inclination of the arm 54 to the horizontal the greater the horizontal movement required of the rod 73 towards the arm 52 to change the differential a certain amount. If the angle of inclination of the arm 54 is great only a small horizontal movement of the rod 73 is necessary to tilt the arm 54. Because it is important to be able to adjust the control to give a narrow differential we indicate the arm 54 at a slight inclination to the horizontal. This enables us to turn the knob 66 several turns and yet only change the elevation of the arms 54 and 53 very slightly. This slight change in elevation causes only a slight increase in the differential between the two expansion elements 62 and 57. The bushing pieces 56 and 59 are threaded and by turning the elements which are rigidly connected to these bushings the relative elevations of the rods 58 and 73 can be changed. The pointer 122 attached to the block 60 and the reference scale 123 are provided to enable the operator to select definite points of operation which can always be changed and returned to when desired. The references scale 123 can be marked in degrees of differential or in percentage humidity. The reference pointer 122 can be taken through the side of the cover 97 as indicated or through the top of the cover.

Referring to Fig. 12 showing the wiring diagram of the electric circuit used in conjunction with our automatic control, the two lines 75 and 76 represent the main electrical alternating current feed lines. Current passes through these lines to the field coil 77 of the shaded pole motor and also from these lines by the leads 182 and 91 through the heater 20A when the mercury switch 87, 93, 93A is in closed position. The lever arm 53 of the control instrument is indicated in this diagram pivoted at 113 and provided with the silver contact 71 which is slightly separated from the silver contact 72 on the rod 58 by a small air gap 110. When the silver contact 71 touches the silver contact 72 on the rod 58 a closed electric circuit is created. If a difference of potential exists current can flow from the silver contact 71 to the rod to ground at 83 from ground at 82 through the lead 114 to the shading coil 81 to the shading coil 81A and by way of lead 115 back to the silver contact 71. The field coil 77 sets up an alternating magnetic field in the magnetic core 79 by virtue of the current flowing in said coil. By closing the electrical circuit containing the shading coils 81 and 81A the current induced in these coils by the alternating magnetic field of the magnetic core is permitted to flow through the circuit containing the said shading coils. Passage of this current unbalances the rotor or movable part 84 of the shaded pole motor, and causes it to rotate in a clockwise direction. The gear or pinion 84A is attached to said rotor 84 and turns with it, its teeth being meshed with the geared face 85 of the movable part 86 cause said movable part to rotate in a counter clockwise direction about the pivot or axis 88. Rotation of this movable part 86 causes the mercury bottle 87 to tip and the mercury inside the bottle to close the gap between the two terminals 93 and 93A of the mercury bottle. Closing of the gap

between said mercury bottle terminals by the mercury allows current to flow from the main line 75 through the lead 82 to the water heater 20A through the lead 92 to the mercury bottle terminal 93 through the mercury to terminal 93A through lead 91 and back to the main line 76. When the circuit through the shading coils is broken by the creation of an air gap at 110 the rocker piece 86 resumes its normal position, under the influence of gravity, which brings the mercury bottle back to the position in which the mercury bottle terminals 93 and 93A are not connected together by the mercury. Current is therefore prevented from reaching the water heater 20A. The field coil of the shaded pole motor is provided with a much larger number of turns of wire than are the shading coils 81 and 81A. The voltage induced in the shading coils is therefore very low compared with the voltage of the main lines 75 and 76 and is actually about 5 volts. This low voltage in the shading coil circuit is very desirable because it prevents excessive sparking when making or breaking occurs between the silver contacts 71 and 72. Low voltage across these parts allows the operation of this type of control with a minimum of trouble.

We have shown here only one electrical form of our invention as applied to full fashioned hosiery machines, but we do not restrict ourselves to this means alone. Obvious modifications of our equipment would be equipment using steam or gas as a heating medium and equipment using compressed air to develop sprays and generate humidity. We therefore do not restrict ourselves to the forms above shown but intend to include other obvious mechanical equivalents and modifications of the same within the scope of our invention.

We have shown in both forms of our invention a return or suction duct system from the cone boxes to the humidifier but we do not restrict ourselves to this form alone but wish to include the obvious modification in which the return or suction duct is dispensed with and in which the air forced through the pressure ducts to the boxes is taken by the humidifying unit directly from the room, the air being forced into the boxes but not recirculated therefrom. In this form of our invention the expansion element 57 is exposed to the room atmosphere so that the wet bulb temperature of the air delivered to the cone boxes is dependent upon the dry bulb temperature of the room which affects the expansion element 57. In this form of our invention the humidified air forced into the boxes is lost after it leaves the boxes and with it of course is lost any heat units and humidity which it contains. The forms of our invention shown in the drawings appear to be superior to this last described form because of the recuperative effect of recirculating the air and the consequent great saving in expense of humidification. The form of our invention in which the air is not recirculated tends to increase the humidity in the room because humidified air is being constantly discharged through the cone boxes into the room atmosphere. In very dry localities this is desirable and it is our intention to include the form within the scope of our invention.

As stated hereinbefore, the dry bulb temperature and wet bulb temperature at the heat expansion element 62 are substantially the same, since the air is substantially saturated. Therefore, no moist covering is needed on the element 62; but it is understood that such covering may be provided, if for instance, it be desired to have the air in the humidifying unit only partially saturated.

All of the species herein are shown with some type of yarn box 16; but in machines such as spinning machines, for instance, where it is not practicable to enclose the rapidly moving spools of yarn in boxes, instead of the boxes 16, we may provide nozzles which blow the moist air from the ducts 5, 5A directly upon the moving spools and the yarn thereon and being drawn therefrom.

While in the great majority of cases high humidity is required for conditioning textiles, we do not restrict ourselves in our humidifying apparatus to means for increasing the humidity but intend to include means also (when required) for dehumidifying the air by cooling the water supplied to the humidifying unit, or by stopping the circulation of said water, or by expanding the air circulating in our system by heating it after it is filtered through our air washing screen. The water circulated may be cooled by admitting fresh water when necessary, or by passing the circulating water through cooling coils or through heat dissipating radiators.

We intend to include these obvious modifications within the scope of our invention.

We claim as our invention:

1. In combination, a yarn chamber; a humidifying unit having means for humidifying with water air passing through the unit; a duct for conducting air from the unit into the chamber to pass through the chamber; means for causing the air to pass through the unit, duct and chamber; a heater for heating the humidifying water; heat sensitive means in said air between the point of humidification and before its discharge from the chamber and the air after it passes the chamber respectively; and means cooperating with said sensitive means for causing said heater to raise the temperature of the humidifying water whenever the temperature in the duct is at least a predetermined amount lower than the temperature of said air that has passed through the yarn chamber.

2. In combination, a yarn chamber; a humidifying unit having means for humidifying air passing through the unit; a pressure duct for conducting air from the unit into the chamber; a suction duct for conducting air from the chamber to said unit; means for causing the air to circulate through the unit ducts and chamber; a heater for heating the humidifying water; heat sensitive means in said ducts respectively; and means cooperating with said sensitive means for causing said heater to heat only whenever the temperature in the pressure duct is a small amount lower than the temperature in the suction duct.

3. In combination, a plurality of textile machines; yarn supply chambers at the respective machines; a humidifying unit having inlet and discharge openings, a water reservoir, means for substantially saturating air passing through the unit with water from said reservoir, whereby the wet and dry bulb temperatures of the humidified air are substantially the same; pressure ducts for conducting air from the discharge opening into the pressure chamber; suction ducts for conducting air from the yarn chamber to said inlet opening; means for causing the air to circulate from said discharge opening through the ducts and chambers back to the unit; a heater in said reservoir; heat sensitive means in said ducts respectively; and means cooperating with said

sensitive means for causing said heater to heat only whenever the wet bulb temperature in the pressure duct is more than a fixed amount lower than the dry bulb temperature in the suction duct.

4. In combination, a yarn box comprising a pressure chamber and a yarn chamber; hollow perforated yarn supports in the yarn chamber and communicating with the pressure chamber; and restricting means in the support for limiting the amount of air passing thereto from the pressure chamber.

5. In combination, a plurality of textile machines; yarn supply boxes at the respective machines; each box comprising a yarn chamber and a pressure chamber; hollow perforated cone supports in the yarn chamber communicating with the pressure chamber and on which cones of yarn are supported, for the yarn to be fed to the machines; a humidifying unit having inlet and discharge openings and means for humidifying air passing through the unit; pressure ducts for conducting air from the discharge opening into the pressure chamber; suction ducts for conducting air from the yarn chamber to said inlet opening; means for causing the air to pass from said discharge opening through the ducts, chambers, supports, and cones; and a restricting member in the hollow support for limiting the amount of air passing therethrough.

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