Aug. 23, 1966 W. F. SOUTHWELL 3,267,584

PROCESS AND APPARATUS FOR DRYING FABRIC BY ELECTRICAL ENERGY

Filed May 24, 1963 2 Sheets-Sheet 1

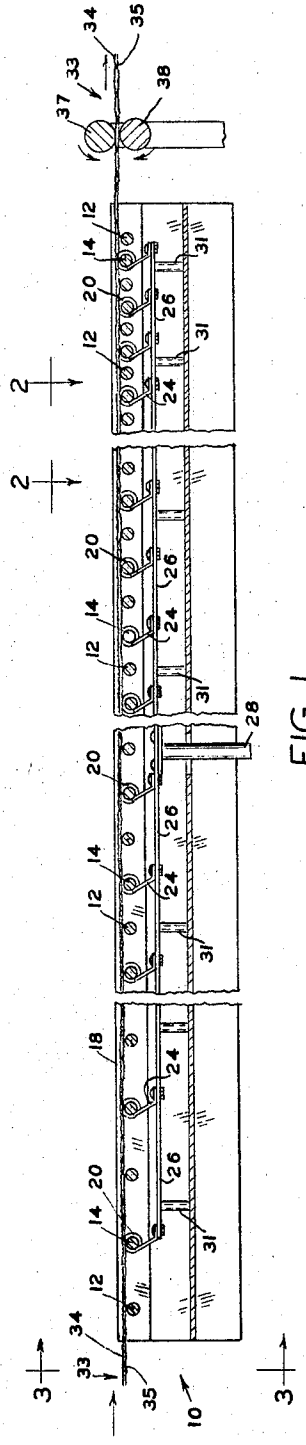

FIG. 1

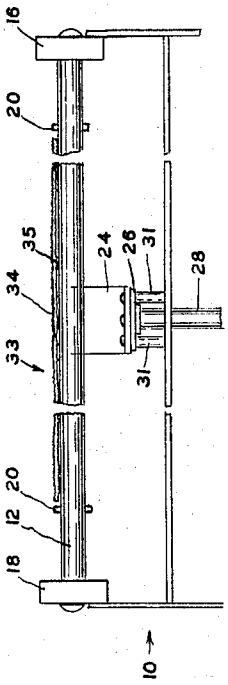

FIG. 3

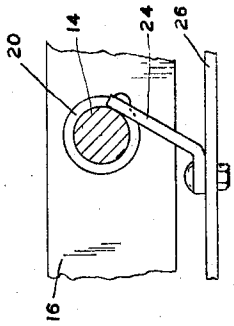

FIG. 4

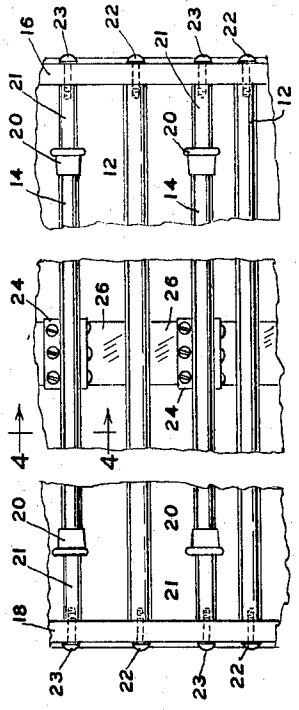

FIG. 2

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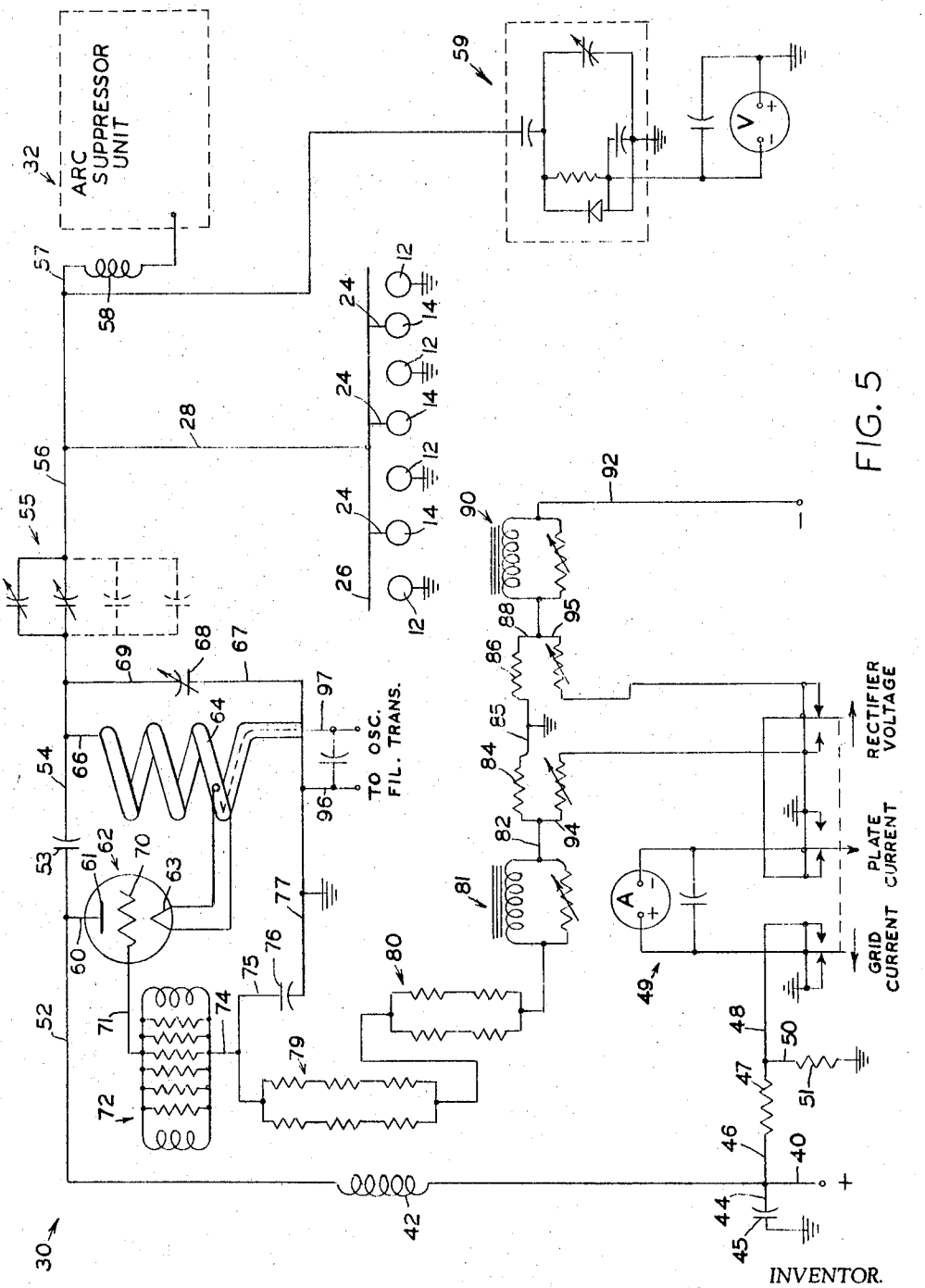

FIG. 5

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PROCESS AND APPARATUS FOR DRYING FABRIC BY ELECTRICAL ENERGY

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10 Claims. (Cl. 34—1)

This invention relates to processes and apparatus for removing moisture from fabrics by the heating effect of molecular disturbance by radio frequency energy to evaporate a desired amount of water therefrom.

The process may be carried out by passing, in a given direction, a fabric having a predetermined average moisture content in a given direction in close proximity to and, preferably and in most instances, in contact with a plurality of alternately disposed negative and positive electrodes which are spaced along an electrode bed and to which a radio frequency energy is supplied over parallel branches of a circuit, the electrodes being so arranged that pairs or groups of electrodes further along the bed in said direction are successively more closely spaced than those less far along in said direction. In this manner, the wettest part of the fabric, where the conductivity is the greatest, is subjected to a less concentrated energy field than it would if the electrodes were closer together, thus avoiding "burning," and the drier part of the fabric where the conductivity and the consequent effectiveness of the drying action is less, is subjected to a more intense field than it would if the electrodes were further apart, thus expediting the removal of moisture at this part to an extent consistent, for example, with the need of expediting the entire process of reducing the moisture content of a forwardly-moving elongated strip of fabric.

It is to be noted that the field strength is lower when the distance between the electrodes is greatest, so that burning at the points of greatest conductivity in the fabric is avoided, and the temperature of the fabric is greatest at the point where it leaves the bed.

Two pairs of electrodes may be used; but, ordinarily an extended series of electrodes gives the most satisfactory results. The spacing of the electrodes may be altered only once in the direction of movement of the fabric along the bed, but preferably the spacing of the electrodes is successively reduced at several points therealong.

In accordance with the invention there may be provided an electrode bed of the character above indicated, a radio frequency oscillator or other source of suitable radio frequency energy and suitable means to connect the source with the positive electrodes—the negative electrodes and the source being grounded, for example—and means to cause relative movement of the bed and fabric—as, for example, means to draw the fabric along the bed and in contact with the electrodes thereof. The latter means may, for example, be an ordinary pair of rollers or may be fabric-treating means which has a fabric-advancing effect and which treats the fabric of which the moisture content has been reduced, such for instance as certain shrinkage control mechanism, one example of which is the belt mechanism illustrated in the Wehrmann Patent 3,007,223 issued November 7, 1961. Desirably the series of electrodes should begin and end with a negative electrode. For example, an electrode bed may be provided which contains nineteen negative electrodes in alternation with which eighteen positive electrodes are provided.

The source of radio frequency energy supply may be of such nature as to be in the "high frequency" designation or from 5 megacycles to 30 megacycles, for example.

While the invention is applicable to the removal of moisture from any of a wide variety of fabrics, it is particularly advantageous for use in the removal of moisture from tubular knitted fabrics, the expeditious drying of which tends to be a matter of great difficulty, and which are unadapted for the drying, by ordinary procedures, of the interior thereof to the same extent as the exterior thereof. A particular advantage is present in the drying of tubular knitted fabrics as a preliminary step in a shrinkage control operation which is especially effective when the fabric contains a particular percentage of moisture distributed uniformly throughout the thickness of a doube-layer of the flattened tube.

In the instant process, the moisture-reduced fabric, moreover, leaves the bed heated uniformly to the 212° F. temperature of the evaporating moisture which is advantageous in certain subsequent processes of which shrinkage control processes are an example.

By means of the invention, not only can the moisture content of a fabric be reduced by a continuous process to a substantially uniform percentage with respect to the dry weight of the fabric, but the percentage of moisture throughout the entire thickness of the fabric can be rendered substantially uniform. For example, a fabric containing 25% or more average moisture content may be reduced to from 20% to 10% uniform moisture content.

In addition, the invention is adapted for the substantially complete elimination of moisture from fabrics containing up to the maximum amount of moisture they will hold.

Since fabrics are not normally wet with distilled water, the water with which the fabric is wet, as it comes from previous treating processes, may, in certain cases, be expected to contain enough dissolved material to render it suitably conductive, and there may, if desired, be added to the water additional soluble conductive material such as, for example, sodium chloride or sodium fluoride.

The invention accordingly, comprises the several steps and the relation and order of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combination of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a partial sectional side view showing in a somewhat diagrammatic fashion the preferred arrangement of the components of the electrode bed and showing also a short section of a long strip of fabric being moved thereover;

FIG. 2 is a fragmentary top view on an enlarged scale taken on the line 2—2 of FIG. 1, and with the fabric removed, showing the manner of the electrode assembly;

FIG. 3 is an end view on an enlarged scale of the bed taken on the line 3—3 of FIG. 1, with the fabric in section;

FIG. 4 is a fragmentary sectional view on an enlarged scale taken on the line 4—4 of FIG. 2 and showing a positive electrode connected to an energy conducting strip; and

FIG. 5 is a circuit diagram showing a preferred RF power source arrangement.

In the exemplified construction there is provided an electrode bed **10** embodying thirty-seven electrodes, which may consist of aluminum rods each one inch in diameter and comprising nineteen grounded negative electrodes **12** in alternation with which eighteen positive electrodes **14** are provided. The first ten electrodes are six inches apart from center to center, the next nine electrodes are

four inches apart, the next nine electrodes are three inches apart, and the last nine electrodes are two inches apart. The electrodes extend between grounded conductive frame pieces **16** and **18**, each negative electrode being fifty-eight inches long, and each positive electrode being fifty inches long with a corona ring **20** and an insulator **21** at each end. Each negative electrode is mounted on the frame pieces by one-quarter inch conductive screws **22**, and each positive electrode by one-quarter inch screws **23** extending into the insulators **21** only. RF energy is supplied to a longitudinal central portion of each positive electrode by a conductive plate **24**, the plates **24** being conductively joined to a conductive strip **26** extending beneath the bed and electrically connected with a conductive post **28** which is electrically connected to a source of RF energy indicated generally at **30**. The plates **24** thus serve to supply equal amounts of energy in parallel. The conductive elements may suitably be made of copper or aluminum. The strip **26** is mounted on insulators **31**. The negative electrodes are grounded thru the frame pieces for connection with the grounded source.

In the present instance the radio frequency source **30** is adapted to supply thirty kilowatts of energy at 13.5 megacycles which may be reduced to 8 or 9 megacycles by load conductions.

A long strip of fabric **33**, exemplified as tubular knitted fabric the sides **34** and **35** of which lie flat against each other, may be drawn over the bed in contact with the electrodes by means such as illustrated in said Patent 3,007,-223, or, as illustrated in the drawings (FIG. 1) for the sake of simplicity by a pair of rollers **37** and **38**. As will be seen from the drawings, the fabric **33** is shown in contact with the electrodes **12** and **14**. The speed of movement of a tubular knitted fabric having a dry weight of 2.1 pounds per square yard spread out or 4.2 pounds double thickness, and containing an average moisture content of thirty percent or lower as it moves onto one end of the bed, may be moved over the exemplified bed at a speed of twenty yards per minute and have its moisture content reduced to a uniform moisture content of 15% as it moves out of the other end of the bed, it being noted that such a moisture content is a desirable one for the preshrinking of knitted cotton fabrics.

By suitably adjusting the conditions various amounts of moisture content in a fabric may be suitably reduced.

In general it is to be noted that with a thirty kilowatt generator and operating at maximum efficiency 1½ pounds of water per minute may be removed, that 56.7 B.t.u. may be generated per kilowatt, and that 1,134 B.t.u. are required to dissipate one pound of water per minute.

By means of an arrangement such as exemplified, the portion of the fabric which is over the initial portion of the bed will have its high moisture content (which provides a high conductivity) reduced without burning, whereas at later portions of the bed the portions of the fabric with lower moisture contents (while of less conductivity) will have their moisture content reduced efficiently and effectively to provide at the terminal ends of the bed a desired low uniform moisture content thruout the fabric.

While any of a variety of types of sources of RF energy may be provided, the particular source **30** (FIG. 5) exemplified comprises an arrangement including a main conductor **40** which extends to an RF choke **42** and from which a lead **44** extends to a grounded condenser **45**, and a lead **46** extends to a resistance **47** whence a lead **48** extends to a metering device **49** as shown. A lead **50** extends from lead **48** to a grounded resistance **51**. From the choke **42** a lead **52** extends to a condenser **53** from which a lead **54** extends to a ganged variable condenser unit **55**, whence the lead **56**, to which the positive electrodes are connected by leads embodying the elements **28** and **26** and the conductive plates **24**, and the arc suppressor unit **32** is connected by a lead **57** containing an RF choke **58** and from this lead is connected to an RF voltmetering unit **59**. From the lead **52** a lead **60** extends to

plate **61** of an oscillator tube **62**, the filament **63** of which is connected to a tank coil **64** one end of which is connected by a lead **66** to the lead **54** and from the other end of which a lead **67** extends to a condenser **68** connected to the lead **54** by a lead **69**. From the grid **70** of the tube **62** a lead **71** extends to a parasitic suppressor **72** from which a lead **74** extends. A conductor **75** is connected to lead **74** and extends to a condenser **76**, whereas a grounded conductor **77** extends to the same end of the tank coil **64** from which the lead **67** extends. The lead **74** is also connected thru two sets of resistances **79** and **80** to a grid overload device **81**, lead **82**, resistance **84**, grounded lead **85**, resistance **86**, lead **88**, plate overload device **90**, and to main lead **92**. Leads **94** from lead **82**, and **95** from lead **88**, extend to variable resistances which are connected into the metering device **49** as shown. Leads **96** and **97** bridged by a filtering condenser **98** extend, respectively, from the lead **77** and from the righthand (FIG. 5) side of the oscillator tube filament **63**, to an oscillator filament transformer.

The terms "negative" and "positive" as used herein in connection with the electrodes **12** and **14** and elsewhere refer to a condition at the particular instant wherein the RF energy is flowing from the "positive" electrode, as the emitter, and thence thru the moisture containing fabric to the "negative" as the receiver. These terms are used for the sake of convenience of descriptive identification and not in an arbitrary limiting sense.

Since certain changes in carrying out the above process and the constructions set forth, which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A process of removing moisture from fabric which comprises passing a wet fabric in flat form continuously first in contact with a set of laterally extending negative and positive electrodes spaced a relatively large distance from each other and subsequently in contact with a set of laterally extending negative and positive electrodes spaced a relatively small distance from each other while supplying heat-producing radio frequency energy over branch circuits each including a positive electrode and a negative electrode of a set and a portion of said fabric.

2. A process of removing moisture from fabric which comprises passing a wet fabric in contact with a plurality of widely spaced electrodes, thereafter in contact with a plurality of less widely spaced electrodes and subsequently in contact with a plurality of more closely spaced electrodes while supplying substantially equal amounts of heat-producing radio frequency energy to branch circuits each including at least a pair of spaced electrodes of each plurality and a portion of the fabric.

3. A process of drying fabric comprising passing a fabric in contact with a plurality of widely spaced electrodes and thereafter with successive pluralities of successively less widely spaced electrodes while supplying substantially equal amounts of high-frequency energy from a source of such energy to alernate ones of said electrodes, passing such energy thru the fabric and conducting the energy from the other of said electrodes to said source.

4. A process of drying fabric to a uniform moisture content adapted for subsequent treatment, comprising passing a fabric having an average moisture content of not substantially under 25% in contact with a plurality of widely spaced electrodes and thereafter with successive pluralities of successively less widely spaced electrodes while supplying substantially equal amounts of high-frequency energy from a source of such energy to alternate ones of said electrodes, passing such energy thru the fabric and conducting the energy from the other of said electrodes of said source, to reduce the moisture content of said fabric to from about 20% to about 10%.

5. A process of drying tubular knitted fabric which comprises passing a wet tubular knitted fabric with the flat sides in contact with each other continuously over a pair of relatively widely spaced electrodes with one side in electrical contact therewith substantially thruout the width thereof and then over a pair of less widely spaced electrodes with one side in electrical contact therewith substantially thruout the width thereof while supplying heat-producing radio frequency energy over branch circuits including the respective pairs and the fabric therebetween.

6. Apparatus for reducing the moisture content of a wet fabric comprising an electrode bed wherein laterally extended spaced negative and positive electrodes are spaced a greater amount near one end of said bed than near the other end of said bed, a source of heat-producing radio frequency energy, conductive means from said source to said positive electrodes, means to electrically connect said negative electrodes to said source, and means to move a wet fabric along said bed from said one end to said other end thereof while in electrical contact with said electrodes.

7. Apparatus for reducing the moisture content of a wet fabric comprising an electrode bed wherein laterally extended spaced negative and positive electrodes are arranged in alternation and wherein the spacing of said electrodes is greater near one end of said bed than near the other end of said bed, a source of heat-producing radio frequency energy, conductive means from said source to said positive electrodes, means to electrically connect said negative electrodes to said source, and means to move a wet fabric along said bed from one end to said other end thereof while in contact with said electrodes.

8. Apparatus as in claim 7 wherein said conductive means are arranged to provide a parallel electrical supply circuit and wherein said energy is from 5 megacycles to 30 megacycles.

9. Apparatus as in claim 7 wherein the spacing of certain intermediate electrodes is less than the spacing of those near said one end and greater than the spacing of those near said other end.

10. Apparatus for reducing the moisture content of a wet fabric comprising an electrode bed wherein laterally extended spaced negative and positive electrodes are arranged in alternation, and wherein the spacing of said electrodes is greater near one end of said bed than near the other end of said bed, grounded conductive electrode frame pieces arranged to support the ends of said electrodes, means for conductively mounting the negative electrodes on the frame pieces, means for non-conductively mounting the positive electrodes on said frame pieces, a source of high-frequency energy, conductive means from said source to the intermediate portion of each positive electrode, conductive means from said source thru said frame pieces to the conductively-mounted negative electrodes, and means to transport a wet fabric along said bed in electrical contact with said electrodes to provide a moisture conductive path thru said fabric.

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