July 23, 1968 R. W. GOBLE 3,393,686

ULTRASONIC METHOD FOR TREATING NATURAL AND SYNTHETIC FIBERS

Filed Aug. 9, 1965

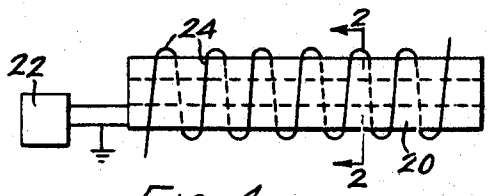

FIG. 1.

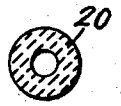

FIG. 2.

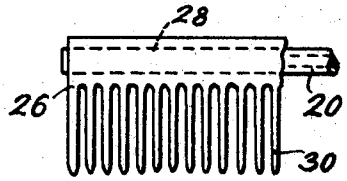

FIG. 3.

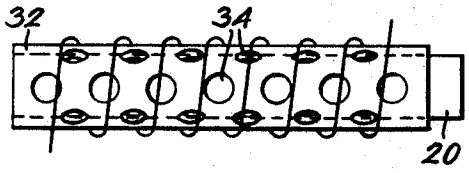

FIG. 4.

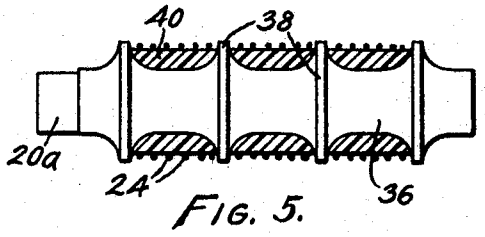

FIG. 5.

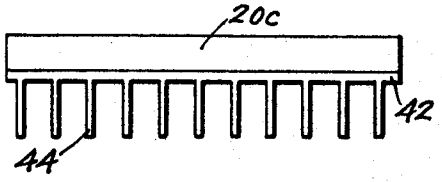

FIG. 6.

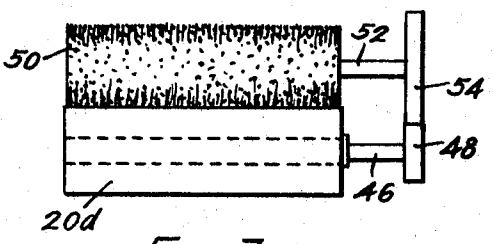

FIG. 7.

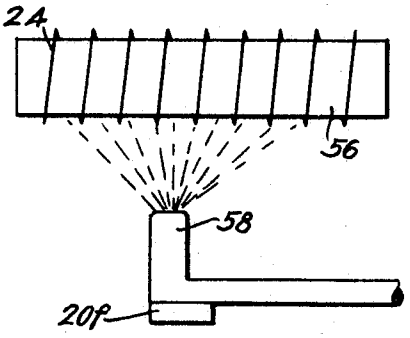

FIG. 9.

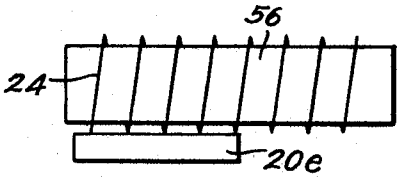

FIG. 8.

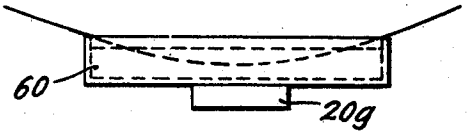

FIG. 10.

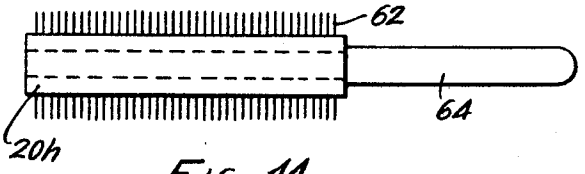

FIG. 11.

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United States Patent Office 3,393,686 Patented July 23, 1968

3,393,686

ULTRASONIC METHOD FOR TREATING NATURAL AND SYNTHETIC FIBERS

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Continuation-in-part of application Ser. No. 190,924, Apr. 30, 1962. This application Aug. 9, 1965, Ser. No. 478,394

9 Claims. (Cl. 132—7)

This application is a continuation-in-part of my copending application Ser. No. 190,924, filed Apr. 30, 1962; now Patent No. 3,211,159.

This invention relates to methods of treating natural and synthetic fibers with ultrasonic energy. More particularly, this invention is directed to methods for producing a predetermined set in natural or synthetic fibers.

Ultrasonics is a general term referring to the generation, detection, and/or utilization of vibratory mechanical energy usually but not necessarily beyond the audible range.

It is known to those familiar with the art that most natural fibers and many chemically related synthetic fibers are structurally similar to or contain a high percentage of the protein keratin and the like. These fibers are believed to comprise long polypeptide chains held in a folded arrangement by hydrogen bonds. The long polypeptide chains are connected laterally by at least five types of attractive forces, namely salt linkages, hydrogen bond linkages, peptide linkages, Vander Walls forces and disulfide bond linkages.

The equilibrium positions that the polypeptide chains may assume under any set of conditions will depend on the interaction of the various linkages and their relative strengths. Thus, unless some change occurs in the forces within the fiber molecule, such as the keratin molecule, which permits the rearrangement of the molecular structure, it is impossible to impart a permanent configuration to fibrous materials different from that originally present therein. It is clear, however, that upon the breaking of the said attracting linkages, the fibers may be bent or curled in any given configuration after which the broken linkages can be reconstituted in their set conformation, thus rendering the wave or curl permanent.

The problem involved, however, is that the prior art methods and apparatus utilized in treating or curling human hair or other natural and synthetic fibers have not been sufficiently successful in breaking the fiber linkages which hold the polypeptide chains together, the fibers will inevitably revert to their original configuration.

It is therefore, an important object of the present invention to provide a novel method of treating natural and synthetic fibers which avoids one or more of the disadvantages of prior art methods and which selectively produces more lasting results.

It is a further object of the present invention to provide a novel method of treating natural and synthetic fibers which requires a minimum of time, and requires no heat.

It is a further object of the present invention to provide a method of treating natural and similar synthetic fibers in which the use of ultrasonic energy is employed.

It is a still further object of the present invention to provide a method in which natural and synthetic fibers are wetted with a liquid chemical substance prior to being treated with ultrasonic energy.

Other objects and advantages of the invention will become apparent from the following description and accompanying drawings wherein:

FIGURE 1 is a view in elevation of a hollow tube of transducer material about which fibers are shown arranged in a circular configuration;

FIGURE 2 is a cross sectional view along lines 2—2 of FIGURE 1;

FIGURE 3 is a view in elevation of a transducer incorporated in a comb to effect the straightening of the fibers;

FIGURE 4 is an elevational view of another transducer arrangement wherein a hollow tube of transducer is inserted within a perforated tube about which fibers are wound;

FIGURE 5 is a view in elevation of another transducer arrangement utilizing a horn configuration to direct a longitudinal energy wave in a radial direction;

FIGURE 6 is an elevational view of another transducer arrangement useful in straightening fibers;

FIGURE 7 is an elevational view of still another transducer arrangement useful in straightening fibers;

FIGURE 8 is a view in elevation of another transducer arrangement according to the invention using an outboard driver;

FIGURE 9 is a view in elevation of another transducer arrangement according to the invention embodying a modulated jet stream;

FIGURE 10 is an elevational view of another transducer arrangement according to the invention utilizing an ultrasonic bath, and

FIGURE 11 is a view in elevation of a transducer arrangement according to the present invention in the form of a brush useful in straightening fibers.

In accordance with the present invention the method of treating natural and synthetic fibers including human hair with ultrasonic energy comprises the steps of arranging and forcibly restraining the fibers in a predetermined configuration, be it curved or straight, applying a coupling medium capable of providing free ions and radicals to the fibers and coupling ultrasonic energy to the fibers via the coupling medium, whereby the fibers will remain in the arranged configuration on removal of the restraining force.

Referring to the drawings, in FIGURE 1 there is shown a tube **20** of transducer material, such as barium titanate with or without additives and the like, driven by an ultrasonic generator **22**. As is known, a transducer of this configuration will vibrate in the radial mode as a function of the frequency of the output of the generator. Strands of the fiber **24** to be treated are wound around the transducer and restrained in the wound condition by suitable means, not shown. A coupling medium described below is applied to the fibers to provide an efficient energy transfer from the transducer to the fibers. The coupling medium may also contain dyes, bleaches and/or other fiber treating agents for concurrent action upon the fibers. A high frequency alternating current is fed from generator **22** to transducer **20** where it is converted into mechanical energy and coupled to the fibers **24** through the coupling medium. It is found that after the application of energy for a short period of time, the fibers will remain in the configuration in which they were wound on the transducer substantially indefinitely. This configuration will be retained even though the fibers are subsequently washed, bleached or subjected to other similar treatment.

The liquid coupling medium employed to wet the fibers for better energy transfer from the transducer to the fibers is characterized by having a weak bonding structure which renders the bonds capable of being easily ruptured with the release of free ions and radicals. Such materials appear to greatly enhance the ultrasonic breakage of the fiber molecular linkages, and they also aid in the reorientation thereof. The coupling medium may be selected from a number of chemical materials which fall under the above general classification. However the preferred substances for use in this invention are methyl iodide, either in the pure form or as a solution with water; preferably a solu-

tion of about 15–20% concentration by volume, and triethanolamine, also both in the pure form or diluted in like manner with water. However, methyl iodide is toxic and would have to be utilized in the treatment of natural fibers disassociated from humans such as wigs, etc. There is no significant toxicity related to triethanolamine and it can be successfully employed in the treatment of human hair without fear of any ill effects therefrom.

The exact manner in which the process of the present invention functions is not completely understood. It is believed that the ultrasonic energy rapidly ruptures most of the molecular bonds and linkages which laterally connect the polypeptide chains in the keratin or similar fibers. This permits the said chains to form new bonds and molecular connections and thus reorient to the configuration in which the fibers have been forcibly constrained.

The manner in which the liquid materials wetting the fibers during the application of ultrasonic energy operate is also not fully understood but it would appear that the materials break down to release and provide an abundance of free ions and radicals which combine with the broken bonds and fiber molecular linkages to considerably enhance the molecular reorientation of said fibers in the constrained configuration. It is believed that in the presence of free ions, the bonds are more easily broken by the application of ultrasonic energy and further bond with these ions in the new configuration as constrained. The free ions are normally carried by a fluid carrier such as a liquid but the ions may provide their own carrier as in the case of a pure liquid or gas.

FIGURE 3 illustrates a comb **26** having a bore **28** receiving a transducer **20**. When the transducer is driven by an ultrasonic signal and fibers wetted with a coupling medium are passed through teeth **30** of the comb, the fibers will assume the configuration they had at the time of passing through the teeth **30**.

FIGURE 4 shows a spool **32**, which may be perforated as at **34**, about which fibers may be wound and restrained, which spool is adapted to receive transducer **20**. Fibers, such as human hair, are wound about about several of these spools, the coupling medium is applied to the fibers and in turn, the transducer is introduced into the spools and energized from a generator. The use of spools **32** permits the use of but a single transducer **20** and driver **22** to service a number of separate fiber treating operations as would be found in applying a permanent wave to a lady's hair.

FIGURE 5 shows a different manner of coupling ultrasonic energy from a transducer **20***a*, through a bar **36** vibrating in a longitudinal mode to fibers **24** wound about the bar. At spaced intervals along bar **36** are provided a series of circumferential exponential horn shaped ribs **38**. The horns of ribs **38** operate in a shear mode and serve to effect a transfer of ultrasonic energy from transducer **20***a* via a plastic material **40** positioned between ribs **38** to fibers **24**.

FIGURE 6 illustrates another arrangement in which a plate **42** is provided with a series of spaced parallel vanes **44**. A transducer **20***c* is attached to the plate to couple ultrasonic energy thereto and to vanes **44**. Fibers carrying a coupling media are passed between vanes **44** and assume the configuration held during such passage.

FIGURE 7 illustrates a transducer **20***d* mounted for rotation on shaft **46** driven from a gear **48**. A cylindrical brush **50** is mounted for rotation on shaft **52** spaced from and parallel to shaft **46**. Shafts **46** and **52** may rotate in the same direction or different directions, as shown, and shaft **52** may be driven from a gear **54** which may mesh with gear **48**. Transducer **20***d* is driven from an ultrasonic generator and fibers carrying a coupling medium are passed between the transducer **20***d* and brush **50**. The fibers will retain the configuration held when passing over transducer **20***d*.

FIGURE 8 illustrates fibers **24** carrying a coupling medium wound about a solid bar **56** which is driven ultrasonically by transducer **20***e*.

FIGURE 9 illustrates a similar arrangement but wherein the ultrasonic energy is coupled to bar **56** and fiber **24** via a stream of liquid coupling medium, as defined above, modulated by a transducer **20***f*, issuing from a nozzle **58**.

FIGURE 10 illustrates a bath **60** of coupling medium driven by an ultrasonic transducer **20***g* and through which fibers are passed and subjected to ultrasonic energy.

FIGURE 11 illustrates an ultrasonic transducer **20***h* in the form of a brush with bristles **62** attached to the surfaces and an attached handle **64**. The arrangement of FIGURE 11 as well as those of FIGURES 3, 6, 7 and 10 are particularly useful in the straightening of fibers.

The frequency of the ultrasonic energy useful in the treatment of fibers according to the present invention does not appear to be critical; however, frequencies above the audible range appear to be most effective. The frequencies most suited to a particular application are determined experimentally and will depend on the size and quality of the fiber treated. The power required will also depend on the size and quality of the fibers and the efficiency of the coupling medium, however, it is believed that a sufficient amount of power must be applied to overcome the forces holding the bonds and break the bonds to permit reorientation thereof.

Thus in carrying out the invention strands of fibers including human hair are wound and restrained about a form and wetted with or subjected to a medium capable of supplying a sufficient amount of free ions and radicals to combine with the broken bonds, such as one of the liquid substances set forth earlier in the specification. After being subjected to a short exposure of ultrasonic energy, the strands were removed from the form. The hair had assumed a permanent set in the configuration as wound and repeated washing, crushing and drying failed to remove or alter the set materially. Other synthetic fibers, having related chemical structures have been similarly treated with satisfactory results. To remove a previously existing set, the fiber is subjected to ultrasonic energy while being restrained in a straightened configuration.

While there have been described what at present are considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention. It is aimed, therefore, in the appended claims to cover all such changes and modifications which fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of treating natural and synthetic fibers to produce a substantially permanent set therein of predetermined configuration comprising the steps of forming the fibers into a predetermined configuration about an ultrasonic transducer, restraining the fibers in said configuration, applying a coupling medium to said fibers, said coupling medium characterized by having a weak bonding structure adapted to be easily ruptured releasing free ions and radicals, and subjecting the fibers to ultrasonic energy from said transducer via the coupling medium while in the restrained configuration.

2. The method according to claim **1**, wherein the frequency of the ultrasonic energy is above the audible range and the coupling medium is selected from the group consisting of methyl iodide, triethanolamine and aqueous solutions thereof.

3. The method according to claim **1** wherein the fibers are wound about a spool having a tightly fitting ultrasonic transducer therein to transmit ultrasonic energy to said spool and to the fibers closely wound thereabout.

4. The method of claim **1**, including the step of passing the fibers between a plurality of teeth and the like energized by ultrasonic energy.

5. The method according to claim **1**, wherein said transducer is a solid core having a plurality of exponential horn shaped ribs spaced longitudinally along the surface

thereof and which core is driven in a longitudinal direction by means of an ultrasonically energized transducer coupled thereto and to the fibers.

6. The method of treating natural and synthetic fibers to produce a substantially permanent set therein of predetermined configuration comprising the steps of forming the fibers into a predetermined configuration about a form, restraining the fibers in said configuration, impinging a jet of a liquid coupling medium on the fibers, said coupling medium characterized by having a weak bonding structure adapted to be easily ruptured releasing free ions and radicals, and modulating the jet by ultrasonic energy from an ultrasonic transducer.

7. The method as defined by claim 6 wherein the liquid coupling medium impinged on the fibers is selected from the group consisting of methyl iodide, triethanolamine and aqueous solutions thereof.

8. The method of producing a substantially permanent wave in human hair, comprising the steps of winding and

securing a portion of the hair about a cylindrically ultrasonic transducer coupling means, dampening the wound hair with a coupling fluid characterized by having a weak bonding structure adapted to be easily ruptured releasing free ions and radicals, applying ultrasonic energy to said coupling means and removing the ultrasonic energy from the coupling means while the hair is secured thereto.

9. The method as defined by claim 8 wherein the liquid coupling medium is selected from the group consisting of methyl iodide, triethanolamine and aqueous solutions thereof.

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