

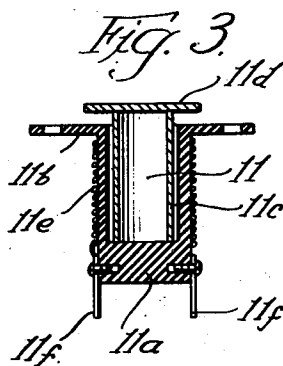
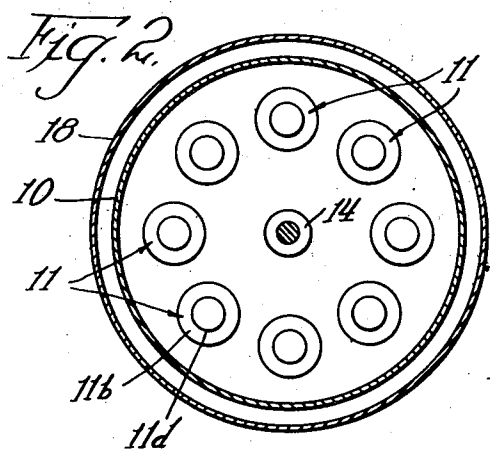
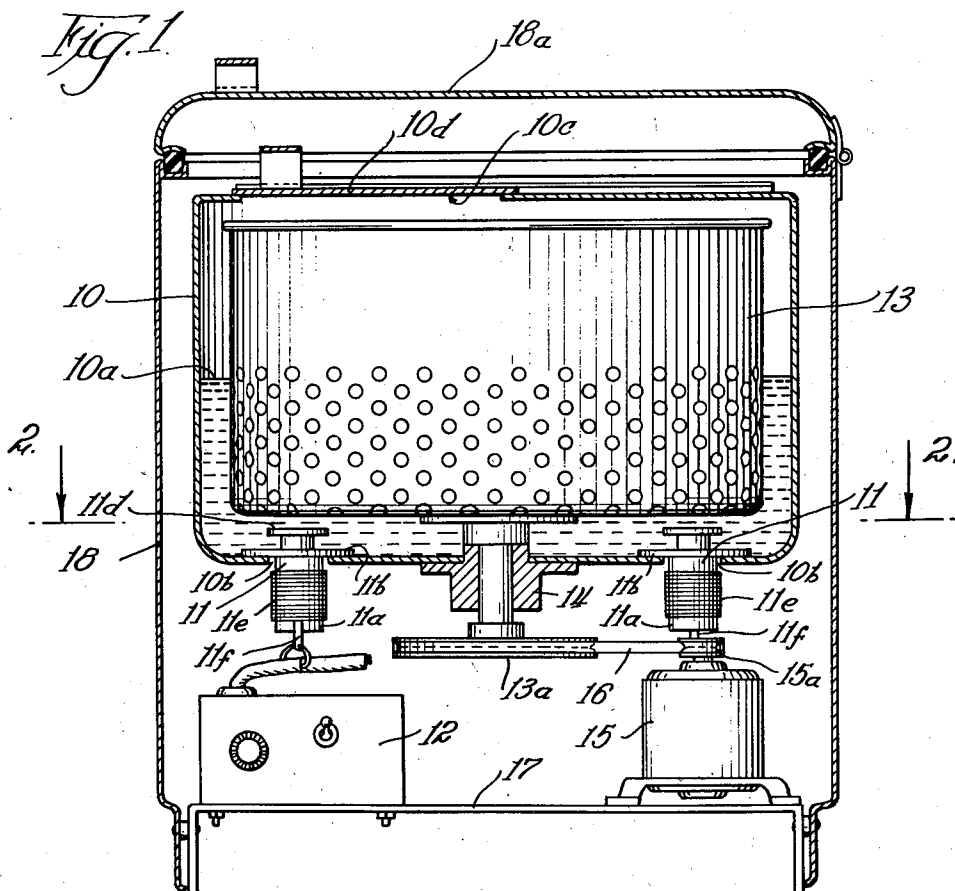
April 26, 1949.

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METHOD OF AND APPARATUS FOR CLEANING
BY ULTRASONIC WAVES.

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2 Sheets-Sheet 1



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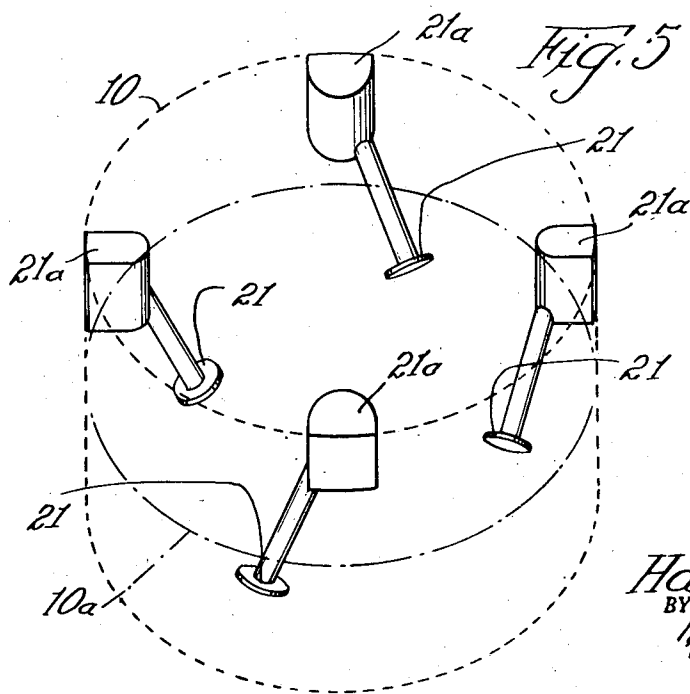
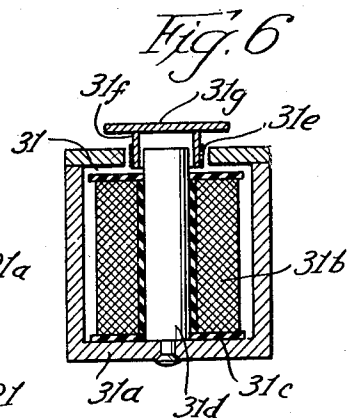
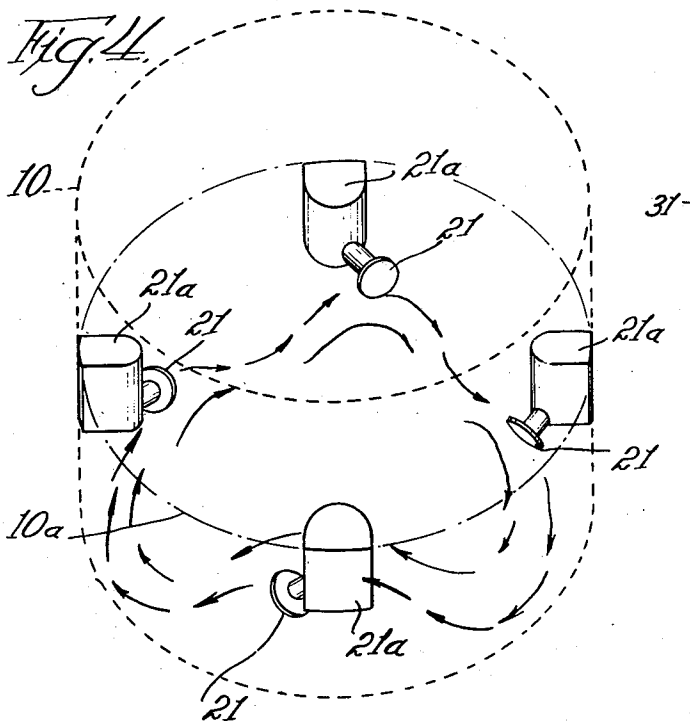
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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METHOD OF AND APPARATUS FOR CLEANING BY ULTRASONIC WAVES

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4 Claims. (Cl. 8-159)

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This invention relates to a method of and apparatus for cleaning textile fabric articles by ultra-sonic waves and, while it is of general application, it is particularly suitable for embodiment in domestic washing machines.

Heretofore there have been proposed numerous domestic washing machines, all of which operated on the principle of agitating or tumbling the articles to be cleaned in a washing emulsion or other cleaning fluid. However, it has been found that, if the agitation is made sufficiently intense to approximate hand washing or scrubbing on a washboard, the articles being cleaned are severely strained, abraded and otherwise damaged. These effects are of course due to the harsh action of the irregular surface of the agitator or impeller of the machine operating at relatively high speed against the articles, which offer increased resistance to agitation due to the fact that they are saturated with the cleaning fluid. According to the present invention, this harsh action of a mechanical agitator or impeller is replaced by a rapid and intense agitation and circulation of the washing emulsion through the articles by developing therein ultra-sonic waves.

It is an object of the invention, therefore, to provide a new method of, and apparatus for, cleaning textile fabric articles by means of which a thorough cleaning is effected without resorting to intense agitation by mechanical agitators or impellers.

It is another object of the invention to provide an improved method of, and apparatus for, cleaning textile fabric articles in which the agitation and circulation of the cleaning emulsion or other cleaning fluid through the articles to be cleaned are effected by the development therein of ultra-sonic waves.

In accordance with the invention, a machine for cleaning textile fabric articles comprises an article container adapted to contain a cleaning fluid, an activator having a substantial surface area submerged in the cleaning fluid, and means for producing vibration of the activator at an ultra-sonic frequency to activate the cleaning fluid.

Further in accordance with the invention, in a machine for cleaning textile fabric articles, there is provided an activator comprising a cup-like member of non-magnetic material having a high eddy current impedance, an elongated magnetostrictive element disposed in the member, and an ultra-sonic-frequency exciting winding surrounding the member.

Further in accordance with the invention, the

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method of cleaning textile fabric articles comprises disposing the articles in a cleaning fluid bath and developing ultra-sonic-frequency waves in said bath.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, while its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 is a longitudinal sectional view of a cleaning and drying machine embodying the invention; Fig. 2 is a top view of the interior of the mechanism with the casing shown in section; Fig. 3 is a cross-sectional detail of an activator embodied in the apparatus of Fig. 1; Figs. 4 and 5 are schematic representations of a modified form of machine embodying the invention; while Fig. 6 is a cross sectional detail of a modified form of activator for use in the cleaning and drying machine of the invention.

Referring now to Figs. 1, 2 and 3 of the drawings, there is represented a machine for cleaning textile fabric articles comprising an apertured article container 10 adapted to contain a cleaning fluid, such as a washing emulsion, normally to a level 10a intermediate the depth of the container. The container 10 is provided with a plurality of apertures 10b and disposed around the periphery of the bottom thereof. A plurality of activators 11 are individually disposed in the apertures 10b and project vertically upward therefrom.

Each of the activators 11 as shown more clearly in Fig. 3, comprises an elongated cup-like member 11a of nonmagnetic material and having a high eddy-current impedance, for example, of thermosetting plastic insulation material such as "Bakelite." Each of the members 11a has an annular flange 11b adapted to be sealed to the periphery of the aperture 10b in which the activator is disposed. The activator 11 also includes an elongated magnetostrictive element disposed in the recess thereof and adapted to project upwardly into the container 10. This magnetostrictive element may be of a hollow cylindrical shaft 11c and a disk-like head 11d secured thereto as by welding, brazing, or the like, and providing a substantial surface area submerged in the cleaning fluid within the container 10. The shaft 11c and head 11d are constructed of magnetostrictive material such as a high nickel or chrome alloy steel.

The activators 11 are also provided with means

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for producing vibration of the magneto-strictive element 11c, 11d at an ultra-sonic frequency to activate the cleaning fluid, for example, an ultra-sonic winding 11e surrounding the cup-like insulation member 11a and provided with end terminals 11f connected to be excited from a suitable source 12 of ultra-sonic-frequency waves, for example, a conventional vacuum-tube oscillator.

The cleaning machine of the invention also includes means for slowly agitating or circulating the articles in the container to be cleaned, for example, a perforated basket 13 rotatably disposed in the container 10 as by being mounted in a sleeve bearing 14 centrally disposed in the bottom of the container 10. The basket 13 may be driven by a suitable motor 15 through a pulley 15a attached to the motor 15, a pulley 13a attached to the shaft of the basket 13 and a belt 16. The container 10 and the accessory devices described may be disposed on a supporting standard 17 and surrounded by an enclosed housing or casing 18 provided with a hinged cover 18a to permit the clothes or articles to be cleaned to be deposited in the container 10 and withdrawn therefrom. If desired, the container 10 may be provided with an opening 10c covered by a sliding door 10d to prevent splashing of the cleaning fluid during cleaning.

The operation of the cleaning machine described above involves a novel method of cleaning textile fabric articles. After disposing the articles to be cleaned in the cleaning fluid bath in the container 10, the ultra-sonic frequency source is energized to develop ultra-sonic-frequency waves which are impressed upon the windings 11a of the several activators 11. When thus excited, longitudinal magneto-strictive vibrations are developed in the shaft 11c and its attached disk 11d which, in turn, develop ultra-sonic-frequency waves in the cleaning fluid bath 10a. These ultra-sonic-frequency waves, when developed by activators such as those described, are in the form of a plurality of conical divergent beams directed vertically upward from each of the activators 11 disposed at spaced points around the periphery of the bath. These beams produce standing compression waves within the cleaning fluid, the differential pressures between the nodes and anti-nodes thereof producing a violent low-amplitude circulation of the cleaning fluid through the articles being cleaned. At the same time a moderate rotational agitation or circulation of the articles in the bath is produced by the basket 13, thus insuring that all portions of the articles to be cleaned are subjected to the action of the ultra-sonic-frequency beams. After cleaning as described, the articles may be withdrawn from the container 10 and dried in any suitable well-known fashion.

In Fig. 4 there is represented schematically a modified arrangement of the activators in which the elongated activators 21 and their associated operating windings or devices 21a are disposed around the periphery of the container 10 with their axes in a direction having a substantial tangential component and pointing downward at an angle to the horizontal, the activators pointing in the same rotational direction to induce a circulatory motion of the cleaning fluid around the container 10, as indicated by the arrows. The general principle of operation is similar to that described above in connection with the apparatus of Fig. 1.

The arrangement of Fig. 5 is similar to that of Fig. 4 with the exception that the activators 21

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are disposed with their operating devices 21a above the normal fluid level in the container 10, so that no sealing devices are required to prevent leakage of the cleaning fluid into the operating mechanism or windings of the activators.

In Fig. 6 is represented a modified form of activator which may be used in place of the magneto-strictive activator of Fig. 1. In this case the activator 31 comprises a pot magnet 31a, similar to that used in a conventional dynamic loud speaker, and provided with an exciting winding 31b disposed in a spool 31c of insulation material surrounding the circular core 31d of the magnet. The pot 31a and core 31d provide an annular uniform air gap in which the magnetical field is also uniform. Disposed within the air gap is a vibratory element comprising a cylindrical shaft 31f having a disk-like head 31g of substantial surface area and adapted to develop ultra-sonic-frequency waves within the cleaning fluid. Surrounding the shaft 31f is a winding 31e adapted to be excited from an ultra-sonic-frequency source, such as the source 12 of the Fig. 1.

The operation of the structure of Fig. 6 is entirely analogous to that of a conventional diagrammatic loud speaker, excitation of the winding 31b from a unidirectional source and excitation of the winding 31e from an ultra-sonic-frequency source producing ultra-sonic-frequency vibration of the element 31f, 31g. If desired, the unidirectional-current winding 31b may be omitted and the pot 31a and core 31d constructed of a permanent magnet material of high retentivity. The activator of Fig. 6 may be mounted in the container 10 in a manner similar to that of any of Figs. 1, 4 and 5.

The frequency of ultra-sonic-frequency source 12, or its equivalent, utilized to excite the activators of any of the several forms of the invention illustrated must, of course, be well above the audible range in order to prevent severe discomfort to the operator. This indicates a lower limit of frequency of the order of 20 kilocycles per second. On the other hand it appears that the wave length of the ultra-sonic-frequency waves developed in the cleaning fluid should not be substantially shorter than the order of the thickness of the textile article being cleaned. Since the velocity of propagation of such waves is the same as that of sound waves which, in water or in an aqueous cleaning solution, is of the order of 5,000 feet per second, an upper limit of acceptable frequency is indicated as approximately 300 kilocycles per second.

The development of ultra-sonic-frequency waves within the cleaning fluid results in a number of features which cooperate to insure a thorough cleansing action of the articles to be cleaned without substantial deterioration of the fabric. The energy of the ultra-sonic waves is absorbed in the cleaning fluid as heat, thereby aiding in maintaining a proper temperature of the washing mixture. It has also been found that such super-sonic-frequency waves in a liquid produce cavitation, that is the formation of bubbles of air or vapor and their intense agitation, and this process accelerates the emulsification of grease and dirt particles by the soap or other detergent in the cleaning fluid. Such ultra-sonic-frequency waves also, to a slight degree, break down the molecular structure of the water producing appreciable quantities of hydrogen peroxide which aids in bleaching the clothes. Further, in case the wash water is hard containing substantial amounts of carbonates, the carbonates tend to

be precipitated by the ultra-sonic-frequency waves, thus softening the water. Such super-sonic frequency-waves, particularly of the shorter wave lengths, tend to destroy bacteria or other simple organisms, thus having a certain sterilizing action.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed as new is:

1. A machine for cleaning textile fabric articles comprising, a cylindrical article container adapted to contain a cleaning fluid, a plurality of elongated activators arranged around the periphery of said container with their axes in a direction having a component tangent to the periphery of said container, each of said activators having a substantial surface area submerged in the cleaning fluid, and means for producing vibration of said activators at an ultra-sonic frequency to activate the cleaning fluid.

2. A machine for cleaning textile fabric articles comprising, a cylindrical article container adapted to contain a cleaning fluid, a plurality of elongated activators arranged around the periphery of said container with their axes in a direction having a component tangent to the periphery of said container and at an angle to the horizontal, said activators all pointing in the same rotational direction, each of said agitators having a substantial surface area submerged in the cleaning fluid, and means for producing vibration of said activators at an ultra-sonic frequency to activate the cleaning fluid.

3. The method of cleaning textile fabric articles which comprises, disposing the articles in a cleaning fluid bath, and developing a plurality of beams of ultra-sonic-frequency waves at

spaced points in said bath and in directions having components in the same rotational direction.

4. In a machine for cleaning textile fabric articles including a main container adapted to contain a cleaning fluid, an activator comprising a cup-like member of non-magnetic material having a high eddy current impedance and adapted to be disposed in said container, sealing means for preventing cleaning fluid from entering said cup-like member, an elongated magnetostrictive element disposed in said member and having a substantial surface area adapted to project into cleaning fluid which might be disposed in said container, and an ultra-sonic-frequency exciting winding surrounding said member.

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