

May 14, 1963

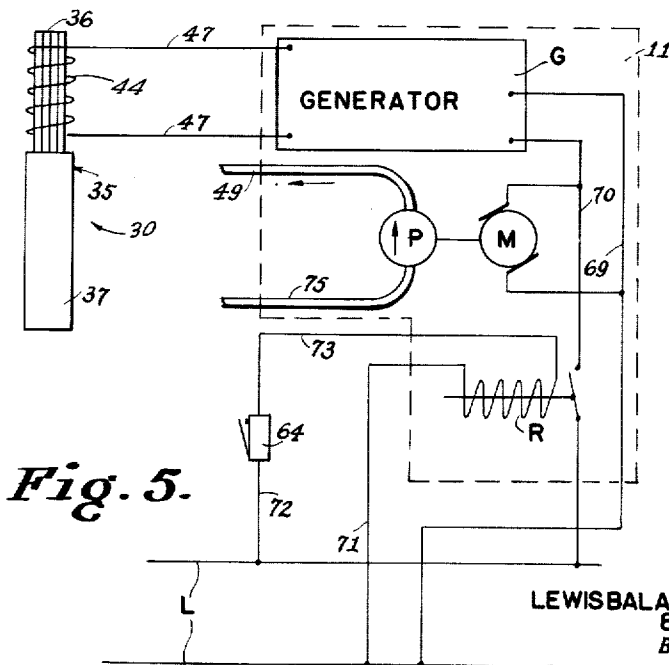
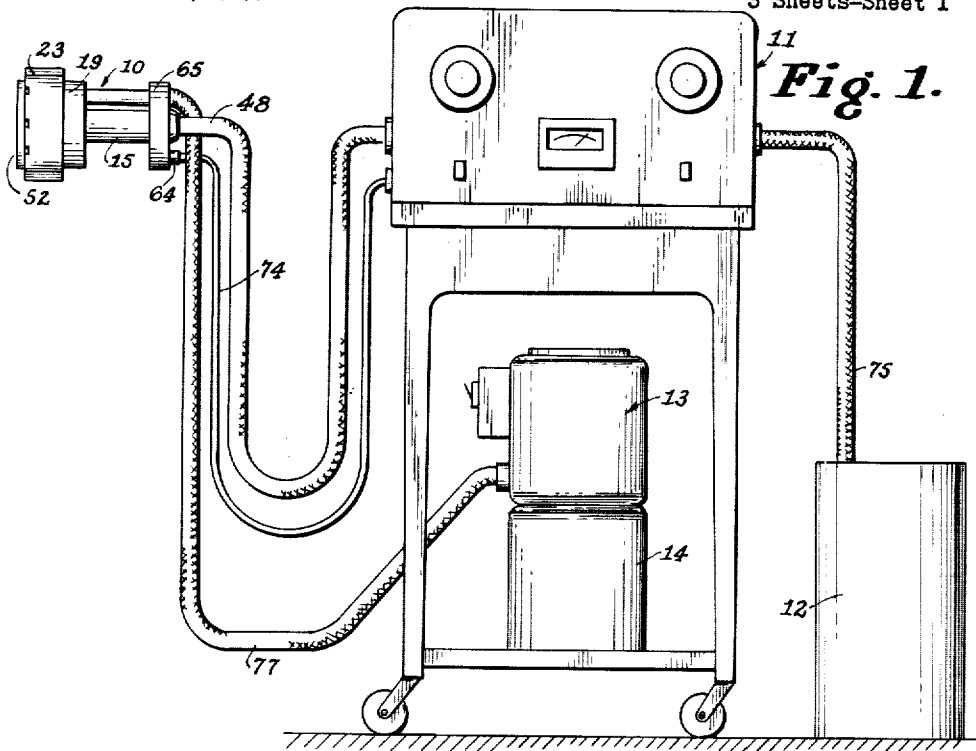
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ULTRASONIC CLEANING DEVICES AND METHOD OF CLEANING

Filed June 9, 1960

3 Sheets-Sheet 1



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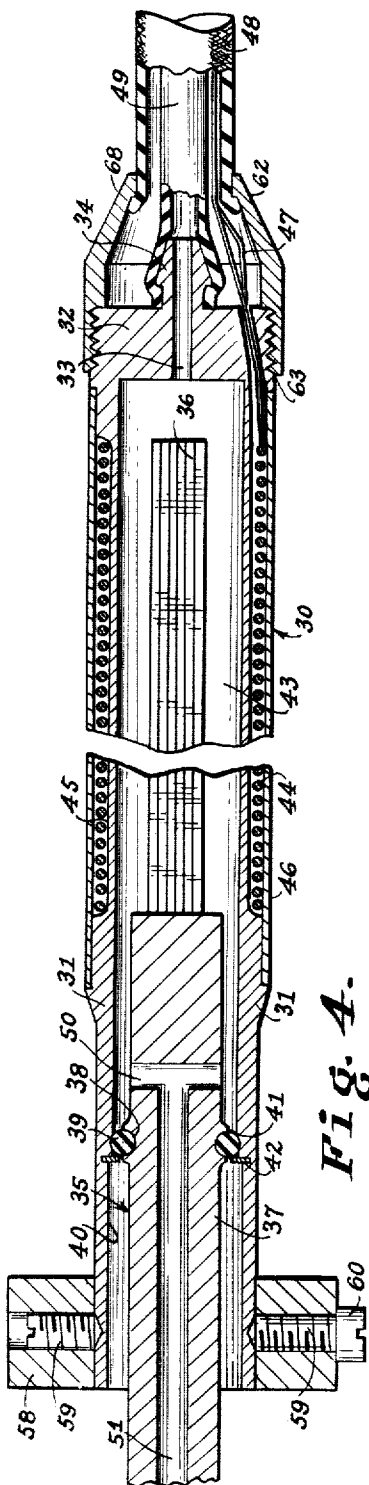


Fig. 4.

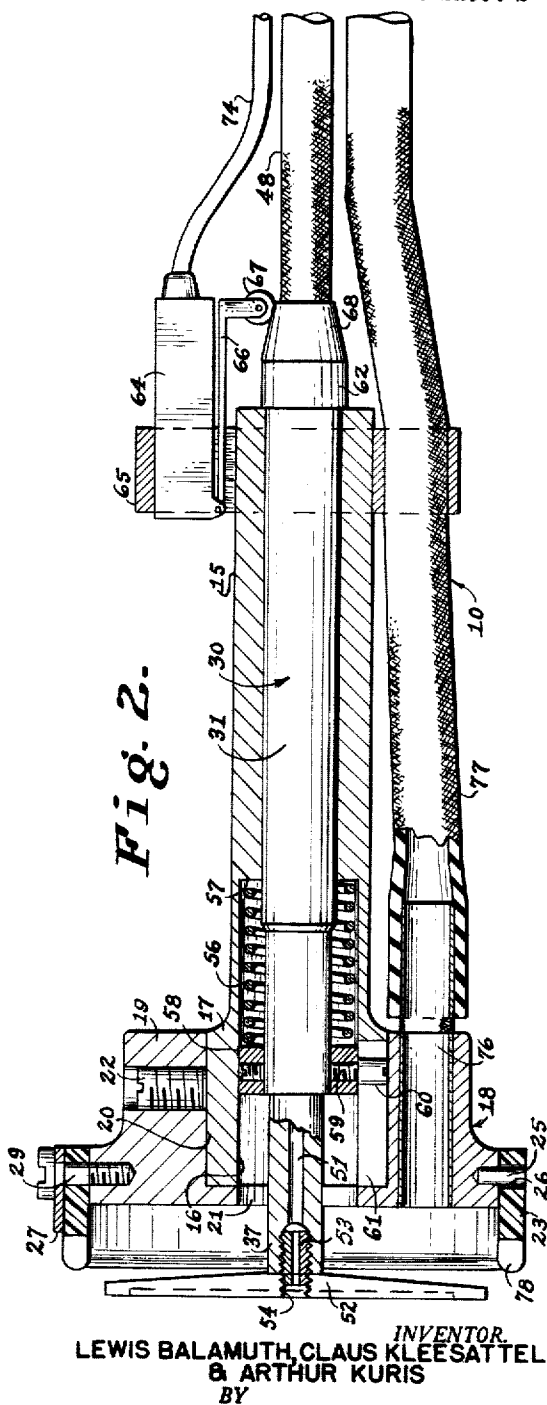


Fig. 2.

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3 Sheets-Sheet 3

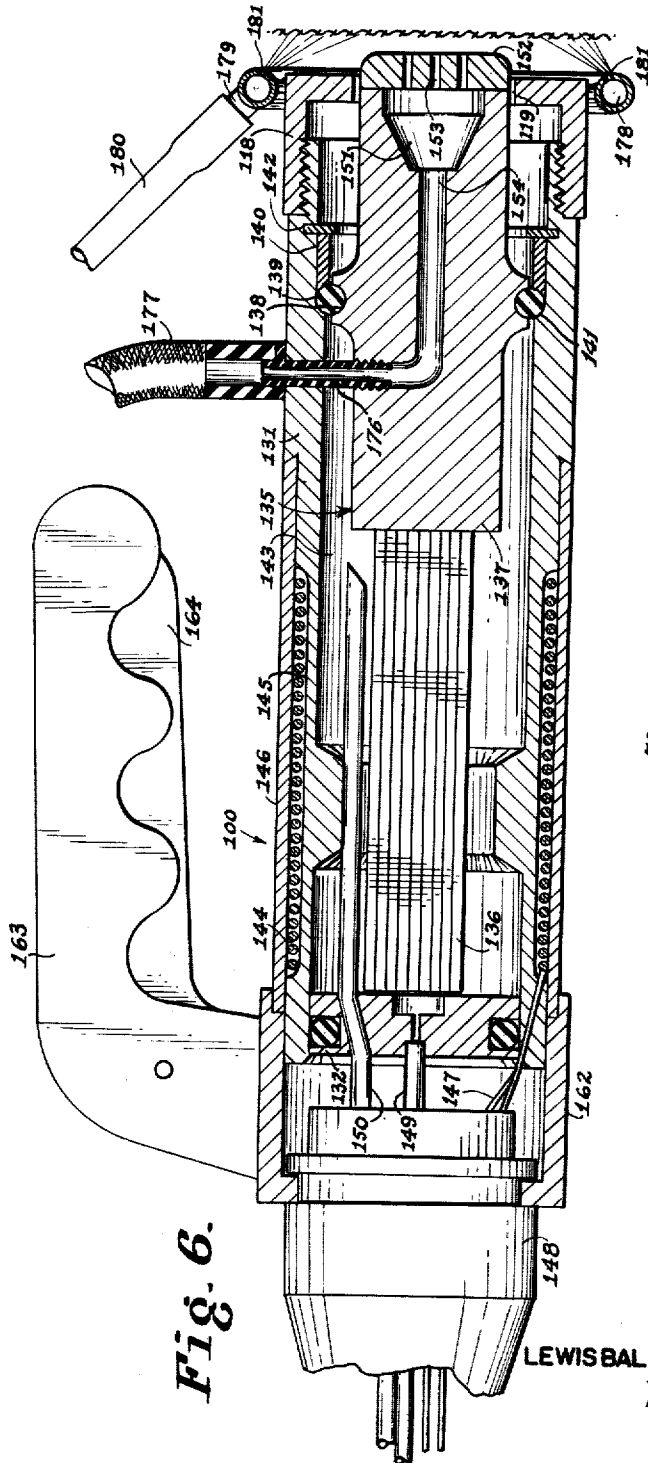


Fig. 6.

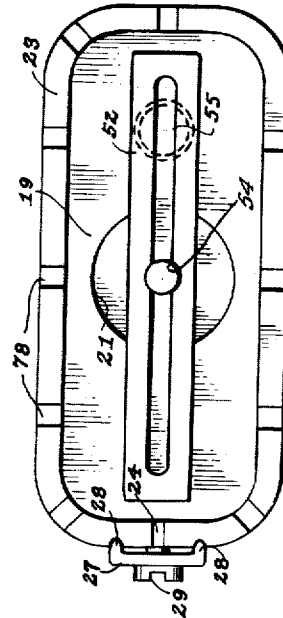


Fig. 3.

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1

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ULTRASONIC CLEANING DEVICES AND METHOD OF CLEANING

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16 Claims. (Cl. 134-1)

This invention relates generally to cleaning devices, and more particularly is directed to cleaning devices in which ultrasonic vibratory energy is employed for enhancing the cleaning action.

It is an object of the present invention to provide cleaning devices and a method of cleaning which ultrasonically vibrate the surface or material to be cleaned, thereby to loosen the dirt from such surface, and which then apply a suction to effect removal of the dirt from the cleaned area.

Another object is to provide cleaning devices of the described character wherein a cleaning liquid is applied to the vibrated area of the surface or material to be cleaned, so that the cleaning liquid is cavitated to enhance its cleaning action.

Another object is to provide cleaning devices of the described character which are operative to remove the dirt-laden cleaning liquid from the cleansed material or surface, thereby to further enhance the cleaning action and permit the cleaning of localized areas, as in the removal of spots from garments.

A further object is to provide cleaning devices of the described character which employ relatively small amounts of the cleaning liquid, thereby to permit the use of cleaning liquids having very effective cleaning actions, but the cost of which makes their use in large quantities economically undesirable.

In one embodiment of this invention, the cleaning liquid is applied to the surface or material through a hollow, ultrasonically vibrated member which is pressed against the dirt-laden surface or material in order to effect cavitation of the cleaning liquid in contact with the latter, whereby the effectiveness of the cleaning liquid in removing dirt or foreign particles is greatly enhanced, and a hood or shroud extends around the vibrated member and is connected to a source of vacuum so that the dirt-laden cleaning liquid spreads outwardly between the vibrated member and the surface or material being cleaned and is immediately removed from the cleansed area.

In another embodiment of the invention, the cleaning liquid is applied to the dirt-laden surface or material at the outside of an ultrasonically vibrated member disposed against the latter and having a hollow interior connected to a source of vacuum and being provided with passages opening from the interior at the surface of the vibrated member which is disposed against the dirt-laden surface or material so that the cleaning liquid is drawn under the vibrated member which effects cavitation thereof for promoting the take-up of dirt by the cleaning liquid, and the latter is then drawn into the hollow interior of the vibrated member for immediate removal from the cleansed area.

The above, and other objects, features and advantages of the invention, will be apparent in the following detailed description of illustrative embodiments thereof which is to be read in connection with the accompanying drawings forming a part hereof, and wherein:

FIG. 1 is a general elevational view of an ultrasonic cleaning device in accordance with one embodiment of the present invention;

FIG. 2 is an enlarged axial sectional view of a cleaning tool forming a part of the device illustrated in FIG. 1;

2

FIG. 3 is an end view of the cleaning tool of FIG. 2; FIG. 4 is an enlarged, axial sectional view of a vibrator mechanism included in the tool of FIGS. 2 and 3;

FIG. 5 is a wiring diagram of electrical components included in the cleaning device of FIG. 1; and

FIG. 6 is an axial sectional view of the tool forming a part of a cleaning device constructed in accordance with another embodiment of the invention.

Referring to the drawings in detail, and initially to FIG. 1 thereof, it will be seen that a cleaning device embodying the present invention may include a cleaning tool generally identified by the reference numeral 10, a power unit 11 containing a generator for supplying energizing current to a vibratory mechanism forming a part of the tool 10 and pumping means by which cleaning liquid is supplied from a tank 12 thereof to the tool 10, and a motor fan unit 13 which, at its inlet, forms a source of vacuum connected to the tool 10 for removing the dirt laden cleaning liquid from the latter and which has its outlet opening into a tank or receptacle 14 intended to receive the dirt laden cleaning liquid.

Referring to FIG. 2, it will be seen that the tool 10 includes a tubular housing 15 having a counterbore 16 at one end which is formed with an external enlarged head 17. A suction hood 18 includes a body 19 formed with a recess 20 receiving the enlarged head 17 and having an opening 21 at the bottom of the recess for alignment with the counterbore 16 of tubular housing 15. Body 19 is removably secured on head 17 of housing 15, for example, by a set screw 22. The hood 18 further includes a side wall or flange 23 which is preferably formed of nylon or other suitable plastic material and depends from the outer periphery of body 19. The flange 23 is preferably split at one side of the body 19, as at 24 (FIG. 3), and is held on body 19 by means of locating pins 25 projecting outwardly from the periphery of body 19 into corresponding holes 26 formed in flange 23 (FIG. 2), and by means of a connector 27 having projecting ribs 28 (FIG. 3) engageable in corresponding grooves formed in flange 23 at the opposite sides of split 24 and a screw 29 extending through a hole in the connector 27 and threadably received in a tapped hole formed in body 19. Thus, flange 23 can be easily removed for replacement thereof merely by loosening the screw 29 to release the ribs 28 from the corresponding grooves, and thereby permit spreading apart of the ends of flange 23 and disengagement of the latter from the locating pins 25.

The cleaning tool 10 further includes a vibratory mechanism 30 having a cylindrical casing 31 which is axially slidable in tubular housing 15. As shown in FIG. 4, casing 31 has a wall 32 at one end formed with a bore 33 opening through a nipple 34, while the opposite end of casing 31 is open to loosely receive a mechanical vibrator 35 that includes a transducer 36. The transducer 36 may be any one of a number of electromechanical types, such as electrodynamic, piezo-electric or magnetostrictive, however, for the operating range of frequencies most desirable for the purposes of a cleaning tool embodying the present invention, transducer 36 is preferably of the magnetostrictive type. The magnetostrictive transducer 36 is preferably formed of a metal, such as, Permalloy, nickel, Permendur, or other metals which have high tensile strength and are highly magnetostrictive in character, so that it will vibrate to a maximum degree when subjected to the influence of an alternating magnetic field established within casing 31.

In the embodiment shown in FIG. 4, transducer 36 comprises a stack of strips of the selected metal secured together at one end and rigidly fixed, at the other end, as by brazing, or soldering, to a coaxial, elongated connecting body or vibration transmitting member 37 also form-

3

ing part of mechanical vibrator 35 and which may be in the form of an acoustic impedance transformer adapted to either increase or decrease the amplitude of the vibration transmitted thereto from the transducer.

In place of the stack of metal strips forming the transducer 36 in the illustrated embodiment of the invention, there may be substituted a bundle of metal wires or rods, preferably of rectangular cross-section so that they can be compactly assembled together, a roll of metal foil, or a longitudinally split hollow metal tube. In any case, the length of the magnetostrictive transducer 36 is selected so that it will be a half-wavelength, or multiples thereof, at the frequency of the alternating magnetic field established within the tubular casing 31.

The vibration transmitting member or connecting body 37 may be made of a strong metal, such as, steel, Monel metal, titanium, Phosphor bronze, brass or beryllium copper, and its length, which is also a half-wavelength, or multiple thereof, is sufficiently great so that connecting body 37 will project substantially out of the open end of casing 31 when the mechanical vibrator 35 is in assembled relation to casing 31 with transducer 36 contained within the latter.

In order to retain the mechanical vibrator 35 in assembled relation to casing 31, the outer surface of connecting body 37 may be formed with an annular groove 38 which receives an O-ring 39 of rubber or the like, and the open end of casing 31 is counterbored, as at 40, to define an axially facing shoulder 41 (FIG. 4) against which O-ring 39 abuts to limit the insertion of mechanical vibrator 35 into the casing. Further, O-ring 39 may be held against shoulder 41 by means of a split washer 42 which is inserted in an annular groove formed in the inner surface of casing 31 adjacent shoulder 41.

O-ring 39 forms a fluid seal between the interior 43 of casing 31 containing transducer 36 and the open end of the casing, and further provides the support for the mechanical vibrator 35 within the casing. O-ring 39 is located substantially at a node of movement of the mechanical vibrator so that the vibrations of high frequency and low amplitude are not dampened or transmitted to the casing.

In order to establish the alternating magnetic field within casing 31 for effecting vibration of transducer 36, the vibratory mechanism 30 further includes a winding 44 of current conducting wire, such as, copper or the like, which is protected by an enamel coating and is wound on the outside of casing 31 in an annular recess 45 extending along that portion of casing 31 which accommodates transducer 36. The winding 44 is enclosed and protected by an outer jacket 46 which is flush with the outer surface of casing 31 so as to avoid interference with the sliding movement of the latter within the bore of housing 15.

The casing 31 and outer jacket 46 are formed of insulating and insulating or non-magnetic materials, respectively, for example, of plastics or the like, so as not to impede the establishment of an alternating magnetic field within casing 31 upon excitation of the winding 44 with a biased alternating current supplied to the winding from the generator G (FIG. 5) of power unit 11 by way of wire leads 47 which extend through a protective flexible conduit 48. Conduit 48 also contains a tube 49 (FIG. 4) which is joined to the nipple 34, and receives the supply of cleaning liquid from the pump P (FIG. 5) of the power unit 11 so as to supply the cleaning liquid to the interior 43 of casing 31 by way of the bore 33. The cleaning liquid leaves the space or interior 43 of casing 31 by way of radial passages 50 (FIG. 4) formed in connecting body 37 of the mechanical vibrator at locations adjacent the end of the connecting body secured to the transducer 36, that is, at the side of the sealing O-ring 39 facing away from the open end of casing 31, and the radial passages 50 open, at their inner ends, into an axial bore 51

4

in connecting body 37 opening at the free end of the latter.

Since transducer 36 is subjected to heating after prolonged operation and most effectively serves its purpose when maintained in relatively cool condition, the flow of cleaning liquid, such as, water or the like, through the interior 43 containing the transducer serves to cool the latter and further maintains the outer jacket 46 at approximately room temperature so that it can be comfortably grasped.

As shown in FIGS. 2 and 3, the cleaning tool 10 further includes a vibrated member 52 which is generally elongated and dimensioned so that it can be received within flange 23 with a substantial clearance therebetween. Member 52 is centrally secured to the free end of connecting body 37 so that it will be vibrated by the latter. In the illustrated embodiment of the invention, the attachment of member 52 to connecting body 37 is effected by an externally threaded, axially bored connector 53 which threadably engages in a central tapped hole 54 extending through member 52 and in a tapped end portion of bore 51 of connecting body 37. Further, as shown in FIG. 3, the surface of vibrated member 52 facing away from connecting body 37 is formed with one or more grooves 55 extending from the central bore 54 and terminating short of the outer edge of member 52 for effecting distribution of the cleaning liquid supplied to that surface of member 52 from bore 51 by way of connector 53.

The vibratory mechanism 30 is yieldably urged to move axially relative to housing 15 to the position illustrated in FIG. 2, where the vibrated member 52 projects beyond the edge of flange 23, by means of a helical compression spring 56 extending around casing 31 in counterbore 16 and abutting, at its opposite ends, against a radial shoulder 57 defined by the inner end of counterbore 16 and against a collar 58 which is slidable in counterbore 16 and secured on the open end portion of casing 31, as by set screws 59. One of the set screws 59 has a head 60 projecting radially from collar 58 and being slidable in a slot 61 (FIG. 2) which extends axially in the enlarged head 17 of housing 15, so that the head 60 and slot 61 cooperate to prevent turning of the vibratory mechanism 30 from the position where the vibrated member 52 is receivable within the flange 23.

The spring urged movement of vibratory mechanism 30 relative to housing 15 is limited by means of a cap 62 which is screwed on the closed end of casing 31 to secure the conduit 48 to the vibratory mechanism and which projects radially beyond the outer surface of casing 31 so as to define a radial shoulder 63 (FIG. 4) engageable with the end surface of housing 15 when casing 31 is urged to the position where vibrated member 52 projects the desired distance beyond flange 23.

It will be apparent that, when cleaning tool 10 is pressed against a dirt-laden surface, member 52 is moved into the hood 18 until the member 52 is flush with the edge of flange 23, and the corresponding movement of casing 31 of the vibratory mechanism 30 is employed for actuating a microswitch 64 which is secured in a bracket 65 (FIG. 2) attached to the end of the housing 15 remote from the hood 18. Microswitch 64 has normally open contacts and is provided with an actuating lever 66 carrying a roller 67 which rides on the cap 62 of casing 31. The cap 62 has a frusto-conical surface portion 68 so that, during the movement of member 52 into hood 18, the axially displaced frusto-conical surface portion 68 acts on the roller 67, and thereby causes angular displacement of lever 66 for actuating microswitch 64 in order to close the contacts of the latter.

As shown in FIG. 5, the input terminals of generator G of power unit 11 are connected to the usual power supply lines L by way of conductors 69 and 70, and the conductor 70 has the normally open contacts of a relay R interposed therein so that the generator G is operated

to supply biased alternating current to the winding 44 of vibratory mechanism 30, for producing the desired vibrations in mechanical vibrator 35, and hence in member 52, only when the coil of relay R is energized. One end of the coil of relay R is connected to one of the supply lines L by way of a conductor 71, while the terminals of the microswitch 64 are connected, by conductors 72 and 73, to the other supply line L and to the other end of the relay coil, respectively. Thus, the coil of relay R is energized to complete the supply circuit to the input of generator G only when microswitch 64 has its contacts closed in response to the axial displacement of vibratory mechanism 30 corresponding to the retraction of member 52 within hood 18. The conductors 72 and 73 shown on FIG. 5 may be contained within a protective flexible conduit 74 (FIGS. 1 and 2) extending from microswitch 64 to a suitable connector on the housing of power unit 11.

It will also be seen in FIG. 5 that the pump P is driven by a motor M which may also be supplied with current from the conductors 69 and 70 so that the motor M is operated to drive the pump P only when the coil of relay R is energized to close the contacts of the latter.

From the above, it is apparent that the vibratory mechanism 30 is operated to effect vibration of member 52, and that the pump P is operated to draw cleaning liquid from the tank 12 by way of a conduit 75 and to supply such liquid through the conduit 49 to the casing 31 for discharge at the operative surface of the vibrated member 52 only when the cleaning tool 10 is pressed against the surface to be cleaned and the vibrated member 52 is thereby retracted within the hood 18.

A suction connection in the form of an open ended tube 76 (FIG. 2) is carried by body 19 and opens at the bottom of the latter, and a suction hose 77 is secured, at one end, to tube 76 and extends to the inlet of motor fan unit 13 so that, when the latter is operated, suction is created within the hood 18. The edge of flange 23 of hood 18 is preferably formed with spaced apart notches 78 to permit air to enter the interior of the hood when the edge of flange 23 engages a surface to be cleaned.

When operating the above described cleaning device embodying this invention, the motor fan unit 13 is initially placed in operation to create a vacuum or suction within hood 18 and the latter is then pressed against and moved over or across the surface or material to be cleaned. As previously mentioned, the member 52 is retracted within hood 18 when the latter is pressed against the surface to be cleaned and the corresponding movement of the vibratory mechanism 30 serves to actuate microswitch 64, whereby both the generator G and the pump motor M are made to operate. Thus, cleaning liquid is pumped from the tank 12 through the casing 31 of vibratory mechanism 30 to cool the transducer 36 prior to issuing from the bored connector 53 and being distributed over that area of the surface to be cleaned which is contacted by member 52. Simultaneously, the supplying of biased alternating current to winding 44 generates vibrations in transducer 36, and these vibrations are transmitted by connecting body 37 to the member 52 which is attached to the connecting body at a loop of longitudinal motion and thereby is made to vibrate in directions parallel to the axis of mechanical vibrator 35 with a relatively small amplitude and with a frequency lying within the range of approximately 5 thousand to 40 thousand cycles per second. Such vibration of member 52 is effective to cause cavitation of the cleaning liquid which can escape from groove 55 only by passing between the vibrated surface of member 52 and the surface or material being cleaned, thereby greatly enhancing the cleaning action. The suction in hood 18 acts at the periphery of member 52 to promote the distribution of the cleaning liquid over the area covered by member 52, and, as the cleaning liquid escapes at the periphery of the vibrated member 52, such

dirt-laden cleaning liquid is carried along with the air flow through the notches 78 into the suction connection 76 for transmission by way of conduit 77 into the tank or container 14 intended to receive the dirt-laden liquid.

It will be apparent that, with the described arrangement embodying the invention, the cleaning liquid does not escape from the confines of hood 18 so that the cleaning tool 10 can be utilized for the liquid cleaning of wall surfaces or the like without the risk of water damage to adjacent objects. Further, by reason of the use of vibratory energy for effecting cavitation of the cleaning liquid, very effective cleaning action can be attained with relatively small quantities of liquid, thereby to make economically feasible the use of cleaning liquids which are relatively expensive but endowed with superior cleaning properties. The cavitation of the cleaning liquid in groove 55 produces a pumping action which tends to drive the cleaning liquid into pores or interstices of the surface or material being cleaned, and thereby further promotes the cleaning action.

Since the dirt-laden cleaning liquid is immediately removed from the cleansed area by the suction applied to the interior of hood 18, very dirty surfaces can be thoroughly cleaned while avoiding streaking and the necessity of using multiple rinses. It is also to be noted that the extremely effective cleaning action that results from the combination of cavitation of the cleaning liquid and the immediate removal of the dirt-laden cleaning liquid from the cleansed surface makes the cleaning device embodying the present invention ideally suited for the decontamination of the surfaces of structures or vehicles that have been exposed to radioactive fall-out.

Although the cleaning tool 10 described above with reference to FIGS. 1 to 4, inclusive, of the drawings is of a type that is intended to be hand manipulated and to effect cleaning of a relatively narrow strip of the surface or material over which the tool is moved, it will be apparent that the described cleaning tool can be constructed with substantially larger dimensions so as to include a relatively wide hood that is particularly suitable for the cleaning of floors or other large surfaces.

In the cleaning tool 10, the cleaning liquid is discharged at the center of the vibrated member 52 and is spread toward the periphery of the latter by the suction within hood 18 which acts in the gap or clearance between member 52 and the flange 23 of the hood. However, it is to be understood that, in a cleaning tool embodying the present invention, the cleaning liquid may be made to flow inwardly from the periphery of the vibrated member between the latter and the surface or material to be cleaned. An example of such an arrangement is illustrated in FIG. 6 of the drawings showing a cleaning tool 100 that is particularly suited for the removal of spots or other localized soiled areas from garments or the like.

The cleaning tool 100 includes a cylindrical casing 131 containing a mechanical vibrator 135 made up of a magneto-strictive transducer 136 and a connecting body 137 brazed or soldered to one end of the transducer 136 and in longitudinal alignment with the latter. The mechanical vibrator 135 is suitably supported within casing 131, for example, by means of a resilient O-ring 139 which is received in an annular groove 138 formed in connecting body 137 at a node of longitudinal movement, and which engages between a shoulder 141 formed in the interior surface of casing 131 and a wedge sleeve 140 which fits into casing 31 and is held against axial displacement by a split ring 142 received in a suitable internal annular groove of casing 131. The O-ring 139 performs the dual function of supporting mechanical vibrator 135 and of forming a liquid seal at one end of the interior space 143 of the casing which accommodates transducer 136.

The alternating magnetic field necessary for producing the vibrations of transducer 136 is established by passing biased alternating current through a winding

7

144 disposed in an annular recess 145 formed in the outer surface of casing 131 along the portion of the latter accommodating the transducer, and the winding 144 is protected by an outer jacket 146. The exciting current for the winding 144 is fed to the latter through wire leads 147 which extend through a flexible protective conduit 148 to a generator (not shown) which, as in the first described embodiment, forms part of an associated power unit. The end of casing 131 remote from connecting body 137 is closed by a plug 132 having tubes 149 and 150 extending therethrough from the conduit 148 and forming an inlet and an outlet, respectively, for a cooling liquid which is circulated within the interior space 143 between plug 132 and sealing ring 139 in order to effect cooling of transducer 136.

Further, the end of casing 131 closed by plug 132 carries a head 162 from which a handle 163 extends for convenient manipulation of the cleaning tool 100. The handle 163 may be conveniently provided with a pivoted trigger 164 by which a suitable switch, for example, a switch corresponding to the microswitch 64 of the cleaning tool 10, can be closed to effect operation of the generator supplying energizing current to the winding 144.

In the cleaning tool 100, the end of connecting body 137 remote from transducer 136 is formed with an internal cavity 151 which is closed by a plate 152 extending across the end of connecting body 137 and rigidly secured to the latter, as by soldering or brazing. Plate 152 is formed with passages 153 extending therethrough and opening into cavity 151, and an internal bore or passage 154 extends from cavity 151 through body 137 and opens radially at the side surface of the latter to receive one end of a flexible connecting tube 176 which extends through a radial opening in casing 131 and is formed, at the outside of the latter, with a nipple for attachment of a suction hose or conduit 177. The suction hose 177 extends to a source of vacuum which may be similar to the motor fan unit 13 associated with the cleaning tool 10.

The cleaning tool 100 is completed by a hood 118 having a central opening 119 through which plate 152 loosely projects and being threadably secured on the adjacent end of casing 131.

The transducer 136 and connecting body 137 of mechanical vibrator 135 also have lengths equal to half-wave lengths, or whole multiples thereof, at the frequency of vibration of the transducer resulting from the alternating magnetic field established within casing 131 so that the plate 152, which is located at a loop of longitudinal motion, is vibrated at a high frequency, and with a relatively small amplitude, in directions parallel to the longitudinal axis of mechanical vibrator 135.

When using the cleaning tool 100, the plate 152 is placed against the soiled spot of the garment or the like and the trigger 164 is manipulated in order to cause the feeding of the exciting biased alternating current to winding 144, thereby to effect the high frequency vibration of plate 152, while the conduit or pipe 177 is simultaneously connected to a source of vacuum or suction, thereby to produce a vacuum within cavity 151. The cleaning liquid is then applied around the vibrated plate 152, for example, from a syringe, dropper or the like, so that the suction in cavity 151 will act through the passages 153 to draw the cleaning liquid inwardly between vibrated plate 152 and the fabric or material of the garment. The vibrated plate 152 causes cavitation of the cleaning liquid in order to enhance the cleaning action of the latter, and the dirt-laden cleaning liquid is then immediately drawn through the passages 153 into cavity 151, and through the passage or bore 154 for discharge through the suction hose or conduit 177.

It will be apparent that, with the cleaning tool 100, relatively small quantities of cleaning liquid can be employed for effectively removing deeply embedded dirt from the fabric of garments or the like by reason of the

8

combined action of the ultrasonic vibration of plate 152 and the effect of the vacuum or suction in cavity 151 which respectively loosen the dirt and draw the latter and the cleaning liquid out of the fabric. Since small quantities of cleaning liquid can be employed, and since the liquid is drawn toward the center of the soiled area and then removed from the fabric, spots or the like can be removed from the fabric without the formation of rings or stains that commonly result from conventional procedures intended to remove spots.

Although selected cleaning liquids may be applied around the vibrated plate 152 from a syringe or the like, as described above, the cleaning tool 100 may also be provided with an annular tube or manifold 178 secured to the periphery of hood 118 and connected, as by a nipple 179 to a flexible hose 180 through which cleaning liquid is supplied to the manifold 178 for discharge from the latter through inwardly directed orifices 181, whereby the cleaning liquid is once again applied to the fabric around the periphery of vibrated plate 152.

Although illustrative embodiments of the present invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein without departing from the scope or spirit of the invention, except as defined in the appended claims.

What is claimed is:

1. An ultrasonic cleaning device comprising a member having a face for contact with the surface to be cleaned, conduit means opening adjacent the periphery of said face and at least at one location on said face spaced from said periphery, respectively, means for supplying cleaning liquid to one of said conduit means, means for applying suction to the other of said conduit means so that the cleaning liquid issuing from said one conduit means is made to travel across said face toward said other conduit means and is removed through the latter, and means operative to vibrate said face of the member at a high frequency of at least 5000 cycles per second and low amplitude in directions perpendicular to said face so that the liquid travelling across said face while the latter is in contact with the surface to be cleaned is pressurized and subject to cavitation for enhancing the effectiveness of the liquid in taking-up dirt from the surface to be cleaned and the vibrations of said face facilitate movement of the latter over the surface to be cleaned.

2. An ultrasonic cleaning device comprising a member having a face for contact with the surface to be cleaned, conduit means opening adjacent the periphery of said face and at least at one location on said face spaced from said periphery, respectively, means for supplying cleaning liquid to one of said conduit means, mean for applying suction to the other of said conduit means so that the cleaning liquid issuing from said one conduit means is made to travel across said face toward said other conduit means and is removed through the latter, and means operative upon contact of said face with the surface to be cleaned to vibrate said face of the member at a high frequency of at least 5000 cycles per second and low amplitude in directions perpendicular to said face so that the liquid travelling across said face while the latter is in contact with the surface to be cleaned is pressurized and subject to cavitation for enhancing the effectiveness of the liquid in taking-up dirt from the surface to be cleaned and the vibrations of said face facilitate movement of the latter over the surface to be cleaned.

3. An ultrasonic cleaning device comprising a member having an active surface adapted to be placed against a surface to be cleaned and at least one aperture opening at said active surface, said active surface further having

at least one recess therein containing said aperture with the periphery of said recess being spaced from the periphery of said active surface, means supplying a cleaning liquid to said aperture for distribution by said recess and escape from the latter between said active surface and the surface to be cleaned, means operative to vibrate said active surface of the member upon contact of said active surface with the surface to be cleaned and at a frequency of at least 5000 cycles per second, thereby to cause cavitation and pumping of the distributed cleaning liquid and increase the cleaning effectiveness thereof while facilitating movement of said active surface over the surface to be cleaned, and means applying a suction around said vibrated member to promote the distribution of the cleaning liquid from said aperture and to remove the dirt-laden cleaning liquid from the surface being cleaned.

4. An ultrasonic cleaning device comprising a casing which is open at one end, means for establishing an alternating magnetic field in said casing, a mechanical vibrator including a transducer disposed in said casing to vibrate at a high frequency of at least 5000 cycles per second and low amplitude when influenced by said magnetic field and a connecting body fixed, at one end, to said transducer and projecting out of said open end of the casing, a member fixed to the other end of said connecting body for contact with a surface to be cleaned and adapted to be vibrated by vibrations transmitted through said connecting body from said transducer, a hood extending around said vibrated member, means for applying a cleaning liquid through said vibrated member to the surface to be cleaned, and means applying a suction to the interior of said hood to cause distribution of the cleaning liquid toward the periphery of said vibrated member where the suction removes the dirt laden cleaning liquid from the surface, while the vibrations of said member cause cavitation of the cleaning liquid travelling between said member and the surface to be cleaned in order to enhance the cleaning action of the liquid and further facilitate movement of said member over the surface to be cleaned.

5. An ultrasonic cleaning device comprising a tubular casing which is open at one end, a winding on said casing for establishing an alternating magnetic field in the latter in response to the passage of a biased alternating current through said winding, a mechanical vibrator including a transducer disposed in said casing to vibrate at high frequency and low amplitude in response to said magnetic field and a connecting body fixed, at one end, to said transducer and projecting out of said open end of the casing, a member fixed to the other end of said connecting body for contact with a surface to be cleaned and adapted to be vibrated by vibrations transmitted through said connecting body from said transducer, sealing means between said connecting body and casing for isolating the portion of the interior of said casing containing said transducer from said open end of the casing, said connecting body having passages therein opening in said portion of the casing interior and at said vibrated member, and means supplying cleaning liquid to said portion of the casing interior to cool said transducer and to flow through said passages of the connecting body for discharge between said vibrated member and the surface to be cleaned so that said vibrated member causes cavitation of the discharged liquid and thereby enhances the cleaning action of the latter.

6. An ultrasonic cleaning device comprising a tubular casing which is open at one end, a winding on said casing for establishing an alternating magnetic field in the latter in response to the passage of a biased alternating current through said winding, a mechanical vibrator including a transducer disposed in said casing to vibrate at high frequency and low amplitude in response to said magnetic field and a connecting body fixed, at one end,

to said transducer and projecting out of said open end of the casing, a member fixed to the other end of said connecting body for contact with a surface to be cleaned and adapted to be vibrated by vibrations transmitted through said connecting body from said transducer, sealing means between said connecting body and casing for isolating the portion of the interior of said casing containing said transducer from said open end of the casing, said connecting body having passages therein opening in said portion of the casing interior and at said vibrated member, means supplying cleaning liquid to said portion of the casing interior to cool said transducer and to flow through said passages of the connecting body for discharge between said vibrated member and the surface to be cleaned so that said vibrated member causes cavitation of the discharged liquid and thereby enhances the cleaning action of the latter, a hood extending around said vibrated member, and means applying suction to said hood so that the cleaning liquid is drawn toward the periphery of the vibrated member and there removed from the surface along with the dirt taken-up by the liquid from the surface.

7. An ultrasonic cleaning device comprising a casing which is open at one end, means for establishing an alternating magnetic field in said casing, a mechanical vibrator including a transducer disposed in said casing to vibrate at high frequency and low amplitude when influenced by said magnetic field and a connecting body fixed, at one end, to said transducer and projecting out of said open end of the casing, a member fixed to the other end of said connecting body for contact with a surface to be cleaned and adapted to be vibrated by vibrations transmitted through said connecting body from said transducer so that the vibrations of said member cause cavitation of a cleaning liquid introduced between the surface to be cleaned and said member for enhancing the effectiveness of the cleaning liquid in taking up dirt from the surface, a hood extending around said vibrated member, means yieldably urging said vibrated member to project beyond said hood so that said vibrated member is retracted into said hood when pressed against the surface to be cleaned, control means actuated in response to the retraction of the vibrated member into said hood to cause operation of said means for establishing the alternating magnetic field, and means applying suction to said hood for drawing the cleaning liquid toward the periphery of said vibrated member where the dirt-laden cleaning liquid is removed from the surface to be cleaned.

8. An ultrasonic cleaning device comprising a tubular housing having a hood on one end thereof, a casing axially slidable in said housing and being open at the end thereof directed toward said hood, a winding carried by said casing, generator means operative to supply a biased alternating current to said winding for establishing an alternating magnetic field in said casing, a mechanical vibrator including a transducer disposed in said casing to vibrate at high frequency and low amplitude when exposed to said magnetic field and a connecting body fixed, at one end, to said transducer and projecting out of said open end of the casing, a member fixed to the other end of said connecting body and adapted to be vibrated by vibrations transmitted through said connecting body from said transducer, spring means yieldably urging said casing axially relative to said housing to a position where said member extends out of said hood, whereby said member is retracted into said hood when pressed against a surface to be cleaned and said casing is correspondingly axially displaced relative to said housing, control means operating said generator means in response to the axial displacement of said casing relative to said housing so that said member is vibrated only when pressed against the surface to be cleaned, means for supplying cleaning liquid between said vibrated mem-

11

ber and the surface to be cleaned so that said vibrated member causes cavitation of the liquid for enhancing the cleaning action thereof, a source of vacuum, and means connecting the interior of said hood with said source so that the vacuum removes the cleaning liquid from the surface to be cleaned at the periphery of said vibrated member.

9. An ultrasonic cleaning device as in claim 8; wherein said control means includes switch means mounted on said housing and having an actuating element which is displaced by said casing to close said switch means upon said axial displacement of the casing relative to the housing.

10. An ultrasonic cleaning device as in claim 9; wherein said means for supplying cleaning liquid includes pumping means operated in response to closing of said switch means so that cleaning liquid is only supplied when said member is pressed against the surface to be cleaned.

11. An ultrasonic cleaning device as in claim 8; further comprising fluid sealing means between said connecting body and said casing to isolate the portion of the interior of the latter containing the transducer from said open end of the casing; and wherein the connecting body has passages therein opening into said portion of the casing interior and at said member, and said means for supplying cleaning liquid includes supply conduit means opening into said portion of the casing interior so that the cleaning liquid cools said transducer prior to issuing from said passages at said member.

12. An ultrasonic cleaning device as in claim 11; wherein said means for supplying cleaning liquid further includes pumping means also operated by said control means so that cleaning liquid is only supplied when said member is simultaneously vibrated in response to the pressing thereof against the surface to be cleaned.

13. A method of cleaning a soiled surface, comprising placing a member against the soiled surface while vibrating the member at a high frequency of at least 5000 cycles per second and with a small amplitude in the direction perpendicular to the soiled surface so that the vibrations of said member facilitate movement of the latter

12

over the soiled surface, supplying a cleaning liquid to the soiled surface so that contact of said vibrated member with the soiled surface pressurizes the liquid and subjects the latter to cavitation for enhancing the effectiveness of the liquid in taking up dirt from the soiled surface, and applying suction to the soiled surface adjacent the vibrated member for removing the dirt laden cleaning liquid from the surface.

14. A method as in claim 13; wherein the cleaning liquid is supplied to the soiled surface and the suction is applied to the soiled surface at spaced apart locations between which at least a portion of the vibrated member is interposed so that the suction induces the cleaning liquid to flow between said vibrated member and the soiled surface for ensuring the action on the cleaning liquid of the vibrations of said member.

15. A method as in claim 14; wherein the cleaning liquid is supplied at the center of said vibrated member and the suction is applied at the periphery of the vibrated member.

16. A method as in claim 14; wherein the suction is applied at the center of said vibrated member and the cleaning liquid is supplied at the periphery of the vibrated member.

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