Jan. 15, 1963 L. R. JEFFREY, JR 3,073,578

ULTRASONIC CLEANING MACHINE

Filed June 25, 1962

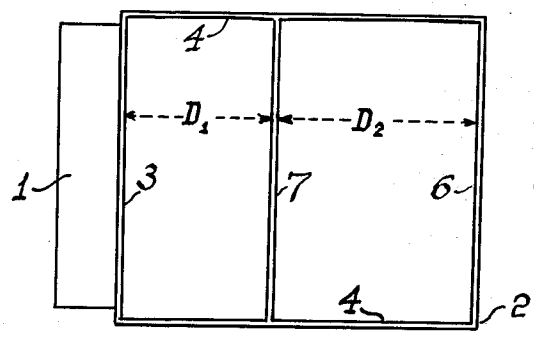


FIG. 1

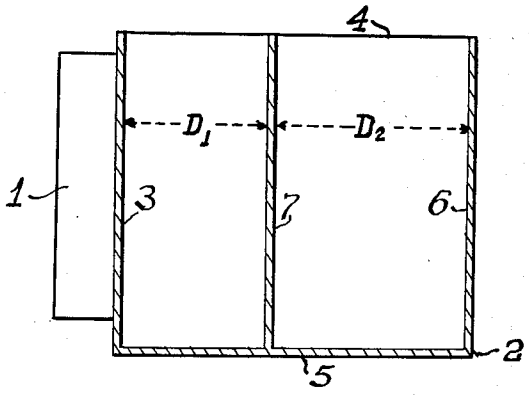


FIG. 2

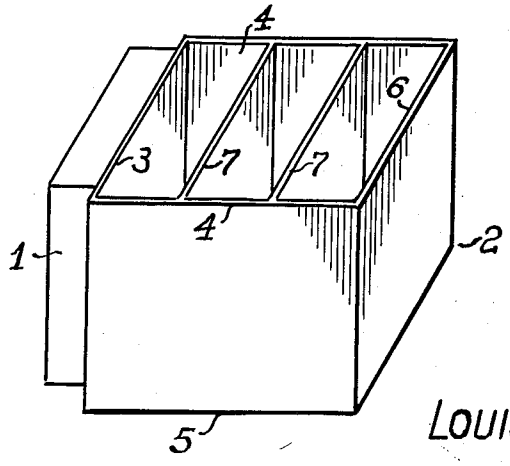


FIG. 3

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United States Patent Office 3,073,578 Patented Jan. 15, 1963

3,073,578

ULTRASONIC CLEANING MACHINE

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Filed June 25, 1962, Ser. No. 207,848
4 Claims. (Cl. 259—54)

My invention relates to ultrasonic cleaning machines, and has particular utility in cleaning processes requiring the simultaneous energization of two or more cleaning fluids; this being a continuation in part of my prior application Serial No. 162,133 filed on December 26, 1961, and now abandoned.

The energy produced by mechanical vibrations at frequencies above 20,000 cycles per second, when transmitted through a liquid, cleans the most delicate and complex parts thoroughly and inexpensively. This technique is known as ultrasonic cleaning. Ultrasonic vibrations in a liquid cause the rapid expansion and contraction of millions of microscopic bubbles. The implosion or collapse of these bubbles during the pressure reduction part of the cycle results in a powerful scrubbing action which pulls the contaminants free from parts immersed in the liquid.

These ultrasonic vibrations in the cleaning fluid are usually obtained by the employment of transducers, which are known in the art. These transducers have the characteristic that, when excited by an electronic oscillator at their resonant frequency, expand and contract at that frequency and thereby produce vibrations of high frequency. These ultrasonic vibrations are usually transmitted to the cleaning fluid by mounting the transducers on the exterior surface of one of the walls of the tank containing the cleaning fluid. In other cases the transducers, properly protected from the chemical action of the cleaning fluid, are immersed in the cleaning fluid within the tank for the purpose of transmitting the vibrations to the cleaning fluid. The present practice, generally followed in the art, is to equip each tank with the necessary transducers to form a complete ultrasonic cleaning machine. This means that in the frequent cases when the cleaning process consists of several stages requiring cleaning fluids dissimilar in composition or concentration, the present practice is to employ as many complete cleaning machines as there are dissimilar cleaning fluids in the process.

One of the important objects of my invention is to provide an ultrasonic cleaning machine, a single unit of which can perform simultaneously two or more stages of a cleaning process employing dissimilar cleaning fluids, thereby eliminating the necessity of providing two or more separate complete cleaning machines of considerable total first cost.

Another important object of my invention is to provide a novel ultrasonic cleaning machine in which the same transducers are utilized to energize simultaneously two or more cleaning fluids, thereby reducing considerably the energy requirement and the operating cost of the cleaning process, as compared with the present practice of energizing each dissimilar cleaning fluid by a separate transducer.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawing, forming a part of the present application, wherein for the purpose of illustration are shown a preferred and a modified form of my invention,

FIGURE 1 is a plan view of my ultrasonic cleaning machine having a tank with two compartments for the simultaneous performance of a two-stage cleaning operation,

FIGURE 2 is a vertical sectional view of the same,

FIGURE 3 is a perspective view of an alternative form of my ultrasonic cleaning machine having a tank with three compartments.

Referring to the drawing, the numeral 1 designates the transducer housing containing the transducers, which are the working element of the ultrasonic cleaning machine. These transducers have the characteristic that when they receive electrical energy at their natural frequency from an electronic oscillator, usually called electronic generator, they expand and contract at their natural resonant frequency producing ultrasonic mechanical vibrations. There are several types of transducers known in the art, each of these types has special qualities which makes it particularly suitable for certain fields of application. In the preferred form of my invention illustrated in FIGS. 1 and 2, the transducers employed contain barium titanate or lead zirconate crystals, known in the art under the name of piezoelectric crystals. Several such transducers are mounted on the outside of the front wall 3, and enclosed within the transducer housing 1, each having its radiating surface secured by means of a metallic or resinous bond to the front wall 3. As a result of this arrangement, the interior surface of said front wall 3 becomes the effective radiating surface of the total output of the transducers enclosed in the housing 1.

As the above described arrangement of the transducers is well known in the art, no illustration of it is necessary for the understanding of my present invention, which resides in another feature of my machine.

The tank shown in FIGS. 1 and 2 comprises two side walls 4 and a base 5 disposed perpendicularly to the front wall also a back wall 6 and a partition 7 disposed parallel to said front wall 3. The partition 7 is a novel feature, dividing the tank 2 into two compartments. The important function of this partition 7 is that it permits the simultaneous energization of two dissimilar cleaning fluids, thereby making it possible to perform simultaneously two stages of a cleaning process with the use of one ultrasonic machine.

In the ultrasonic cleaning machines of the prior art such subdivision of the tank was avoided because it was found that randomly disposed partitions in most cases disturbed the propagation of the ultrasonic vibrations in the cleaning fluid so as to jeopardize the cleaning efficiency. My invention solves this problem and makes the subdivision of these tanks practicable by the right positioning of the partitions. I have found that in such subdivided tanks, as shown in FIGS. 1 and 2, the propagation of the ultrasonic vibration is very satisfactory when the partition 7 and the back wall 6 are so located that, in the instant when the vibration at the radiating surface 3 reaches maximum amplitude, the amplitude of the vibration at the partition 7 and also at the back wall 6 is practically zero. This condition can be obtained by choosing the distance D1, measured at right angle to the radiating surface 3, to be equal to the quarter wave length of the vibration produced in the cleaning fluid within the compartment bounded by the walls 3, 4 and 7, multiplied by an odd integer, and by choosing the distance D2 to be equal to the quarter wave length of the vibration of the cleaning fluid within the compartment bounded by the walls 4, 6 and 7, multiplied by an even integer. The magnitude of these integers is determined by the size of the objects to be cleaned and other practical requirements. As long as these multipliers are odd and even integers, respectively, as specified above, their magnitude will not affect the proper synchronization of the partition.

The same rule applies to subdivided tanks having more than two compartments, such as illustrated in FIG. 3. Here the conditions required for a satisfactory propagation of the ultrasonic vibrations are that the back wall 6 and each of the partitions 7 must be so positioned with

respect to the radiating surface 3 that in the instant when the amplitude of the vibration at the radiating surface 3 reaches its maximum the amplitude of the vibration at the back wall 6 and at each of the partitions 7 must be near zero. These conditions can be obtained if the radiating surface 3, the back wall 6 and all the partitions 7 are parallel and they are so spaced that the distance between the radiating surface 3 and the adjacent partition 7 equals to the quarter wave length of the vibrations of the cleaning fluid within this first compartment, multiplied by an odd integer; and the distances between the adjacent partitions and between the last partition and the back wall 6 are equal to the quarter wave length of the vibrations within the respective compartments, multiplied by even integers.

In alternative forms, where the transducers are immersed in the cleaning fluid of the first compartment, the thus calculated distance of the first partition to be measured from the actual radiating surface of the transducers. It is also within the spirit of my invention to employ transducers, other than piezoelectric crystals, known in the art.

It is to be understood that the forms of my invention herein described and illustrated are only examples of the same, and that various modifications in the shape, size, and arrangement of parts may be resorted to, without departing from the spirit of my invention or the scope of the subjoined claims.

I claim:

1. An ultrasonic cleaning machine for the simultaneous performance of two stages of cleaning operation, comprising a transducer housing containing transducers producing ultrasonic vibrations when energized; a tank having two compartments each containing cleaning fluid, said tank having a front wall carrying said transducer housing and transducers and acting as a radiating surface transmitting the vibrations produced by said transducers to the cleaning fluid; disposed parallel to said front wall said tank has a back wall, and a partition interposed between said front wall and back wall and separating said two compartments, said partition and back wall are so located that the perpendicular distance between said partition and front wall equals the quarter wave length of the vibrations, produced in the cleaning fluid between said front wall and partition, multiplied by an odd integer; and the perpendicular distance between said partition and back wall equals the quarter wave length of the vibrations, produced in the cleaning fluid between said partition and back wall, multiplied by an even integer.

2. An ultrasonic cleaning machine for the simultaneous performance of a multiplicity of cleaning operations, comprising a transducer housing containing transducers producing ultrasonic vibrations when energized; a tank having a multiplicity of compartments each containing cleaning fluid, said tank having a front wall carrying said transducer housing and transducers and acting as a radiating surface transmitting the vibrations produced by said transducers to the cleaning fluid; disposed parallel to said front wall said tank has a back wall and a multiplicity of partitions interposed between said front wall and back wall and separating said compartments, said back wall and partitions are so located that the perpendicular distance between said front wall and the nearest partition is equal to the quarter wave length of the vibrations, produced by said transducers in the cleaning fluid within the compartment bounded by said front wall and nearest partition, multiplied by an odd integer; and the perpendicular distances between said back wall and the adjacent partition, also between adjacent partitions are equal to the quarter wave length of vibrations produced in the respective compartment, multiplied by an even integer, said even integer varying with each compartment.

3. An ultrasonic cleaning machine for the simultaneous performance of two cleaning operations, comprising transducers for the production of ultrasonic vibrations and having a radiating surface for the transmission of said vibrations to a cleaning fluid; a two-compartment tank carrying said transducers and containing cleaning fluid and having said radiating surface in contact with said cleaning fluid within said tank; disposed parallel to said radiating surface said tank having a back wall and a partition, interposed between said radiating surface and back wall, which are so spaced that, in the instant when said vibrations reach maximum amplitude at said radiating surface, the amplitudes of said vibrations at said back wall and at said partition are near zero.

4. An ultrasonic cleaning machine for the simultaneous performance of a multiplicity of cleaning operations, comprising transducers producing ultrasonic vibrations and having a radiating surface for the transmission of said vibrations to a cleaning fluid; a multi-compartment tank carrying said transducers and containing cleaning fluid and having said radiating surface in contact with said cleaning fluid within said tank; disposed parallel to said radiating surface said tank having a back wall and partitions interposed between said radiating surface and back wall, which are so spaced that, in the instant when said vibrations reach maximum amplitude at said radiating surface, the amplitudes of said vibrations at said back wall and at each of said partitions are near zero.

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