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3,466,017

ULTRASONIC WAVE GENERATOR

Filed Dec. 19, 1967

2 Sheets-Sheet 1

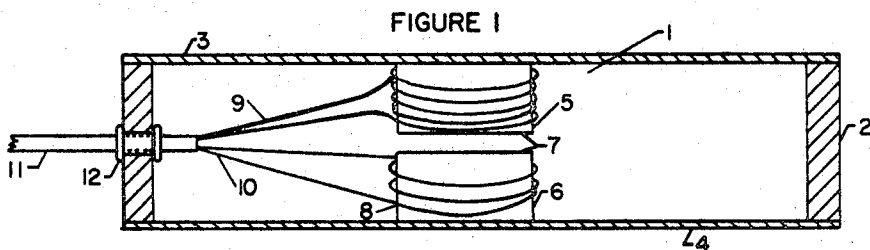
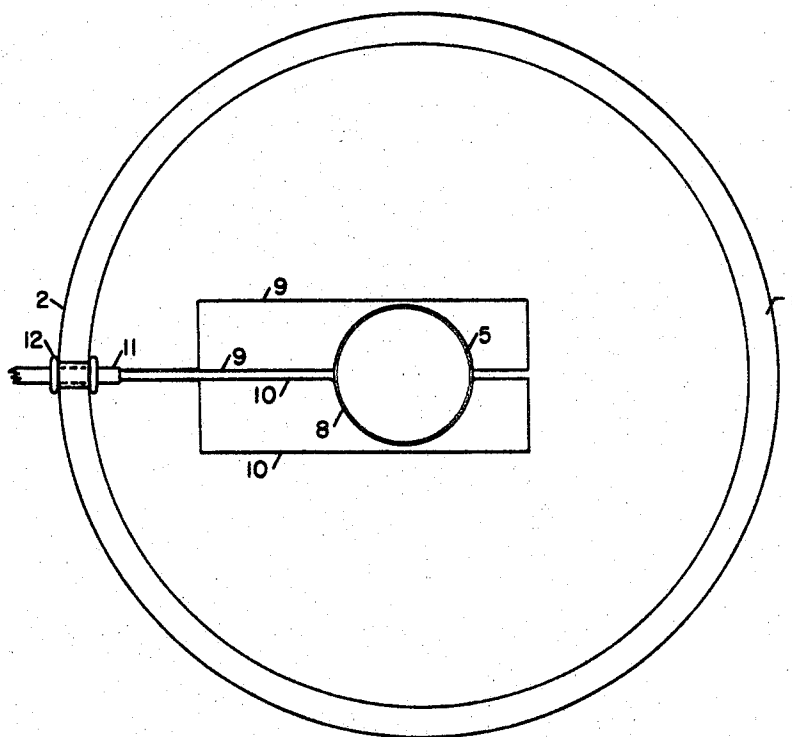


FIGURE 2



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FIGURE 3

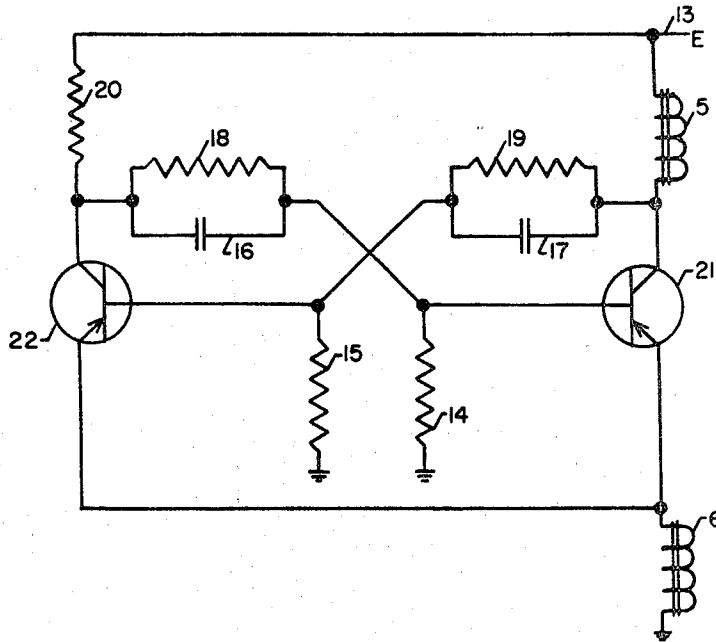
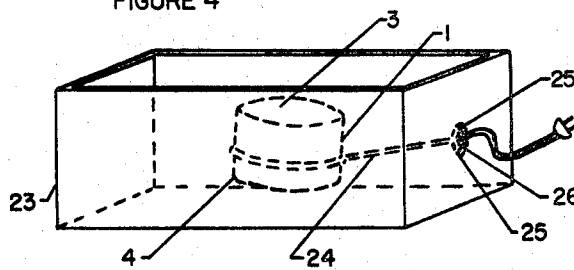


FIGURE 4



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ULTRASONIC WAVE GENERATOR

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8 Claims

ABSTRACT OF THE DISCLOSURE

The specification describes an ultrasonic wave generator comprising a housing with oppositely disposed flexible plates, a first continuously energized coil pole attached to one of the plates and a second coil pole attached to another of the plates oppositely disposed to the first pole and periodically energized by a multivibrator circuit so that when energized the coil poles are directed from one another due to magnetic repulsion and when deenergized the poles are directed toward one another due to magnetic attraction.

The present invention relates to an ultrasonic wave generator, an apparatus for transforming electrical energy to sound energy. The apparatus and system of the present invention have a variety of applications. Specifically the system is employed to produce high intensity ultrasonic waves which in a fluid medium create cavitation which has a multiple of uses. One application of the present invention is in the cleaning of a variety of objects which are immersed in a cleaning solution to which the ultrasonic wave is applied. The ultrasonic vibrations generated have the ability to disrupt certain molecular links of an electrical character such as surface cohesion, and to impart oscillations to very small particles, whereby the latter are subjected to accelerations which may attain several thousand times gravitational force. Thereby, the vibrations dislodge undesirable foreign particles from surfaces to which they stick and move them away from these surfaces even though the particles are of sub-molecular size.

In another application the transducer can be utilized to produce cavitation which aids in dispersing metals or other components in solutions. The present invention also is surprisingly useful in fluids besides liquids. For example, the system can be adapted to produce waves in gases such as in air where it can be used as a unique means for insect control.

The present invention is particularly characterized by its use of direct electromagnetic force rather than piezoelectric effect or magnetostrictive force for the production of the ultrasonic waves. The present invention is dependent strictly and uniquely on direct electromagnetically generated mechanical motion, thus eliminating many of the disadvantages of the prior art devices.

Numerous patents of the prior art described and claim ultrasonic wave generators and use of these generators as cleaning devices. Gander, 2,760,501, teaches a cleaning device comprising a generator, a transducer which is connected to the generator and which converts electrical to mechanical vibrations and a container for a liquid body. The generator is a piezoelectric quartz plate connected to a triode tube the filament of which is heated by an alternating current of 50 cycles per second by the transformer. Parts to be cleaned are placed in the liquid body. The generator produces an ultrasonic frequency and the transducer converts the electric vibrations into mechanical vibrations which are transmitted into the cleaning body.

Murdoch, 2,874,316, describes an ultrasonic transducer with a plurality of magnetostrictive strips secured together in a hollow cylindrical form of which one end is secured to a container to impart vibrations thereto. A

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coil means encircles the cylindrical form. A regulatable electrical circuit is connected to the coil means encircling the cylinder of strips to excite the strips to cause them to vibrate at a recited high frequency. This apparatus utilizes these high frequency magnetostrictive vibrations for producing cavitation.

Branson, 2,891,176, discloses a cleaning tank with a flexible diaphragm which is oscillated by means of transducers which comprise piezoelectric elements in both electrical and mechanical contact with the diaphragm. A plurality of transducers are utilized in phase opposition to one another to allow a burst of oscillatory energy while maintaining a balanced load on the generator. The patent also teaches that the transducers can be located in different walls of the tank.

Harris, 2,962,695, claims a tubular electromechanical transducer. The transducer element is magnetostrictive or piezoelectric. The vibration is provided by an axially compliant section intermediate the ends of the tubular member. Carlin, 3,117,768, teaches a piezoelectric transducer system comprising a composite stack of elements bonded together but with each element having its own electrode whereby the element can be individually activated. Scarpa, 3,140,859, claims a transducer comprising a piezoelectric material sandwiched between a pair of cylindrical metal members which have sound-transmitting characteristics substantially equal to those of the material wafer. Jacke et al., 3,179,381, teaches a sonic coupling between a transducer and the wall of a cleaning tank and is not concerned with the mechanism of generation of sonic vibrations. McCracken et al., 3,183,378, claims a transducer with piezoelectric or electrostrictive materials in association with metal blocks characterized by lower driving impedance. Branson, 3,318,578, discloses a sonic cleaning apparatus comprising a container with both magnetostrictive or electrostrictive elements and emitting circuits therein.

Generally the inventions of these patents utilize electrostrictive transducers or magnetostrictive transducers which rely on deformation applied indirectly by a magnetic force through a pulsating element. Again generally the circuitry utilized in these devices comprises inductively coupled oscillators. In contrast the apparatus of the present invention utilizes electromagnetic transduction which makes use of an applied mechanical force which is directly generated by alternating attraction and repulsion of the transducer coils. The circuitry of the present invention comprises a simple pair of coils in combination with a capacitor coupled oscillator, namely a multivibrator.

By the present invention an ultrasonic wave generator is provided which is improved in efficiency in use of electricity and substantially improved in cost of manufacture. The transducer of the present invention can operate under extremes of temperature which would destroy original characteristics of piezoelectric transducers, thereby reducing their efficiency. Furthermore, the apparatus of the present invention produces cavitation more efficiently than a magnetostrictive transducer.

The transducer of the present invention utilizes oppositely disposed moveable driving coils in contrast to magnetostrictive transducers which utilize a stationary driving coil with the magnetostriction of the coil core transmitted to the vibrating plates. The present invention utilizes magnetic force to directly cause the vibration necessary to produce cavitation. By the invention, oppositely disposed electromagnetic coils impart a pulsating mechanical movement to respectively attached plates thereby creating sonic or ultrasonic waves. One coil is energized to create a constant magnetic flow in one direction while the other coil is energized and deenergized at a predetermined rate to create an opposing magnetic

flux when energized and none when deenergized. This results in an alternating attraction and repulsion between the two coils. The mechanical movement of the coils is transmitted to respectively attached flexible plates which generate compression waves in surrounding medium.

The invention is shown in the accompanying drawings in which FIGURE 1 is a vertical sectional view through the ultrasonic wave generator. FIGURE 2 is a top cut-away view of the ultrasonic wave generator of the present invention. FIGURE 3 shows schematically a multivibrator circuit which can be used to energize the electromagnets. FIGURE 4 is a perspective view of the generator immersed in a cleaning tank.

In FIGURE 1, the body of the transducer illustrated by 1 is a cylinder with $\frac{1}{8}$ inch carbon steel sides 2 and a top plate 3 and a bottom plate 4 of flexible $\frac{1}{64}$ inch transformer steel spot welded to the cylinder sides. The whole outside cylindrical assembly is covered with a flexible inert material which in this case is a tetrafluoroethylene polymer. Oppositely disposed electromagnets 5 and 6 are attached respectively to top plate 3 and bottom plate 4. Both electromagnets are encapsulated coils with $\frac{3}{4}$ inch diameter soft carbon steel cores with insulated wire wrappings 8. The cores 7 of the electromagnets are set at rest with opposing faces about $\frac{1}{8}$ inch apart as shown. Electromagnet 5 has about twice as many wrappings (in this example, about 100) as electromagnet 6. Power is provided to the electromagnets by leads 9 and 10 which converge into a four conductor cable 11. The cable passes through the wall 2 of the cylinder via grommet 12 to a power source not shown.

FIGURE 2 is a top cut-away view of the ultrasonic wave generator and shows generally the cylinder 1 with carbon steel sides 2 and oppositely disposed electromagnets 5 and 6 connected to leads 9 and 10, and conductor cable 11 which passes through the cylinder wall 2 via grommet 12.

FIGURE 3 shows a multivibrator circuit which can be used to energize the apparatus of the present invention. In the figure, electromagnets 5 and 6 are represented schematically. Shown in the circuit are lead 13 to the power source; potentiometer 14; constant resistor 15; capacitors 16 and 17; and resistors 18, 19 and 20; and transistors 21 and 22. Potentiometer 14 in combination with resistor 18 and capacitor 16, and constant resistor 15 in combination with resistor 19 and capacitor 17 give a particular time constant for a particular frequency and particular desired oscillation. When the circuit is energized, transistors 21 and 22 conduct. Transistor 22 conducts faster than 21 and applies a negative charge to the base of 21 to prohibit 21 from conducting. The negative charge bleeds off resistor 14 to cause 21 to conduct and 22 to stop conducting. The alternating conduction of transistor 21 alternately energizes coil 5. The alternate energizing of coil 5 alternately causes repulsion and attraction of coil 5 with coil 6 which is constantly energized. In the apparatus shown with a power source of about 25 volts DC the frequency of the conduction of coil 5 can be varied between about 20 and 40 kilocycles.

The apparatus shown in the drawings, particularly FIGURES 1 and 2, can be described as an ultrasonic wave generator comprising: a housing with oppositely disposed flexible plates, a first continuously energized electromagnetic coil attached to one of the oppositely disposed flexible plates and a second electromagnetic coil attached to another of the oppositely disposed flexible plates and oppositely disposed to the first electromagnetic coil and periodically energized by a multivibrator circuit so that when energized, the coils are directed from one another due to magnetic repulsion to drive the oppositely disposed plates from one another and when deenergized the coil plates are directed toward one another due to magnetic attraction to drive the oppositely disposed plates toward one another, the alternating movement of the flex-

ible plates toward and away from one another generating compressional waves.

Although the ultrasonic wave generator of the present invention has a multiplicity of uses, the preferred use is as a cleaning device. This preferred embodiment is shown in FIGURE 4.

FIGURE 4 is a perspective view of the ultrasonic wave generator immersed in a cleaning tank. Referring to FIGURE 4 in particular, there is shown a tank 23 which is adapted to be filled with a cleaning fluid. A liquid tight submersible ultrasonic wave generator 1 with flexible, diaphragm-like top 3 and bottom 4 plates is shown supported by the ring of an L-shaped ring bracket 24. The bracket is supported by the side wall of the tank 23 by bolts 25. The cable 11 which provides electrical energy to the generator 1 is supported by the bracket 24 and passes through the wall of the tank 23 at 26 to the multivibrator circuit of FIGURE 3.

This novel cleaning arrangement comprises the sealed submersible enclosure which contains the electromagnetic coils necessary for vibrating the flexible plates 3 and 4 to cavitate the cleaning solution contained in the tank 23. The enclosure can also contain the multivibrator electrical circuit which accepts the electrical energy at power line voltage and frequency and converts this energy to the voltage and frequency necessary for driving the plates. Thus the electrical circuit can be contained with the electromagnetic driving coils within a single enclosure which is immersible in the cleaning solution whereby the plates cavitate the solution and the cleaning solution, by virtue of its contact with the enclosure, acts as a heat sink or cooling medium for the power dissipating electrical circuit elements of the power convention circuit.

What is claimed is:

1. An ultrasonic wave generator comprising:

- (a) a housing with oppositely disposed flexible plates,
- (b) a first continuously energized coil pole attached to one of said oppositely disposed flexible plates, and
- (c) a second coil pole attached to another of said oppositely disposed flexible plates oppositely disposed to said first coil pole and periodically energized by a multivibrator circuit so that when energized said coil poles are directed from one another due to magnetic repulsion to drive said oppositely disposed plates from one another and when deenergized said coil poles are directed toward one another due to magnetic attraction to drive said oppositely disposed plates toward one another, said alternate movement of flexible plates toward and away from one another generating compressional waves.

2. The ultrasonic wave generator of claim 1 in which said second coil is periodically energized by said multivibrator circuit at between 20 to 40 kilocycles.

3. The ultrasonic wave generator of claim 1 in which said housing is covered with a flexible inert material.

4. An ultrasonic washing device comprising a container for a liquid ultrasonic transmitting medium, means for suspending an ultrasonic device within said medium and an ultrasonic device suspended within said medium by said means and comprising a housing with oppositely disposed flexible plates, a first continuously energized electromagnetic coil attached to one of said oppositely disposed flexible plates and within said housing and a second electromagnetic coil attached to another of said oppositely disposed flexible plates and within said housing, said second coil oppositely disposed to said first coil and periodically energized by a multivibrator circuit so that when said second coil is energized, said coils are directed from one another due to magnetic repulsion to drive said oppositely disposed plates from one another and when said second coil is deenergized said coils are directed toward one another, said alternate movement of flexible plates toward and away from one another generating compressional waves.

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5. The washing device of claim 4 in which said second coil is periodically energized by said multivibrator circuit at between 20 to 40 kilocycles.

6. The washing device of claim 4 in which said housing is covered with a flexible inert material.

7. The washing device of claim 4 in which said housing comprises a cylinder with $\frac{1}{8}$ inch carbon steel sides and oppositely disposed plates of $\frac{1}{64}$ inch transformer steel spot welded to said cylinder sides.

8. The washing device of claim 7 in which said housing is covered with a tetrafluoroethylene polymer.

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References Cited

UNITED STATES PATENTS

1,589,962	6/1926	Hecht et al.	340—14 X
1,974,920	9/1934	Hecht	340—8
2,776,558	1/1957	Vang	68—3 X
3,318,578	5/1967	Branson	259—1
3,321,189	5/1967	Scarpa	259—1 X

WILLIAM I. PRICE, Primary Examiner

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259—1; 68—3; 340—8, 14