# United States Patent

Jacke

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## [54] SONIC DISPERSING APPARATUS


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[51] Int. Cl. ..... B01f 11/02, B06b 3/00

[58] Field of Search ..... 259/2, 1, 72, DIG. 44



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[57] ABSTRACT

A sonic dispersing apparatus comprises an elongated mechanical transmitting member resonating along its longitudinal axis. An annular sleeve is disposed around the vibrational loop region of said member to form with said member a narrow annular chamber through which liquid to be emulsified is passed.


**10 Claims, 3 Drawing Figures**

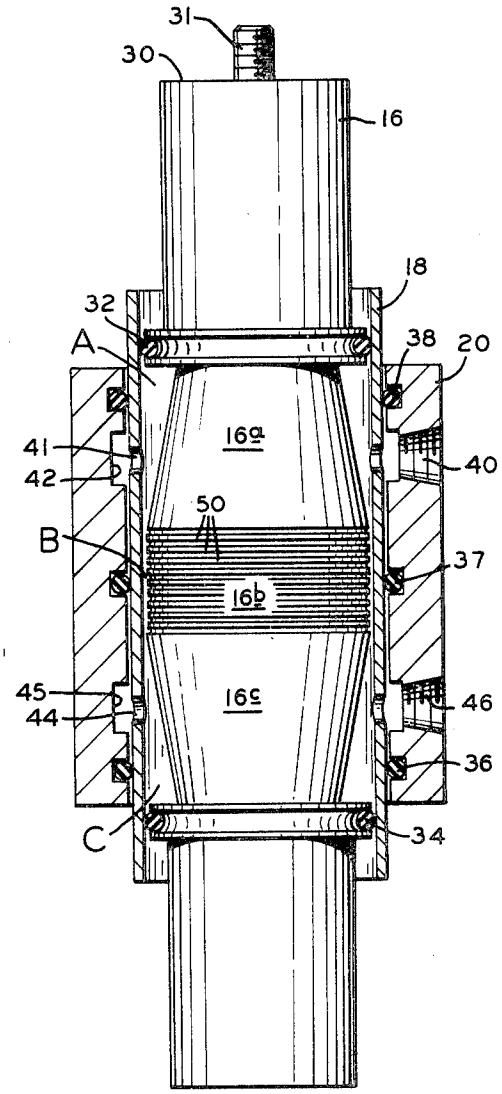


FIG. 1

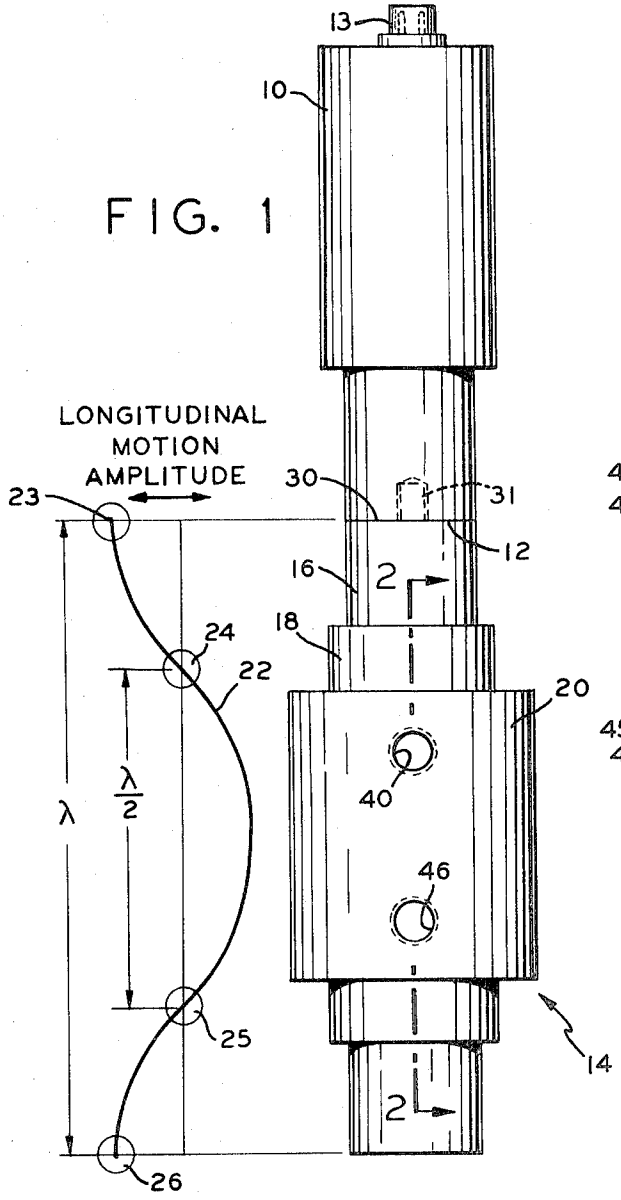



FIG. 2

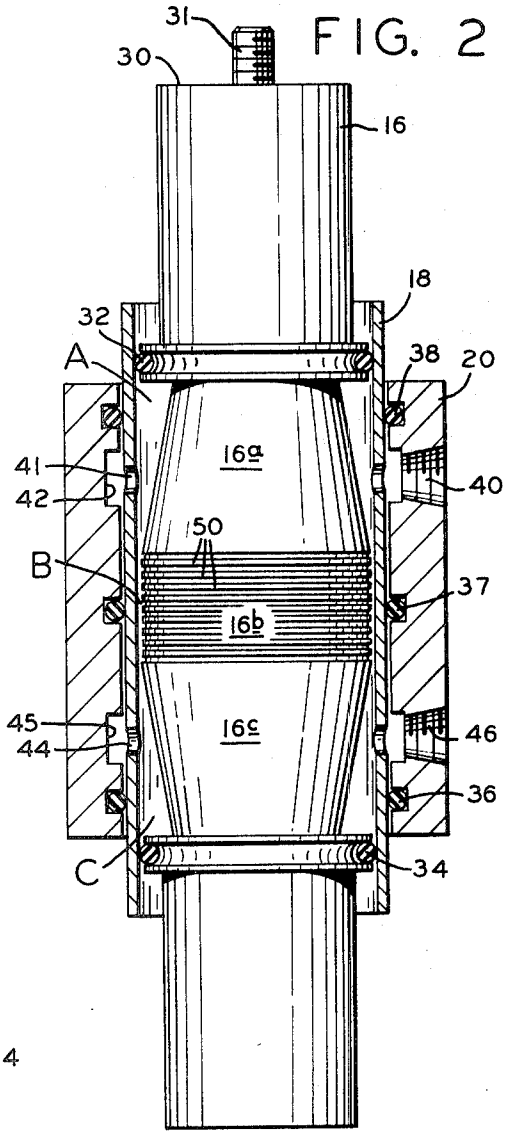
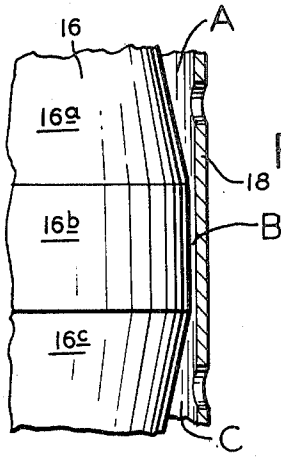



FIG. 3




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# SONIC DISPERSING APPARATUS

This invention is related to sonic dispersing apparatus and has particular reference to a dispersing apparatus operating in the sonic or ultrasonic frequency range and subjecting the liquid to be emulsified to predominantly shear forces.

Prior patents show various types of dispersing or emulsifying arrangement using acoustic energy in the sonic or ultrasonic frequency range. Typical of such an arrangement is the device entitled "Sonic Dispersing Device", U.S. Pat. No. 3,394,274, dated July 23, 1968. This patent shows a dispersing device wherein an ultrasonic energy converter provides vibrations to an elongated horn, which is dimensioned in such a way that its front end vibrates at maximum amplitude in the longitudinal direction. A tubular chamber surrounds the frontal end of the horn, and liquid to be emulsified is admitted to this chamber and passed across the front radial surface of the horn. The liquid receives compressional wave energy, causing emulsification.

While the above-described arrangement provides satisfactory results, it has been discovered that in many instances a more favorable result can be obtained if the liquid is subjected to shear forces. In order to accomplish this, the apparatus described above has been redesigned and rearranged in such a manner as to provide a relatively simple and inexpensive dispersing device imparting predominantly shear forces to the liquid to be treated.

In its simplest arrangement, the vibration transmitting member or horn oscillating along its longitudinal axis as a half wavelength resonator, is fitted with a sleeve which surrounds the loop region of the transmitting member and forms with the transmitting member an annular chamber. Liquid to be treated for the purpose of emulsification is admitted to the chamber and withdrawn therefrom, thereby subjecting the liquid while flowing along the outside of the longitudinally vibrating horn predominantly to shear forces.

One of the principal objects of this invention is, therefore, the provision of a new and improved sonic dispersing apparatus.

Another important object of this invention is the provision of a dispersing apparatus using an elongated vibration transmitting member which vibrates at an ultrasonic frequency.

Another important object of this invention is the provision of an ultrasonic energy dispersing apparatus using an elongated vibration-transmitting member adapted to oscillate along its longitudinal axis, and an annular sleeve surrounding the loop region of the transmitting member for forming a chamber through which liquid to be emulsified is passed, the liquid being subjected predominantly to shear forces.

Further and still other objects of this invention will become more clearly apparent by reference to the following description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an elevational view of the dispersing apparatus;

FIG. 2 is a sectional view along lines 2—2 of FIG. 1, showing the dispersing device, and

FIG. 3 is an alternative construction of certain portions in FIG. 2.

Referring now to the figures and FIG. 1 in particular, numeral 10 identifies an electroacoustic converter which includes piezoelectric or magnetostrictive transducer means for receiving electrical energy and providing vibrational energy at an output surface 12. The converter 10 receives electrical energy from a high-frequency generator (not shown) at an electrical input connector 13. The converter 10 is shown in greater detail in U.S. Pat. No. 3,394,274 supra and, typically, is designed to provide vibrations having a frequency of 20 kHz. It shall be understood, however, that other frequencies in the sonic or ultrasonic range may be used without deviating from the principle described. The converter means 10 is coupled to a dispersing device 14 which comprises principally an elongated vibration transmitting member 16, typically a longitudinal bar of titanium metal. The vibration transmitting member 16 is dimensioned so that it oscillates along its longitudinal axis as a half-wavelength resonator at the frequency



provided by the converter means 10 and, as shown, the overall length of the member 16 corresponds substantially to one wavelength of sound travelling longitudinally through the material. The length of the vibration transmitting member 16, also known as "solid horn", can be calculated as is described in considerable detail in "Ultrasonic Engineering" (book) by Julian R. Frederick, published by John Wiley & Sons, Inc., New York, New York (1965), pages 87 to 103. The vibration transmitting member 16 is fitted, moreover, with an annular sleeve 18 and a collar 20.

The curve 22 shows the instantaneous longitudinal motion amplitude along the length of the vibration transmitting member 16 and illustrates that the member 16, when dimensioned to correspond to one wavelength of sound travelling longitudinally through the material, receives its vibrational energy at a region of maximum longitudinal vibration 23, frequently called loop or antinodal region. The element exhibits, moreover, two regions of minimum longitudinal motion called nodal regions 24, 25 and terminates in an end zone 26 which once again is a region of maximum longitudinal displacement or loop region. The region disposed medially with respect to the nodal regions 24 and 25 is a loop region, exhibiting maximum motion in the longitudinal direction of the member 16.

Referring now to the detailed construction of the dispersing device depicted in FIG. 2, the upper radial end surface 30 is adapted to be coupled by means of a threaded stud 31 to the output end of the converter means 10 for receiving therefrom longitudinal vibrations, causing the member 16 to resonate at the designed frequency. A pair of annular O-ring gaskets 32 and 34 are disposed in respective annular grooves of the member 16. These grooves are so located along the length of the member 16 that the grooves coincide substantially with the nodal regions of longitudinal motion 24, 25 shown in connection with the curve 22. In these regions there is substantially no longitudinal vibratory motion of the member 16. The annular metallic sleeve 18 is fitted over the O-ring gaskets 32, 34 which serve also as sealing means for liquid. The annular collar 20 is disposed about the sleeve 18 and held and sealed to the sleeve 18 by means of three longitudinally spaced O-ring gaskets 36, 37, and 38. The center portion of the member 16, that is, the portion lying between the nodal regions 24 and 25, FIG. 1, has an upper tapered portion 16*a*, a central straight portion 16*b*, and a lower tapered portion 16*c*. The tapered portion 16*a* together with the inside surface of the sleeve 18 forms a first chamber A into which liquid to be treated is admitted by means of an inlet port 40 disposed in the collar 20 and a plurality of radial holes 41 which are in alignment with an annular groove 42 of the collar 20. The gaskets 37 and 38 provide a seal for liquid between the collar 20 and sleeve 18. Liquid transmitted to this upper chamber A is distributed about the circumference of the member portion 16*a*.

The portion 16*b* of the sound-transmitting member 16 is disposed substantially in the region of maximum longitudinal motion known as loop region and in this region the longitudinal motion of the member 16 is a maximum. Thus, the portion 16*b* will oscillate at substantially maximum amplitude relative to the substantially stationary sleeve 18, the latter being supported from respective nodal zones. The portion 16*b* of the member 16 is enlarged to provide with the inside surface of the sleeve 18 a rather narrow treatment chamber B through which liquid to be emulsified is passed. Due to the longitudinal oscillation of the member 16 in this area, the liquid flowing through the chamber B is exposed predominantly to shear forces. The clearance between the outside diameter of the member portion 16*b* and the inside surface of the sleeve 18 may vary from a fraction of a thousandth of an inch to several thousandths of an inch, depending primarily on the substances to be emulsified, and thus is adjusted to cause the liquid to flow in the form of a film. The portion 16*c* is essentially a duplicate of the portion 16*a*, forming with the sleeve 18 an annular chamber C for receiving the emulsified liquid which then is withdrawn therefrom via the radial holes

44, a groove 45, and a fluid discharge port 46. The gaskets 36 and 37 provide a seal between the sleeve and collar. In order to increase the turbulence as the liquid flows through the chamber B and to provide areas of high shear intensity, the inside surface of the sleeve 18 or the outside surface of the member 16 may be provided with protrusions, such as the annular ridges 50 encircling the member portion 16*b*.

FIG. 3 shows an alternative construction wherein the member portion 16*b* omits such protrusions.

In summary, the operation of the dispersing device may be visualized as follows: The converter means 10 provides vibratory energy in the sonic to ultrasonic frequency range to the elongated transmitting member 16 which is dimensioned to oscillate as a half wavelength longitudinal resonator at the frequency supplied by the converter 10, typically 20 kHz. The member 16 has a length substantially equal to one full wavelength of sound travelling longitudinally through the member, thus providing two nodal regions 24 and 25, and a region of maximum longitudinal motion, or loop region, disposed medially between the nodal regions. A sleeve 18 is fitted over the member 16 at its loop region and by means of gaskets 32 and 34 provides with the member 16 an annular treatment chamber for liquid to be emulsified. Liquid to be emulsified is admitted to the treatment chamber through the port 40 outside the area of maximum longitudinal motion, distributed about the member 16, then brought into the area of maximum longitudinal motion where, by virtue of the longitudinal motion of the member 16 and the substantially absence of motion of the sleeve 18, the liquid is exposed predominantly to shear forces. Subsequently, the treated liquid collects in the chamber C and is withdrawn therefrom via the port 46. Obviously, the direction of flow may be reversed.

It has been found that the dispersing apparatus described above is extremely effective in producing, for instance, an emulsion of oil and water and many similar emulsions or dispersions.

What is claimed is:

1. A sonic dispersing apparatus comprising:
- an elongated vibration transmitting member dimensioned to oscillate when excited with vibrations of predetermined frequency along its longitudinal axis as a half wavelength resonator and exhibiting a pair of nodal regions and a medially disposed loop region of longitudinal motion;
- a sleeve surrounding said loop region and providing with said vibration transmitting member an annular chamber for treating a liquid to be emulsified;
- means for causing liquid to be treated to be admitted to said chamber and withdrawn therefrom, and
- said chamber in said loop region being of restricted cross-sectional area to cause said liquid to form a film subjected to shear forces.

2. A sonic dispersing apparatus as set forth in claim 1, said member being dimensioned for oscillation in the ultrasonic frequency range.

3. A sonic dispersing apparatus as set forth in claim 1 and including a set of axially spaced liquid inlet and outlet ports for admitting liquid to said chamber and withdrawing it therefrom.

4. A sonic dispersing apparatus as set forth in claim 3, said chamber comprising a first annular space disposed for receiving said liquid and distributing it radially around the periphery of said member, a second narrower annular space for guiding the liquid through said loop region, and a third annular space for receiving and collecting the treated liquid from said second space.

5. A sonic dispersing apparatus as set forth in claim 4, one of said surfaces forming said second space being provided with protrusions to increase the turbulence of the liquid.

6. A sonic dispersing apparatus as set forth in claim 5, said protrusions being disposed radially about the circumference of said vibration transmitting member.

7. A sonic dispersing apparatus as set forth in claim 1, and electroacoustic transducer means adapted to be coupled to said elongated vibration-transmitting member at one end thereof.

8. A sonic dispersing apparatus comprising:
- an elongated vibration transmitting member adapted to oscillate along its longitudinal axis as a half-wavelength resonator at an ultrasonic frequency; said member having a length substantially corresponding to one wavelength of sound travelling longitudinally through the material forming said member and thereby providing a centrally located loop region of longitudinal motion, two nodal regions of longitudinal motion straddling said loop region and opposite ends of said member being disposed substantially at respective loop regions of longitudinal motion;
- electroacoustic converter means coupled to one of said ends for causing said member to resonate;
- a sleeve closely surrounding said centrally disposed loop region and providing with the exterior surface of said member an annular chamber for treating a liquid film to be emulsified;
- resilient means in engagement with said member at said respective nodal regions and said sleeve for supporting said sleeve around said member and forming a liquid tight seal therewith, and
- means for causing liquid to be treated to flow through said chamber whereby to cause said liquid film to be exposed to the effects of ultrasonic shear forces.

9. A sonic dispersing apparatus comprising:
- an elongated vibration transmitting member adapted to oscillate along its longitudinal axis as a half-wavelength resonator at an ultrasonic frequency; said member having a length substantially corresponding to one wavelength of sound travelling longitudinally through the material forming said member and thereby providing a centrally located loop region of longitudinal motion, two nodal regions of longitudinal motion straddling said loop region, and opposite ends of said member being disposed substantially at respective loop regions of longitudinal motion;
- electroacoustic converter means coupled to one of said ends for causing said member to resonate;
- a cylindrical sleeve surrounding said centrally disposed loop region and providing with the exterior surface of said member an annular chamber for treating a liquid to be emulsified;
- resilient means in engagement with said member at said respective nodal regions and said sleeve for supporting said sleeve around said member and forming a liquid tight seal therewith;
- a collar having axially spaced liquid inlet and outlet port means disposed about said sleeve;
- further resilient means in engagement with said collar and said sleeve for supporting said collar about said sleeve and providing liquidtight seals;
- aperture means for causing liquid to be treated to flow from said inlet port means through said sleeve to said chamber for causing said liquid to be exposed to the effects of ultrasonic shear forces, and causing the exposed liquid to be withdrawn from said chamber through said sleeve and outlet port means, and
- said chamber in the loop region being of restricted cross-sectional area to cause the liquid therein to be in film form.

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