

[54] APPARATUS FOR PRODUCING ACOUSTIC VIBRATIONS IN LIQUIDS

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3,169,013	2/1965	Jones	259/4 R
3,176,964	4/1965	Cottell	259/1 R
3,356,345	12/1967	Goodman	259/4 R

Primary Examiner—Harvey C. Hornsby

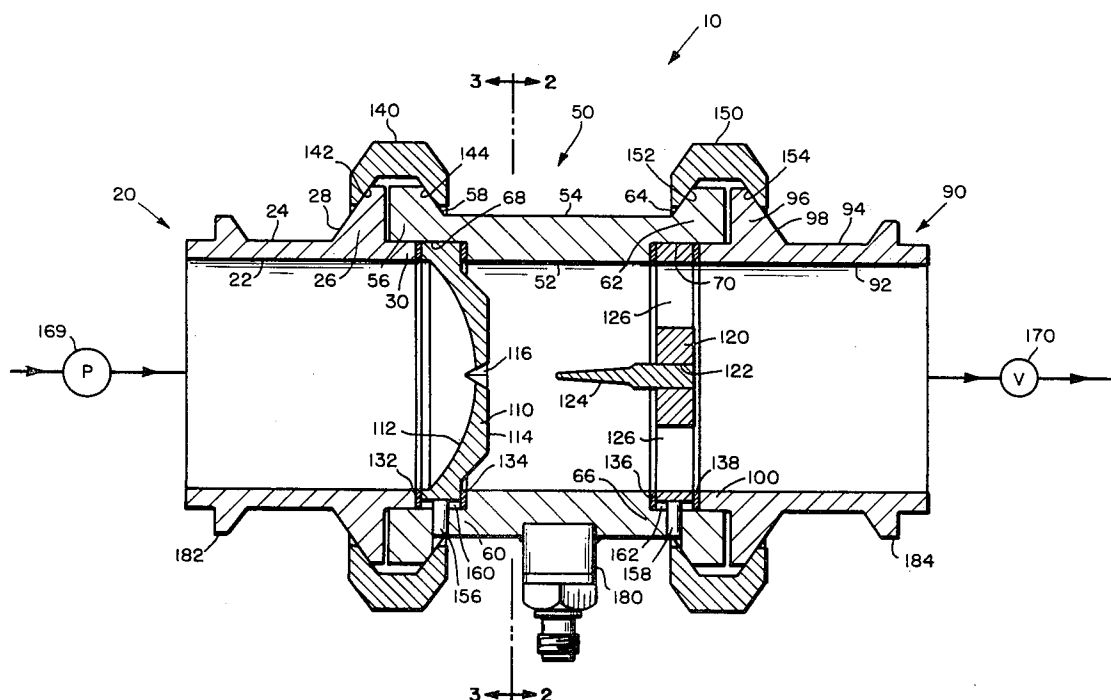
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[57] **ABSTRACT**

An apparatus for producing acoustic vibrations in a flowing liquid comprises a body section, an inlet section, and an outlet section. Each of the sections has a substantially cylindrical inner surface and an outer surface. A first flange extends radially outwardly from an inlet end of the body section and a second flange extends radially outwardly from an outlet end of the body section. A first counterbore is located at the inlet end of the body section and a second counterbore is located at the outlet end of the body section. The inlet

section is located adjacent to the inlet end of the body section and has an axially extending cylindrical flange extending into the first counterbore. The outlet section is located adjacent to the outlet end of the body section and has an axially extending flange extending into the second counterbore. An orifice plate is mounted in the first counterbore and has one face that is substantially spherical and another face that is substantially flat. The orifice plate has an eye-shaped orifice at its approximate midpoint. A blade plate is mounted in the second counterbore. The blade plate has a blade-like vibratory element aligned with the orifice. An annular sealing ring is located on each side of the orifice plate in the first counterbore. Annular sealing rings are also located on each side of the blade plate in the second counterbore. Each of the annular sealing rings has a substantially cylindrical inner surface. A flange extends radially outwardly from the inlet section adjacent to the body section. Another flange extends radially outwardly from the outlet section adjacent to the body section. A first clamping means surrounds the radially extending flanges of the inlet section and the inlet end of the body section to mount the inlet section to the body section. A second clamping means surrounds the radially extending flanges of the outlet section and the outlet end of the body section to mount the outlet section to the body section. Pins are provided to prevent rotation of the orifice plate in the first counterbore and the blade plate in the second counterbore. The inner surfaces of the inlet section, the body section, the outlet section, and the annular sealing rings being substantially equal in diameter and free of any crevices to minimize the possibility of bacteria buildup as liquid flows through the apparatus.

7 Claims, 4 Drawing Figures

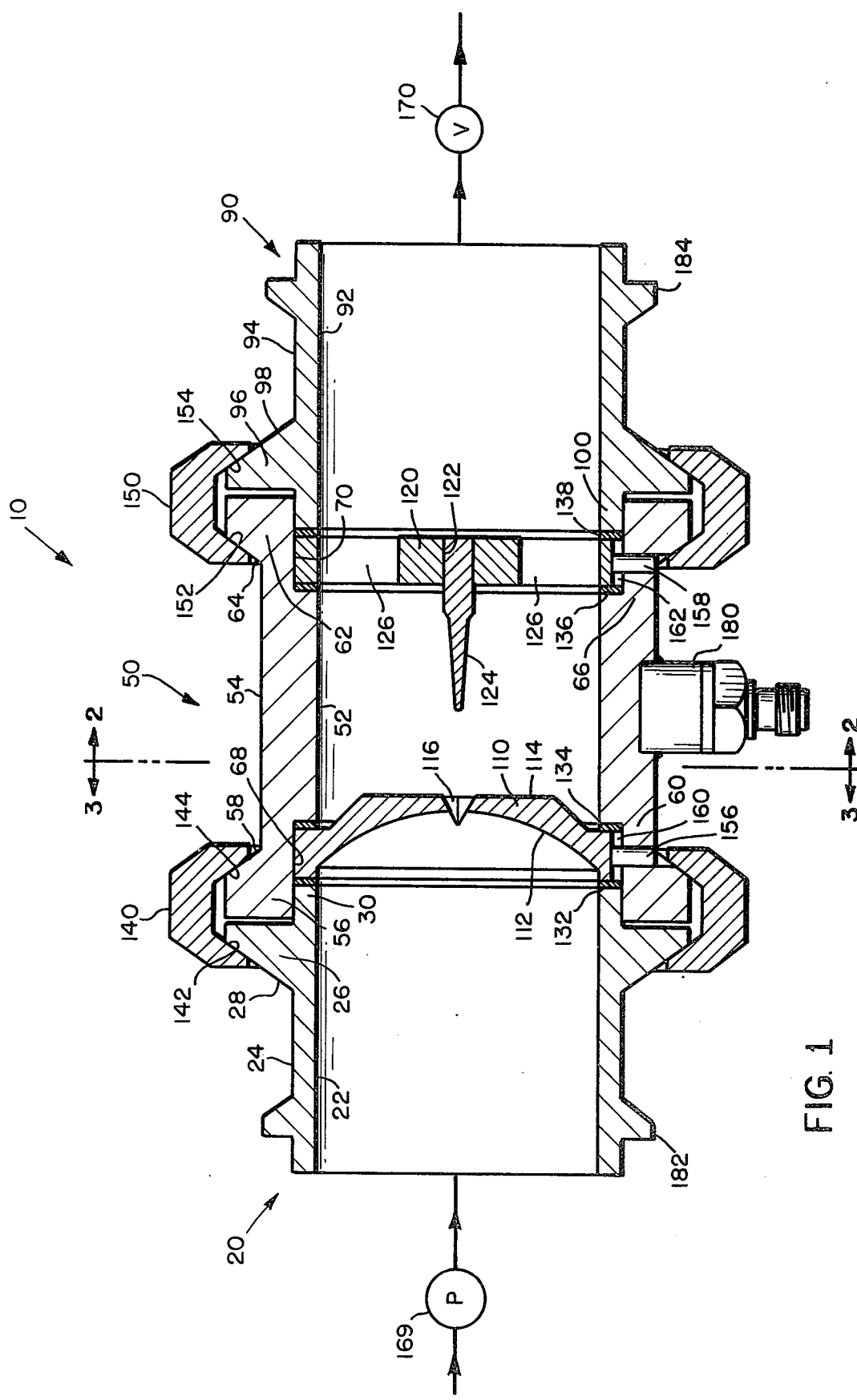
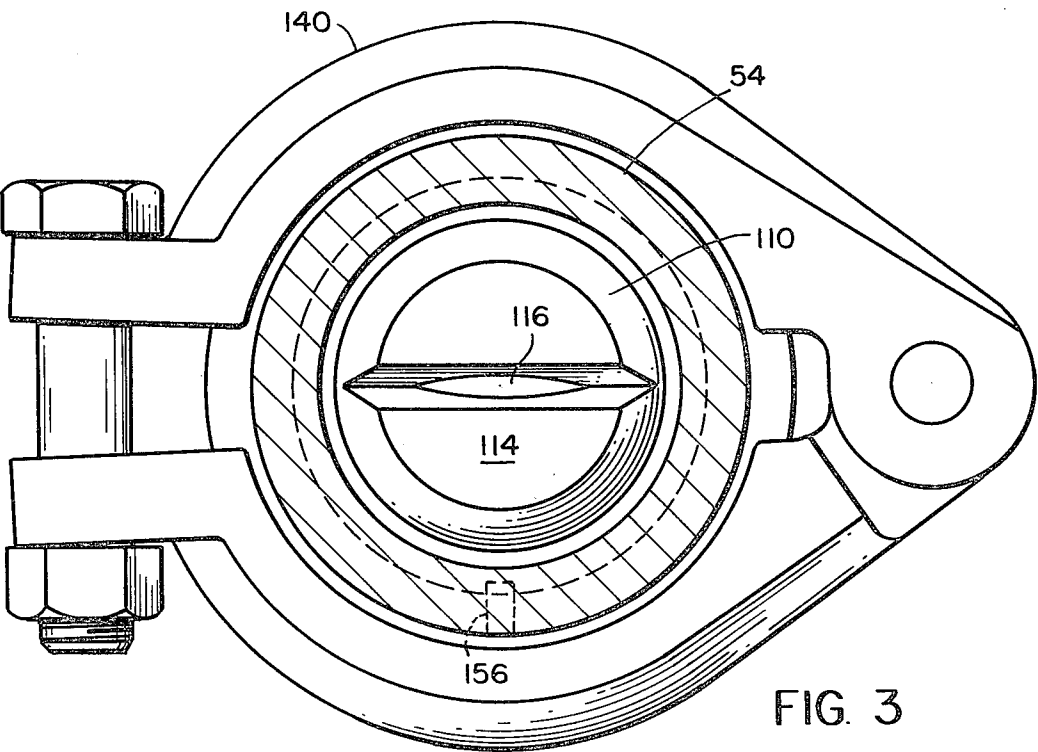
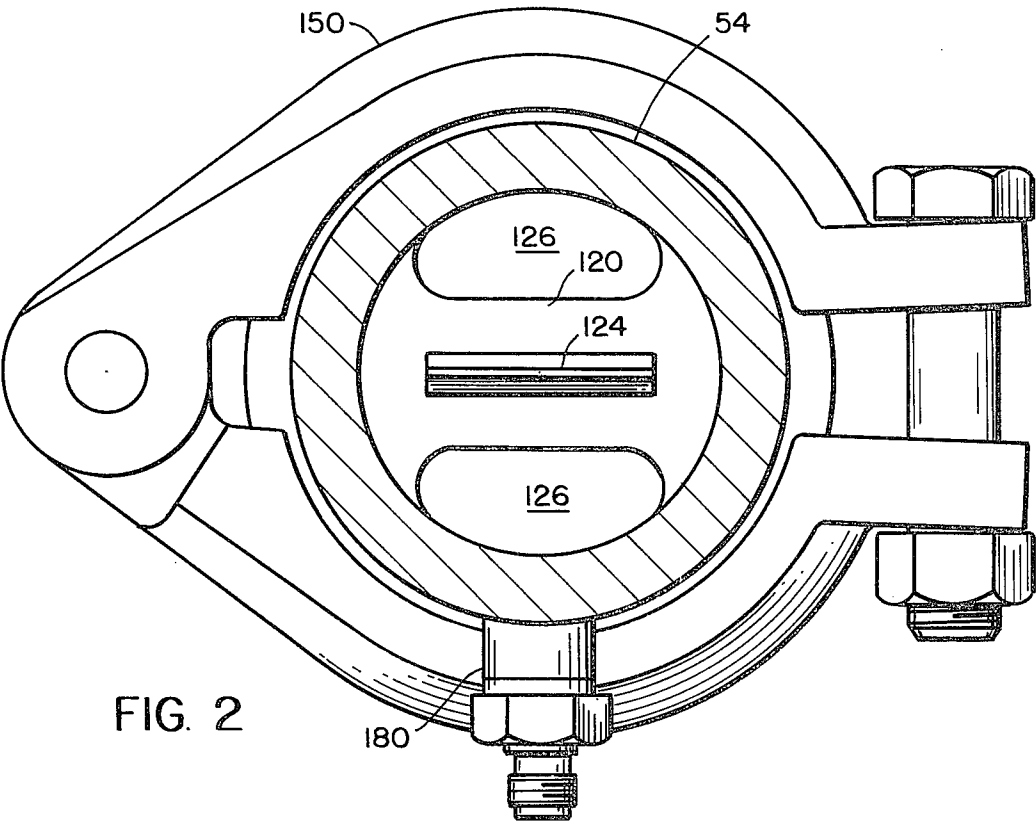


FIG. 1



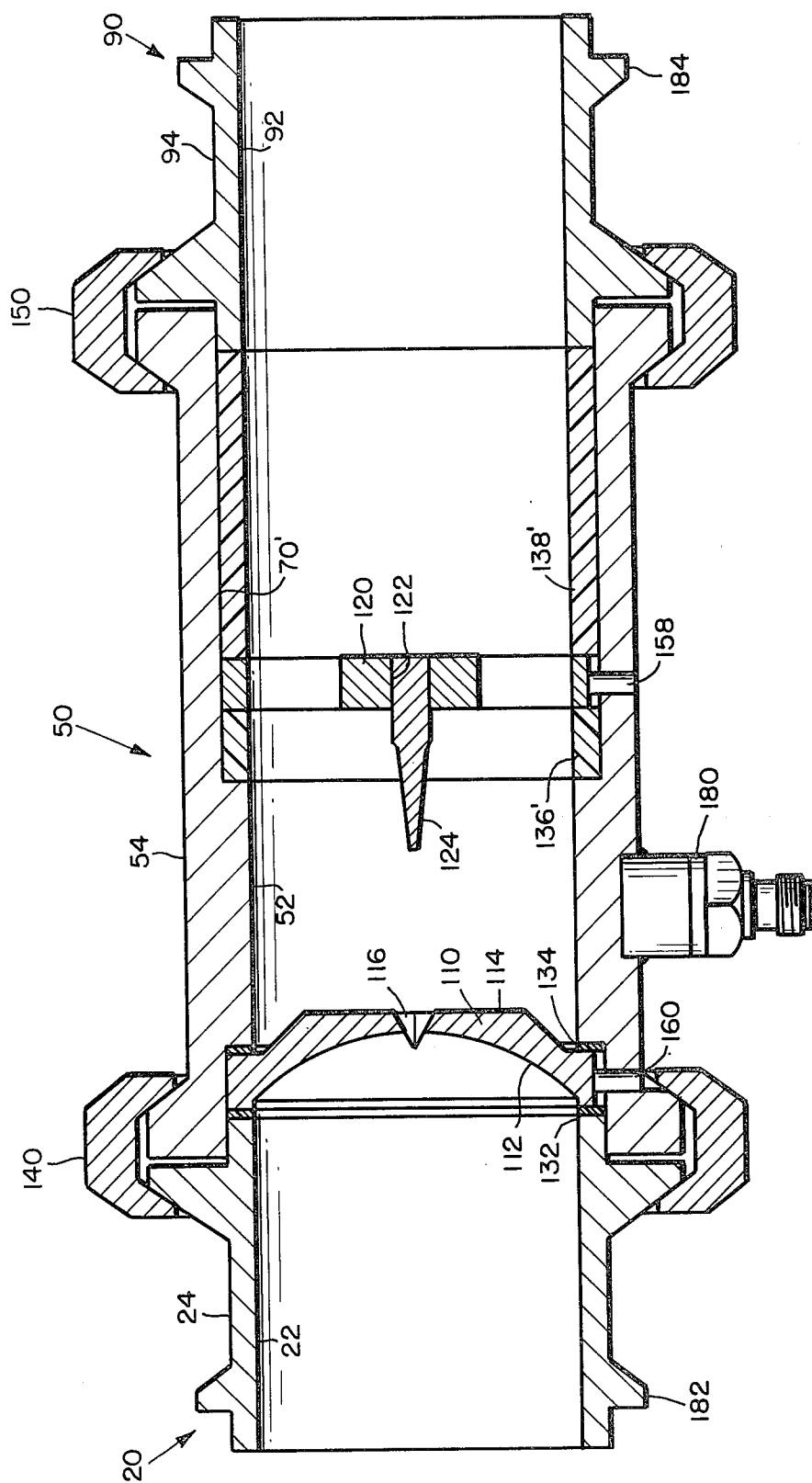


FIG. 4

APPARATUS FOR PRODUCING ACOUSTIC VIBRATIONS IN LIQUIDS

BACKGROUND OF THE INVENTION

1. Field of Use

While the invention is subject to a wide range of applications, it is especially suited for use in environments where sanitary requirements do not permit contamination and will be particularly described in that connection.

2. Description of the Prior Art

For many years, apparatuses have been commercially available for homogenizing and emulsifying liquids by producing acoustic vibrations in the flowing liquid. An example of such an apparatus is a SONOLATOR homogenizer, sold by the Sonic Corp., a unit of General Signal. The SONOLATOR homogenizer is a highly refined, in line device capable of converting the kinetic energy of a high velocity stream of liquid into a high intensity mixing action. To do this, a liquid is pumped through an orifice against a bladelike obstacle immediately in the jet stream of the liquid. The liquid itself oscillates in a stable vortexing pattern, which in turn causes the blade-like obstacle to resonate, resulting in a high level of cavitation, turbulence, and shear.

U.S. Pat. No. 3,176,964 to Cottell et al. describes the SONOLATOR homogenizer in detail and its disclosure is hereby incorporated herein by reference. The apparatus disclosed produces a high intensity mixing action that produces particle sizes in a micron and sub-micron range which previously could only be accomplished by using high pressure piston homogenizers or high shear mixers. In addition, the liquid is usually mixed without any temperature rise and at low operating pressures. Further, product uniformity has been obtained by adjusting the mixing intensity.

While the SONOLATOR homogenizer has met with commercial success, it has now been discovered that it would be suitable for food processing areas if it conformed to customary sanitary requirements and could be cleaned in place.

It is an object of the present invention to provide an apparatus for producing acoustic vibrations in a flowing liquid that meets sanitary requirements which prohibit contamination.

It is a further object of the present invention to provide an apparatus for producing acoustic vibrations in a flowing liquid that can be cleaned in place in a matter of a few minutes.

It is a further object of the present invention to provide an apparatus for producing acoustic vibrations in a flowing liquid that utilizes fittings that are customary in the food processing industry.

It is a further object of the present invention to provide an apparatus for producing acoustic vibrations in a flowing liquid that needs no lubricant.

SUMMARY OF THE INVENTION

In a first embodiment of the present invention, there is disclosed an apparatus for producing acoustic vibrations in a flowing liquid comprising a body section, and inlet section, and an outlet section. Each of the sections has a substantially cylindrical inner surface and an outer surface. A first flange extends radially outwardly from an inlet end of the body section and a second flange extends radially outwardly from an outlet end of the body section. A first counterbore is located at the

inlet end of the body section and a second counterbore is located at the outlet end of the body section. The inlet section is located adjacent to the inlet end of the body section and has an axially extending cylindrical flange extending into the first counterbore. The outlet section is located adjacent to the outlet end of the body section and has an axially extending flange extending into the second counterbore. An orifice plate is mounted in the first counterbore and has one face that is substantially spherical and another face that is substantially flat. The orifice plate has an eye-shaped orifice at its approximate midpoint. A blade plate is mounted in the second counterbore. The blade plate has a blade-like vibratory element aligned with the orifice. An annular sealing ring is located on each side of the orifice plate in the first counterbore. Annular sealing rings are also located on each side of the blade plate in the second counterbore. Each of the annular sealing rings has a substantially cylindrical inner surface. A flange extends radially outwardly from the inlet section adjacent to the body section. Another flange extends radially outwardly from the outlet section adjacent to the body section. A first clamping means surrounds the radially extending flanges of the inlet section and the inlet end of the body section to mount the inlet section to the body section. A second clamping means surrounds the radially extending flanges of the outlet section and the outlet end of the body section to mount the outlet section to the body section. Pins are provided to prevent rotation of the orifice plate in the first counterbore and the blade plate in the second counterbore. The inner surfaces of the inlet section, the body section, the outlet section, and the annular sealing rings being substantially equal in diameter and free of any crevices to minimize the possibility of bacteria buildup as liquid flows through the apparatus.

In an additional embodiment of the present invention, means are provided for adjusting the distance between the orifice and the blade-like element so that the apparatus may be used to homogenize or emulsify many liquids.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a first embodiment of an apparatus made in accordance with the present invention;

FIG. 2 is a cross-sectional view taken along lines 2 — 2 of FIG. 1;

FIG. 3 is a cross-sectional view taken along lines 3 — 3 of FIG. 1; and

FIG. 4 is a cross-sectional view of a second embodiment made in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the first embodiment of the present invention, illustrated in FIGS. 1 to 3, an apparatus 10 homogenizes or emulsifies a liquid by producing acoustic vibrations in the flowing liquid. Apparatus 10 includes an inlet section 20, a body section 50, and an outlet section 90. Sections 20, 50, and 90 have substantially cylindrical inner surfaces 22, 52, and 92, respectively, and outer surfaces 24, 54, and 94, respectively.

A first flange 56 extends radially outwardly from outer surface 54 at the inlet end 60 of the body section 50. A second flange 62 extends radially outwardly from outer surface 54 at outlet end 66 of body section 50. A first counterbore 68 is located at the inlet end 60 and a second counterbore 70 is located at the outlet end 66.

The inlet section 20 is adjacent to the inlet end 60 of body section 50. Flange 26 extends radially outwardly from the outer surface 24 of inlet section 20 adjacent to the inlet end 60 of body section 50. Flange 26 has a wedge-shaped surface 28. Axially extending cylindrical flange 30 extends into the first counterbore 68 of body section 50 to form an annular recess.

Outlet section 90 is adjacent to the outlet end 66 of the body section 50. Flange 96 has a wedge-shaped surface 98 and extends radially outwardly from the outer surface 94 adjacent to the outlet end 66. Axially extending cylindrical flange 100 extends into the second counterbore 70 of body section 50 to form another annular recess.

An orifice plate 110 is mounted in the first counterbore 68. One face 112 is substantially spherical and the other face 114 is substantially flat. A eye-shaped orifice 116 is located at the approximate midpoint of face 110. Face 112 need not be spherical, but is preferably so, since this makes it easier to machine the eye-shaped orifice. One can plainly see that by milling a groove through an object having a back face that is spherical, an eye-shaped orifice will result.

A blade plate 120 is mounted in the second counterbore 70. Blade plate 120 has a central opening 122 aligned with orifice 116. As shown, a blade-like element 124 is welded in opening 122. However, it should be understood that other mounting means for the blade-like element 124 are contemplated. For example, element 124 may be securely held in central opening 122 by set screws. Openings 126 provide a means for the fluid to leave the apparatus after it has been homogenized.

An annular sealing ring 132 is provided between cylindrical flange 30 and the orifice plate 110. Annular sealing ring 134 is provided between orifice plate 110 and the bottom wall of the first counterbore 68. Similarly, annular sealing rings 136 and 138 are provided in the second counterbore on either side of blade plate 120. These sealing rings may be made of any suitable corrosion resistant material, but polytetrafluoroethylene has proven to be desirable. Each of the annular sealing rings 132, 134, 136, and 138 has a substantially cylindrical inner surface. Axially extending flange 30 clamps the orifice plate in position between sealing rings 132 and 134, while axially extending cylindrical flange 100 clamps the blade plate 120 in position between sealing rings 136 and 138.

A clamp 140 surrounds radially extending flanges 26 and 56. Wedge-shaped surfaces 142 and 144 bear against wedged surfaces 28 and 58 to mount inlet section 20 to body section 50. Any suitable clamp may be used, but Model No. 131, manufactured by the Cherry-Burrell Company, is satisfactory. Similarly, clamp 150 surrounds radially extending flanges 62 and 96. Wedge-shaped surfaces 152 and 154 bear against wedge-shaped surfaces 64 and 98, respectively, to mount the outlet section 90 to the body section 50.

It is important, in practicing the present invention, that the eye-shaped orifice 116 be maintained in rotational alignment with the blade-like element 124. It can be seen that if either the orifice 116 or the blade-like

element 124 were rotated even a few degrees, efficiency of the apparatus would be sacrificed. For this reason, pins 156 and 158 extend into slots 160 and 162, respectively, to prevent rotation of the orifice plate 110 and the blade plate 120.

It should be understood that all surfaces of the apparatus that are exposed to the flowing liquid should be smooth and free of any crevices to minimize the possibility of bacteria buildup as the liquid flows through the apparatus. In addition, it is desirable to have the inner surfaces of the apparatus of substantially the same diameter.

A valve 170, illustrated diagrammatically in FIG. 1, is installed downstream of blade-like element 124 to control the back pressure. A typical valve is disclosed in U.S. Pat. No. 3,176,964 to Cottell et al. However, it should be understood that while variations of downstream back pressure are most easily affected by throttling devices, it is also possible to vary back pressure by raising the level of the final downstream discharge. For example, if this results in a certain amount of static head, gentler throttling devices may be used or throttling valves which are more precise. Other means of varying downstream pressure, such as fixed orifices or flexible conduits with clamps may be used.

If maximum precision is desired, it is advantageous to have knowledge of acoustic pressure at the point of maximum agitation near the blade-like element 24. This is affected, for example, by mounting a piezoelectric transducer 180, which may be made of barium titanate and which produces an electrical output that may be amplified by an amplifier (not shown). To eliminate contamination of the fluid, the transducer 180 does not extend entirely through the wall of the body section 50. It has been discovered that by mounting transducer 180 in a housing welded to body section 50, an accurate reading of accoustical energy is obtained without contaminating the fluid.

Flanges 182 and 184 permit apparatus 10 to be easily installed in any sanitary line.

Referring to FIG. 4, there is shown an alternate embodiment of the present invention. The embodiment shown in FIG. 4 is generally similar to the embodiment shown in FIGS. 1 to 3 and like elements receive like reference numbers. Note that the second counterbore 70' has been elongated so that annular sealing rings 136' and 138' of varying axial dimensions may be inserted to alter the distance between orifice 116 and blade-like element 124. This functions as a means for varying the spacing between the eye-shaped orifice 116 and the blade-like element 124. One skilled in the art will realize that there are many alternate ways of varying the spacing between the orifice and the blade-like element. For example, it is possible to hold the blade in the blade plate with set screws. Then, by merely loosening the set screws, the blade may be slid to an alternative position. Tightening of the set screws will maintain the blade in this position.

While the present apparatus has been described in connection with liquids, it should be understood that the materials handled need not be, and more often than not are not a pure liquid. On the contrary, one of the most important fields of utility of the invention is in emulsification where a plurality of liquids are present and homogenization where there are suspensions of liquids in solids. Mixtures of liquids and gases are also sometimes encountered. However, the invention does require that there be at least sufficient liquids present

so that the material as a whole has the flow characteristics resembling a liquid. Thus, the device will not operate with pure gases and no liquids. In such a case, it will not produce the high acoustic energy and cavitation for which it is of primary importance.

Inlet section 20, body section 50, outlet section 90, orifice plate 110, blade plate 120, blade-like element 124, clamps 140 and 150, and transducer 180 may be made of any high tensile, non-corrosive material. Where sanitary requirements are present, 316 stainless steel is often used.

In operation, any suitable pump 169 forces the liquid to be treated through the inlet section 20 toward body section 50. Orifice 116 acts as a nozzle to direct the fluid toward the blade-like element 124. A substantially flat jet of liquid from orifice 116 is preferred, and for this reason the orifice is eye-shaped. If a rectangular-shaped orifice were used, this stream would resemble a dumbbell in shape.

As the jet of liquid strikes the blade-like element, the liquid itself oscillates in a stable vortexing pattern causing the blade-like element to resonate. The result is a high level of cavitation, turbulence in shear, yielding excellent emulsions and dispersions.

Since the present apparatus has relatively few parts, it is much easier to disassemble than the prior art devices. For example, the present apparatus may be disassembled, cleaned, and assembled in approximately five minutes. This compares with about two hours for the apparatus illustrated in U.S. Pat. No. 3,176,964. For this reason, the present apparatus may be referred to as a "clean-in-place" apparatus. This coupled with the fact there is no place for bacteria to collect makes the present apparatus ideal for use in food processing environments. Further, since the present invention has no moving parts, maintenance is a simple matter.

While there has been described what is at present considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An apparatus for producing acoustic vibrations in a flowing liquid comprising an inlet section, a body section, and an outlet section,
each of said sections having a substantially cylindrical inner surface and having an outer surface,
a first flange extending radially outwardly from an inlet end of said body section and a second flange extending radially outwardly from an outlet end of said body section,
a first counterbore at the inlet end of said body section and a second counterbore at the outlet end of said body section,
said inlet section being adjacent to said inlet end of said body section and having an axially extending cylindrical flange extending into said first counterbore,

said outlet section being adjacent to said outlet end of said body section and having an axially extending flange extending into said second counterbore, an orifice plate mounted in said first counterbore and having one face that is substantially spherical and another face that is substantially flat, said orifice plate having an eye-shaped orifice at its approximate midpoint,

a blade plate mounted in said second counterbore, said blade plate having a blade-like vibratory element aligned with said orifice,

an annular sealing ring on each side of said orifice plate in said first counterbore, and annular sealing ring on each side of said blade plate in said second counterbore, each of said annular sealing rings having a substantially cylindrical inner surface,

a flange extending radially outwardly from the inlet section adjacent to the body section,

a flange extending radially outwardly from the outlet section adjacent to the body section,

a first clamping means surrounding the radially extending flanges of the inlet section and the inlet end of the body section to mount said inlet section to said body section,

and a second clamping means surrounding the radially extending flanges of the outlet section and the outlet end of the body section to mount said outlet section to said body section,

means for preventing rotation of the orifice plate in the first counterbore,

means for preventing rotation of the blade plate in the second counterbore,

and the inner surfaces of the inlet section, the body section, the outlet section, and the annular sealing rings being substantially equal in diameter and free of any crevices to minimize the possibility of bacteria buildup as the liquid flows through the apparatus.

2. An apparatus as recited in claim 1, wherein said first clamping means has wedging surfaces engaging wedging surfaces on the radially extending flanges of the inlet section and the inlet end of the body section and the second clamping means has wedging surfaces engaging wedging surfaces on the radially extending flanges of the outlet section and the outlet end of the body section.

3. An apparatus as recited in claim 2, further including a valve to create back pressure in the apparatus.

4. An apparatus as recited in claim 3, wherein the annular sealing rings are made of polytetrafluoroethylene.

5. An apparatus as recited in claim 4, further including a means for adjusting the distance between the orifice and the blade-like element.

6. An apparatus as recited in claim 5, further including an external acoustic sensor for reading acoustical energy.

7. An apparatus as recited in claim 6, wherein the body section, the inlet section, and the outlet section are constructed of stainless steel.

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