The present invention has been made in light of the aforementioned problem, and an object of the present invention is to provide an ultrasonic cleaning method and an ultrasonic cleaning apparatus by which a high particle removal rate is obtained in a stable manner.

Means for Solving the Problems

The inventors have earnestly studied a relationship between the dissolved gas concentration and the particle removal rate, and as a result, have obtained the following findings. Specifically, the inventors have found that, by stirring a liquid having a certain range of dissolved gas concentration while irradiating the liquid with ultrasonic waves, the particle removal rate of the liquid can be increased, and the inventors have arrived at the present invention.

An ultrasonic cleaning method according to an aspect of the present invention is an ultrasonic cleaning method for cleaning an object to be cleaned in a liquid in which a gas is dissolved, by irradiating the liquid with ultrasonic waves, and the method has the following steps. The liquid in which the gas is dissolved is prepared. The liquid is stirred by rotating a stirring portion with a rotation speed of at least 1400 rpm to trigger a state where bubbles containing said gas continue to be generated by driving said stirring portion in said liquid while the liquid is irradiated with the ultrasonic waves, and a state where bubbles containing the gas dissolved in the liquid continue to be generated is realized. After the liquid is stirred, sonoluminescence occurs. The object to be cleaned is cleaned in the state where the bubbles containing the gas continue to be generated.

In the ultrasonic cleaning method according to the present invention, the liquid is stirred while the liquid is irradiated with the ultrasonic waves. Therefore, it is possible to realize the state where the bubbles containing the gas dissolved in the liquid are more likely to be generated

continuously. Since cleaning is done in this state, a high particle removal rate can be obtained in a stable manner.

~~Preferably, i~~In the ultrasonic cleaning method, the step of realizing a state where bubbles containing the gas continue to be generated is triggered by driving a stirring portion in the liquid. With this, generation of bubbles serving as nuclei is promoted on the surface of the stirring portion, and the cleaning effect can be enhanced.

~~Preferably, i~~In the ultrasonic cleaning method, the step of cleaning the object to be cleaned includes a step in which sonoluminescence occurs. With this, a high particle removal rate is obtained in a more stable manner.

Preferably, in the ultrasonic cleaning method, the gas is nitrogen and a dissolved gas concentration in the liquid is 5 ppm or more and less than 11 ppm.

An ultrasonic cleaning apparatus according to an embodiment of the present invention is an ultrasonic cleaning apparatus for cleaning an object to be cleaned in a liquid in which a gas is dissolved, by irradiating the liquid with ultrasonic waves, the apparatus having: irradiation means for irradiating the liquid with the ultrasonic waves; a container for containing the liquid; and a mechanism for stirring the liquid. With the mechanism for stirring the liquid, the liquid can be stirred and it is possible to realize the state where the bubbles serving as nuclei are more likely to be generated in the liquid. As a result, the cleaning effect can be enhanced and a high particle removal rate can be obtained in a stable manner.

Effects of the Invention

Claims

1. An ultrasonic cleaning method for cleaning an object (W) to be cleaned in a liquid in which a gas is dissolved, by irradiating said liquid with ultrasonic waves, the method comprising the steps of:
- preparing said liquid in which said gas is dissolved;
- stirring said liquid while irradiating said liquid with the ultrasonic waves, and realizing a state where bubbles containing said gas dissolved in said liquid continue to be generated; and
- cleaning said object (W) to be cleaned in the state where the bubbles containing said gas continue to be generated.

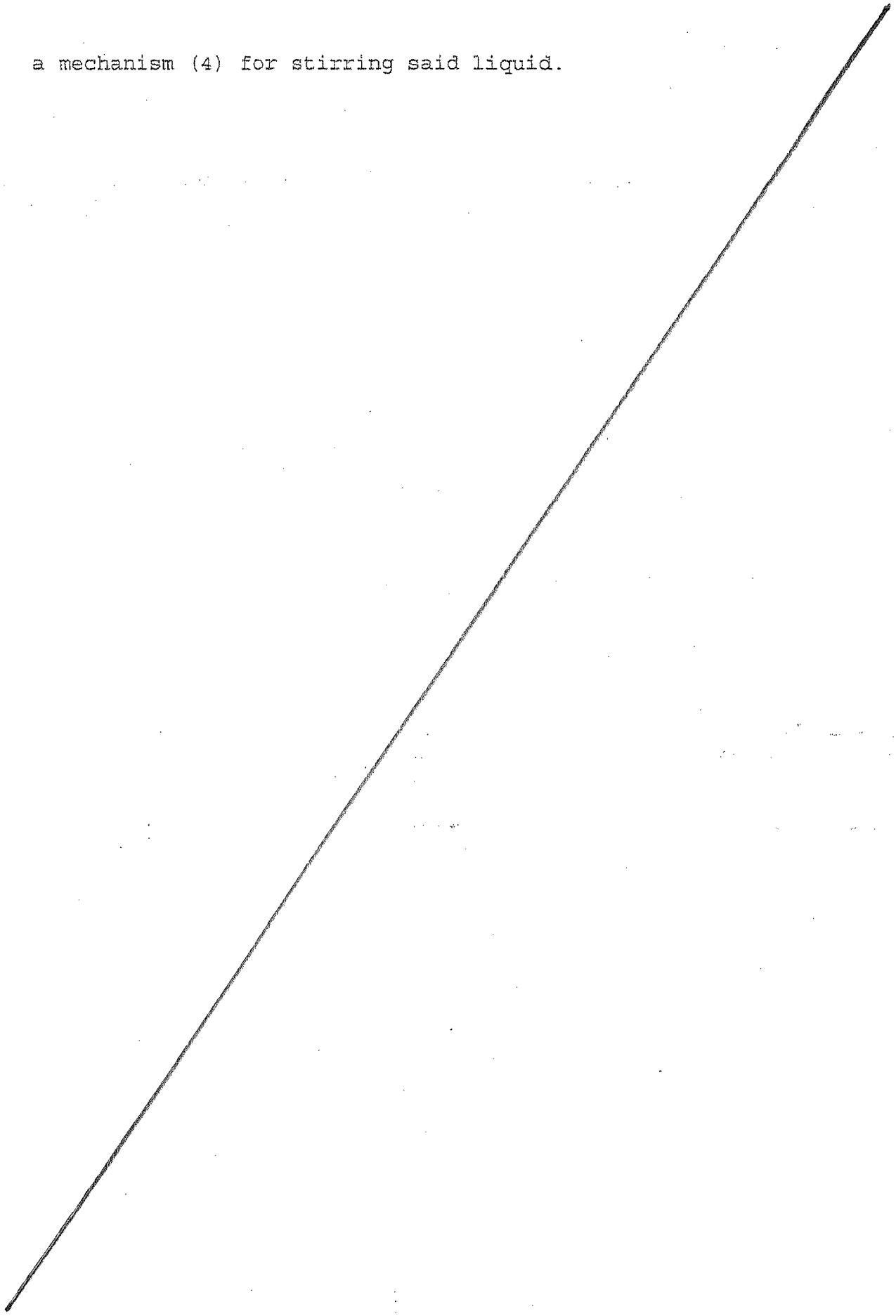
2. The ultrasonic cleaning method according to claim 1, wherein the step of realizing a state where bubbles containing said gas continue to be generated is triggered by driving a stirring portion (4) in said liquid.

3. The ultrasonic cleaning method according to claim 1 or 2, wherein the step of cleaning said object (W) to be cleaned includes a step in which sonoluminescence occurs.

4. The ultrasonic cleaning method according to any one of claims 1 to 3, wherein said gas is nitrogen and a dissolved gas concentration in said liquid is 5 ppm or more and less than 11 ppm.

5. An ultrasonic cleaning apparatus (100) for cleaning an object (W) to be cleaned in a liquid in which a gas is dissolved, by irradiating said liquid with ultrasonic waves, the apparatus (100) comprising:
- irradiation means (30) for irradiating said liquid with the ultrasonic waves;
- a container (20) for containing said liquid; and

a mechanism (4) for stirring said liquid.



Claims

1. An ultrasonic cleaning method for cleaning an object to be cleaned in a liquid in which a gas is dissolved, by irradiating said liquid with ultrasonic waves, the method comprising the steps of:
- preparing said liquid in which said gas is dissolved;
- stirring said liquid by rotating a stirring portion with a rotation speed of at least 1400 rpm to trigger a state where bubbles containing said gas continue to be generated by driving said stirring portion in said liquid while irradiating said liquid with the ultrasonic waves, and realizing a state where bubbles containing said gas dissolved in said liquid continue to be generated;
and wherein after the liquid is stirred sonoluminescence occurs and
- cleaning said object to be cleaned in the state where the bubbles containing said gas continue to be generated.

2. The ultrasonic cleaning method according to claim 1, wherein during the step of cleaning the rotation of the stirring portion is stopped.

3. The ultrasonic cleaning method according to any one of claims 1 to 2, wherein said gas is nitrogen and a dissolved gas concentration in said liquid is 5 ppm or more and less than 11 ppm.