Feb. 25, 1969 N. G. BRANSON 3,429,743

SHOCK WAVE TREATMENT METHOD AND APPARATUS

Filed Nov. 17, 1966

FIG. 1

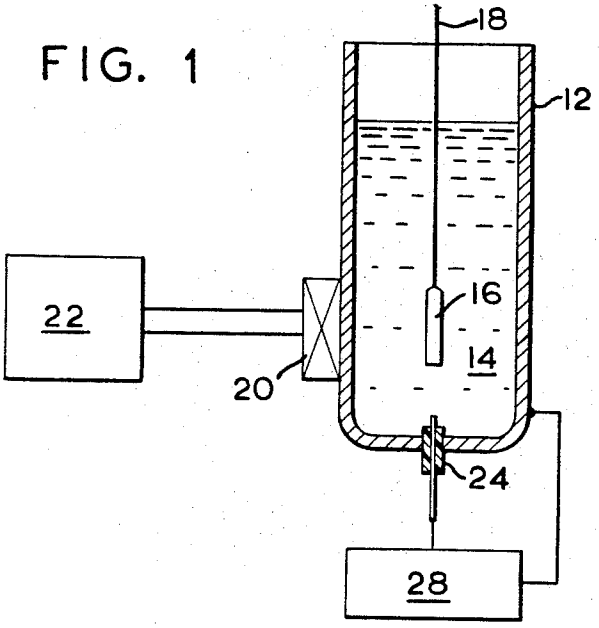


FIG. 2

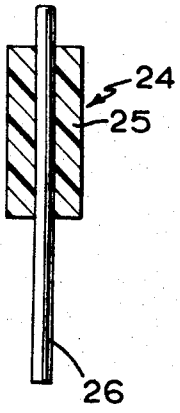


FIG. 3

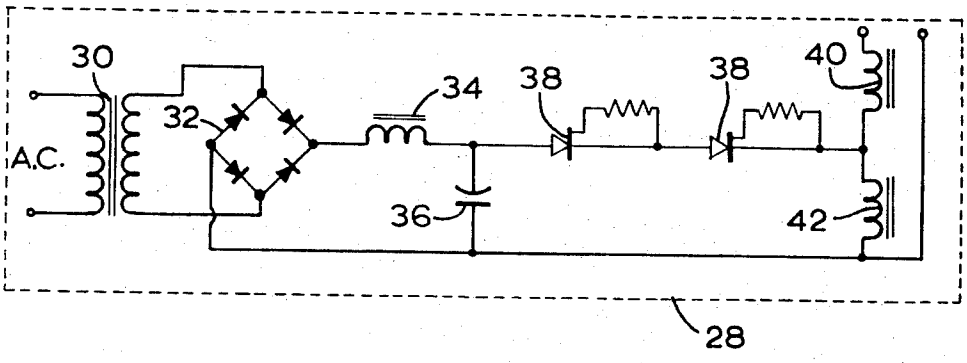
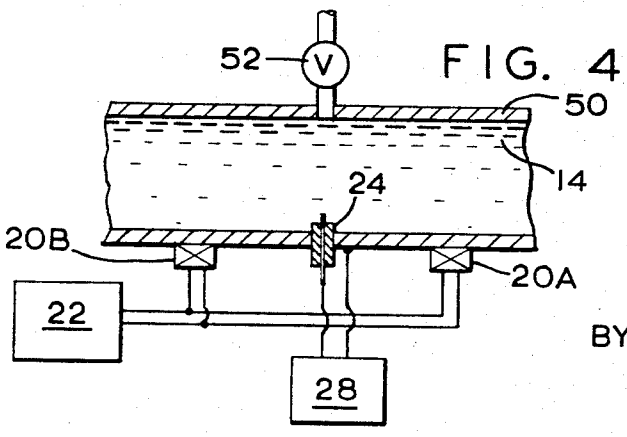


FIG. 4



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SHOCK WAVE TREATMENT METHOD AND APPARATUS

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Int. Cl. B08b 3/10

ABSTRACT OF THE DISCLOSURE

Method and apparatus providing high intensity shock waves caused by electrical spark discharges in a sonically degassed liquid for the purpose of cleaning, sterilization, etc. The sonic energy means causing degassing and the electrical discharge circuit means may be operated simultaneously or sequentially.

This invention refers to a method and apparatus for subjecting a liquid, or articles confined therein, to high intensity shock waves. More particularly, the present invention concerns a method and apparatus which employs high energy shock waves propagated in a liquid and produced by electrical discharges for treating articles. Such treatment may comprise sterilization, disloding of particles, removal of surface soil and the like.

While the prior art shows various arrangements for producing high intensity shock waves resulting from electrical discharges, the method and apparatus used heretofore have not been particularly effective because gas absorbed in the liquid has impeded the forceful propagation of such shock waves. The method and apparatus described hereinafter attempt to overcome this heretofore existing shortcoming by including means for degassing the liquid, hence, providing an improved arrangement which accomplishes more work in relation to the input power. Moreover, the arrangement disclosed hereafter is suited particularly for cleaning of parts. For instance, it is well known that ultrasonic cleaning is most effective for removing soil and contamination from the surface of articles. However, when heavy contamination, such as rust or carbonaceous deposits, is involved, the ultrasonic energy propagated in the cleaning liquid is not possessed of sufficient power to remove such deposits.

As has been found these deposits can readily be dislodged by the application of repetitive high intensity shock waves which result from electrical discharges in the cleaning liquid. Therefore, both processes can advantageously be used to cause first the removal of heavy and strongly adhering contaminants using high intensity shock waves, followed by the more gentle sonic or ultrasonic cleaning method for removing the remaining smaller and finer contamination still adhering to the article surface. Hence, heavily contamination articles may be cleaned to a fine degree in a single step method.

One of the principal objects of this invention is, therefore, the provision of an improved arrangement for treating articles using high intensity shock waves.

Another important object of this invention is the provision of an improved method and apparatus for cleaning articles by high intensity shock waves using a substantially degassed cleaning liquid.

Another object of this invention is the provision of a cleaning method which combines the desirable characteristics of high intensity shock waves with those produced by ultrasonic cleaning.

A further important object of this invention is the provision of an improved method and apparatus for treating articles in a container which is provided with electrical spark gap means and ultrasonic energy means.

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

FIGURE 1 is an elevational view, partly in cross section, of a typical embodiment of the invention;

FIGURE 2 is a sectional view of the typical spark gap device used in connection with FIGURE 1;

FIGURE 3 is a schematic diagram of the electrical circuit which provides the electrical discharges for producing high intensity shock waves in the liquid, and

FIGURE 4 is a sectional view of an alternative arrangement for treating a liquid.

Referring now to the figures and FIGURE 1 in particular, numeral **12** refers to a heavy-walled open-ended, tubular metal container **12** which contains a liquid **14**. An article **16** to be treated, such as a heavily corroded metal part, is suspended in the liquid **14** by a wire **18**. The liquid may be a caustic solution or another suitable cleaning liquid, preferably having a small amount of electrical conductivity. In a typical embodiment the container **12** is fitted with a set of electro-acoustic transducers **20** which are adapted to be energized by a high frequency generator **22** providing electrical current at 20 kHz. The transducers may be of the piezoelectric or of the magnetostrictive type. It should be understood that the frequency at which the transducers are operating is not critical and frequencies in the lower or higher region may be used.

Additionally, the container **12** is fitted with a spark gap device **24** which comprises, as seen in FIGURE 2, an insulating bushing **25** and a central metal electrode **26**. This spark gap device **24** is connected to an electrical circuit **28** which, when energized, produces periodic pulses of energy. When a potential of sufficient magnitude is applied between the electrode **26** and the tank **12**, an electrical discharge occurs between this electrode and the tank wall, which discharge produces high intensity shock waves in the liquid **14**. These shock waves impinge upon the surface of the article **16**, thereby causing gross contamination to be dislodged therefrom. In order to enhance the intensity of the shock waves, avoiding the absorption of energy by entrained gas, the liquid **14** is subjected to sonic or ultrasonic energy generated by the transducers **20**, such energy, as is known, causing a degassification of the liquid. This degassification process may be carried out either prior to the operation of the spark gap discharge device or concurrently therewith, depending upon the circumstances. Alternatively, both energy devices may be operated in alternate manner.

A typical electrical circuit for connection to the spark gap device **24** is shown in FIGURE 3. It should be clearly understood that the circuit may serve to energize several spark gap devices connected in parallel and provided on the container **12**, although for the sake of simplicity only one such device is illustrated. The circuit comprises a charging circuit which includes a transformer **30**, a bridge rectifier **32**, a series inductance **34** and a capacitor **36**. The discharge circuit comprises two series connected controlled rectifiers **38** connected to the capacitor **36** and two indutcances **40** and **42**. The capacitor **36** periodically is charged with direct current from the rectifier **32** and is discharged through the series connected rectifiers and the spark gap device. In this way there is produced a train of electrical discharges, each discharge causing the propagation of a high intensity shock wave in the liquid **14**, and, as is known, such shock wave, in turn, by reflection generates additional shock waves.

The embodiment per FIGURE 1 is well suited for cleaning parts which are heavily corroded. The sonic energy produced by the transducers **20** not only degasses the liquid to enhance the effect of the high intensity shock waves but causes also a fine scrubbing of the sur-

face of article **16**. Hence, heavy contamination which requires high impact forces may be removed by the high intensity shock waves, while follow-up cleaning is done with the sonic energy, preferably operating at a power level which produces cavitation in the liquid **14**.

The entire process may advantageously be carried out in a single container. The procedure comprises (a) immersing the article **16** in the liquid **14**; (b) degassing the liquid **14** by operating the transducers **20**; (c) repetitively producing high intensity shock waves by firing the spark gap device **24** until coarse particles are dislodged from the article surface, and (d) finishing the cleaning of the article surface under the influence of sonic or ultrasonic energy propagated from the transducers **20**. In this last step, it is desirable that there exists cavitation in the liquid. Obviously steps (c) and (d) may be combined to be effective substantially simultaneously.

FIGURE 4 shows an alternative arrangement which is particularly adapted for treating a flowing liquid or particles suspended within the liquid. Numeral **50** refers to a section of a pipe through which the liquid **14** flows. A spark gap device **24** is mounted into the pipe wall and transducers **20A** and **20B** are mounted at either side. In order to vent liberated gas, a vent valve **52** is provided. Liquid can be treated as it flows past this treatment station.

While there have been described and illustrated certain preferred embodiments of my invention, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the broad principle and scope of my invention.

What is claimed is:

1. The method for treating an article in a liquid comprising the steps of:

(a) immersing the article surface to be treated in the liquid, and while said surface is immersed,

(b) subjecting said liquid to:

(b–1) sonic energy of sufficient intensity to cause degassification, and

(b–2) high intensity shock waves resulting from electrical spark gap discharges produced within said liquid.

2. The method for treating an article as set forth in claim **1** wherein said sonic energy and said shock waves are produced sequentially.

3. The method for treating an article as set forth in claim **1** wherein said sonic energy and said shock waves are produced substantially concurrently.

4. The method for treating an article as set forth in claim **1** wherein said sonic energy is of an intensity sufficient to cause cavitation in said liquid.

5. The method for treating an article as set forth in claim **1** wherein said sonic energy is in the ultrasonic frequency range.

6. The method for treating an article as set forth in claim **1** wherein said liquid is a cleaning solution.

7. The method for treating an article as set forth in claim **1** wherein said liquid is stationary.

8. The method for treating an article as set forth in claim **1** wherein said liquid is flowing while being subjected to said sonic energy and to said high enregy shock waves.

9. The method for treating an article as set forth in claim **1** wherein said liquid is electrically conductive.

10. The combination of:

a container adapted to hold a liquid;

sonic energy means coupled to said container for imparting sonic energy to the liquid disposed in said container, and

electrical spark gap discharge means coupled to said container for causing in said liquid high intensity shock waves.

11. The combination per claim **10** wherein said sonic energy means comprises electro-mechanical transducers and an electrical high frequency generator coupled thereto for supplying electrical energy to said transducers.

12. The combination per claim **11** wherein said sonic energy means is adapted to cause cavitation in said liquid.

13. The combination per claim **10** wherein said spark gap discharge means comprises a spark gap device in contact with the liquid and an electrical circuit for causing periodic firing thereof.

14. The combination per claim **13** wherein said sonic energy means comprises a set of electro-mechanical transducers straddling said spark gap device.

15. The combination per claim **10** wherein said container holds a stationary quantity of liquid.

16. The combination per claim **10** wherein said container is a section of a pipe and the liquid is adapted to flow therethrough while said sonic energy means and said discharge means are actuated.

17. The combination per claim **16** wherein said pipe section is fitted with a gas vent valve for discharging gas liberated by the operation of said sonic energy means.

18. The combination per claim **10** wherein said container is metal and said discharge means produces an electrical discharge between an electrode in contact with the liquid and the container.

References Cited

UNITED STATES PATENTS

3,234,047	2/1966	Olson	134—1 XR
3,284,991	11/1966	Ploeger et al.	55—277 XR

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U.S. Cl. X.R.

259—1; 55—15, 277; 21—2, 102, 61