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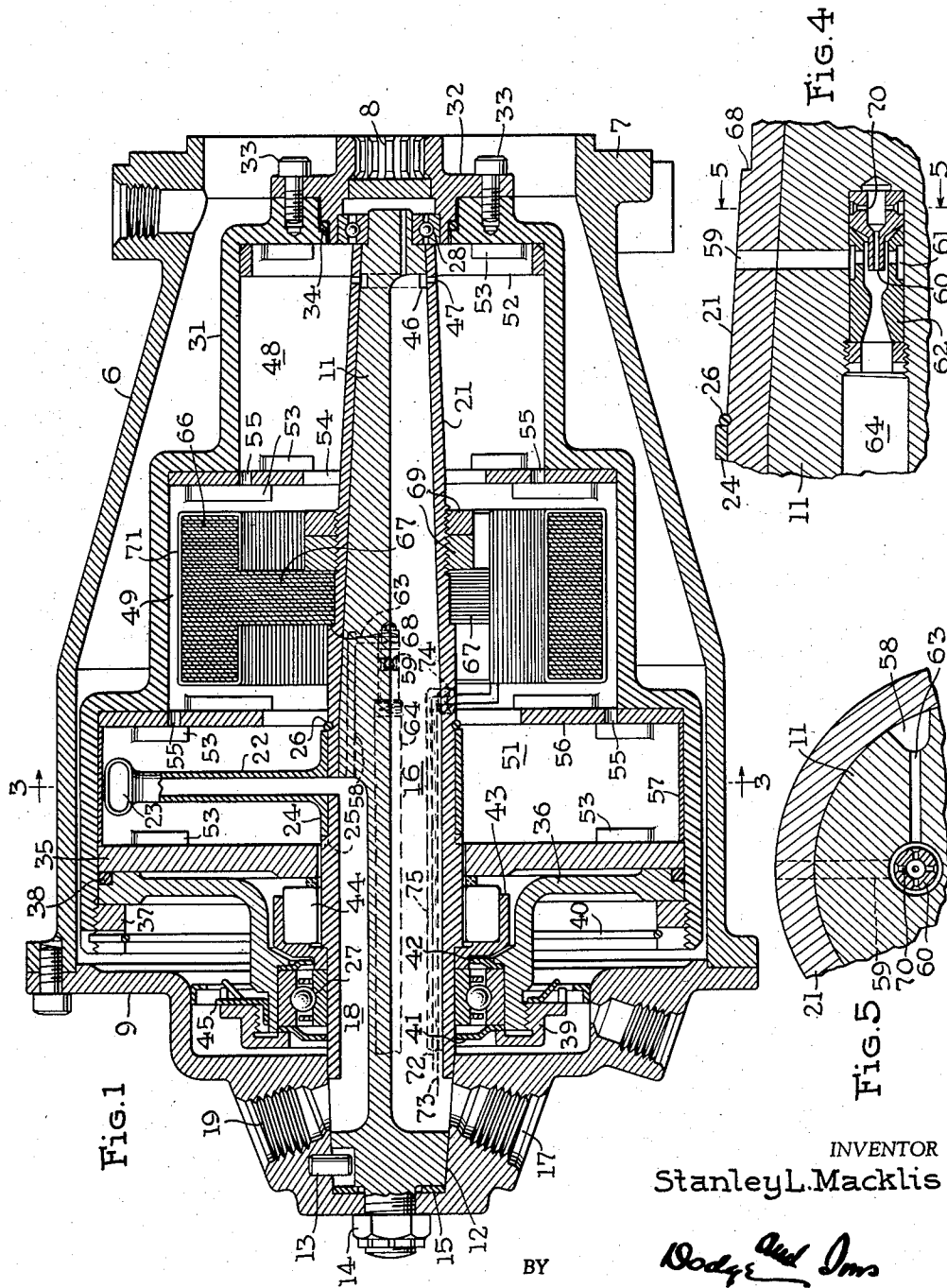
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2,889,983

DEAERATOR FOR HYDRAULIC SYSTEMS SUBJECT TO HIGH TEMPERATURES

Filed May 17, 1957

3 Sheets-Sheet 1



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Fig. 2

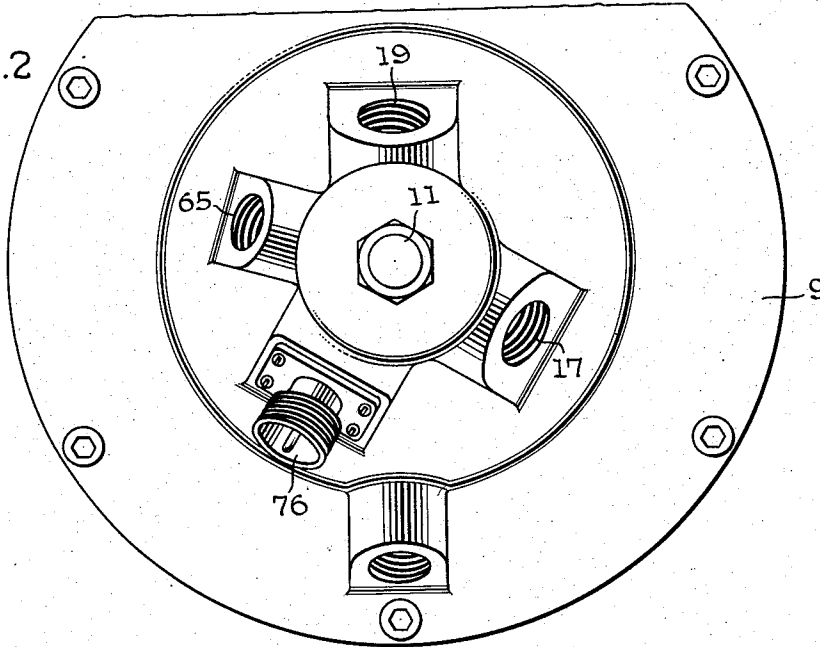
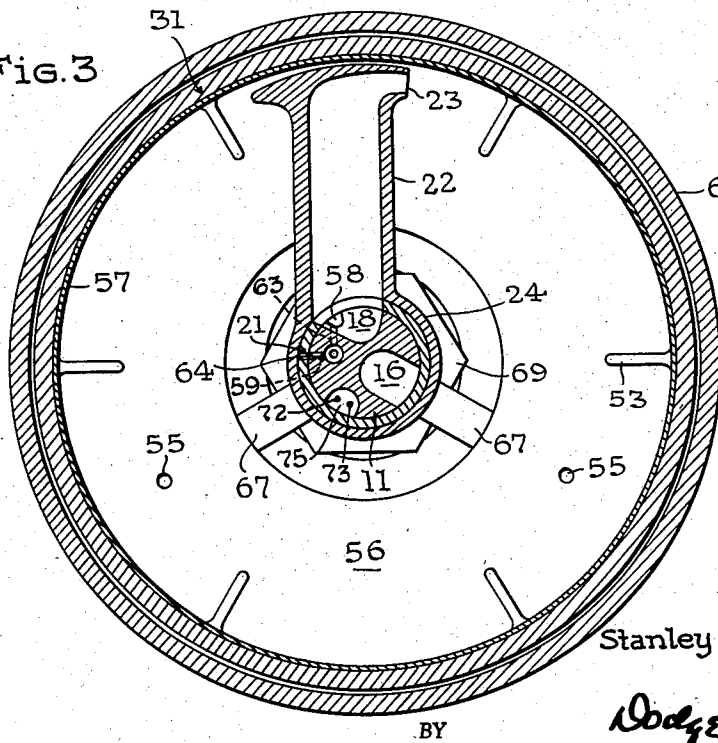


Fig. 3



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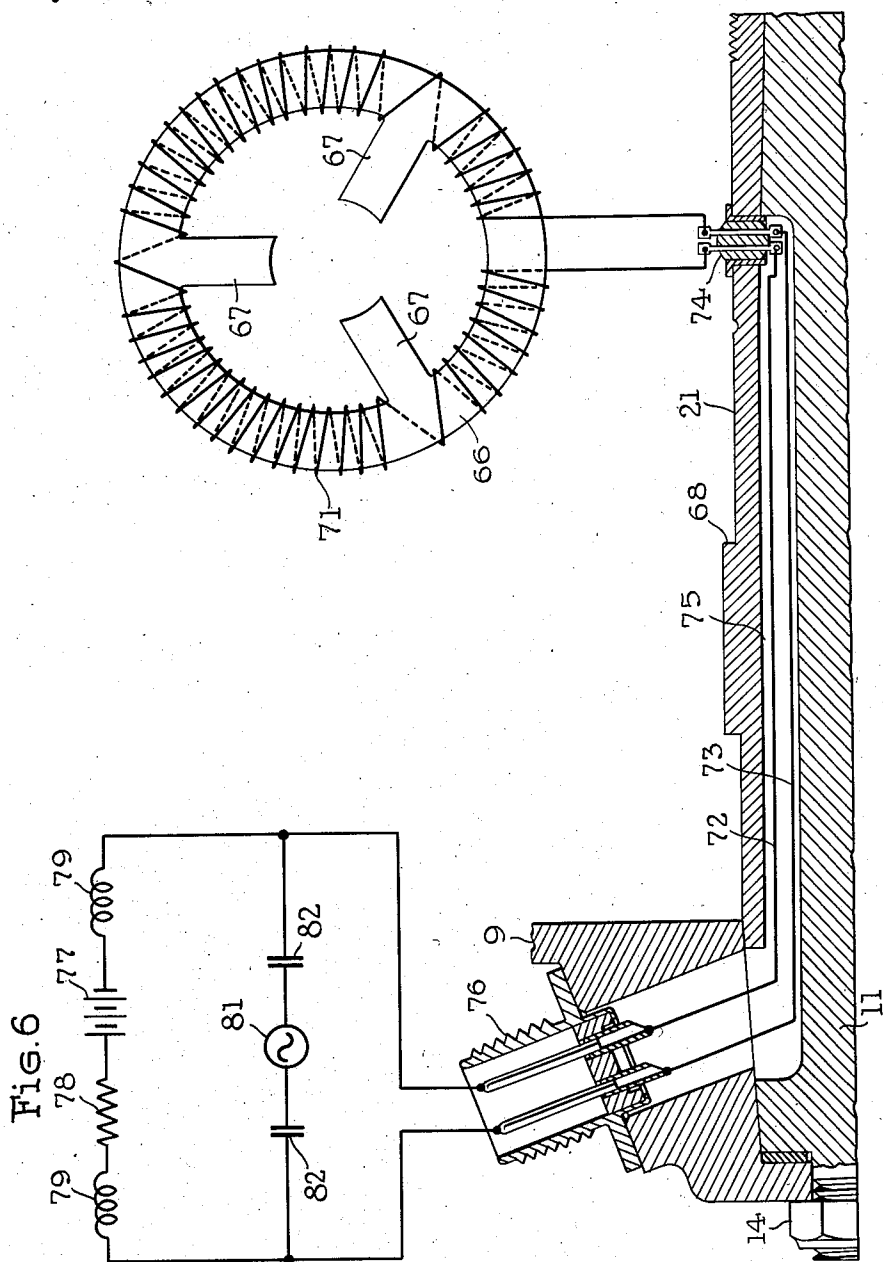
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DEAERATOR FOR HYDRAULIC SYSTEMS SUBJECT TO HIGH TEMPERATURES

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Application May 17, 1957, Serial No. 659,924

8 Claims. (Cl. 233-27)

This invention relates to means for degassing (deaerating) foam forming liquids, and particularly pressure transmitting liquids used in the hydraulic systems of high speed airplanes, and the like, where the system may be subjected to temperatures of the order of 500° to 750° F.

At such temperatures mineral base oils, such as are used in hydraulic systems operating at ordinary temperatures, cannot be used. Various specially compounded hydraulic liquids have been and are being developed for high temperature installations. The discussion will proceed on the basis of silicone-base oils which are taken as typical, but without limiting implications.

These are polymers or co-polymers and solve the heat problem while introducing several secondary problems which this invention was developed to overcome. The secondary problems are: (1) gradual breakdown of polymer bonds in the presence of air, while at high temperatures, (2) very active generation of foam of particularly persistent type, and (3) a tendency to take air into solution under the conditions of use in an hydraulic system. The dissolved air may be 20% or even 25% by volume.

The attractive concept of a sealed hydraulic system completely filled with gas-free liquid appears to be unworkable, since the oil itself generates gases at elevated temperatures. Hence, there is need for a deaerator to be included in even a closed, pressurized hydraulic system, operating continuously. This device must meet severe limits as to size and weight and must afford the utmost reliability.

There are several known procedures for degassing liquids, but none of these is adequate when used alone. The invention is based on the concept that several degassing procedures, if simultaneously performed in a single device, can be made synergetic. Generally stated, centrifuging under subatmospheric pressure gains effectiveness because low pressure favors bubble growth and a growing bubble moves faster and faster towards the center of the centrifuge. The gain is thus self-intensifying. Spraying helps to free gas from a sprayed liquid, but spraying into an evacuated space multiplies the effect. These three reactions, applied concurrently, are very effective for removing occluded gases, and will remove some dissolved gas. Ultrasonic vibration can be made effective to free gases, particularly dissolved gas, and gains in effectiveness when used in connection with centrifuging and evacuation (either or both), partly because of rapid removal of the freed gas.

Ultrasonic vibration is so applied as to cause alternate densification and rarefaction in response to pressure pulses acting on the fluid at frequencies of the order of 25,000 cycles per second. The pressure in each bubble varies past (i.e. above and below) the equilibrium pressure so that gas tends to go into and out of solution in the enveloping liquid. On rarefaction the bubbles enlarge and present a larger surface area. On rising pressure the reverse effects occur. The larger area during rarefaction favors release of the gas. Thus active growth of the bubbles and escape of dissolved gas occurs.

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Gas so freed has the beneficial secondary effect of stimulating bubble growth with attendant improvement of the vacuum and centrifuge separations. The various effects are congruent and assist one another. They cannot be clearly distinguished as they occur.

The primary inventive concept is the method, but the apparatus developed to carry it out has patentable features.

A preferred scheme for practicing the invention will now be described by reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal axial section of a degassing unit operable according to the invention.

Fig. 2 is a partial elevation of the left-hand end of the unit shown in Fig. 1.

Fig. 3 is a transverse section on the line 3-3 of Fig. 1.

Fig. 4 is a fragmentary axial section through the evacuating unit which withdraws the separated gas and maintains the degassing unit under sub-atmospheric pressure.

Fig. 5 is a fragmentary section on the line 5-5 of Fig. 4.

Fig. 6 is a view, part in section and part in diagram, showing the electric circuit and its relation to the ultrasonic degassing component.

The unit illustrated in Fig. 1 contains some features disclosed in my prior application, Serial No. 639,297, filed February 11, 1957, and combinations claimable in said application will not be claimed herein.

All statements of direction refer to the device positioned as in Fig. 1.

Referring first to Figs. 1, 2 and 3. The deaerating unit is enclosed in a fixed housing 6 which has a mounting flange 7 intended to be bolted to the housing of a driving motor (not shown). The driving motor drives the rotary components of the deaerator through a splined hub 8. The rotary speed is held constant at approximately 6,000 r.p.m.

Releasably mounted on the left end of the housing 6 is a closure cap 9 which also serves to support a fixed shaft 11. The shaft 11 contains the inlet and discharge passages for the liquid to be treated and for the separated liquid and air. There is also a channel for necessary electrical conductors. The shaft 11 is sustained at its left-hand end by the cap 9. The left end of the shaft is tapered to fit a conical socket 12 formed in the cap, and is held against rotation by a pin 13.

The end of the shaft is drawn into the socket 12 by a nut 14, entry into the socket being appropriately limited by shims 15. Liquid to be treated enters a longitudinal port 16 formed as a groove in the shaft 11. It reaches this by way of the inlet connection 17 formed in cap 9, and leaves by way of a second groove port 18 which leads to an outlet connection 19 for liquid. The shaft 11 is tapered toward its right-hand end throughout the major portion of its length to receive a close fitting sleeve or quill 21 which is brazed in place and thus is a permanent part of the shaft assembly. This construction offers a convenient way to machine the ports 16 and 18 and another port to be described hereinafter, as grooves in the principal shaft member 11.

Fixed on the shaft structure above-described is a radially-extending tubular arm 22 which carries, at its outer end, a scoop or pitot head 23. The bore of the arm 22 communicates with the port 18. The arm is formed on a hub 24 which encircles a portion of the sleeve 21, has dental engagement therewith at 25 and is locked in position by a snap ring 26.

Mounted to rotate on the shaft 11 by means of annular ball bearings 27 and 28 is a rotary shell which houses three centrifuging chambers in which separation

of gas and liquid proceeds concurrently by spraying treatment, by centrifuging at sub-atmospheric pressure and by treatment with ultrasonic waves or vibrations.

The rotary shell comprises a stepped three-diameter integral unit generally indicated by the numeral 31. This has an inward turned flange at its right-hand end. The opening within the flange is closed by a head 32 which is held in place by machine screws 33 and sealed by a commercial static seal 34. The head 32 carries the splined hub 8 through which the shell is rotated.

The left-hand end of the rotary shell 31 is closed by a disc 35 which is held against spacer 57 by an annular bearing carrier 36. The bearing carrier is held in place by threaded ring 37 and is sealed at its outer periphery to the shell 31 and the member 35 by a commercial static seal 38. A locking ring is shown at 40. The bearing carrier 36 is formed with an annular seat for the outer race of the annular ball bearing 27. This race is held in place by a ring nut 39. The nut 39 also clamps two annular lubricant retainers 41 and 42 for the bearing as well as the flanged positioning ring 43 for a conventional running seal shown (in diagram) at 44. A conventional nut lock 45 prevents the nut 39 from backing off. The construction is such that the space within the shell 31, between the head 32 and the closure 35, is completely enclosed and sealed from the atmosphere. Various specifically different arrangements to this end might be substituted.

Oil charged with air enters through the connection 17 and flows through the passage 16 to an annular distributor groove 46 from which the spray ports 47 lead. The spray ports discharge into an annular chamber 48 within and at the right-hand end of the shell 31. This is the smallest one of three axially aligned chambers 48, 49, 51 afforded by the stepped configuration of shell 31.

Fixed in chamber 48 at its right-hand end is a ring 52 which carries vanes 53 designed to cause liquid in chamber 48 to rotate with shell 31.

Mounted against the right-hand offset in shell 31 is an annular plate 54 which has several functions. It serves as a dam to sustain rotating liquid in chamber 48, except as it is released to chamber 49 by ports 55 which are of appropriately limited flow capacity. It carries vanes also numbered 53 which cause liquid in chambers 48 and 49 to rotate with shell 31.

Mounted against the left-hand offset in shell 31 is a second annular plate 56 similar in function to plate 54 and carrying on its opposite faces vanes 53. It also has limited capacity through ports 55 functionally similar to the ports 55 in plate 54.

The end plate, or disc 35 has vanes 53 but no ports 55. Fig. 3 shows the vanes 53 in chamber 51. The reference numeral 53 has been used for all vanes, regardless of size and location in successive chambers 48, 49, 51, since they are identical in function. A cylindrical spacing sleeve 57 is used in chamber 51 to sustain the disc 35. The pitot head 23 is in this chamber. The pitot head is presented to the whirling ring of liquid which, because of centrifugal force, hugs the outer periphery of the chamber.

To develop and maintain sub-atmospheric pressure in the chambers 48, 49 and 51 (which are in free communication with each other), use is made of an ejector actuated by pressure liquid tapped off from passage 18 via port 58 (see Figs. 3 to 5). A passage 59 (Fig. 4) leads from the central space (air space) in chamber 49 to the intake ports 61 of the ejector combining tube 62, which is a Venturi. The ejector jet 60, which is directed into the throat of the combining tube 62, is fed from passage 58 by branch 63 and the cross-drilled ports 70 shown in Figs. 4 and 5. The gas and liquid discharged from the combining tube returns to the low pressure reservoir of the system (not shown) via passage 64 and connection 65 (see Figs. 2 and 3).

The ultrasonic magnetostrictive transducer comprises

an annular laminated core 66 of nickel-iron supported by laminated spokes 67 on the fixed shaft 11. The laminae are spot welded into an assembly. The spokes are clamped against a shoulder 68 by the nut and check nut indicated at 69, 69 in Fig. 1. The winding 71, which is diagrammed in Fig. 6 and somewhat more precisely indicated in Fig. 1, is of heavily anodized aluminum. The anodized coating functions as an insulator, and is the best known insulation capable of use at the contemplated temperatures and presently commercially available. Better insulation is being sought and will be used as it becomes available.

The leads 72 and 73 pass through an insulating and sealing plug 74 to a passage 75 and are accessible exteriorly of the device through a threaded fixture 76. See Fig. 6 which is largely schematic and requires no detailed elaboration.

One possible scheme for high frequency energization is diagrammed in Fig. 6. The winding 71 is used for polarization and high frequency excitation. A D.C. source 77 is diagrammed as a battery, but could be (for example) a 24 to 32 volt D.C. supply on an airplane, in which event a resistor 78 could be used to drop the voltage to 12 to 20 volts. Two radio-frequency coils 79 are shown in series with the source 77 and resistor 78. These are intended to provide radiation shielding and reduce interference effects in airborne radio equipment.

The high frequency excitation is shown imposed on the same winding 71 to produce the magnetostrictive effect and the resulting ultrasonic vibration of the fluid. The frequency should be of the order of 25,000 cycles per second, the voltage approximating 70 volts and the current between 0.5 and 1.5 amperes.

The source 81 of high frequency voltage may be either a high speed generator or an electronic source. Blocking condensers 82, 82 are indicated as means to prevent the D.C. from affecting the high frequency supply.

Details as to excitation are subject to considerable modification, depending on environment and kindred details such as temperature, allowable weight, available space, and the like.

What is claimed is:

1. The method of continuously removing dissolved or occluded gas, or both, from a liquid, which method comprises maintaining a space at sub-atmospheric pressure; continuously delivering gas-carrying liquid at higher pressure and spraying it into said space; centrifugally separating in said space gas and liquid; subjecting the liquid, while being centrifuged, to ultrasonic pressure pulses; and separately discharging gas and liquid from said space.

2. The process defined in claim 1 in which the rate of discharge of gas from said space is effective to maintain the space at sub-atmospheric pressure.

3. The combination of rotary centrifuging means enclosing a series of coaxial generally cylindrical chambers of successively larger diameters; annular partitions between chambers and propelling blades in the chambers the central openings of the partitions affording free communication between said chambers, while the blades serve to develop centrifugal liquid pressure heads between chambers in the outer annular liquid spaces, said partitions having restricted flow ports for passing liquid serially through the chambers toward the chamber largest in diameter; means for spraying gas-bearing liquid into the gas space of a smaller chamber; pumping means for withdrawing liquid from a chamber late in the series and discharging it under a pressure head; an ejector arranged to receive part of said liquid under pressure head and apply it as motor fluid to withdraw gas from said gas space and discharge it from said enclosing means; and means for developing in an intermediate chamber ultrasonic pressure pulses.

4. The combination defined in claim 3 in which the ultrasonic pulse means extends around the chamber, part

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submerged in liquid and part in a foam-filled portion of the gas space.

5. The combination defined in claim 3 in which the ultrasonic pulse means comprises an annular core of laminated magnetostrictive material with a winding energized by a high-frequency electric source.

6. Means for deaerating foamy liquids comprising in combination a rotary container closed from the atmosphere; means for rotating said container about an axis at an angular velocity such as to induce centrifugal separation of gas and liquid mixtures contained therein; means for spraying foamy liquid into said container; means for withdrawing gas from the gas-filled space in said container near its axis of rotation, at rates such as to maintain the interior of the container at a low subatmospheric pressure; means to subject liquid and foam within said container to ultrasonic vibration; means to withdraw liquid from said container at a rate such, with reference to the rate at which foamy liquid is sprayed, as to assure maintenance of a centrifugally sustained ring-bath of liquid; and means to withdraw liquid from the outer portion of said ring bath.

7. The combination defined in claim 6 in which the

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container comprises a plurality of coaxial right circular cylinders all in free intercommunication at the axis of rotation and differentiated in diameter to afford a stepped configuration, there being annular liquid retaining dams between adjacent cylinders but with restricted through ports to permit liquid to flow under centrifugal head from the smaller toward the larger of two adjacent cylinders; and the foamy liquid spraying means delivers to the smallest cylinder and deaerated liquid is withdrawn from the largest cylinder.

8. The combination defined in claim 7 in which the means for subjecting liquid and foam to ultrasonic vibration is located in an intermediate cylinder.

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