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M. R. CANNON ETAL

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CONSTANT TEMPERATURE BATH

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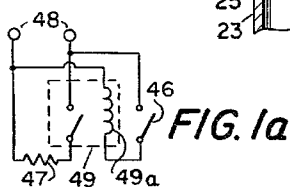
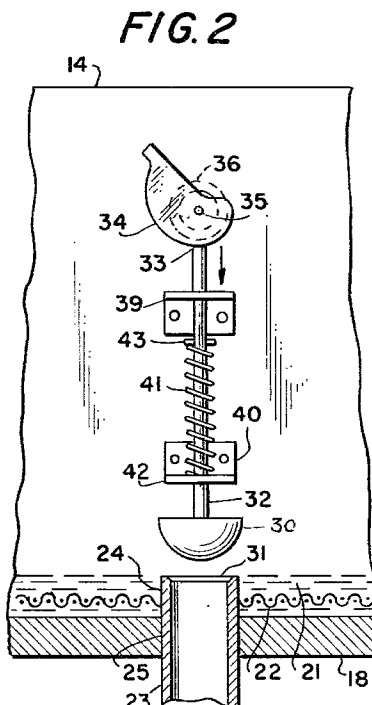
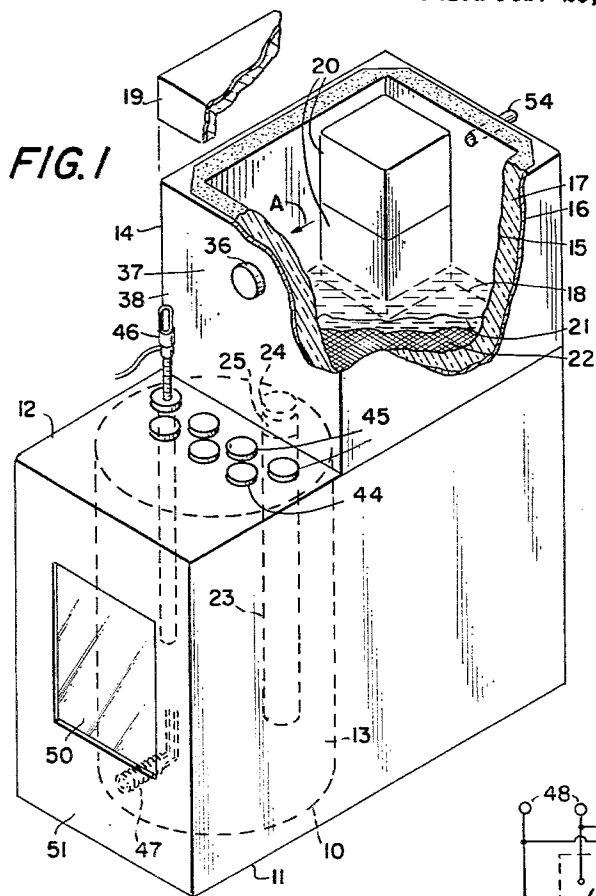


FIG. 3

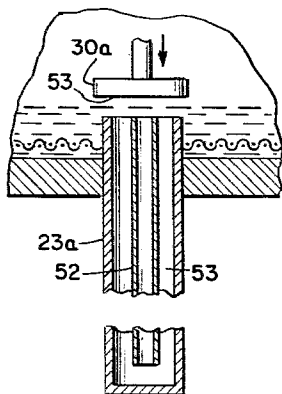
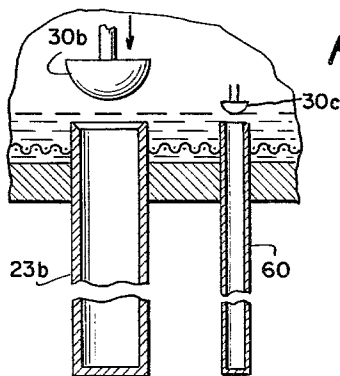


FIG. 4



INVENTORS

MICHAEL R. CANNON, DECEASED
BY ELIZABETH L. CANNON, EXECUTRIX
ROBERT E. MANNING
WALLIS A. LLOYD

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CONSTANT TEMPERATURE BATH

Michael R. Cannon, deceased, late of Boalsburg, Pa., by Elizabeth L. Cannon, executrix, and Robert E. Manning, Boalsburg, and Wallis A. Lloyd, State College, Pa., assignors to Cannon Instrument Company, Boalsburg, Pa., a corporation of Pennsylvania
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This invention relates to a constant, low temperature bath useful for conducting experiments, such as viscosity measurements, at a low temperature which is closely controlled within narrow limits.

The need for a dependable laboratory bath of this kind is growing, owing to the increasing interest in the behavior and utility of lubricants, fuels, hydraulic fluids, and the like at low temperatures. For example, military installations in arctic climates have generated an ever widening investigation of the viscosity behavior of lubricants and other fluids at reduced temperatures, and as a natural consequence, considerable attention has been devoted to instruments and apparatus for measuring viscosity at these temperatures. While conventional refrigeration equipment can be used to hold a test material at low temperature, it tends to be quite bulky and to require valuable laboratory or other space usually ill spared. Furthermore, such equipment is complicated to install and operate, entails high initial costs, and is apt to require expert maintenance.

By contrast, the invention provides a cooling device which, in respect of the foregoing, is in sharp contrast to conventional equipment, and which avoids the disadvantages described. The device is of desirable simplicity, and has proved to be sound. It comprises generally a bath liquid which is to be maintained at a constant low temperature, a container for the liquid, a member of heat conducting material extending into the liquid in heat exchange relation therewith, and, in communication with the member, a reservoir of coolant or heat transfer medium adapted to flow into the member to cool down the bath liquid. Suitably the member is connected to the floor of the reservoir, which enables the cooling medium to flow by gravity into the member, the latter being closed at its lower end. While a number of coolants are suitable, commercial Dry Ice, or frozen carbon dioxide, is admirable, and the invention may be described in detail in connection with this material. The Dry Ice is placed in chunks in the reservoir together with a small amount of a solvent therefor. Cooled solvent, together with some dissolved Dry Ice, flow into and fill the member, and the latter acts to cool the bath liquid by heat exchange. Heat abstracted from the bath boils out dissolved carbon dioxide from the solvent, which flows upwardly in the member to the reservoir, pushing upward some solvent somewhat depleted in dissolved carbon dioxide, and the member is then automatically refilled by cold solvent from the reservoir. In this way the temperature of the bath liquid may be brought down to a desired low temperature, at which point the flow of cold solvent into the member is reduced, and a fine control temperature-regulating system is actuated to maintain the temperature.

The invention may be better understood by referring to the accompanying drawings, which are diagrammatic, and in which

FIG. 1 is a perspective view of the constant temperature device, with portions being broken away;

FIG. 1a is a simplified circuit diagram of the heater and control circuit;

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FIG. 2 is a fragmental view looking in the direction of arrow A in FIG. 1; and

FIGS. 3 and 4 are views like FIG. 2 but showing modifications.

Referring to FIG. 1, the constant temperature device comprises a container 10 supported by means not shown in a cabinet 11 which encloses the container on all sides. The container, which is in the form of an open top glass Dewar cylinder, although it may have any other suitable form, is disposed in the forepart of the cabinet and is covered by a lid 12 which provides a working area for placing test equipment in the container. The latter is nearly filled with bath liquid 13 comprising the liquid which is to be cooled and maintained at constant temperature. Back of lid 12, and resting on the back part of cabinet 11, is a reservoir 14 comprising a thick-walled tank for holding coolant. Suitably the tank has inner and outer walls 15 and 16 of metal between which is a thick layer of insulation 17. The floor 18 of the tank is similarly constructed, as is the lid 19, shown exploded and partially in section. The lid may engage the tank through hinges (not shown).

The coolant in reservoir 14 comprises chunks or blocks 20 of Dry Ice, the lower blocks of which are partially immersed in a Dry Ice solvent 21 such as methanol or acetone. The blocks rest on a screen 22 which is disposed a small distance above floor 18, say $\frac{1}{4}$ to 1 inch, preferably $\frac{1}{2}$ to $\frac{3}{4}$ inch, and thus solvent has free access to the blocks. The level of solvent in the tank may be up to about 6 inches, preferably about $\frac{3}{4}$ to 2 inches.

In the forward part of tank 14 where it overlaps the Dewar vessel 10, a member 23, preferably in the form of a hollow tube, extends downwardly from the floor of the tank into the bath liquid 13. Tube 23 may, but not necessarily, project above the tank floor a short distance, identified as 24, which is less than the depth of solvent 21, to insure that there will be a constant flow of solvent into the tube. The latter extends through the floor insulation at 25, and suitably may have a press or weld fit with the floor in order to be supported thereby.

Flow of solvent plus dissolved carbon dioxide into tube 23 is suitably controlled by a valve arrangement such as that shown in FIG. 2 comprising a plug 30 of a generally suitable shape, such as hemispherical, or conical, or some other tapered, or even flat contour. As shown, the plug is hemispherical and is adapted to seat on the upper end 24 of the tube, the latter being suitably bevelled or concaved, as at 31, to receive the plug. The plug is attached to and moved by the rod 32, which at its upper end 33 is energized by cam 34 connected by pin 35 to manually operated knob 36 on the outer surface 37 of wall 38 of the tank. Pin 35 extends through the wall. The rod 32 is supported by right-angled bearing brackets 39 and 40. A coil spring 41 engages the rod, and at its lower end bears on the shelf 42 of bracket 40 while its upper end engages a retainer 43 fixedly secured to the rod. The spring thus biases the rod against the cam.

Forwardly of tank 14, the lid or working area 12 is provided with a number of openings 44 for receiving conventional instrument-holding stoppers 45. The latter have suitable openings (not shown) for the instruments. One stopper may be used to hold a conventional thermometer 46, shown with a length of lead connected thereto and comprising a temperature-controlled switch which operates a conventional relay (not shown) to turn on or shut off an electric heater shown diagrammatically at 47. The heater 47 is disposed in the bath liquid 13. This arrangement, which is conventional, is illustrated by the simplified circuit diagram in FIG. 1a comprising the heater 47 connected on one side to the power source 48 and

on the other side to the relay 49. Thermoregulator switch 46 connects the relay coil 49a to the power source. A stirrer (not shown) helps keep the bath liquid in temperature equilibrium, as is conventional, and a window 50 in front panel 51 of the cabinet 11 enables the operator to watch the progress of the tests. A fluorescent light (not shown) is located below the window inside the housing to provide good visibility. Also, a circular electric heater (not shown) is located in the annular air space between housing or cabinet 11 and container 10, and adjacent the lower end of the container, in order to prevent frosting and water condensation on the window and the outer surfaces of the container.

To operate the device, Dry Ice in large chunks, say 1 to 5 or 10 inches on a side, is placed in the tank and sufficient solvent added to overflow into and fill the tube 23. The Dry Ice quickly cools the solvent to a low temperature; for example, with acetone the temperature is rapidly decreased to below -100°F . within a few minutes. Cooled solvent plus dissolved carbon dioxide, hereinafter referred to as solution, flows down into the tube 23, displacing the warmer liquid, and creating a cycle which repeats itself over and over. As cooled solution flows into tube 23, thermal convection currents are set up immediately, and the bath liquid, which normally is mechanically stirred, proceeds to cool rapidly. The tube transfers heat rapidly not only because of these convection currents but also because dissolved carbon dioxide is boiled out of the solution inside the tube. As a result, solution flows or gushes rapidly out of the tube as it becomes warmer through abstraction of heat from the bath liquid, and colder solution from the tank immediately replaces the same. This cycle repeats itself automatically. Gaseous carbon dioxide may be vented to hood or outdoors through tube 54, to which rubber or other flexible tubing is connected.

When the bath is near the desired temperature, the valve plug 30 is moved to partially close tube 23 by rotating knob 36. This reduces the flow in tube 23 and decreases the rate of cooling. After further adjustment of the valve as may be necessary, fine control of the bath temperature is provided by the electric heater 47 in response to the thermoregulator 46.

During the conduct of tests, such as viscosity tests, it is desirable to have over-cooling capacity so that when test instruments are immersed in the bath the heat imparted to it will not increase its temperature undesirably. Over-cooling may be accomplished by further opening tube 23 by the valve 30.

A modified heat transfer member is shown in FIG. 3 wherein a tube 52 of smaller diameter is disposed within and concentric to tube 23a of larger diameter, creating an annular space 53. Tube 52 is open at both ends and terminates within an inch or two of the bottom of tube 23a. The latter is closed off at the bottom. Both tubes at their upper ends open in the same plane and may be closed off by a plug valve 30a having a flat lower face 53 which covers both tube openings. In this modification, cold liquid initially fills both tubes, and as the liquid is warmed by the bath liquid in the process of abstracting heat therefrom, carbon dioxide gas flows upwardly in the small tube. An advantage of this arrangement is that the flow of gas up and cold liquid down tends to be more rapid since each has its own path, so to speak. Thus less time is required for the bath to cool from room to test temperature.

In the modification of FIG. 4, two heat transfer members are again employed, a smaller and a larger one, but the smaller one, comprising the tube 60, is disposed to one side of the larger tube 23b. The plug valve 30b seals off only the tube 23b, as in FIG. 2. The tube 60 is open at the top and closed at the bottom. After the bath liquid has attained constant temperature, the heat transfer rate is much smaller than it is during the cooling-down period, and consequently the larger tube can be closed

and the smaller one kept in operation as needed to maintain the desired temperature. If desired, a valve, shown in dotted outline as 30c, may be used with the smaller tube for fine control, the valve arrangement being just like that for the larger tube but appropriately scaled down in size.

The desired low temperature of the bath will depend in part on the solvent, but with this in mind, a wide range of temperatures is available, extending for example from just below room temperature down to about -100°F . The bath liquid 13, of course, is one that is liquid and stable at the chosen temperature, and may include wax-free hydrocarbons, acetone, methanol, etc. If desired, the bath liquid may be the same as the carbon dioxide solvent, described below.

Accurate control over the bath test temperature is possible, the variation being less than plus or minus 0.04°F . at bath temperature of 0 to -65°F ., and in many cases the variation being no more than plus or minus 0.01°F . For bath temperatures between room and 0°F . the variation may be less than 0.02°F .

The carbon dioxide solvent may suitably be chosen from low molecular weight compounds including alcohols, ketones, ethers, esters, aldehydes, organic acids, etc. Low molecular weight compounds are desirable because, in general, their viscosity is low and they flow easily at the low temperatures involved. Illustrative specific solvents are methanol, ethanol, propanol, isopropanol, n-butanol, isobutanol, acetone, methyl ethyl ketone, methyl acetate, ethyl acetate, methyl butyrate, acetaldehyde, propionaldehyde. Other compounds are normal and iso-hexanes and pentanes.

The position of the Dry Ice tank 14 relative to the bath holder 10 is a convenient one and permits gravity flow of the Dry Ice solution in the heat transfer member 23. It will be understood in this connection that the tank may have other positions relative to the bath liquid or holder and that forced flow of the Dry Ice solution may be employed. Also, the member 23 need not necessarily extend from the floor of the tank, although that is a preferred arrangement; if need be, it can be operatively connected to the tank through a side or end wall, or the top. This member is shown as circular in cross section, but may have any suitable cross-sectional shape, such as a square, triangular, rectangular, pentagonal, hexagonal, or other multi-sided shape, including a star shape of any number of points, and further including curved as well as angular shapes. It will be appreciated, in this connection, that the rate of heat transfer increases with increasing surface area, all other things being the same. Any suitable material may be used to construct the heat transfer member, due care being observed to select a material of suitable strength and durability as well as heat transfer capability. Stainless steel is satisfactory, as is brass, aluminum, copper, nickel, zinc, iron, titanium, molybdenum, etc.

EXAMPLE

A cooling device constructed substantially in the manner illustrated in FIG. 1 had as bath holder a Pyrex glass Dewar or about 12 inches inside diameter and 16 inches depth, and a Dry Ice tank of stainless steel measuring 13 inches by 11 inches by 11 inches and having 2 inches of insulation on all sides, including top and bottom. A thin-walled stainless steel, cylindrical heat transfer tube of 2 inches outside diameter and 13 inches length was fixedly secured to the bottom of the tank, with the opening of the tube controlled by a spring-loaded cam-operated hemispherical plug valve that was movable by turning a knob on the front side of the tank, substantially as shown in FIG. 2. A conventional electric heater, thermoregulator, and stirrer were installed to operate in the Dewar, and the heater and thermoregulator connected in series with a relay and a main A.C. supply. The thermoregulator (a thermometer incorporating a

switch) actuated the relay, which turned the heater on or off. The stirrer was connected directly to the main supply.

About 6 gallons of acetone were placed in the glass Dewar. Chunks of Dry Ice were placed on a screen on the tank floor, and the latter filled to a depth of about 2 inches with acetone, after first filling the tube. The mouth of the tube was below the level of the acetone in the tank. Movement into the tube of acetone containing dissolved carbon dioxide began almost immediately, with warmer acetone in the tube being displaced. Beginning with the bath liquid at room temperature, temperature measurements of the bath were made at short intervals and are recorded below. Two such runs were made, each on different days.

Run 1:

Time, p.m.	Temp. ° F.
1:23 -----	63
1:25 -----	56
1:28 -----	44
1:32 -----	28
1:35 -----	18
1:38 -----	8
1:42 -----	-5
1:45 -----	-13
1:52 -----	-30
2:03 -----	-49
2:11 -----	-59
2:15 -----	-63
2:17 -----	-65

Run 2:

Time, p.m.	Temp. ° F.
1:29 -----	66
1:34 -----	35
1:39 -----	20
1:47 -----	-7
1:57 -----	-30
2:02 -----	-38
2:12 -----	-54
2:21 -----	-63
2:24 -----	65

It will be seen that rapid cooling rates were obtained, in each case the bath going from room temperature to -65° F. in less than an hour. It may be noted that a standard low test temperature currently in use is -60° F.

Besides Dry Ice, other useful coolants are liquid carbon dioxide, liquid helium, liquid air, liquid oxygen, liquid nitrogen, liquid argon and, in fact, any other normally gaseous material which can be liquified at a suitably low temperature, including the Freons (a group of halogenated hydrocarbons containing one or more fluorine atoms). Liquid carbon dioxide under pressure is suitable. The liquid coolants may be used with or without a solvent.

Other temperature sensing devices may be substituted for the thermoregulator, such as a resistance thermometer, thermister, gas thermometer, bi-metallic strip, etc., each controlling through a relay, or a magnetic amplifier, or directly, the current through the immersion heater. If desired, the immersion heater may be omitted if the opening of the valve 30-31 is automatically controlled by the temperature sensing device.

It is apparent that the Dry Ice tank and the heat transfer member associated therewith are adaptable for use with many existing constant temperature baths, that is, baths normally operated at high temperatures, such as 100° F. or 210° F., and that these baths may thereby be converted to constant low temperature baths without difficulty.

It may now be seen that the invention makes available a compact bath of simple construction which takes up little space and which is easy to operate. It is capable of rapidly attaining test temperatures. After use, or during overnight periods, it may be shut off, and later

restarted without difficulty and without an unduly large waiting period.

It will be understood that the invention is capable of obvious variations without departing from its scope.

In the light of the foregoing description, the following is claimed:

1. A constant low temperature bath comprising a bath liquid which is to be maintained at a constant temperature below room temperature, a hollow member of heat conducting material extending into the bath liquid in heat exchange relationship therewith, a reservoir for a coolant in communication with the member, said coolant being adapted to flow from the reservoir into the member and thereby cool the bath liquid, means to reduce the flow in the member, and means in the bath liquid independent of the member for assisting to maintain the bath liquid at said constant low temperature.

2. A constant low temperature bath comprising a bath liquid which is to be maintained at a constant temperature below room temperature, a tube of heat conducting material extending into the bath liquid in heat exchange relationship therewith, a reservoir of a low boiling carbon dioxide solvent adjacent the upper end of the tube, said upper tube end being in communication with the solvent, a mass of solid carbon dioxide resting in the solvent and serving to cool the same, said cooled solvent being adapted to flow by gravity from the reservoir into the tube and thereby cool the bath liquid, the heat of the bath liquid acting to boil out dissolved carbon dioxide from the solvent and said tube conducting the resulting carbon dioxide gas to said reservoir, said tube in turn being refilled by colder solvent from the reservoir, means to reduce the flow into and out of the tube, and means in the bath liquid independent of the tube for helping to maintain the bath liquid at said constant low temperature.

3. A constant low temperature bath comprising a bath liquid, a container of cold heat transfer medium in the non-gaseous phase adjacent said bath liquid, said medium being a gas at bath temperatures, a supply of solvent for said medium in contact therewith and forming a solution of the same on the floor of the container, a heat transfer member extending from the container into the bath liquid and having means for permitting flow of said solution therein, the solution in the container being adapted to flow in said member to cool down the bath liquid by heat exchange therewith, means for venting gaseous medium from the container, means for reducing the flow of solution into the member, and a second heat transfer member extending from the container into the bath liquid.

4. The bath of claim 3 wherein said second member is concentrically disposed within the first member.

5. The bath of claim 3 wherein said second member is separate from and disposed laterally of the first member.

6. In a constant temperature bath comprising a bath liquid, the improvement comprising a tank for Dry Ice adjacent said bath, a supply of solvent for Dry Ice in contact therewith and forming a Dry Ice solution in the floor of the tank, a hollow heat transfer member extending from the tank into the bath liquid, said member having an open end portion which extends just above said tank floor and which receives solution only from adjacent the tank floor, said member having a closed end portion disposed in and terminating in the bath liquid, the solution in the tank being adapted to flow in said member and to cool down the bath liquid by heat exchange therewith, said solution being out of contact with the bath liquid, the heat of the bath acting to boil out dissolved carbon dioxide gas from the solution in said member, said member conducting said gas back to said tank, said member also serving to transfer warmed solution therein back into said tank, means for venting carbon dioxide gas from the tank, and means for re-

ducing the flow of solution into the member comprising a movable plug for said open end portion.

7. A constant low temperature bath comprising a bath liquid which is to be maintained at a constant temperature below room temperature, a single hollow member of heat conducting material extending into the bath liquid in heat exchange relationship therewith, said member having a substantially vertical disposition in said bath liquid, a reservoir for a low boiling solvent for carbon dioxide adjacent the upper end of the member, said member having a short open end portion thereof which extends into said reservoir and terminates adjacent the floor of the latter, the other end of said member being closed and extending into and terminating in said bath liquid, said reservoir being adapted to hold solid carbon dioxide resting in the solvent and serving to cool the same, a portion of said carbon dioxide dissolving in the solvent, said cooled solvent and dissolved carbon dioxide being adapted to flow by gravity from the reservoir into the member and thereby cool the bath liquid, the heat of the bath liquid acting to boil out dissolved carbon dioxide from the solvent and said member conducting the carbon dioxide gas to said reservoir, and said member in turn being automatically refillable by colder solvent from the reservoir.

8. In a constant temperature bath comprising a bath liquid, the improvement comprising a supply of cold heat transfer medium in the non-gaseous phase adjacent said bath liquid, said medium being a gas at bath temperatures, a supply of solvent for said medium in contact therewith and forming a solution of the same, a heat transfer member extending into the bath liquid for vertical disposition therein, said member having an open end portion extending into said solution for receiving the same and a closed end portion disposed in said bath liquid, the solution being adapted to flow in said member to cool down the bath liquid by heat exchange therewith, said solution being out of contact with the bath liquid, said member also serving to transfer medium therein in the reverse direction back to said supply, and means for reducing the flow of solution into the member, comprising a plug for said open end portion of said member.

9. The bath of claim 8 wherein said cold heat transfer medium is in the solid phase.

10. The bath of claim 8 wherein said cold heat transfer medium is in the liquid phase.

11. In a constant temperature bath comprising a bath liquid, the improvement comprising a source of supply of cold heat transfer medium in the liquid phase adjacent said bath liquid, said medium being a gas at bath temperatures, a heat transfer member extending into the bath liquid and having an end portion which terminates therein, the other end portion of said member extending into said supply source for permitting flow of said liquid medium therein, the liquid medium being adapted to flow in said member to cool down the bath liquid by heat exchange therewith, said member also serving to transfer liquid medium therein in the reverse direction back to said supply source, and means for reducing the flow of liquid medium into the member.

12. A constant low temperature bath comprising a bath liquid, a walled container of cold heat transfer medium in the non-gaseous phase adjacent said bath liquid, said medium being a gas at bath temperatures, a supply of solvent for said medium in contact therewith and forming a solution of the same on the floor of the container, a heat transfer member extending from the container into the bath liquid and having a short open end portion thereof which extends into said container and terminates adjacent the floor thereof, said open end portion permitting flow of said solution therein, the solution being adapted to flow in said member to cool down the bath liquid by heat exchange therewith, means for venting gaseous medium from the container, means comprising a plug on said open end portion for reducing the flow of solution into the member, and said flow-reducing means being attached to a wall of said container and being manually operable.

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MEYER PERLIN, *Primary Examiner*.

ROBERT A. O'LEARY, *Examiner*.