Aug. 21, 1951 R. S. GAUGLER 2,565,220

REFRIGERATING APPARATUS

Filed Feb. 8, 1946 2 Sheets-Sheet 1

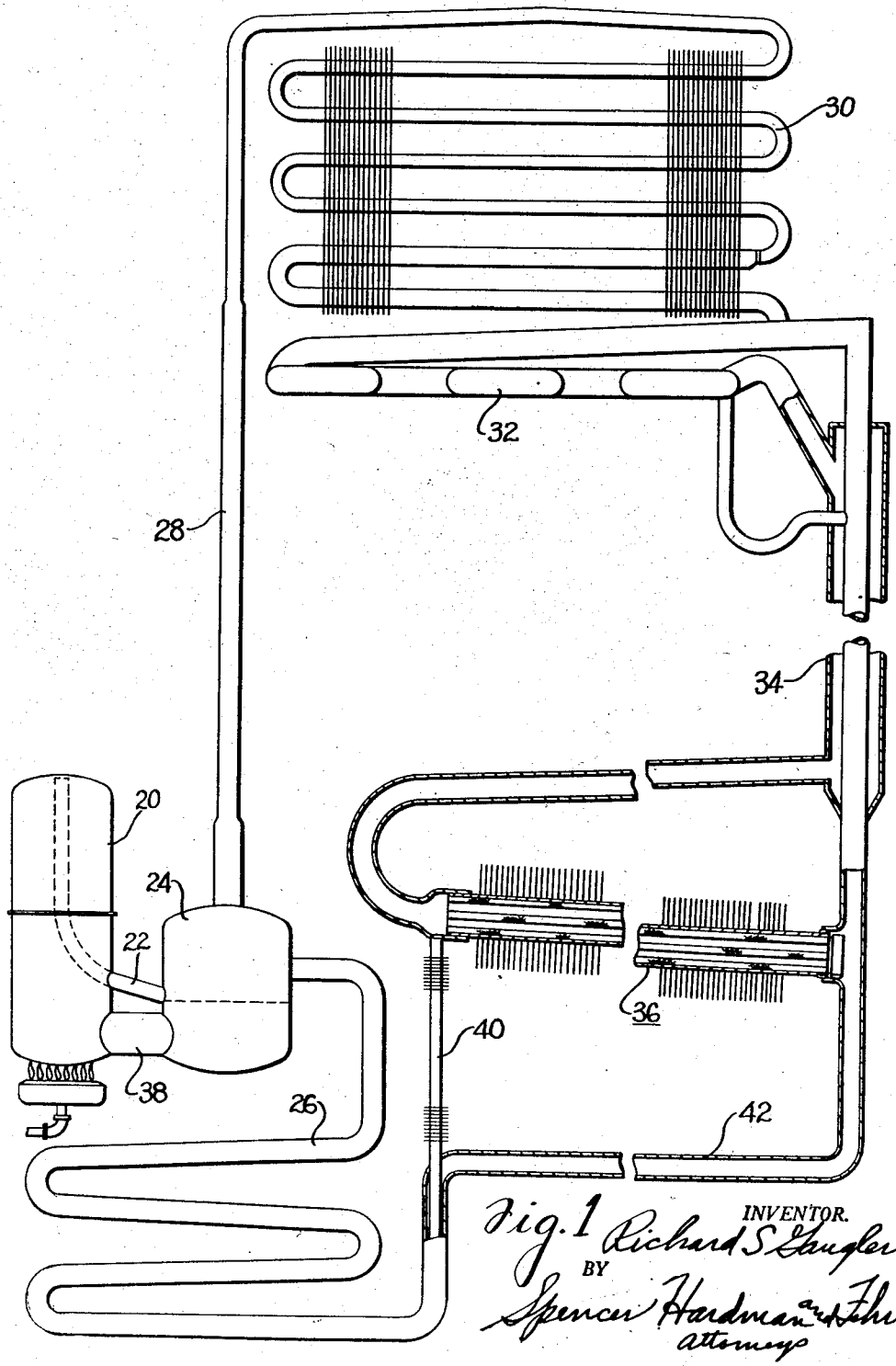


Fig. 1

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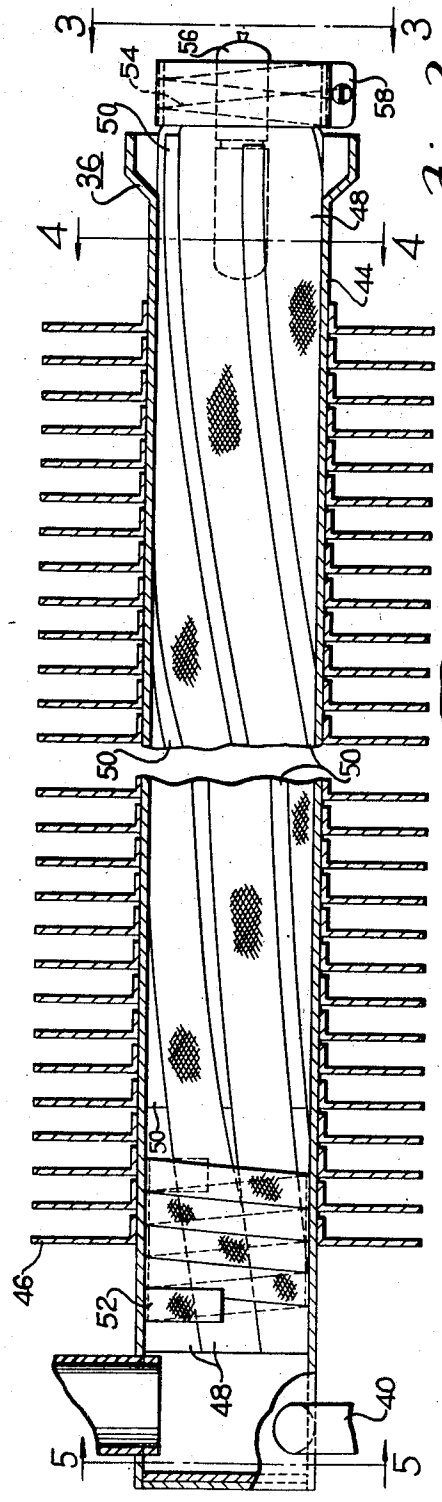


Fig. 2

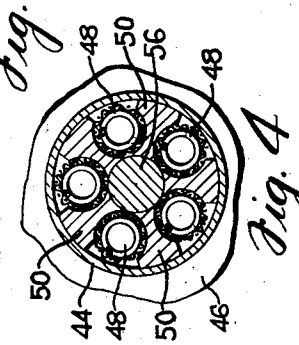


Fig. 4

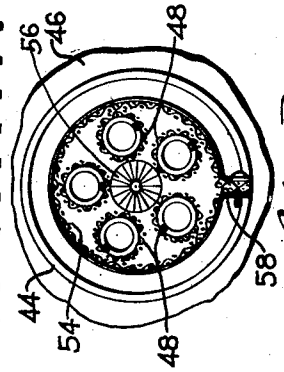


Fig. 3

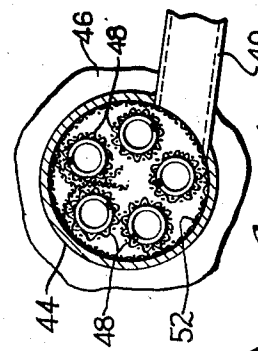


Fig. 5



Fig. 6

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REFRIGERATING APPARATUS

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9 Claims. (Cl. 261—104)

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This invention relates to gas and liquid contact apparatus such as, for example, may be used in absorption refrigeration apparatus.

The efficiency and effectiveness of absorption refrigerating systems largely depends upon the effectiveness of the gas and liquid contact in the absorber, in the evaporator and in the fractionator or analyzer. In addition to this contact, it is necessary to dissipate large amounts of heat from the absorber and to absorb large amounts of heat into the evaporator.

It is an object of my invention to provide a very efficient compact gas and liquid contact apparatus capable of exchanging heat readily, which is easy to build and low in cost.

It is another object of my invention to provide an efficient gas and liquid contact apparatus with large areas of exposed liquid film in the gas space which film is in good heat exchange relation with the walls of the gas and liquid contact container.

It is another object of my invention to provide an efficient gas and liquid contact apparatus employing woven wire sleeving in an effective manner to expose extensive areas of a thin film of liquid to a gas.

It is another object of my invention to provide an efficient gas and liquid contact apparatus employing woven wire sleeving in an effective manner to flow the liquid in a thin film of extensive area through a turbulent flow of gas.

It is another object of my invention to provide an efficient gas and liquid contact apparatus having means to effectively distribute the flow of liquid to a plurality of woven wire members of capillary construction in a parallel flow arrangement.

It is another object of my invention to provide an efficient gas and liquid contact apparatus having woven wire capillary means to effectively distribute liquid in a parallel flow arrangement.

To illustrate one way of carrying out the above objects I have disclosed an absorption refrigerating system of the Platen-Munters type provided with a gas and liquid contact apparatus in the form of an absorber consisting of a single tubular member slightly inclined and provided with cross fins for readily dissipating heat to the air. The tube contains five sleeving assemblies each made up of a single coil of wire over which are four sleeves of braided wire of different thickness and different tightness of weave. The space between each pair of these assemblies is blocked by a heat conducting member of compressed steel wool which is held tightly between each pair of assemblies and presses tightly against the wall

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of the tube so as to transmit the heat of absorption from the sleeving assemblies to the wall of the tube. The assemblies are arranged in the form of a helix and at the upper end they are wrapped in a ribbon formed of tightly flattened sleeving having a fine wire sleeve within a coarser wire sleeve. The weak liquor is fed to the bottom of this ribbon and is carried by capillary attraction to each of the assemblies and flows slowly downwardly within the walls of the sleeving assemblies to the other end where there is provided a second ribbon of similar composition which drains the rich liquor from the sleeving assemblies.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic view of an absorption refrigerating system embodying one form of my invention;

Fig. 2 is a vertical longitudinal sectional view of the absorber shown in Fig. 1;

Fig. 3 is a view taken along the lines 3—3 of Fig. 2;

Fig. 4 is a sectional view taken along the lines 4—4 of Fig. 2;

Fig. 5 is a sectional view taken along the lines 5—5 of Fig. 2; and

Fig. 6 is a view of one of the sleeving assemblies shown in Fig. 2.

Referring now more particularly to Fig. 1, there is shown an absorption refrigerating system including a generator 20 for distilling refrigerant vapor from the liquor in the generator. This hot vapor is conducted through the tube 22 to the fractionator 24. The rich liquor fed into the fractionator 24 from the heat exchanger 26 is stripped of some of its refrigerant vapor by the hot refrigerant vapor from the tube 22. The refrigerant vapor leaves the fractionator 24 through the conduit 28 and is conducted to the condenser 30 where the refrigerant is condensed and is fed to the evaporator 32.

The refrigerant in the evaporator is caused to evaporate by a stream of hydrogen which is fed to it from the heat exchanger 34 and passes through the evaporator taking the refrigerant vapor with it. By gravity, this mixture of hydrogen refrigerant falls through the heat exchanger removing heat from the rising hydrogen in the heat exchanger and then this gaseous mixture flows upwardly through the inclined absorber 36.

Weak liquor from the generator 20 is conducted through the connection 38 to the fractionator 24 and through the heat exchanger 26 and the tube 40 to the upper end of the absorber 36.

The absorber 36 contains extensive surfaces of multiple layers of woven wire material which holds the weak liquor in thin films of extensive area and exposes it to the mixture of hydrogen and refrigerant. Under these conditions the refrigerant vapor is absorbed from the gaseous mixture by the weak liquor in its downward flow through absorber so that the weak liquor becomes enriched and is returned through the tube 42 and the heat exchanger 26 to the fractionator 24 where it is partially stripped and thence carried into the generator 20. The efficiency of such a system depends very largely upon the efficiency and effectiveness of the gas and liquid contact in the absorber 36, in the evaporator 32 and in the fractionator 24. To do this requires extensive liquid surfaces in contact with flowing gas.

For the purpose of illustrating my invention I have shown my improved gas and liquid contact apparatus as applied to the absorber 36. The absorber 36 includes a piece of straight tubing 44 forming a part of the hydrogen circuit and also part of the liquor circuit of the refrigerating system. This tubing 44 is provided with a plurality of transverse fins 46 for keeping the tubing 44 as cool as possible. As shown in Fig. 1 the tubing 44 is slightly inclined, and the weak liquor is fed to the upper end by the tube 40. In order to provide a large area of liquid film exposed to the flow of gas, there are provided five flexible tubular conduits formed of woven wire sleeving each designated by the reference character 48. The detailed construction of these conduits is illustrated in Fig. 6. The sleeving is mounted upon a core of wire 49 in the form of a helix having about two turns per inch. Preferably this helix is formed of flat wire edge wound, but other forms of wire may be used. Over this wire there is slipped the first layer 60 of single braided sleeving made up of the heaviest wire used in this assembly. This first layer is primarily intended for the carrying of the liquor and to hold a large area of films of liquor. Preferably this first layer 60 is formed of single braided wire sleeving consisting of 48 ends of .010 steel weaving wire one end up.

The second layer 62 of sleeving is designed to provide high capillarity to prime the assembly on starting up the apparatus so that through this layer the entire assembly will become wetted with the liquor through capillary action. This second layer 62 consists of multiple braided wire sleeving having 48 ends of .004 steel weaving wire with four ends up and eight picks.

The third layer 64 assists in the priming of the assembly but also serves to carry liquid. This third layer 64 consists of single braided wire sleeving having 48 ends of .008 steel weaving wire with one end up.

The fourth or outer layer 66 consists of multiple braided wire sleeving having 48 ends of .004 steel weaving wire with five ends up and sixteen picks. This is a very tightly woven outer sheathing of multiple braided wire sleeving which tends to prevent the gas and liquid from escaping from the interiors of the conduits. When wetted, it is substantially airtight because the liquid seals the spaces between the wires.

Between each pair of conduits there is provided a blocking spacer 50 of highly compressed steel wool which is held tightly between the adjacent pairs of conduits and forced against the inner surface of the outer wall of the tubing 44. There are five conduits 48 and a spacer 50 between each of the conduits making five spacers. These are packed tightly into the tube so that both the conduits and the spacers fit tightly against the inner surfaces of the tube 44.

The liquid fed by the tube 40 is carried to the conduits 48 by the woven wire ribbon 52 which is formed of two sleeves one inside the other. The inner sleeve is preferably made up of 48 ends of multiple braided steel weaving wire four ends up eight picks, while the outer sleeve is made up of 48 ends of single braided .005 steel weaving wire one end up. These sleeves, one inside the other, are pulled out and flattened to the ribbon-shape shown in Fig. 2 and wrapped around the conduits 48 at the upper or left end thereof. The liquid from the tube 40 contacts the bottom of the ribbon 52 and spreads throughout with the inner flattened sleeve providing the capillarity and the outer sleeve the liquid carrying capacity. By contacting with each of the conduits the ribbon provides a flow of liquid in substantially equal amounts to these conduits. The braided wire of the sleeving assemblies holds the liquid by capillary action and carries it from one end to the other keeping the surface exposed on the inner layer. The conduits and the spacer members are twisted to form a helix having about one and one-quarter turns from one end to the other. The helix aids in equally distributing the capillary flow of liquid through the five conduits and for this purpose it should have one turn or more. The spacing members 50 in addition to blocking the spaces in between the sleeving conduits and transmitting heat, also prevent the liquid from escaping from the conduits and running to the bottom of the tube 44. They force the liquid to flow through the walls of the conduits in the helical arrangement provided. While compressed steel wool seems the best material for this, thin or thick metal or other spacers might be used in their place.

At the opposite end, the conduits 48 are wrapped within a second but shorter ribbon 54 of a construction and formation similar to the ribbon 52. The central space within the five conduits is plugged or blocked by the plug insert 56 which at the outer or right end thereof is covered with wire mesh material. This plugged end of the assembly is clamped together tightly by a clamp 58 binding the ribbon 54 to the outer surfaces of the conduits 48 and clamping the conduits tightly in contact with the plug 56. The ribbon 54 extends downwardly between the jaws of the clamp 58 where the clamping screw is located, so that the liquid from the conduits 48 will be carried by the ribbon down to the ends thereof where it will drain into the rich liquor conduit 42.

The spacers 50 stop short of the ribbon 52 at the one end and the clamping member 58 at the other end of the structure. The gas consisting of hydrogen and a refrigerant flows upwardly; that is, from right to left, through the interior of the conduits. It is prevented from by-passing the interior of these conduits by the central plug 56 and by the spacing members 50. The gas is thus forced to pass through the interior of the conduits 48 and in so doing is caused, by the helical wire 49, to travel partially in a helical path with relatively high turbulence thereby intimately contacting the film of liquid held by the inner layer of braided wire sleeving

to permit a high rate of absorption of the refrigerant by the weak liquor. The conduits are kept saturated at all times with the weak liquor which gradually by absorption of the refrigerant from the gas increases in concentration from the left end where it enters to the right end where it is drained. The first layer of sleeving, which is contacted directly by the gas, holds the liquid in a relatively thin film spread over a wide area. The mesh of this layer is comparatively open and holds a considerable exposed amount of liquid for contact directly with the gas.

The structure provides a very efficient absorber because of this efficiency of contact and wiping action between the gas and the liquid. The use of the five small conduits **48** greatly increases the liquid surface and the area of liquid contacted by the gas. By having the conduits themselves as well as the spacers **50** in contact with the inner surface of the tubing **44** and with each other and through the use of sufficiently large and numerous fins **46** on the outer surface of the tubing **44**, very good heat transfer is obtained.

While this apparatus is shown as an absorber for an absorption refrigerator apparatus it may also be used as an evaporator or a fractionator in such apparatus or it may be used in other cases where it is desired to provide good gas and liquid contact with a minimum of pressure drop. The gas in its flow through the conduits is not greatly obstructed and ample and effective circulation of the gas can be obtained by gravity convection.

Although four sleeves of braided wire are shown for each conduit, it is not necessary to use this exact number but as few as two sleeves may be used and any desired number of conduits may likewise be used. Also, although the wire **49** improves the contact between the gas and the liquid, and provides internal support for the conduits, it may be omitted if desired. It is not necessary to use the exact form of wire sleeving shown, but this has been found most effective in tests.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. Gas and liquid contact apparatus including an elongated hollow generally horizontal container forming a passage for the flow of gas therein, a plurality of conduits extending longitudinally within the container, said conduits being formed of a plurality of thicknesses of woven wire sleeving in close contact with each other, means for blocking the major portion of the space between the conduits and the adjacent walls of the container and for holding said conduits in firm contact with the walls of the container, and means for feeding a liquid to the conduits.

2. Gas and liquid contact apparatus including an elongated hollow slightly inclined container forming a passage for the flow of gas therein, a plurality of conduits extending longitudinally within the container, said conduits being formed of a plurality of thicknesses of woven wire sleeving in close contact with each other, and means for feeding a liquid to the conduits, said conduits each being formed of fine and coarser wire sleeving for carrying liquid laterally by gravity through capillary action.

3. Gas and liquid contact apparatus including

an elongated inclined hollow container forming a passage for the flow of gas therein, a plurality of conduits extending longitudinally within the container in contact with the walls thereof, said conduits including an innermost sleeve of coarse woven wire enclosed by a second sleeve of fine woven wire which in turn is enclosed by a third sleeve of woven wire having a fineness intermediate that of the first and second sleeves, the third sleeve being enclosed by a fourth sleeve of very tightly woven wire, and means for feeding a liquid to the conduits.

4. Gas and liquid contact apparatus including an elongated inclined hollow container forming a passage for the flow of gas therein, a plurality of conduits extending longitudinally within the container in contact with the walls thereof, said conduits including an innermost sleeve of coarse woven wire enclosed by a second sleeve of fine woven wire which in turn is enclosed by a third sleeve of woven wire having a fineness intermediate that of the first and second sleeves, the third sleeve being enclosed by a fourth sleeve of very tightly woven wire, means having good heat conduction having contact with and blocking the spaces between the conduits and the adjacent walls of the container, and means for feeding a liquid to the upper end of the conduits.

5. Gas and liquid contact apparatus including an elongated hollow container means having one end portion lower than the other end portion, means providing a path for the flow of gas therein, a plurality of conduit means having capillary properties providing a capillary flow of liquid in a plurality of parallel paths through the gas in the container means, means providing a pool of liquid beneath said conduit means, and a ribbon formed of a plurality of thicknesses of woven wire extending from said pool of liquid upwardly to each of said conduit means for feeding and distributing the liquid to each of conduit means providing flow into said plurality of parallel paths.

6. Gas and liquid contact apparatus including an elongated hollow slightly inclined container having a gas inlet adjacent one end and a gas outlet adjacent the other end forming a passage for the flow of gas from said gas inlet to said gas outlet therein, a plurality of substantially cylindrical capillary structures having an exposed surface of woven wire material, said container having a liquid inlet adjacent its upper end and a liquid outlet adjacent its lower end, said capillary structures being capable of conducting liquid by gravity flow from the higher end to the lower end of the container, said structures extending from said liquid inlet to said liquid outlet within said container each substantially in the form of an elongated coil with the coil axis being generally parallel to the container, said structures each substantially contacting the inner wall of the container throughout a major portion thereof, said structures being spaced from each other and being substantially parallel, and means for feeding liquid to the end of said capillary structures adjacent the liquid inlet and draining liquid from the end adjacent to the liquid outlet.

7. Gas and liquid contact apparatus including an elongated hollow slightly inclined container having a gas inlet adjacent one end and a gas outlet adjacent the other end forming a passage for the flow of gas from said gas inlet to said gas outlet therein, a plurality of substantially cylindrical capillary structures having an

exposed surface of woven wire material, said capillary structures being capable of conducting liquid by gravity flow from the higher end to the lower end of the container, said structures extending from said liquid inlet to said liquid outlet within said container each substantially in the form of an elongated coil with the coil axis being generally parallel to the container, said structures each substantially contacting the inner wall of the container throughout a major portion thereof, spacing means at each end of said structures for holding said structures spaced from each other and in contact with the inner wall of the container, and means for feeding liquid to the end of said capillary structures adjacent the liquid inlet and draining liquid from the end adjacent to the liquid outlet.

8. Gas and liquid contact apparatus including an elongated hollow slightly inclined container having a gas inlet adjacent one end and a gas outlet adjacent the other end forming a passage for the flow of gas from said gas inlet to said gas outlet therein, a plurality of substantially cylindrical capillary structures having an exposed surface of woven wire material capable of holding and conducting liquid by gravity flow from the higher end to the lower end of the container, said structures extending generally longitudinally from said liquid inlet to said liquid outlet within said hollow container, holding means for holding said structures in contact with the inner surface of the walls of said container, and capillary liquid feeding means extending into contact with the end of each of said structures adjacent the liquid inlet for feeding liquid thereto, said capillary structures being provided with a draining arrangement adjacent the liquid outlet for draining liquid into the liquid outlet.

9. Gas and liquid contact apparatus including an elongated hollow slightly inclined container

having a gas inlet adjacent one end and a gas outlet adjacent the other end forming a passage for the flow of gas from said gas inlet to said gas outlet therein, a plurality of substantially cylindrical capillary structures having an exposed surface of woven wire material capable of holding and conducting liquid by gravity flow from the higher end to the lower end of the container, said structures extending generally longitudinally from said liquid inlet to said liquid outlet within said hollow container, spacing means at the opposite ends of said structures for holding said structures in contact with the inner surface of the walls of the container, and means for feeding liquid to the end of said structures adjacent the liquid inlet and draining liquid from the end adjacent to the liquid outlet.

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