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TWO-PHASE DISK CONTACTOR

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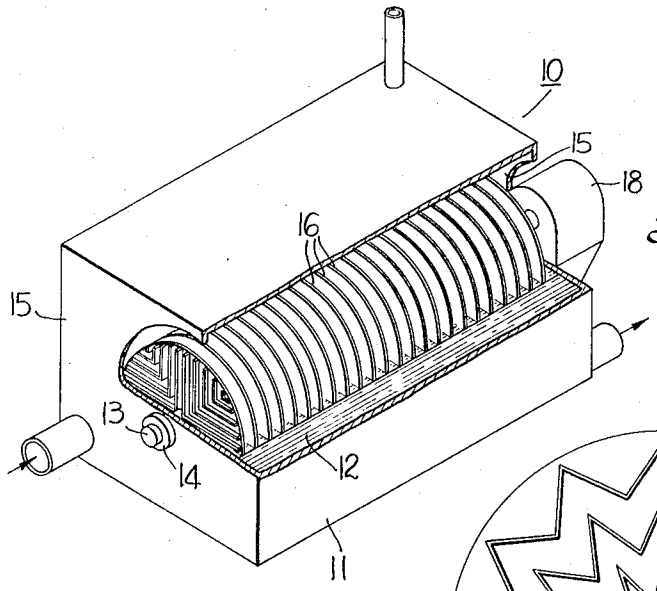



Fig. 1

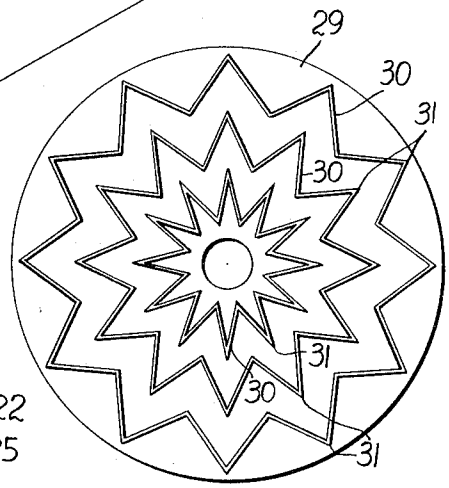



Fig. 4

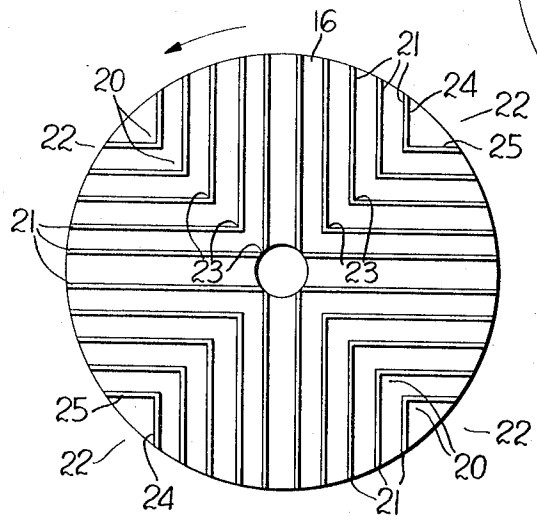



Fig. 2

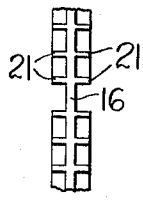



Fig. 3

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# TWO-PHASE DISK CONTACTOR

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1 Claim. (Cl. 261—92)

This invention relates generally to what is known in the art as two-phase contactors. More specifically, this invention relates to disks used in two-phase contactors.

The two phase contactor generally utilizes a plurality of elements which are dipped into a liquid, exposed to gas and then returned into the liquid. This type of device is used as a means to selectively absorb into or remove from a fluid certain elements or gases. Examples of successful applications of this type of a device are removing dust particles from an air stream and oxygenating liquids.

Two-phase contactors frequently utilize a plurality of disks which are rotated into a liquid and then exposed to a gas. As they are being rotated, the surface of the disks picks up a thin film of liquid. Hence, these disks rotate slowly to avoid throwing the liquid off by centrifugal force. As a result, the surface of the liquid film is usually saturated with the gas passing over the exposed portion of the disk within a very short time after the film emerges from the liquid. It has been recognized that a greater amount of gas can be absorbed on these disks if the amount of liquid retained on the disks and exposed to the gas is increased.

It has been suggested that roughing the surface of the disk would provide a larger surface area to which the liquid would adhere and thereby expose a greater surface area of liquid to the gas so as to absorb more of the gas. While this is true, roughing the surface of the disk has proved relatively inefficient.

This invention concerns a unique way of exposing a greater amount of liquid film to the gas so as to absorb a greater volume of gas and thereby improve the efficiency of the two-phase contactor. It has been observed that if the flow path of the liquid film picked up by the disk is elongated, a greater area of liquid film surface is exposed to the gas and a greater volume of gas is absorbed into the liquid being treated.

To elongate the flow of liquid on the disk, the disk of this invention has a plurality of projections which are arranged on the flat surface of the disk in the form of V's. The V-shaped projections are arranged in sets or groups with the vertices of the V-shaped projection being spaced outwardly of each other. In each case the opening of the V-shaped member faces the outer periphery of the disk.

Liquid is picked up in the troughs formed by the projections and the projections guide the flow of liquid on the disk surface. The liquid flows along the sides of a projection as the disk rotates through the gas phase of the contactor. Hence, the disk of this invention, significantly and efficiently elongates the flow path of the liquid on the disk.

Therefore it is the object of this invention to provide a new and improved two-phase contactor.

Another object of this invention is to provide a new and improved disk for two-phase contactors.

Another object of this invention is to provide a new and improved two-phase contactor having disks that provide an elongated flow of liquid on the disk.

Another object of this invention is to provide a more efficient two-phase contactor.

Other objects and advantages of this invention will be apparent from the following description when read in



connection with the accompanying drawings, in which:

FIG. 1 is an isometric view of a two-phase contactor having disks of this invention;

FIG. 2 is a front view of a disk showing the preferred embodiment of this invention;

FIG. 3 is an end view of the disk of FIG. 2; and

FIG. 4 is a front view of a disk showing an alternate embodiment of this invention.

Referring more specifically to the drawing by characters of reference, the two-phase contactor **10** of this invention is illustrated as a liquid gas contactor having a tank **11** with a bulk liquid to be treated flowing in the lower portion of the tank. A horizontally disposed shaft **13** is rotatably mounted in a pair of spaced apart bearings **14** which are mounted in the end walls **15** of the tank. A plurality of disks **16** are mounted on the shaft **13** for rotation therewith in a substantially vertical plane. The disks are illustrated as being one-half submerged in the bulk liquid **12** but the exact depth to which the disk is submerged would have to be set according to the materials used to obtain maximum results. A suitable source of power such as the electric motor **18** is provided for rotating the shaft. Preferably the shaft is rotated at a relatively slow speed to avoid throwing liquid off of the disks by centrifugal force.

As the disks are rotated through the bulk liquid **12** a film of liquid adheres to the surface of the disks **16** and is carried through and is exposed to the gas phase of the contactor. As the portion of the disk out of the water is being rotated, the liquid film on the surface tends to flow downward due to gravitational force. Naturally the amount of flow depends on the thickness of the film and its natural adherence to the material which forms the surface of the disk. In the disk **16**, more liquid is picked up than the amount which would naturally adhere to the disk surface through surface tension alone. The excess portion of that liquid flows downward along the surface of the disk more easily than the film adhering to the disk surface. Since flow along the disk surface is desired in this invention, an attempt is made to lift as much liquid as possible on the disk. Also, the speed of the disk has to be kept slow enough so that the gravitational force will overcome any tendency of centrifugal force of the disk to throw this liquid radially outward or to neutralize the forces on it so that the liquid does not flow at all.

It has been found by experimentation that the surface area exposed to the gas in this type of contactor is saturated with gas within a very short time after the disk emerges from the bulk liquid. Hence, one way to increase the amount of gas absorbed in the liquid is to expose a larger surface area of liquid to the gas. As the liquid film on the surface of the disk flows along the disk, it exposes additional film surface to the gas phase and more gas is absorbed into the liquid. This is a continuing process and hence, the greater distance the film flows on the disk before reentering the bulk liquid in the tank, the greater the amount of surface exposed to the gas and the greater the amount of gas absorbed in the liquid on the disk.

The disk **16** illustrated in the drawings is the preferred embodiment of this invention. The disk **16** has a plurality of projections **21** mounted on the surface thereof and arranged to form V-shaped troughs **20** opening to the outer periphery of the disk. These projections **21** are arranged in sets **22** with the projections of each set being spaced outwardly from the center of the disk. Preferably, the vertices **23** of each projection of a set are located along a radius of the disk.

The projections **21** may be considered as comprising a pair of legs **24**, **25** extending inwardly from the outer periphery of the disk and meeting to form a V-shaped

trough. The projections near the periphery of the disk are smaller than those that extend to near the center of the disk. For purposes of discussion, the leg first to emerge from the bulk liquid will be referred to as the leading leg **24** and the other leg as the trailing leg **25**.

The initial function of the projections is to trap liquid on the disk in excess of that which would normally adhere to the surface of the disk by surface tension alone. Then the projections guide the flow of liquid along the disk in an elongated path as the disk rotates in the gas phase of the contactor.

As a leading leg **24** emerges from the bulk liquid **12** it traps and lifts liquid on the disk. The leading legs of the projections closer to the center tend to trap more liquid because they are longer and are more nearly horizontal when emerging from the bulk liquid **12**. As the leading legs rise toward a vertical position the water in the adjacent troughs **20** tends to flow down the disk to the vertices **23**. When the trailing leg **25** of the projection has passed the horizontal position, the liquid trapped by that leg is also flowing toward the vertices **23**. As the leading leg again passes the horizontal position as it moves toward the bulk liquid, the liquid in the trough tends to flow back along the leading leg **24** toward the outer periphery of the disk and hence back into the bulk liquid.

The specific arrangement of the projections can be varied but generally the angle between the legs is held to 90° or less to obtain the best results.

In the alternate embodiment illustrated in FIG. 4, the projections are arranged differently on the surface of the disk **29**. Specifically, the projections are joined at their ends to form a continuous saw tooth shaped member **30** forming a closed loop around the center of the disk. A plurality of these members **30** are mounted on the disk in radially spaced relation. Each of the members **30** can be considered as being made up of a plurality of contiguous V-shaped projections **31**. In operation the V-shaped projections **31** function in substantially the same way as the V-shaped projection **21** described in connction with disk **16**. In addition, the members **30** trap liquid therebetween further prolonging the length of time and travel of the liquid film on the disk.

Experiments using the disks of this invention as compared with a plain disk with a roughed surface show that the amount of oxygen absorbed in the liquid film on the disk and hence dissolved into the bulk liquid in a given length of time can be increased by as much as 60 percent.

In operation, the liquid to be treated flows through the tank **11** by means of the inlet and outlet pipes. If a gas other than atmosphere is to be used in the contactor, gas such as oxygen is injected into the enclosed tank by any suitable means. The disks **16** are then rotated slowly with preferably 40 to 60 percent of their surface in the liquid. As one of the leading legs **24** emerges from the bulk liquid **12**, it is in a substantially horizontal position and traps liquid between the projection **21** and the surface of the disk in an amount which exceeds that which would naturally adhere to the disk by surface tension alone. As the disk continues to rotate, the leg **24** gradually assumes a vertical position. During this time, some of the liquid on the disk is flowing inward along the leg **24**. When the leg **24** is in the vertical position, all of the gravitational force on the liquid is downward and all the liquid tends to flow downward in the trough between adjacent projections to the vertices **23**. As the leading leg **24** passes through the vertical into the next quadrant the trailing leg **25** is passing the horizontal position and the liquid on the disk ends to be trapped in the trough formed by projection and the disk surface. When the leading leg **24** again assumes a substantially horizontal



position, the liquid from the trough **20** flows back along the leg **24** toward the bulk liquid.

Thus, the flow of molecule of water could be described as being picked up between projections, flowing radially inward along the leg **24** across the bottom of the trough **20** and then back down the leg **24** to the bulk liquid. The trailing leg **25** traps much less liquid than the leading leg but during its upward swing tends to direct the flow of liquid to the vertices **23** of the projection. By the time the trailing leg reaches the vertical position, the leading leg is passing through the horizontal position and the liquid picked up by the trailing leg flows from the vertex along the leading leg to the bulk liquid.

By comparison, if there were no projections on the disk, the liquid would tend to flow directly to the bulk liquid immediately upon emerging from the liquid and would find the shortest path to the liquid. As was pointed out above, the increased path of travel of the liquid causes a greater surface area of liquid film to be exposed to the gas resulting in a much higher volume of gas absorbed in the liquid film and returned to the bulk liquid being treated.

In connection with the disk of FIG. 4, liquid trapped by a projection tends to flow into a vertex on one of the projections and roll around there until the leading leg of the projection passes the horizontal position on its way to the bulk liquid. Then the liquid from the vertex flows along the leading leg and is dumped into the bulk liquid.

Although but two specific embodiments of this invention have been illustrated and described, it will be apparent to those skilled in the art that various modifications and changes can be made therein without departing from the spirit of the invention or scope of the appended claim.

Having now particularly described and ascertained the nature of my said invention and the manner in which it is to be performed, I declare that what I claim is:

A two-phase contactor comprising a casing, means to direct a liquid to be treated through the lower portion of said casing, a shaft within said casing mounted for rotation about a horizontal axis, a plurality of imperforate, generally planar disks on said shaft spaced apart axially of said shaft and partially immersed in said liquid, a plurality of V-shaped, liquid flow guiding projections protruding from at least one surface of each of said disks perpendicular to said axis and forming V-shaped troughs opening to the outer periphery of said disk, said V-shaped projections being arranged in sets in each of which the vertices are spaced apart along a radius of said disk, the legs of said V-shaped projections extending at an angle to and terminating on the outer periphery of said disk, and means for rotating said shaft at a sufficiently slow speed to prevent liquid from being thrown off said disks by centrifugal force and to permit said projections to entrap liquid on said surface when emerging from said liquid and to direct the flow of said liquid in an elongated path along said surface under the force of gravity.


**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 199,450 | 1/1878 | Kirkham et al. | 261—92 |
| 1,511,834 | 10/1924 | Marien | 55—407 X |
| 1,893,667 | 1/1933 | Darlington. | |
| 2,374,238 | 4/1945 | Schneible et al. | 55—231 |
| 2,698,287 | 12/1954 | Bowden et al. | 202—175 X |

FOREIGN PATENTS

| | | |
|---|---|---|
| 21,708 of 1891 | 1/1892 | Great Britain. |



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