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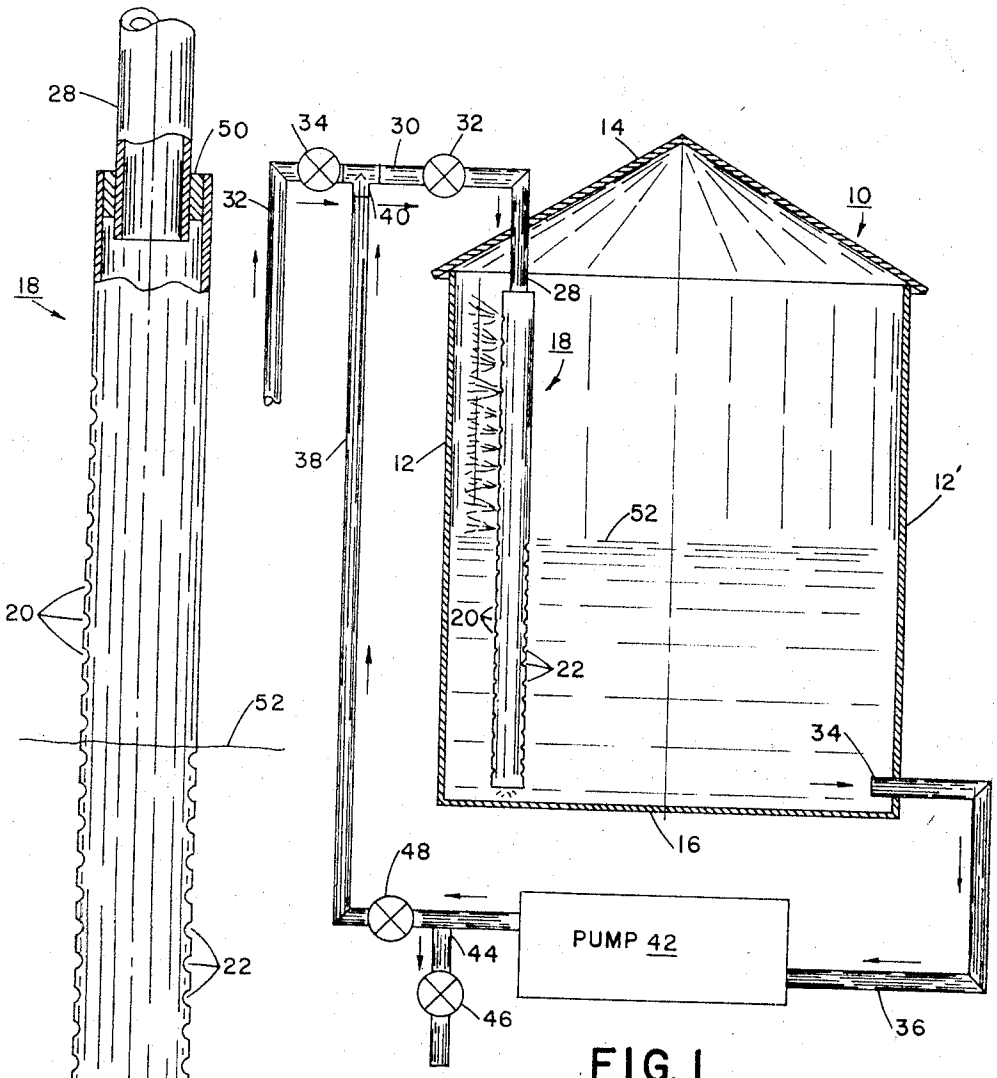


FIG. 1

FIG. 2

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TANK MIXING BY PUMP CIRCULATION

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The present invention relates to a method and apparatus for mixing liquids in a tank. More particularly, this invention relates to a method and apparatus adapted to mix such liquids by circulation of the liquids until a uniform consistency throughout the mixture is obtained. Specifically, the present invention relates to the mixing of volatile liquids which by their nature are subject to the hazard of static discharges.

It is well known in the fluid handling art that a dangerous static charge will be produced if a non-conductive volatile fluid is poured from any appreciable height into a storage tank. This static charge is built up in the tank due to the fluids free-falling into the non-conducting body of fluids previously collected in the tank. The static charge becomes hazardous when it accumulates to a point at which it arcs to the nearest conductor since, if the proper mixture of air and vapor is present when the arc occurs, an explosion is likely to result. The present invention insures against such a static discharge by eliminating the free fall of the fluids and yet provides for a rapid and complete mixing of the fluids within the tank.

Several different types of mixing devices have been proposed and used to prevent the static charge problem in fluid mixing and handling systems. Perhaps the most widely used of these prior art systems employs an open-ended pipe, known as a dip pipe. This pipe extends into the mixing tank from the top of the tank to within a short distance of the bottom, the liquid to be mixed being introduced through the open end of the dip tank. The liquid in the tank is then drawn off, recirculated, and again introduced through the dip pipe. As will be appreciated by those working in the fluid handling field, this method mixes only the fluid at the bottom of the tank and, consequently, requires a great deal of recirculation to assure a complete mixing. It is, therefore, quite time consuming, but does provide static electricity protection since there is no free-fall of liquid into the tank.

A second well known method of mixing is to eliminate the dip pipe and to interject the liquid from the top of the tank, recirculating it as before to complete the mixing. This method provides for a more rapid mixing, but, due to the free-falling liquid, has no static electricity protection.

A third type of prior known mixing apparatus consists of a conventional jet arrangement whereby a pump supplies high pressure fluids to a jet nozzle placed inside the tank. The aspirating effect of the jet allows mixing of the tank contents adjacent to the jet. However, this method is rather inefficient and has the disadvantages of high initial cost and maintenance expense, to say nothing of the fact that it provides no static electricity protection.

The present invention provides a method of mixing liquids which may be utilized on tanks of any size, which is more efficient than the aforementioned prior art methods, and which protects against the possible hazard of a static discharge during the mixing. These objectives are accomplished in the present invention by the utilization of a perforated, vertically disposed dip pipe arranged as in the prior art devices in that it extends through the top of the tank (or from a point in the side wall near the top) to within a short distance of the bottom. The dip pipe is located near a side wall of the tank and, preferably, runs substantially parallel thereto. A minimum

volume of liquid is maintained in the tank during the mixing operation so that at least a predetermined portion of the dip pipe is beneath this minimum liquid level at all times relevant hereto.

Located on the dip pipe and extending from the bottom thereof upwardly, and ending just below the minimum liquid level, are perforations through which the liquids pass into the tank. More perforations are located in the portion of the pipe which extends above the minimum liquid level. These, however, are located only on the side of the pipe which faces the near side wall for reasons which will be set forth more fully hereinafter. By introduction of the liquid through these vertically arranged perforations, the liquids are mixed into the top portions of the maintained liquid volume as well as the lower portions, thus, providing for a more rapid and complete mixing. The liquids passing through the perforations located below the liquid level provide no static electricity build-up since there is no free-fall of liquids. The pipe is arranged sufficiently close to the aforementioned side wall that liquid passing through the perforations which are above the liquid level fall onto the side wall and flow down the wall into the accumulated pool of liquid, thus preventing any appreciable free-fall of liquid into the tank. It is for this reason that it is essential that the last-mentioned perforations be located only on the side of the pipe nearest the side wall. Due to the location of the pipe and the arrangement of the perforations with regard to the minimum fluid level and their proximity to the side wall, one can readily see that substantially all of the free-falling of the fluids into the tank is prevented.

To provide for a complete mixing, the fluids are recirculated until an even consistency is obtained throughout. Due to the better mixing provided by the present invention, the recirculation time is reduced considerable over that of the prior art devices.

It is, therefore, an object of the present invention to provide a simple and inexpensive arrangement for a tank which will efficiently provide a rapid and complete mixing of liquids.

A further object of this invention to provide a method and apparatus for mixing liquids more efficiently than was possible with the prior art devices by introducing the liquids in a static free manner into the tank at various levels within the tank and by recirculating the liquids until the mixing is complete.

A still further object of the present invention is to introduce the liquids into the tank at various levels by the use of a vertically disposed pipe having perforations therein.

An additional object of the present invention is to provide a method and apparatus to mix volatile liquids quickly and efficiently with no build up of static electricity within the tank.

Yet another object of this invention is to mix such volatile liquids by means of the aforementioned vertically disposed perforated pipe arrangement.

A still further object is to prevent a static electricity build-up in non-conducting liquids by elimination of the free-fall of the liquids into the mixing tank.

These and other objects and advantages of this invention will be more apparent upon reference to the following description, appended claims, and drawings wherein:

FIGURE 1 is an elevation view of the arrangement of the present invention in relation to a mixing tank, the tank being shown in section for purposes of illustration, and

FIGURE 2 is an enlarged elevation view of the dip pipe utilized in the present invention, portions thereof being broken away for purposes of illustration.

With continued reference to the accompanying figures wherein like reference numerals designate similar parts

throughout the various views, and with initial attention directed to FIGURE 1, the reference numeral **10** indicates a mixing container or tank having side walls **12–12'**, a top **14** and a bottom **16**. Located within the tank **10** is a fluid input conduit or dip pipe **18**. As shown in the drawing, the pipe **18** is located relatively close to the side wall **12** and extends to within a short distance of the bottom **16** of the tank. In the preferred embodiment described herein, a row of apertures or perforations **20** is located in the side of pipe **18** which is closest to the side wall **12**. These perforations extend substantially the entire length of the pipe. Opposite the perforations **20** is a second row of perforations **22**. These extend from the approximate minimum liquid level line formed by the liquids normally held in the tank **10**, which for purposes of illustration is shown to be about the mid-point of the pipe **18**, to the bottom thereof. The lower end of the pipe is located near the bottom of the tank and is partially closed by the member **24** (FIGURE 2) which has an aperture **26** therein. The upper end of pipe **18** is connected to a feed pipe **28** which extends substantially vertically through the top **14** of the tank. Pipe **28** is connected to an input pipe **30** by a flow control valve **32**. Pipe **30** is in turn connected to a supply pipe **32** by a control valve **34**. The liquids which are to be mixed are conveyed from their storage containers through pipes **32**, **30** and **28** to dip pipe **18**. To insure that the flowing fluid pressure drop in pipe **18** will be low, pipe **18** is of a larger diameter than pipes **32**, **30** and **28**.

Located in the side wall **12'** of the tank is input end **34** of a recirculating pipe **36**. In the preferred embodiment of the invention, the end **34** is located at a point in the side wall **12'** which is furthermost from the pipe **18**, and which is near the bottom **16** of the tank. The other end **38** of the pipe **36**, which is opposite the end **34**, is connected to the pipe **30** by a T unit **40**. A pump **42** is operatively connected to recirculating pipe **36** to provide means to draw the liquids from the tank **10** and to convey the liquids to pipe **30**. Branching from the pipe **38** intermediate the ends thereof is outlet pipe **44** in which is located valve **46**. Located in pipe **38** adjacent to its juncture with pipe **44** and on the side closer, in the direction of fluid travel, to the pipe **30**, is a valve **48**.

Referring now to FIGURE 2 of the drawings, the detail of the dip pipe **18** can be more clearly seen. The vertical input pipe **28** is attached to the top of the dip pipe by means of a sleeve **50**. This sleeve may be welded to the pipes **18** and **28** or attached by threading the respective members. Regardless of which method is used, an air tight fit is achieved. Such a fit is necessary to prevent liquid from escaping at this connection of the two pipes, and possibly free-falling to the minimum liquid level **52**. A row of perforations **20** extends the length of the dip pipe **18** on the side of the pipe which is located nearest the side wall **12** of the tank. Opposite this first row of perforations is a second series of perforations which are indicated by the numerals **22**. The second row of perforations extends from the bottom of the pipe to about the minimum liquid level or, in the illustrated embodiment, the mid-point of the tank **10**. It is important that this row of perforations does not extend above the minimum liquid level **52** for reasons that will be more fully discussed hereinbelow. The bottom of the pipe **18** is partially closed by the member **24** leaving an aperture **26**.

In the operation of the present invention, liquids traveling in the direction of the arrows are brought by the pipe **32** from their storage areas and are delivered to the top of the dip pipe **18** through the pipes **30** and **28**. The liquid which enters pipe **18** passes through the apertures **20** and **22** located therein and thus into the tank **10**. Due to the perforations extending throughout the length of the pipe, the liquid is introduced at numerous levels within the tank. This results in a better mixing than was possible with prior art devices. The liquid is then withdrawn by

the pipe **36** through the end **34**. The withdrawing of the liquid is controlled so that the level **52** is normally maintained above the perforations. The liquid which is taken from the tank is then conveyed, as shown by the arrows, through the pipe **36** by means of pump **42** to the pipe **30**. From pipe **30** it flows through pipe **28** into pipe **18** and is again introduced into the tank **10** as before. If desired, the valve **34** in pipe **32** can be closed thereby making the recirculating system closed to the introduction of additional liquids. The recirculation is continued until the liquids are completely mixed.

Due to the more thorough mixing which is obtained by the use of the vertically disposed perforations, the amount of recirculation necessary to achieve a complete mixing is greatly reduced, thus substantially reducing time and cost of the mixing operation. Furthermore, the simplified nature of the arrangement and its individual parts, in contrast to some of the prior art methods, results in low initial and maintenance costs and decreases the likelihood of breakdown.

As an example of the more efficient results obtained from the present invention, a storage tank containing 25,800 gallons of acetic acid having a freezing point of 16.30° C. was mixed with a tank car containing 7,800 gallons of acetic acid with a freezing point of 16.40° C. A complete mixture would give a theoretical freezing point of approximately 16.32° C. The following analyses were taken as the liquids were mixed using the arrangement of the present invention:

Time of mixing:	Freezing point
Before circulation	16.36
10 minutes	16.30
20 minutes	16.32
30 minutes	16.32
60 minutes	16.33

It was concluded that the tank was mixed within 30 minutes. (It is to be recognized that the analytical procedure will vary the answer somewhat and that the theoretical freezing point of 16.32 was merely a rounded off figure, the actual freezing point being slightly above that value. The 16.33 is within the precision normally expected.) The mixing of this volume of acetic acid by a conventional dip pipe arrangement takes approximately 269 minutes. The great savings in time resulting from the present invention is clearly seen by the forgoing example.

After the liquid has been thoroughly mixed, the mixture can be taken from the mixing arrangement through the pipe **44** by opening valve **46** which is normally closed during the recirculation, and closing valve **48**. Drainage of the pipe **18** is accomplished through the opening **26** in the lower end of the pipe.

The second primary objective, that of achieving static electricity protection, is accomplished in the present invention in the following manner. As will be apparent, the liquid which passes into the tank **10** through the perforations **20** and **22** that are below the liquid level **16** go directly into the body of liquids which is maintained in the tank. Therefore, since there is no free-falling of these liquids there is no resultant static charge build-up. However, a static problem would exist if the liquids being fed into the tank **10** were permitted to free-fall for any appreciable distance from the perforations **20** or **22** into the liquid pool. To avoid this free-fall liquid flow from the perforations **22**, the liquid level **16** is never permitted to fall any appreciable distance below the uppermost perforation **22'**. This level is thus referred to as the minimum liquid level.

Although the liquid level in the pipe and the tank tends to equalize itself due to the constant inflow of liquid in the pipe **18**, the level within the pipe is usually somewhat higher than that in the tank. Consequently, some liquid must flow from the perforations **18** that are located above the liquid level **52**. There is also the ever present possi-

bility that the dip pipe **18** may become clogged thereby decreasing the number of submerged perforations through which the liquid may pass. This would tend to further increase the back-up of liquid within the pipe allowing liquid to pass through more of the higher perforations **20**. This liquid, if allowed to free-fall through any appreciable distance onto the body of liquid within the tank, would cause a build-up of a static charge. However, due to the location of the dip pipe **18** near the side wall **12** and the locations of the perforations **20** on the dip pipe next to this wall, any liquid which passes through these higher perforations will fall upon the side wall rather than free-falling onto the liquid in the tank thus eliminating the possible static electricity build-up.

Since the level of liquid in the tank may increase (although it is never allowed to fall appreciably below the minimum level) as liquid is brought into the tank, the perforations **20** extend the length of the dip pipe in order that the liquids will be introduced at all levels of the liquid in the tank whatever the volume in the tank may be. Therefore, when the tank is nearly full, mixing is still carried out at all levels due to the perforations **20** extending the full length of pipe **18**.

The size of the perforations is, of course, variable as are the sizes of the feed and recirculating pipes, the dip pipe and the mixing tank. Good results, however, have been obtained in arrangements having perforations of such a size and spacing that the sum of the areas in a three foot length of the dip pipe equals the cross-sectional area of the dip pipe. Results are also improved by the use of more than one perforated dip pipe in large mixing tanks.

As one can readily see the desired objectives have been achieved by the present invention as herein described. A simple and inexpensive arrangement has been presented which provides for a rapid and efficient mixing of liquids. Due to its simplicity, the likelihood of breakdown has been greatly reduced. The possibility of static electricity build-up and the consequent hazard of a static discharge has also been eliminated due to the noval and unobvious arrangement herein set forth.

While a preferred form of the invention has been shown and described, it is to be understood that various modifications and uses may be resorted to without departing from spirit of the invention which is within the scope of the appended claims. For example, a baffle plate or false wall could be placed adjacent the perforations **20** to serve as the surface upon which the liquid impinges rather than upon the wall of the tank.

What is claimed and desired to be secured by U.S. Letters Patent is:

1. An antistatic mixing system for liquids comprising:

(A) liquid container means;

(B) liquid conduit means disposed within said container means for delivering liquids into said container means,

(a) said conduit means having perforations formed on a first side thereof above the minimum liquid level line at which the liquids held in said container means are normally maintained,

(b) said conduit means having further perforations extending downward from approximately the minimum liquid level line of said container means on a side other than the first side of said conduit;

(C) means for delivering to said conduit means the liquids which are to be mixed within said container means; and

(D) baffle means positioned adjacent at least the perforations formed on the first side of said conduit means for preventing the free-fall of the liquids passing through the perforations onto the surface of any liquids that have been previously introduced into said container thereby preventing the build-up of static electricity.

2. An antistatic mixing system for liquids according to claim **1** wherein said conduit means extends from approximately the top to the bottom of said container means.

3. An antistatic mixing system for liquids according to claim **2** wherein said conduit means is an input pipe having perforations extending along the first side thereof from approximately the top of the container means to the bottom thereof, and further perforations extending from approximately the minimum liquid level line of said container means to the bottom thereof on a side other than the first side of said pipe.

4. An antistatic mixing system for liquids according to claim **3** wherein the first side of said input pipe is located adjacent one wall of said container means so that said wall acts as the baffle means for preventing the free-fall of the liquids passing through the perforations onto the surface of any liquids that have been previously introduced into said contained thereby preventing the build-up of static electricity.

5. An antistatic mixing system for liquids according to claim **4** wherein recirculating means is provided for withdrawing a predetermined quantity of liquid from said container means and reintroducing it into said input pipe to thereby assure a complete mixing.

6. An antistatic mixing system for liquids according to claim **5** wherein said recirculating means is a recirculating pipe which is connected to said container means so that it takes liquids from said container means at a point removed from the bottom of said input pipe.

7. An antistatic mixing system for liquids according to claim **6** wherein the perforations on said input pipe are so spaced and are of a size that the sum of the areas of the perforations within a three-foot length of said input pipe is equal to the cross sectional area of said input pipe.

8. An antistatic mixing system for liquids according to claim **7** wherein the end of the input pipe located near the bottom of said container means is partially closed.

9. An antistatic mixing system for liquids according to claim **8** wherein the cross sectional area of the input pipe is greater than the cross sectional area of the pipe feeding liquids into said input pipe.

10. A method of mixing liquids in a container comprising the steps of:

(A) maintaining a volume of the liquids in the container during the mixing so that the level of liquids in the container is held above a predetermined minimum level;

(B) simultaneously introducing the liquids to be mixed into the container at different levels, said levels being below the minimum level of the liquids in the container; and

(C) simultaneously with the introduction of the liquids below the minimum level of the liquids, introducing further amounts of the liquids onto the wall of the container at various levels above the liquid level so that the liquids do not free-fall onto the surface of any liquids that have been previously introduced into said container thereby preventing the build-up of static electricity.

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