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(54) Title: CLEANING COOLING TOWERS

(57) Abstract: A method of and apparatus and an aqueous descaling solution for cleaning a cooling tower is described. The cooling tower is cleaned by spraying an aqueous descaling solution into the upper end of the plenum chamber of the tower to cause it to foam and contact packing members located therein for a period sufficient to effect descaling of the packing members. The tower is then flushed through with water to remove the descaling solution. The solution used is a solution of hydrochloric acid, either alone or in combination with orthophosphoric acid, and an acid-resistant foaming agent.

Cleaning Cooling Towers

Field of the Invention

The invention relates to the cleaning of cooling towers.

Background of the Invention

Cooling towers are heat transfer devices which are used to transfer process heat to the atmosphere. The working fluid from which such heat is transferred to the atmosphere is water, whether as a primary working fluid extracting heat directly from a heat source or as a secondary working fluid, which extracts heat from a primary working fluid circuit, which extracts heat from a heat source. Cooling towers may transfer process heat to the atmosphere using either the evaporation of water to cool the water to near the wet-bulb air temperature or through the circulation of air in contact with the water to cool it to near the dry-bulb air temperature.

Typically, cooling towers are used to extract process heat in power stations, oil refineries (petroleum refineries and petrochemical plants), chemical plants, natural gas processing plants, food processing plants and in other industrial processes in which large amounts of heat are generated and in large air conditioning applications such as are used in hospitals, schools, large office buildings and the like. Cooling towers vary significantly in size depending on the application in which it is used and may be small roof-top units to very large hyperboloid structures which may be over 40m tall and 100m in diameter.

Within such cooling towers, warm or hot water from which heat is to be extracted is fed into the top of the tower to flow downwardly through the tower whilst air is introduced into the tower at the bottom or through the sides to flow upwardly through the tower. Contact between the water and the air is maximised by filling the tower with packing members, which provide convoluted flow paths through which the water flows in contact with surfaces provided by the packing members to expose a large surface area of water to the counter-current flow of air. Water exiting from the bottom of the cooling tower collects in a pool or basin from which it may be recirculated to the top of the tower.

The packing members are typically made of wood, plastic or metal, but are usually of plastic, and typically are 1m high. The packing members are arranged in layers within the tower.

Typically, the water used in the cooling towers is extracted from local water sources such as rivers, lakes and towns' main water supply. Consequently, salts of, for example, calcium, magnesium and iron deposit on the surfaces of the packing members reducing the efficiency of heat transfer and, in extreme conditions, reducing the flow of water through the towers. Additionally, the contamination of such surfaces may increase the likelihood of the growth of biological species on such surfaces, the main danger being the growth of hazardous species such as the Legionella organism on such surfaces.

Consequently, cooling towers require regular cleaning in addition to other necessary maintenance operations. In the UK, the HSE regulations appertaining to cooling towers recommend such towers are subjected to a cleaning regime, which may includes treatment with a biocide, at least twice a year. As will be appreciated, the removal of packing members for removal of the deposits is a time-consuming and costly exercise, made all the more difficult by such members becoming locked in place by the deposits. Thus, although removal of the packing members for cleaning may be achieved in smaller cooling towers, it is impractical to remove packing members from larger cooling towers and it is necessary to implement *in situ* cleaning regimes.

For many years cooling towers were cleaned using pressure hoses to jet high-pressure water to try and remove the deposits from the surfaces. However, this procedure is not very effective and requires a large labour force. For surfaces hidden from the operators, the process is almost totally ineffective.

It has been proposed to circulate a biocide containing a foaming agent through the tower. However, this process has been found to be substantially ineffective at removing any scale from the packing members within the tower and, consequently, is also inefficient in neutralising bio

It has been proposed to fill equipment that requires descaling with a selected inorganic or organic acid and to circulate it in a closed loop to descale surfaces within the equipment. In that process, the acid strength is monitored to determine how the descaling process is progressing, and, if necessary, the acid may be topped up to maintain its strength during the descaling process. Such a process requires the use of large quantities of acid with subsequent flushing out of equipment and neutralisation of the acid. An example of such a process may be found in US 2003/200997.

In an alternative process, it has been proposed to descale a vessel using mineral acid containing a foaming agent that flows through the vessel and, optionally, treating the descaled vessel with an antifoaming agent to remove any traces of the foaming agent. Examples of such processes may be found in GB 923281, GB 1120684, US 2009/114247 and CA 2676517.

Cleaning and descaling solutions for other applications, for example for cleaning and descaling sanitary ware, have been proposed which are based on mineral acids contained within thickened solutions to improve their adherence to the surfaces of the sanitary ware being cleaned and descaled. Examples of such solutions may be found in GB 1443244 and GB 2971688.

Summary of the Invention

It is an object of the present invention to provide a method of cleaning a cooling tower, a descaling solution for use in cleaning cooling towers and apparatus for spraying a descaling solution.

According to the present invention, a method of cleaning a cooling tower which comprises a plenum chamber which is packed with packing members, said method comprising spraying an

aqueous descaling solution into the top of the plenum chamber to cause it to foam and to contact the packing members for a period sufficient to effect descaling of the packing members and flushing the tower with water to remove the descaling solution, wherein the aqueous descaling solution is foamable on spraying to form a stable wet foam and comprises a solution of hydrochloric acid, either alone or in combination with orthophosphoric acid, and an acid-resistant foaming agent.

The present invention also includes an aqueous descaling solution for use in cleaning cooling towers, which solution is foamable on spraying to form a stable wet foam and comprises hydrochloric acid, either alone or in combination with orthophosphoric acid, and an acid-resistant foaming agent.

Also, according to the present invention, apparatus for spraying an aqueous descaling solution comprising a solution of hydrochloric acid, either alone or in combination with orthophosphoric acid, and an acid-resistant foaming agent into a plenum chamber of a cooling tower, which solution being foamable on spraying to form a stable wet foam, said apparatus comprising a spray means by which the aqueous descaling solution may be distributed in the top of a cooling tower during use of the apparatus, a pump mechanism connectable to and operable to pump the solution from a container for the solution to the spray means, a pressure control valve operable to control the pressure of the solution delivered to the spray means and a pressure relief valve for returning the solution to the container should the pressure of solution being pumped to the spray means during use of the apparatus become too high.

Preferably, the pressure control valve controls flow in a solution flow line connected between a solution supply line connecting the pump to the spray means and the container.

Preferably, the apparatus further comprises the container for the solution, said container typically being an intermediate bulk container (IBC).

Preferably, the spray means may comprise a lance capable of delivering a flow of 150 to 360 l/hr, typically around 300 l/hr, of the aqueous descaling solution under pressures of up to about 10 bar. In one preferred embodiment, the end of the lance from which the solution exits is open, that is, it is not constricted by any form of nozzle. This arrangement has been found to deliver the solution in a spray from which wet stable foam of the required consistency may be produced.

In preferred embodiments of the invention, the aqueous descaling solution is sprayed in a smooth continuous flow. Should a particular pump mechanism used in the apparatus of the invention or a particular configuration of the connection of the pump mechanism to the spray means result in pulsing of the solution as it exits the lance, it is preferred that the apparatus further comprises pulse damper means to dampen pulses in the flow of the solution to the spray means.

The cooling tower may be cleaned whilst it is "off line". In other words, circulation of cooling water through the tower is terminated prior to spraying the solution into the plenum chamber and it is recommenced following flushing of the tower with water after the period allowed for effecting descaling of the packing members.

However, in some plants, it may not be practicable to take the cooling tower "off line" and it may be necessary to perform the cleaning operation with the cooling tower "on line". In this instance, as the packing members are typically arranged in segments within the plenum chamber, it is possible to take advantage of such segmentation and clean the segments in sequence. In this embodiment, circulation of the cooling water through each segment of the tower within the plenum chamber being terminated prior to spraying the solution into the segment being cleaned and recommenced following flushing of the segment with water after the period allowed for effecting descaling of the packing members within that segment.

It will be appreciated that, as the cooling tower remains "on line" in this embodiment, it may be necessary to ensure the circulating cooling water does not have too low a pH or foams to much. This may be achieved by monitoring the quality of the water being extracted from the collection pool or lagoon for circulation through the plant and, if necessary, adding neutralising agents and/or antifoaming agents to the water to adjust those parameters to within acceptable limits.

The solution may be sprayed into the plenum chamber, or a segment thereof, for a period of up to 12 hours. The period for which the solution is left in contact with the packing members will vary depending upon the composition of the solution being used and the amount of scale present on the packing members and other structures within the cooling tower. Typically, the period exclusive of the period during which the solution is sprayed into the plenum chamber, may be a few hours say 8 or 12 hours but could be up to 24 hours or 48 hours.

In a preferred embodiment, the aqueous descaling solution used in the present invention comprises hydrochloric acid in combination with orthophosphoric acid. Such a descaling solution is particularly useful when the cooling tower is cleaned "off line".

If the cooling tower is to be cleaned "on line", it is preferred that the aqueous descaling solution used in the present invention comprises hydrochloric acid alone, thereby avoiding problems which may be potentially caused by the presence of the orthophosphoric acid and any phosphates it may generate within the plant.

Preferably, the acid solutions used to formulate the aqueous descaling solution used in the present invention are 20 to 50 % v/v aqueous hydrochloric acid solution, more preferably 30 to 40 % v/v aqueous hydrochloric acid solution and 75 to 95 % v/v aqueous orthophosphoric acid solution, more preferably 80 to 90 % v/v aqueous orthophosphoric acid solution.

In one embodiment, the aqueous descaling solution comprises between 5 and 25 % w/w hydrochloric acid solution as defined in the preceding paragraph, more preferably between 10 and 20 % w/w hydrochloric acid solution. In a preferred embodiment, the aqueous descaling solution comprises between 10 and 30 % w/w of orthophosphoric acid solution as defined in the preceding paragraph, more preferably between 15 and 25 % w/w orthophosphoric acid solution and between 5 and 25 % w/w hydrochloric acid solution as defined in the preceding paragraph, more preferably between 10 and 20 % w/w hydrochloric acid solution. Preferably, in either embodiment, the balance is made up with demineralised water.

The pH of the solution is preferably not more than 3 and typically may be about 1 to 2 dependent upon the condition and design of the cooling tower.

Preferably, the aqueous descaling solution comprises at least 0.1% w/w, more preferably at least 0.5% w/w and more especially at least 1% w/w of the acid-resistant foaming agent. Preferably, the aqueous descaling solution comprises up to 20 % w/w, more preferably up to 15 % w/w, and typically about 5% w/w to 10 % w/w of the acid-resistant foaming agent.

The foaming agent may be any suitable acid-resistant foaming agent capable of generating stable wet foam that will flow slowly through the packing members of the cooling tower to coat the surfaces of those members for a period sufficient to enable the acids in the foam to react with the deposits on the members and resolubilize them. Typically, the foamed solution flowing through a 6m high cooling tower would exit from the bottom of the tower in about 10 to 30 minutes, for example in about 15 minutes. The foaming agent may be one or more alkyl amine oxides, eg alkyldimethyl amine oxide, or alkylamine dicarboxylates or mixtures thereof.

In a preferred embodiment of the present invention, the aqueous descaling solution comprises an inhibitor to reduce the corrosive action of the acids on metal within the cooling tower, either present as packing members or in fittings and fixtures within the tower or both. The inhibitor may be anodic and/or cathodic dependent upon the cooling system being cleaned. The inhibitor may be Inhib 200 or Inhib 201 available from Biochemica UK Ltd.

In another embodiment of the present invention, the aqueous descaling solution comprises up to 1 % w/w, more preferably up to 0.1 % w/w, and typically about 0.05 % w/w of a biocidal substance capable of functioning in an acid environment or a substance capable of generating a biocidal substance in the presence of acid in the solution. The biocidal substance is preferably chlorine dioxide or bromine dioxide, preferably chlorine dioxide, which gas dissolves in the water of the solution. These dioxides may be generated by including an alkali metal chlorite or bromite, preferably sodium chlorite or bromite, in the solution. In a preferred embodiment, sodium chlorite is included in the solution.

In an alternative embodiment, the biocidal substance capable of functioning in an acid environment or a substance capable of generating a biocidal substance in the presence of acid is added to the solution in the proportions mentioned in the preceding paragraph immediately prior to it being sprayed into the plenum chamber of the cooling tower and onto the packing members.

Following descaling of the packing members of the cooling tower, the tower is flushed through with water, usually by initiating recirculation of the water from the pool or basin below the tower. Although the spent descaling solution drains into the pool or basin, because the pH of the solution has increased owing to its reaction with and resolubilization of the deposited salts neutralising the acids in the solution and depending upon the size of the pool or basin it may not be necessary to neutralise the pool or basin water. However, if required, the residual acids in water in the pool or basin may be neutralised by adding a suitable base such as an alkali metal or alkali earth metal salt such as sodium hydroxide or (bi)carbonate or calcium hydroxide. Also, if required, the pool or basin may be at least partially drained, before or after neutralisation, and the water disposed of in an environmentally safe manner, the pool then being refilled prior to the start of circulating the fresh water through the cooling tower.

In many instances, it will also not be necessary post-cleaning of the cooling tower to counteract affects of the foaming agent. However, again, should mild foaming persist, it is possible to add an antifoaming agent to the water recirculating through the cooling tower. Examples of suitable antifoaming agents are silicon-based antifoaming agents.

Brief Description of the Drawings

The present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of apparatus of the invention;

Figure 2 is a photograph taken within packing members in a cooling tower prior to cleaning; and

Figure 3 is a photograph taken within packing members in the cooling tower shown in Figure 2 following cleaning using the present invention;

and with reference to the Example described below.

Detailed Description of the Preferred Embodiments

Referring to Figure 1, apparatus 10 according to the present invention has a pump 12 capable of delivering an aqueous descaling solution in accordance with the invention to a spray lance 14. The pump 12 is typically capable of delivering the solution at up to 360 l/hour at a pressure of up to 10 bar. The spray lance 14 has a trigger release for permitting the solution to spray from the

lance 14 under the delivery pressure and the end of the lance from which the solution exits is open, that is, it is not constricted by any form of nozzle.

The suction inlet of the pump 12 is connectable via a flexible connector 16 to an IBC 18 for containing the solution. A line 20 connects the outlet of the pump 12 to an isolation valve 22, the outlet from which is connected by a flexible hose 24 to the spray lance 14.

The line 20 is also connected to the IBC 18 via a line 26 flow through which is controlled by a pressure control valve 28, which valve 28 is operable to control the pressure of the solution in the line 20 and, consequently, the pressure of the solution delivered through the isolation valve 22 to the spray lance 14. The pressure in the lines 20 and 26 may be monitored using a pressure gauge 30 connected to the line 26. A line 32, flow through which is controlled by pressure relief valve 34, which typically may be set between 0 and 9 bar, for returning the solution to the IBC 18 should the pressure of solution delivered by the pump 12 to the spray lance 14 during use of the apparatus become too high.

In operation, an aqueous descaling solution in accordance with the invention is charged into the IBC 18. The pressure relief valve 34 is set to a desired value such that, if over pressure occurs in the delivery line to the spray lance 14 it will recycle the solution back to the IBC 18. The pressure control valve 28 is manually adjusted such that, when the pump 12 is operated to deliver the solution to the spray lance 14, the solution is delivered to the lance 14 at the required pressure. Once the operative has taken the lance 14 with its trailing flexible hose 24 into the top of the plenum chamber of the cooling tower to be cleaned and is in position to spray the solution on to the pack in the tower, the pump 12 is then started to deliver the solution through the hose 24 to the lance 14. The operator then uses the trigger of the lance 14 to permit the solution to flow through the lance 14 and be sprayed on to the packing members. Once spraying is complete, the pump is switched off.

Example

An aqueous descaling solution in accordance with the present invention was prepared by mixing 36 % v/v aqueous hydrochloric acid solution, 85 % v/v aqueous orthophosphoric acid solution and alkyldimethyl amine oxide together with additional demineralised water as required to 100% to form a descaling composition having a composition of 21 % w/w of orthophosphoric acid solution 14 % w/w hydrochloric acid and 10 % w/w of alkyldimethyl amine oxide.

The solution was charged into the IBC 18 together with sodium chlorite and used to clean a cooling tower in which the packing members were covered in significant amounts of deposits as shown in the photographs of Figure 2.

An operator suitably attired in protective clothing entered the top of the plenum chamber of the tower with the lance 14 with its trailing flexible hose 24. The pump 12 was then switched on and

the operator triggered the lance 14 to spray the solution over and into the packing members. As the solution was sprayed over the packing members, it foamed to form stable wet foam that slowly flowed through the packing members under the influence of gravity to cover the surfaces to be cleaned. The spraying operation typically takes 3 hours per IBC load. Foam is sprayed the plenum chamber for a period of 12 hours.

After a period of time sufficient for the foamed solution to effect removal of the deposits from the surfaces of the packing members, typically up to 48 hours, the packing members are flushed down using pressurised water jets to remove the remnants of the foamed solution and any remaining loose debris leaving the surfaces of the packing members substantially clean and free of deposits as is shown in the photographs of Figure 3.

The surfaces of the packing members cleaned using the aqueous descaling solution according the present invention were significantly cleaner than the level of deposit removal achieved in a similar cleaning operation performed using a descaling solution containing only phosphoric acid and a foaming agent.

Claims

1. A method of cleaning a cooling tower which comprises a plenum chamber which is packed with packing members, said method comprising spraying an aqueous descaling solution into the top of the plenum chamber to cause it to foam and to contact the packing members for a period sufficient to effect descaling of the packing members and flushing the tower with water to remove the descaling solution, wherein the aqueous descaling solution is foamable on spraying to form a stable wet foam and comprises a solution of hydrochloric acid, either alone or in combination with orthophosphoric acid, and an acid-resistant foaming agent.

2. A method according to claim 1 wherein the aqueous descaling solution comprises 20 to 50% v/v aqueous hydrochloric acid solution and, when present, 75 to 95% v/v orthophosphoric acid solution.

3. A method according to claim 2 wherein the aqueous descaling solution comprises between 5 and 25% w/w of said aqueous hydrochloric acid solution and, when present, 10 and 30 % w/w of said aqueous orthophosphoric acid solution.

4. A method according to any one of the preceding claims wherein the aqueous descaling solution has an initial pH of not more than about 3.

5. A method according to any one of the preceding claims wherein the aqueous descaling solution comprises between 0.1 and 15 % w/w, of the acid-resistant foaming agent.

6. A method according to any one of the preceding claims wherein the acid-resistant foaming agent is selected from alkyl amine oxides and alkyl amine dicarboxylates and mixtures thereof.

7. A method according to any one of the preceding claims wherein the aqueous descaling solution comprises a solution of hydrochloric acid and orthophosphoric acid.

8. A method according to any one of the preceding claims wherein cooling water circulation through the tower is terminated prior to spraying the solution into the plenum chamber and recommenced following flushing of the tower with water after the period allowed for effecting descaling.

9. A method according to any one of claims 1 to 6 wherein cleaning of the cooling tower is carried out segmentally, cooling water circulation through each segment of the tower within the plenum chamber being terminated prior to spraying the solution into the segment being cleaned and recommenced following flushing of the segment with water after the period allowed for effecting descaling of the packing members within that segment, and wherein the aqueous descaling solution comprises a solution of hydrochloric acid alone.

10. An aqueous descaling solution for use in cleaning cooling towers, which solution being as defined in any one of method claims 1 to 7.

11. Apparatus for spraying an aqueous descaling solution as defined in any one of method claims 1 to 7 into a plenum chamber of a cooling tower comprises a spray means by which the aqueous descaling solution may be distributed in the top of a cooling tower during use of the apparatus, a pump mechanism connectable to and operable to pump the solution from a container for the solution to the spray means, a pressure control valve operable to control the pressure of the solution delivered to the spray means and a pressure relief valve for returning the solution to the container should the pressure of solution being pumped to the spray means during use of the apparatus become too high.

12. Apparatus according to claim 9 wherein the pressure control valve controls flow in a solution flow line connected between a solution supply line connecting the pump to the spray means and the container.

13. Apparatus according to claim 9 or claim 10 further comprising the container for the solution.

Figure 1

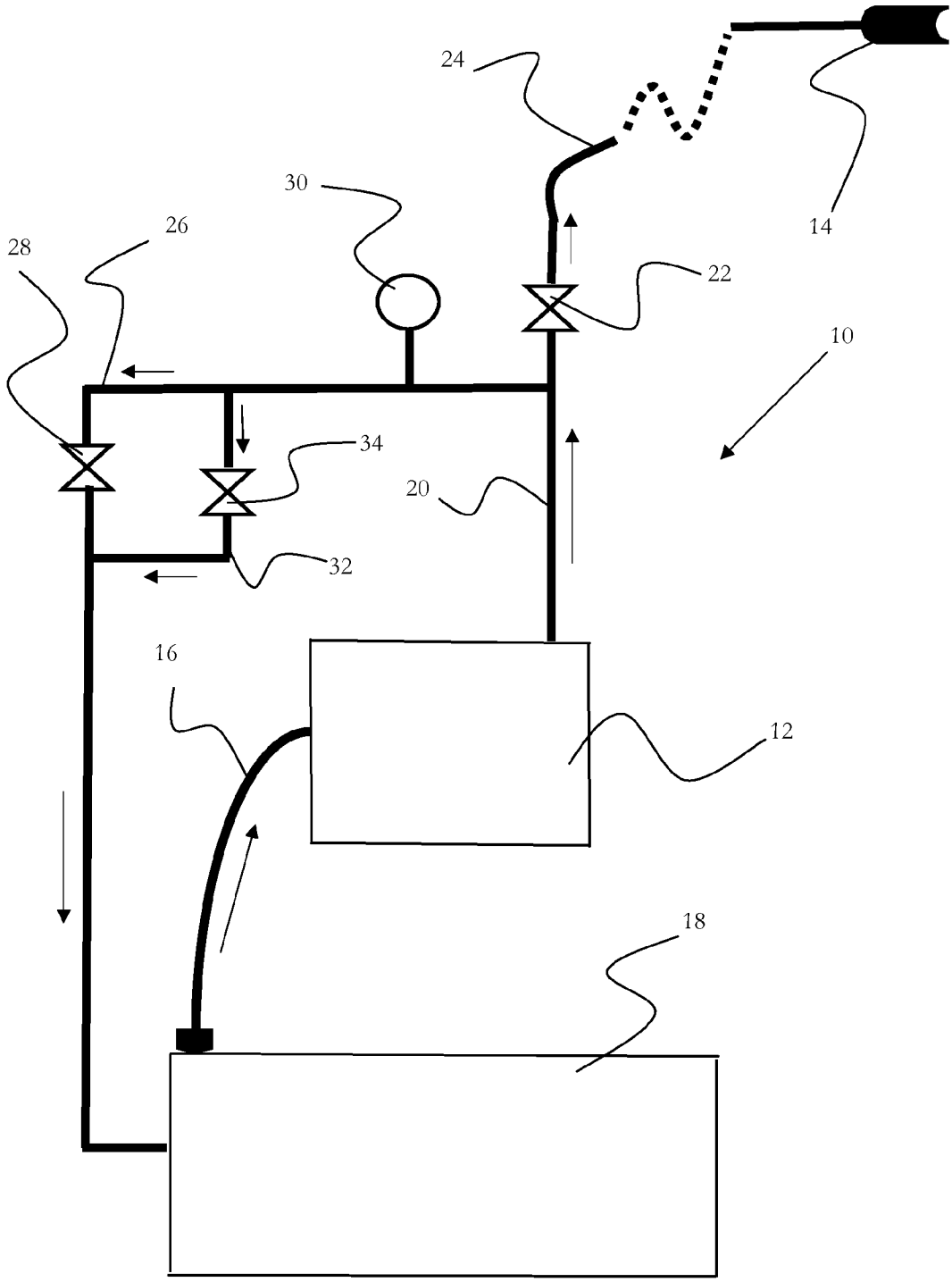

Figure 2

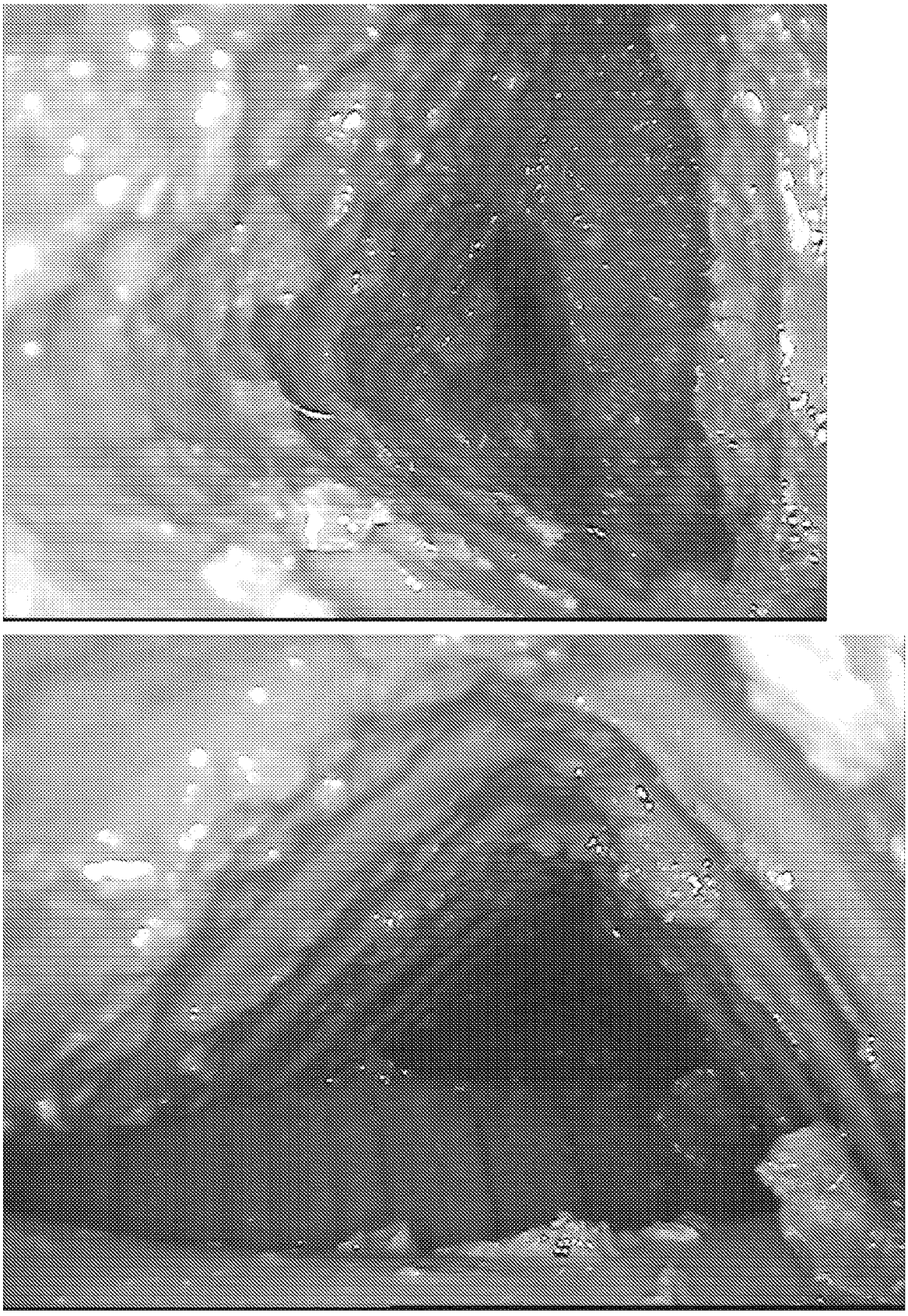

Figure 3