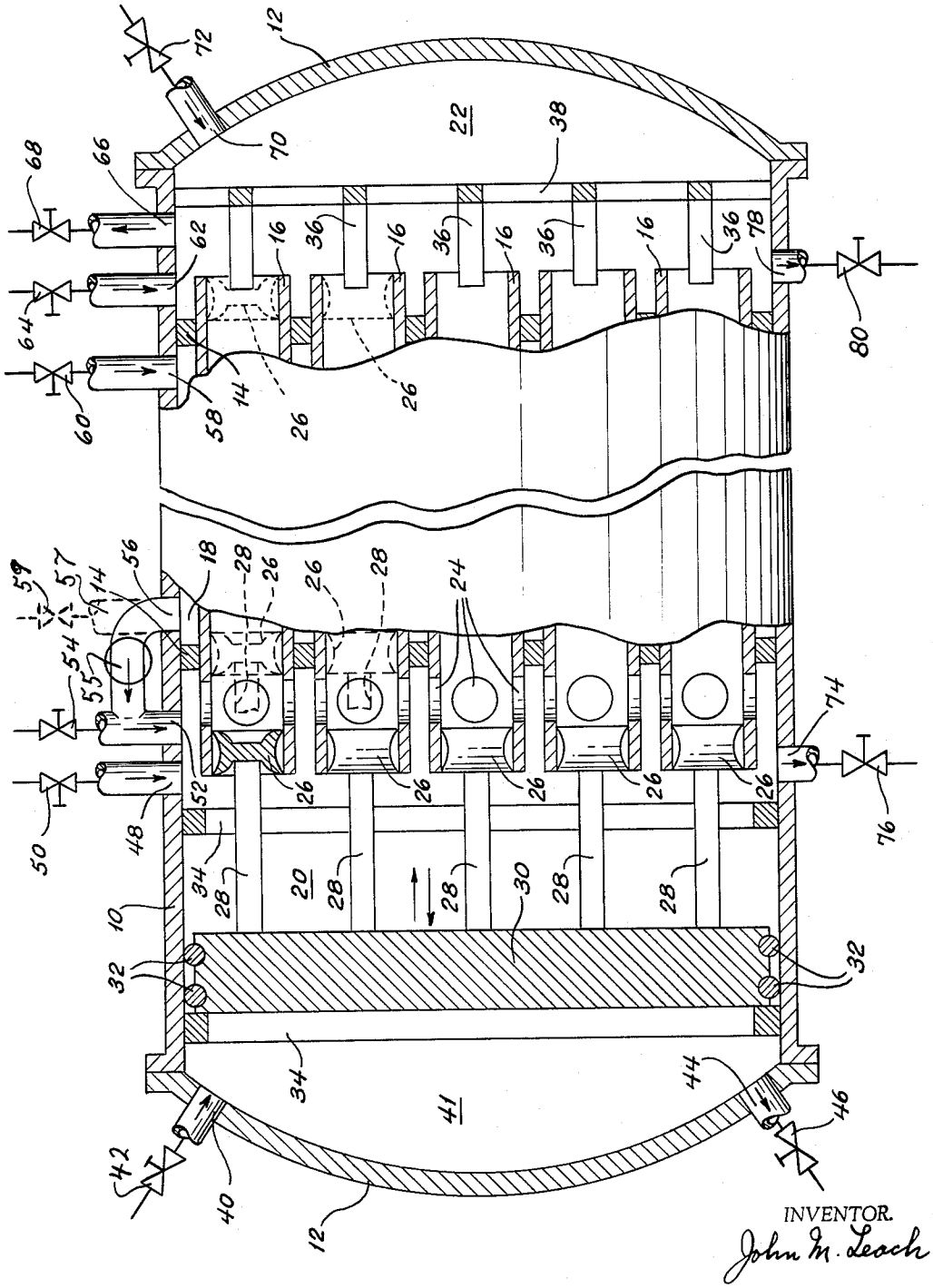
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TUBE CLEANER

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TUBE CLEANER

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The present invention relates to cleaning equipment. More particularly, it relates to in place cleaning equipment which is permanently associated with tubular processing surfaces which are subject to operating conditions which leave a deposit on the processing surfaces which will interfere with or impede the processing operation unless the deposit is periodically removed or reduced in intensity.

Many types of processing equipment such, for example, as stills, evaporators, salt water converters, water and steam boilers, coolers, other types of heat exchangers, chemical reactors, polymerizers, deactivators, mixers, concentrators, dryers, etc., employ surfaces, usually tubular in form, over which the substance undergoing treatment passes. In almost all cases some deposit of material is left upon the surface either inevitably or intentionally. In the cases where the surface is a heat exchange surface this deposit must be removed at intervals dependent upon the rate of deposit and nature of the deposit in order to maintain the heat exchange efficiency of the surface. In other operations the deposit must be removed to prevent contamination or effect recovery of the deposit substances.

Since most processing operations are carried out either above or below atmospheric pressure, such processing (treating) operations are conducted within closed apparatus which makes it difficult, time-consuming and expensive to reach the surfaces to clean them. Many attempts have been made to provide scrapers for such surfaces which were activated by shafts and levers on the outside which extended through the outer casings. All such contrivances have been conducive to leaks, space consuming, awkward to operate, inefficient and frequently impractically expensive.

It is an object of the present invention to provide a surface cleaner for processing equipment which effectively overcomes all of the foregoing shortcomings of prior cleaners.

It is another object of the present invention to provide a surface cleaner which can be constructed as a part of the processing equipment with which it will be associated and not require any drastic change in normal design of the processing equipment.

It is a further object of the present invention to provide a surface cleaner of the so-called "in place" type which will not add to the overall size or complexity of the equipment with which it is formed "in place."

It is still another object of the present invention to provide a surface cleaner which is simple in nature and still effective in operation.

It is a still further object of the invention to provide a surface cleaner which can be operated without requiring any disassembly of anything.

It is still another object of the present invention to provide a surface cleaner which can be operated as frequently as required to maintain a clean operating surface without any substantial interruption or other interference with the normal processing operation.

Other objects and advantages of the present invention will become apparent to those skilled in the art upon recourse to the following description of what is now considered the preferred physical embodiment of the invention.

Throughout the specification and claims, the terms "processing" and "treating" are to be construed as including all operations which result in a deposit of any

substance upon any surface which admits of being cleaned off or removed by the apparatus of the present invention. The term "fluid" includes both gases and liquids. The term "cleaning" means removing for any purpose, and "deposit" includes all substances accumulated upon any surface which admits of being cleaned by the apparatus of the present invention regardless of the form or character of the accumulation or how the accumulation occurred or what caused it. The term "scrape" means to wipe gently and to shear off mechanically and operations requiring all applications of force falling in between these two extremes. The term "tube" means all continuous surfaces which in cross section are circular, square, elliptical or of any other shape, and regardless of the type or identification of the apparatus of which it forms a part as long as it admits of being cleaned by the apparatus of the present invention.

For the purpose of explanation only, the present invention will be described as applied to a multitube heat exchanger but this example selected for illustration purposes solely is not to be construed as any limitation upon the application of the invention to any apparatus to which it is intrinsically applicable.

Referring to the drawings, a multi-tube heat exchanger is shown to which a form of cleaner of the present invention is applied and in which the heat exchanger comprises an external shell in the form of a cylinder **10** having closure heads **12** at each end suitably attached to the cylinder **10** in any desired manner not shown.

The cylinder **10** is provided with tube plates **14** suitably attached to its interior and provided with suitable openings which receive tubes **16** suitably fastened in place as by internal rolling at the areas encompassed by the tube plates **14**. The space between the tube plates and surrounding the tubes provides an intermediate compartment **18** which is segregated pressurewise from the two end compartments **20** and **22** which are also segregated pressurewise from each other by the tube plates **14**. In the modification illustrated the tubes **16** extend for a short distance into the compartment **20** and are provided with openings **24** which extend through the walls of the tubes.

A piston scraper preferably having the shape shown at **26** in cross section in the upper tube of the drawing is positioned inside the extended end of each tube as shown in solid lines. The piston scraper is formed so as to present a solid face surface on each end and have resilient scraper surfaces or edges which can deform to conform to any slight irregularity of the shape of the interior of the tube and thus not miss any surface area on the tube interior. This can be accomplished in many other known ways such as by using washer-like blades, piston rings, O-rings, etc.

A frame **38** which is preferably in the form of a lattice is suitably fastened within the compartment **22** and is provided with projections **36**, each of which provides a stop for a piston scraper **26** as later described.

A movable wall **30** which is in effect a large piston is provided with O-rings **32** so as to have close-fitting movable contact with the interior of the cylinder **10** and is limited in movement in both directions by suitable stop rings **34**. The movable wall **30** closes off a space **41** between itself and the adjacent head **12**. The wall **30** is provided with projections **28** each of which acts as a stop for a piston scraper **26** to retain the piston scraper just within the end of its tube **16**.

When the heat exchanger is to be used, for example, as an evaporation converter to desalt sea or brackish waters, the exterior casing formed by the shell and two heads will be provided with the following connections: steam line and valves **40–42**, **58–60** and **70–72**; water line and valves **48–50** and **62–64**; exhaust line and valve **44–46**; brine

withdrawal lines and valves 74–76 and 78–80 and a steam transfer line 52–56.

Salt or other raw water is admitted to the compartment 20 by line 48 and valve 50. The water flows through openings 24 into tubes 16 where it is evaporated and enters compartment 22 as a vapor which is exhausted by line 66 and valve 68 to any conventional type of raw water preheater (not shown) and therein condensed to fresh or potable water.

Super heated steam is introduced into the compartment 18 by line 58 and valve 60 where it surrounds the exterior of the tubes 16 and evaporates the raw water therein. The saturated steam remaining is transferred by line 52–56 to the compartment 20 where it mixes with and heats the raw water and condenses. Valve 55 is open at this time. This causes the evaporator to function as a two effect evaporator with the saturated steam providing one effect and the superheated steam the second effect. If desired, the saturated steam can be returned to the steam generator instead of entering the compartment 20. This could be done by replacing the transfer line 52–56 by a steam return line and valve 57–59 as shown in dotted lines. Valve 55 is closed at this time. Also, the vapor from compartment 22 flawing through line and valve 66–68 can be directed to a second effect evaporator which is a duplicate of that shown if such is desired and as many subsequent effects so created as the nature of the operation dictates.

The evaporation of the raw water in the tubes 16 precipitates a substantial deposit of scale within the tubes which if permitted to accumulate indefinitely would rapidly form an insulation layer and severely reduce the rate of heat transfer through the tube walls and ruin the efficiency of the evaporator. When a sufficient deposit of scale has accumulated to warrant removal, which is usually determined empirically, the vapor valve 68 is usually closed to prevent any stray liquid from entering line 66 and brine release valve 80 is opened to vent pressure from compartment 22. Steam valve 42 is then opened which creats a pressure in space 41 which is greater than the pressure in compartment 20 because of the water in 20 and this dominant pressure moves the wall or piston 30 to the right and through the projections 28 moves all of the piston scrapers 26 from one side of the openings 24 to the other side as shown in dashed lines in the upper tube and then stops when it contacts the limit stop 34 and leaves all of the piston scrapers at the position shown. This has the effect of shutting off flow of water through the tubes 16. As the water pressure builds up the pressure against the faces of the piston scrapers 26 forces them through the tubes 16 scraping scale from the interiors of the tubes and carrying it along as they go and finally projecting the concentrated scale into the compartment 22 when the piston scrapers contact the stops 36 as shown in dotted lines to the right in the top tube in the figure. The valve 64 is then opened to discharge water from the line 62 into the compartment 22 to flush the concentrated scale from the compartment 22 through the release line and valve 78–80 in the form of a brine. The valves 64 and 80 are then closed as well as valves 50 and 60. Valve 76 is opened to vent compartment 20 and valve 72 is opened to admit steam to compartment 22 which acts on the piston scrapers 26 to return them along the interiors of tubes 16 scraping any residual scale as they go until they contact the stops 28. They are allowed to remain in this position for a short time to insure that all of them have reached their stops before the pressure activating them is released and then valve 42 is closed and exhaust valve 46 is opened. This releases the pressure in space 41 and the pressure against all of the piston scrapers 26 causes them to move the wall 30 to the left through the extensions 28 until it contacts stop 34 at which time piston scrapers 26 will have uncovered the openings 24 by moving to their original positions as well as projected all concentrated scale into compartment 20. Water valve 50 is then opened long enough to flush out all of the concentrated scale from compartment 20 through release line 74 as a brine.

This scale cleaning operation can be repeated as many times as found necessary to remove all tenacious scale or the original evaporation operation can be restarted. Because so little time is required to complete this cleaning operation and the temperature balance of the equipment is disturbed so slightly it is usually found advisable to perform the cleaning operation with sufficient frequency to prevent the scale from becoming hard so that only a gentle wiping operation is required of the piston scrapers. However, if the piston scrapers do encounter hard and tough scale, sufficient force can be built up behind them to cause them to shear off anything they encounter. Because the novel design of the present invention prevents pressure from being released from behind any piston scraper until it is released from all, the possibility of any one or more tubes not being properly cleaned or any one or more piston scrapers not being returned to the original position is completely eliminated.

In any operation where it is undesirable for any reason to use the fluid or fluids already in the system to operate the piston scrapers, all flow of the operating fluids can be discontinued by closing the proper valves and some preferred extraneous fluid can be introduced by suitable valving into the compartments 20 and 22 and space 41 to effect the operation of the piston scrapers. Such extraneous fluids may be gases such as steam, air, nitrogen or carbon dioxide, or liquids such as water, water and molecular lowering substance where a cooling operation is involved or any cleaning liquid or detergent where a perishable substance such as milk, cream or other food stuff is being processed.

It will be noted that the above described operation causes the piston scrapers to first act as a valve to stop flow through openings 24 and then act as scrapers which greatly simplifies the apparatus of the present invention. If desired for any reason, separate valves could be employed to shut off flow through openings 24 without departing from the scope of the present invention. Also, the movable wall 30 and space 41 actually provide a pneumatic or hydraulic cylinder which actuates the piston scrapers 26 to serve as valves. It is, therefore, within the purview of the present invention to utilize a separate either internally or externally positioned pneumatic or hydraulic cylinder to actuate the piston scrapers 26. Furthermore, the hand operated valves shown may be replaced by solenoid valves operated either individually or under a scheduled control similar to the schedule control system described in copending application Ser. No. 326,884 if desired.

When a different substance from that being processed is to be used to actuate the cleaning apparatus of the present invention, all of the valves in the modification illustrated, including valve 55, will be closed at the start of the cleaning operation. Valve 80 will immediately be opened to vent the system and valve 76 can also be opened to accelerate the venting. Valve 42 is then opened and steam or other fluid being used will enter 41 and move piston wall 30 to the right to position piston scrapers 26 to the right of all openings 24 as above explained. Valve 76 is then closed and valve 54 is opened to permit steam or other fluid being used to enter compartment 20 and exert pressure on piston scrapers 26 to move them through the tubes to remove deposit and ultimately project it into compartment 22. Valve 54 is then closed and valve 76 opened and the fluid is permitted to drain out of line 74 for recovery of the fluid when such is desired. A suitable vent valve may be placed at any desired point near the top of compartment 20 to facilitate the drainage if desired. Valve 64 is then opened to direct water into compartment 22 to flush the concentrated deposit out through line 78 and then valves 64 and shortly after valve 80 is closed when the drainage is completed. Valve

72 is then opened and steam or other fluid will enter compartment 22 and force piston scrapers 26 back through tubes 16 to remove scale and stop when they contact projections 28 which will be in the dashed line position shown just to the right of openings 24. Valve 46 is then opened and the pressure will force piston scrapers 26 to their original position and return piston wall 30 to the left hand position which was its original position. Valve 72 is then closed and valve 50 will be opened to flush all deposit out of compartment 20 after which valves 44, 54 and 76 are all closed which returns the system to original status at the start of the cleaning operation.

When using a different fluid to actuate the cleaning apparatus from that being normally processed, it is desirable to as far as practicable use a fluid which is compatable with the fluid being processed and does not itself leave any appreciable deposit. It is always feasible to repeat a cleaning operation using air or water on the repeat cleaning operation where extreme cleanliness is required, for example, where food stuffs or potent chemicals are being processed.

It is also desirable where time is a factor to maintain the fluid used as the cleaning apparatus actuator at as close as possible to the same temperature as the operating temperature of the material being processed. This will limit the heat balance disturbance of the processing operation to a bare minimum. For example, where salt or brackish water is being converted to fresh or potable water, the best fluid to use during a cleaning cycle is the raw water itself preferably mixed with steam to keep its temperature high and steam can be maintained in the compartment 18 during the cleaning operation so that practically no loss of operating temperature is caused and only a very short loss of time and production is experienced.

Under low disturbance conditions such as explained above it is practical to schedule cleaning cycles with sufficient frequency as to insure that the heat exchange surfaces are at all times functioning with maximum efficiency.

It is also practical because of the simple and inexpensive nature of the cleaning apparatus of the present invention to practically eliminate all production time loss by operating two units in parallel and alternate cleaning cycles on the two units. This is very applicable to many operations, such as power plant steam boilers, where a standby unit is always used. When used on two steam boilers in this manner, the cleaning apparatus of the present invention will greatly reduce the down time on both of the boiler units.

The unique flexibility of the cleaning apparatus of the present invention obviously qualifies it for numerous applications.

The invention having been described, what is claimed is:

1. A heat exchanger comprising an external shell, plates positioned within the shell dividing the interior thereof into a central and two end compartments, a multiplicity of tubes positioned through the plates having interior communication with both end compartments but not with the central compartment, the tubes at at least one end extending into the end compartment, a piston scraper positioned within each tube near the so extending ends, each tube being provided with an opening through its wall between the piston scraper and the nearest plate to provide communication between the interior of the tube and the end compartment into which it extends, a movable wall positioned adjacent the so extending tube ends, projections extending from one side of said wall into contact with said piston scrapers, fluid pressure exerting means operable upon the opposite side of said wall to at selected times move said piston scrapers from one side of said tube wall openings to the other side along the interior of the tube, means for applying pressure to the end compartment into which the tubes extend to force the piston scrapers along the interiors of the tubes to remove any deposit therefrom, stops for the piston scrapers at the opposite ends of the tubes, and means for applying pressure to the other of said end compartments to force the piston scrapers back along the interior of the tubes to their original positions.

2. A heat exchanger comprising an external shell, plates positioned within the shell dividing the interior thereof into a central and two end compartments, a multiplicity of tubes positioned through the plates having interior communication with both end compartments but not with the central compartment, the tubes at at least one end extending into the end compartment, a piston scraper positioned within each tube near the so extending ends, each tube being provided with an opening through its wall between the piston scrape and the nearest plate to provide communication between the interior of the tube and the compartment into which it extends, a piston-like wall mounted for limited movement along the interior of said shell in the end compartment into which the tubes extend, projections extending from one side of said wall, each into contact with a piston scraper, means for applying fluid pressure to the opposite side of said movable wall to at selected times move said piston scrapers from one side of said tube wall openings to the other side along the interiors of the tubes, means for applying fluid pressure to the interior of the end compartment into which the tubes extend to force the piston scrapers along the interiors of the tubes to remove any deposit therefrom, stops for the piston scrapers at the opposite ends of the tubes, and means for applying fluid pressure to the other of said end compartments to force the piston scrapers back along the interiors of the tubes to their original positions.

3. A heat exchanger comprising an external shell, plates positioned within the shell dividing the interior thereof into a central and two end compartments, tubes positioned through the plates having interior communication with both end compartments but not with the central compartment, the tubes at at least one end extending into the end compartment, means for supplying fluid under pressure to said last-named compartment, a piston scraper positioned within each tube near the so extending ends, each tube being provided with an opening through its side wall between the piston scraper and the nearest plate to provide communication between and allow free flow of fluid from the said end compartment in which the tubes extend and into the tube, and means for moving the said piston scrapers from one side of said openings to the other to thereby cut off communication between the adjacent end compartment and the interior of the tubes so that fluid pressure within said end compartment within which the tubes extend will exert force upon the outer faces of the piston scrapers to drive them along the interior of the tubes to clean the tubes.

4. An apparatus for cleaning tubes as defined in claim 3 further characterized by stops positioned adjacent the ends of the tubes in said other end compartment which are struck by the piston scrapers to project all removed deposit into said other compartment, and means to flush the thus concentrated deposit from said other end compartment.

5. An apparatus for cleaning tubes as defined in claim 3 further characterized by a stop at the end of each tube in communication with the other of said end compartments which causes each piston scraper to deposit concentrate into the other of said end compartments, means for flushing the concentrated deposit from said other compartment, and means for exerting force upon the piston scrapers to return them through the tubes to their starting positions.

6. An apparatus for cleaning tubes comprising an external shell, a partition dividing the shell into compartments, a tube subjected to conditions which result in a deposit being formed on its interior and extending through said partition, one end of the tube being open and extending into one of the compartments, a piston scraper positioned in the end of the tube so extending, a source of fluid pressure in communication with the compartment

into which the tube extends, the tube having an opening extending through its side wall between the piston scraper and the partition to allow free flow of fluid from the compartment into the side wall opening and through the tube, and means operable at any desired time to close off fluid flow through the tube from said opening which causes the fluid pressure to exert force upon the outer face of the piston scraper and thus drive it through the tube to remove the deposit.

7. A heat exchanger comprising an external shell, a partition dividing the shell interior into compartments, a tube subjected to conditions which result in a deposit being formed on its interior and being open and extending through said partition, one end of said tube extending into one of the compartments, a piston scraper positioned in the end of the tube so extending, a source of fluid pressure in communication with the compartment into which the tube extends, the tube having an opening extending through its side wall between the piston scraper and the partition to allow free flow of fluid from the compartment into the side wall opening and through the tube, a stop at the end of the tube in communication with another of said compartments, means operable at any desired time to close the said tube wall opening and discontinue flow of fluid through the tube from said opening which causes the fluid pressure to exert force upon the outer face of the piston scraper and drive it through the tube to remove the deposit and project the concentrated deposit into the said other compartment when the piston scraper contacts the stop, means for flushing the concentrated deposit from the said other compartment, means for exerting force upon the piston scraper to force it back through the tube and further remove any residual deposit until it reaches its original position and projects concentrated deposit into the first mentioned compartment, and means for flushing concentrated deposit from said first mentioned compartment.

8. A cleaning apparatus comprising a tube having open ends and an access opening extending through its side wall near one end thereof, a piston scraper positioned in said tube between said one end and said access opening, means to direct fluid under pressure through said access opening into and through said tube, means to move said piston scraper away from said end of the tube and to the opposite side of said access opening where it impedes flow of fluid through said tube and causes the fluid pressure to exert force on the outer end of said piston scraper which force moves the piston scraper through the tube and scrapes out all deposits from the interior thereof.

9. An apparatus for cleaning tubes comprising a closed compartment, at least one tube having an open end extending into said compartment and having an access opening extending through its side wall near said open end and within said compartment, a piston scraper positioned in said tube between said access opening and said open end, means to direct fluid under pressure into said compartment and into and through said access opening and said tube, means operative to move said piston scraper away from said end of the tube and to the opposite side of said access opening where it impedes flow of said fluid through said tube which fluid exerts force upon the outer end of said piston scraper which force moves the piston scraper through the tube and scrapes all deposits from the interior of said tube.

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