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APPARATUS FOR CLEANING THE INTERIOR SURFACES OF ENCLOSURES

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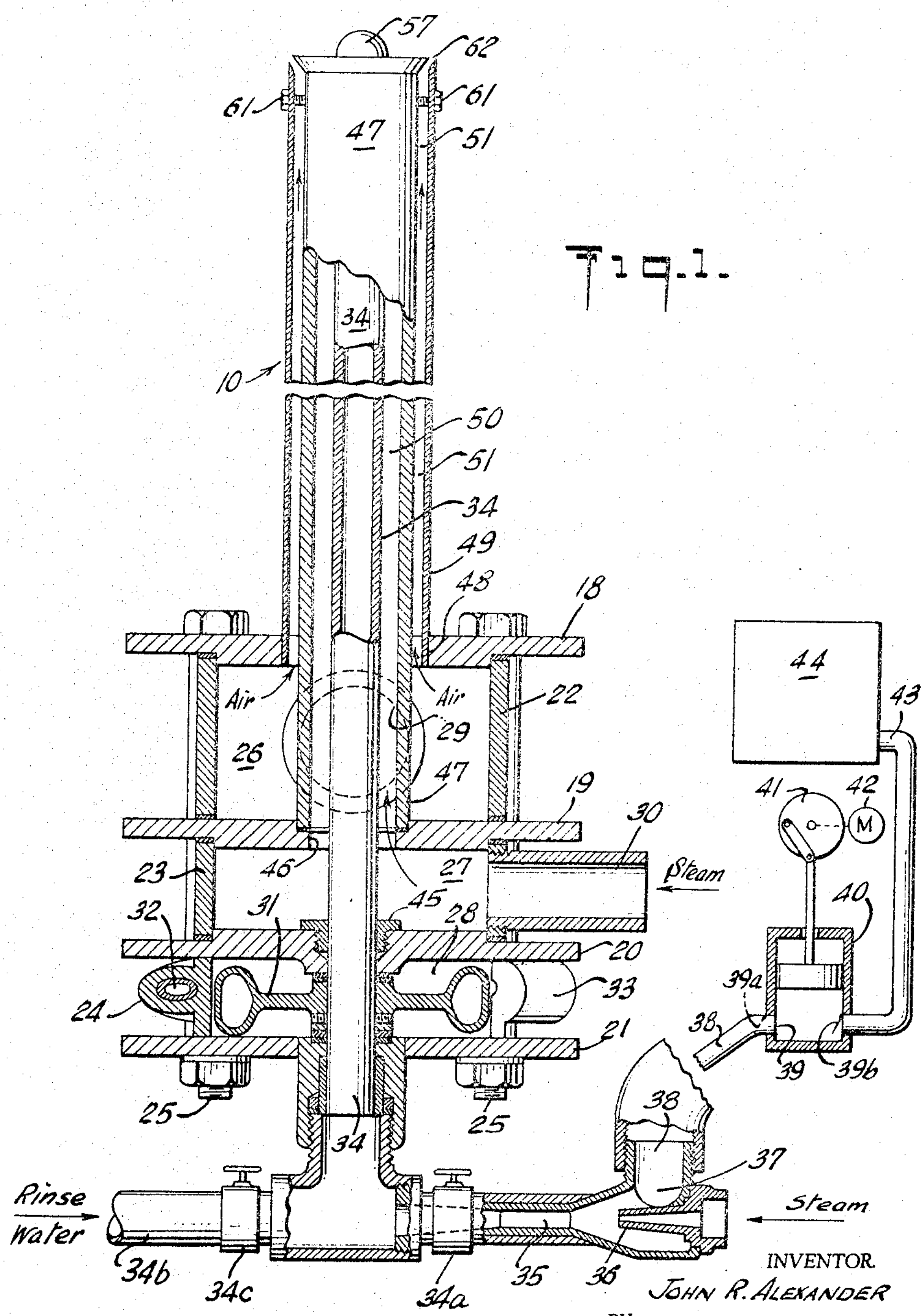

Fig. 1.

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Fig. 2.

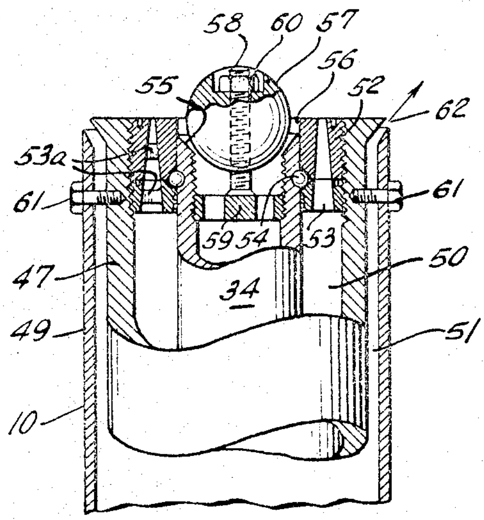


Fig. 3.

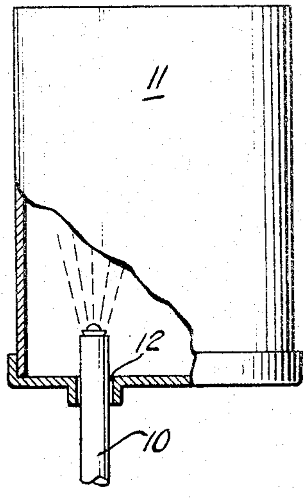
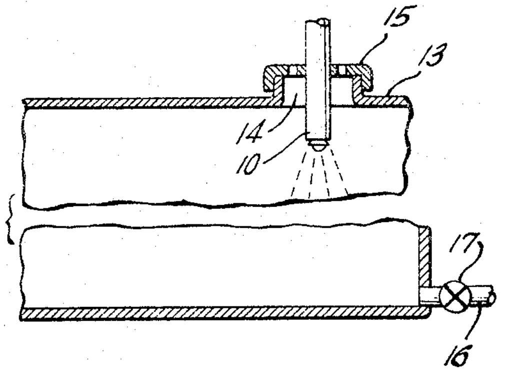


Fig. 4.



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APPARATUS FOR CLEANING THE INTERIOR SURFACES OF ENCLOSURES

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Original application Dec. 4, 1962, Ser. No. 242,329. Divided and this application Aug. 31, 1965, Ser. No. 495,000

10 Claims. (Cl. 239—101)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This application is a divisional application of applicant's co-pending application Serial No. 242,329, filed December 4, 1962, which in turn is a continuation-in-part of application Serial No. 766,160, filed October 8, 1958, now abandoned.

This invention relates to the cleaning of metal surfaces in enclosures to remove contaminants therefrom, where direct access to such surfaces is not possible or practical. For example, ferrous metal drums and barrels are used extensively for the shipment and storage of petroleum and other products. Such drums are fabricated and because of this, their interiors have small cracks and crevices around the reinforcement at the bung hole and where separate parts are united. The surfaces that form the interiors also have very small and minute pores, indentations, or cavities, and all of such pores, cavities, cracks, indentations and crevices in use become filled with rust, scale, dirt and remnants of the various products with which the enclosure was filled in use. It is important that all traces of such contaminants be removed, even from the pores, cavities, cracks and crevices, to avoid undesired contamination of fresh products to be stored and shipped in such enclosures.

In turbine casings, cargo tanks, trim tanks, heat exchangers, condenser and evaporator casings and the like, scale rust and other contaminants form or accumulate on the interior exposed surfaces, and heretofore the thorough cleaning of such surfaces has been difficult, slow and expensive, usually requiring the dismantling of such devices. To take an apparatus such as a turbine apart to clean its blades, for example, is a slow procedure and means taking it out of service for quite a period of time which is not always practical.

It has been proposed to clean such enclosures by applying cleaning solutions to such surfaces, such as by spraying the cleaning liquid as small droplets against the surfaces, but liquids applied to small openings such as pores, indentations, cracks and crevices, often form liquid bridges across them, instead of fully entering them. For example, upon spraying an ordinary window screen with water, some of the openings in the screen will have these liquid bridges formed across them that prevent passage through them of ambient air. Many of the pores, recesses, indentations, or cracks of walls of an enclosure are so small in face dimensions that a liquid sprayed against such walls will form liquid film bridges across such indentations, pores, recesses or cracks, and confine air that is within them against escape and also prevent replacement of the trapped air with the liquid. Hence a liquid contaminant removing agent heretofore has been prevented from entering many of such small pores, recesses or cracks to act upon the contaminants therein to remove them. When ordinary wet steam is admitted to such an enclosure, as a cleaning agent or a carrier of such an agent, the steam is so close to its condensation temperature that much of it immediately condenses on such surfaces and forms liquid bridges across such small pores and indentations so that the uncondensed steam cannot enter and reach the contaminant.

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In the case of scale accumulations on surfaces of metal within an enclosure, the scale commonly is formed largely of magnetite (Fe_3O_4) and ferric oxides attached to the metal surfaces by a thin layer of ferrous oxide (FeO) or an iron hydroxide layer. While the magnitite is quite resistant to acids, the binding layer of ferrous oxide is easily dissolved by acid and when so dissolved it releases the magnetite and ferric oxides part of the scale which then falls to the bottom of the enclosure. The rust scale is usually somewhat porous, and it is very difficult for cleaning liquids to penetrate the small pores of such scales or other contaminants in order to reach the bonding material and by an interaction with the bonding material release the scale or other contaminant. Attempts have been made to maintain contact with such surface by a cleaner or dilute acid solution for many hours to enable the acid to diffuse slowly into such pores and indentations in the scale and surfaces, but to fill a large enclosure even with a dilute acid or cleaning agent is not only a waste of acid or cleaner but is time consuming and the disposal of such large bodies of acid or cleaning agent often is a serious problem.

An object of the invention is to provide an improved apparatus for cleaning the metal interior surfaces of enclosures and apparatus and parts therein to remove contaminants therefrom, with which contaminant removal may be accomplished rapidly and easily with relatively simple and inexpensive apparatus, with which the cleaning is exceptionally complete and thorough, and with minimum waste of cleaning agent, and which does not require dismantling of the enclosure.

Other objects and advantages will appear from the following description of one example of the invention, and the novel features will be particularly pointed out in connection with the appended claims.

In the accompanying drawings:

FIG. 1 is an elevation partly in section of an improved nozzle assembly and connections for use in removing contaminants from the interior metal surfaces of enclosures by the use of a fine, colloidal mist;

FIG. 2 is an enlarged section of the top portion of FIG. 1;

FIG. 3 is a schematic illustration of the manner of use of such a nozzle and connections in removal of contaminants from the interiors of metal drums or barrels and similar containers; and

FIG. 4 is another schematic illustration of how such a nozzle and its connections may be used to clean the interior surfaces of enclosures such as cargo tanks, trim tanks, economizers, condensers, evaporators and turbine housings, without dismantling or extensively opening such enclosures.

The invention and its practice will first be explained as applied to the cleaning of metal barrels and drums used for storage and transportation of petroleum products. Such drums are formed of ferrous materials and during use scale and rust form on the interior surfaces, cracks, crevices, pores and indentations, and some of the petroleum or other products stored or transported therein also remain on such interior surfaces and in many of such cracks, crevices, pores, and indentations when the drums are emptied and collect dirt. To clean such drums they are disposed in an upended position, as shown schematically in FIG. 3 and a nozzle assembly **10** inserted into the lower part of the drum **11** through an open bung hole **12**.

Through this nozzle assembly a stream of a preheated fluid is passed upwardly into the inverted drum until the drum walls are well heated, preferably as close to the temperature of the steam as is practical. For example, I have heated the drums with steam at about 15 lbs. to 65 lbs. pressure until after about one minute the exterior surfaces of the walls of the drums are at temperatures between about 150° F. and 165° F. and the interior surfaces of those walls were at somewhat higher temperatures. This preheating may also be caused by passing a stream of hot air into the drum for a period of time sufficient for the walls of the drum to be well heated. The heating fluid, and particularly the steam, in addition to heating the walls of the drum, tends to soften some of the contaminants within the drum, such as to soften thick or viscous adhering remnants of the petroleum that had been stored therein.

After the preheating fluid is discontinued, a stream of heated fluid is immediately passed into this preheated drum. This cleaning fluid is a mixture of dry or superheated steam to which has been added a preheated cleaning solution or agent of a selected type depending on the nature of the contaminants to be removed. A mixture of different cleaning agents may even be added to the steam. The liquid cleaning solution is preheated well above room temperature and I have found that very satisfactory results have been obtained when the cleaning solution or agent is preheated to about 130° F. or more before it is mixed at about that temperature with the dry or superheated steam. This mixture of steam and liquid cleaning agent is then delivered through the nozzle assembly or other discharge means into the drum as a continuous stream of a very fine mist or fog, which fog is so fine that its particles can remain largely or entirely in suspension in fairly quiet air in the same manner that moisture particles in a natural fog remain in suspension in the air. For lack of a better term, this fineness may be designated as colloidal, and the fog or mist so created may be called a colloidal fog or mist. The steam so used is dry or superheated, and I have found that steam under a pressure of from 15 to 65 lbs. gives good results for mixing with the preheated cleaning liquid.

When this fine or colloidal fog or mist of the mixture of superheated or dry steam and the preheated liquid cleaner are introduced into the preheated barrel or enclosure, the fog or mist will diffuse like a gas or vapor into the air in the pores, cracks, crevice and other indentations of the interior surfaces of the enclosure, so that the cleaning agent will be immediately brought into contact with the contaminants and act upon them. The steam being superheated and the cleaning liquid being so finely divided and hot, there will be little or no condensation of moisture as large droplets on the inner surfaces of the enclosure which could create large numbers of liquid bridges across the cracks, crevices, pores and other indentations that would block repeated material penetration and diffusion by this fog of cleaning liquid into such small cavities and indentations for action on the contaminants. When the contaminant is rust or scale the liquid cleaner is, or includes in it, a solution of a non-oxidizing mineral acid, such as hydrochloric or sulphuric acid, for example, usually a dilute solution of the acid, so that it will not react materially with the metal of the enclosure. For example, sulphuric acid may be used at concentrations in water of at least about 0.20 percent by volume and up to 1% or more by volume, when it is not buffered. A buffering agent may be added to the acid solution, if desired, in order to be able to use a somewhat stronger solution of the acid without causing material damage to the metal of the enclosure. Such buffering agents for acids are well known and any of them may be used. By way of example, the detergent or cleaning agent for drums used to store petroleum products can be a dilute aqueous caustic solution of about 3% to 5% strength. The buffering agent, if used with an acid, is frequently a salt of the acid used as the active agent or the salt of another and weaker acid, generally salts of acids with a low dissociation.

To facilitate the cleaning action due to the fog or mist, I prefer to add a small amount of a wetting agent to the cleaning solution, which causes more rapid and uniform contact and spreading of the cleaning solution on the contaminant. In the case of ferrous metal enclosures, the addition to the cleaning solution of an iron phosphate may be advantageous, since the phosphate provides a protective coating on the cleaned interior steel or iron surfaces of the enclosure without interfering materially with the action of the acid, detergent, or other cleaning agent on the contaminant to be removed. When phosphates are included, the detergent or cleaning agent should be non-caustic. The phosphate also fills some of the smallest pores, cracks, crevices or indentations and thus makes the interior surfaces of the enclosure smoother, with less opportunity for subsequent contaminants to collect where they are the most difficult to reach and remove.

In the case of iron scale, which forms slowly on hot as well as cool surfaces subjected to contact with water and air, as in turbines, evaporators, condensers, heat exchange units, and the like, the acid cleaning agent acts upon the porous ferrous oxide (FeO) or an iron hyroxided layer, and since this ferrous oxide or hydroxide binds together the rest of the scale, largely of magnetite (Fe_3O_4) and ferric oxides, it is unnecessary for the acid to act directly on the magnetite or ferric oxides. The removal of the ferrous oxide, which is the binder for the rest of the scale, releases the rest of the scale so that it can disintegrate into small pieces and fall off.

In the case of turbines, evaporators, condensers and like apparatus, the cleaning previously has generally been by taking the enclosure apart to gain access to the parts to be cleaned. Then the interior contaminated surfaces are mechanically cleaned. It would be impractical to flood the interiors of such assembled enclosures with a liquid cleaning agent, especially with the large volume of liquid necessary, with only a small portion active and actually in direct contact with the contaminated surfaces. With this invention only a relatively small amount of the cleaning agent is required, it is unnecessary to dismantle the apparatus for cleaning, and the time required for cleaning is very small. In the case of turbines the blades require cleaning at intervals and such cleaning can, by this invention, be performed easily, effectively, rapidly and inexpensively. For turbines an ionized cleaning agent can be advantageously employed in cleaning the blades. The interior surfaces of such apparatus have very small pores, cracks, crevices and indentations as exist in drums and barrels and the mist or fog being somewhat like a gas will diffuse with the air into all such crevices and indentations and the porous scale, and thus more rapidly reach and remove the contaminants and the ferrous oxide binders.

In the case of turbines, evaporators, heat exchangers, condensers and the like, the nozzle assembly is inserted somewhat into the enclosures of the same through an opening, and such enclosures usually have a drain. In FIG. 4, this is schematically shown where the enclosure **13** has an opening **14** normally closed by a cap **15**. The nozzle assembly **10** is inserted somewhat through this opening into the interior of the enclosure, such as by fitting it into a substitute vented cap **15**. The enclosure has a drain pipe **16** controlled by a valve **17** through which the loosened or released contaminants may be washed out. Of course these enclosures will vary in size and shape, and in the arrangements and positions of entrance openings and drains.

After the heated fog or mist has been passed into the enclosure of a drum or other enclosure until the contaminants are released or removed from the metal surfaces, this hot mist is discontinued, and a rinse stream of water, preferably and usually hot, is sprayed into the drum, barrel or enclosure to wash out the released contaminants. After this is done, a stream of dry or superheated steam or dehumidified air, usually heated, is passed into and through the drum, barrel or enclosure to dry it out rapidly.

Any suitable nozzle assembly which will create a fine or colloidal mist or fog may be used. One nozzle which produces a very fine mist or fog is disclosed in U.S. patent to Day #2,116,879, issued May 10, 1938, but the nozzle assembly and connections to it which I have found to be most satisfactory to date, is disclosed in FIG. 1 to which reference may now be had. In this example of the nozzle assembly, a plurality of plates **18**, **19**, **20**, and **21** are arranged in superposed, spaced apart relation and spaced apart by endless walls **22**, **23** and **24**, all clamped together by bolts **25**. This provides superposed, closed chambers **26**, **27** and **28**. Chamber **26** has an inlet opening **29** which is connected to a source of hot, dry or dehumidified air. The chamber **27** has an inlet **30** for connection to a source of dry or superheated steam, such as to steam under a steam pressure of from about 15 lbs. to about 65 lbs. or more. The chamber **28** houses a simple turbine rotor **31** that is rotatable therein and a jet inlet passage **32** is provided in the wall **24** to direct a stream of steam or compressed air against the rotor **31** to rotate it. The chamber **28** has an exit passage (not shown) for the propelling air or stream in a boss **33** on the wall **24**.

Passing upwardly through the plates **19**, **20** and **21** and rotor **31** and rotatably mounted in the plates **20** and **21** is a tube **34** to which the rotor **31** is fixed, so that the tube is rotated by the rotor. The tube **34** extends below the plate **21** and there is connected through a valve **34***a* to one end of a Venturi passage **35**, the other end of which is connected to a stream injector wherein the steam is directed by a jet nozzle **36** into the adjacent end of the Venturi passage, and the cleaning liquid is admitted to the area **37** around the jet from a conduit **38**. The conduit **38** is connected to the delivery port **39** of a reciprocating, single acting pump **40**, operated by a crank device **41** that is driven by a suitable motor **42**. The intake port of the pump is connected by a pipe **43** to a source **44** of the cleaning liquid that has been preheated, preferably to a temperature of at least 130° F. The pump has an outwardly opening check valve **39***a* at the delivery port **39**, and also an inwardly opening check valve **39***b* at its intake port. In an example, the pump was operated to deliver about one gallon of cleaning liquid per minute. The lower end of the tube **34** has a swivel coupling to the pipe with the Venturi passage to enable rotation of the tube without rotation of the valve **34***a* and the Venturi passage. A stuffiing gland **45** is provided around the tube **34** where it passes through the plate **20**.

The opening **46** in the plate **19** through which the tube **34** passes is larger than the tube, and a sleeve **47** fixed at its lower end in the opening **46** extends upwardly along and spaced from the tube **34** through and well beyond the plate **18**. The opening **48** in the plate **18** through which the tube **34** and sleeve **47** extend is larger than the sleeve **47** and another sleeve **49** is fixed at its lower end in the opening **48** and extends upwardly along and spaced from the sleeve **47** and tube **34**. The tube **34** and the sleeves **47** and **49** have passages **50** and **51** between them.

The sleeves **47** and **49** extend to approximately the upper end of the tube **34** and sleeve **47** at its upper end has an internal threading into which is threaded an annular ring **52** made in two superposed, separate sections. A plurality of upwardly converging, tapered or jet passages **53** are arranged at intervals around the ring **52** and discharge directly upwardly. The upper end of the tube **34** is rotatably mounted in the ring **52** by ball bearings **54** disposed at the horizontal junction between the superposed sections of the ring **52**. The upper end of tube **34** terminates in an upwardly and outwardly diverging seat **55** located slightly below the upper face of the ring **52** so as to provide an upright wall **56** that extends upwardly beyond the seat **55**. A spherical ball **57** is disposed upon the seat **55** and is spaced slightly from the upright wall **56**, but with the ball extending upwardly beyond the ring **52**. A stud **58** is secured to and extends upwardly from a spider or apertured partition **59** across the passage of tube **34** and passes slidingly through the ball and carries on its threaded, upper end a nut **60** that abuts the ball by which the possible displacement of the ball from its seat **55** may be selectively varied and adjusted. The sleeve **49** is secured at its upper end to the sleeve **47** by screws **61** and the annular exit **62** for the upper end of the passage **51** is outwardly and upwardly divergent.

When this nozzle assembly is inserted into an enclosure to be internally cleaned, suitable valves (not shown) in the connections to inlet **29**, **30** and **32** enable one to selectively control the flow of the dry or superheated steam to inlets **30** and **32** and hot dry dehumidified air to inlet **29**. To preheat the enclosure the steam is passed through passage **30** to chamber **27** and from there upwardly along passage **50** between the tube **34** and the sleeve **47**, and it is discharged through jet passages **53** into the enclosure to preheat it. After this preheating of the enclosure is accomplished this steam is left on and the mixture of steam from jet **36** and the cleaning liquid is conveyed through the Venturi passage and upwardly through the tube **34** and discharged at its upper end between the ball **57** and its seat **55**. By adjusting the nut **60**, the fineness of the delivered mixture may be varied, and it is discharged as an upwardly diverging conically shaped stream or curtain of fine mist. This stream or curtain of mist is similar to that produced by the nozzle disclosed in the Day patent, #2,116,879 above referred to, and the fine curtain of the mixture after passing between the ball and its seat strikes against the upright wall or shoulder **56** where it is broken up somewhat more into a finer mixture.

Since the steam discharged from the jets **53** continues to escape, the jets of steam so formed will impinge against the curtain of the mixture of steam and cleaning agents and further subdivide it into extremely fine particles that are so fine as to largely remain in suspension in and diffuse through and displace some of the air of the enclosure, and thereby reach all parts of the enclosure interior and penetrate all of the small cavities on the interior surfaces. Since there is little or no condensation of the steam in the preheated enclosure there will be few or no liquid bridges across those cavities that would block entry into such cavities of the finely divided mist of the cleaning liquid. I have found that the admission of the cleaning liquid into the tube **34** by the steam injector in periodic pulses, due to the single stroke action of the pump appears to give a more effective cleaning action.

At the same time the turbine rotor is rotating the tube **34** so that the curtain of discharge of the mixture of steam and cleaning solution or liquid will also rotate about the axis of rotation of the tube and the impact of the steam from the non-rotating jets **53** upon the rotating curtain of the steam and cleaning mixture is very effective in breaking up the curtain into even finer particles of the cleaning liquid.

After this cleaning has continued until the contaminant is loosened or released, these streams are discontinued, and a rinsing solution, preferably hot, is passed into and through the enclosure to wash out the loosened and released contaminants, through a separate nozzle, or by alternately connecting tube **34** through conduit **34***b* and valve **34***c* to a source of rinsing water. After rinsing of the enclosure, the rinse water is cut off and a stream of hot, dry, dehumidified air is passed through inlet **29** into and along passage **51**, and discharged through the annular orifice **62** into the enclosure until the interior of the enclosure is dry.

While the divided annular ring **52** at the discharge end of the nozzle may have a plurality of separate jet passages **53**, arranged side by side along the ring, the passages may be, and preferably are, as shown, substantially a continuous, annular passage where the inner and outer parts of each section of the ring are connected by a few radially extending cross arms or bars 53a arranged at intervals around each section of the ring, so that the discharge through jet passages 53 will be, as nearly as practical, an approximately annular, thin, curtain of steam that impinges against the somewhat conical thin curtain of the mixture of cleaning liquid and steam escaping from around the ball 57.

In the application of the fluid used for cleaning, rust removal, and the applicataion of a rust inhibitor, the intermittent addition of the cleaning solution to the dry steam, such as caused by the single acting pump 40, for discharge through rotating tube 34 aids materially in preventing the formation of liquid bridges across any of the small indentations, cracks, recesses and crevices, and hence results in a rapid and effective cleaning of the interiors of the enclosures. It is postulated that the dry or superheated steam discharged into the enclosure between pressure strokes of the pump 40, will evaporate any cleaning liquid or water that might possibly condense as liquid bridges across any of the indentations, pores or crevices in the surfaces being cleaned and interfere with entry of the colloidal particles of cleaning fluid into the indentations, pores, recesses or crevices in the interior surfaces of the enclosure or objects therein. If liquid cleaning agents are delivered continuously and rapidly, such as by a stream in liquid form impinging upon an open screen, there is a tendency for the liquid to form liquid bridges across the screen openings or across the faces of pores, recesses, indentations, cracks and crevices that slow or deter the action of the cleaning agents employed, in penetrating such bridges. The danger of formation of bridges is lessened by the intermittent delivery of the cleaning liquid to the steam injector.

In one example of the practice of the invention, the single acting pump was operated at about 300 revolutions per minute and delivered on each discharge or feed stroke about 0.9 ounce per stroke which for 150 feed or discharge strokes would deliver about 135 ounces of cleaning solution per minute. At the same time the steam was supplied continuously at about 3.5 to 4 lbs. per minute at 50 lbs. gage pressure, which appeared to be ample to completely convert the cleaning liquid being used into a fine mist with sufficient energy and heat to accomplish the desired results. Steam at higher pressures of 100 lbs. gage pressure or higher would have given swifter cleaning. Because of this intermittent addition of the cleaning agent, along with continued flow of the dry or superheated steam, the concentration of the cleaning agent can be greater than might be used if continued contact of the liquid with the contaminated surface was employed. In the use of acids to remove rust and scale, the intermittent admission of the acid along with the diluting dry or superheated steam that is being continuously discharged into the disclosure enables one to use much stronger or more concentrated acid solutions without danger of damage to the metal of the enclosure by such acids. Concentrations of mineral acids of up to 25% or more can be safely used since the steam dilutes the acid further and the time of contact of the acid with the metal is merely a matter usually of only a few minutes and is followed promptly by a water rinse.

The dry and superheated steam applied between the strokes of the pump keeps the interior surfaces or areas of the enclosure and of objects therein dry, hot and free from any condensation on those surfaces. When the steam pressure as supplied is increased, it is possible to locate the discharge nozzle, such as is disclosed in the drawings, for example, at a greater distance from the surfaces to be cleaned, because the increased steam pressure would impart more energy to the discharged steam and thus allow for this increase in distance from the discharge nozzle to the interior areas, objects, or surfaces to be cleaned. For large tanks, such as cargo tanks of ships or large stationary storage tanks, this is advantageous and more economical.

In the cleaning of surfaces that are contaminated with oils, the addition to the cleaning liquid of a small amount of any emulsion breaking agent, such as carbon tetrachloride for example, will accelerate and more effectively complete the cleaning by breaking the emulsions of the oils adhering to any surfaces within an enclosure and facilitate their removal from such surfaces.

It will be understood that various changes in the details, steps, materials and arrangements and constructions of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. Apparatus for use in cleaning the exposed metal interior surfaces of an enclosure to remove adhering contaminants from such surfaces, which comprises:
   - one tube having an inlet at one end, terminating at its other end in an annular, outwardly facing and divergent end seat,
   - a ball engaging said seat,
   - means for adjustably limiting movement of said ball away from said seat to vary the thickness of a cone of a fluid passing said ball,
   - another tube larger than and surrounding said one tube and terminating at one end adjacent to said ball in a plurality of jet nozzles that are pointed toward the side of a cone of a fluid that may pass said ball from said one tube,
   - a tubular casing surrounding, larger than and extending along said another tube and terminating at one end in a discharge port, adjacent said ball,
   - means for closing the other ends of said another tube and said casing,
   - means for supplying air to the space between said casing and said another tube at a location remote from said discharge port,
   - means for supplying steam to the space between said tubes at a location remote from said nozzles, and
   - a conduit connected to the other end of said one tube for supplying a fluid thereto.

2. The apparatus according to claim 1, wherein said conduit has a portion of its passage of venturi shape with an injector in front of said venturi passage.

3. The apparatus according to claim 2, and means connected to said injector at one side of the injector nozzle for supplying liquid to the injector in pulses.

4. The apparatus according to claim 1, wherein said one tube is mounted to rotate about its longitudinal axis within said another tube, and power means connected to said one tube for causing its such rotation.

5. Apparatus for use in cleaning the exposed metal interior surfaces of an enclosure to remove adhering contaminants from such surfaces, which comprises:
   - one tube having an inlet at one end, terminating at its other end in an annular, outwardly facing and divergent end seat,
   - a ball engaging said seat,
   - means for adjustably limiting movement of said ball away from said seat to vary the thickness of a cone of a fluid passing said ball,
   - another tube larger than and surrounding said one tube and terminating at one end adjacent to said ball in a plurality of jet nozzles that are pointed toward the side of a cone of a fluid that may pass said ball from said one tube,
   - a tubular casing surrounding, larger than and extending along said another tube and terminating at one end in a discharge port adjacent said ball,
   - means for closing the other ends of said another tube and said casing,

means for supplying a fluid to the space between said casing and said another tube at a location remote from said discharge port,

means for closing the space between said tubes at a location remote from said nozzles,

means for supplying a fluid to the space between said tubes at said location remote from said nozzles, and

a conduit connected to the other end of said one tube for supplying a fluid thereto.

6. The apparatus according to claim **5**, wherein said means for closing the other end of said another tube and casing and said means for closing the space between said tubes at a location remote from said nozzles comprises a plurality of plates arranged in superposed spaced apart relation by endless walls, all secured together by clamping means.

7. The apparatus according to claim **5**, wherein said means for adjustably limiting movement of said ball away from said seat comprises an apertured partition across the passage of said one tube, said apertured partition having a stud secured thereto and extending upwardly therefrom, said ball having a passage therethrough slidingly receiving said stud, said stud being of greater length than the passage through said ball, said stud being threaded, and a nut on the outer end of the threaded stud for engaging the ball and by which the possible displacement of the ball from its seat may be varied.

8. The apparatus according to claim **7**, wherein said apertured partition has threaded engagement within the upper end of said one tube, whereby it is adjustably held in said tube relative to said seat and ball.

9. The apparatus according to claim **5** wherein said another tube which terminates in a plurality of jet nozzles, has an internal threading into which is threaded an annular ring having an upwardly converging tapered or jet annular passage therein with radially extending cross bars arranged at intervals around said ring in said annular tapered passage, and providing said jet nozzles.

10. The apparatus according to claim **9** in which said annular ring is made in two superposed, separate sections, with ball bearings disposed in a groove at the junction between the superposed sections of the ring and in a cooperating groove in the upper end of said one tube, for rotatably mounting said tube in said ring.

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