

United States Patent

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Continuation of application Ser. No.
463,781, June 14, 1965, now abandoned.

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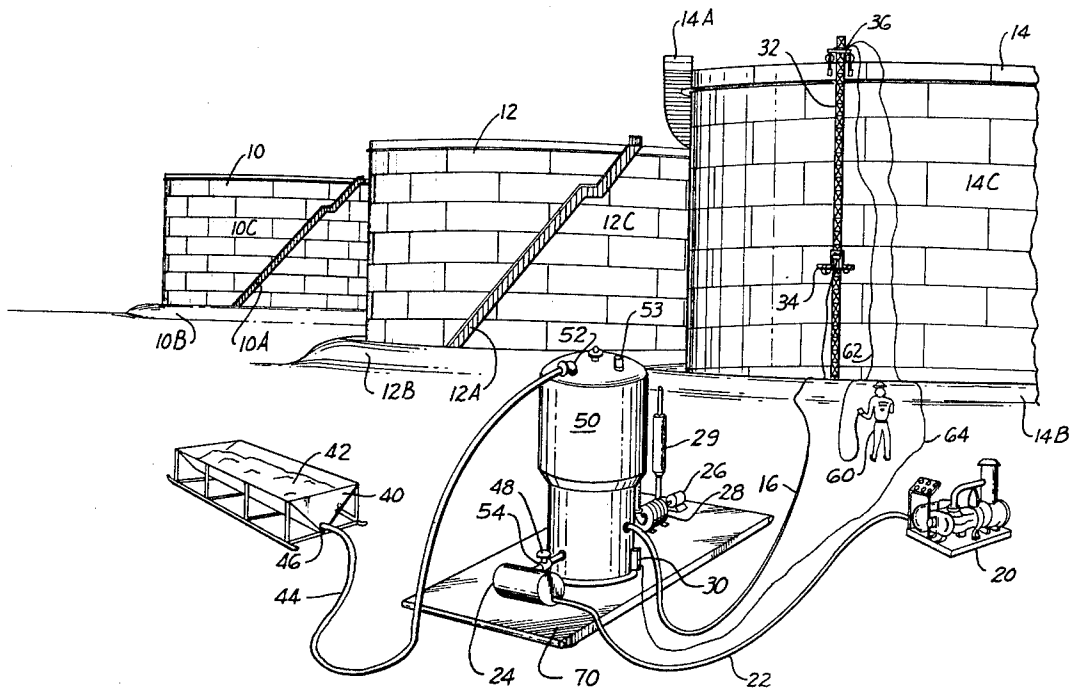
[54] **SURFACE TREATMENT APPARATUS**
4 Claims, 26 Drawing Figs.

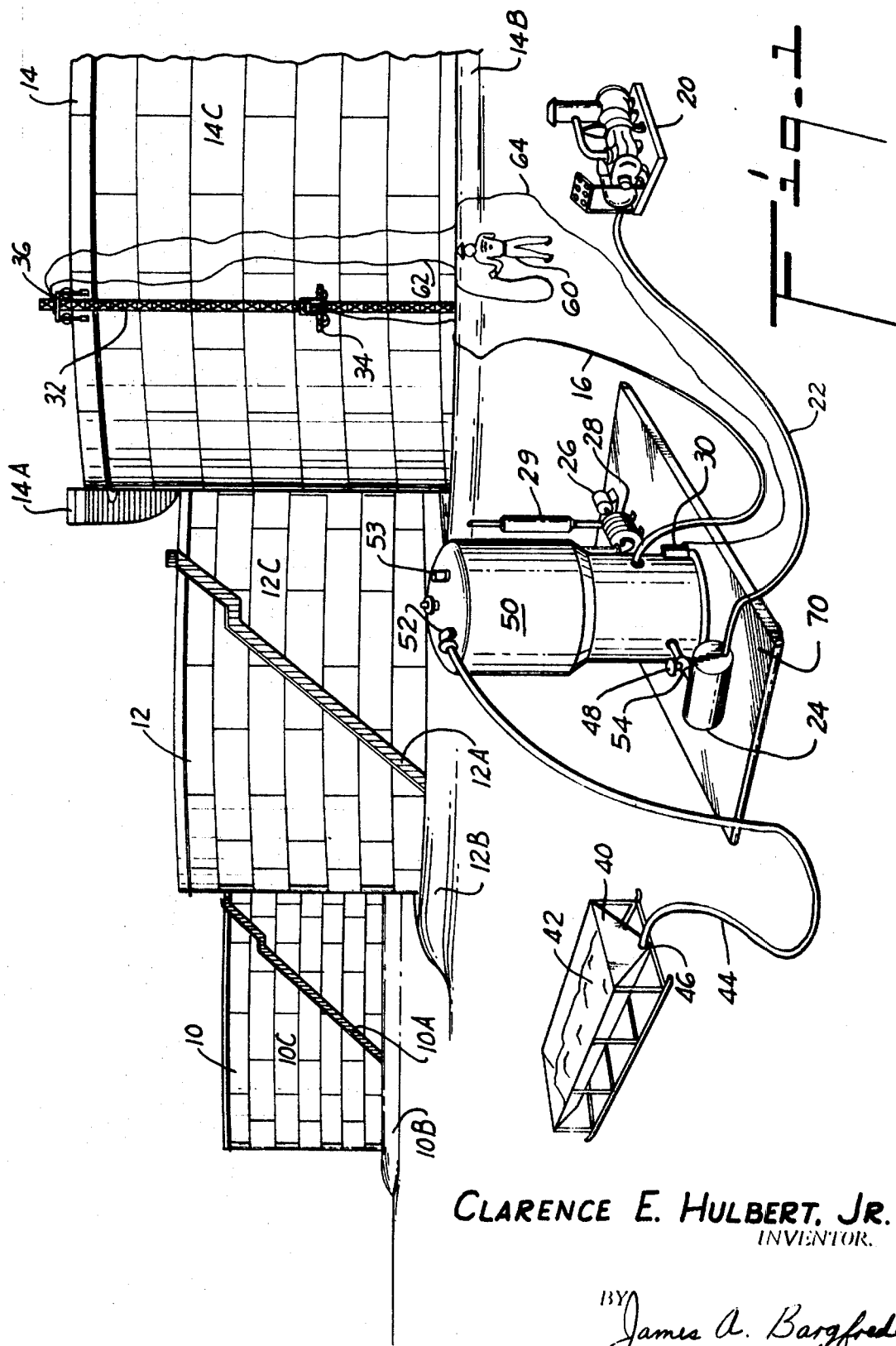
[52] U.S. Cl. **51/8**
[51] Int. Cl. **B24c 3/06**
[50] Field of Search **51/8, 11,**
12, 14; 302/28, 64

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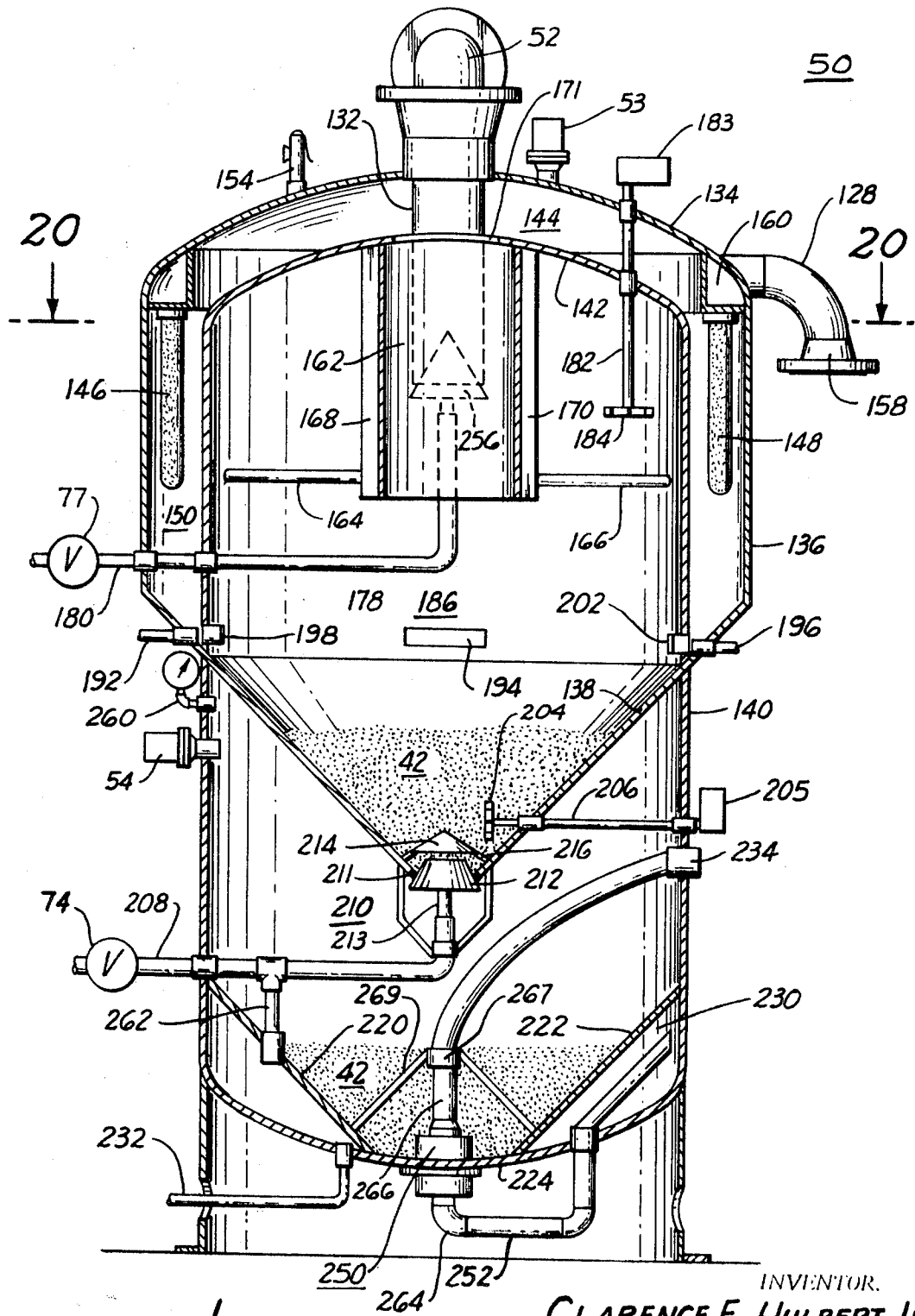
ABSTRACT: Apparatus and method of conveying granular material substantial distances from an open storage container through vessel means which provides alternate vacuum and pressure to chamber means in said vessel means to said material from said vessel means continuously over substantial distances. Distributor outlet means are provided for discharging said material continuously. Tower means may be utilized to position said distributor outlet means whereby a uniform anchor pattern is provided on a surface in proximity to said distributor outlet means.





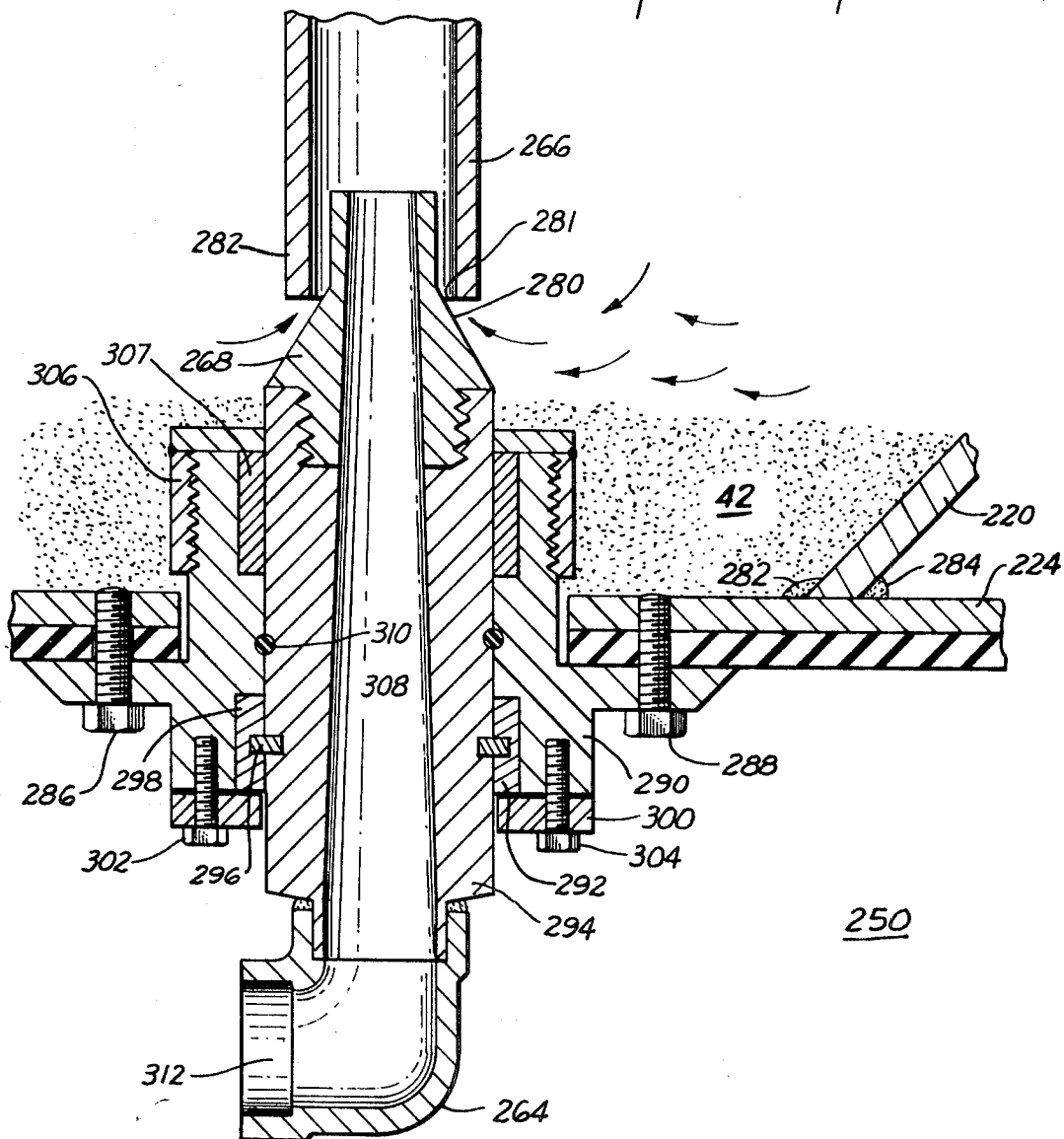
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Fig. 5

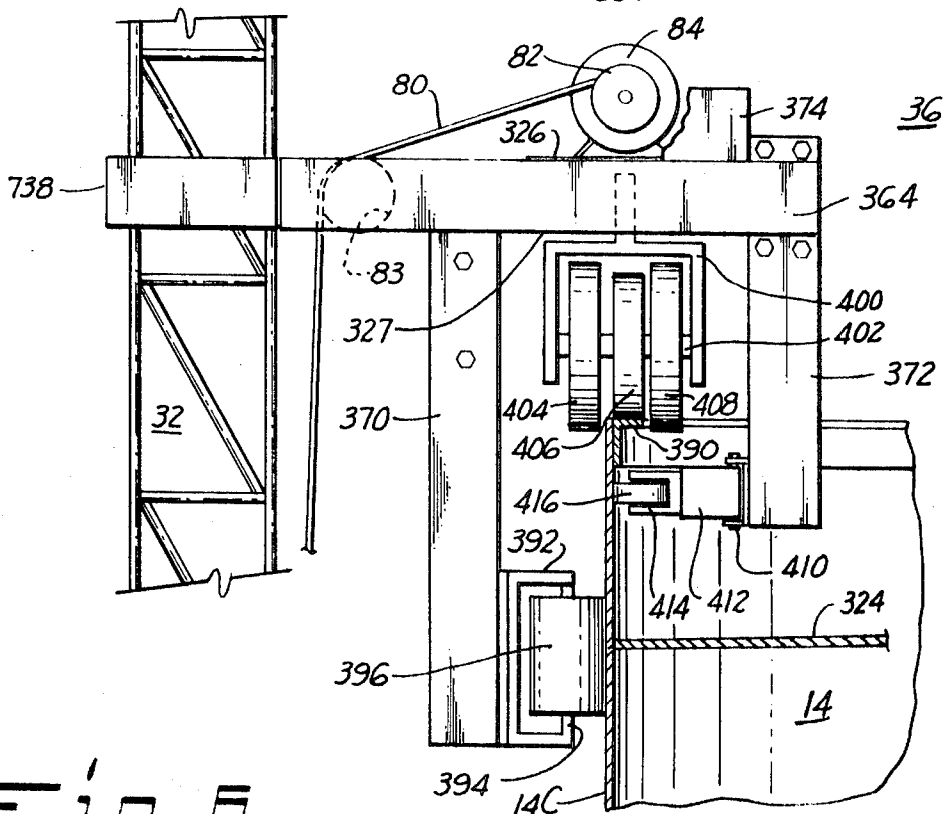
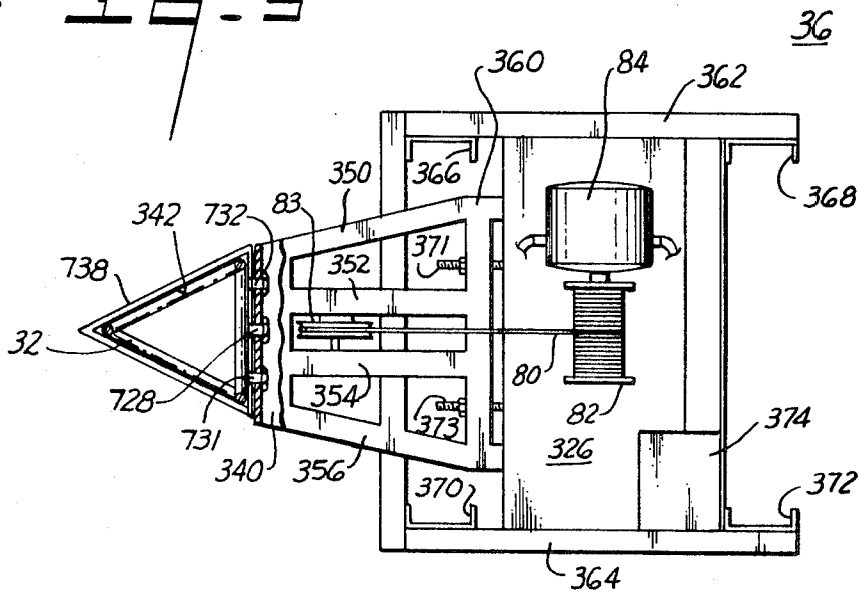


Fig. 6

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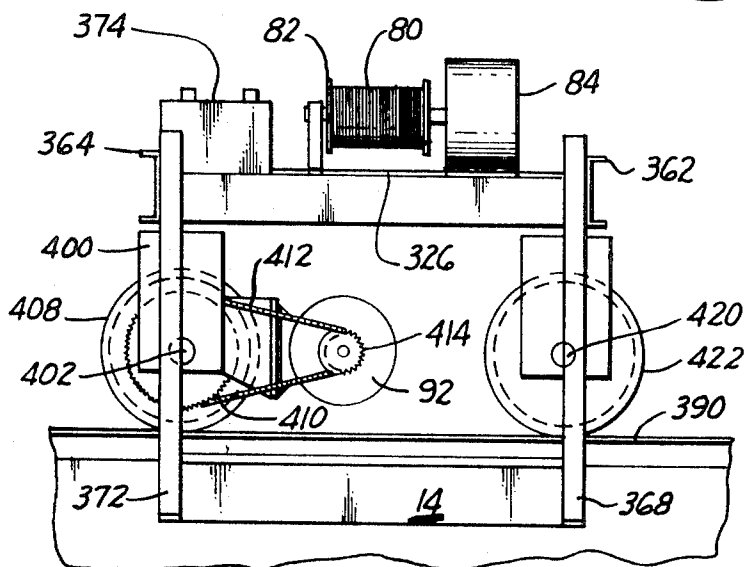
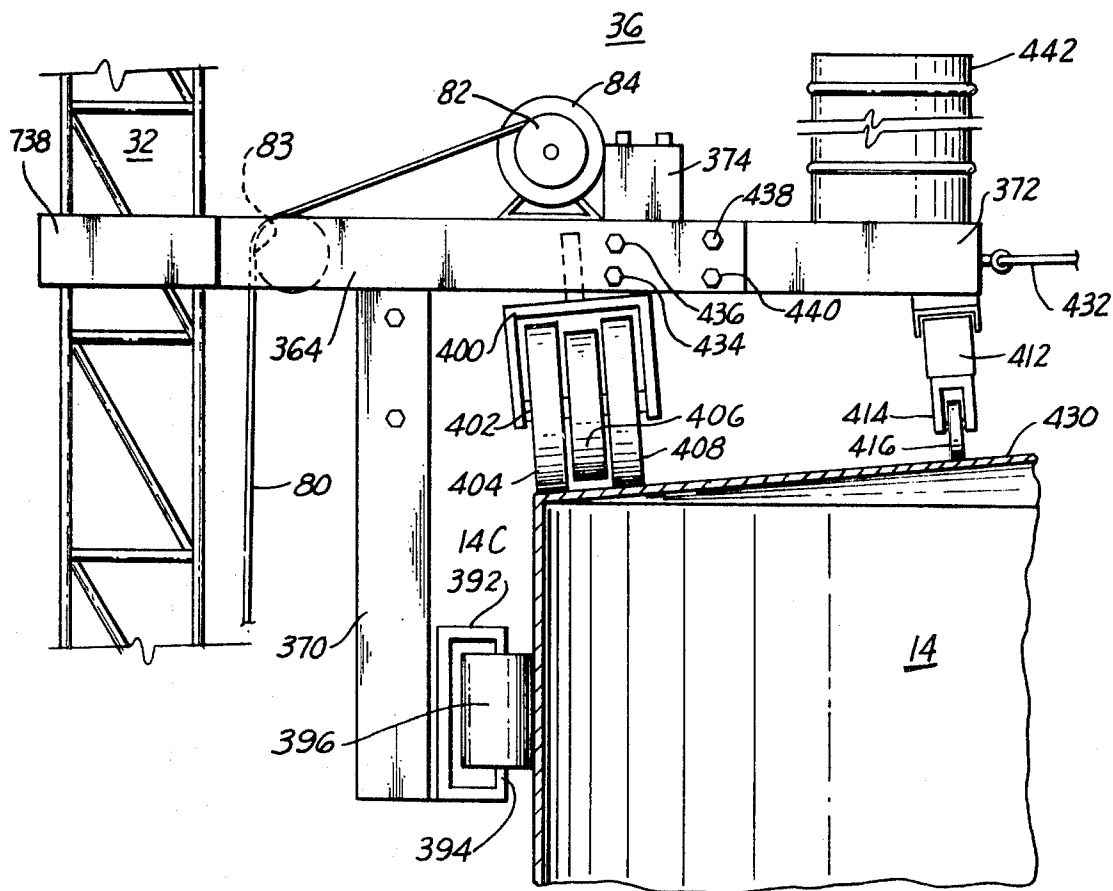
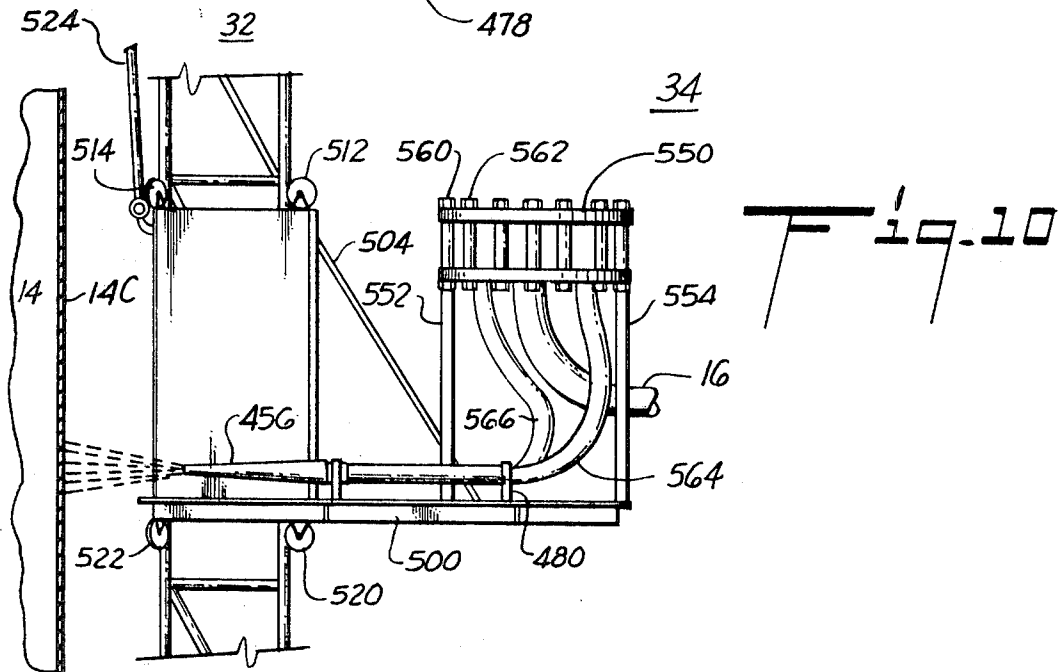
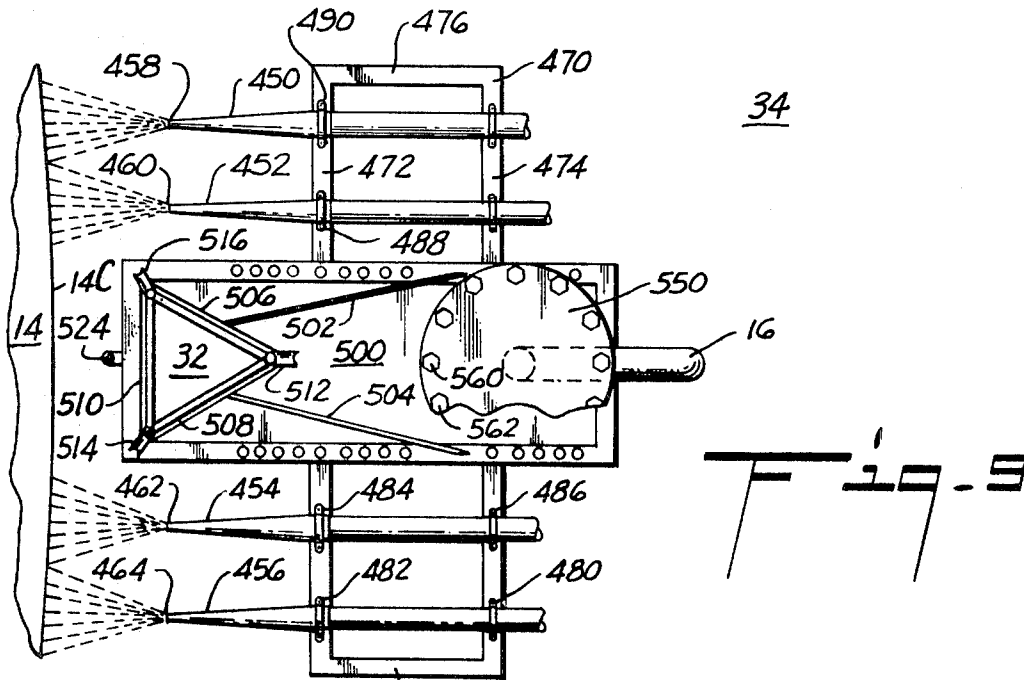


Fig. 8

Fig. 7

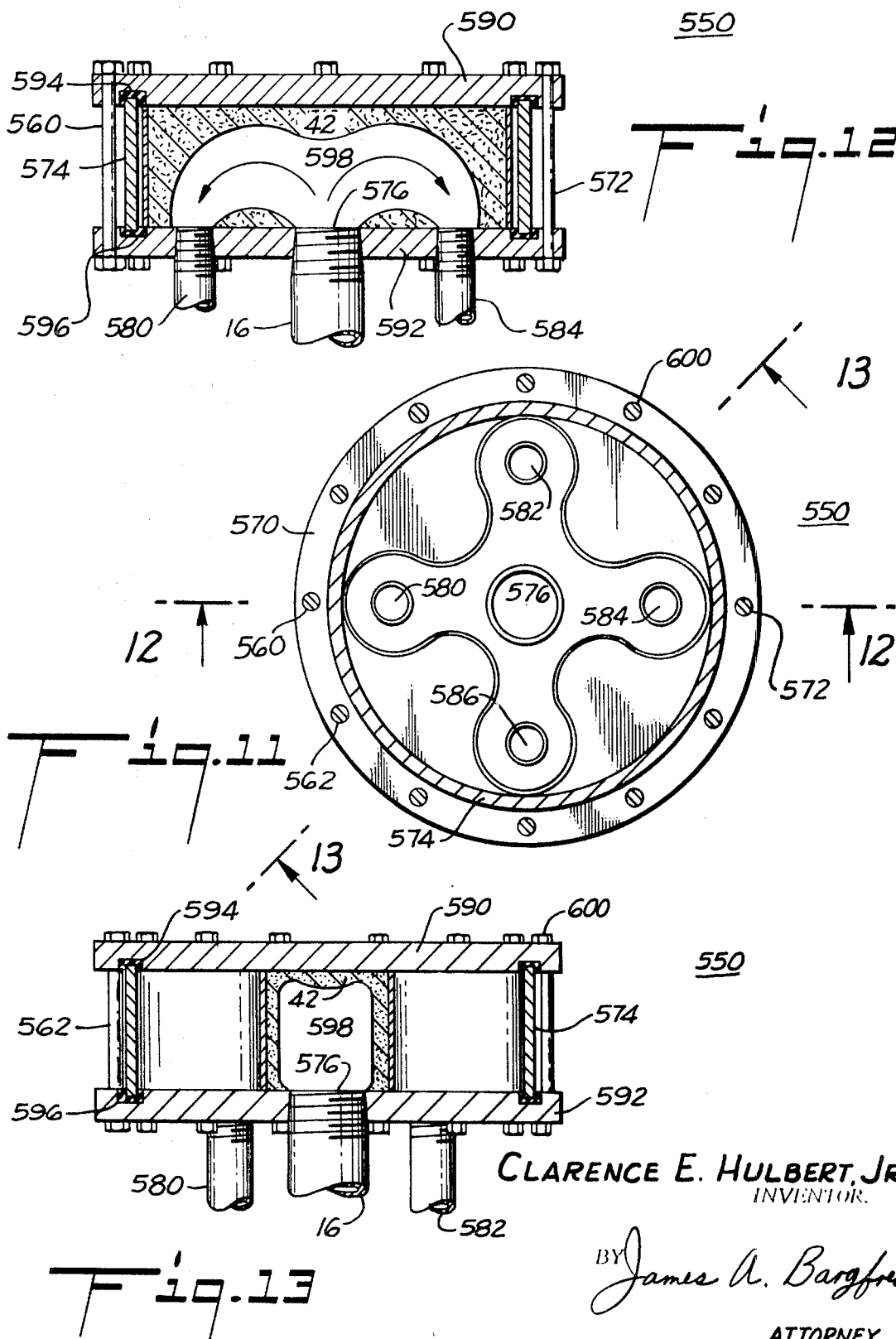
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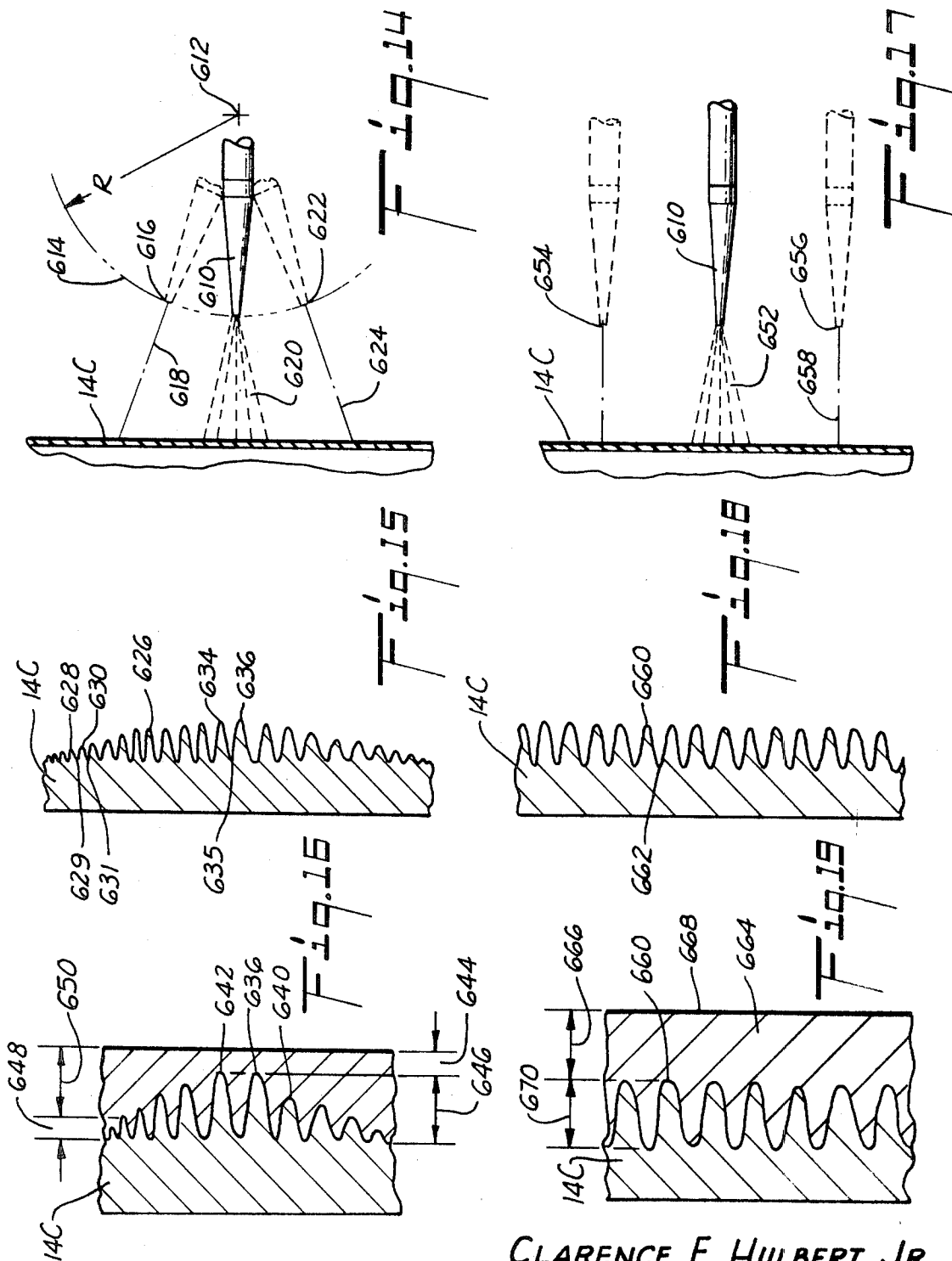
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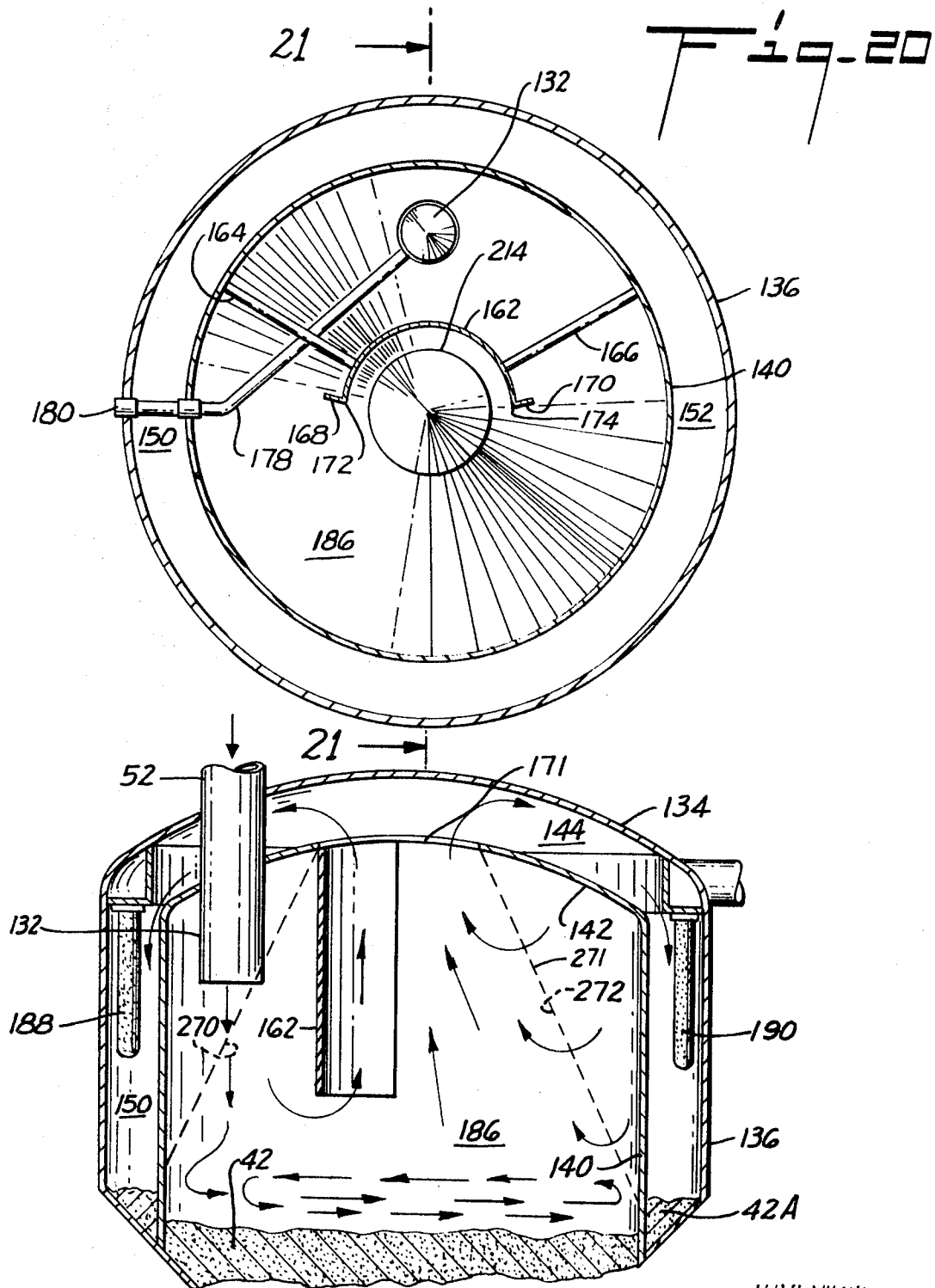
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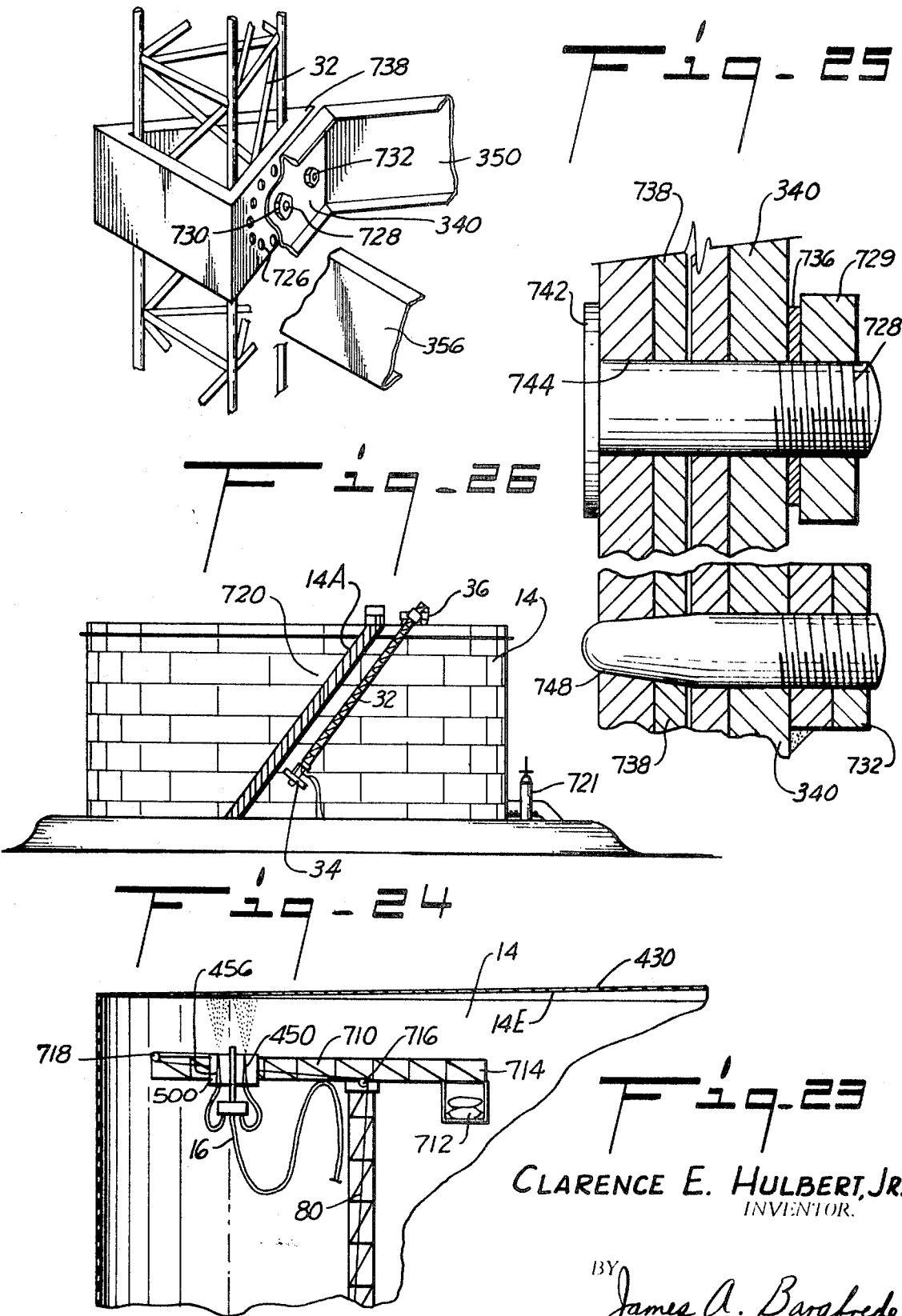


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Fig. 21

Fig. 20



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SURFACE TREATMENT APPARATUS

This application is a continuation of my application Ser. No. 463,781 filed June 14, 1965, and now abandoned.

This invention pertains generally to automatic cleaning equipment and methods and particularly to equipment and methods which may be utilized in moving products substantial distances while maintaining a velocity of the product at a greater rate than has been heretofore obtained.

Sandblasting is old in the art. Many devices have provided a source of abrasives, passed such abrasives through suitable equipment to increase the velocity of the abrasive, and discharge the abrasive through a nozzle onto a surface to be cleaned. The surface to be cleaned had a variable anchor pattern or holding quality because the manual movement of the nozzle caused the nozzle to be at a varying distance and angle from the surface to be cleaned, thereby causing a variable anchor pattern to be formed on such surface. As set forth in *Surface Preparation Specifications No. 5 Blast Cleaning to "White" Metal*, approved as tentative Aug. 28, 1952 by Steel Structures Painting Council, 4400 Fifth Avenue, Pittsburgh, Pennsylvania on page 2, paragraph 3.8: "The height of profile of the anchor pattern produced on the surface shall be limited to a maximum height that will not be detrimental to the life of the paint film." On page 3, paragraph A.3 is the following: "The maximum height of profile is the height of the anchor pattern produced on the surface, measured from the bottoms of the lowest pits to the tops of the highest peaks . . . the allowable maximum height of profile is, in turn, dependent upon the thickness of paint to be applied." It is impossible to produce a quality-controlled anchor pattern by manual means. The present invention has created the first method controlled by angle, distance and constant velocity of abrasive emitting from the nozzles to produce a true height and depth control of anchor pattern for the purpose of controlling the uniform etched surface. The paint or coating film of uniform thickness known to exist from the tip of the highest peak to the exterior surface of the paint film, depends upon uniformity of the profile of the surface thereby enabling control of the thickness and adding longevity and durability to the coating system used when applied over this method of sand blasted surface. Heretofore known manual means cannot accomplish this result yet it is desired by all who apply or manufacture paints or coatings and by the recipients of those services. Equipment which has been available in the past has been cumbersome and has not provided adequate velocity through conduits so that long lengths of hose could be used with such cleaning equipment. Also, automated cleaning equipment has been limited generally to flat surfaces on substantially small workpieces. Among the expired patents which show various types of abrasive cleaning equipment and methods are the following:

U.S. Pat. No. 1,462,296, Moore et al., issued July 17, 1923.
U.S. Pat. No. 1,616,777, Booth, issued Feb. 8, 1927.
U.S. Pat. No. 1,625,721, Hahn, issued Apr. 19, 1927.
U.S. Pat. No. 1,635,539, Coleman et al., issued July 12, 1927.

U.S. Pat. No. 1,858,474, Wolever, issued May 17, 1932.

U.S. Pat. No. 2,380,738, Eppler, issued July 31, 1945.

U.S. Pat. No. 2,409,722, Stark et al., issued Oct. 22, 1946.

Among the prior art patents which have not expired but which indicate various types of cleaning equipment and methods, are the following:

Reissue U.S. Pat. No. 23,186, Mead, issued Jan. 3, 1950.

U.S. S. Pat. No. 2,597,434, Bishop et al., issued May 20, 1952.

U.S. Pat. No. 2,570,603, Shoemaker, issued Oct. 9, 1951.

U.S. Pat. No. 2,845,091, Neer, issued July 29, 1958.

U.S. Pat. No. 3,015,913, Anderson, issued Jan. 9, 1962.

U.S. Pat. No. 3,139,705, Histed, issued July 7, 1964.

U.S. Pat. No. 3,179,378, Zenz et al., issued Apr. 20, 1965.

One of the major cleaning problems in the sandblasting or abrasive cleaning art has been in the cleaning of large oil and petroleum products storage tanks which are generally cylindrical in shape except for the upper part of such tank. The

upper part of such tanks is conical. Some oil storage and petroleum products storage tanks have a floating or variable position top which prevents evaporation from being as great as would be encountered if the top was not a floating top. Present practice in cleaning such oil and petroleum products storage tanks involves having cumbersome scaffolding and cumbersome equipment when cleaning the outside and the inside of such tanks. Many men are needed to operate the equipment which has heretofore been used in cleaning such oil and petroleum products tanks. The danger to men working on the scaffolding in cleaning both the exterior and interior of the tanks has been great due to the possibility of men falling from the scaffolding and from the tanks. Also, the men who have been cleaning such tanks have been subjected to silicosis. In cleaning the inside of such tanks, an additional danger has been the possibility of workmen being overcome by fumes from the products being stored in such tanks as well as the excessive temperature and poor air circulation on the inside of such tanks. The present invention is directed to overcoming and eliminating many of the problems heretofore encountered in the cleaning, particularly petroleum and chemical products storage tanks, ships, barges, and the like not excluding buildings, dams, and other structures, but the present invention also is adaptable for use in a plurality of endeavors which will be set forth in detail later.

Thus, it is an object of the present invention to provide improved equipment for cleaning and coating surfaces, particularly the exterior and interior surfaces of products storage tanks.

Another object of the present invention is to provide an apparatus for cleaning a surface whereby such surface is provided with uniform anchor pattern for the purpose of painting or applying a protective coating film, the uniform thickness of such coating film being essential to the life of such coating film.

Still a further object of the present invention is to provide cleaning apparatus wherein a single human operator is capable of remotely controlling the cleaning operation on the surface to be cleaned. A still further object of the present invention is to provide improved cleaning equipment, utilizing simplified equipment and less man power.

Yet another object of the present invention is to provide cleaning equipment wherein workmen are removed from the hazards of dust, fumes, and temperature extremes.

Yet another object of the present invention is to provide cleaning equipment wherein scaffolding is eliminated, thereby preventing accidents to workmen which have been required in the past to work on such scaffolds.

A still further object of the present invention is to provide cleaning equipment wherein fewer workmen are required.

Yet another object of the present invention is to provide cleaning equipment wherein workmen no longer need to handle or hold a high-pressure sandblast hose at dangerous elevations while working on surfaces to be cleaned.

A still further object of the present invention is to provide equipment for cleaning the interior of tanks in a safe, fast, and controlled manner.

A further object of the present invention is to provide an improved distributor head characterized by smaller friction loss.

Yet another object of the present invention is to provide a universal cleaning rig structure adaptable for use on various configurations, sizes, and types of vessels to be cleaned.

Briefly stated, the present invention includes an apparatus for providing uniform anchor pattern characteristics to a surface to be cleaned. The equipment of the present invention when utilized for cleaning a surface includes a source of cleaning material such as sand or other abrasives, compressor means, pressure vessel means coupled to said compressor means and to the source of cleaning material, means coupled to the vessel means for providing continuous flow of abrasives from the vessel means, trolley means and guide tower means coupled to the surface to be cleaned, and distributor and nozzle carrier means coupled to the guide tower means and trolley

ley means. The vessel means of the present invention include an upper inlet portion which acts both as a high-pressure and low-pressure chamber and a lower portion wherein high-pressure is maintained continuously. Means are provided in the vessel means between the upper chamber and lower chamber to allow sand or other material moving through said vessel to be dropped from the upper chamber to the lower chamber whenever the level in the upper chamber reaches a selected amount. Handle means are also provided on the vessel means to allow material which has accumulated near filters positioned near the outer portion of said vessel means to be dropped into the upper chamber of said vessel means. A moisture bleed is provided near the lower chamber to allow removal of moisture which accumulates in the bottom of the vessel means. An important feature of the vessel means is the movement of abrasive material in said vessel means. Movement of material in the vessel means provides minimum friction loss while allowing maximum use of suction created by blower means coupled to the vessel means. The vessel means further includes a discharge outlet which may be moved to a limited extent to provide constant metered quantity and velocity to the abrasive or other material being discharged from the lower portion of the vessel means. The guide tower means and trolley means are suspended from the surface to be cleaned with the trolley means providing horizontal movement to the vertical guide tower means. Horizontal movement of the trolley and guide tower means is achieved remotely by an operator controlling the entire cleaning operation. Distributor and nozzle means are coupled to the guide tower and trolley means with the distributor and nozzle means moving vertically along the guide tower means. Vertical movement of the distributor head and nozzle means also is accomplished remotely by the same operator who controls the horizontal movement of the guide tower means and trolley means. The guide tower means provides a controlled cleaning path for the nozzle means. Thus, it will be appreciated that the distributor head and nozzle means where the cleaning substance is discharged against the surface to be cleaned may be moved vertically and horizontally simultaneously by the operator thereby allowing the operator to write his name, for example, on the surface being cleaned. The position of the distributor head and nozzle means from the surface being cleaned is maintained at a substantially constant angle and substantially constant distance from such surface to provide a substantially constant, uniform anchor pattern on the surface being cleaned. Thus, the surface being cleaned will retain paint or other coatings applied to such surface after the cleaning operation is completed much better than a surface which does not have a uniform anchor pattern. Although the invention has been described briefly in connection with a cleaning operation of a surface, it will be appreciated that the principles involved in the present invention allow such invention to be used for the purpose of applying paint and other coatings to such surface automatically. Although the invention has been described briefly with the cleaning operation of a surface, it will be appreciated that the invention allows movement of liquids and solids from storage facilities at a rate heretofore unattainable. The present invention may be utilized, for example, in loading or unloading grain or other materials to or from the hold of a ship, storage bin, or other storage facility where it is difficult or impossible to locate workmen or to provide equipment which heretofore would satisfactorily perform the required operation.

In the drawings FIG. 1 is a perspective sketch showing the present invention utilized in cleaning storage tanks;

FIG. 2 is a combined flow sheet and sketch of the present invention used in cleaning tanks;

FIG. 3 is a sectional elevational view of the vessel means of the present invention;

FIG. 4 is a sectional elevational view of the outlet means of the vessel means shown in FIG. 3;

FIG. 5 is a top view of the guide tower means and trolley means of the present invention;

FIG. 6 is a side elevational view of a portion of the guide tower means and trolley means shown in FIG. 5;

FIG. 7 is a side elevational view showing a portion of the guide tower means and the trolley means of the present invention when used on another type tank;

FIG. 8 is an elevational view of the trolley means shown in FIG. 7 taken from the upper tank side;

FIG. 9 is a top plan view of the distributor head and nozzle means of the present invention;

FIG. 10 is a side elevational view of the distributor head and nozzle means of the present invention;

FIG. 11 is a bottom view of the distributor head of the present invention;

FIG. 12 is a sectional elevational view of the distributor head taken along line 12-12 of FIG. 11;

FIG. 13 is a sectional elevational view of the distributor head of the present invention taken along line 13-13 of FIG. 11;

FIG. 14 is a top plan view of a conventional nozzle moved about a fixed radius;

FIG. 15 is a top plan view of a surface showing the anchor pattern when cleaned in the manner shown in FIG. 14;

FIG. 16 is a top plan view showing a surface and the coating thereon when an anchor pattern shown in FIG. 15 is present;

FIG. 17 is a top plan view showing a plurality of nozzle positions in accordance with the present invention;

FIG. 18 is a top plan view of a surface which has been cleaned in accordance with the present invention showing a uniform anchor pattern on the cleaned surface;

FIG. 19 is a top plan view of the surface shown in FIG. 18 wherein such surface has been coated;

FIG. 20 is a top plan view in section showing the vessel means of the present invention;

FIG. 21 is a sectional elevational view taken along line 21-21 of FIG. 20;

FIG. 22 is a partial sectional elevational view showing the upper inside portion of a tank being cleaned in accordance with the present invention;

FIG. 22 is a partial sectional elevational view of the interior of a storage tank being cleaned in accordance with the present invention;

FIG. 23 is a partial sectional elevational view showing the upper inside portion of a tank being cleaned in accordance with the present invention;

FIG. 24 is a side elevational view of a tank being cleaned in accordance with the present invention;

FIG. 25 is a partial sectional perspective view of the guide tower means coupling shown in FIG. 24; and

FIG. 26 is a sectional top view of the fastening means shown in FIG. 25.

Referring now to the drawings in detail, FIG. 1 is a perspective sketch showing a typical use of the present invention. A plurality of oil storage tanks 10, 12 and 14 are shown. It will be appreciated that oil storage tanks 10, 12, and 14 are provided with steps 10A, 12A, and 14A to allow personnel to go from the ground to the top of the tanks. Also, mounds of earth such as 10B, 12B, and 14B surround each one of the respective tanks.

The elevated protective banks 10B, 12B, and 14B surrounding each one of tanks 10, 12 and 14, respectively, act to protect the lower portion of the tanks and to act as an auxiliary storage area in the event liquid leaks from the tanks thereby minimizing fire hazards in the event that tanks 10, 12, and 14 contain combustible liquids. The banks such as 10B, 12B, and 14B present problems, however, when conventional cleaning methods are utilized in cleaning the surfaces 10C, 12C, and 14C of the tanks. Also, steps 10A, 12A, and 14A present a problem in positioning scaffolding and workmen on the exterior of the tanks when such tanks are cleaned by conventional apparatus and conventional methods.

Tank 14 is shown in FIG. 1 being cleaned by the apparatus of the present invention. A hopper 40 is utilized in storing abrasive material such as sand 42. Hopper 40 may be open as

shown to allow abrasives such as sand or other material to be positioned in the hopper. By having an open hopper such as the hopper shown in FIG. 1, workmen can visibly ascertain when additional material is needed to be placed in the hopper. Also, by having an open hopper there is no necessity for utilizing overhead hoppers or pressurized vessels for storing abrasives or other material in the manner previously utilized in known prior art apparatus. The open hopper allows sand or other abrasives to be positioned in the hopper at any convenient time and in variable quantities, inasmuch as the operation of the storage hopper is not dependent upon any fixed level or amount of abrasive material 42 positioned in such hopper. The portable hopper 40 shown in FIG. 1 allows easy loading from dump trucks or other rapid loading means.

A suitable conduit such as hose 44 is coupled at 46 to the hopper 40. Hose 44 extends upwardly to the vessel means 50. Vessel means 50 will be explained in detail subsequently, inasmuch as such vessel means is an important part of the present invention. Suffice it to say for the present, however, the vessel means 50 has an intake section 52 where the abrasive 42 enters the vessel means 50.

Coupled to vessel means 50 is a suitable air compressor 20 which may have, for example, a 1,200 cubic feet per minute capacity. Compressor 20 is coupled through suitable conduits such as hose 22 to a reservoir tank 24. Reservoir tank 24 is coupled to vessel means 50 through suitable pipe means 54 having a two-way remote-operated valve 48. The air compressor provides the pressurized air which is utilized in vessel means 50 in a manner to be explained hereinafter to allow pressurized abrasive 42 to pass through pressure outlet hose 16 to the distributor head and nozzle means 34 positioned on guide tower means 32. Guide tower means 32 is suspended by trolley means 36 from the upper portion of tank 14 in a manner to be explained subsequently. An operator 60 is positioned at a suitable location to cause horizontal movement of trolley means 36 and guide tower means 32. Operator 60 further provides vertical movement of the distributor head and nozzle means 34 through a control box 30 coupled through lead 62 to an instrument control box held by operator 60. Lead 64 also comes from the instrument control box panel held by operator 60 and is coupled to trolley means 36 to effectuate horizontal movement of the trolley means 36 to guide tower means 32 in a manner to be explained subsequently. It will be appreciated that the guide tower means 32 is not rigidly or movably coupled to the earth or to bank 14B surrounding tank 14, but guide tower means 32 and trolley means 36 move around the periphery of tank 14 without substantial contact at the lower portion of guide tower means 32 with the earth.

Also coupled to vessel means 50 is a blowdown valve 53 and an exhaustor or blower 28 which is driven by suitable motive means such as a motor 26. The function and operation of the exhaustor or blower 28 will be explained subsequently in connection with the detailed explanation of the interior operation of vessel means 50. A suitable manifold exhaust 29 also is coupled to blower or exhaustor 28.

It will be appreciated that the vessel means 50 and associated components may be skid mounted on a suitable plate 70. Such plate or skid 70 may be provided with wheels to allow the vessel means 50 to be easily and effectively moved to desired locations with a minimum amount of effort. Thus, it will be appreciated in viewing the overall system shown in FIG. 1 that operator 60 by simply manipulating a hand-carried group of switches or buttons on the instrument control box to remotely control the cleaning operation of surface 14C of tank 14. The movement of the nozzles which discharge the abrasive under pressure from pressure outlet 16 are movable vertically and horizontally simultaneously so that, for example, operator 60 could write his name on surface 14C. The movement and cleaning swath accomplished with the present invention is thought to be completely new and allows effective, rapid, and safe cleaning of surfaces with a minimum amount of man power and equipment required. As stated previously, although all of the components shown in FIG. 1

may be utilized in practicing the present invention vessel means 50 and distributor head and nozzle means 34 along with guide tower means 32 and trolley means 36 are an important part of the invention.

Referring now to FIG. 2, a combined flow chart and diagrammatic layout is shown in FIG. 2. Hopper 40 is shown containing abrasive such as sand 42. The abrasive or sand 42 passes through flow line 44 to the intake 52 on vessel means 50. As explained previously, an exhaustor or blower 28 is coupled to vessel means 50 through line 128. Reservoir tank 24 is coupled to the upper part of the vessel means 50 through valve 77 in line 76 and valve 74 is coupled to the lower portion of the vessel means 50. Valve 77 is coupled to panel 30 through line 79. The discharge from vessel means 50 passes through line 78 to the distributor head and nozzle means 34 positioned on guide tower means 32. Guide tower means 32 is coupled to trolley means 36 and cable 80 provides vertical movement of the distributor head and nozzle means 34 along guide tower means 32 in a manner to be explained subsequently. Cable 80 is coupled to a winch 82 on trolley means 36. Winch 82 may be driven by a pneumatic motor 84 or other suitable power means positioned on the trolley means 36 with pneumatic motor 84 being coupled to valve 88. Valve 88 and valve 98 are coupled through line 86 to air compressor 20 which may be driven by an electric motor 21 or other suitable power means. It will be appreciated that another pneumatic motor 92 is a component of the trolley means 36 and pneumatic motor 92 drives a smaller diameter wheel positioned between wheels 100 and 102 to cause movement of the trolley means 36 around the periphery of tank 14 so that surface 14C is cleaned. Pneumatic motor 92 is coupled through line 96 to valve 98. Pneumatic line 86 is coupled to line 90 to air compressor 20. Pneumatic line 86 is coupled to a manifold in unit 374. Valves 88 and 98 are double-acting electric solenoid-actuated air valves and are operated by line 62 to box 87 which is manually operated by a workman through power source 30 and line 64. Block 31 is a commercial power source or generator coupled through line 33 to panel 30. It is possible to actuate box 87 by suitable signals from a transmitter capable of transmitting an actuating electromagnetic signal. Further it may be noted that limit switches and timer devices may be incorporated on the guide tower means 32 and on the trolley means 36 to actuate the control solenoids in unit 374. The selection of manual control or automatic control may be made by selecting a type of operation in box 87.

Line 90 from air compressor 20 is coupled through line 110 to valve 112 and to the reservoir tank 24. Blowdown valve 53 is coupled through line 55 to panel 30. Panel 30 provides an electric source through lead 114 to electric motor 21 and through lead 130 to electric motor 26. Panel 30 provided an electric source through line 203 to control devices 183 and 205 on vessel means 50. Control devices 183 and 205 may be of the type known in the trade as ROTO-BIN-DICATORS marketed by The Bindicator Company, 17190 Denver Avenue, Detroit, Michigan and shown in catalog BD-15B-7500-7-61. Blower 28 has coupled thereto exhaust 29 and blower 28 is driven by an electric motor 26 coupled through lead 130 to panel 30.

In viewing FIG. 2 it will be noted that panel 30, power source 31, box 87, and units 183, 205 and 374 act to provide effective operation of the system of the present invention. As explained previously, air compressor 20 provides air pressure to reservoir tank 24 through valve 112. Valves 53, 77, 88, 98, and 126 may be double-acting electric solenoid air valves or other suitable means such as air-controlled valve operators or manually operated valves such as are commercially available to operate effectively with water or other liquids as well as air. Such valves generally are rated at 150 pounds per square inch. The pressure in the upper and lower portions of the vessel means 50 is equalized periodically in a manner to be explained subsequently. Valve 88 controls pneumatic motor 84 which in turn provides rotation to winch 82 thereby causing the distributor head and nozzle means 34 to move vertically because

of the coupling to winch 82 through cable 80 past sheave 83. Valve 98 provides actuation to pneumatic motor 92 to cause horizontal movement of the trolley means 34 through rotation of wheels 100 and 102 on tank 14, thereby providing horizontal movement near the tank. Valve 112 is opened upon actuation of the system to allow continuous flow of air from air compressor 20 to reservoir tank 24.

Referring now to FIG. 3, vessel means 50 of the present invention is shown in sectional elevational form. As explained previously, intake 52 in the upper portion of the vessel means allows products to be brought into the vessel means 50. The products which may be passed into the vessel means 50 may be liquid or solid. The only limitation on the type product which may be passed through the vessel means 50 is the ability of such product to move through a conduit such as pipe. The product brought through inlet 52 passes through a circular chamber such as a pipe 132. Pipe 132 is positioned substantially in the upper portion of the vessel means in order to enter near outer limits of the interior shell of top inner chamber 186. The upper portion of the vessel means includes an outer shell 134 and a cylindrical portion 136. The cylindrical portion 136 has a conical portion 138 coupled thereto. Conical portion 138 is positioned within shell 140 which is substantially the same as many conventional tanks insofar as the external portion of the tank is concerned. Thus, upper portion 142 of the interior tank has a configuration similar to the configuration of upper portion 134 to allow chamber 144 to be provided. Chamber 144 extends downwardly between outer shell 140 and 136 to form chamber 150. A plurality of filters such as filters 146 and 148 shown in FIG. 3 are positioned in chamber 150 extending around chamber 186. A vacuum pressure relief valve 154 is coupled to the upper portion 134 of the vessel shell and a pressure relief blowdown valve 53 also is coupled to upper portion 134 on the other side of product inlet 52. Inlet 158 is coupled through chamber 160 to provide a suction source. Chamber 160 is a manifold whereby a plurality of filters such as 146 and 148 are attached extending circumferentially around the interior of the exterior wall 136 and interior wall 140 in chamber 150. Doors may be provided in wall 136 to provide access to filters such as 146 and 148 for easy service and replacement of the filters. The filters such as 146 and 148 may be of the perforated cylinder type with filter cloth and screw attachment provided to fasten the filters to manifold 160. The upper inner chamber 186 is a product collecting and metering system and contains a centripetal particle separator. The exterior chamber 150 is a product classifier and injection system. Portions 194, 198 and 202 are openings with portions 198 and 202 coupled to handles 192 and 196 respectively to allow material accumulated in chamber 150 to pass into top inner chamber 186, thus allowing full recovery of product brought into vessel means 50. Inlet 158 is coupled to blower 28 shown in FIG. 1 and provides suction force for the vessel means 50.

Referring to FIG. 20, taken along line 20-20 of FIG. 3, baffle 162 is rigidly coupled by members 164 and 166 to shell 140. It will be appreciated that the baffle 162 is solid and shaped as half an open-ended cylinder with curved lip portions 168 and 170 coupled respectively to edge 172 and 174. Product inlet 132 shown in FIG. 20 is coupled through pipe 178 to an on-off product intake valve 256 which is coupled at 180 to a valve 77 shown in FIG. 3 which is coupled to a commercial level-indicating device known as a BIN-DICATOR as explained previously. The upper BIN-DICATOR portion is indicated generally as 183 in FIG. 3 and includes a rotating element 184 and a shaft 182. The upper BIN-DICATOR 183 indicates when material reaches the level of the rotating vane 184 to stop rotation of such vane thereby indicating that the product has reached the level which has been set by movement of the shaft 182 within chamber 186. Chamber 186 is the product-collecting section in the upper portion of the vessel means 50 within tank shell 140. It will be appreciated in viewing FIG. 20 that chamber 150 extends as a concentric ring or annulus about shell 140 and inside of shell 136.

Thus, when referring to FIG. 21 taken along line 21-21 of FIG. 20, it will be apparent that the product entry through intake section 52 moves into chamber 186 as shown with incoming product hitting the product 42 already positioned in chamber 186. Movement of the product is across chamber 186 of FIG. 21 with a circular, upward movement occurring near baffle 162 into chamber 144 between outer shell 134 and shell 142. In viewing FIG. 21 it will be noted that inlet 52 is located behind baffle 162 extending into top inner chamber 186 one-half the longitudinal axis distance of 162. Opening 171 is located directly on the opposite side of baffle 162 in relation to inlet 52. The phenomena occurring in chamber 186 will be explained subsequently. Filters 188 and 190 are shown positioned in chamber 150. Movement of fine product occurs through chamber 144 downwardly as indicated past filters 188 and 190 as well as other filters extending around the entire periphery of chamber 150 so that fine material 42A accumulates at the juncture of shell 136 and shell 140 which is chamber 150.

Thus, it will be apparent in viewing FIG. 20 and FIG. 21 and FIG. 3 that entry of the product is into chamber 186 with a centripetal movement. The finely ground particles or dust particles are passed upwardly through opening 171 near baffle 162 into chamber 144, filtered by the filter system positioned in chamber 150 and the finely ground or small particles come to rest as shown at 42A in FIG. 21. When sufficient particle accumulation has occurred as shown in FIG. 21, a plurality of doors positioned around shell 140 as shown in FIG. 3 may be opened to allow movement of the finely ground material into chamber 186. A plurality of handles such as handles 192, 194, and 196, allow movement inwardly as indicated by member 198 on handle 182 and by member 202 on handle 196. Thus, communication is established between chamber 150 into the lower conical portion of the upper part of the vessel means 50 shown in FIG. 3.

Positioned near the apex of the cone portion 138 is another BIN-DICATOR or control unit 205 having vane 204 coupled to shaft 206 which extends inwardly to chamber 186. Control unit 205 acts when the top level of product 42 passes below the rotational circle subscribed by the outer part of vane 204 thus indicating that chamber 186 is empty. The control unit 205 operates a microswitch which actuates an electric solenoid air valve in panel 30 through line 203, which air valve in turn actuates valves 126, 77, 53, 212, and 156 to begin a new cycle of filling chamber 186 by putting the upper portion of vessel means 50. Member 212 of valve 213 is actuated by the change in pressure in chamber 186 thus causing upward movement of member 212 into opening 211 to close communication between upper chamber 186 and lower chamber 210. Member 214 is a conical shaped solid material to support the weight of product 42 in chamber 186 thus allowing member 212 to function without restriction because of the weight of product 42 in chamber 186. Conduit or pipe 208 extends into chamber 210 in the lower portion of the vessel means 50 and is in communication with member 212. Member 212 is disposed from member 214 on which product 42 accumulates when there is no communication between chamber 186 and chamber 210. Product 42 moves downwardly along edge 215 of member 214 through opening 216 and opening 211 into chamber 210, which is a high-pressure chamber with respect to chamber 186 in the upper portion of the vessel means 50. Chamber 186 is subject to vacuum or high pressure as the need arises for performing various functions. Product 42 accumulates in the lower portion of chamber 210 and the lower portion of chamber 210 having conical section 220 extending from shell 140 to lower shell 224 so that material is accumulated in the lower portion of chamber 210. Pressure blow down valve 54 is used for relieving pressure in chamber 210 when the entire pressure system is shut down. Thus, a conical chamber 230 is provided at the extreme bottom of vessel means 50 known as a moisture-eliminating device. Moisture accumulates in chamber 230 and is bled off through pipe 232 when desired. The outlet from the vessel means 50 is at 234

with a communication conduit extending to product-metering valve means 250 positioned in the lower portion of vessel means 50. Valve means 250 will be explained in detail subsequently. Pipe 262 is a continuation of line 208 to provide communication to chamber 230. A communication conduit 252 extends from the valve means 250 to chamber 230 to allow the moisture-free air accumulated in chamber 230 to be discharged through outlet 234.

The suction provided from blower 28 through line 158 of FIG. 3 goes through chambers 160, 150, 144, and 186 into opening 132 and line 44 of FIG. 1 thereby producing incoming air through these lines and chambers to blower 28 which allows for the movement of entrained granular or loose products by aeration. Dense or dilute phase pneumatic conveying principles are provided from source 40 to vessel means 50. The relation of air to mass ratios for dry, granular product movement regulates the amount of flow of that product into chamber 186, in direct proportion to size of the line 44, the actual cubic foot per minute displacement of blower 28, the amount of vacuum created in chamber 186, and the velocity created by air movement in line 44 through inlet 132. Inlet 132 should be of an enlarged diameter with respect to line 44 so that the velocity of product entering vessel means 50 is reduced substantially. As an example, a 3-inch diameter line 44 may be used successfully with a 6-inch diameter inlet 132 to reduce the velocity of the incoming product by 4. Abrasive products entering lines 44 and inlet 132 into chamber 186 are moving at high velocities as set forth in Stokes' laws and Newton's laws.

The design of the chamber 186 of vessel means 50 takes into consideration the fact that opening 171 must be provided. Considering the fact that the discharge angle from a nozzle decreases along the longitudinal axis as the pressure increases so that increased pressure provides a smaller flare at the tip of the nozzle. As shown in FIG. 21 the lines 270 and 272 define an angle from opening 171 that provides a reverse effect from that normally encountered when a product leaves a nozzle. By the installation of baffle 162 as shown in FIG. 21 the inverted conical effect of the cone 271 defined by lines 270 and 272 is partially destroyed. The cone 271 is produced by suction through opening 171. The inlet 132 extends into chamber 186 behind baffle 162 which is positioned between opening 171 and inlet 132. The incoming air and product from inlet 132 seeks an exit through opening 171, the hyperbola described by baffle 162 in cone 271 creates a centripetal separator. The centripetal motion extending from inlet 132 in chamber 186 tends to flow in spiral path thus providing a level product to be formed in chamber 186. Product 42 is brought to rest by striking other particles in product 42 and the energy of incoming product to chamber 186 is dissipated by expansion because of increased volume and because of centripetal motion. Thus accurate measurement of product may be obtained. The distance from opening 171 to the product level control vane 184 is such that the vertical velocity of the air moving through opening 171 allows gravity to act upon the mass of the particles entrained in the air stream. For example, blower 28 producing 300 cubic feet per minute of air exhaust will produce a vacuum of 10 inches of mercury and create a velocity of incoming air through a 3-inch line 44 of 6,800 feet per minute. The velocity is reduced to 1,700 feet per minute in a 6-inch inlet 132 and there is a further reduction in 30-inch diameter chamber 186 to 68 feet per minute. A velocity of 755.5 feet per minute will exist at opening 171 upon entering a 60-inch diameter chamber 144 and the velocity of air will be approximately 15 feet per minute. When considering gravitational force on particles attempting to rise through opening 171 it will be appreciated that such gravitational force is substantially equal to the upward force through opening 171. It will be noted also that fine particles make a 90° turn after entry through opening 171 into chamber 144 thereby losing velocity by gravity and then being filtered by a plurality of filters in chamber 150 and falling to the juncture of shell 140 and shell 136 to be injected into chamber 186.

Product captured in chamber 186 allows the control unit 183 to control the quantity captured by actuating valves 126 to a closed position, valve 77 to an open position, valve 53 to an open position, and member 256 to a closed position to stop incoming product when vane 184 does not rotate. Chambers 186, 144, and 150 are then charged to high pressure by line 178 to equalize the high pressure in chamber 210 thus allowing member 212 to open by gravity and by the weight of the product. Product 42 will flow from chamber 186 to chamber 210 in such a rate as the product is being discharged from outlet 234. When product in chamber 186 passes below control unit 205 vane 204 rotates to provide an actuating electrical signal. Valve 77 is closed and valve 53 is opened to relieve pressure in chambers 150, 144, and 186 with member 212 being closed by pressure in chamber 210. By a timing device positioned in panel 30, valve 53 is closed after pressure in chamber 150, 144, and 186 returns to atmospheric pressure. Then valve 126 is opened and member 256 is opened to allow product to again enter chamber 186. The cycle continues automatically to provide a continuous supply of product in chamber 210 to operate under continuous high pressure. A metered uninterrupted flow of product and air mixture continues to flow through line 16 to distributor head and nozzle means 34 for operating upon a surface. The product level in chamber 186 is automatically controlled by the leveling device system to store additional product so chamber 210 is continuously supplied with product.

High-pressure chamber 210 is a product totalizer and delivery system. Chamber 210 remains under constant high pressure while the complete system in vessel means 50 is functioning. Product is being moved through outlet 234 at a continuous pressure suitable to move the product substantial distances. The kinetic energy of the product when moved through a hose at other conduit from vessel means 50 encounters less friction loss in such hose or conduit thereby allowing more pressure at the point of discharge of the product at distributor head and nozzle means 34. For example, when the system is made operative, inlet 208 coupled to reservoir tank 24 through valve 74 shown in FIG. 2 provides pressure to chamber 210. Air simultaneously enters chamber 230 through line 262 of FIG. 3 and exits through line 252 into product-metering valve means 250. Valve means 250 produces a venturi effect at port 281 by the movement of air at high velocity through chamber 308 shown in FIG. 4. The pressure on the product in chamber 210 and the reduced pressure at port 281 causes the product to flow unrestricted through port 281 into line 266. The product 42 then mixes with the air provided through tapered chamber 308 and the mixture of product and air passes through line 266 and outlet 234. The distance of shoulder 280 from member 268 from line 266 controls the size of port 281 to allow a variable mixture of product and air to be discharged through line 266. It will be noted however that the pressure in line 266 is substantially constant with velocity of product 42 being variable so that the amount of product discharged at the distributor head and nozzle means 34 will vary according to the positioning of member 294 thereby varying the size of port 281. This feature produces a positive nonclog, constant flow of product.

To shut down vessel means 50, valves 74, 77, and 126 are closed from panel 30, and valves 53 and 54 are opened to relieve pressure in chambers 186, 210, and 230.

Referring again to FIG. 4, the valve means 250 shown in FIG. 3 at the lower portion of the vessel means 50 is presented in cross-sectional enlarged elevational form. Pipe member 266 is positioned above finger 268 and held in a fixed position by guide clamp 267 coupled to support member 269. Shoulder 280 on finger 268 acts to close port 281 in pipe member 266 thereby preventing material 42 from passing out of member 266. Product 42, it will be remembered from viewing FIG. 3, is positioned at the bottom of the vessel means 50 and FIG. 4 shows conical member 220 welded at 284 and 282 to shell 224. Fastening means such as screws 286 and 288 couple flange 290 to shell 224. Flange 290 includes a recessed area

292 wherein member 294 may move vertically within the limits established by stop 296. When member 294 is moved upwardly manually, shoulder 280 will engage member 266 to cut off flow through chamber 282 and the stop 296 will be at the upper portion of recess 298. Cover 300 is bolted by suitable means such as screws 302 and 304 to flange 290. Flange 290 has at its upper portion a threaded member 306 for maintaining packing 307 in place. Finger member 268 is threadedly coupled to member 294 and member 294 has a tapered chamber 308 extending to elbow 264. An O-ring seal 310 prevents leakage during movement of member 294 vertically. It will be appreciated that pressure through chamber 312 and elbow 264 passes upwardly through tapered chamber 308 through chamber 282 and member 266 to allow air to discharge from the chamber 230 of vessel means 50. Movement of the member 294 is actuated manually to adjust selected amount of product flow desired at distributor head and nozzle means 34. Thus, the valve means 250 shown in FIG. 4 acts to allow selective discharge of material 42 through port 281 and chamber 282 of member 266 to provide an extremely high velocity to the product as it moves upwardly in the direction of the arrows shown in FIG. 4. However, it will be remembered that material 42 when used for cleaning surfaces will be a granular abrasive such as sand and care must be exercised to maintain product 42 in a mild state of turbulence which will prevent the product from bridging and clogging or entraining. Thus, operation is achieved by the movement of member 294 in allowing substantial pressure buildup to move the product 42 through chamber 282. Although high pressure is involved, the parts specified to be used with the valve means 250 shown in FIG. 4 need not have special wear characteristics but must be merely of durable material which will have a substantial life.

The phenomena encountered in the present invention may be termed a reverse-venturic effect to allow rapid filling of chamber 186 with product 42 so that uninterrupted flow of product will occur through vessel means 50.

One of the principal limitations with prior equipment has been the inability to provide constant supply of product at high pressure to supply a constant and continuous portable sandblasting operation for cleaning surfaces. The present invention by utilizing the structure and results obtained in vessel means 50 allow rapid filling of the storage portion of vessel means 50 and measurement of selected quantities to be passed into chamber 210 to assure a continuous and uniform supply of pressurized product to pass through distributor head and nozzle means 34. The vessel means 50 provides means, function, and result heretofore unattainable with other vessel means which handle abrasive materials. Although known vessels have provided high-pressure flow and movement of liquids the circulation, movement, and abrading characteristics of abrasive materials has not allowed utilization of such known vessels because improper movement or motion of abrasives within the vessel would cause breakdown, erosion, and deterioration of the vessel shell thickness. Maintaining shell thickness is of primary importance when operating pressure vessels because of safety requirements. It is evident that if a vessel which is processing granular abrasives moving at high velocity within such vessel that the vessel shell will be subject to bombardment by the abrasive thereby causing destruction of the shell of such vessel. In known vessels using cyclone separator principles the circular pattern of the abrasives causes wear on the shell of the vessel. A novel feature of the present invention is the fact that abrasive product flow enters the vessel means and moves downward to strike upon other abrasive particles rather than upon the vessel shell or vessel components thereby providing abrasive to abrasive contact instead of abrasive to metal or other material subject to wear. The circular action of the abrasive within vessel means 50 is by centripetal motion rather than by centrifugal motion as in vessels known prior to the present invention. Such known vessels act as a centrifuge instead of the centripetal separator baffle action of the present invention. Therefore the present invention prevents destruction of vessel shells.

The present invention, particularly the vessel means 50, further prevents destruction of the exterior vessel shell by locating chamber 186 so that such chamber is not defined by the outer shell of the vessel means 50 but is positioned in a housing within the outer shell of vessel means 50 thus preventing wear on the outer shell. This feature allows chamber 186 to capture the abrasive entering the top section of vessel means 50 thus providing for complete protection of the filter system and outer shell from damage and wear by abrasion.

The chamber 150 or outer chamber selective product classifier and injection system allows recovery of all fines and dust of the abrasive conveyed into vessel means 50 to be returned without loss of any abrasive whatsoever.

Referring again to FIG. 20, FIG. 21 and FIG. 3 it will be apparent that movement of abrasives or other products within vessel means 50 is controlled to provide maximum pressure outlet for the metered product upon exit from vessel means 50 while utilizing a compact vessel having optimum baffle positions and optimum chamber shapes. Such vessel means 50 continually supplies product to the distributor head and nozzle means 34 by continuous action, vacuum pressure automatic conveying.

Referring now to FIG. 5, a top plan view is shown of the trolley means 36 of the present invention. FIG. 6 is a side, elevational view of trolley means 36 showing the trolley means operating on a tank 14 having a floating roof 324. Surface 14C is the portion of tank 14 to be cleaned and guide tower means 32 is shown positioned near surface 14C.

Pneumatic motor 84 is shown positioned on platform 326. A spool 82 containing cable 80 is shown coupled to pneumatic motor 84. Obviously, pneumatic motor 84 provides rotation to spool 82 thereby causing cable 80 to be moved over sheave 83. As will be explained in detail subsequently, movement of cable 80 causes movement of the distributor head and nozzle means along guide tower means 32.

FIG. 5 shows frame 738 as an elongated triangular structure with an opening 342 adapted to receive guide tower means 32 with such opening. Frame 738 may be used to support guide tower means 32. Guide tower means 32 may be moved vertically through opening 342 to cause movement to the distributor head and nozzle means 34 when distributor head and nozzle means 34 is attached to guide tower means 32. Frame 738 may be coupled to member 360 by suitable fastening means such as a swivel bolt 730 and pins 731 and 732 as shown in detail in FIGS. 25 and 26. With guide tower means 32 attached to member 738 and by removing pins 731 and 732 the guide tower means 32 may be pivoted about swivel bolt 730 and positioned at a selected angle by positioning pins 731 and 732 in holes surrounding the swivel bolt 730. Brace members 350, 352, 354 and 356, 360 and 340 are coupled to form an adjustable boom which is coupled between plates 326 and 327. Such boom can be moved to vary the distance from spool 82 to guide tower means 32 by anchor bolts 371 and 373 which may be coupled to plate 326. Plate 326 may be coupled by suitable means to angle iron members 362 and 364. Channel members 366 and 368 are coupled to member 362 with channel members 370 and 372 being coupled to member 364. Unit 374 which was explained previously is also shown in FIG. 5.

Referring now particularly to FIG. 6, the trolley means of the present invention is shown positioned on edge 390 of tank 14. It will be remembered that tank 14 shown in FIG. 6 is of a floating roof type wherein the roof height varies as the amount of liquid varies inside the tank. Member 370 extends on the outer portion of tank 14 and coupled to member 370 is member 392. Coupled to member 392 is an axle 394 having mounted thereon a roller 396. Roller 396 moves along edge 14C when the trolley moves about the periphery of the tank. Another roller may be positioned on member 366 shown in FIG. 5 but not shown in FIG. 6. Coupled between members 362 and 364 is a channel member 400 having attached thereto axle 402. Axle 402 has mounted thereon wheels 404 and 408 having substantially the same diameter and a smaller wheel 406 positioned intermediate wheel 404 and 408. As shown in

FIG. 6, the trolley means 36 moves on edge 390 with wheel 406 being in contact therewith while wheels 404 and 408 are not in contact with the top of the tank since the tank has a floating top. Another set of rollers may be coupled near member 362 to provide stability and easier movement of the trolley means 36. Coupled to member 372 by suitable fastening means such as a bolt 410, is a support member 412 having mounted thereon an axle 414 with a roller 416 moving along the inside portion of tank surface 14C. Another roller may be coupled to member 368 to provide stability and easier movement of the trolley means 36 on the tank. It will be appreciated from viewing FIG. 5 and FIG. 6 that the trolley means 36 provides support for guide tower means 32 and for the distributor head and nozzle means 34 coupled to the guide tower means 32, thereby supporting substantial weight. Yet trolley means 36 moves easily along the edge of the tank and is, to a large degree, balanced in an optimum manner to prevent the trolley means 36 from falling from the tank while providing support for guide tower means 32. Thus, trolley means 36 shown in FIGS. 5 and 6 to be adapted for use on a floating roof tank provides support to guide tower means 32 and further allows movement of the trolley means 36 along the tank so that surface 14C may be easily and effectively cleaned in accordance with the present invention.

FIG. 8 is a back elevational view of part of trolley means 36 as shown in FIGS. 5 and 6 of the present invention on a floating roof tank showing pneumatic motor 84, spool 82, cable 80, positioned on platform 326. Unit 374 has been described previously and is the control unit for pneumatic motors 84 and 92. Members 362 and 364 are shown along with member 372 and member 368. Member 400 is shown supporting axle 402, having wheels 408, 406, and 404 thereon. Wheel 408 is the only wheel visible in FIG. 8. Suitable driving means may be coupled to the wheels supported on axle 402 and such driving means may include a toothed gear 410 having a chain 412 positioned thereon. Motor 92 has coupled thereon a toothed sprocket 414 so that when motor 92 is actuated to provide rotation of sprocket 414, chain 412 engages sprocket 410 and causes movement of the trolley means along the upper portion of the tank 14. Edge 390 of the tank is shown in FIG. 8 and it will be appreciated from viewing FIG. 6 that edge or lip 390 provides the area at the upper part of the tank on which the wheels of the trolley means move. Coupled at member 368 is axle 420, having wheel 422 and two other wheels thereon similar to the wheel assembly associated with axle 402. Axle 420 provides an idler support for the trolley means 36. The operation and structure of the assembly associated with the axle 420 is substantially identical with the structure and assembly associated with axle 402 except that the power drive means is not coupled to the assembly of axle 420.

FIG. 7 is a front elevational view of the trolley means adapted for use on a tank having a conical roof structure. The roof 430 of tank 14 is substantially conical in shape and at the apex of the cone a support member may be mounted and coupled with a cable 432 to member 372. It will be noted in FIG. 6 that member 372 extends downwardly into the tank having a floating roof. It will be appreciated that members 372 and 368 are adjustable to a horizontal position to act as a ballast carrier and safety device when utilized on a conical top tank. No tension will be present on cable 432, but cable 432 acts merely as a safety device and also aids in keeping the trolley means at the proper location for tanks which are "out of round." The wheel assemblies on axles 402 and 420 are adjustable to fit the curvature of any size tank. It will be appreciated in viewing FIG. 7 wherein the trolley means is positioned on a fixed roof tank that the trolley means shown in FIG. 6 is easily adaptable for use with a flat roof tank or with a tank having a conical-shaped roof. The wheel assemblies on axles 402 and 420 are pivotal to allow inward and outward movement from the center of a tank being cleaned and such wheel assemblies also swivel movement about a vertical axis thus fitting any diameter of tank having any type of roof. Guide tower means 32 is positioned in member 738. Cable 80 passes over sheave 83

onto spool 82 coupled to motor 84. Platform 326 supports motor 84 and spool 82. Members 372 and 368, with member 368 not being visible in FIG. 7, are extended in the same direction as members 364 and 362 by coupling bolts 434, 436, 438, and 440. Suitable weight means or ballast is coupled on members 372 and 368 and supported by wheel 416 on roof 430.

Weight means 442 positioned on number 372 may be a suitable counterbalance weight for the guide tower means 32. Member 370 on which axle 394 is positioned by member 392 allows roller 396 to engage surface 14C of tank 14. It will be appreciated that axle 402 of assembly 400 is tilted from the vertical slightly so that large diameter wheels 404 and 408 are on top 430 while wheel 406 rides above top 430. The other axle assembly 420 shown in FIG. 8, but not visible in FIG. 7, operates in substantially the same manner. Wheel assembly 412 also is positioned slightly out of the vertical plane to allow wheel 416, which is rotating on axle 414, to ride on tank top 430. Wheel assembly 412, acting in conjunction with the power-driven wheel assemblies identified as axle assemblies 402 and 420, allow the trolley means 36 to move along the conical surface 430 so that the trolley means 36 does not become unbalanced or become overstressed. Insofar as is known to applicant, applicant is the first to devise a commercial cleaning device capable of moving at a uniform rate continuously over a conical surface of a fixed or floating roof tank without danger of overstressing component parts of the device and without danger of the entire device falling from the tank roof.

FIG. 9 is a top plan view of the distributor head and nozzle means 34. Tank 14 to be cleaned is shown with surface 14C being bombarded by a plurality of nozzles such as nozzle 450, nozzle 452, nozzle 454, nozzle 456. It will be appreciated when viewing FIG. 9 that the positioning of nozzles 450, 452, 454 and 456 is such that a fixed distance from surface 14C is maintained from the end of each nozzle so that the distance from nozzle end 458 of nozzle 450 is the same distance from surface 14C as nozzle end 460 of nozzle 452. Likewise, nozzle end 462 of nozzle 454 is the same distance from surface 14C as the other nozzles, and nozzle end 464 also is the same distance from surface 14C even though surface 14C generally will be a curved surface. The nozzles 450, 452, 454 and 456 are fixedly coupled to a platform 470 having long members 472 and 474 and short members 476 and 478. Suitable coupling means identified as 480, 482, 484, 486, 488 and 490 may be utilized in maintaining the nozzles at a fixed distance from the surface to be cleaned. It will be appreciated that the fastening means for the nozzles may be of the type which allows easy setting of the nozzles for a particular curvature tank or for a particular operation wherein a specified finish is required on the surface to be cleaned. Such fastening means may be remotely operated to allow remote setting and adjustment of the nozzles and the blast pattern. Guide tower means 32 is shown positioned in a platform 500. Platform 500 is supported by members 502 and 504 on a carrier 506. Carrier 506 includes a side 508 and 510. Rollers 512, 514 and 516 are positioned on the carrier to allow the distributor head and nozzle means to be moved on guide tower means 32. As shown in FIG. 10, additional wheels at the lower portion of the carrier are provided, such as wheel 520 and 522, to allow stability of the carrier. Support 524 is coupled to cable 80 so that the distributor head and nozzle means may be pulled upwardly. Obviously, when the distributor head nozzle means is lowered, the weight of the unit will lower itself by gravity. Distributor head 550, shown in FIG. 9 and FIG. 10, is supported on platform 500 by support members 552 and 554 with members 502 and 504 providing support to platform 500. Input 16 feeds pressurized abrasives to distributor head 550. Since substantially high pressures are involved, distributor head 550 is coupled together by a plurality of bolts such as bolts 560 and 562. Input 16, as shown in FIG. 10, is provided on the bottom portion of distributor head 550 with output hose 564 and 566 coupled at the bottom portion of distributor head 550. Hoses

564 and 566 are coupled to the nozzles. Although two hoses such as 564 and 566 are shown in FIG. 10, it will be appreciated in viewing FIG. 9 that since four nozzles are being utilized, four hoses similar to hoses 564 and 566 will be required. Any number of nozzles may be used with any desired pattern of blast.

FIG. 11 is a sectional plan view of distributor head 550. Ring 570 includes a plurality of bolts 560 and 562 around the outer edge of the distributor head 550. As explained previously, the purpose of these bolts is to provide proper coupling to the entire assembly since substantially high pressures are involved. 572 is the bolt visible in FIG. 12 which is a sectional elevational view on line 12-12 of FIG. 11. A steel pipe 574 may be utilized as the principal housing of distributor head 550 as shown in FIG. 11. Inlet 576 is coupled to hose 16. A plurality of outputs 580, 582, 584 and 586 are positioned at substantially equal distances from the input 576 with the center portion of the outputs 580, 582, 584 and 586 being substantially on a circle having as its center the input 576. Any number of outlets may be used so long as material or product builds up in hollow cylinder or pipe 574.

Referring now to FIG. 12, it will be appreciated that the inlet from hose 16 through 576 allows abrasive material 42 to accumulate within the distributor head 550, so that as abrasives are brought into the distributor head 550, there is no wear on the component parts of the distributor head since the static abrasive 42 is formed and the abrasives entering the distributor head 550 hits against the static abrasive. Thus, abrasives entering through inlet 16 and 576 go out through outlets 584 and 580. Steel tank 574 is positioned between upper plate 590 and lower plate 592. A suitable gasket, such as rubber, may be positioned at 594 around the upper portion of ring or pipe member 574, and another rubber gasket 596 may be positioned on the lower portion of steel pipe 574. Thus, a configuration as shown at 598 in FIG. 12 is provided when the abrasive enters through inlet 16 and 576 and is discharged through the various outlets 580, 582, 584 and 586 shown in FIG. 11 with only outlets 580 and 584 being visible in FIG. 12. The static abrasive build up occurs as the system of the present invention begins operation, and is maintained until the system is shut down.

FIG. 13 is a sectional elevational view of the distributor head 550 taken along line 13-13 of FIG. 11. Bolt 562 is visible showing upper plate 590 being joined to lower plate 592. A plurality of bolts is used to couple upper plate 590 and lower plate 592 to the steel pipe 574. As has been explained previously, upper rubber gasket 594 is positioned between steel plate 574 and upper plate 590 and lower gasket 596 is positioned between lower plate 592 and steel pipe 574. Inlet 16 enters at 576 into chamber 598. The static abrasive 42 is positioned as shown in FIG. 13. Outlets 582 and 580 are coupled to the distributor head 550 as explained previously, and 580 and 582 are coupled to nozzles shown in FIGS. 9 and 10. Inlet 16 may be threadedly coupled to lower plate 592, and it will be appreciated that the distributor head positioning provides the static abrasive pattern set forth in FIGS. 12 and 13 thereby allowing the discharge from the distributor head to be more effective than has been heretofore possible.

FIG. 14 is a top plan view of a nozzle 610 positioned away from a surface such as surface 14C of a tank 14 to be cleaned. R may indicate a radius such as the length of a man's arm with point 612 being the center and arc 614 being described by the radius R. It will be apparent that when nozzle 610 is in position 616, for example, that the distance 618 from the nozzle to the surface 14C is substantially greater than the distance of the nozzle end 610 positioned for a blast pattern indicated as 620, for example. Likewise when nozzle 610 is moved to position 622, the distance 624 from the nozzle end to surface 14C is greater than the distance from the nozzle end to surface 14C when nozzle 610 is in the position shown to give a pattern 620. In blasting surfaces with a human, the distance, angle, and pattern of abrasive flow from the nozzle will vary thereby causing a variable anchor pattern on the surface being cleaned. The

human error is compounded because of the pivotal movement of a human at the feet, knees, shoulders, elbows, and wrist thereby causing an erratic anchor pattern to be formed whenever manual sandblasting is performed.

FIG. 15 is a greatly enlarged sectional view of surface 14C showing the anchor pattern 626 obtained when a nozzle is moved as indicated in FIG. 14. Thus, it will be appreciated from viewing FIG. 15, that the peaks identified as 628 and 630 have small valleys 629 and 631, when compared with peaks 634 and 636 having a valley 635 in the portion of surface 14C nearest nozzle 610. The anchor pattern of a surface being cleaned is very important in determining the holding characteristics of the cleaned surface when a coating of paint or other protective material is put on a cleaned surface.

Thus, in FIG. 16, which shows a coating of material 640 applied to surface 14C, it is apparent that the distance from the outer edge 642 of the coating to the peak 636 is a distance identified as 644, and such distance 644 indicates that only the wear depth 644 is required before surface 14C is encountered thereby increasing oxidation or other corrosion as the coating 640 is removed. The coating 640 varies from a distance of 644 to a thickness of 644 plus 646. The protrusions of surface 14C vary from distance 648 to a distance of 646. The average coating thickness may be set forth as distance 650. Thus, it is apparent, when viewing FIG. 14, FIG. 15 and FIG. 16 that the anchor pattern of surface 14C varies considerably when the nozzle angle is varied. In known methods of cleaning a manually operated nozzle being moved by workmen will vary distances and angles of the nozzle to the workpiece to be cleaned, thereby providing an uneven anchor pattern which resulted in less than optimum coating of the cleaned material after the cleaning job had been completed. Thus, when uneven or nonuniform anchor patterns are provided, the durability and life of the coating on the material which has an uneven anchor pattern is substantially lessened due to the fact that the native metal soon will protrude through the coating at certain areas thereby beginning the oxidation process which results in underneath erosion of the film thus causing peeling and scaling and general deterioration of the coating on the surface which had been cleaned.

Referring now to FIG. 17, there is shown surface 14C with surface 14C being bombarded with a blast pattern 652 from nozzle 610. The dotted portions of nozzle 610 are identified as position 654 and 656, indicates that distance 658 is the same for the three positions of nozzle 610 shown in FIG. 17.

Referring now to FIG. 18, which is an enlarged sectional profile of the peaks of surface 14C, it will be appreciated that all of the peaks 660 have uniform valleys 662, thereby providing a uniform anchor pattern.

Referring now to FIG. 19, coating 664, which has been put on surface 14C, provides a constant distance 666 from the outer edge 668 of coating 664 to the peak 660 of surface 14C. Thus, the distance 666 and the distance 670 are substantially identical thereby providing uniform coating and adherence of coating 664 of surface 14C. It is apparent that the wearing qualities of the coating 664 as exemplified in FIG. 19, will be substantially greater than the wearing pattern provided by coating 640 shown in FIG. 16. In FIG. 19 the coating 664 has no areas where the coating is thin to allow early contact of peaks 660 with the atmosphere outside of coating 664. Nozzles 654, 610 and 656 are at the same distance and striking angle to the surface regardless of the direction of travel.

Referring now to FIG. 22, FIG. 22 shows the interior of tank 14 being cleaned with apparatus of the invention. Inner surface 14D is being cleaned with the apparatus of the present invention mounted on tracks 672, 674 and 676. Tracks 672, 674 and 676 are mounted on a roller assembly 680 which includes wheels 682, 684 and 686. The assembly 680 is in an arc form of segments to allow the guide tower means 32 to be moved in a circle within tank 14 to maintain distance 688 constant. It will be appreciated that by keeping the angle of the nozzles constant and the distance 688 constant, that a uniform anchor pattern will be provided on surface 14D of tank 14. Nozzle

456 of the distributor head and nozzle means 34 is shown coupled through hose 564 to the distributor head 550. Inlet 16 provides pressurized abrasive to the distributor head 550 in a manner explained previously. Platform 500 supports the nozzles and the distributor head 550. Rollers 520 and 522 are shown to allow travel of the distributor head and nozzle means 34 along guide tower means 32. Cable 80 passes over sheave 690 and over sheave 692, to the spool positioned on platform 694. It will be apparent that the movement of the nozzle means as well as the distributor head 550 is accomplished by rotation of spool 82 driven by motor 84 and vertical movement of platform 500 thus occurs.

In order to counterbalance the guide tower means 32 and the equipment mounted on such guide tower means, platform 700 is provided with weight 702 positioned on the outer portion of platform 700 near the track or rail 676. Rail 676 is a greater elevation from the floor than rails or tracks 672 and 674. Such greater elevation of track 676 causes guide tower means 32 to move toward surface 14D. However, weight 702 restrains movement of guide tower means toward surface 14D thereby allowing track 676 to provide a double counterbalancing effect. Brace members 704 and 706 are provided and couple platform 700 to member 708 of guide tower means 32. Thus, in viewing FIG. 22, movement occurs along tracks 672, 674 and 676 after a section of track has been positioned by movement of platform assembly 680. Tracks 672, 674, and 676 are segmental so that any number of segments of track can be used depending upon the particular need. Vertical movement of the distributor head 550 and the nozzle platform 500 is accomplished in the manner previously set forth wherein pneumatic motor 84 rotates spool 82 having cable 80 thereon. The arrangement set forth in FIG. 22 provided uniform, fast, reliable cleaning of the interior of vessels so that workmen are required inside the tank only for positioning of platform assembly 680. The procedure of present invention inside a tank as shown in FIG. 22 is important since workmen may be removed from the dust hazards in the tank. Such dust hazards result from explosion of the abrasive upon impact with the surface being cleaned by such abrasive. Present methods for sandblasting the interior of enclosed structures requires that workmen work on platforms on scaffolds with airfed dust hoods and numerous safety devices attached to such workmen. Sandblasting creates heavy dust conditions and visibility becomes zero so that rework becomes necessary after inspection. The heavy dust is a health hazard to the workmen and it is impractical to exhaust all of the dust from the interior of the structure. High temperatures and poor ventilation result in fumes and contaminating chemicals being present in the structure being cleaned so that the hazardous dust and other contaminants restricts visibility of the workmen thereby requiring the workmen to wear safety devices which are cumbersome and dangerous in themselves. Thus it will be appreciated that workmen cannot properly hold a nozzle discharging abrasive so that a uniform anchor pattern is provided. The present invention allows workmen to be removed from the interior of the structure being cleaned while sandblasting is performed. It will be appreciated that the abrasive source may be brought in through conduit or coupling 16 so that abrasive storage inside the tank is not required as has been heretofore done. The arrangement set forth in FIG. 22 is thought to be completely novel insofar as applicant is concerned, inasmuch as no prior art patents show or suggest in any way any of the arrangement set forth in FIG. 22 for allowing cleaning of the interior of tanks by remote control. Furthermore applicant is not personally aware of any devices or methods which anticipate the arrangement set forth in FIG. 22.

Referring now to FIG. 23, tank 14 is shown having a top or roof 430 with a surface 14E to be cleaned. The nozzle arrangement is shown mounted on a boom 710 having counterbalance weight 712 positioned on end 714. Cable 80 passes over sheave 716 and sheave 718, thereby providing movement to nozzle platform 500. Intake 16 is shown with nozzles 456

and 450. Thus, the roof 430 and the surface 14E to be cleaned are provided with distributor head and nozzle means movement horizontally along boom 710. It will be appreciated that the movement is achieved substantially identically with the movement set forth previously when cable 80 is moved. FIG. 23, along with FIG. 22, clearly shows the apparatus of the present invention applying the method of the present invention to achieve uniform anchor pattern within the interior of a tank to be cleaned with many dangers to workmen being removed.

FIG. 24 shows tank 14 having steps 14A thereon. In one modification of the present invention guide tower means 32 may be easily moved from a substantially vertical plane to allow the distributor head and nozzle means 34 to be positioned under stairs or steps 14A. Trolley assembly 36 moving on top of the tank 14 will allow the area near stairs 14A to be cleaned properly. After the trolley means 36 moves around the tank, the area 720 near stairs 14A may be cleaned in a similar manner after the guide tower means 32 has been positioned as shown in FIG. 24. It may be noted in FIG. 24 that an obstruction such as a valve 721 may be passed over by the guide tower means 32 and by distributor head and nozzle means 34 by pivotal positioning of guide tower means 32 and actuation of the trolley means 36. Also guide tower means 32 may be moved vertically through member 738 to avoid such obstruction. Extension arms to hold the nozzles may be attached to distributor head and nozzle means 34 to sandblast areas immediately above such obstruction.

FIG. 26 shows the pivotal connection of the trolley frame 738 positioned on guide tower means 32. A plurality of holes, such as hole 726, are provided around a central hole containing a suitable fastening means 728 such as a swivel bolt. Locking assembly 732 allows guide tower means 32 to be pivotally positioned around swivel bolt 728.

FIG. 25 is an enlarged sectional view showing locking assembly 732 which is threadedly coupled to member 340 and protrudes through opening 748 in frame 738. Swivel bolt 728 has a nut 729 threadedly coupled thereto. Head 742 is positioned against frame 738. Washer 736 is positioned between nut 729 and member 340. Thus, frame 738 may be rotated about swivel bolt 728 to position guide tower means 32. Thus, it is apparent that when the position of frame 738 is to be changed, the removal of locking assembly 732 is accomplished by removing the assembly from tapered opening 748 so that the assembly 732 may be positioned in the desired hole, such as the hole set forth as 726 in FIG. 25. It will be appreciated that a plurality of locking assemblies such as 732 may be utilized in a plurality of openings. The arrangements shown in FIG. 25 and FIG. 26 to allow positioning of guide tower means 32 and the distributor head and nozzle means 34 as shown in FIG. 24, is easily, effectively, and quickly accomplished to give versatility to the guide tower means 32 and the work area available to the distributor head and nozzle means 34 is increased.

Thus, the present invention provides apparatus for moving products at a high velocity substantial distances so that granular abrasives, for example, may be effectively utilized in the automatic cleaning of work surfaces such as the exterior and interior of large storage tanks such as oil tanks, grain storage tanks, or petrochemicals. The vessel means of the present invention provides effective continuous flow of abrasives through the system so that a uniform anchor pattern is provided on the area being cleaned. In the event that the vessel means is to be utilized merely for product transportation, such transportation can be effected. For example, material in ships and other storage areas may be rapidly and effectively removed with the vessel means of the present invention. The automatic movement of the distributor head and nozzle means of the present invention allows simultaneous movement in both horizontal and vertical directions to obtain any desired path. Thus the present invention provides apparatus and methods which keep pace with recent technological developments in the protective coating industry so that lives, money,

and time are saved. Although a preferred embodiment of the present invention has been shown and described in accordance with the statutory mandate of the U.S. Pat. Laws, the invention is defined by the following claims. Although such claims may be presented in indented format to facilitate reading and understanding thereof, such indented format is not to be construed as a structural or functional limitation of the elements or steps recited in such claims.

I claim:

1. A distributor head for distributing sand from a source to plurality of sandblasting nozzles including in combination a hollow cylinder,
an upper plate fixedly coupled to said cylinder, lower plate means fixedly coupled to said cylinder, said lower plate means including a sand inlet, and a plurality of said outlets each disposed substantially the same distance from said inlet, and in communication with said sandblasting nozzles,
and means for connecting said sand inlet to a source of sand.
2. A distributor head for distributing sand from a source to a plurality of sandblasting nozzles, comprising
a housing having a first end and an opposite end spaced away from said first end,
connection means in said first end adapted to be connected to said sand source to conduct sand from said source to the interior of said housing and direct it toward the opposite end of said housing, the distance from the interior end of the connection means to the opposite end of the housing being substantially as great as the distance between the first end of the housing and the opposite end,

and a plurality of sand outlets in said first end of said housing, each disposed substantially the same distance from said connection means,

whereby sand entering the housing must turn substantially 180° therein before exiting through the outlets, thereby building up static sand in the housing to protect the housing from wear.

3. A distributor head as defined by claim 2 wherein said housing comprises an outer housing between the first end and the opposite end, and an inner housing between the first end and the opposite end, the inner housing being in the form of a sinuous wall extending outwardly to enclose each outlet and inwardly toward the connection means intermediate the outlets.

4. An apparatus for providing treatment to a surface, said apparatus including in combination

first means including guide tower means having a vertically movable single column structure, distributor head and nozzle means coupled to said column structure, and trolley means supporting said first means, said trolley means including a horizontally extending member having a plurality of rollers pivotally coupled to said horizontally extending member and a vertically extending member coupled to said horizontally extending member and having a roller pivotally coupled to said vertically extending member, said first means being disposed near the surface to be treated, and

second means coupled to said column structure for providing controlled movement of said first means.

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