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3,416,732

WASHING APPARATUS FOR ENCLOSED SPACES

Filed June 5, 1967

3 Sheets-Sheet 1

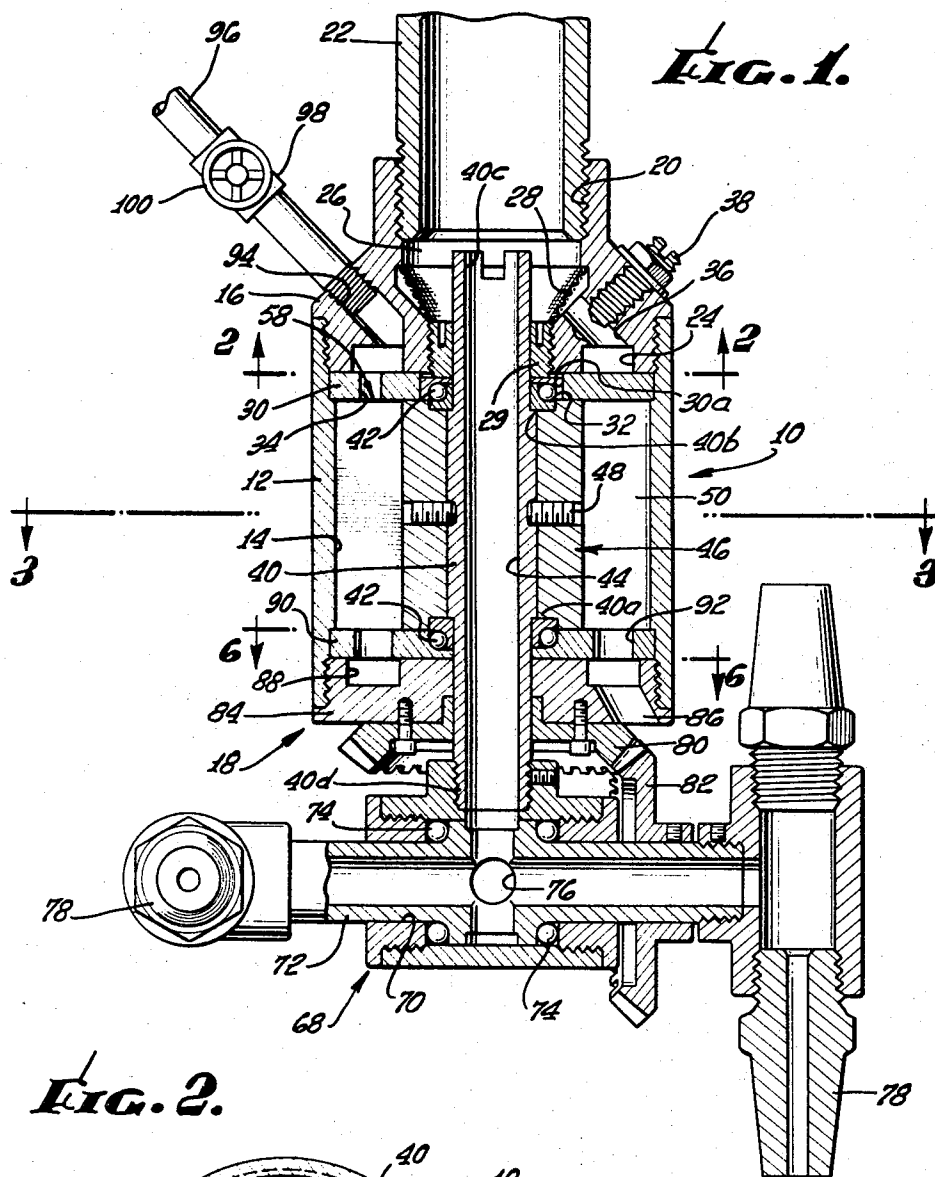
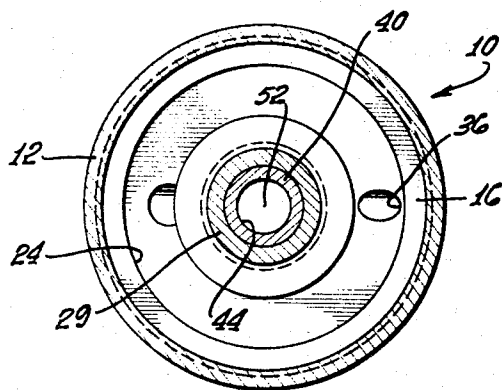


FIG. 2.



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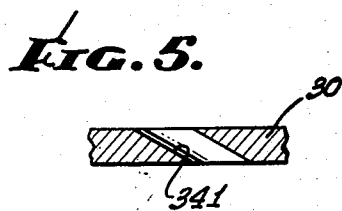
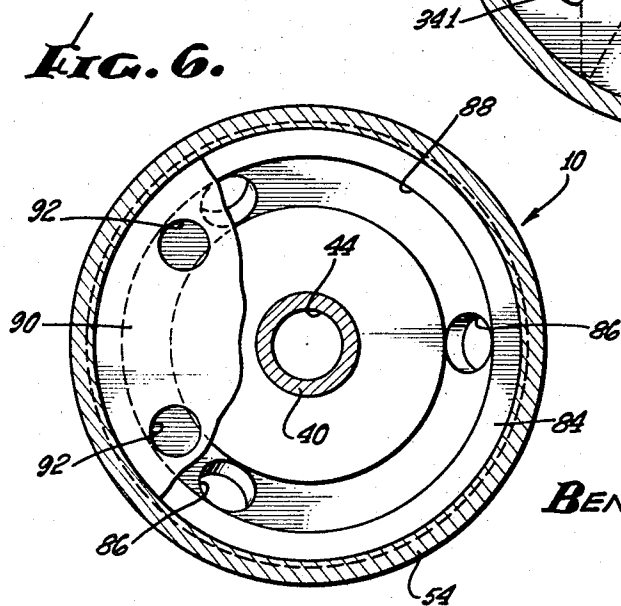
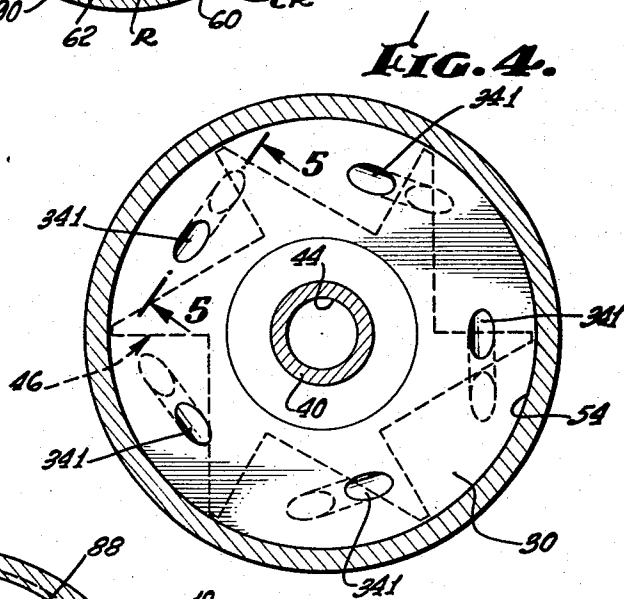
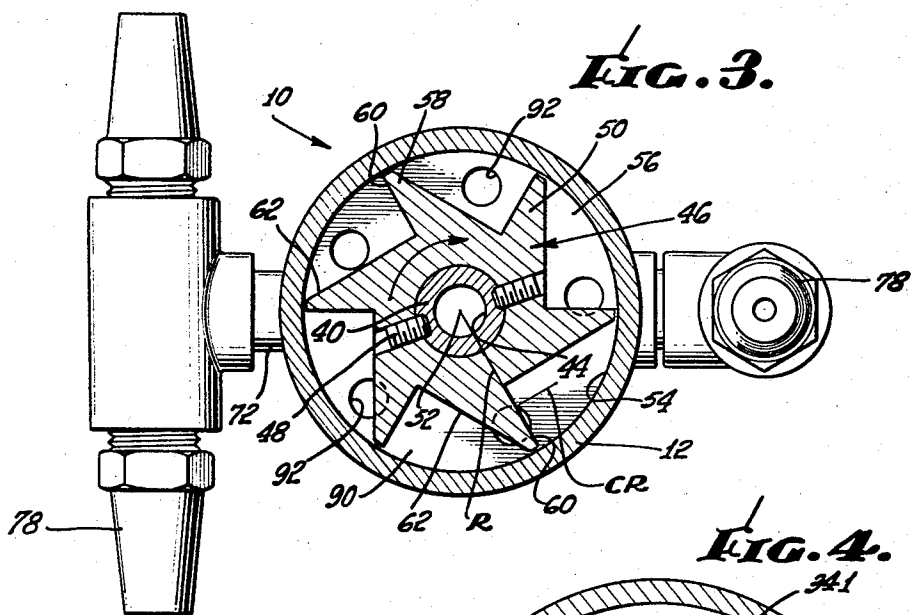
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WASHING APPARATUS FOR ENCLOSED SPACES

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3 Sheets-Sheet 2



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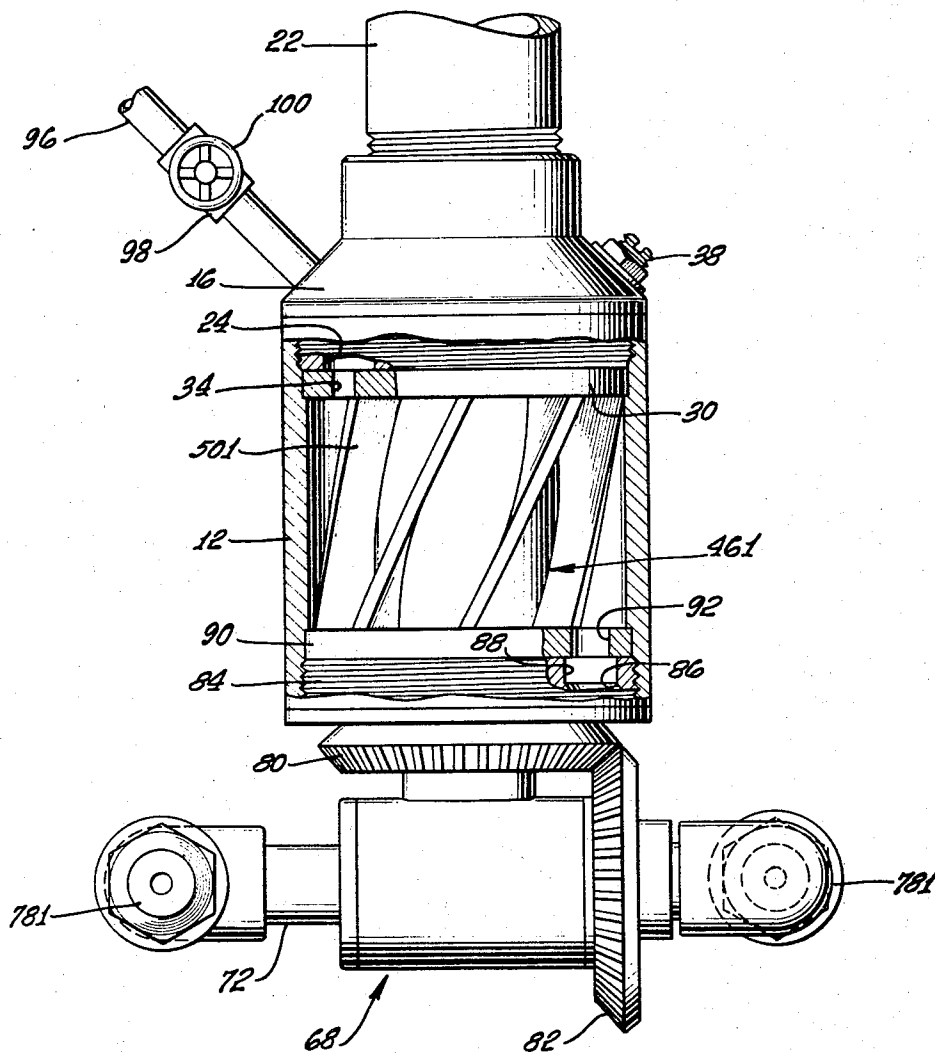
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WASHING APPARATUS FOR ENCLOSED SPACES

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3 Sheets-Sheet 3

FIG. 7.



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3,416,732

WASHINGTON APPARATUS FOR ENCLOSED SPACES
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22 Claims. (Cl. 239-227)

ABSTRACT OF THE DISCLOSURE

A rotating spray device is provided in which rotative and counter-rotative moments for rotation of the spray head are generated about a rotor axis within a rotor chamber, the rotor having plural circularly arranged teeth with oppositely pressure responsive surfaces so aligned within the chamber that a differential moment in favor of rotation is generated, resulting in slow, pulsation-free rotation in response to circumambient uniform fluid pressure produced by fluid moving through the rotor spaces in the rotor chamber between sets of circularly distributed openings.

BACKGROUND OF THE INVENTION

Field of the invention

This invention has to do with rotating spray devices of the kind generally employed to wash the interiors of large vats or vessels, ship holds, tank cars and the like. The present spray device is useful and advantageous in applications requiring projection throughout an extensive volume of great quantities of liquid, such as aqueous cleaning solutions. The advantage of the present device lies in its ability to throw great quantities of liquid against spaced walls of enclosed areas without acquiring undue rotational speed.

Much transportation and processing equipment consists of large volume storage containers in which or through which many different materials are handled. In the transportation field ship holds and rail tank cars are used to ship liquid and other free flowing commodities, each to be kept uncontaminated by residue from the last shipment. In food processing plants cleanliness is of utmost importance, requiring frequent washings of equipment, even between every batch in some cases.

For accomplishing quickly these necessary cleaning operations a class of rotating spray device has been developed. Characteristically these devices operate at or near an opening in the center top of the vessel and project streams of liquid cleaning materials to the vessel walls. Planetary gear actuated nozzle arrangements are employed to insure multiple coverage in a 360° pattern. Because foreign matter is often adherent to the vessel walls, it is highly desirable to impinge the cleaning solution against the vessel walls with considerable force, force sufficient to physically dislodge the foreign matter. In addition, rapid effective cleaning is most easily accomplished by hurling torrents of water-based cleaning material all over the vessel walls.

The dual requirement of high solution volume and great impinging force poses equipment design considerations which until the present device have appeared impossible of achievement at an economical cost.

Prior art

Presently known devices are generally self-driven, i.e. the cleaning solution itself is the motive power supplying the energy to rotate the spray head. It is known, for example, to drive a spray head rotatively by the use of offset nozzles which by reaction on issuance of the water therefrom generate a torque about the spray head axis and thus

2

cause rotation. This type of device, illustrated in many patents will rotate at high speed if great quantities of liquid are forced through it, to the point where the projected liquid streams are bent sharply by centrifugal forces and feather into mist-like rain before striking widely spaced enclosure walls. The desired impact for foreign matter removal is lost if high volumes of liquid, also desirable, are used. Expedients involving complicated gearing and counteracting turbines have been devised e.g. U.S. Patent No. 3,292,863 to Nelson to overcome this basic drawback of reaction nozzle devices.

Other types of devices have employed variations of water motors and turbines or eccentric throwouts and striker bars, e.g. U.S. Patent No. 3,306,541 to Lord.

Among the disadvantages associated with one or each of the aforementioned rotating spray devices is the requirement of gearing. Such gearing requires lubrication. If loss of lubricant and resultant gear failure or vessel contamination is to be avoided, seals must be provided between the gear-box and the cleaning solution. Seal materials impose limitations on the aggressiveness and use temperature of cleaning materials. Moreover, even if properly lubricated delicately balanced gearing wears rapidly and is a source of maintenance difficulties.

It has been mentioned that distant throwout of hard liquid streams against enclosure walls is desirable. To achieve coherent, unfeathered streams at the point of impingement, slow rotation of the spray device is required. Presently known devices, if attempted to be run at very low speeds e.g. under 20 r.p.m., tend to pulse unevenly or stall at start up or in operation.

The present invention was made in recognition of these shortcomings in the art and with a view to providing a rotating spray device able to rotate slowly at virtually any throughput rate and thus able to deliver coherent streams of liquid with high impingement impact against enclosure walls at considerable spacing therefrom. In addition, the new device here disclosed achieves spray head rotation under 20 r.p.m. without reduction gearing. Further this device requires no lubricants or seals for operation.

Summary of the invention

There is provided in accordance with the present invention a rotating spray device adapted to traverse the wall of a surrounding enclosure with a coherent stream of cleansing liquid comprising a housing, a rotating spray head adapted when slowly driven to project liquid with great force against the wall and means to supply liquid to the spray head for projection. Means are provided to slowly drive the spray head including a cylindrical rotor chamber within the housing, a rotor rotatably mounted within and closely enclosed by the chamber, which is drivingly connected to the spray head.

In a highly novel aspect hereof the rotor has plural circularly arranged teeth which define a plurality of rotor spaces with the chamber wall, and which are provided with oppositely pressure responsive first and second surfaces disposed within the chamber to produce in response to circumferentially exerted fluid pressure therein a first, relatively larger, rotative moment and a second, relatively smaller, counter-rotative moment about the rotor axis, the differential in these moments being sufficient to induce slow rotation of the rotor to correspondingly slowly drive the spray head. Means are provided for passing motive fluid through the rotor chamber in a manner producing fluid pressure circumferentially about the rotor.

Particular forms of the device will employ circularly distributed fluid inlet ports at one end of the rotor chamber and circularly distributed fluid outlet means at the other end, in opposed relation across the rotor spaces to provide for such spaces simultaneous fluid inlet and outlet. The inlet ports may be lesser in number than the rotor

teeth to ensure smooth, nonpulsating operation and may all be supplied equal pressure fluid.

The rotor may be star-wheel configured and have four, six or eight teeth the first surface of which lies radially of the chamber axis and in a radial axial plane of the rotor and the second side of which intersects the first side plane at an angle of more than 60° and preferably 90° to 120° and lies chordally of the chamber axis.

Liquid may be supplied to the spray head through a central passage formed by a tubular shaft carrying the spray head and to which the rotor is fixed. Means in the form of a side passage may be provided for distributing a portion of the liquid circularly of the shaft and into the rotor chamber as motive fluid for the rotor after which this portion is discharged from the rotor chamber outside the spray head.

The spray head may include multiple nozzles mounted for planetary motion with cooperating gear means on the head and the housing and the liquid discharge from the chamber may be flushed over the gears to keep them from fouling.

Brief description of the drawings

In the drawings:

FIG. 1 is a view in vertical section of an embodiment of the rotating spray device of the present invention;

FIG. 2 is a view in cross section of the liquid delivery means taken along line 2—2 of FIG. 1;

FIG. 3 is a view partly in cross section showing the rotor and apertured bottom plate taken along line 3—3 in FIG. 1;

FIG. 4 is a view of an alternate form of annular top plate for the device having angled inlet ports;

FIG. 5 is an enlarged detail of an angled inlet port of the annular top plate shown in FIG. 4 and is taken along line 5—5 of FIG. 4;

FIG. 6 is a plan view of the bottom portion of the housing with a fragmentary view of the annular bottom plate overlying it taken along line 6—6 in FIG. 1; and

FIG. 7 is a view like FIG. 1 partly in section and showing an alternate form of rotor in elevation and having offset spray nozzles.

Description of the preferred embodiments

Before proceeding with the description of the device in conjunction with the drawings, it should be pointed out that an understanding of the operating principle of the present invention which enables constant low speed rotation is basic to what follows. The present device utilizes uniform fluid pressure, be it liquid or gaseous fluid, to produce a nonuniform result, i.e. rotation in a particular direction. This is achieved by a careful arrangement of rotor surfaces relative to the rotor axis and the provision of uniform pressures all around the rotor. The rotor is of a size providing sufficient surface area on the driving faces to move the rotor in the intended direction against inertia owing to the rotor mass, friction, the spray head mass and reaction if any from the spray nozzles and importantly against counter-rotative forces generated at the tooth surfaces opposing the driving faces thereof.

The tooth faces are proportioned in their transverse i.e. nonvertical extent to provide a centroid for the resulting triangle-like figure (when the surfaces are considered with the rotor chamber wall) such that a larger "arm" or lever for the pressure existing in the "triangular" rotor space is provided in the desired direction of rotation than in the opposite direction. Thus by measuring from the resulting centroid of the triangle defining rotor tooth surfaces to the rotor axis in the direction of force exertion on each tooth surface, it is apparent that relatively large rotative moments may be obtained with respect to accompanying counter-rotative moments by appropriate specification of the rotor tooth surfaces. Slow rotation is achieved by carefully approaching a balancing of the rotative and counter-rotative moments. Fluid pressure exertion is constant around 360° to provide pulsation-free slow rotation.

Turning now to the drawings, with reference to FIGS. 1-3 and 6, a rotating spray device is depicted including a housing 10 having a tubular central body portion 12 in which a cylindrical rotor chamber 14 is formed, and threaded into the central portion is a generally conical top portion 16 closing the upper end of the housing. At the opposite end of the housing 10 a generally circular bottom portion 18 is threaded into the central portion 12.

The top portion 16 is provided with a threaded, upwardly opening central aperture 20 adapted to connect to a fluid supply pipe 22 which may conveniently be used to support the entire device in a vessel or other enclosure (not shown). The supply pipe 22 leads from a source (not shown) of pressurized liquid such as cleaning solution under pump pressure e.g. 100 to 300 pounds/square inch. A downwardly opening annular recess 24 is provided in the base of top portion 16 in open communication with the rotor chamber 14 for purposes to appear. An inlet chamber 26 is formed in the top portion 16 between the central aperture 20 and annular recess 24. A screen or filter pack 28 supported on bushing 29 is provided within the inlet chamber 26 for removal of solid materials from portions of the liquid entering the inlet chamber ahead of the rotor chamber.

An annular top plate 30 is disposed below the annular recess 24 and above the rotor chamber 14. Ball bearing race 32 is secured in opening 30a of the top plate 30. A plurality of inlet ports 34 are provided in equispaced relation circularly in the top plate 30 about the opening therein. These inlet ports are equisized so as to deliver equal amounts of liquid and are preferably an odd number such as five, seven or nine where an even number toothed rotor 46 is employed. The inlet ports 34 lead downwardly through the top plate 30 into the rotor chamber 14 for conveying liquid thereto.

The orientation of the inlet ports 34 in FIG. 1 is noteworthy in that liquid jetting therefrom passes into the rotor space parallel to and without first impinging on the surface of a tooth 50 in contrast to operation of a water wheel or turbine device. This device as explained above is fluid responsive to uniform pressures within a rotor space 56 and mass velocity actuation such as is provided by jetting liquid against a tooth surface is not required to achieve rotation in the present device.

A side liquid passage 36 is provided in the top portion 16 extending between the inlet chamber 26 and the annular recess 24. Valve 38 is thread rotatable in top portion 16 to throttle liquid flow through the side passage 36. Liquid entering the top portion 16 fills the inlet chamber 26. A portion of the liquid passes through filter pack 28 and enters side passage 36. This liquid fills the annular recess 24 creating a uniform pressure condition in that recess, the annular top plate 30 acting as a pressure plate. The pressure equalized liquid then enters inlet ports 34 uniformly and passes into the rotor chamber 14 circumferentially.

A tubular shaft 40 extends centrally of the housing 10 journaled at its lower extent at shoulder 40a in the bottom housing portion 18 and at its upper extent at shoulder 40b in the annular top plate 30 with ball bearings 42 in each instance. The shaft 40 terminates upwardly within inlet chamber 26 having an opening 40c above the side passage 36 and just below the central aperture 20. The shaft 40 terminates downwardly in a threaded portion 40d below the housing bottom portion 18 and thus provides a central liquid passage 44 from the inlet chamber 26 through the rotor chamber 14.

A vertically extending star wheel rotor 46 is fixed to the shaft 40 with set screws 48 for rotation therewith within the rotor chamber 14. Plural teeth 50 are provided on the rotor 46 (see FIG. 4) e.g. four, six or eight i.e. an even numbered quantity of teeth equispaced and circularly arranged about the rotor axis 52 (FIG. 3). The teeth 50 and the rotor chamber wall 54 define a like num-

ber of rotor spaces 56 of generally triangular transverse or horizontal section.

The teeth 50 have each an individual thickness tapering outwardly from the rotor axis 52 and sufficient at a point e.g. 58 opposite the inlet port 34 to close any port to liquid flow and collectively have a transverse extent opposing the ports sufficient to keep the equivalent of at least one port closed at all times during rotation of rotor 46, as will be more fully explained in connection with the description of FIG. 4.

Each of the teeth 50 has first and second vertical surfaces 60 and 62 respectively. The tooth surfaces 60 and 62 are oppositely pressure responsive, that is fluid pressure against these surfaces tend to move them in opposite directions. The surfaces 60 and 62 are disposed within rotor chamber 14 in a manner such that the surfaces 60, the "first surface" lie radially of the rotor chamber axis 52, coincident with the rotor axis, and thus within an axial radial plane of the rotor. The surfaces 62, the "second surface" are disposed within the rotor chamber 14 such that they lie chordally of the rotor chamber axis 52 and in a plane intersecting the surface 60 plane at an angle generally more than about 60° and preferably at an angle between 90° and 120°. Surfaces 60 and 62 are of even vertical extent corresponding to the height of rotor chamber 14, but will vary in the transverse dimension, herein termed their width. Surface width and thus area will vary with the line of intersection of the planes in which the respective surfaces lie. In a star-wheel rotor arrangement, the first surface 60 will be less wide than the second surface 62. The second surface 62 thus will have a greater area exposed to pressure of fluid in the adjacent rotor space 56. Rotation of the rotor 46 in the direction urged by the second surfaces 62 does not occur, however, despite the pressure-area factor, because the force on the second surface is exerted around the rotor axis by a considerably shorter arm, line CR (FIG. 3) than is the force resulting from the same pressure against the smaller area first surface 60 which is exerted around the rotor axis radially thereof, along line R, in FIG. 3.

As liquid is introduced uniformly circumferentially into the rotor chamber 14 about the rotor 46, rotor spaces 56 are filled and hydraulic pressure P is exerted uniformly in all directions, including against the tooth surfaces 60 and 62 which results in a first, relatively larger rotative moment, $P \times R$, and a second, relatively smaller counter-rotative moment, $P \times CR$, about the rotor axis 52. The differential, D, between these moments, represented by

$$(P \times R) - (P \times CR) = D$$

is a force sufficient to induce rotor rotation.

It is apparent that the close balancing of rotative and counter-rotative moments will limit the rotative speeds achieved by this device at all rates of throughput. The device may thus be considered self-balancing or self-compensating in that increased throughput, such as by adjustment of throttle valve 38 will change the rotor speed absolutely, but will not alter the ratio of rotative and counter-rotative moments and thus rotor speed does not build indefinitely with continued passage of motive fluid through the rotor chamber 14. It is noteworthy that the valve 38 provides an externally operable speed-of-rotation adjustment, which is a feature not found on presently marketed spray devices of this kind.

A further factor limiting rotor speed is the carriage of a quantity of motive fluid circularly in the rotor spaces, as will be explained below.

A spray head 68 is provided dependent from the threaded shaft portion 40d and fixed for rotation therewith. If desired for ultra-low rotative speeds, e.g. 3-4 r.p.m. a reduction gear (not shown) may be interposed between the rotating shaft 40 and the spray head 68. The constancy of the drive provided by the present device makes revolution reduction to such low rates practicable for the first time. A passageway 70 is formed within the spray head 68 in open communication with the central passage 44

of the shaft which, as described, leads from inlet chamber 26 of the housing. Liquid entering the spray head 68, therefore, by-passes the rotor chamber 14 and does not contribute to spray head rotation. Journaled in passageway 70 with ball bearings 74 tubular distribution shaft 72 is provided having circumferential aperturing 76 opposite the end of shaft 40. Two pairs of opposed jet nozzles 78 are provided secured to the distributing shaft 72 in mutually perpendicular alinement. As shown the nozzles 78 are balanced in their operation and do not exert a reaction torque. Nozzles may be placed in offset relation as at 781 in FIG. 7 where reaction displacement of the spray head 68 is desired. In such case, the rotor 461 acts to control the resulting rotation. The nozzles 78, in FIGS. 1 and 3, it will be seen are mounted for planetary rotation, i.e. they will rotate about the horizontal axis of the distributing shaft 72 while the spray head 68 as a whole rotates about the vertical axis of the central shaft 40. In this manner a very comprehensive spray pattern is achieved.

Rotation of the nozzles 78 about the axis of shaft 72 is secured by provision of cooperating bevel gears 80 and 82 on the housing 10 and spray head 68 respectively, as is well known.

Introduction of liquid into the rotor chamber 14 from inlet ports 34 has been described. This liquid is exhausted from the rotor chamber 14 through the bottom housing portion 18. With particular reference to FIG. 6 the bottom housing portion 18 is seen to have the form of a circular disc 84 having circularly distributed openings 86 and an upwardly opening annular groove 88 providing communication between these openings. The groove 88 is opposite the inlet ports 34 in the top plate 30. Between the disc 84 and rotor chamber 14, an apertured bottom plate 90 may be provided. The bottom plate 90 has circularly distributed apertures 92 equal in number and in spacing to inlet ports 34 in the top plate 30. With or without bottom plate 90 in position, rotation of rotor 46 successively moves rotor spaces 56 into line with an inlet port 34 and an outlet in the form of opening 92 or groove 88 or its integral openings 86. For the time it takes the rotor tooth 50 to move through a rotor space sized area, communication is established across the rotor space between the inlet port 34 and a bottom opening 86. During this time liquid moves rapidly through the rotor space 56 and out the bottom openings 86. Continued movement of the rotor 46 closes the inlet port 34 and if provided, the openings 92 in the bottom plate. A portion of liquid entering the rotor space is thus carried angularly until exhausted ultimately through an opening 86. It will be noted the openings 86 are individually larger than inlet ports 34 but totally smaller in area so that a back-pressure will exist within the rotor chamber 14 during operation of the device. This back-pressure is measurable in terms of a pressure drop across the rotor chamber, which typically will be on the order of 90 pounds/square inch e.g. 100 pounds at the inlet ports 34 and 10 pounds/square inch at the outlet openings 86. This pressure drop is the value of P in the mathematical representation of device operation given above.

The openings 86 may be arranged as shown to discharge spent liquid from the rotor chamber 14 onto the meshing bevel gears 80 and 82 passing therebelow. This feature provides continued flushing of the gear 80 and 82 surfaces to remove foreign matter which may become lodged there during cleaning operations.

In any case, the outlet openings 92 exhaust the liquid from the rotor chamber 14 past or outside of the spray head, to waste.

As described above the principle of operation of the present device is utilization of differing opposing moments to induce slow rotation about an axis. Rotative moment may be enhanced by mass velocity forces resulting from impingement of the inlet port stream against the rotor teeth surfaces 60. To do this, the inlet ports may be angles as shown at 341 in FIGS. 4 and 5. It is highly de-

sirable for smooth operation to have such impinging streams drive the rotor 46 directly by a particular tooth 50 only for a portion of each revolution. Thus in a six toothed rotor (60° spacing) five inlet port top plate (72° spacing) arrangement illustrated in FIG. 4, the jet stream issuing from the inlet port strikes the tooth surface 60 directly for only 12°, and provides a decreasing power assist for an additional 48°.

The angular orientation of the inlet ports 341 relative to the tooth surface and the rotor axis is not narrowly critical and should be selected to provide fairly continual power to the rotor passing thereunder.

The mass velocity assist can be realized by a combination of straight inlet ports and helical rotor teeth. This is shown in FIG. 7 where helical rotor teeth 501 lie in the path of liquid issuing from inlet ports 34. Otherwise the apparatus is the same.

The foregoing description has been concerned with use of liquid as the motive fluid, particularly a portion of the liquid to be projected by the spray head. The device is not limited to such operation. As shown in FIG. 1 a secondary inlet 94 may be provided leading directly to annular recess 24 by-passing the inlet chamber 26. Thread connected to the inlet 94 is a fluid delivery tube 96 with shut-off valve 98 controlled by wheel 100. The fluid introduced at inlet 94 may be air, gas or vapor or a liquid the same as or compatible or incompatible with the liquid passing to the spray head. Since the motive fluid does not contact the projection liquid their respective natures are immaterial.

In addition to fluid flow downwardly through the rotor spaces, there is fluid flow between spaces, through the clearance between teeth edges and rotor chamber wall. The clearance is sufficient to permit fluid flow between chambers. The effect of this relatively lateral flow is to create on either side of the tooth a pressure condition. On the one side a rotation favoring pressure condition, i.e. a negative pressure or suction and on the other a rotation retarding pressure condition i.e. a positive pressure. It will be appreciated from a consideration of the teeth illustrated in the drawings that there will occur different levels of drag on either side of the tooth with drag in the direction of the first surface lower than opposing drag. Thus rotation is favored over counter-rotation. The flow along the second surface to and through the tooth clearance is smoother and more closely approximates venturi conditions whereby a suction or lifting effect may be created to endure desired rotor movement. It has been found that on initial flow of fluid through the device, rotor rotation commences as a result of lateral flow between the rotor cavities and resultant pressure conditions about the rotor teeth.

I claim:

1. A rotating spray device adapted to traverse the wall of a surrounding enclosure with a coherent stream of cleansing liquid comprising
 - a housing,
 - a rotating spray head adapted when slowly driven to project liquid with great force against said wall
 - means to supply liquid to said spray head for projection
 - means to slowly drive said spray head including
 - a cylindrical rotor chamber within said housing,
 - a rotor rotatably mounted within and closely enclosed by the chamber drivingly connected to said spray head
 - said rotor having plural circularly arranged teeth to define a plurality of rotor spaces with said chamber, said teeth being provided with oppositely pressure responsive first and second surfaces disposed within the chamber to produce in response to fluid pressure therein a first, relatively larger, rotative moment and a second, relatively smaller, counter-rotative moment about the rotor axis, the differential in said moments inducing slow rotation of said rotor to correspondingly slowly drive the spray head,

and means for passing motive fluid through the chamber in a manner producing fluid pressure circumferentially about the rotor, whereby rotor rotation is induced.

2. Spray device according to claim 1 including circularly distributed fluid inlet means at one end of the rotor chamber and circularly distributed fluid outlet means at the opposite end of the chamber.

3. Spray device according to claim 2 in which the inlet and outlet means comprise inlet ports and outlet means having an opposed relation across said rotor spaces providing therefor simultaneous fluid inlet and outlet.

4. Spray device according to claim 3 including also means providing equal pressure fluid at said inlet ports.

5. Spray device according to claim 4 in which said inlet ports are fewer in number than said rotor teeth.

6. Spray device according to claim 5 in which said inlet ports are circularly arranged and axially oriented relative to the tooth surfaces to impinge rotor displacing fluid against each of said rotor teeth but less than all of said teeth simultaneously in a direction enhancing said rotative moment.

7. Spray device according to claim 1 in which each tooth of said rotor is provided on said first side with a pressure surface lying in a radial axial plane of the rotor.

8. Spray device according to claim 7 in which the plane of said second side of each rotor tooth lies at an intersecting angle of more than 60° to the plane of the first side surface of the next adjacent tooth.

9. Spray device according to claim 8 in which the planes of first and second sides of adjacent teeth lie at right angles to one another.

10. Spray device according to claim 1 including also a shaft extending centrally through the chamber, said rotor and said spray head being fixed to said shaft.

11. Spray device according to claim 10 in which said liquid supply means includes a liquid passage means formed centrally of said shaft and leading to said spray head.

12. Spray device according to claim 11 including also means connectable to a liquid supply for conveying liquid to said shaft passage and means formed in said liquid conveying means for distributing a portion of said liquid circularly of said shaft and thence into said rotor chamber.

13. Spray device according to claim 12 including also means to discharge said liquid portion from said rotor chamber outside of said spray head.

14. Spray device according to claim 13 including also nozzle means on said spray head and cooperating gear means on said spray head and said housing to rotate said nozzle means on a different axis from said head, said gear means being adjacent the liquid discharge means from the rotor chamber whereby said gear means is flushed with liquid during spray head rotation.

15. Spray device according to claim 1 including also reaction nozzle means on said spray head tending to drive said rotor in a direction and in which one set of said pressure responsive surfaces on the rotor teeth acts to oppose nozzle reaction-produced rotation of the rotor, thereby slowing such rotation.

16. Spray device according to claim 13 including also a plurality of liquid inlet ports between the liquid conveying means and said rotor chamber, said inlet ports being circularly distributed about said shaft and outlet means opposite said inlet ports across said rotor spaces to provide therefor simultaneous liquid inlet and outlet.

17. Spray device according to claim 16 including also an annular channel remote to said rotor chamber connecting said inlet ports and providing equal pressure liquid thereto.

18. Spray device according to claim 17 in which said inlet ports are fewer in number than said rotor teeth and their number is not evenly divisible by the number of rotor teeth.

19. Spray device according to claim 18 in which each

inlet port is oriented relative to the tooth surfaces to impinge rotor displacing liquid against each of said rotor teeth in succession but the totality of such ports is arranged to impinge on less than all of said teeth simultaneously, said impinging being in a direction enhancing said rotative movement.

20. Spray device according to claim 19 in which the planes of oppositely responsive pressure surfaces of adjacent teeth intersect at an angle between 90° and 120° and one of said surfaces lies in a radial axial plane of said rotor.

21. Spray device according to claim 1 including means for carrying fluid between adjacent rotor spaces lying beyond the outer edge of said rotor teeth in a manner creating different pressure conditions on either side of the tooth thereby to induce rotor rotation.

22. A rotating spray device for circumferentially projecting coherent streams of liquid across a space including: a generally cylindrical, normally vertically disposed housing having

- a tubular central body portion defining a cylindrical rotor chamber,
- a generally conical top portion closing the upper end of the housing, and
- a generally circular bottom portion across the lower end thereof

said top portion having an upwardly opening central aperture therein adapted to connect to a pipe leading from a pressurized liquid supply and a downwardly open annular recess in open communication with said rotor chamber, and an inlet chamber between said aperture and recess,

an annular plate disposed below said recess adjacent said rotor chamber

an odd number plurality of equispaced equisized inlet ports formed in said plate leading angularly downwardly from said inlet chamber to said rotor chamber,

a side liquid passage between the inlet chamber and said annular recess having valve means controlling liquid flow therethrough;

a tubular shaft extending centrally of the housing and journaled at its lower extent in said bottom housing portion and at its upper extent in said annular plate, said shaft terminating upwardly within said inlet chamber and having an opening above said side passage and below said central aperture and terminating downwardly below said rotor chamber to define a central liquid passage from said inlet chamber through said rotor chamber;

a vertically extending star-wheel rotor mounted on said shaft for rotation therewith within said rotor chamber, said rotor having an even number of equispaced circularly arranged teeth which with the rotor chamber wall defines a like number of rotor spaces generally triangular in horizontal section,

each of said teeth having an outwardly tapering indi-

vidual thickness sufficient to close one of said inlet ports and collectively sufficient to keep the equivalent of at least one port closed at all times during rotor rotation,

each of said teeth further being provided with oppositely pressure responsive first and second surfaces disposed within the chamber in a manner such that said first surfaces lie radially of the chamber axis within an axial radial plane of said rotor and said second surfaces lie chordally of the chamber axis and in a plane intersecting the first surface plane at an angle between 60° and 120° to produce in response to uniform pressure on the rotor surfaces resultant from liquid introduced circumferentially of the rotor into the rotor chamber through said inlet ports above the rotor spaces a first, relatively larger rotative moment from liquid pressure against the first of said surfaces and a second, relatively smaller counter-rotative moment from liquid pressure against the second of said surfaces about the rotor axis, the differential in said moments being sufficient to cause rotor rotation slowly against the counter-rotative force to correspondingly rotate the shaft slowly on its axis;

a spray head secured to said shaft for rotation therewith and having a passageway therein in open communication with the central liquid passage of said shaft, nozzle means carried by said shaft including multiple differently directed nozzles communicating with said passageway and mounted on the spray head for planetary rotation,

bevel gear means on said spray head and said housing for rotating said nozzles upon rotation of said spray head by the shaft;

liquid receiving means in the housing bottom portion including an annular groove about the rotor shaft generally opposing said inlet ports across the rotor spaces for receiving liquid passing the rotor teeth and

multiple discharge ports formed in the bottom of said groove leading downwardly from the rotor chamber adapted to discharge spent liquid past said spray head, said discharge ports being sized relative to said inlet ports to maintain liquid under pressure within said rotor chamber.

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EVERETT W. KIRBY, *Primary Examiner.*

U.S. Cl. X.R.

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