Dec. 20, 1966 W. L. NELSON 3,292,863

TANK WASHER EMPLOYING AN IMPELLER BRAKING MEANS

Filed Sept. 26, 1963 4 Sheets-Sheet 1

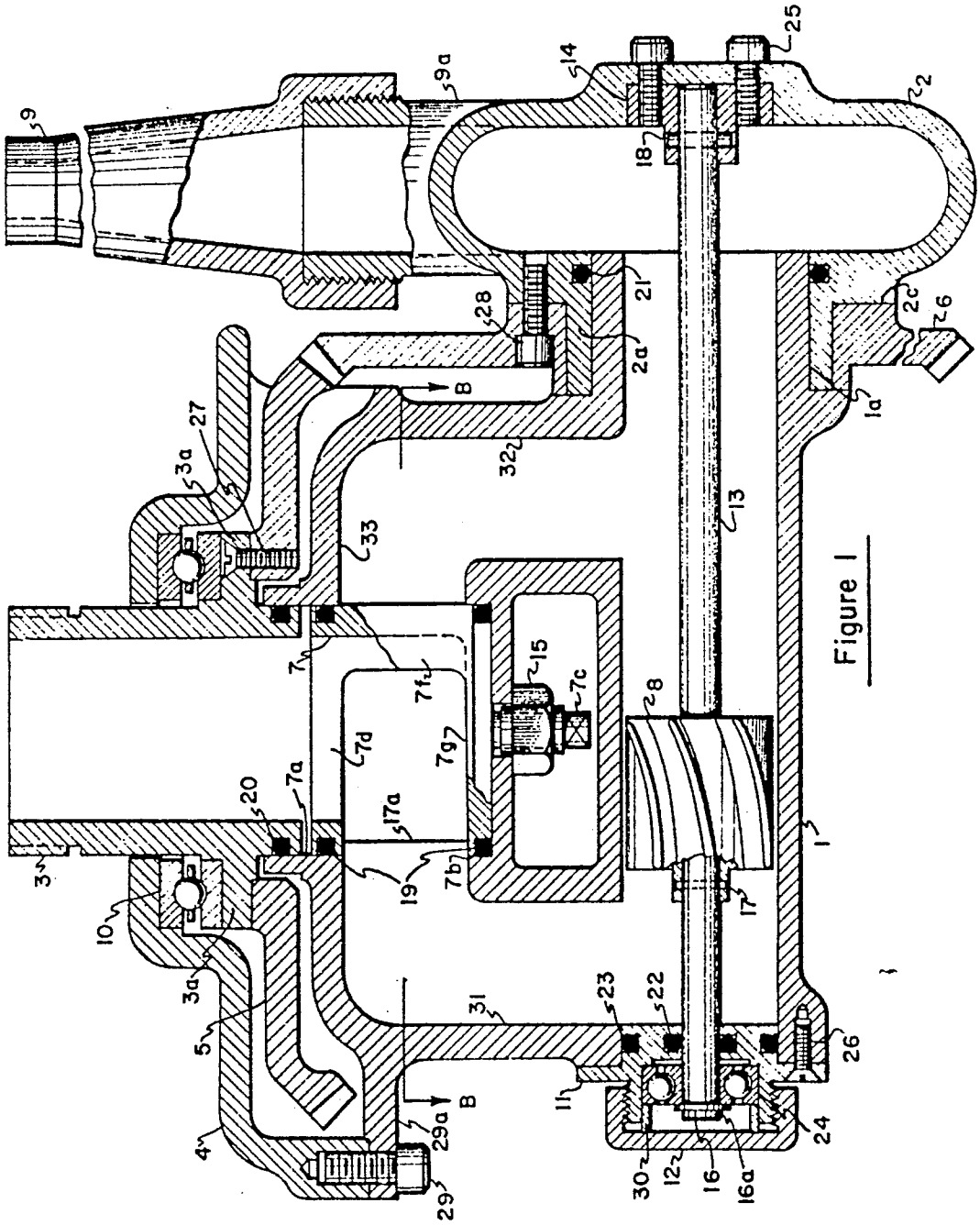

Figure 1

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TANK WASHER EMPLOYING AN IMPELLER BRAKING MEANS

Filed Sept. 26, 1963 4 Sheets-Sheet 2

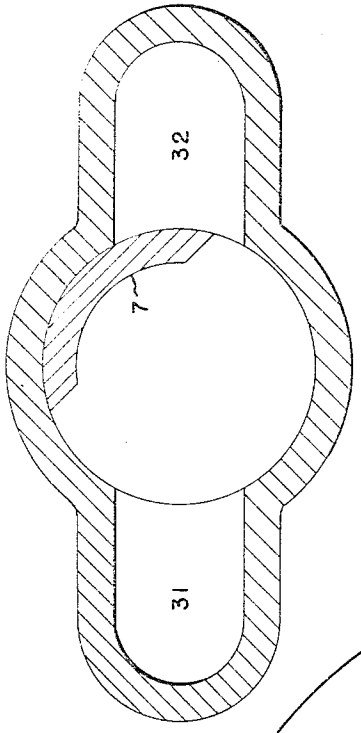

FIG.-3

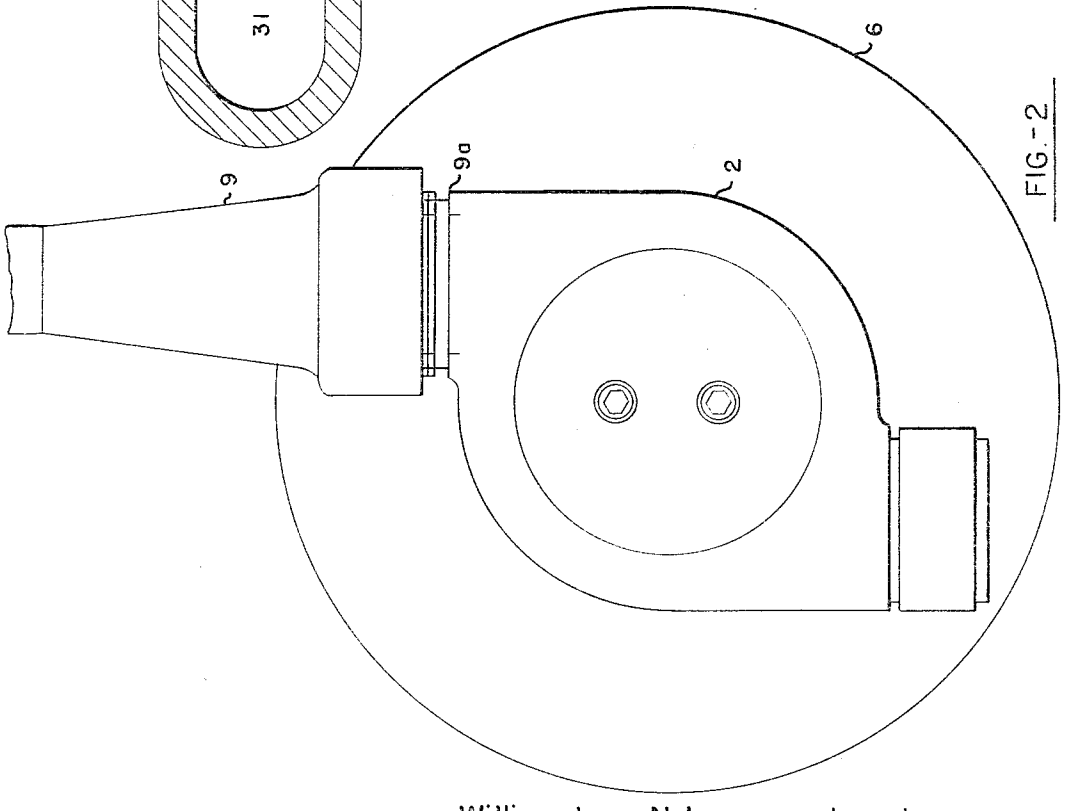

FIG.-2

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TANK WASHER EMPLOYING AN IMPELLER BRAKING MEANS

Filed Sept. 26, 1963 4 Sheets-Sheet 3

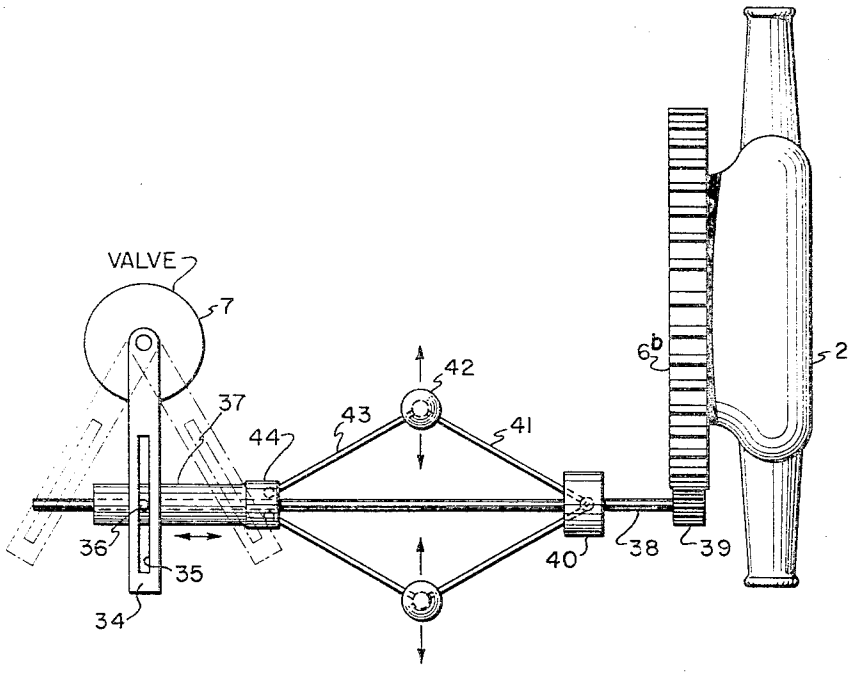

Figure 4

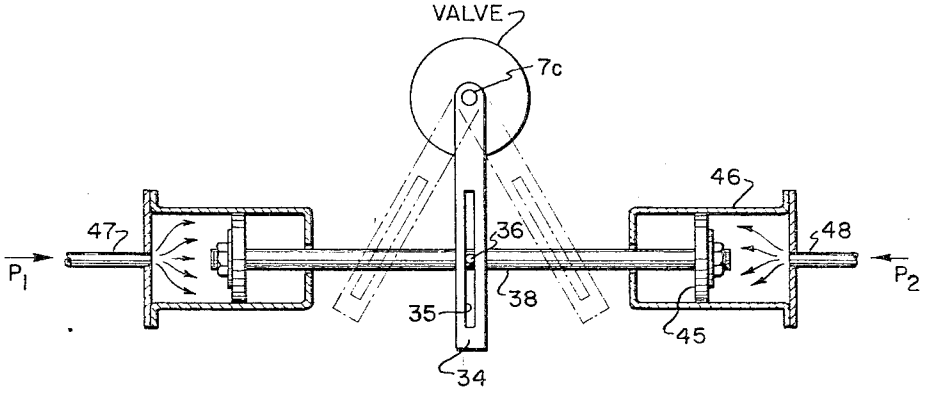

Figure 5

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TANK WASHER EMPLOYING AN IMPELLER BRAKING MEANS

Filed Sept. 26, 1963 4 Sheets-Sheet 4

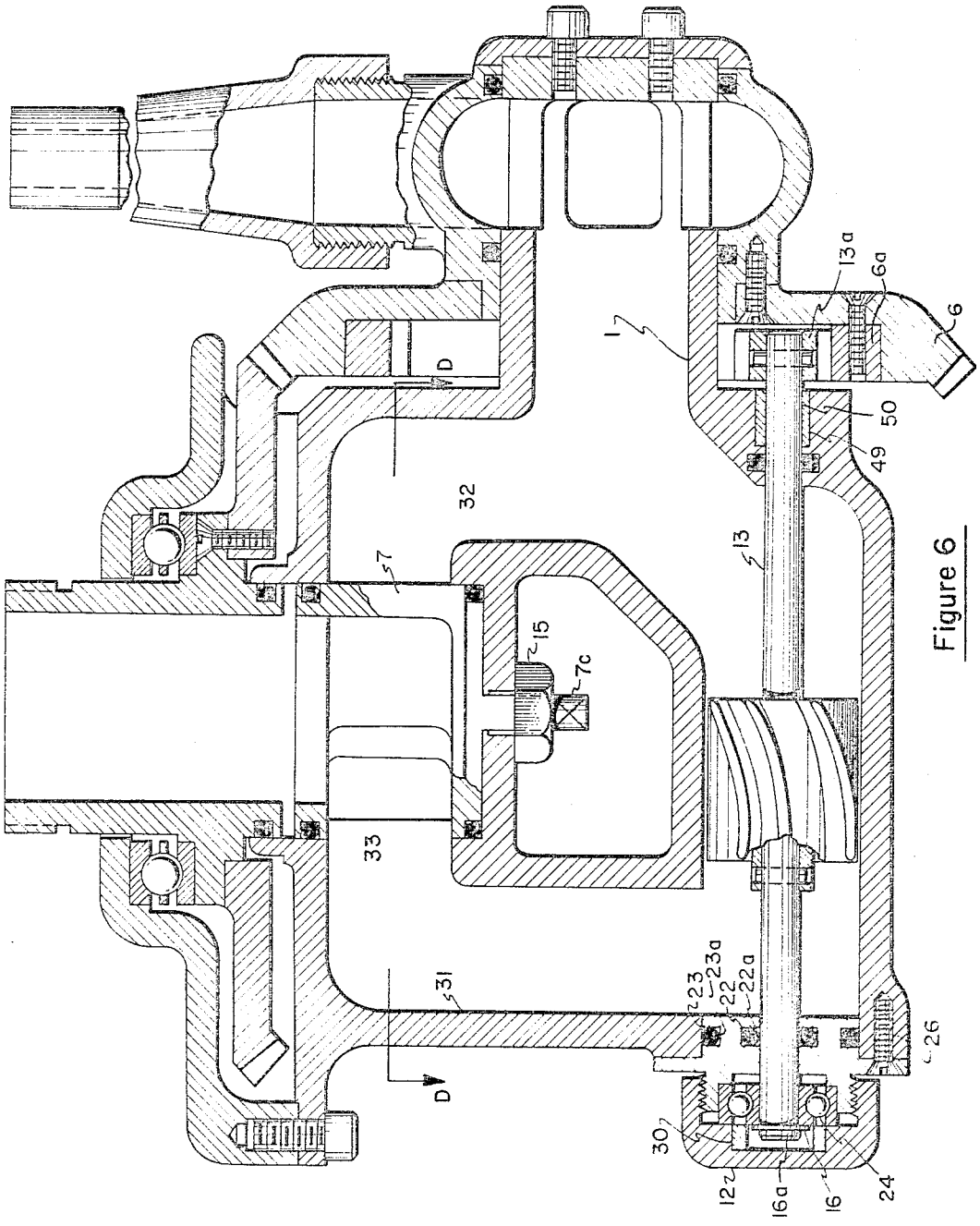

Figure 6

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United States Patent Office 3,292,863
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3,292,863

TANK WASHER EMPLOYING AN IMPELLER BRAKING MEANS

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11 Claims. (Cl. 239—227)

This invention relates to a method and apparatus for automatically distributing liquid under pressure, particularly apparatus for washing tanks and the like, and is particularly concerned with a method of controlling the operation of the same.

In the cleaning or washing of tanks, for example in sea-going tankers, it is common practice to employ tank-washing machines in which the washing liquid is ejected through nozzles attached to a spray head adapted to rotate whereby the jets follow a constantly changing direction and impinge against the walls of the tank at constantly changing positions. According to one form, the nozzles are caused to rotate about a first axis e.g. a horizontal axis and the spray head is caused to rotate about a second axis perpendicular to the first axis e.g. a vertical axis so that the jets impinge on the wall, tracing a pattern and eventually cover substantially the entire walls of the tank. Such devices are commonly driven by means of a hydraulic motor or turbine coupled to the spray head through reduction gearing and the said hydraulic motor or turbine is normally operated by the stream of fluid under pressure fed to the spray head and nozzles. With this type of equipment, it is desirable to control the speed of rotation of the spray head and the nozzles and the apparatus is usually designed to revolve at a substantially constant speed, usually 2 to 3 revolutions per minute in the case of ships' tanks, but may be considerably more in the case of other types of tanks or other applications.

Such machines give satisfactory service but are relatively costly to produce and require periodical maintenance. The life of such machines is also somewhat limited, owing to wear on the gears and bearings. To overcome these difficulties, it has been proposed to construct similar apparatus driven by the reaction from the jets issuing from the nozzles of the spray head to impart motive force to the nozzles and/or spray head to rotate the same.

With such machines the control of the speed of rotation of the spray head and the nozzles has presented major problems, mainly by reason of the fact that the device is sensitive to small pressure changes and therefore tends to rotate too fast or too slow. Such fluctuations of speed, due to variations in pressure, will also occur with the turbine motor driven models but will be much less apparent than with the reaction driven devices.

Attempts to control the rate of rotation by the use of friction devices have not proved satisfactory and this invention has for its object to provide an improved method and means for controlling the speed of rotation of the nozzles and spray head.

The present invention accordingly comprises a method for controlling the speed of rotation of a rotating liquid distributing device operated by the stream of liquid fed to and distributed by the device comprising diverting a portion of the liquid stream fed to the device to a driven means positively connected indirectly or directly to the distributing device and adapted to be driven by the diverted portion of the liquid stream in opposition to the motion of the liquid distributing device in accordance with the amount of liquid diverted, and thereby exert a corresponding braking action on the liquid distributing device and varying the amount of liquid diverted to the

said driven means in accordance with the speed of rotation of the liquid distributing device to maintain the same substantially constant independent of variations in the pressure of the liquid supply. According to a further feature of the invention the amount of liquid diverted to the driven means is varied automatically in accordance with the speed of rotation of the distributing device.

The invention also comprises an apparatus for distributing jets of liquid automatically in a constantly changing direction, for example for use in washing the walls of an enclosed space, for example a tank, comprising a nozzle head provided with one or more nozzles for the ejection of said jets of liquid against the walls of the said tank, said nozzle head and nozzles being adapted to rotate about one or more axes, means for supplying the nozzle head and nozzles with liquid under pressure and means operated by the said liquid under pressure to cause rotation of the said nozzle head and nozzles, including controlling means connected directly or indirectly to said nozzle head and operated by a portion of the liquid feed to the nozzle head, adapted to act in opposition to the motion of the nozzle head to control its motion in accordance with the pressure and quantity of the liquid supplied to operate the controlling means and means to divert a portion of the liquid under pressure fed to the nozzle head to operate the said controlling means, automatically in accordance with the speed of rotation of the spray head or nozzles.

According to one form of the invention, the nozzle head is preferably rotated by the reaction forces of the jets of liquid issuing from the nozzles.

According to a further form of the invention, the means for controlling the rate of rotation of the nozzle head comprises a shaft positively connected at one end to the nozzle head, an impeller mounted on the other end or connected thereto through a suitable chain of gears or the like, said impeller being constructed to be driven in opposition to the motion of the nozzle head and being operated by a stream of liquid diverted from the liquid feed to the nozzle head. The shaft is preferably coaxial with the nozzle head and firmly attached thereto but may also be parallel to or at an angle to the axis of the nozzle head and positively connected thereto by a suitable train of gears. In operation the impeller is driven by the diverted liquid stream in opposition to the rotation of the nozzle head and thereby exerts a braking force on the nozzle head through the shaft and gears if any.

According to a further feature of this apparatus, a branch line is provided in the liquid feed line to the nozzle head, said branch line passing a portion of the liquid from the said feed line to the controlling means and a valve is provided in the said branch line, preferably at a point between the junction of the branch line and the nozzle head in the feed line, adapted to control the amount of liquid passing through the said branch line in accordance with the speed of rotation of the spray head. The valve controlling the diversion of the liquid to the driven means may also be arranged at a point between the junction of the branch line to the main line and the nozzle head.

The movement of the valve may be effected by hand or automatically or by a combination of manual and automatic means.

The automatic operation may be effected conveniently by the use of any of a number of devices available commercially and particularly pressure-sensitive devices actuated by the varying pressures in the feed or branch lines or the differential pressures between the branch line and the nozzle head supply line and adapted to operate the valve to allow more liquid to pass to the controlling mechanism when the nozzles rotate too fast and vice versa. Alternatively a governor device operated

by the rotating nozzle head could be employed to control the valve.

The invention is illustrated by way of example in the accompanying drawings, in which:

FIGURE 1 shows a vertical sectional view of one form of apparatus according to the invention.

FIGURE 2 shows an end elevation of the apparatus shown in FIGURE 1 viewed from the righthand side and illustrating the positioning of the nozzles on the nozzle head.

FIGURE 3 shows an enlarged plan sectional view on the line B—B of FIGURE 1 of one form of valve mechanism used in the device.

FIGURE 4 shows a sectional view of one form of arrangement for controlling the setting of the valve automatically in accordance with the rate of rotation of the nozzles.

FIGURE 5 shows a section of an alternative arrangement for controlling the setting of the valve automatically in accordance with the differences in pressure in the liquid streams.

FIGURE 6 shows a vertical section of an alternative arrangement to FIGURE 1 in which the impeller is mounted on a shaft displaced from the axis of the nozzle and is connected to the nozzle head by a gear system.

Referring to FIGURE 1, the figure represents the spray head in the form of a horizontal tubular member **1** having an inverted U-shaped tubular member **33** with both its arms **31** and **32** in open communication with the interior of the horizontal tubular member through its upper wall and having its horizontal upper portion **33** communicating with and rotatable about a vertical tubular member **3** connecting with the liquid supply pipe.

At one end of the horizontal tubular member **1** is arranged a nozzle head **2** in the form of a hollow substantially cylindrical member closed at one end and having its opposite end formed with a flange member **2***a* closely fitting and rotatable about the end **1***a* of the tubular member **1**. The cylindrical wall of this member is provided with at least two nozzle tubes **9***a*, arranged symmetrically and preferably tangentially with respect to the circle of rotation of the member. Each of these tubes **9***a* is provided with a nozzle tip **9** suitably attached thereto, for example by coacting screw threads on the nozzle tip and tube.

The outer surface of the flange member **2***a* is preferably recessed to form a shoulder portion **2***c* in which is fitted the hub of a bevel gear member **6**, which is firmly attached coaxially to the nozzle head **2** for example by bolts **28**. In the face of the flange member **2***a* abutting against the tubular member **1** is provided a groove **21** holding a sealing ring **21***a* of any desired type to prevent leakage of liquid through the joint.

Within the horizontal tubular member **1** is arranged a horizontal shaft **13** coaxial with the axis of rotation of the nozzle head **2** having one end firmly attached to the said nozzle head, for example held by means of a pin **18** in a bushing member **14** attached to the inner side of the nozzle head **2** by bolts **25**. The opposite end of this shaft passes through the tubular member **1** and is rotatably mounted in a closure member **11** firmly attached to the other end of the member **1** by means of bolts **26** and having a recessed portion in its outer face to hold a bearing **24**, preferably a ball bearing, on the said shaft **13**. The end of the shaft **13** is provided with a groove **16***a* and a retaining ring abutting against the outer surface of the bearing.

The bearing **24** is held in position in the recess by means of a ring **30** clamped against it by a cap member **12** screwed on to a flanged portion of the closure member **11**. The retaining ring prevents lateral movement of the shaft **13** and holds the nozzle head **2** firmly on its bearing **1***a*. Grooves and sealing rings **23** and **22** to prevent egress of the liquid are provided on the outer rim of the closure member **11** against the inner surface of

the tubular member **1** and in the central bore abutting against the shaft **13**.

On the shaft **13** at a point between the entry of the arms of the U-member is arranged an impeller **8**, preferably in the form of a cylinder keyed by key or pin **17** to the shaft **13** and provided on its outer surface with a series of vanes so arranged as to tend to rotate the member **8** and the shaft **13** in the opposite direction to the rotation of the nozzle head **2** when liquid is passed down the left-hand arm **31** of the inverted U-member. If desired a fixed vane member may be arranged on the stream of liquid from arm **31** to direct the liquid against the vanes of the impeller **8**. The horizontal portion **33** of the inverted U-member is provided at its midpoint with an upturned vertical flange member **7***a* which is rotatably arranged around the end of a tubular member **3**, attached at its upper end to the liquid supply tube. The outer surface of this member **3** within the flange **7***a* is provided with a groove and sealing ring **20** abutting against the inner surface of the flanged member to prevent egress of liquid through the joint. The tubular member **3** is provided on its outer surface above the flange member **7***a* with an external horizontal circumferential flange member **3***a* against the lower face of which is attached, for example by bolts **27**, a bevel gear wheel **5** coacting with the gear wheel **6** on the nozzle head. On the upper surface of this flange member **3***a* is provided a ball or other type of bearing **10** on which rests a gear cover **4** covering the gear wheel **5** and bolted to a flange or lugs **29***a* on the U-shaped member by bolts **29**. This gear cover forms the support by which the entire device is rotatably suspended about the member **3**. Within the horizontal portion **33** of the U-member **31**, **32** and **33** is arranged a valve member **7** in the form of a hollow cylinder having a closed lower end and a major portion of the side wall cut away, as shown in FIGURE 3, leaving a member in the form of an upper ring portion **7***d* and a lower plate or dished portion **7***g* joined by a concentric, arcuate portion **7***f*. The circular portions of this member **7** are arranged coaxially rotatable in the lower part of the flange member **7***a* and in a coaxial recess **7***b* in the lower wall of the horizontal portion **33** of the U-shaped member. The faces of the circular portion abutting against the inner surfaces of the flange **7***a* and the recess **7***b* are provided with grooves and sealing rings **19**. The lower member of the valve **7** is provided with a central shaft **7***c* passing through a suitable aperture in the lower wall of the part **33**, the outer part of which shaft is adapted to be connected to a device for rotating it and the valve **7** within the member **33**. As shown in FIGURE 1, the end of the shaft is shaped to engage a key so that it can be rotated by hand. In this figure, the shaft is also provided with a screw thread and nut **15** to allow it and the valve to be locked in any position. As shown in FIGURE 3, the arcuate wall of the valve member **7** is so dimensioned that according to the position of the valve, access of the liquid to either arm **31** or **32** of the U-member can be completely or partially closed or full access can be allowed to both arms **31** and **32**.

FIGURE 4 illustrates one form of arrangement for automatic control of the valve **7**. According to this arrangement, a horizontal lever arm **34** is fixedly attached to the shaft of the valve **7** so that rotation of the arm rotates the valve. The outer end of the said arm **34** is provided with a slot **35** in which rides a pin **36** carried on a sliding member **37** of a centrifugal governor. This member is carried on a shaft **38** suitably mounted on the exterior of the device and having at one end a pinion gear **39** engaging a further gear **6***b* mounted on and rotating with the nozzle head **2**. This may conveniently be formed on the gear **6** already provided thereon. On this shaft **38** is affixedly mounted the fixed member **40** of the centrifugal governor. This fixed member **40** is rotatable with the shaft **38** and is provided at spaced intervals with a plurality of hinged arms **41** each hingedly attached to a

separate ball or weight member **42**, each of which is in like manner hingedly connected by arms **43** to the sliding member **37**. These arms **43** are attached to a member **44** attached to sliding member **37** freely rotatably about the shaft **38** and slidable therealong together with the sliding member **37** and adapted to slide the member **37** to and fro along the shaft **38** and thus adjust the position of the valve **7** in accordance with the speed of the governor which is, in turn, controlled through the gears **6** and by the rate of rotation of the nozzle head **2**.

FIGURE 5 shows diagrammatically an alternative method of operating the arm **34** attached to the shaft **7***c* and operated by the differential pressures in the arms **31** and **32** of the U-shaped member, that is, on either side of the impeller device. In this arrangement, a shaft **38** is suitably mounted parallel to the horizontal tube member **1** to be slidable to and fro and having a pin **36** riding in the slot **35** in the arm **34**. Each end of this shaft is attached to a piston or bellows **45** in a closed chamber **46**, the closed ends of which are connected by pipes **47** and **48**, in open communication with the arms **31** and **32** of the tubular member. As the differential pressures between the two arms varies, so the pressures in cylinders **46** is varied accordingly and therewith, the arm **38** is caused to move to and fro under the action of the pistons or bellows and so actuate the arm **34** to operate the valve **7** in accordance with the differences of pressures in the two arms **31** and **32**.

FIGURE 6 illustrates an alternative form of the FIGURE 1 in which the shaft **13** bearing the impeller **8** is laterally offset with respect to the axis of rotation of the nozzle head and is operated by a pinion gear **13***a* coacting with a further gear **6***a* bolted on to the said nozzle head and suitably within the gear wheel **6** already provided thereon.

According to this modification, the horizontal tubular member **1** is provided with a lower recessed portion below the center part of the U-members **31–33** and the limbs **31** and **32** of the U-member are extended downwardly to this lower portion so that, in effect, the horizontal tube **1** is stepped down below the horizontal portion of the U-member. In the outside wall of this stepped-down portion adjacent the nozzle head, is provided an aperture **49** and a sleeve bearing member **50** forming a bearing for the shaft **13**, the other end of which is mounted rotatably in the opposite wall in a manner similar to that shown in FIGURE 1. Valve **7** is provided in similar manner as shown in FIGURE 1 and operated in any suitable manner, for example as shown in FIGURES 1, 4 and 5.

In operation, the stream of liquid under pressure is supplied through the member **3** and valve **7** to the horizontal portion **33** of the inverted U-member. In accordance with the position of valve **7** part of the liquid stream is passed down arm **32** to the nozzle head **2**. The liquid under pressure issuing through the nozzle tips **9** attached to the nozzle head **2** cause the latter to rotate under the reaction forces set up by the jets issuing from the nozzles. As shown in the drawings, this will be clockwise. With the nozzle head **2**, is rotated the shaft **13**, either direct as shown in FIGURE 1, or through the train of gears **6***a* and **13***a* shown in FIGURE 6 and the impeller **8** is thereby rotated. When the nozzle head **2** rotates above a desired speed, the valve **7** is operated either manually as shown in FIGURE 1 or automatically for example as shown in FIGURES 4 and 5 to allow an increase in the amount of the fluid passing down member **3** to pass into member **31** and thus directly through to the impeller **8**, which owing to the formation of the vanes, tends to turn this in a counterclockwise direction (viewed from FIG. 2) opposite to that of the nozzle head **2**, thus exerting a braking action on the rotation thereof.

It will be understood that this braking action can be varied by controlling the amount of liquid allowed to pass down the arm **31** by the positioning of the valve **7**. The operation of the device can also be arranged to a substantially constant rate of rotation of the nozzle head and spray head at any desired rate by adjusting the valve manually to achieve the desired speed and then further adjusting the valve manually or automatically or by both means periodically when the speed of rotation of the nozzles deviates from the desired rate. For various reasons it will be preferred to effect the main speed control manually and to effect the subsequent controls rendered necessary by fluctuations in the operating conditions automatically when required.

The rotation of the nozzle head **2** also rotates the gear **6** which coacts with the gear **5** mounted on the member **3** and causes the spray head to rotate about the axis of the fixed gear **5**, so that circular motion in two planes is imparted to the nozzles **9**.

While this invention has been described with respect to an apparatus driven by the reaction of the liquid issuing from the nozzles, it will easily be seen that it could be also applied to similar devices operated by the liquid stream supplied to the device.

The apparatus of the invention, when used with reaction driven spray heads, has the advantage that it eliminates the necessity of complicated gearing and high speed bearings and its construction is comparatively simple. Tests have shown that by simply closing or opening the control valve in a device adapted for cleaning ships' tanks, the speed of the nozzle head can be varied from 2 to 3 to 11 revolutions per minute and maintained at a substantially constant speed throughout a relatively wide range of pressure variations in the liquid feed line. By use of this device, it will thus be possible to provide a nozzle head with given nozzle sizes having a variable speed range. While the device has been described particularly with respect to a reaction driven machine, it can equally be applied to a machine driven by a liquid motor or turbine operated by the liquid stream to the nozzles, although in such cases, the variation and speed due to fluctuations in the liquid pressures is much less evident than in the simple reaction driven devices.

What is claimed is:

1. An apparatus for distributing jets of liquid in continuously changing direction, e.g. for use in washing the walls of a closed space, e.g. a tank, comprising a nozzle head provided with one or more nozzles for the ejection of said jets, said nozzle head and nozzles being adapted to rotate about one or more axes, means for supplying the nozzle head and nozzles with liquid under pressure and means operated by the said liquid under pressure to cause the said nozzle head and nozzles to rotate in a predetermined first rotational direction, braking means fixedly connected to said nozzle head operated by a portion of the liquid fed to the nozzle head and adapted to continuously apply a resisting torque to said nozzle head in a second, predetermined rotational direction in opposition to the first rotational direction of said nozzle head to retard its motion in accordance with the pressure and quantity of liquid supplied to operate it and means to divert a portion of the liquid under pressure fed to the nozzle head to operate the said braking means in accordance with the speed of rotation of the said nozzle head to maintain a desired speed thereof substantially independent of variations in the pressure of the liquid supply.

2. Apparatus as claimed in claim **1** wherein the means for rotating the nozzle head comprises the reaction force exerted by the jets issuing from the nozzles.

3. Apparatus as claimed in claim **2** wherein the braking means for controlling the rate of rotation of the nozzle head comprises a shaft positively connected at one end to the nozzle head and an impeller connected thereto, said impeller being constructed to operate in torque opposition to the motion of the nozzle head and being operated by a stream of liquid diverted from the liquid fed to the nozzle head.

4. Apparatus as claimed in claim **3** wherein a branch line is provided in the liquid feed line to the nozzle head,

said branch line passing the liquid to the said braking means and a valve is provided adapted to control the amount of liquid passing through said branch line in accordance with the speed of rotation of the nozzle head.

5. Apparatus as claimed in claim 4 wherein the valve is provided at the junctions of the branch line and the main feed line.

6. Apparatus as claimed in claim 5 wherein the said valve is operated by a pressure sensitive device in accordance with the fluctuations of pressure in the supply of liquid to the nozzle head.

7. Apparatus as claimed in claim 5 wherein the valve is operated by a governor device in accordance with the fluctuations of the speed of rotation of the nozzle head.

8. Apparatus as claimed in claim 2 wherein the braking means for controlling the rate of rotation of the nozzle head includes a reduction gear means, a shaft connected to said gear means, and an impeller upon said shaft, said impeller being constructed to operate in torque opposition to the motion of the nozzle head and being operated by a stream of liquid diverted from the liquid fed to the nozzle head.

9. Means for controlling the speed of rotation of a rotating liquid distributing device driven by the stream of liquid distributed, said means comprising adjustable means for diverting a portion of the liquid stream fed to the distributing device, and means for passing the said diverted portion of liquid through a driven means connected to said liquid distributing device, said driven means being adapted to be driven by the diverted liquid to continuously produce a resistive torque in opposition to the motion of the distributing device to exert a braking action on the said distributing device in accordance with the amount of diverted liquid.

10. Means for controlling the speed of rotation of a rotating liquid distributing device driven by the stream of liquid distributed, said means comprising means for diverting a portion of the liquid stream fed to the distributing device, and means for passing the said diverted portion of liquid through a driven means connected to said liquid distributing device, said driven means being adapted to be driven by the diverted liquid to continuously produce a resistive torque in opposition to the motion of the distributing device to exert a braking action on the said distributing device in accordance with the amount of diverted liquid, and means for varying the amount of liquid diverted to the driven means in accordance with the speed of rotation of the liquid distributing device to thereby maintain the speed of rotation substantially constant independent of variation in pressure of the liquid supply.

11. Apparatus in accordance with claim 10 including in addition means for directing the liquid diverted through said driven means back to the main liquid feed stream to be subsequently distributed by said distributing device.

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