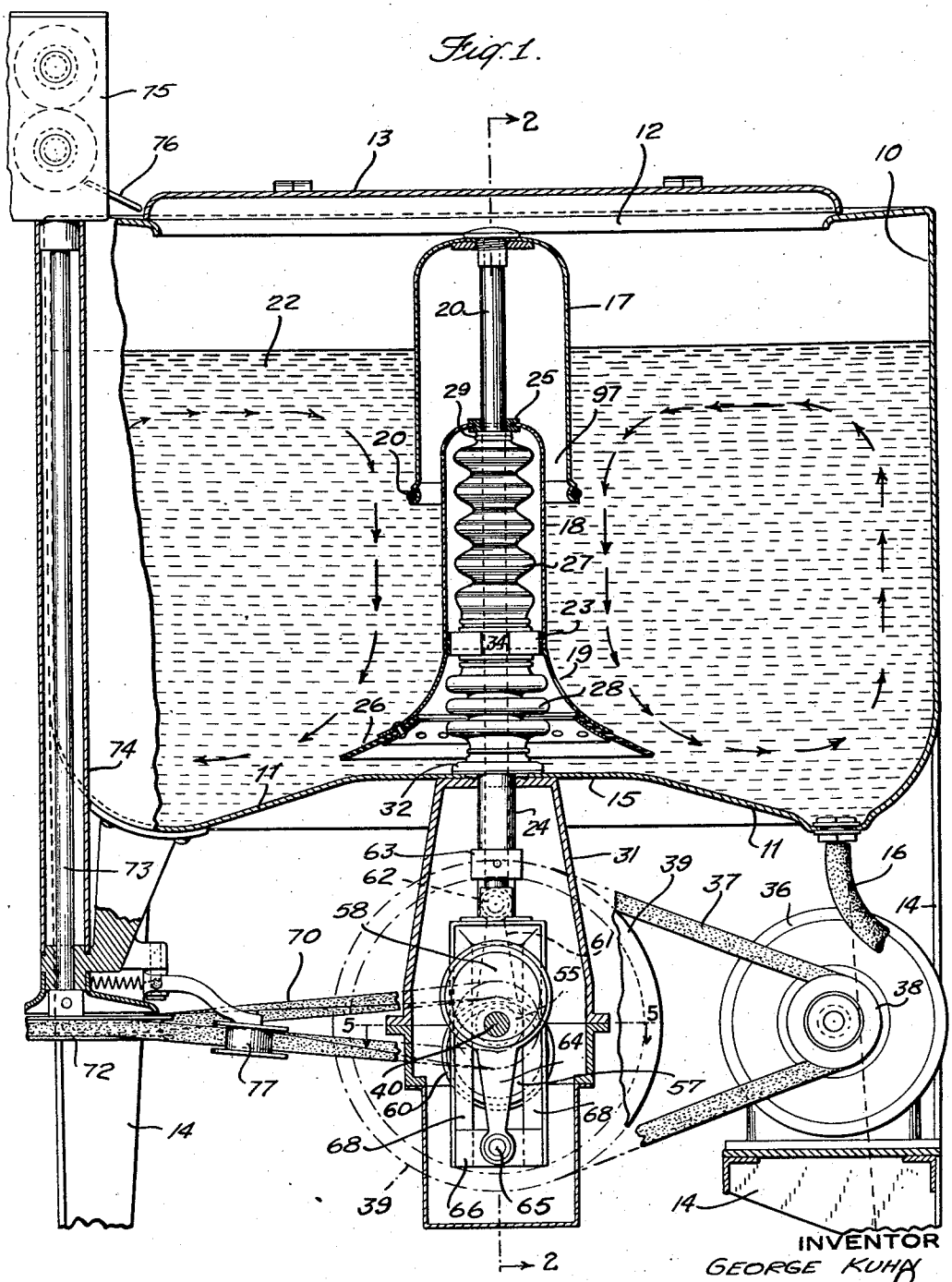
March 10, 1942. G. KUHN 2,275,444

FLUID TREATING APPARATUS

Filed Sept. 20, 1937 4 Sheets-Sheet 1

Fig. 1.



INVENTOR
GEORGE KUHN
BY
ATTORNEY

March 10, 1942. G. KUHN 2,275,444

FLUID TREATING APPARATUS

Filed Sept. 20, 1937 4 Sheets-Sheet 2

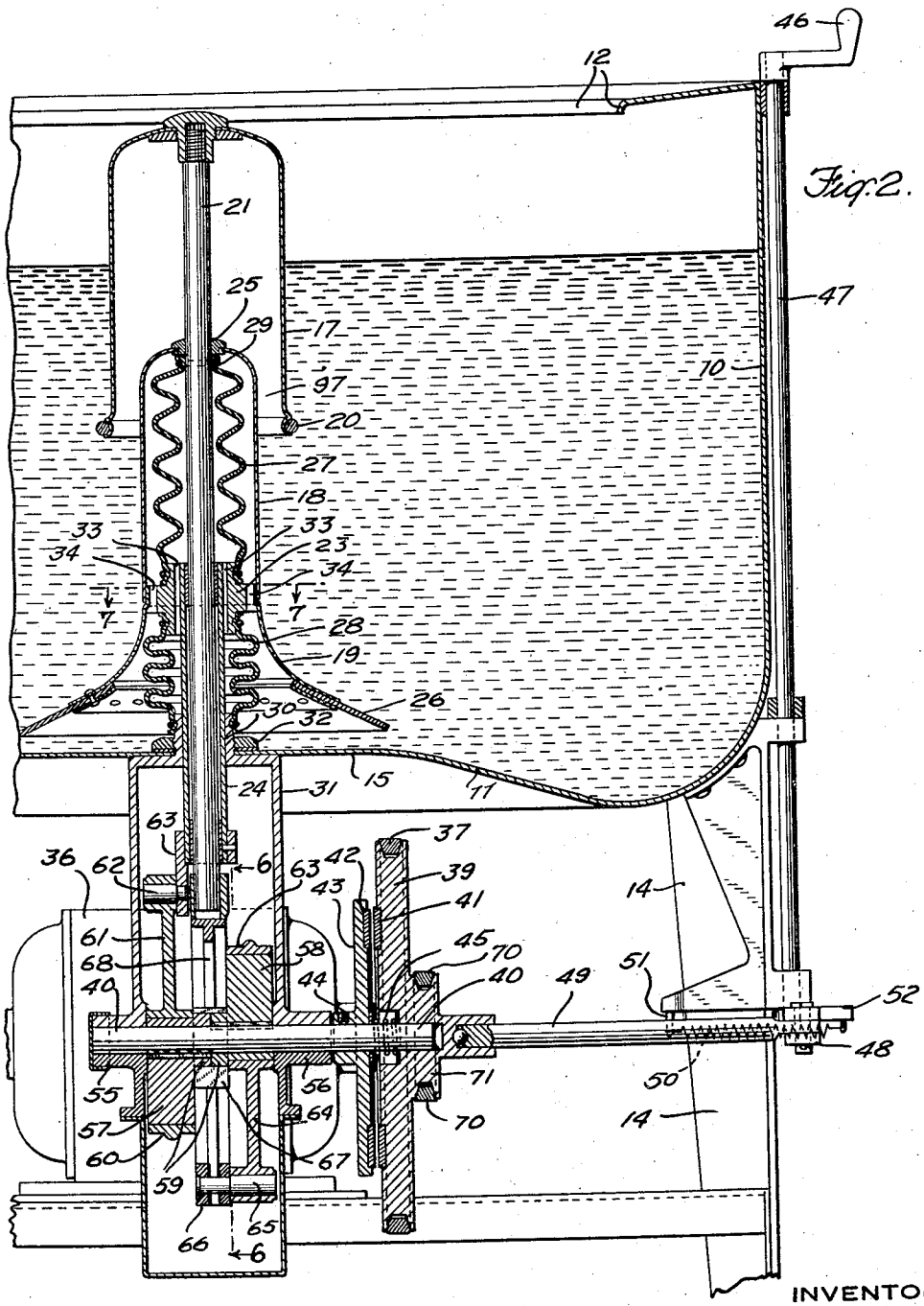


Fig. 2.

INVENTOR
GEORGE KUHN.

BY

ATTORNEY

March 10, 1942. G. KUHN 2,275,444

FLUID TREATING APPARATUS

Filed Sept. 20, 1937 4 Sheets-Sheet 3

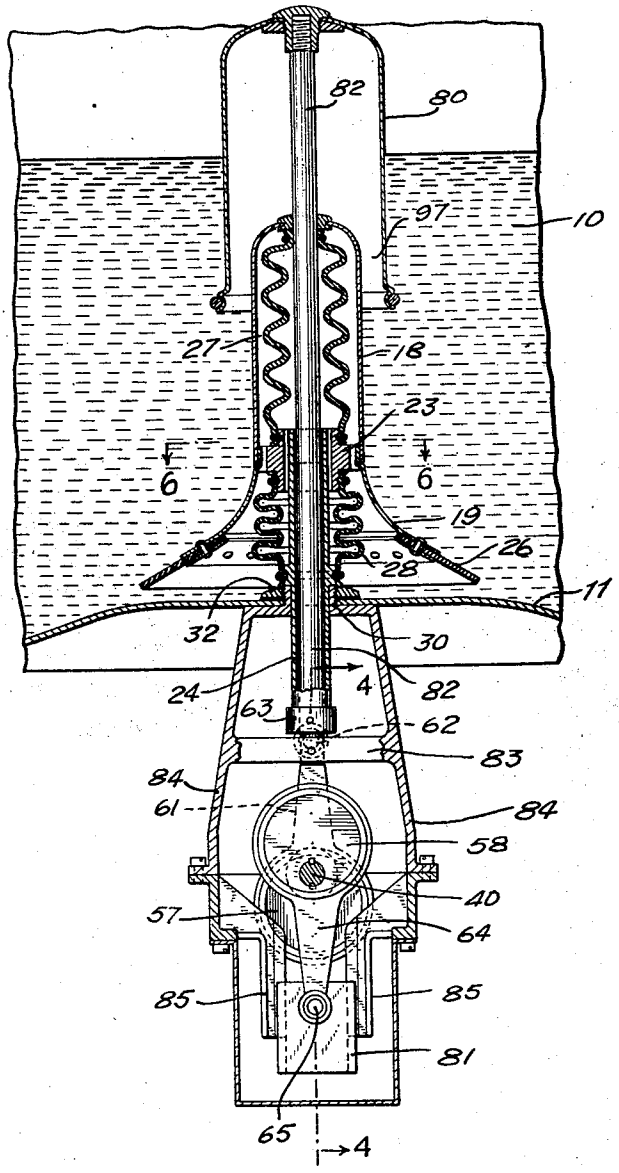


Fig. 3.

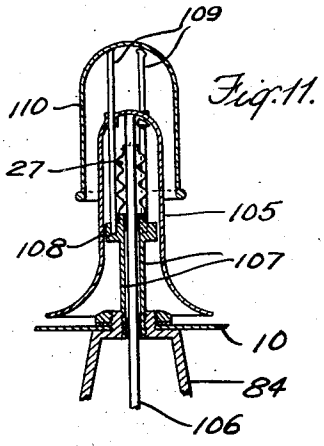


Fig. 11.

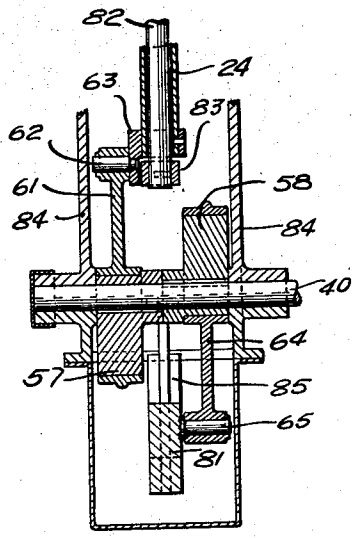


Fig. 4.

INVENTOR
GEORGE KUHN
BY
ATTORNEY

March 10, 1942. G. KUHN 2,275,444

FLUID TREATING APPARATUS

Filed Sept. 20, 1937 4 Sheets-Sheet 4

Fig. 6.

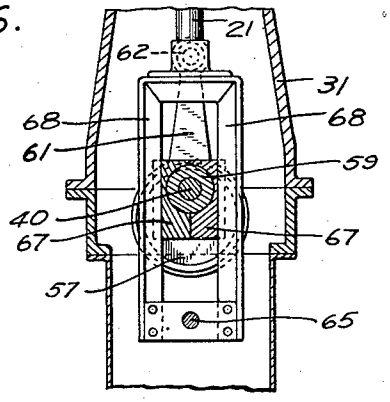


Fig. 5.

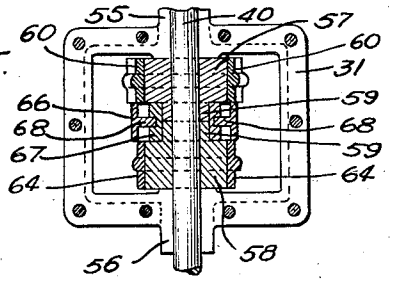
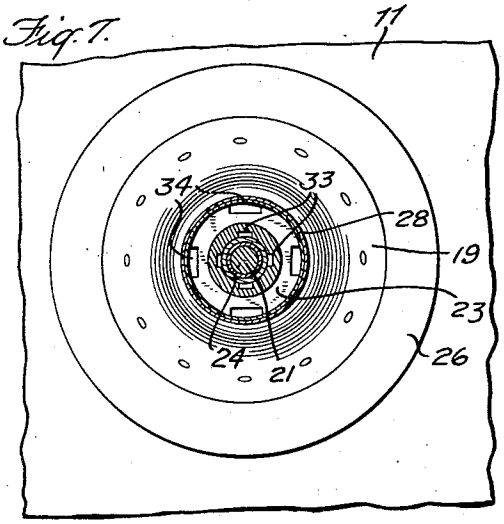


Fig. 7.



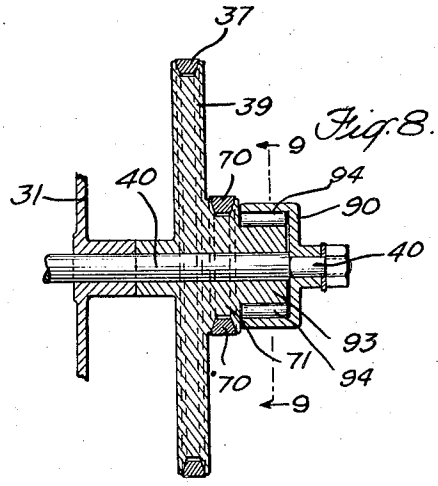


Fig. 8.

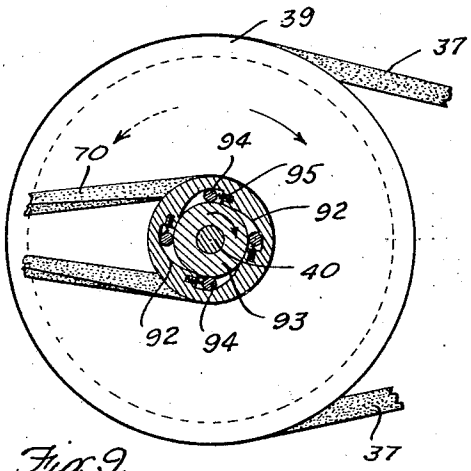


Fig. 9.

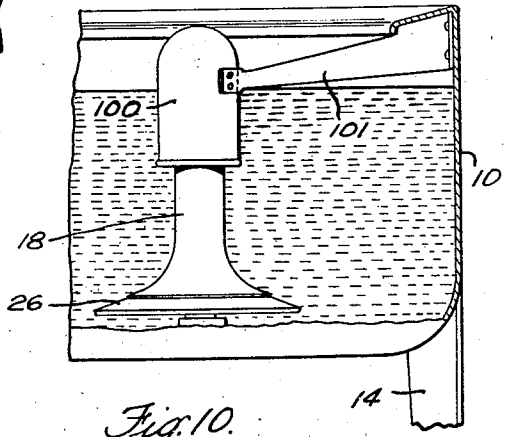


Fig. 10.

INVENTOR
GEORGE KUHN
BY
ATTORNEY

Patented Mar. 10, 1942 2,275,444

UNITED STATES PATENT OFFICE

2,275,444

FLUID TREATING APPARATUS

George Kuhn, Silver Spring, Md.

Application September 20, 1937, Serial No. 164,820

13 Claims. (Cl. 68—190)

This invention relates to the washing and cleaning of fabrics and articles and more particularly pertains to power driven washing and cleaning machines.

The invention provides a washing and cleaning machine which provides all essential operations to effect a rapid and thorough cleaning or washing of the articles without vibration or the production of unbalanced forces. The operations performed by the machine include circulation of the articles in the washing fluid, scrubbing and shaking of the articles, agitating and flexing of the fabric of the articles and rapidly pulsating the fluid through the fabric.

The features and advantages of the invention will be apparent from the following description when considered in connection with the accompanying drawings, forming a part thereof, and in which:

Fig. 1 is a vertical sectional view of a washing machine embodying the invention;

Fig. 2 is a vertical sectional view of part of the machine taken on line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view, similar to Fig. 1, showing another form of washing machine;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 1;

Fig. 6 is a sectional view taken on line 6—6 of Fig. 2;

Fig. 7 is a sectional view taken on line 7—7 of Fig. 2;

Fig. 8 is a partial vertical sectional view showing another form of drive for the washing machine;

Fig. 9 is a sectional view taken on line 9—9 of Fig. 8;

Fig. 10 is a fragmentary elevational view showing another means for supporting the pulsator cylinder, and

Fig. 11 is a vertical sectional view illustrating a further arrangement for supporting the stationary pulsator cylinder.

Like characters of reference refer to the same or similar parts throughout the several views.

Referring to Figs. 1 and 2 of the drawings, reference character 10 designates the tub of the washing machine which is preferably cylindrical in form with a closed bottom 11 and an opening 12 at the top which is closed by a hinged cover 13. The tub is supported on a suitable pedestal indicated 14. The bottom of the tub has a raised central portion 15 and a drain 16 connects with the lowermost part of the bottom 11.

The fluid circulating or propelling means is axially disposed in the tub 10 and, in general, comprises a pulsator consisting of a hollow tubular member such as a cylinder 17 and a piston 18, and an element such as a fluid propelling and directing piston skirt 19. The cylinder 17 is of metal and has a closed upper end and an open lower end around the outer periphery of which is a ring 20 of rubber or other suitable material. The cylinder is secured on the upper end of a reciprocable shaft 21 which passes through the upper end of the cylinder and the lower end of the cylinder is submerged so long as the water or other fluid 22 is maintained at substantially the level shown in Figs. 1 and 2. The inner and outer walls of the cylinder are disposed parallel to the direction of motion of the cylinder and during normal operation the cylinder is neither completely submerged nor entirely out of the fluid so that splashing is prevented. The pulsator piston 18 is a cylindrical metallic member shaped similarly to the cylinder 17 but is of sufficiently smaller diameter to provide an annular opening 97 of substantial flow area between the cylinder and piston through which the fluid may readily flow. The piston is axially disposed with respect to the cylinder and is mounted on a fitting 23, preferably a die casting, which is fixed to the upper end of a piston sleeve 24 through which shaft 21 passes and upon which the sleeve bears at its upper end. Shaft 21 passes in a smooth running fit through a collar 25 carried by the upper closed end of the piston 18. The fluid propelling and directing skirt 19 has an outer surface which curves gradually outwardly and downwardly and has a metallic upper part and a flexible fin 26 which is preferably rubber but may be of other suitable flexible material, secured to the upper part. The upper end of the skirt 19 is secured to the fitting 23 and the skirt is axially disposed with respect to the piston 18 and cylinder 17. The piston skirt 19 may be made integral with or separate from the piston 18 and may have other shapes than that disclosed. For example, the outer surface of the skirt may be shaped so that it is horizontal, or approximately so, with a fin on its periphery which extends downwardly and outwardly like the fin 26. This horizontal skirt is effective for the purpose because the opposing streams of fluid from the upwardly moving skirt and from the cylinder will meet and be thrown radially outwardly. Shaft 21 and sleeve 24 extend through an opening in the bot-

tom 11 of the tub to the operating mechanism disposed beneath the tub. To prevent leakage of fluid through this opening and to eliminate the necessity of a stuffing box, upper and lower bellows 27 and 28 of rubber or other fluid-proof flexible material are used. The upper end of the upper bellows 27 is secured by means of a metallic ring 29 or the like in fluid pressure tight relationship to shaft 21 at a point which will not interfere with the movement of the piston 18, and the lower end is similarly fixed to the upper portion of fitting 23. The upper portion of bellows 28 is also similarly fixed to the lower end of fitting 23 and the lower end is fixed to a neck 30 on the operating mechanism housing 31 through which the sleeve 24 and shaft 21 pass. A nut 32 threaded on neck 30 compresses packing material against the bottom 11 of the tub which is pressed against the upper part of the housing 31 thereby preventing leakage of fluid at this point. A plurality of air vents 33 pass through fitting 23 next to sleeve 24 to connect the chambers formed by the upper and lower bellows 27 and 28 to relieve air pressure and vacuum produced during operation. The fitting 23 is also provided with a plurality of water vents 34 next to the walls of the pulsator piston to relieve water pressure in the upper portion of the pulsator piston during operation. In place of the lower bellows 28, a diaphragm, of rubber or other suitable material, of the type disclosed in my copending application Serial No. 106,080, filed October 17, 1936, may be used.

The fluid circulating or propelling means is driven by an electric motor 36 through mechanism which is mechanically balanced and the parts of which move with complete symmetry of motion during all phases of the operative cycle. A belt 37 runs over a small driving pulley 38 on the shaft of the motor and a larger driven pulley 39 which runs freely on one end of an eccentric shaft 40. Pulley 39 has an annular friction surface 41 on one face thereof which engages a cooperating friction surface 42 on one face of a disc 43 which is fixed to eccentric shaft 40 by a set screw 44. Pulley 39 and disc 43 are normally disengaged due to the action of a coil spring 45 on eccentric shaft 40 positioned within a recess in the hub of pulley 39. This pulley-disc arrangement constitutes a friction clutch which may be operated from the top of the machine. In the form shown, a handcrank 46 at the top of the tub 10 operates a vertically disposed rod 47 at the side of the tub, the lower end of which operates a link 48 which is pivotally connected at one end to a shaft 49 disposed in axial alignment with eccentric shaft 40 and with its other end in a socket of the shaft 40. A coil biasing spring 50 extending between a pin 51 on the frame of the machine and a properly located arm on link 48, retains the clutch in engagement after it has been engaged.

The eccentric shaft 40 has bearings 55 and 56 in the sides of the housing 31 and has keyed thereto within the housing, eccentrics 57 and 58 having laterally extending, abutting hub portions 59. The eccentrics are fixed to the shaft 40 in such manner that their maximum points of eccentricity are diametrically opposed. Eccentric 57 has a strap 60 which carries a connecting rod 61 extending upwardly from strap 60 and shaft 40 and which is connected at its upper end through a wrist pin 62 to an extension 63 fixed to sleeve 24 upon which the pulsator piston 18 and the skirt 19 are mounted. Eccentric 58 has a strap 63 which carries a connecting rod 64 extending downwardly from the strap 63 and shaft 40 and which is connected at its lower end through a wrist pin 65 to the lower end of a yoke 66 of rectangular configuration which straddles shaft 40 and is connected at its upper end to the lower end of rod 21 upon which pulsator cylinder 17 is mounted. The abutting hubs 59 of the eccentrics bear in a vertically split block 67 having oppositely disposed recesses which receive guides 68 which extend vertically along the inner side walls of the yoke 66. With this arrangement, eccentric 58 causes pulsator cylinder 17 to vertically reciprocate in the tub 10 and eccentric 57 causes pulsator piston 18 and skirt 19 also to vertically reciprocate in the tub but in directions opposite to the direction of movement of the cylinder 17. The strokes of the piston and cylinder are such that the piston moves into the cylinder as far as is practically possible to provide the maximum displacement. The several parts are so proportioned that the weight of the cylinder 17 and the parts reciprocating with it are equal to the total weight of the piston 18 and skirt 19 and the parts reciprocating with them. The "opposed" relationship of the connecting rods 61 and 64, that is, the arrangement of the operating mechanism so that connecting rod 61 extends above and is connected to sleeve 24 above a horizontal plane passing through the axis of eccentric shaft 40, and so that connecting rod 64 extends below and is connected to shaft 21, in effect, below such plane, results in absolute symmetry of motion through all phases of the operative cycle of the oppositely reciprocating parts and the parts connected to and moving with them with complete mechanical balance being obtained with resultant freedom from vibration. It will be understood that complete symmetry of motion would not be obtained if both of the connecting rods 61 and 64 extended in the same direction, that is, if they were both connected to the respective parts which they operate at the same side, either above or below, of a horizontal plane passing through the axis of eccentric shaft 40. Also since the cylinder 17, the piston 18 and the skirt 19 are disposed, and operate, in alignment with the axis of shaft 21, and the eccentrics are located and operate equidistantly from said axis and also operate in "opposed" relationship as previously mentioned, no unbalanced couples or forces will be produced during operation. So arranged, or similarly arranged, the fluid circulating or propelling means and its operative mechanism is in absolute mechanical balance, so that no vibration results which originates in a mechanical source. Complete hydraulic balance is also obtained, due to the fact that the pulsator cylinder and piston are proportioned to perform the same amount of work on the fluid in the tub on each stroke as the skirt performs, and since this work is done in opposite directions and in alignment, no unbalanced forces result. It will be appreciated that mechanical and hydraulic balance has been emphasized herein because these factors have not presented themselves as problems in prior types of fluid treating machines, due to the fact that prior machines operate at speeds many times slower than the machine of the present invention. The mechanism herein disclosed for actuating the fluid propelling means is not limited in its application to fluid treating machines but is capable of a wide variety of uses.

The pulsator piston and cylinder and the skirt

19 are rapidly reciprocated with relatively short strokes. The movement of the members 17, 18 and 19 should be materially faster than the articles being treated can follow such movement. Good results are obtained with a speed of the eccentric shaft of 500 R. P. M. with strokes of the reciprocating elements of 1½ in. to 1¾ in., but satisfactory results will be obtained at speeds between 400 and 650 R. P. M. with the same stroke. The stroke in the form of the invention shown in Figs. 1 and 2 may be varied between 1 in. and 1¾ in. with satisfactory results.

During operation, on the upstroke of the cylinder 17 and the downstroke of the piston 18, fluid is sucked into the cylinder from all directions which draws the articles in the upper portion of the fluid radially inwardly toward the cylinder. At the same time, the skirt 19 has moved downwardly and has forced fluid from below the skirt radially outwardly along the bottom of the tub. On the downstroke of the cylinder and the upstroke of the piston, fluid is expelled from the cylinder in a downward direction parallel to the wall of the cylinder through the annular opening 97 and against the upwardly moving, outwardly and downwardly curving surface of the skirt 19 which deflects the fluid downwardly and radially outwardly in the lower portion of the tub, with gradually increasing velocity as it moves over the skirt. On each upstroke of the skirt 19 fluid is forced outwardly and downwardly thereof due to the action of the upper surface of the skirt, and fluid is also drawn under the skirt and is expelled on the downstroke as previously described, along the bottom of the tub. Due to the flexibility and downward inclination of the fin 26 on the skirt 19, it pumps fluid toward the bottom of the tub in the upper portion of its downward stroke, while in the lower portion of its downward stroke it flattens out due to the radial flow of water from under the skirt 19 thus allowing free escape of the fluid from under the skirt. The use of the fin also makes it possible to bring the skirt almost into contact with the bottom of the tub at the end of its downstroke without danger of injury to one who might put his hand under it, whereby it functions as a safety feature. With rapid reciprocation of these elements 17, 18 and 19, the fluid is subjected to a series of unidirectional, intermittent jerks or pushes which result in the fluid and the articles therein being continually moved in unidirectional circulatory paths about these elements in directions radially outwardly along the bottom of the tub, upwardly along the wall thereof, radially inwardly at the upper portion of the body of fluid and downwardly along the cylinder 17 and piston 18 as indicated by the direction-of-flow arrows in Fig. 1. These short, fast fluid jerks, pushes, or squirts originate at the open edge of the pulsator cylinder and at the edge of the skirt and set up a series of rapid pulsations in the fluid which spread throughout the body of the fluid and result in the pulsing or forcing of the fluid through the fabric of articles being treated. They also cause rapid shaking and flexing of the articles being treated with consequent scrubbing due to the rubbing of the articles one on another and rubbing of parts of each article on other parts in the active zones adjacent the open lower end of the pulsator cylinder 17 and at the lower edge of the skirt 19. As the articles move into the aforesaid active zones, the end of an article first coming under the influence of the zone adjacent the pulsator cylinder is vigorously shaken, scrubbed and jerked and gradually fed downwardly. These jerks spread through the article so that its other portions and other end are liberated from the other articles which have not yet entered said zone, thus untangling the article. At the beginning of the fluid treating operation, the action of the pulsator on the fluid heretofore described, breaks up bubbles of air in articles such as clothes and the like, which if left unbroken would cause the articles to float on the top of the fluid, and pushes the articles under the surface of the fluid. During normal operation, when the machine is not jammed so that the motion of the articles is not restricted, the articles ordinarily do not come in actual contact with the rubber ring 20 on the cylinder 17 or with the rubber ring 26 on the skirt 19. The scrubbing action produced by the machine, results primarily from the vigorous flexing and shaking of the articles as previously described during the circulatory movement.

As an illustrative example, but without limiting effect, a washing machine embodying the form of the invention heretofore described and having the dimensions set forth, when operated at speeds between 450 and 500 R. P. M. with a full load of eight pounds of clothes, completed the wash in ten minutes without previous soaking of the clothes. Pulsator cylinder—4 in. in diameter and 7⅛ in. in axial length. Pulsator piston—2¾ in. in diameter and 6 in. in axial length to the piston skirt. Piston skirt without fin—6½ in. bottom diameter and 2¼ in. axial length. Fin on skirt—8¾ in. in its outermost diameter. Mechanism stroke—1¾ in. With previous soaking of the clothes, the washing time would be less than ten minutes. Actual tests with this machine have resulted in washings at least 33⅓% faster than the washing time required by conventional washing machines now on the market in a ten minute washing test, with 20% less wear on washed clothes, measured by the amount of lint collected after two hours of continuous washing.

The conventional worm and gear wringer drive, driven by a belt from the loose pulley 39 may be used if desired. However, the form of wringer drive disclosed in Fig. 1 eliminates the necessity for the gear, worm, bearings and an oil tight housing required for such conventional drive and thereby effects considerable saving in manufacture. As shown, the wringer is driven from loose pulley 39 by a belt 70 which is driven by a small pulley 71 fixed to the loose pulley 39, the belt 71 driving a relatively large pulley 72 which is horizontally positioned and is fixed to the end of the wringer drive shaft 73 disposed in a housing 74. A bevelled gear on the upper end of the drive shaft 73 meshes with a bevelled gear on the shaft of the lower wringer roll. The wringer 75 mounted at the top of the tub 10 is provided with the usual drain board 76. A spring-pressed pulley 77 engages the belt 70 to prevent it from running off the pulleys 71 and 72. With this arrangement, the proper speed for the wringer is obtained through the speed reduction resulting from the use of the loose pulley 39 which is used to drive the machine mechanism and the small pulley 71 fixed thereto. It will be appreciated that the belt wringer drive is possible only because of the use of the loose pulley 39 in the mechanism for driving the fluid circulating or propelling means. It is believed this form of wringer drive has not been used before.

It may be advantageous to provide a depression in the bottom of the tub into which the piston skirt or disc drops at the bottom of the down-

stroke, which will cause the velocity of the fluid ejected from under the skirt to be increased and its direction of flow altered depending upon the shape of the surface of the depression.

In the form of the invention disclosed in Figs. 3 and 4, the arrangement of the fluid circulating or propelling means is the same as the other form shown in Fig. 1, excepting that the pulsator cylinder **80** is stationary and the eccentric **58** and connecting rod **64** drive a vertically reciprocable counterweight **81** to obtain the same mechanical balance obtained in the other form. Cylinder **80** is mounted upon the upper end of shaft **82** which is fixed at its lower end to a cross bar **83** in the mechanism housing **84**. The counterweight **81** moves between spaced guides **85** which are fixed in the housing **84**. The weight of counterweight **81** will, of course, equal the weight of the pulsator piston **18**, the skirt **19** and the parts reciprocating therewith. In operation, on the upstroke, the skirt **19** moves a volume of water upwardly and outwardly and the piston **18** ejects a volume of water downwardly from the cylinder **80** parallel to the wall of the cylinder and against the curved upper surface of the skirt **19**. The sizes of the pulsator cylinder and piston and the skirt **19** are so proportioned that the two actions just described neutralize each other thereby producing hydraulic balance. On the downstroke, fluid is sucked into the cylinder **80** from all directions so that no hydraulic unbalance results. Also on the downstroke, the skirt **19** ejects fluid radially therefrom along the bottom of the tub which also results in no hydraulic unbalance. In this form of the invention, as in the other form, both mechanical and hydraulic balance are maintained at all times. To provide the same fluid displacement per stroke and the same downward speed of the fluid ejected from the cylinder as in the other embodiment shown in Fig. 1, the cross-sectional area of piston **18** should be twice that of the piston in Fig. 1 and the area of the cylinder **80** should be sufficiently great so that the flow area of the annular clearance **97** between the piston and the cylinder will be the same as in Fig. 1. This follows from the fact that in this embodiment the stroke of the fluid circulating and propelling means is one-half of that in Fig. 1, due to the fact that the cylinder **80** is stationary. For example, if the piston of Fig. 1 is 2¾ in. in diameter and the cylinder 4 in. in diameter, the piston in Fig. 3 should be approximately 3⅞ in. in diameter and the cylinder 4⅞ in. in diameter. Otherwise, the proportions of the several parts are the same as in the other form, and the results obtained are the same as described in connection with the other form, including the unidirectional circulatory movement of the fluid and the articles being treated and the washing action produced which comprises pulsating of the fluid through the fabric of the articles, the flexing and shaking of the articles which produces rubbing contact of the articles as previously described with consequent scrubbing of the articles on themselves, together with the separating and untangling of the articles resulting from the pulling forces produced by the series of short fast fluid jerks produced by the action of the pulsator cylinder and the piston. During the first few strokes of the fluid circulating or propelling means in both forms disclosed, the air is knocked out of the cylinder, after which the action is entirely hydraulic.

Figs. 8 and 9 illustrate a form of drive for the machine which may be employed in lieu of the drive shown in Figs. 1 and 2. Referring to Figs. 8 and 9, the drive is essentially a free wheeling arrangement which cooperates with the loose pulley **39** on the eccentric shaft **40**. A cup-shaped member **90** is fixed to the eccentric shaft **40** by any suitable means, and the inner annular surface of the member **90** is formed to provide a series of eccentrically curved surfaces **92** between which and the hub portion **93** of the pulley **39** are a plurality of rollers **94** which are spring-pressed away from the radial surfaces **95** of the cup-shaped member. With this arrangement, it is only necessary to reverse the motor **36** which drives the pulley **39** to engage or disengage the mechanism for driving the fluid circulating or propelling means, while the wringer **75** remains available at all times. An ordinary ratchet and pawl mechanism may be used in place of this free wheeling arrangement, if desired.

If desired, the outer wall of the piston **18** and skirt **19** may be provided with a plurality of small rubber projections or a plurality of spaced rubber ridges or flanges to provide an actual mechanical scrubbing action on the articles as they move past these members. Other suitable material than rubber may be used for this purpose if desired.

Fig. 10 illustrates another supporting arrangement for a stationary cylinder. In this arrangement, the cylinder **100** is mounted on one end of an arm **101**, the other end of which is secured to the tub **10** or to any part associated with the tub. Preferably, the supporting arm is positioned so that it is above the level of the fluid in the tub where it will not interfere with the circulation of the fluid or the articles moving therein. With this arrangement, a single shaft projects through the tub which supports the piston **18** and its skirt **19**. Either bellows or a diaphragm, heretofore mentioned, may be used for packing the shaft where it passes through the tub and housing. If desired, the arm **101** may be attached to the tub in such manner that it may be moved to thereby move the cylinder from above the piston when desired.

Fig. 11 shows a further arrangement for supporting a stationary cylinder. The piston **105** is mounted on a shaft **106**. A stationary sleeve **107** is threaded into the housing **84** at its lower end and has a fitting **108** at its upper end into which are secured three equidistantly spaced rods **109** which pass through apertures in the top of the piston **105** and to the tops of which is secured the cylinder **110**. This arrangement eliminates the necessity for a lower bellows, such as the bellows **28**, Fig. 1, and for a bearing in the housing.

Although the fluid propelling and directing means is disclosed herein as being centrally or axially disposed in the hub **10**, it will be understood that other positions of said means in the tub will produce satisfactory results, such as any suitable off-center position and in some instances it may even be disposed closely adjacent the wall of the tub.

Variations in the rate of speed of the eccentric shaft and consequent variations in the rate at which the fluid propelling and directing means reciprocates may be readily accomplished by any suitable means, such for example, as a belt drive which will provide speed variations between the motor **36** and the loose pulley **39**.

Due to the unique character of the circulatory motion obtained in the machine of my invention, the shape of the tub is immaterial except as

otherwise mentioned herein, and rounded corners or inclined walls or the like are unnecessary.

It will be apparent to those skilled in the art that changes may be made in the form, location, relative arrangement and the materials of the several parts of the machine disclosed without departing from the principles of the invention. Accordingly, the invention is not to be limited excepting by the scope of the appended claims.

What is claimed is:

1. Apparatus for treating articles with fluid comprising a tub, a pulsator cylinder having a closed upper end and an open lower end which remains submerged in the fluid in the tub, a pulsator piston having a portion reciprocable within but spaced from the walls of the cylinder and operable through the open end of the cylinder, a fluid propelling and directing member operable with said piston and spaced from the open end of the cylinder and having a fluid engaging surface extending radially outwardly from the axis of the piston, and means for reciprocating the piston, the arrangement being such that fluid is drawn radially inwardly toward and into the cylinder and is discharged from the cylinder toward and against the upper surface of said member which causes the fluid to flow radially outwardly and downwardly thereof, the lower surface of said member being operable to force fluid radially outwardly thereof along the bottom of the tub, whereby unidirectional, circulatory movement of the fluid and the articles through the tub is produced.

2. Apparatus for treating articles with fluid comprising a tub, a stationary pulsator cylinder having a closed upper end and an open lower end which remains submerged in the fluid in the tub, a pulsator piston having a portion reciprocable within but spaced from the walls of the cylinder and operable through the open end of the cylinder, a fluid propelling and directing member operable with said piston and spaced from the open end of the cylinder and having a fluid engaging surface extending radially outwardly from the axis of the piston, and means for reciprocating the piston, the arrangement being such that fluid is drawn radially inwardly toward and into the cylinder and is discharged from the cylinder toward and against the upper surface of said member which causes the fluid to flow radially outwardly and downwardly thereof, the lower surface of said member being operable to force fluid radially outwardly thereof along the bottom of the tub, whereby unidirectional, circulatory movement of the fluid and the articles through the tub is produced.

3. Apparatus for treating articles with fluid comprising a tub, a pulsator cylinder having a closed upper end and an open lower end which remains submerged in the upper portion of the fluid in the tub, said cylinder being reciprocable in an axial direction and having outer walls extending through the surface of the fluid in the tub and disposed parallel to the direction of movement of the cylinder, a pulsator piston having a portion reciprocable within but spaced from the walls of the cylinder and operable through the open end of the cylinder, a fluid propelling and directing member operable with said piston and spaced from the open end of the cylinder and having a fluid engaging surface extending radially outwardly from the axis of the piston, and means for reciprocating the cylinder and piston in opposite direction, the arrangement being such that fluid is drawn radially inwardly toward and into the cylinder and is discharged from the cylinder toward and against the upper surface of said member which causes the fluid to flow radially outwardly and downwardly thereof, the lower surface of said member being operable to force fluid radially outwardly thereof along the bottom of the tub, whereby unidirectional, circulatory movement of the fluid and the articles through the tub is produced.

4. Apparatus for treating articles with fluid comprising a tub, a reciprocable pulsator cylinder in the tub, a pulsator piston having a portion reciprocable within but spaced from the walls of the cylinder, and a fluid propelling member operable with said piston and spaced from the cylinder, said cylinder, piston and member being constructed and disposed in the tub and in relation to each other so as to perform substantially the same amount of work in opposite directions on the fluid on each stroke to thereby hydraulically balance the devices operating in the fluid in the tub.

5. Apparatus for treating articles with fluid comprising a tub and fluid propelling means in the tub comprising a reciprocable pulsator cylinder, a pulsator piston having a portion in the cylinder and oppositely reciprocable with respect to the cylinder and spaced from the wall thereof to provide a fluid passage of substantial flow area between the piston and cylinder, and a fluid propelling member reciprocable with the piston and spaced from the end of the cylinder.

6. Apparatus for treating articles with fluid comprising a tub and fluid propelling means in the tub comprising a stationary pulsator cylinder, a reciprocable pulsator piston having a portion in the cylinder and spaced from the wall thereof to provide a fluid passage of substantial flow area between the piston and cylinder, and a fluid propelling member reciprocable with the piston and spaced outwardly from the end of the cylinder.

7. Apparatus for treating articles with fluid comprising a tub, a hollow tubular member having one end closed and the other end open, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto and having a surface extending radially outwardly from its axis of reciprocation, and means for rapidly reciprocating said element, whereby reciprocation of the element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against said radially outwardly extending surface and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

8. Apparatus for treating articles with fluid comprising a tub, a hollow tubular member having one end closed and the other end open, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto, said element having a portion of convex configuration disposed to cooperate with the open end portion of said member and a surface extending radially outwardly from its axis of reciprocation, and means for rapidly reciprocating said element, whereby reciprocation of the element displaces

fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against said radially outwardly extending surface and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

9. Apparatus for treating articles with fluid comprising a tub, a hollow tubular member having one end closed and the other end open with the open end portion flared outwardly, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto and having a surface extending radially outwardly from its axis of reciprocation, and means for rapidly reciprocating said element whereby reciprocation of the element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against said radially outwardly extending surface and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

10. Apparatus for treating articles with fluid comprising a tub, a hollow tubular member having one end closed and the other end open, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto and having a surface extending radially outwardly from its longitudinal axis and a flexible surface extending outwardly from the peripheral portion of the first mentioned surface, and means for rapidly reciprocating said element, whereby reciprocation of the element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against the first mentioned surface of said element and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

11. Apparatus for treating articles with fluid comprising a tub, a stationary hollow tubular member having one end closed and the other end open, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto and having a surface extending radially outwardly from its axis of reciprocation, and means for rapidly reciprocating said element, whereby reciprocation of the element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against said radially outwardly extending surface and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

12. Apparatus for treating articles with fluid comprising a tub, a reciprocable hollow tubular member having one end closed and the other end open, said member being disposed so that its open end remains below the normal fluid level in the tub, an element disposed at the open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto and having a surface extending radially outwardly from its axis of reciprocation, and means for rapidly reciprocating said member and said element in opposite directions, whereby reciprocation of said member and said element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against said radially outwardly extending surface and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

13. Apparatus for treating articles with fluid comprising a tub, a hollow tubular member having its upper end closed and its lower end open, said member being disposed so that its lower open end remains below the normal fluid level in the tub, an element disposed at the lower open end portion of said member for reciprocation in axial alignment therewith and in spaced relationship thereto, said element having a portion of convex configuration disposed to cooperate with the lower open end of said member and a surface extending radially outwardly and downwardly from its axis of reciprocation and a flexible surface extending outwardly from the peripheral portion of the first mentioned surface, and means for rapidly reciprocating said element, whereby reciprocation of the element displaces fluid from the hollow member and fluid is drawn into the zone between said member and said element and is discharged against the first mentioned surface of said element and rapidly pulsating unidirectional impulses are generated in the fluid and unidirectional circulatory movement of the fluid and the articles in the tub is produced.

GEORGE KUHN.