June 11, 1968 D. E. MARSHALL 3,387,310

WASHING APPARATUS AND METHOD

Filed Sept. 22, 1966 4 Sheets-Sheet 1

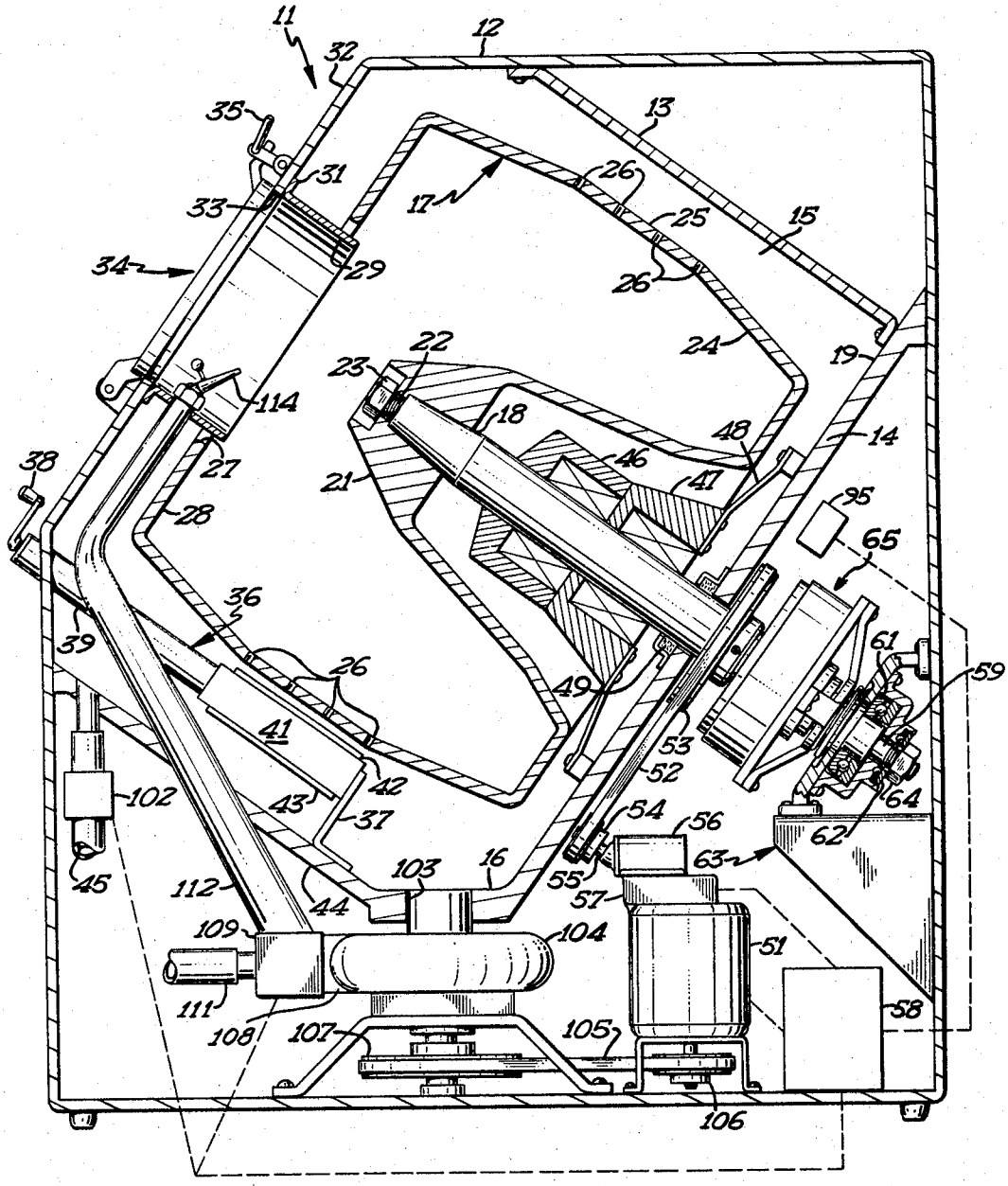

Fig 1

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WASHING APPARATUS AND METHOD

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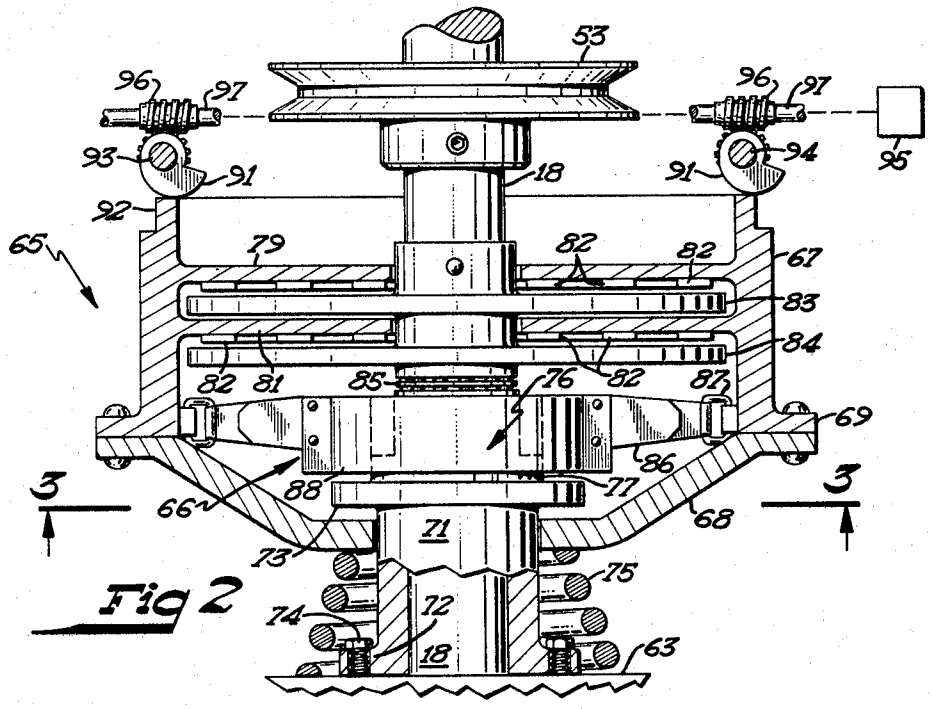

Fig 2

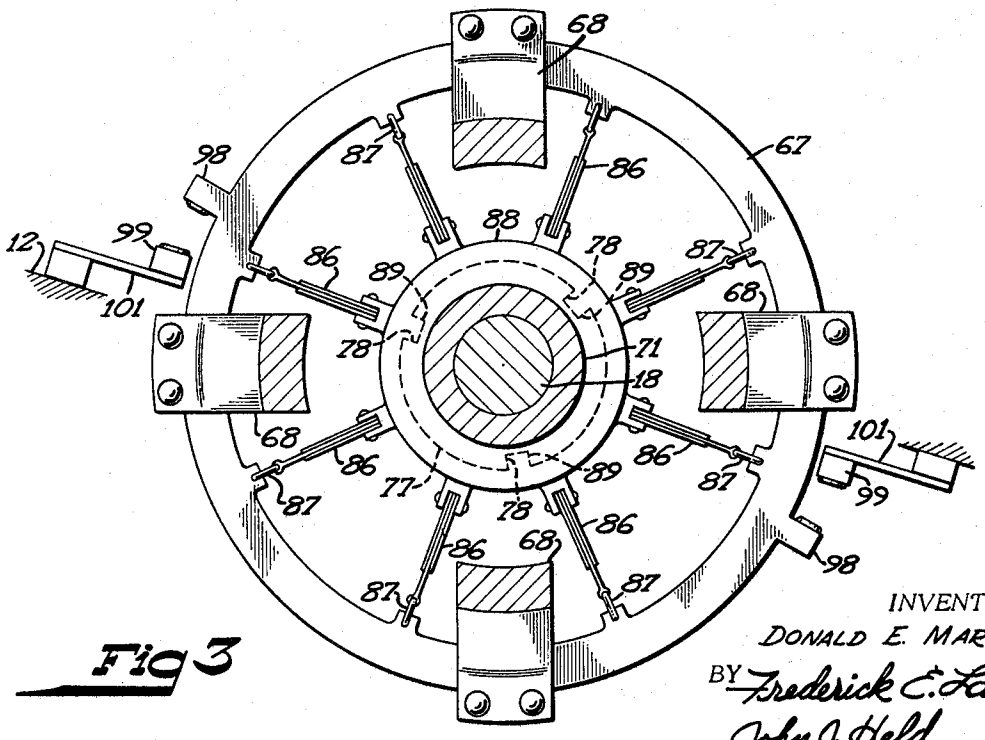

Fig 3

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WASHING APPARATUS AND METHOD

Filed Sept. 22, 1966 4 Sheets-Sheet 3

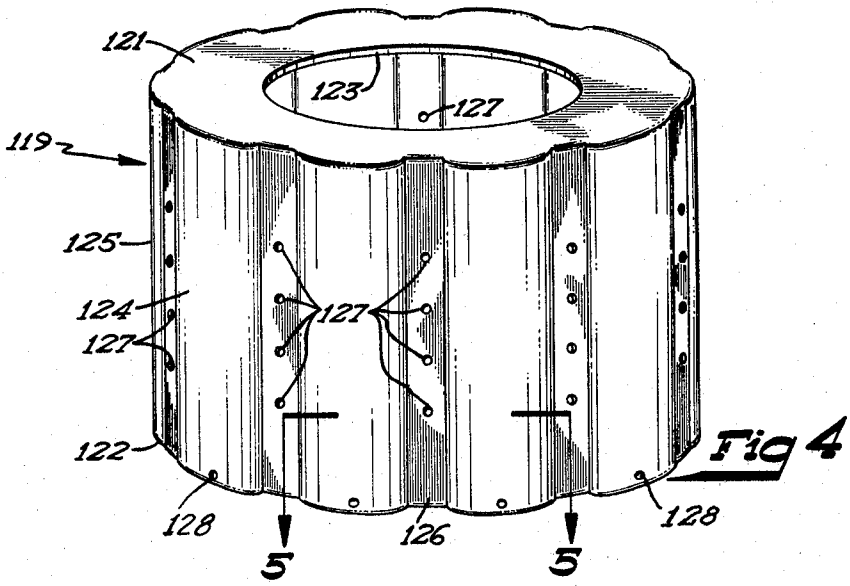

Fig 4

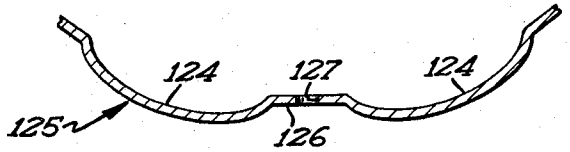

Fig 5

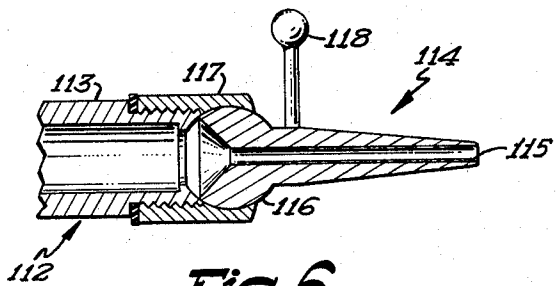

Fig 6

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WASHING APPARATUS AND METHOD

Filed Sept. 22, 1966 4 Sheets-Sheet 4

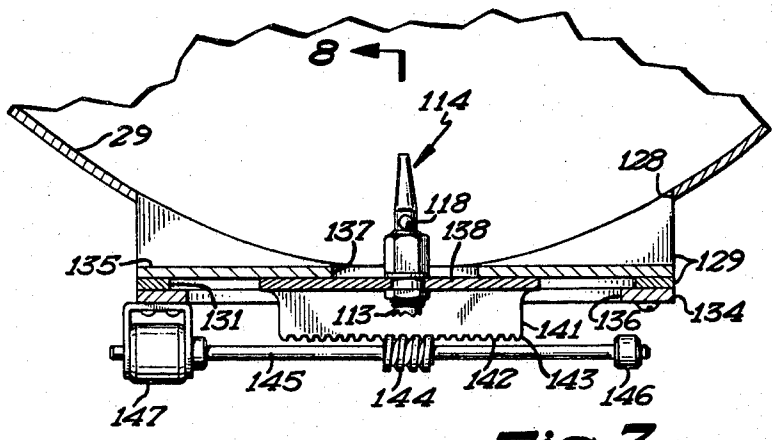

Fig 7

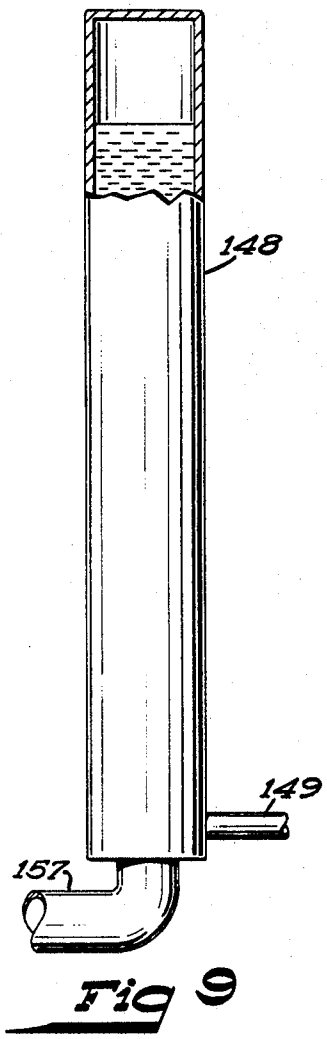

Fig 9

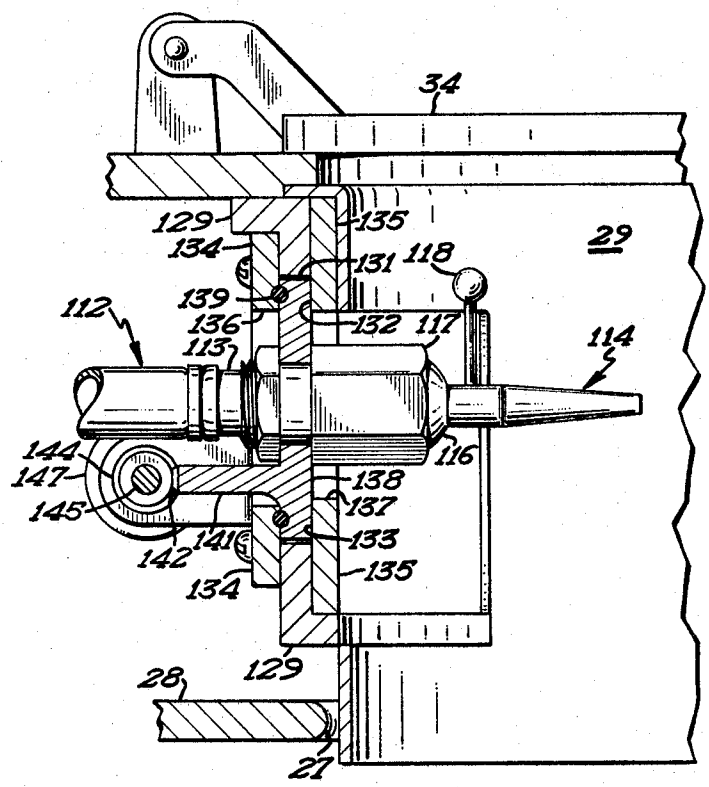

Fig 8

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3,387,310

WASHING APPARATUS AND METHOD

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Continuation-in-part of application Ser. No. 552,807, May 25, 1966. This application Sept. 22, 1966, Ser. No. 586,918
34 Claims. (Cl. 8—158)

ABSTRACT OF THE DISCLOSURE

An improved machine and method for cleaning clothes in which the clothes to be washed are rotated in a washing chamber at a relatively high speed so that the clothes and the wash water form and maintain an annular layer about the axis of rotation of the chamber. Periodically, abruptly during the washing operation, the clothes and the wash water in the chamber are tumbled and rearranged. In the improved machine described herein, a brake is periodically used to abruptly stop the rotation of the chamber and this abrupt stopping of the chamber causes the clothes and wash water therein to tumble and to be rearranged. The improved machine also includes a recoil means which partially rotates the chamber in the opposite direction after the brake has stopped the rotation of the chamber and before the chamber is again rotated at relatively high speed.

During the washing operation, a jet of high pressure wash water is directed against the annular layer and this jet may be used to assist or accomplish the tumbling and rearrangement of the clothes in the chamber. Also, wash water is continually removed from the chamber at a predetermined rate throughout the washing operation so that a certain volume of wash water always remains in the chamber in excess of that necessary to saturate the clothes.

This is a continuation-in-part of application Ser. No. 552,807, filed May 25, 1966.

This invention relates to an improved washing machine and an improved method of washing clothes and the like. More particularly, this invention relates to an improved washing machine and improved method of washing clothes which significantly reduces the time and the volume of the water required for the washing operation while obtaining superior washing characteristics.

Since the introduction of the washing machine, it has been recognized that in order to get clothes clean, the clothes must be moved about in the wash water so that relative motion occurs between the clothes and the wash water. To achieve this, the present, commercially available washing machines utilize various different types of centrally disposed agitators for inducing the necessary relative motion between the clothes and the wash water. While these machines perform satisfactorily, they are inefficient since the washing operation cannot begin until the washing chamber of the machine is filled with water, and particularly in larger machines, the time required to fill the washing chamber can be substantial. Moreover, the rate of agitation or relative movement between the clothes and the wash water in such machines is limited because the agitator is immersed in the wash water in the washing chamber. This, of course, increases the time required for the washing operation. Furthermore, the incorporation of a mechanical agitator in the washing machine presents design and structural problems, particularly if the washing chamber is also used to "spin-dry" the clothes.

In another known type of washing machine, the requisite relative motion between the clothes and wash water is obtained by revolving the washing chamber slowly

about a horizontal axis so that the rotating chamber carries the clothes with it for a portion of a revolution and then permits the clothes to fall away, by gravity, from the side of the chamber and drop back into and through the pool of wash water in the bottom of the chamber. While this type of machine has the advantage of not requiring an agitator, the washing operation is slow because the rotational speed of the washing chamber must by necessity be relatively slow.

In the past it has also been proposed that clothes could be washed in a washing chamber which is rotated about its central axis at a relatively high speed. In these centrifuge-type machines, the wash water may be introduced into the washing chamber adjacent the central axis of rotation so that the water may forcibly be leached through the clothing and then expelled from the chamber through holes in the side of the washing chamber, by centrifugal force. In some machines, it has been proposed that the wash water be recirculated through the machines, although satisfactory recirculation would be difficult to obtain, as a practical matter, in all these machines because of the tendency of the wash water to foam and retard or block the rotation of the washing chamber. However, the principal disadvantage of the prior centrifuge-type washing machines was that the clothes tended to be pressed, or literally plastered, against the side of the rotating washing chamber, and this made thorough cleaning of the clothes impossible. Also, in these prior machines, the rate of flow of wash water through the washing chamber and thus through the clothes, was insufficient to obtain satisfactory cleaning unless the washing operation was unduly extended.

One previously suggested way of overcoming the principal disadvantage of the centrifuge-type washing machine was a device which included a plurality of washing chambers, mounted in planetary fashion about a central axis. During the washing operation the chambers were not only rotated about the central axis but were also rotated about their own axes so that the clothes were continuously tumbled and rearranged in the individual washing chambers. However, this washing device required a complicated, and thus expensive, operating mechanism, and this may have been the reason why the device has never been commercialized.

Briefly and in contrast, the improved washing machine of the present invention incorporates the advantageous features of the centrifuge-type washing machines while effectively overcoming the previous disadvantages of such machines, so that for the first time, this type of washing machine becomes commercially feasible. Thus, the washing chamber of this improved machine is rotated at a relatively high speed about a central axis of rotation while the clothes in the chamber are tumbled and rearranged so as to insure that the clothes are thoroughly cleaned. In one embodiment of the invention, this tumbling and rearrangement of the clothes is achieved by periodically, abruptly stopping the rotating washing chamber, and then briefly, but sharply, rotating the chamber in the opposite direction, before again rotating the chamber at a high speed.

In another embodiment of the invention, the necessary tumbling and rearrangement of the clothes is achieved by periodically changing the rotational speed of the chamber during the washing operation. In other words in this embodiment, the rotating washing chamber is never stopped during the entire washing operation, but rather the rotational speed of the chamber is periodically, abruptly changed from a high speed to an intermediate speed, and then quickly returned to the high speed, thereby causing the clothes to be skidded and tumbled within the chamber.

In the washing machine of this invention, the wash water may be introduced into the interior of the washing chamber in the form of a high volume and high pressure jet. This jet of wash water can be directed against the interior side wall of the washing chamber so that the force of the jet will churn, flex and tumble the clothes in the chamber. The flexing and tumbling action, caused by the jet, may supplement the rearrangement of the clothes resulting from the abrupt changes in rotational speed of the washing chamber, or in some machines, may be the sole means of flexing and tumbling the clothes in the washing chamber.

Furthermore, in the washing machine of this invention, a generally annular layer of wash water and clothes is maintained within the washing chamber at all times during the rotation of the chamber. This layer of wash water facilitates the rearrangement of the clothes as it more readily permits relative movement between the clothes and the side of the chamber when the speed of the chamber is abruptly changed. Also this layer of water imposes a certain hydraulic pressure on the clothes which aids in obtaining thorough leaching of the wash water through the clothes. In order to maintain this layer of wash water in chamber, the rate of flow of the wash water being introduced into the rotating chamber is at least equal to the rate at which the wash water is removed or expelled from the chamber by centrifugal force.

The wash water removed or expelled from the rotating chamber by centrifugal force is collected and is quickly removed from the compartment adjacent to the chamber so that the wash water cannot impede or block rotation of the chamber. As noted above, this collected wash water, together with fresh wash water, is introduced into the interior of the rotating washing chamber in the form of a relatively high volume and high pressure jet. This jet, in addition to being able to tumble the clothes in the chamber, also provides a commercially attractive feature in that when the water strikes the clothes in the chamber, sudsing instantaneously occurs, and it is a well recognized fact that users of washing machines prefer machines in which sudsing wash water is utilized. Unlike other commercially available washing machines, the sudsing does not, and cannot, detrimentally affect the operation of the washing chamber of this invention since the suds and wash water are quickly drawn or leached through the clothes, expelled from the rotating chamber, collected and recirculated as described above.

Because of the high rates of flow of the wash water utilized, the clothes washed in the improved washing machine of this invention are exposed to an equivalent amount of "cleaning action" or, relative motion between the clothes and water, as they would be in the presently available washing machines but in a significantly shorter period of time. Furthermore, in view of the rapid recirculation of the wash water, a much smaller total volume of wash water is required to wash the clothes. Also the soap or synthetic detergent concentration of the wash water may be increased to further facilitate cleaning the clothes, without using a larger total amount of soap or detergent than that presently used in conventional washing machines. Moreover, inexpensive soaps and detergents may be utilized, since as explained above, control of the sudsings does not present a problem.

Accordingly, it is a primary object of the present invention to provide an improved washing machine which significantly reduces the time and the volume of water required to wash clothes satisfactorily.

Another object of the present invention is to provide an improved washing machine which includes a washing chamber adapted to receive clothes and wash water and to be rotated at a relatively high speed whereby a generally annular layer of clothes and wash water are formed in the chamber and which also includes means for rearranging and tumbling the clothes in the chamber so as to insure thorough cleaning of the clothes.

Another object of the present invention is to provide an improved washing machine which includes a washing chamber adapted to receive clothes and wash water and to be rotated about its central axis at a relatively high speed whereby a generally annular layer of clothes and wash water is formed and maintained about said axis and which also includes means for periodically, abruptly changing the rotational speed of the chamber and thereby tumbling and rearranging the clothes in the chamber. A related object of the present invention is to provide an improved washing machine of the type described wherein the rotational speed of the washing chamber is periodically, abruptly reduced from the relatively high speed to a lower speed so as to cause the clothes to skid and tumble in the chamber.

Still another object of the present invention is to provide an improved washing machine which includes a washing chamber adapted to receive clothes and wash water and to be rotated about its central axis at a relatively high speed whereby a generally annular layer of clothes and wash water is formed and maintained about said axis and which also includes braking means for periodically, abruptly stopping the rotation of the chamber and thereby tumbling and rearranging the clothes in the chamber. A related object of the present invention is to provide an improved washing machine of the type described which also includes recoil means for briefly, but sharply, rotating the washing chamber in the opposite direction after the braking means has stopped the rotation of the chamber and before the chamber is again rotated at said speed, said recoil means being utilized to assist in tumbling and rearranging the clothes in the chamber.

Another object of the present invention is to provide an improved washing machine which includes a washing chamber adapted to receive clothes and wash water and to be rotated about its central axis at a relatively high speed whereby a generally annular layer of clothes and wash water is formed and maintained about said axis and which also includes means for introducing wash water into the interior of the rotating chamber in the form of a high pressure, high volume jet, said jet being arranged and directed so that the force of the jet impinging on the layer of clothes and water causes the clothes to be tumbled in the chamber. A related object of this present invention is to provide an improved washing machine of the type described wherein the jet of wash water is arranged whereby the jet strikes the annular layer of water and clothes so that the jet substantially opposes the direction of rotation of the annular layer thereby causing tumbling of the clothes in the washing chamber.

Another object of the present invention is to provide an improved washing machine in which clothes and wash water are rotated in the washing chamber at a relatively high speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation, the washing machine including means for rearranging the clothes within the chamber, and also including means for continuously introducing wash water into the chamber and for continuously removing wash water from the chamber during the rotation of the washing chamber.

A further object of the present invention is to provide an improved washing machine in which clothes and wash water are rotated in the washing chamber at a relatively high speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation, the washing machine including means for rearranging the clothes within the chamber and also including means for introducing wash water into the rotating chamber at a first predetermined rate of flow and means for removing wash water from the rotating washing chamber at a second predetermined rate of flow, said first predetermined rate of flow being at least equal to said second predetermined rate of flow. A related ob-

ject of the present invention is to provide a washing machine of the type described in which the wash water removed from the rotating chamber is collected and reintroduced back into the rotating chamber. A still further related object of the present invention is to provide an improved washing machine of the type described wherein the wash water is introduced into the interior of the rotating chamber in the form of a high velocity, high pressure jet and wherein the wash water is removed from the rotating chamber through a plurality of holes in the side of the washing chamber.

A still further object of the present invention is to provide an improved washing machine in which clothes and wash water are rotated in the washing chamber at a relatively high speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation, the washing machine including means for rearranging the clothes within the chamber, means for introducing water into the rotating chamber, means for removing water from the rotating chamber and pumping means having its inlet arranged to receive the wash water being removed from the rotating chamber and its outlet connected with the water introducing means whereby the water removed from the chamber may be recirculated and reintroduced back into the rotating chamber. A related object of the present invention is to provide a washing machine of the type described in which the capacity of the pumping means is greater than the rate at which water is removed from the rotating chamber whereby wash water is not permitted to accumulate adjacent to the rotating chamber.

Another object of the present invention is to provide an improved washing machine which includes a washing chamber adapted to receive clothes and wash water and to be rotated about its central axis at a relatively high speed whereby a generally annular layer of clothes and wash water are formed and maintained about said axis and which also includes means for periodically, abruptly changing the rotational speed of the chamber so as to induce relative motion between the chamber and the clothes, and thereby tumble and rearrange the clothes in the chamber, the rotating washing chamber being generally cylindrical shaped and also including a plurality of longitudinal, dished grooves spaced circumferentially about the cylindrical wall of the chamber with substantially flat ridge portions formed between adjacent grooves and with the central axis of rotation of the chamber being the central longitudinal axis of the cylindrical chamber. A related object of the present invention is to provide a washing machine of the type described wherein the rotating washing chamber includes at least four longitudinal, dished grooves spaced symmetrically and circumferentially about the side wall of the chamber and having substantially flat, perforated portions formed between adjacent grooves, the inner surface of the side wall of the chamber being completely free of sharp corners whereby the clothes in the annular layer may be easily slid and skid along and relative to the side wall.

Another object of the present invention is to provide an improved washing machine in which the clothes and wash water are rotated in the washing chamber at a relatively high speed about the central axis of the washing chamber whereby the clothes and wash water form and maintain a generally annular layer about the axis, the washing machine including means for periodically, abruptly changing the rotational speed of the rotation chamber thereby rearranging the clothes within the chamber and also including a frame for supporting the rotating chamber so that the central axis of the washing chamber forms an angle with the vertical thereby permitting rearrangement of the clothes in the chamber by gravity when the speed of the chamber is abruptly, periodically changed and minimizing the inertial twisting forces acting on the frame due to the abrupt rotational speed changes.

Still another object of the present invention is to provide an improved method of washing clothes including the steps of rotating the clothes to be washed and the wash water at a relatively high speed whereby the clothes and water form and maintain a generally annular layer about the axis of rotation and tumbling and rearranging the clothes so as to insure the thorough cleaning of the clothes.

A further object of the present invention is to provide an improved method of washing clothes in a washing machine having a rotatable washing chamber adapted to receive the clothes to be washed and the wash water including the steps of rotating the clothes and wash water in the chamber at a relatively high speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation and periodically tumbling and rearranging the clothes in the chamber by periodically, abruptly changing the rotational speed of the chamber. A related object of the present invention is to provide an improved method of washing clothes, as described herein, including the step of periodically, abruptly changing the rotational speed of the chamber from the high speed to a lower speed so as to cause the clothes to skid and tumble in the chamber.

A still further object of the present invention is to provide an improved method of washing clothes in a washing machine having a rotatable washing chamber adapted to receive the clothes to be washed and the wash water including the steps of rotating the clothes and wash water in the chamber at a relatively high speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation and periodically tumbling and rearranging the clothes in the chamber by periodically, abruptly stopping the rotation of the chamber. A related object is to provide an improved method of washing clothes as described herein including the further step of briefly rotating the clothes in the opposite direction after the rotation of the chamber has been stopped and before the clothes and chamber are again rotated at the high speed.

Another object of the present invention is to provide an improved method of washing clothes in a washing machine having a rotatable washing chamber adapted to receive the clothes to be washed and the wash water including the steps of rotating the clothes and wash water in the chamber at a speed whereby the clothes and wash water form and maintain a generally annular layer about the axis of rotation and continuously introducing wash water into the chamber and continuously removing wash water from the rotating chamber. A related object of the present invention is to provide an improved method of washing clothes including introducing the wash water into the interior of the rotating washing chamber in the form of a high pressure, high volume jet, said jet being arranged and directed so that the force of the jet impinging on the layer of clothes and water causes the clothes to be tumbled in the chamber. A further related object of the present invention is to provide an improved method of washing clothes, as described herein, including the step of introducing wash water into the chamber at a rate which is at least equal to the rate at which wash water is removed from the chamber.

Another object of the present invention is to provide an improved washing machine which includes a number of standardized, commercially available components, which has a relatively uncomplicated mode of operation and operating mechanism which is inexpensive to manufacture and which provides relatively trouble-free operation.

These and other objects and features of the invention will become apparent from the following description of the preferred embodiment of the invention, taken in conjunction with the accompanying drawing, in which:

FIGURE 1 is a partial vertical cross-sectional view of the improved washing machine of this invention and also shows, schematically, the control system for the washing machine;

FIGURE 2 is a partial vertical cross-sectional view of the braking and recoil means utilized in the washing machine of the present invention;

FIGURE 3 is a partial horizontal cross-sectional view taken along lines 3—3 in FIGURE 2 showing further details of the braking and recoil means;

FIGURE 4 is a perspective view of a modified washing chamber which may be utilized with the washing machine of the present invention;

FIGURE 5 is a horizontal cross-sectional view taken along lines 5—5 in FIGURE 4 showing the configuration of the wall of the modified washing chamber;

FIGURE 6 is a vertical cross-sectional view of the nozzle utilized to introduce water into the interior of the washing chamber;

FIGURE 7 is a view of a nozzle, similar in structure, to that shown in FIGURE 6, and a mechanism for automatically controlling the positioning of the nozzle relative to the washing chamber;

FIGURE 8 is a vertical cross-sectional view taken along lines 8—8 in FIGURE 7; and

FIGURE 9 is a vertical cross-sectional view of an auxiliary water reservoir that may be utilized in the water inlet line of the washing machine shown in FIGURE 1.

Referring now to FIGURE 1, an improved washing machine embodying the principles of the present invention is shown generally at 11. The washing machine has a sheet metal, outer body 12 which acts as a frame for supporting the components of the washing machine as well as providing a protective cover for these components. A flat panel 13 and a generally L-shaped panel 14 are mounted in the body 12 so as to define therein a generally rectangular compartment 15 which is arranged so that one corner 16 is lower than the other corners of the compartments. The compartment 15 is isolated from the remainder of the interior of body 12 and gaskets, not shown, prevent the leakage of fluids from compartment 15.

A generally cylindrical washing chamber 17 is mounted on a rotatable shaft 18 in compartment 15. The shaft 18 projects into the chamber 15 through an aperture in the side 19 of panel 14. The central portion 21 of the chamber 17 is secured to the threaded end 22 of the shaft 18 by the retaining nut 23 so that the longitudinal central axis of the chamber coincides with the longitudinal central axis of the shaft 18. The dimensions of the chamber 17 are such that when the chamber is mounted on shaft 18, as shown in FIGURE 1, there is ample clearance between the chamber and the panels which define compartment 15, so that the chamber may be rotated within the compartment at relatively high speeds without any danger of the rotating chamber contacting the compartment panels.

While the chamber 17 is generally barrel shaped, the side wall 24 thereof has a central, annular flat portion 25 in which a plurality of relatively small diameter holes 26 are drilled, eight such holes being shown in FIGURE 1. These holes 26 are spaced evenly about the circumference of flat portions 25, and it is through these holes that wash water in the rotating chamber 17 is expelled, by centrifugal force. For this reason, the number of and diameter of the holes 26 are important and must be carefully predetermined since the rate of flow of water through these holes must be correlated with the rate of flow of water into the rotating chamber to achieve optimum washing results, as explained hereinbelow.

A relatively large diameter aperture 27 is formed in the end 28 of the chamber 17 with the center of aperture 27 coinciding with the central longitudinal axis of the shaft 18. A cylindrical shield 29, fastened at one end 31 to the front wall 32 of the body 12, extends through the aperture 27 and into the interior of the chamber 17, with the outer diameter of the shield 29 being slightly less than the diameter of the aperture 27, so that there can be no contact between the rotating chamber and the shield. The shield 29 is used to facilitate loading clothes into the washing chamber 17 and to prevent clothes from inadvertently falling into the compartment 15. End 31 of shield 29 surrounds an opening 33 formed in the wall 32 and which may be closed and sealed by a hinged door 34.

The door 34 may include a central window, not shown, that permits observation of the wash water being introduced into the chamber 17 and of the sudsing action of the wash water in the chamber 17. A conventional latch mechanism 35 may be utilized to keep the door 34 securely closed and if desired for safety, this latch mechanism may be of the type that cannot be opened during operation of the washing machine.

A soap or synthetic detergent dispenser 36 is mounted in compartment 15 by a bracket 37 and may be operated by turning the crank handle 38. The dispenser 36 includes a soap storage tube 39 and a grinder unit 41 which may be of the type disclosed in the United States Patent No. 3,153,688, granted on Oct. 20, 1964, to Donald E. Marshall. The principal advantage of using the Marshall grinder unit is that the soap may be dispensed from opposite faces 42 and 43 of the grinder. A further practical advantage of using the Marshall grinder is that inexpensive bar soap may be used in the washing machine, instead of soap or synthetic detergent powders.

As shown in FIGURE 1, face 42 of the grinder unit 41 is positioned adjacent the flat portion 25 of the chamber 17 so that the water expelled from the chamber 17 through holes 26 impinges on face 42 and washes the soap therefrom. Face 43 of the grinder unit 41 is positioned adjacent the side 44 of panel 14 so that the soap may be dispensed directly into the water being introduced into the compartment 15 through water inlet conduit 45, as hereinafter described.

As shown in FIGURE 1, the central longitudinal axis of the shaft 18 is disposed at an angle of approximately 45° with the vertical. This arrangement minimizes the inertial twisting forces acting on the washing chamber and the washing machine during rotation of the chamber 17 and also permits clothes in the chamber to fall away from the side 24 thereof whenever the rotation of the chamber is abruptly halted as hereinafter described. The shaft 18 is journaled in bearing blocks 46 and 47 which are mounted in the compartment 15 by a plurality of leaf springs 48. This leaf spring mounting arrangement is conventional and is utilized to absorb shock and other forces resulting from nonuniform loading of the chamber during rotation thereof. A shaft seal 49 surrounds the shaft 18 to prevent the leakage of fluid along the shaft.

The shaft 18, and thus the chamber 17, are rotated by an electric motor 51 which is connected to the shaft 18 by means of a belt 52. The belt 52 passes around a pulley 53 fastened to the shaft 18 so as to prevent relative movement therebetween and a second, smaller diameter pulley 54 fastened on the output shaft 55 of a conventional gear box 56 which interconnects the shaft 55 and the motor 51. A conventional clutch 57 is positioned between the gear box 56 and the motor 51 so that the motor may be disengaged from the shaft 18 when it is desired to stop the rotation of the chamber 17. The operation of the motor 51 and the clutch 57 are controlled by a conventional timing mechanism 58 which may be of the type normally utilized in washing machines. The control circuit for the mechanism 58 being schematically shown in FIGURE 1 by dotted lines.

The other end 59 of the shaft 18 is supported and journaled by bearings 61 and 62, the latter being a thrust bearing, and these bearings are mounted on a support bracket 63. The end 59 is threaded and receives a retaining nut 64, which arrangement prevents longitudinal movement of the shaft 18 during rotation of the chamber.

As best shown in FIGURES 2 and 3, a brake 65 and recoil assembly 66 are mounted about the shaft 18 and

positioned between the pulley 53 and the support bracket 63. The brake 65 is utilized to abruptly, periodically change the rotational speed of the shaft 18 and thus the chamber 17 so that the clothes in the chamber will be tumbled and rearranged in order to insure that the clothes will be thoroughly cleaned and to prevent the clothes from becoming "plastered" against the side 24 of the chamber. The brake 65, as shown in FIGURES 2 and 3, is primarily designed to stop, abruptly and completely, the rotation of shaft 18. However, it is obvious that the brake 65 could also be utilized to change or reduce, abruptly, the rotational speed of the shaft, rather than completely stop the shaft. When the brake 65 completely stops the rotation of the shaft 18, the recoil assembly 66 is utilized to assist the brake 65 in obtaining a complete rearrangement of the clothes every time the brake is actuated. The recoil assembly 66 acts only after the brake 65 has initially stopped the rotation of the chamber and causes the chamber to be rotated sharply, but briefly, in the opposite direction from that which it is normally rotated by motor 51. Thereafter the shaft 18, and thus the chamber 17, are again rotated in the normal direction until the next periodic actuation of the brake 65.

As shown in FIGURES 2 and 3, the brake 65 comprises a generally cylindrically body 67 which may be of two piece construction to permit assembly. The body 67 has four guide arms 68 attached to its lower flanged portion 69 and these arms extend radially inwardly from the body 67 to a point adjacent to, but slightly spaced from, a flanged tubular collar 71 which is positioned about the shaft 18. The spacing between the ends of the arms 68 and collar permit the body 67 to be rotated about the collar 71 without wobbling, and also because of the integral flanges 72 and 73 formed on the collar 71, limits the longitudinal movement of the body 67, relative to the collar. The flange 72 of the collar 71 is secured to the support bracket 63 by a plurality of bolts 74, and the inner diameter of the collar 71 is slightly larger than the outer diameter of the shaft 18 so that the shaft may rotate freely within the collar. A coil compression spring 75 is positioned about the collar 71 and between the arms 68 and the support bracket 63, and the spring biases the body 67 away from the bracket 63.

The upper end 76 of the collar 71 includes a larger diameter portion 77 formed adjacent the flange 73 which has three longitudinal grooves 78 formed therein. The grooves 78 are spaced at 120° intervals about the collar.

The body 67 also includes two, integral, longitudinally spaced plates 79 and 81 that have central apertures formed therein through which the shaft 18 projects. A plurality of annular brake bands 82 are securely bonded onto the lower surface of the plates 79 and 81. Two circular discs 83 and 84 are secured on the shaft 18 so that the discs rotate with the shaft at all times. The disc 83 is positioned between the plates 79 and 81 and the disc 84 positioned immediately below the plate 81. The longitudinal distance between the plate 79, including the thickness of the brake bands 82, and the plate 81, is greater than the thickness of the disc 83, and the longitudinal distance between the lower side of the disc 83 and the upper side of the disc 84 is greater than the thickness of the plate 81 and including its brake bands, so that when the body 67 is positioned, as shown in FIGURE 2, e.g., when the brake 65 is not being applied, the shaft 18 and the discs 83 and 84 may be rotated at high speed without contact occurring between the discs and plates. A bearing 85 is positioned between the rotating hub portion of the disc 84 and the end 76 of the stationary collar 71 to minimize friction therebetween.

The body 67 also carries the recoil assembly 66. This assembly includes eight, radially inwardly extending flexible leaf springs 86 which each have one end attached to the body 67 by a link 87 that permits the springs to pivot about the point of attachment. The other ends of the springs are attached to a collar 88 which is positioned about the shaft 18 between the flange 73 and the disc 84. The leaf springs 86 include three leaves, which are interconnected so that the length of the springs may be extended. The inner diameter of the collar 88 is slightly larger than the outer diameter of the portion 77 of the collar 71 so that the collar 88 may be moved longitudinally and rotationally relative to the collar 71 when in the position shown in FIGURE 2.

The collar 88 includes three tabs 89 which are integrally formed on the upper half of the collar and which project radially inwardly from the collar. The tabs 89 are of such a size and shape that they may easily fit within the grooves 78 formed on the collar 71 whenever the collar 88, together with the body 67, are moved longitudinally downward toward the flange 73. Moreover, the tabs are of sufficient size and strength to withstand the torque applied thereto when the tabs engage the slots 78.

As noted above, the member 67, together with its component parts, is adapted to be moved longitudinally with respect to the axis on the shaft 18. The compression springs 75, positioned between the support bracket 63 and the arms 68, urges the member 67 in an upward direction, away from bracket 63. The member 67 may be urged in a downward direction, as shown in FIGURE 2, by a plurality of identical cams 91 that engage the upper end 92 of the member 67. These cams are mounted on shafts 93 and 94 that are rotated by a conventional control motor 95 through worm gears 96 and shaft 97. The operation of the control motor is controlled by the timing mechanism 58 which is programmed so that when the motor 95 is actuated the clutch 57 is disengaged, i.e. the motor 51 no longer drives the shaft 18, and vice versa.

Returning again to the description of the cams 91, when the motor 95 is actuated, the cams 91 are slowly rotated in a clockwise direction and force the body 67 to move downwardly against the bias of spring 75. This movement of the body 67 forces the brake bands 82 on the plates 79 and 81 into contact with the discs 83 and 84 and this engagement between the bands and the discs causes the rotating shaft 18 to be abruptly stopped. As noted above and as more fully explained hereinbelow, this abrupt stopping of the shaft 18 and thus the chamber 17, causes the clothes in the chamber to be tumbled and rearranged.

During this cam-induced downward movement of the body 67, the collar 88 is, of course, also moved downwardly and this movement permits the tabs 89 to engage or to fit into the grooves 78. This engagement between the tabs and grooves occurs after the brake bands 82 have been brought into contact with discs 83 and 84, but before the shaft 18 has completely stopped. As a result of this engagement, there is relative rotation between the collar 88 and the body 67 which is briefly rotated with the shaft 18 during the initial contact between the brake bands 82 and the discs 83 and 84. This relative motion bends or flexes the springs 86 so that when shaft 18 completely stops, springs 86 cause the body 67 to rotate quickly but briefly in the opposite direction. This rotation of the body 67 is imparted through plates 79 and 81, bands 82 and discs 83 and 84 to the shaft 18, and this in turn causes the chamber 17 to be also briefly but sharply rotated in the opposite direction, thereby further tumbling and rearranging the clothes in the chamber.

As shown in FIGURE 3, the body 67 also includes a pair of abutments 98 formed on its outer periphery which are adapted, when the body is moved downwardly by the cams 91, to strike abutment members 99. The members 99 are mounted on one end of flexible leaf springs 101 which are attached, at their other ends, to the body 12. The purpose of these abutments 98 and 99 is to absorb the rotational energy of the body 67 so as to prevent the body 67 from rotating relative to the collar 88 to such an extent that the springs 86 will be damaged by excessive flexing or bending.

The speed of the motor 95 is selected so that during the time mechanism 58 actuates the motor 95, i.e. during the time the shaft 18 is being stopped and rotated

briefly in the opposite direction, the cams 91 will have been rotated through one complete revolution. In other words, for each brake application, the timing mechanism 58 is programmed to actuate the motor 95 for the period of time required for the shaft 97 to make one complete revolution. When the shaft 97, and thus the cams 91, have completed a revolution, and the motor 95 is no longer actuated, the brake 65 and recoil assembly 66 have been returned to the position shown in FIGURE 2 by the spring 75. As noted above at this point, the timing mechanism 58 is programmed to actuate the clutch 57 so that the motor 51 is again permitted to rotate the shaft 18 and thus the chamber 17, at high speed, e.g., above 350 r.p.m.

As mentioned hereinabove, water, preferably hot water, may be introduced into the compartment 15 through the conduit 45. The conduit 45 is connected with a source of water, not shown, and the flow of water through the conduit is regulated by a conventional solenoid valve 102 which is, in turn, controlled by the timing mechanism 58. The water introduced into the compartment 15 through conduit 45 runs down the side 44 of the panel 14 past the face 43 of the soap dispenser 41 to the lower corner 16 of the compartment. To reduce the time required for the washing operation, water may be introduced into the compartment 15 while the clothes are being put into the chamber.

The inlet 103 of a pump 104 communicates with the corner 16 of the compartment 15 so that water collected there may be drawn directly into the pump. Since the water in the corner 16 will undoubetdly include a certain amount of foam or suds, the pump 104 should be a multiphase pump which will deliver a liquid discharge. Such a pump is the two stage centrifugal pump manufactured by Nash Engineering of Norwalk, Conn. The pump 104 should have a capacity which is greater than the sum of the maximum rate of flow through the conduit 45 and the maximum rate that water is expelled from the rotating chamber 17. This is because it is undesirable to let any water stand in the corner 16 of the compartment during rotation of the chamber 17 since this water might impede the rotation of the chamber and also since the foam and suds in the water might foul the bearings 46 and 47 or retard the rotation of chamber 17.

The pump 104 may be directly driven by the motor 51 by means of a belt 105 and pulleys 106 and 107, as shown in FIGURE 1. As noted above, the timing mechanism 58 controls the operation of the motor 51 and thus the operation of the pump 104.

The outlet 108 of the pump 104 communicates with the conventional solenoid valve 109, which is controlled by the timing mechanism 58. The valve 109 may selectively interconnect pump outlet 108 either with a sump or drain, not shown, through conduit 111, or with the conduit 112 which extends through the side 44 of the panel 14 and through the shield 29. As shown in FIGURE 6, the terminal end 113 of the conduit 112 has a nozzle 114 attached thereto.

The nozzle 114 has an internal, small diameter bore 115 and a relatively high pressure, high volume jet of fluid is emitted therefrom. The rear end 116 of the nozzle is ball-shaped and is seated within a cap 117 which is threaded onto the end 113 of the conduit 112. The ball end 116 and cap 117 cooperate so that the nozzle may be swiveled or turned relative to the end 113 of the conduit thereby permitting the jet of water to be directed to different portions of the interior of the chamber 17. A handle 118 is integrally formed on the nozzle 114 to enable the user of the machine to direct the nozzle.

The advantage of using a swiveled nozzle is that the nozzle may be arranged so that the jet provides maximum foaming and sudsing in the chamber or so that the jet opposes the direction of rotation of chamber 17 and thereby aids in the tumbling, flexing and churning of the clothes in the chamber. Of course as noted above, if desired, the jet alone may be used for tumbling and flexing the clothes in the rotating chamber. In this case, obviously the brake 65 and recoil assembly 66 would be omitted from the washing machine.

FIGURES 4 and 5 show a washing chamber 119 which may be used in place of washing chamber 17. Chamber 119 is generally cylindrical in shape except that the diameter of the top portion 121 is slightly less than the diameter of the bottom portion 122. Like chamber 17, chamber 119 has an aperture 123 formed in its top portion 121 through which the shield 29 fits without contact therebetween.

The primary difference between chambers 17 and 119 is that a plurality of longitudinal dished grooves 124 are spaced circumferentially about the side wall 125 of the chamber 119. Interconnecting the adjacent grooves 124 are flat portions 126 in which four holes 127 are drilled. These holes 127, like holes 26, permit the wash water to be expelled from the rotating chamber. A hole 128 is drilled in each groove 124, adjacent the bottom 122 of the chamber so as to permit the water to drain from the grooves 124 when the chamber is not rotating and during the spin-dry cycle.

During rotation of the chamber 119, the grooves 124 are full of water and the water expelled from the chamber 119 flows from these grooves along the flat portions 126 and out through the holes 127. This arrangement insures that there will always be at least a thin layer of water between the clothes and the side 125 of the chamber during rotation thereof so that when the rotational speed of the chamber is periodically, abruptly changed, relative motion may easily occur between the clothes and the side 125 of the chamber to insure proper tumbling of the clothes.

Chamber 119, rather than having the plurality of grooves 124 therein, as shown in FIGURE 4, may have as few as, for example, four grooves. When a fewer number of grooves are used, the circumferential widths of the flat portions 126 are not increased, but the sides of the grooves are longer and have a smoother, more gradual slope. In this situation, the grooves may be large enough so that the clothes never actually skid over the flat portions 126, but rather are tumbled and churned within the grooves during the abrupt speed changes. This latter arrangement would have the advantage that the chamber 119 could be easily balanced and would remain balanced throughout the washing cycle, particularly if the tumbling of the clothes was caused by abruptly reducing the speed of, rather than stopping, the chamber. Furthermore, it is obvious that the chamber 119 could also be made barrel shaped, like chamber 17, particularly when only a few grooves 124 are formed therein.

As noted above, the rearrangement of the clothes within the rotating washing chamber may be achieved by the use of the brake 65 and recoil assembly 66. However, this tumbling and rearranging action may also be achieved, when chamber 119 is utilized with the machine, by periodically, abruptly reducing the rotational speed of the chamber from the normal relatively high speed, for example, 400–600 r.p.m., to an intermediate speed, for example, 350 r.p.m., and then quickly returning the chamber to the high speed. It should be noted that the intermediate speed should be high enough so that the annular layer of clothes and water is substantially maintained within the rotating chamber during the speed change. The advantage of rearranging the clothes in this manner is that the rotating chamber 119 is never stopped, except for emergencies, from the beginning of the washing operation to the end of the spin-dry operation.

The abrupt speed changes may be accomplished by designing the cams 91 so that the brake 65 will be applied for a shorter period of time than when the brake is used to completely stop the chamber. Of course as noted above, as soon as the brake 65 is released, the clutch 57 is reenergized and the motor 51 again drives the shaft 18.

Furthermore, it is obvious that, rather than utilize the brake **65**, an electric motor could be used in place of motor **51**, that included motor mounted disc brakes. Such motors are manufactured by the Stearns Electric Corporation of Milwaukee, Wis. Also, an electric motor could be used which would include means for electrically braking the motor upon de-energization of the motor. Typical of such braking means is a circuit which shunts the armature of the motor upon de-energization of the motor, this commonly being called "plugging" the motor.

Further, as noted above, the jet from the nozzle **114** may be used to supplement the tumbling and flexing of the clothes in the chamber resulting from the abrupt speed changes of the chamber. Moreover, to increase the effectiveness of the churning and flexing of the clothes caused by the jet and also to reduce further the time required for the washing operation, the nozzle **114** may be arranged so that it is moved automatically during the washing operation. Thus, the jet may be directed so that during the high speed rotation of the washing chamber and during the time the brake **65** is being applied, the jet of water strikes the side of the annular layer and the side wall of the chamber so as to oppose the direction of rotation of the annular layer of clothes and water and, of course, the chamber. However, during the time the chamber is being accelerated back to high speed, the nozzle is moved so that the jet strikes the side of the annular layer and side wall of the chamber so as to assist the acceleration of the chamber.

The mechanism for automatically moving the nozzle **114** is shown in FIGURES 7 and 8. As in FIGURE 6, the nozzle **114** is mounted on the end **113** of conduit **112** by means of a cap **117**, and the vertical inclination of the jet is controlled by the handle **118**. However, when the nozzle is used with this mechanism, a flexible connection (not shown) must be positioned between the end **113** and the conduit **112** so as to permit movement of the nozzle relative to the conduit **112**.

As shown in FIGURES 7 and 8, a portion of the shield **29** is cut away at **128** and a wall **129** extends radially outwardly from this cut-away portion and upwardly so as to close the cut-away portion of the shield. A central, rectangular slot **131** is cut in the wall **129** and upper and lower channels **132** and **133** are formed along the upper and lower edges of the slot by the support members **134** and **135**. The support members **134** and **135** also have central, rectangular slots **136** and **137**, respectively, cut therein, these slots being smaller than slot **131**. The upper and lower edges of a plate **138** are positioned in the channels **132** and **133**, respectively, so that the plate **138** may slide within the channels along the straight slot **131**. The length of the slots **131**, **136** and **137** and the length of the plate **138** are selected so that the plate **138** always completely blocks slot **131**. A seal **139** is positioned between the upper and lower edges of the plate **138** and the member **134** so as to prevent leakage of fluid around the plate.

The end **113** of the conduit **112** is tightly mounted in the center of the plate **138** so that the nozzle **114** moves with the plate.

The plate **138** has a radially outwardly projecting straight flange **141** formed thereon, which flange has a plurality of teeth **142** formed along its outwardly extending edge **143**. The teeth **142** are engaged by the teeth of the worm **144** mounted on a shaft **145**. The ends of the shaft **145** are journaled in bearings **146** and the shaft is driven by a conventional, reversible electrical motor **147**. The operation of the motor **147** is controlled by the timing mechanism **58**.

From the foregoing, it is apparent that rotation, in one direction, of the shaft **145** causes the plate **138**, and thus the nozzle **114**, to slide along the slot **131** in one direction. Likewise, rotation of the shaft **145** in the opposite direction causes the nozzle to be moved in other directions, relative to the slot **131**. Of course, by moving the jet across or through the centerline of the shield and thus the centerline of the chamber, will determine whether the jet assists or opposes the rotation of the chamber.

As noted hereinbefore, the washing machine of this invention significantly reduces the time required for the washing operation. However, the time required to introduce fresh water into the machine ordinarily cannot be decreased beyond a certain point because it is dependent on the local water pressure. Therefore, in order to further decrease the washing time or more particularly, the time required for introducing fresh water into the machine, an accumulator **148**, as shown in FIGURE 9, may be positioned in the water inlet conduit. The inlet line **149** to the accumulator would be of a size, for example, three-quarter inch, normally used to connect a washing machine with a source of water. However, the outlet line **157**, connecting the accumulator with the conduit **45**, would be of a larger diameter, for example, two inches, so as to permit a much larger flow rate therethrough. The accumulator, itself, may be four inches in diameter and thirty inches in height, and such an accumulator, utilizing air trapped in its upper portion thereof, could deliver fifty pounds of water through the two inch outlet line in less than one-half a minute. This obviously is a considerably higher rate of flow than could normally be achieved, and this reduces even further the total time required for the complete washing operation.

The accumulator may be insulated if utilized in the hot water line and, if desired, may be positioned in the body **12** of the washing machine.

Operation

As noted above, water may be introduced into compartment **15** through conduit **45** and valve **102** while the user of the machine is putting clothes into the chamber **17**. To dispense soap or detergent into the water, the handle **38** must be turned a number of times.

After the clothes are in the chamber, and door **34** is closed and sealed, the timing mechanism is programmed to begin the washing operation. Thus, the motor **51** begins rotating the chamber **17** at a high speed, e.g., at least 350 r.p.m. and preferably over 500 r.p.m., and the pump **104** begins pumping. Initially there is no water in the chamber and the brief dry spin permits the clothes to be distributed evenly in the chamber **17**. However, the pump **104** soon begins forcing the wash water through the nozzle **114** and the washing of the clothes commences. As the jet of water emitted from nozzle **114** strikes the clothes in the chamber, billowing suds are formed. These suds and the water in the chamber are immediately leached through the clothes by centrifugal force and this relative movement between the wash water and the clothes cleans the clothes. As noted above, the size of the holes **26** are such that a certain annular volume of water builds up in the chamber during the rotation of the chamber. This annular volume of water provides an important feature of this invention since it facilitates the tumbling and rearranging of the clothes thereby insuring thorough leaching of the water through the clothes. Moreover, for optimum results, the water in the chamber should weigh between three and four times the dry weight of the clothes in the chamber.

The water expelled from the chamber **17** is quickly collected in the corner **16** of the compartment **15** and thereafter is drawn into the inlet **103** of the pump **104**. As noted above, the capacity of the pump is such that at any time during the washing operation, only a minimum amount of water is in the compartment **15**.

The washing operation continues until the timing mechanism **58** actuates motor **95** which causes the cams **91** to apply the brake **65** in the manner described hereinabove. After the brake **65** has stopped the chamber and the recoil assembly **66** has rotated the chamber in the opposite direction or after the brake **65** has been applied in the manner described to abruptly reduce the speed of chamber

119 from the high speed to an intermediate speed, the washing operation is repeated with the chamber again rotating at high speed and the pump 104 recirculating the water in the washing machine.

Examples of washing cycles for the washing machine of this invention are shown in the following tables. The washing cycle shown in Table I may be utilized with a washing machine having an 18-inch diameter chamber 17 that is rotated at approximately 600 r.p.m. during the washing operation with the rate of water removed from the rotating chamber being approximately three to ten pounds of water per second when ten to sixteen pounds (dry weight) of clothes are in the chamber. In this machine, the brake 65 is capable of completely stopping the shaft 18 within a short period of time and the motor 51 has sufficient power so as to be able to return the chamber 17 to a speed of 600 r.p.m. within approximately 12 seconds after a brake application. The washing cycle shown in Table II may be utilized with a machine having an 18-inch mean diameter chamber 119 that is rotated at approximately 600 r.p.m. during high speed and having the same water flow rate through the chamber as in the machine in Table I. The machine, e.g. the brake 65, is capable of abruptly reducing the speed flow 600 r.p.m. to 350 r.p.m. in 4 seconds and the motor 51 has sufficient power to be able to return the chamber to 600 r.p.m. within 9 seconds. Table III shows a typical rinse and spin-dry operation for a washing machine, such as the machine used in the washing operation set forth in Table II.

TABLE I.—WASHING OPERATION

Stage	Time (Seconds)	Elapsed Time
1st Wash	60	1:00
Stop	15	1:15
2nd Wash	30	1:45
Stop	15	2:00
3rd Wash	30	2:30
Stop	15	2:45
4th Wash	30	3:15
Stop	15	3:30
5th Wash	30	4:00
Stop	15	4:15
Rinse and Spin Dry Operations		

TABLE II.—WASHING OPERATION

Stage	Time (Seconds)	Elapsed Time
1st Wash (including time to bring chamber to high spped)	29	0:29
Brake (to intermediate speed)	4	0:33
Return to High Speed	9	0:42
Brake	4	0:46
Return to High Speed	9	0:55
Brake	4	0:59
Return to High Speed	9	1:08
Brake	4	1:12
Return to High Speed	9	1:21
Brake	4	1:25
Return to High Speed	9	1:34
Brake	4	1:38
Return to High Speed	9	1:47
Brake	4	1:51
Return to High Speed	9	2:00
Pump Wash Water to Sump	6	2:06
Extraction Spin (at high speed)	20	2:26
Rinse and Spin Dry Operations		

TABLE III.—RINSE AND SPIN DRY OPERATIONS

Stage	Time (Seconds)	Elapsed Time
Rinse Water Added (washing chamber still at high speed)	30	0:30
Brake (to intermediate speed)	4	0:34
Return to High Speed	9	0:43
Brake	4	0:47
Return to High Speed	9	0:56
Brake	4	1:00
Return to High Speed	9	1:09
Brake	4	1:13
Return to High Speed	9	1:22
Pump Water to Sump	6	1:28
Extraction Spin	15	1:43
2nd Rinse Operation (identical to 1st rinse)	1:43	3:26
Spin Dry Operation	5	8:26

In the washing operations shown in Tables I, II and III, approximately 155 pounds of water are used as compared to the approximately 425 pounds of water that a conventional washing machine uses for the same weight wash load. Also, a total of 4,850 pounds of wash water are recirculated through the clothes during the complete washing cycle which is equivalent to approximately twenty-four times the amount of water used in presently available conventional washers. Further, it should be noted that the time required for the complete washing cycle is approximately 2½ times less than the time required for the washing cycle of conventional washing machines.

Also, it should be noted that the washing machine of this invention may use soft water, e.g. water having less than 50 p.p.m. of calcium and magnesium salts, having 0.3% to 1.0% anhydrous soap dissolved therein. The advantages of using anhydrous soaps, rather than low sudsing synthetic detergents, is that the soap is less expensive and also is bio-degradable.

Furthermore, the significant reduction of the time required for the washing cycle makes it feasible for the first time to add a "break" stage to the washing cycle in home washing machines. Such a "break" stage has been commonly used heretofore in commercial laundries to remove the very dirty first wash water and to add chemicals for gaining the correct alkalinity for the later "suds" stage. Moreover, in view of the reduction of the washing time, and the fact that high soap concentrations may be used, even in extremely "soft" wash water, soil redeposition is remarkably reduced.

After the washing cycle has been completed, the clothes may be rinsed and spin-dried in the washing machine. In both cases, the abrupt stopping of the chamber or changing of the rotational speed of the chamber insures that the clothes will be completely rinsed and dried since the clothes will be periodically tumbled within the chamber. Also due to the high rotative speed, there will be approximately one-half as much residual water remaining in the clothes after the complete cycle as compared to clothes washed in present washing machines.

As shown in Table III, the rinse operttion, like the washing operation, may be completed in less time than in conventional washing machines since the rotating chamber does not have to be filled with water. During rinsing operation, the valve 109 would first be positioned by the timing mechanism 58 so that the outlet 108 of the pump 104 communicates with the sump through conduit 111 thereby removing the dirty wash water from the machine. Thereafter the valve 109 would again interconnect outlet 108 with conduit 112 and additional water may be introduced into the compartment 15 through conduit 45 and valve 102. At the termination of the rinsing operation, the valve 109 may be again positioned so as to connect the outlet 108 of the pump 104 with the sump during the spin-drying operation. During these rinsing and spin-drying operations, clothes may be rearranged and tumbled in the washing chamber by actuating the brake 65 as described above. However, the intervals between applications of the brake may be longer than during the washing operation.

In view of the foregoing, it is apparent that an improved washing machine and method of washing clothes disclosed herein provides significant competitive advantages, particularly to an operator of a commercial laundry or owner of a coin-op station. The principal advantage resides in the fact that the washing machine of this invention utilizes far less water to achieve cleaner clothes in significantly less time than in presently available commercial washers. Moreover, even though less water is utilized and the washing operation takes less total time, the total relative motion obtained between the wash water and the clothes is greater than the amount of relative motion obtained in a presently available, agitator type washing machine.

In conclusion, it should be noted that the term "clothes," as used herein, should not be limited to its conventional definition but should be read to include all fabrics or materials which are or could be washed in washing machines. Furthermore, the basic concept and invention herein described may be embodied in other specific forms and structures without departing from the spirit or essential characteristics thereof. The preferred embodiment described herein is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing descriptions, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

I claim as my invention:

1. An improved washing machine including a rotatable washing chamber adapted to receive clothes to be washed in wash water; means for rotating the chamber about its central axis at a relatively high speed whereby the clothes and the wash water in the chamber form and maintain a generally annular layer about said central axis; means effective to tumble and rearrange the clothes in the chamber; and means for maintaining a volume of wash water in the chamber during said high speed rotation in excess of that necessary to saturate the clothes.

2. The washing machine described in claim 1 wherein the means for maintaining a volume of wash water in the chamber includes water inlet means for introducing water into the rotating chamber at a first predetermined rate of flow; water outlet means for permitting the removal of water from the rotating chamber at a second predetermined rate, said first rate of flow being at least equal to said second rate of flow.

3. The washing machine described in claim 1 in which said means for tumbling the clothes includes brake means for periodically, abruptly stopping the rotation of the chamber.

4. The washing machine described in claim 1 which includes water outlet means for removing water from the rotating chamber and in which the means for tumbling the clothes includes nozzle means for introducing a high pressure jet of water into the interior of the rotating chamber.

5. The washing machine described in claim 1 wherein the means for tumbling the clothes includes means for periodically, abruptly changing the rotational speed of the chamber whereby the clothes in the chamber are tumbled and rearranged.

6. The washing machine described in claim 1 in which the speed of the rotating chamber is maintained above a predetermined value throughout the entire washing operation.

7. The washing machine described in claim 1 in which the weight of the wash water in the rotating chamber is approximately three to four times the dry weight of clothes in the chamber.

8. The washing machine described in claim 2 in which the water outlet means comprises a plurality of holes formed in the side of the chamber and the water inlet means includes nozzle means whereby the wash water is introduced into the interior of the rotating chamber in the form of a high pressure jet which is directed onto the layer of wash water and clothes whereby the jet causes the clothes in said layer to tumble and churn, said wash water in the chamber being forcibly leached through the clothing in the chamber and then passed out of the chamber through the outlet holes in the side of the chamber.

9. The washing machine described in claim 2 in which the second predetermined rate of flow is approximately equal to three to ten pounds of water per second when the dry weight of the clothes in the rotating chamber is from ten to sixteen pounds.

10. The washing machine described in claim 3 in which a plurality of longitudinal, dished grooves are spaced circumferentially about the wall of the chamber with substantially flat ridge portions formed between adjacent grooves and in which said central axis is the central longitudinal axis of the chamber.

11. The washing machine described in claim 3 wherein said means for tumbling the clothes also includes recoil means for partially rotating the chamber in the opposite direction after the brake means has stopped the rotation of the chamber and before the chamber is again rotated by the rotating means.

12. The washing machine described in claim 3 including a frame member for supporting the chamber so that the central axis of the chamber forms an angle with the vertical thereby permitting rearrangement of the clothes in the chamber by gravity, when the chamber is abruptly, periodically stopped and minimizing the inertial twisting forces acting on the frame due to the abrupt stopping of the chamber.

13. The washing machine described in claim 3 in which the means for tumbling the clothes also includes nozzle means for introducing a high pressure jet of water into the interior of the rotating chamber.

14. The washing machine described in claim 4 in which a plurality of longitudinal, dished grooves are spaced circumferentially about the wall of the chamber with substantially flat ridge portions formed between adjacent grooves.

15. The washing machine described in claim 5 wherein the means for tumbling the clothes also includes nozzle means for introducing a high pressure jet of water into the interior of the rotating chamber.

16. The washing machine described in claim 8 which includes means for collecting wash water removed from the rotating chamber; pump means having its inlet connected with the water collecting means, and its outlet connected with the water inlet means, and means for operating the pump means when the chamber is rotated.

17. The washing machine described in claim 8 in which the means for tumbling the clothes includes brake means for periodically, abruptly stopping the rotation of the chamber and in which a frame member supports the chamber so that the central axis of the chamber forms an angle with the vertical thereby permitting rearrangement of the clothes in the chamber by gravity, when the chamber is abruptly periodically stopped and minimizing the inertial twisting forces acting on the frame due to the abrupt stopping of the chamber.

18. The washing machine described in claim 8 in which the means for tumbling the clothes includes means for periodically, abruptly changing the rotational speed of the chamber from said high speed to an intermediate speed, and then quickly returning the speed of the chamber to said high speed.

19. The washing machine described in claim 8 which includes means for reintroducing the wash water flowing through the outlet holes into the rotating chamber through the nozzle means and in which the chamber has a plurality of longitudinal dished grooves spaced circumferentially about the wall of the chamber with substantially flat ridge portions formed between adjacent grooves; said outlet holes being formed in said ridge portions.

20. The washing machine described in claim 14 wherein, during rotation of the chamber, the water is continuously introduced into the chamber through the nozzle means and the water is continuously removed from the chamber by the water outlet means.

21. The washing machine described in claim 15 which includes means for moving the nozzle means between a first position wherein the water jet emitted from the nozzle strikes the wall of the chamber and the annular layer of clothes and water in the chamber so that the force of the jet opposes the rotation of the chamber and annular

layer, and a second position wherein the water jet strikes the wall of the chamber and annular layer so that the force of the jet assists the rotation of the chamber and annular layer.

22. The washing machine described in claim 16 in which the pump means has a pumping capacity greater than said second predetermined rate of flow.

23. The washing machine described in claim 17 wherein said stop means includes brake means for stopping the rotation of the chamber and recoil means for imparting abrupt, limited rotational movement to the chamber in the opposite direction after the brake means has stopped the chamber and before the chamber is again rotated by the rotating means.

24. The washing machine described in claim 20 which includes means for collecting the wash water removed from the rotating chamber, pump means having its inlet connected with the collecting means and its outlet connected with the nozzle means whereby the wash water removed from the rotating chamber may be reintroduced into the rotating chamber through the nozzle means.

25. The washing machine described in claim 21 wherein the nozzle means is maintained in said first position during high speed rotation of the chamber and during the de-accelerating portion of the speed change, and is moved to said second position during the accelerating portion of the speed change.

26. The washing machine described in claim 24 wherein the nozzle means directs the high pressure jet onto the annular layer of wash water and clothes and wherein the water outlet means comprises a plurality of holes formed in the ridge portions of the chamber.

27. The washing machine described in claim 24 which includes means for introducing additional water and a soap material into the collecting means; drain means for receiving used wash water and valve means for selectively interconnecting the pump means outlet with the nozzle means and the drain means.

28. The method of washing clothes and the like in wash water in a washing machine having a rotatable chamber adapted to receive the clothes and wash water, comprising the steps of rotating the clothes and the wash water in the chamber at a high speed whereby the clothes and the wash water form and maintain a generally annular layer about the axis of rotation of the chamber; tumbling and rearranging the clothes in the chamber; and maintaining a volume of wash water in the chamber during said high speed rotation in excess of that necessary to saturate the clothes.

29. The method of washing clothes as described in claim 28 wherein the clothes are tumbled and rearranged by periodically abruptly changing the rotational speed of the chamber.

30. The method of washing clothes described in claim 28 wherein the clothes are tumbled by periodically, abruptly stopping the rotation of the chamber and thereafter briefly, partially rotating the clothes in the opposite direction.

31. The method of washing clothes described in claim 28 including the steps of continuously introducing water into the interior of the rotating chamber in the form of a high pressure jet which is directed onto the layer of wash water and clothes, whereby the jet causes the clothes in said layer to tumble and churn; and continuously removing wash water from the rotating chamber in such a manner that the wash water in the chamber must leach through the clothing before being removed from the chamber.

32. The method of washing clothes described in claim 28 including the steps of continuously introducing water into the rotating chamber at a first predetermined rate of flow and continuously removing wash water from the rotating chamber at a second predetermined rate of flow, said first predetermined rate of flow at least equal to said second rate of flow whereby a volume of wash water is always present in the rotating chamber.

33. The method of washing clothes described in claim 28 including the step of maintaining in the chamber, wash water having a weight approximately three to four times the dry weight of the clothes in the chamber.

34. The method of washing clothes described in claim 31 including the steps of collecting the wash water removed from the rotating chamber and reintroducing said wash water back into the rotating chamber.

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