

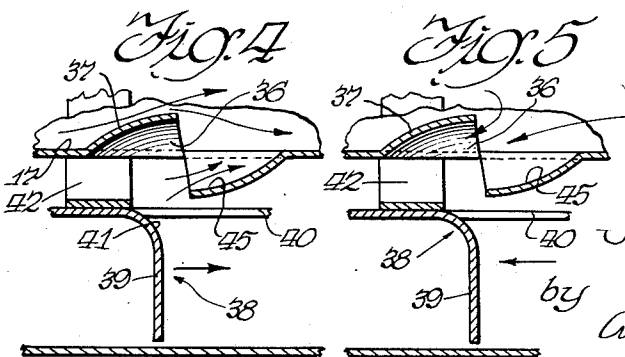
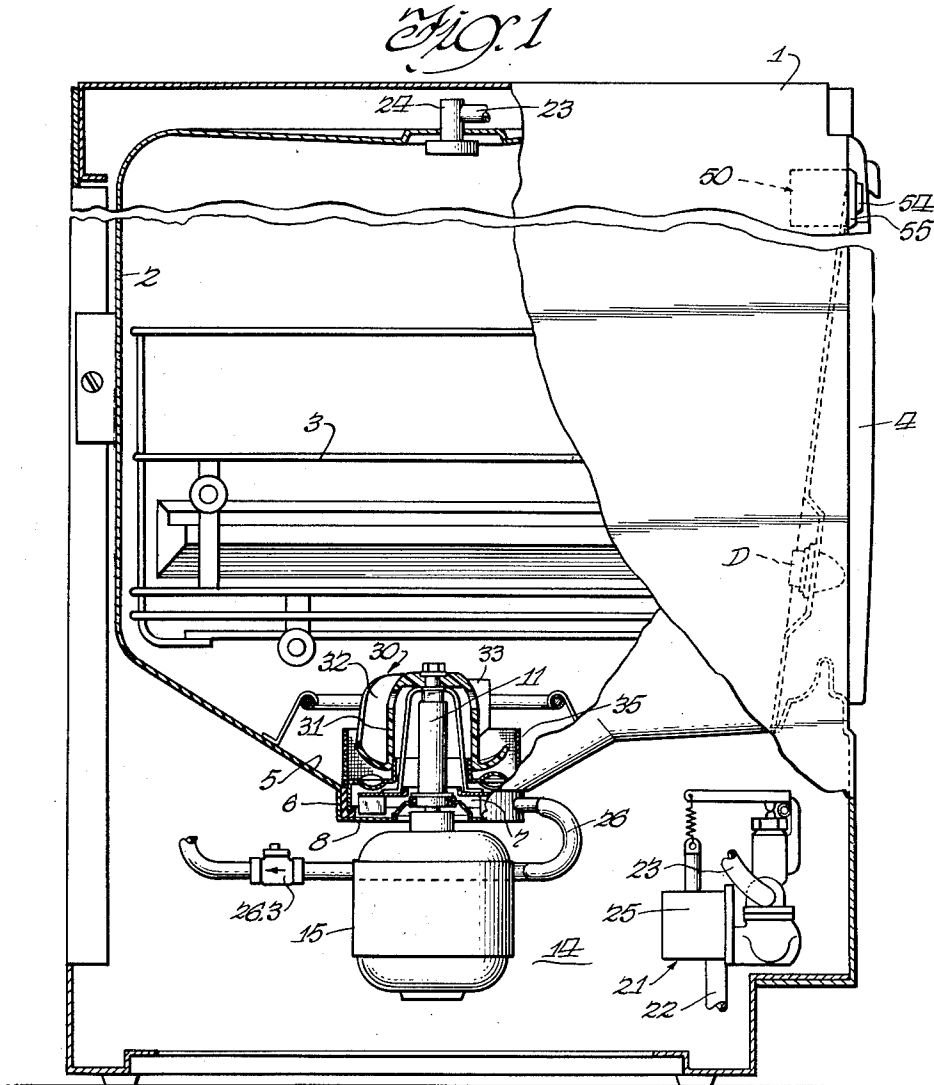
**Jan. 1, 1957**

J. L. ANDREWS  
DRAIN CONTROL SYSTEM

**2,775,975**

Filed Feb. 1, 1954

3 Sheets-Sheet 1



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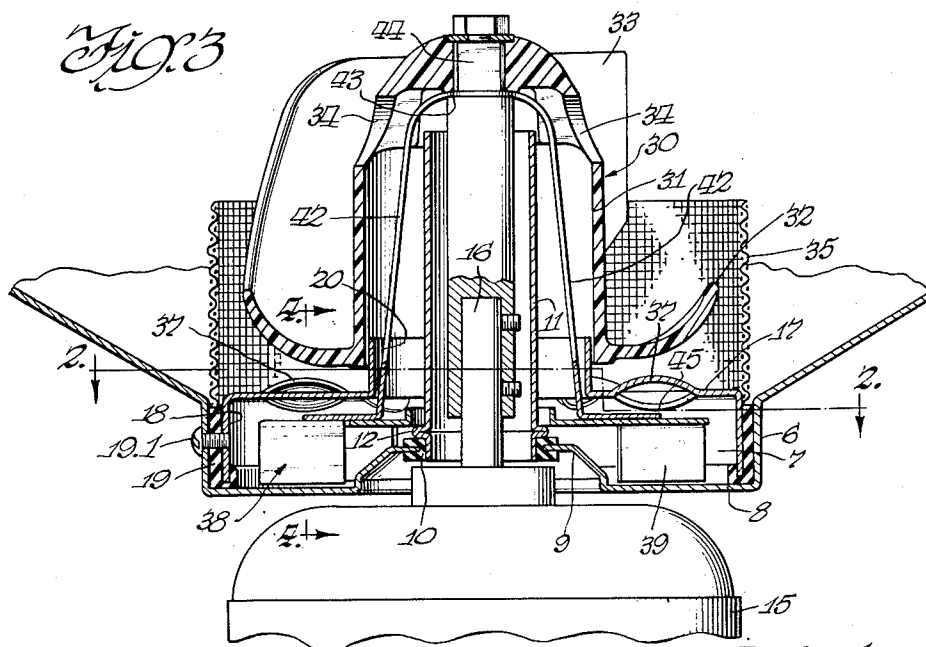
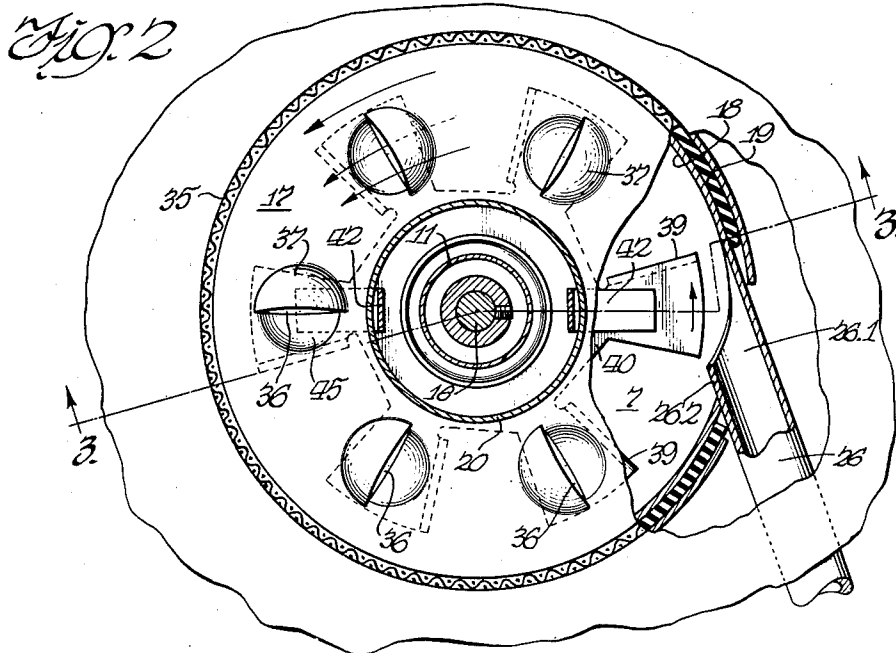
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3 Sheets-Sheet 2



Inventor  
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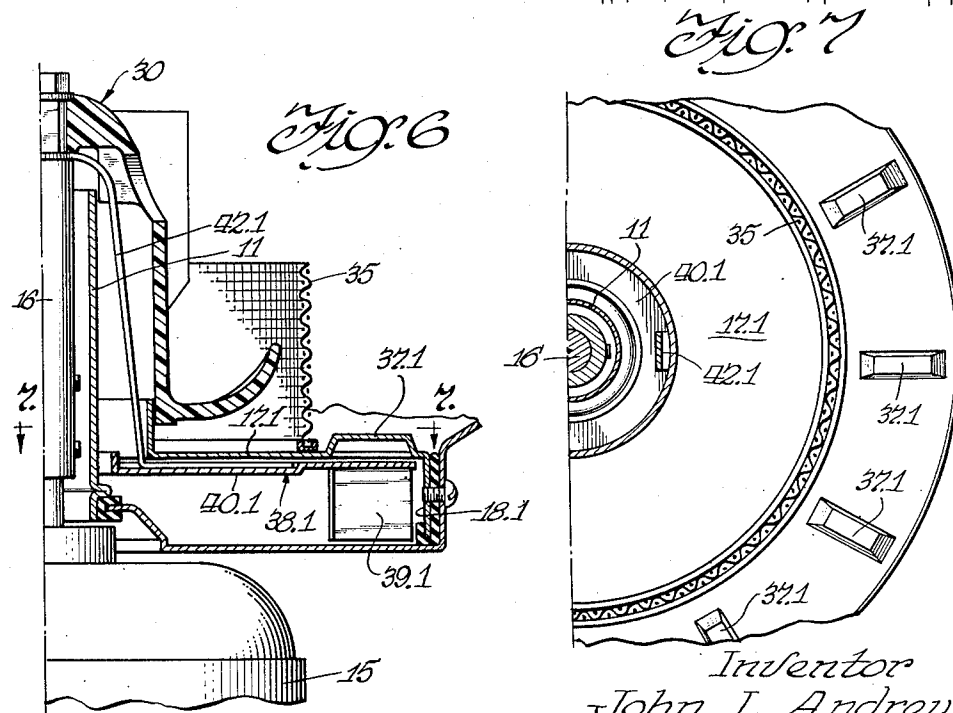
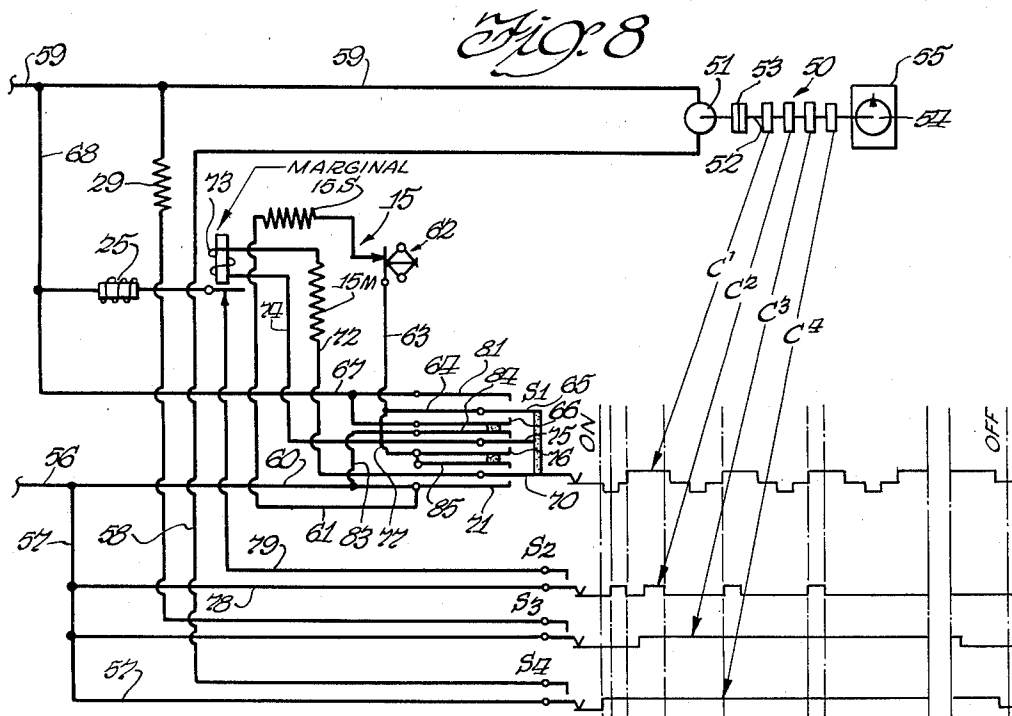
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DRAIN CONTROL SYSTEM

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3 Sheets-Sheet 3



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2,775,975

## DRAIN CONTROL SYSTEM

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Application February 1, 1954, Serial No. 407,436

10 Claims. (Cl. 134—182)

This invention relates to dishwashers and, in particular, to means for controlling drainage from the tub in which the dishes and the like are washed.

In presently known and used dishwashers of the domestic type, it is the practice to use a relatively small amount of water for the washing operations and for certain of the rinsing operations, and to circulate the water throughout the tub at the rate of many gallons per minute. It is customary, for example, to use only about twelve pints of water in each of said operations, but with a motor-driven impeller disposed in a low portion of the dishwasher tub, liquid which collects in said sump is thrown forcefully about, whereby the dishes and other articles are subjected to the cleansing and rinsing action of multitudinous particles of the washing or rinsing liquid. A single washing operation may be of five minute duration, and it is obviously important to prevent drainage from the tub so as to conserve the charge of washing liquid; for the lessened charge of liquid would soon reach the soil-saturation point and the impeller itself would become less efficient with the drop of the level of free liquid about the impeller blades.

Mechanically operated drainage valves and valve systems are well known and commonly used in dishwashers. They are, however, subject to mechanical failure and also subject to failure by reason of sticking or jamming because of food particles accumulating therein. It has also been proposed to eliminate mechanical drainage valves by locating the drainage opening in the tub about the impeller axis and providing a centrifugal pump fixed to the dishwasher impeller to sweep the water away from said opening during periods of rotation of the impeller. Thus, so long as the impeller is operating, water is kept from entering the drainage opening, whereas drainage can be quickly accomplished merely by stopping the rotation of the impeller and its associated centrifugal pump. However, this arrangement is subject to the criticism that the action of the centrifugal pump repels the liquid from the dishwasher impeller itself and thereby reduces the efficiency of the impeller.

It is therefore an object of my invention to provide a dishwasher having a drainage control system which does not embody mechanically operated valves or the like and which does not in operation interfere with the normal dishwashing action of the impeller.

It is still another object of my invention to provide a dishwasher having a reversible impeller and in association therewith a drainage system which will prevent drainage from the tub when the impeller is rotating in one direction and effect drainage when the impeller is stopped or is rotating in the opposite direction.

It is a further object of my invention to provide a drainage control system which is applicable for gravity drainage into the plumbing waste line of the building, or to a drainage system in which it is necessary to raise the effluent from the dishwasher to an elevated level before discharge into the plumbing waste system.

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In a presently preferred embodiment, I utilize a centrifugal pump placed externally of the dishwasher tub and provide a plurality of drainage connections between the tub and the pump chamber. Said connections may 5 comprise lanced-out openings in a wall which is common to the tub and the pump chamber. The openings are disposed about a circle coaxial with the impeller, in an area in which the rotation of the impeller causes the free water to rotate in the direction of impeller rotation. By providing baffles about the openings to cause said rotating 10 water to be diverted about the openings, little of the water in the tub will pass through the openings into the pump chamber, and that which does is returned to the tub. When it is desired to drain the tub, the impeller is reversed, whereupon the free water rotates in a direction 15 in which the baffles direct the water into the pump chamber from which it is discharged under pressure into the plumbing waste system.

Other features and advantages of the invention will be understood from the following detailed description of a presently preferred embodiment in which:

Fig. 1 is a fragmentary side sectional elevation of a dishwasher embodying the present invention;

Fig. 2 is a plan view of a portion of the dishwasher sump with certain portions being broken away to reveal 25 underlying structure and being otherwise in section on lines 2—2 of Fig. 3;

Fig. 3 is a vertical elevation in section in the direction of the lines 3—3 of Fig. 2;

Fig. 4 is a sectional elevation in the direction of lines 4—4 of Fig. 3, illustrating liquid flow for one direction 30 of impeller rotation;

Fig. 5 is a view similar to Fig. 4, illustrating liquid flow for the opposite direction of impeller rotation;

Fig. 6 is a partial vertical section taken through the 35 impeller hub and associated structure of a second embodiment of the invention;

Fig. 7 is a plan view, in section in the direction of the lines 7—7 of Fig. 6; and

Fig. 8 is a schematic wiring diagram showing an arrangement whereby the dishwasher may be operated pursuant to an automatic time cycle.

Fig. 1 shows a dishwasher of the general type disclosed in U. S. Patent No. 2,620,811, granted to F. A. Walker 45 on December 9, 1952, for "Dishwashing Apparatus with Automatic Detergent Introduction Arrangement." For example, the dishwasher includes an outer cabinet 1 with-in which is supported a tub 2. Suitable roller-mounted racks 3 are arranged to be brought forwardly through a door opening of the tub when the door 4 is brought from its substantially vertical closed position to a substantially 50 horizontal open position. With the racks then supported by the door, the dishes and other articles are loaded therein and the rack returned to the tub. The user then places a charge of granular detergent into the detergent dispenser D and closes the door whereupon the dishwasher is ready for operation.

The floor of the dishwasher is shaped to provide a sump 5 of inverted frusto-conical configuration. At the 60 central portion of the sump the tub bottom wall extends downwardly to form the cylindrical side wall 6 of the pump chamber 7 and then inwardly and upwardly to form the bottom 8 of said chamber and a central neck portion 9. The upper extremity of the neck extends 65 inwardly to accommodate an annular gasket 10, as best appears in Fig. 3. A guard tube 11 fits snugly within said gasket and is provided with a shoulder or equivalent 12 to fix the relationship of the tube to the gasket. As is now well understood, the guard tube extends above the maximum free liquid level within the sump and thus 70 prevents spillover of liquid into the machinery compartment 14. The drive motor 15 is suitably supported rela-

tive to the bottom of the tub and a motor shaft and extension 16 extends upwardly through the tube 11.

The sump and pump chamber are completed by the drainage-control plate 17 having a depending flange 18 which seats within the resilient gasket 19. Said gasket is crowded against the wall 6 of the sump chamber thereby frictionally retaining the plate 17 in position. It will be understood, however, that any suitable fastening means such as the machine screw 19.1 may be placed at convenient locations about the wall 6 so as positively to secure the plate 17 against rotational or other displacement with respect to the bottom of the hub. A neck 20 provides a central opening of sufficient diameter to accommodate portions of the drain control structure as presently described.

The supply of washing liquid to the apparatus is preferably under the control of a solenoid actuated valve 21 of any suitable design. Illustratively, valve 21 is suitably mounted within the machinery compartment below the tub 2 and the valve body is arranged to receive the heated water from the building supply (not shown) through the inlet pipe 22 and to discharge it through the tube 23 to a spray type fitting 24 disclosed in an upper portion of the tub 2. A solenoid 25 is operatively associated with the valve by suitable linkage and dashpot mechanism which provides quick opening, slow closing operations and thus minimizes water hammer in the piping system. It will be understood that the valve mechanism itself comprises no part of the present invention. By suitable means—for example, a suitable time-fill control or a load-responsive relay, as later described—the inflow of water to the tub is limited to the quantity necessary for washing or for “power rinsing.” In one presently known domestic machine approximately twelve pints of water are used in each of said operations. A permanently open drain connection 26 opens into the pump chamber at 26.1. The drain connection is tangential to the pump chamber, and has a projecting lip 26.2, as shown in Fig. 2. Drain connection 26 communicates with the plumbing waste system (not shown) of the building. As is now well understood, said drain connection 26 may be of the gravity type in which it would communicate directly with a conventional plumbing trap (not shown); or alternatively, the drain connection may rise to an elevated level to discharge into a waste disposal piping arrangement (not shown) placed suitably above the floor line. This latter arrangement, which is contemplated in Fig. 1, makes it advantageous to use a check valve 26.3 as close as possible to the actual waste line opening 26.1 so as to prevent backflow of effluent into the pumping chamber. A heating element 29 of the sheathed conductor type is suitably mounted within the tub for maintaining liquid temperature therein and heating air during a drying stage later described.

Washing is accomplished by means of the forceful circulation of a detergent solution throughout the tub 2. For this purpose, I mount on the motor shaft extension 16 an impeller 30 which is preferably of the type disclosed in the Koertge U. S. Patent 2,422,022 which issued June 10, 1947, for “Dishwashing and Drying Apparatus.” That is to say, the impeller has a substantially cylindrical hub 31 from which extend the water circulation impeller blades 32 and the diametrically opposed air circulation blades 33. The hub has openings 34 adjacent the air circulation blades, as indicated in Fig. 3. During washing and power rinsing operations, the impeller rotates at motor speed—usually about 1750 R. P. M.—and the blades 32 pick up water in the sump and circulate it in a multitude of drops and sprays over the articles arranged in the racks 3. During such an operation, the water level in the sump is sufficient to submerge only the lower portion of the impeller blades and the quantity in the sump is constantly being replenished by return flow along the sides and bottom of the tub and by direct drippage from the articles within the tub. The liquid flows to the impeller at a relatively

high velocity because of the slope of the sump wall. A relatively large mesh screen 35 disposed about the lower portion of the impeller permits free flow of liquid to the impeller blades, and, of course, screens out the larger food soil particles to prevent the redeposit thereof on the articles being washed. For example, the lowermost one inch of the screen should have a plurality of openings about one quarter inch in diameter. The remaining openings may be much smaller.

I have observed that when the impeller 30 is rotating at motor speed, free liquid in an area beneath the blades 32 will rotate rapidly in the same direction, and there is an area radially outward of the screen which will also be in rotation, although at a substantially lower rate. This rotation of liquid is utilized as the basis of the valveless drain control presently described. The embodiment of Figs. 2 and 3, for example, takes advantage of the relatively rapid rotation of the liquid in the area surrounded by the screen 35. Plate 17 is formed with a plurality of openings 36 which are preferably radial to shaft 16 and disposed about a circle concentric therewith. Said openings 36 are advantageously formed by lancing plate 17 so as to strike upwardly therefrom the dome-like baffle portions 37 which effectively limit or establish the mouth of the openings as vertical passages at the end of an otherwise imperforate baffle. As shown in Fig. 4, openings 36 are downstream of the direction of rotation of liquid during operation of the impeller in any operational phase of the dishwashing machine during which it is desired to maintain the liquid in the machine. Conversely, of course, the openings will face upstream when the liquid is rotating in the opposite direction. The result of this relationship of the baffle to direction of liquid rotation is to cause the rapidly-rotating liquid to spill over the baffles 37 and substantially completely bypass the openings 36 during the first-named direction of rotation of the liquid and to pour directly into the openings when the liquid is rotating in the opposite direction.

A pump impeller 38 of the centrifugal type is arranged for operation within the pump chamber 7. As illustrated in Fig. 4, the pump impeller comprises blades 39 struck downwardly from a plate 40, and it will be observed that there is an arcuate juncture 41 between the blade and the plate. The radially extending blades 39 make the pump essentially non-directional and it will later be apparent that the pumping action is utilized for both directions of rotation of the dishwasher and pump impellers. The pump impeller is arranged to be driven by the motor shaft by means of a yoke 42 which seats on a shoulder 43 at the upper end of the motor shaft extension and said yoke is engaged by the flat side walls 44 of said shaft extension. The impeller 30 is similarly related to the shaft extension to be driven thereby.

During a dishwashing operation, or any other in which it is necessary to retain liquid in the tub, motor 15 will be operated to drive the dishwasher impeller 30 and the pump impeller 38 in a counterclockwise direction, as viewed in Fig. 2. The impeller will be driven in the opposite direction when it is desired to expel the liquid from the tub. Free liquid rotating in a counterclockwise direction will spill over the baffles 37 and will escape the openings 36 thereby; although it is possible that a small amount of liquid may enter the pump chamber through said openings. In actual operation of this embodiment, so little liquid escapes through the openings 36 during counterclockwise rotation of the impeller that a gravity-drain dishwasher constructed according to the embodiment of Figs. 2 and 3 will function without detrimental loss of liquid with the pump 38 eliminated. However, dishwasher manufacturers are now finding it advantageous to standardize on the pump-discharge type. In the pump type, I have found it advantageous to provide the depressions 45 immediately forward of the openings 36 and to carry the free edge of the depressions into rela-

tively close relationship with the plate 40 of the pump impeller 38, as best appears in Figs. 3 and 4. With the pump impeller rotating at motor speed—which will be of the order of 1700 R. P. M.—liquid which may drip into the pump chamber from the lip of the several depressions 45 will strike the pump plate 40. By far the greater part of such drippage will be immediately deflected forwardly and upwardly by the arcuate portions 41 of each blade and will be returned directly to the tub through the openings 36; the residue will flow radially outward of the pump plate and eventually form as a rotating annulus about the inner wall of the pump chamber. The centrifugal pressures generated in the rotating annulus will cause the liquid to return to the tub through the passages 36, for said passages are the most immediate facility for the relief of such pressure. The lip or deflector 26.2 at the discharge conduit 26 substantially completely diverts the liquid from the conduit opening 26.1. The result is that only an insignificant part of the charge of liquid will be lost during impeller operation. When the dishwasher and pump impellers are reversed, however, the baffles 37 serve to deflect the liquid into the pump chamber. The blades 39 cause the annulus of liquid to rotate in the clockwise direction, as viewed in Fig. 2, and it is thereby forcefully expelled through opening 26.1 into the discharge conduit 26. The deflector 26.2 obviously assists the expulsion of liquid from the pump chamber.

In the embodiment of Figs. 6 and 7, the pump chamber and pump have been enlarged to position the pump chamber inlet openings radially outward of the screen 35, so that during the drainage periods the water flow will serve to purge the screen of food particles which may have accumulated thereon. Accordingly, I shape the tub 2 to accommodate a suitably larger diameter plate 17.1 and appropriately increase the effective diameter of the pump 38.1 and the shape of the drive yoke 42.1. In view of the slower rotation of free liquid in the area outside of the screen 35, as compared with rotation immediately below the impeller blades 32, I prefer to form the baffles 37.1 with a more abrupt rise than in the earlier embodiment, and to eliminate depressed portions such as the elements 45. It will be noted that the openings 36.1 are radially arranged as before, and that they extend about the complete periphery of the screen. As shown in Fig. 6, however, the pump plate 40.1 is close to plate 17.1, and the openings 36.1 are closer to the side wall 18.1 of the pump chamber than in the previous embodiment. Because of the slower rotation of the free liquid in the area outside of screen 35, there is more opportunity for drippage into the pump chamber, and it is of greater importance that such drippage be thrown back through the openings 36.1. The outlet fitting (not shown) will be tangential to the pump chamber, as previously, and it is contemplated that a diversion lip corresponding to lip 26.2 will be employed. During the phases of operation in which it is necessary to hold the liquid in the tub, the impeller and the pump 38.1 operate in the counter-clockwise direction, as previously described.

When the tub is to be drained, the motor is reversed. There will at this time be an accumulation of liquid within the space bounded by the screen. As the pump impeller 38.1 begins the positive evacuation of liquid from the tub, liquid will flow outwardly through the screen around its entire periphery, because the openings into the pump chamber are disposed entirely about the screen. This outward flow of liquid will cleanse the screen of any accumulations of food waste.

Fig. 8 illustrates a somewhat schematic control circuit for operating the dishwasher through a predetermined cycle of rinsing, washing, and drying operations.

With the dishwasher loaded with the articles to be washed, detergent placed within the cup D and the door closed, the operator initiates the automatic operation by the simple manipulation of a time-cycle switch.

For example, there is mounted on the front of the dishwasher cabinet adjacent the door 4, or in any other convenient location, a time-cycle controller 50 which may be of any conventional type; for example, that shown in the D. F. Illian Patent 2,624,352, granted January 6, 1953, for "Control Circuits for Dishwashing Apparatus." Such a time-cycle controller has a conventional timer motor 51 which drives the cam shaft 52 through a slip-clutch 53. Mounted on said shaft for rotation therewith are a series of insulated cams C1, C2, C3, C4. A manual setting knob 54 is fixed to the end of the shaft 52 and said knob will have a pointer or other indexing mark which will have reference to indicia such as "off" and "on" marked on an escutcheon plate 55 behind the knob.

Cam followers respectively control switches of the spring-leaf contact type as follows: Cam C1 is operatively associated with a triple pole, double throw switch S1, which energizes the motor 15 for operation in a direction according to the closure of the contacts of switch S1. Cam C2 is associated with a single pole, single throw switch S2, which controls the energy to the water inlet valve solenoid 25. Cam C3 operates the switch S3 in circuit with heating element 29. Cam C4 controls the energy to the timer motor 51.

The first hot water introduction into the dishwasher is for a "flushaway" rinse to remove loose food soil from the articles within the tub. The water is therefore not permitted to remain in the vat and for the positive expulsion of the soil bearing liquid, the impeller 30 and the associated centrifugal pump 38 are caused to rotate in a clockwise direction, as viewed in Fig. 2.

Assuming the dishwasher to have been loaded and ready for operation, the user turns the knob 54 clockwise of Fig. 6 to "on" position. This has the effect of rotating all of the cams and specifically rotates C4 to a position closing its switch S4 to energize the timer motor 51 through the circuit comprising line conductor 56, conductor 57, switch S4 and conductor 58 to the timer motor and line conductor 59. The cam shaft then continues rotation under power, and very shortly thereafter cam C1 closes switch S1 in one of its throw positions to energize the motor 15. The rinsing operation requires the motor to run in its "drain" direction as contrasted to its opposite or "wash" direction. It will be observed that cam C1 is a three level cam, having a low or "drain" position, an intermediate or "off" position, and a high or "wash" position. As shown, the cam follower first drops to the drain position. This closes the circuit to the windings of motor 15 as follows: Conductors 56, 60, 61 start winding 15S, centrifugal switch 62 (which would at that time be closed) conductors 63, 64, contacts 65 and 66 of switch S1, and conductors 67 and 68 to line conductor 59. The main winding 15M is also energized at this time in the circuit comprising conductors 56, 60, contacts 70 and 71 of switch S1, conductor 72, winding 15M, marginal relay 73, conductor 74, contacts 75, 76 of switch S1, conductors 77 and 64, contacts 65 and 66 of switch S1, and conductors 67 and 68 to line conductor 59. As the motor develops speed, the centrifugal switch 62 will break the circuit to winding 15S and the motor continues under its main winding.

The current drawn by the motor is light and is below the threshold point of the marginal relay 73 which therefore remains in closed circuit condition. After the motor begins operation, cam C2 closes switch S2 to energize the water inlet valve solenoid coil through the circuit which includes conductors 56, 57, 78, switch S2, conductor 79, the closed contacts of relay 73, solenoid 25 and conductor 68 to line conductor 59. The motor is then operating under a very light load, and the current drawn by the relay 73 remains below its pull-level. At the end of a suitable spray rinse period, cam C2 causes switch S2 to open, interrupting the solenoid circuit and the inlet valve closes. Motor 15 may if desired continue in operation for a brief additional period to insure the complete re-



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volume of liquid in an area of the bottom of said tub below said blade members to rotate in the direction of said impeller means; a pump chamber disposed externally of said tub and having a wall portion common to the bottom of said tub in said area of rotation of said liquid; pumping means in said pump chamber; a continuously open discharge line from said chamber; means for conjointly driving said liquid circulation impeller and said pumping means; drainage means communicating between said tub and said pumping chamber and comprising at least one opening through said common tub bottom and pumping chamber wall in said area of liquid rotation; baffle means extending upwardly from said tub bottom wall to form a continuous imperforate wall rising about side portions of each said drainage means opening and about the upstream portion thereof, considered as respects the said rotation of liquid during impeller operation, said baffle means forming, further, an imperforate top wall extending over said opening in the direction of rotation of said liquid, whereby said baffle means diverts from the associated drainage means opening, the liquid rotating in said tub bottom wall area while providing for entry into said opening when rotation of liquid in said direction is interrupted; and means for controlling the periods of operation of said liquid circulation impeller.

6. In a dishwasher or the like, the combination of a tub adapted to receive a quantity of liquid; a rotatable impeller mounted in the bottom of said tub to circulate liquid throughout said tub, said impeller having blade means effective during rotation to induce free liquid in the area immediately below and radially outward of said blade means into rotation in the direction of rotation of said impeller; a pump of the centrifugal type disposed externally of said tub, the chamber of said pump having a wall comprising a portion of the bottom of said tub below said impeller blade means; a pump impeller disposed within said pump chamber; means for driving said pump impeller conjointly with said first-named impeller and in the direction thereof; drainage means comprising an opening in said pump chamber wall to afford drainage of liquid from the area of said tub in which said liquid rotation occurs, into said pump chamber near the periphery of said pump impeller; continuously open discharge means from said pump chamber; and a baffle disposed within said tub about said drainage opening to divert therefrom liquid rotating in a predetermined direction within said tub area, a portion of said pump chamber wall adjacent said drainage opening and immediately downstream of said baffle, considered with respect to said rotation of said liquid, extending into said pump chamber in relatively close proximity to said pump impeller to define an opening disposed at substantially the same radial distance from the axis of said impeller and facing in a direction opposite to the said predetermined direction of liquid rotation.

7. In a dishwasher or the like, the combination of a tub adapted to receive a quantity of liquid, a liquid-circulating impeller rotatably mounted within said tub at a low point thereof, said impeller having means for inducing in the liquid, in an area radially outward of it, a rotary motion in the direction of rotation of said impeller, a pump chamber disposed externally of said tub below said impeller, a discharge line leading from said chamber, a pump impeller in said chamber, a reversible motor for rotating said first impeller in a first direction or an opposite direction, drainage means communicating between said tub and said pump chamber, said means opening into said tub radially outward of said first-named impeller and within the area of rotating liquid, said drainage means including an imperforate guard disposed above the opening thereof and extending into liquid-tight juncture with said tub at all but the extreme trailing portion of said drainage means opening, considered as respects the direction of rotation of the liquid in said first direc-

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tion, and means for selectively effecting the desired direction of operation of said first-named impeller.

8. The combination according to claim 6, in which said pump chamber discharge means comprises a conduit extending substantially tangentially outwardly from said chamber in a direction opposite to said direction of rotation of said liquid, a wall portion of said conduit upstream of said direction of rotation extending into said pump chamber into relatively close proximity to said pump impeller.

9. In a dishwasher or the like, the combination of a tub for the reception of a quantity of washing liquid, means for introducing liquid into said tub, impeller means rotatably mounted at the bottom of said tub at a low point thereof, said impeller means having a hub portion and blade members extending therefrom to circulate liquid throughout the upper portion of said tub and to cause a volume of liquid in an area of the bottom of said tub below said blade members and radially outward of said hub portion to rotate in the direction of said impeller means; a pump chamber disposed below the bottom of said tub in said area of rotation of said liquid; pumping means in said pump chamber; a continuously open discharge line from said chamber; drainage means communicating directly between said tub and said pumping chamber and comprising at least one opening through said tub bottom wall in said area of liquid rotation; baffle means extending upwardly from said tub bottom wall to form a continuous imperforate wall rising about side portions of each said drainage means opening and about the upstream portion thereof, considered as respects the said rotation of liquid during impeller operation, said baffle means forming, further, an imperforate top wall extending over said opening in the direction of rotation of said liquid, whereby said baffle means diverts from the associated drainage means opening the liquid rotating in said tub bottom wall area while providing for entry into said opening when rotation of liquid in said direction is interrupted; and means for controlling the periods of operation of said liquid circulation impeller.

10. In a dishwasher or the like, the combination of a tub for the reception of a quantity of washing liquid, means for introducing liquid into said tub, impeller means rotatably mounted at the bottom of said tub at a low point thereof, said impeller means having a hub portion and blade members extending therefrom to circulate liquid throughout the upper portion of said tub and to cause a volume of liquid in an area of the bottom of said tub below said blade members to rotate in the direction of said impeller means; a discharge chamber disposed externally of said tub and having a wall portion common to the bottom of said tub in said area of rotation of said liquid; a continuously open discharge line from said chamber; drainage means communicating between said tub and said discharge chamber and comprising at least one opening through said common tub bottom and discharge chamber wall in said area of liquid rotation; imperforate baffle means extending upwardly from said tub bottom wall to form a continuous wall rising about side portions of each said drainage means opening and about the upstream portion thereof, considered as respects the said rotation of liquid during impeller operation, said baffle means forming, further, an imperforate top wall extending over said opening in the direction of rotation of said liquid, whereby said baffle means diverts from the associated drainage means opening the liquid rotating in said tub bottom wall area while providing for entry into said opening when rotation of liquid in said direction is interrupted; and means for controlling the periods of operation of said liquid circulation impeller.

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