CONTROL SYSTEM FOR DISHWASHER


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Field of Search 134/570, 113; 68/12 R

References Cited

UNITED STATES PATENTS
2,218,698 10/1940 Clark 68/12 R
2,430,668 11/1947 Chamberlin 68/12 R
3,114,253 12/1963 Morey et al. 68/12 R
3,116,982 11/1964 McIlvaine 34/45
3,279,481 10/1966 Sones et al. 134/57 D
3,600,819 8/1971 Getz et al. 134/57 D X
3,807,418 4/1974 Jenkins 134/57 D

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ABSTRACT

A dishwasher having a single control pushbutton adapted to perform a multiplicity of different dishwashing and dish treating operations. The dishwasher includes an improved automatic control which has the capability to determine an optimum treatment of the dishes in the dishwasher based on the condition of the dishes when they are in the dishwasher. The control not only causes the dishwasher to effect an amount of washing of the dishes necessary to substantially fully clean the dishes irrespective of the condition of the dishes when placed therein, but also may automatically cause the dishes to be merely rinsed and dried where the dishes are only dusty and no washing is required. Structure for receiving suitable charges of dishwashing detergent and the like are incorporated in the dishwasher and the control responds includes means for responding to the provision of such detergent for automatically effecting use of the detergent at the appropriate time in the dishwashing cycle. The control further automatically senses the cleanliness condition of the dishes at the end of each subcycle and automatically controls the length of the drying cycle so as to terminate the drying cycle substantially immediately upon completion of the drying of the dishes.

13 Claims, 7 Drawing Figures
**Fig. 7.**

**START**

1. IS DETERGENT CUP LID CLOSED?
   - **NO**: FILL FOR 1/2 MIN., PUMP FOR 1 MIN., PAUSE FOR 15 SEC.
   - **YES**: DETERGENT CUP LID CLOSED?
     - **NO**: FILL FOR 1/2 MIN., PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL FOR 1/2 MIN., PUMP FOR 1 MIN., PAUSE FOR 15 SEC.
     - **YES**: TURBIDITY-DRYNESS SENSOR 26

2. IS WATER TURBID?
   - **YES**: 2 FILL RINSE ONLY CYCLE
   - **NO**: FILL RINSE-DRY CYCLE

3. PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL FOR 1/2 MIN., PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL RINSE-DRY CYCLE

4. TURBIDITY-DRYNESS SENSOR DRYNESS SENSOR

5. OPEN CUP LID 19a
   - PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL FOR 1/2 MIN., PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL FOR 1/2 MIN., PUMP FOR 4 MIN., PAUSE FOR 4 SEC., DRAIN FOR 1 MIN., FILL RINSE-DRY CYCLE

6. TURBIDITY-DRYNESS SENSOR

7. DRY FOR 35 MINUTEN, OR UNTIL SENSOR INDICATES THAT WATER HAS EVAPORATED: WHICH EVER COMES FIRST

8. DRY FOR 35 MINUTES

9. IS SENSOR WORKING PROPERLY?
   - **NO**: STOP
   - **YES**: TURBIDITY-DRYNESS SENSOR

**Notes:**
- Single pushbutton on dishwasher control panel 17.
- 3,888,269 SHEET 4.
CONTROL SYSTEM FOR DISHWASHER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to washing apparatus, and in particular, to dishwashers.

2. Description of the Prior Art

In the conventional dishwasher, a timer control is provided which cycles the dishwasher to provide different dishwashing functions. For example, the timer effects a preselected pre-rinse cycle, a plurality of wash cycles, one or more post-rinse cycles, and a dry cycle, the duration of each of which is controlled by the timer clock means. As the dishwasher may be used for different operations in treating the dishes, such as rinse only, rinse-dry, light wash or heavy wash, or heat only, it has been conventional to provide a plurality of pushbutton controls or selector means for manipulation by the user to effect the desired specific dish treatment cycle.

The use of such timer controlled devices presents a number of disadvantages. The user may inadvertently set the control wrong for the desired operation either by not recognizing the need for a different operation in connection with the particular dishes being treated or by accidentally pushing the wrong button or setting the selector control in the wrong mode. Further, because the drying cycle is time controlled, the cycle is conventionally set for the longest drying time necessary for the varying conditions to which the dishwasher may be subject and a substantial amount of drying of dishes may extend the drying time substantially beyond the time necessary to complete the drying of the particular dish load thereby wasting electrical power and unnecessarily heating the kitchen space or other area in which the dishwasher is located. Where the dishwasher is being used in a warm or hot area, such wasted heat further taxes air conditioning equipment or raises the temperature of the kitchen space providing a less comfortable working condition.

Where an unnecessary number of washing steps is caused to be effected by the user, the dishwashing may further be wasteful of water and electrical power necessary to heat the water to the relatively high temperatures normally used in dishwashers. Where the user sets the dishwasher for a washing cycle which is insufficient to clean the particular batch of dishes, the dishes may be dried with food and other particles remaining adhered thereto, making the subsequent food soil removal extremely difficult.

It is further desirable to minimize the amount of detergent used to wash the dishes, particularly for ecological reasons.

In one form of prior art washing structure, as shown in the United States Letters Patent to Morey et al 3,114,253 for an "Automatic Washing Machine Having Means to Measure the Rate of Change of Turbidity," a control is provided for measuring the turbidity of the wash liquid.

In United States Letters Patent to Sones et al 3,279,481, a dishwasher is shown having means for varying the speed of the fluid distributing pump to vary the quantity and pressure of washing fluid directed against the articles to be cleaned. In this patent, a turbidity sensor is used to determine the turbidity of the rinse water. The control further uses a timer controlled switch to control the drying operation and means for varying the speed of the air moving means to vary the drying effect as a function of the sensed humidity.

United States Letters Patent to Clark 2,218,698 for a Washing Machine illustrates the use of a photocell means responsive to the change in light received thereby when the suds level raises to a preselected level in the apparatus.

United States letters Patent 2,430,668 to J. W. Chamberlin shows a washing machine and automatic control mechanism therefor wherein the different batches of clothes being washed in the machine provide different signals to the sensing means for varying the washing operation depending on the soil conditions thereof.

United States letters Patent 3,477,258 to D. J. Walker et al shows an electronic sequential control in a total sensing automatic washer which effects cycling of the washer by a preselected time delay or response to sensed conditions.

United States letters Patent 3,116,982 to O. T. McIlvaine shows a photocell arrangement in a dryer exhaust for sensing the amount of moisture therein to control the operation of the dryer.

Other U.S. Pat. Nos. which are of interest in connection with the structural concepts of such timer controlled devices are those of: Schoenberg 1,940,373; Robinson 2,503,770; St. Palley 2,771,892; Skinner 2,968,688; Sharpe 3,013,400; Jacobs 3,070,714; Hill 3,074,277; Gawron 3,399,652; Eaton et al 3,504,184; Peube et al 3,511,572.

SUMMARY OF THE INVENTION

The present invention comprehends an improved dishwasher which eliminates the need for the user to manually select the desired operation of the dishwasher such as for short wash, medium wash, super wash, rinse only, or rinse-dry operations. The present invention permits the user to effect the proper treatment of the dishes placed in the dishwasher by manual operation of a single pushbutton. Where a washing rather than a rinsing operation is required, the user places the necessary detergent in the appropriate receptacle in the dishwasher prior to initiating operation thereof and the control of the dishwasher automatically effects the necessary amount of washing. The dishwasher automatically terminates the dish treating operation upon completion of the drying of the dishes by sensing different conditions rather than relying on a time controlled drying cycle, thereby minimizing the total time and energy expended in the dish treating operation.

The control utilizes means for sensing the turbidity of the water charge or fill in the dishwashing chamber automatically during the dish treating cycle. The control further senses the depth of a collected portion of the dish treating water in a receptacle communicating with the dishwashing chamber. Control means are associated with the dishwasher which are responsive to the sensed turbidity and collected liquid depth to provide the above-described desirable operation of the dishwasher. If the user wishes to wash the dishes, the user places detergent in the detergent receptacle in the dishwasher and closes an overlying lid associated with the receptacle. If the user wishes to merely rinse only, or rinse-dry the dishes, no detergent would be placed in the receptacle and, thus, the lid would be maintained in the open position. Information indicating the selec-
In the preferred embodiment, a maximum of two turbidity sensings are effected, namely, during the second and, if necessary, third fill, so that if the treating liquid is turbid upon sensing of the third fill liquid, the subsequent cycle is caused to be a washing cycle notwithstanding to limit the total cycles to 6 in the operation of the dishwasher.

The sensing means of the present invention is illustrated in greater detail in my copending application Serial No. 380,101, filed July 17, 1973, entitled “Sensor For Dishwasher,” (PA-4654). Said application is incorporated by reference herein and may be referred to for a detailed description of the structure and functioning of the sensing means. Briefly, however, the sensing means includes means for directing light radiation upwardly into dish treating liquid collected in a shallow receptacle communicating with the dishwashing chamber. Means are provided for sensing the light radiation reflected either from the solids carried by the liquid above the receptacle to provide a turbidity determination, or reflected from the underside of the upper surface of collected liquid in the receptacle to provide the dryness determination. Thus, the same sensor is used for determining the turbidity condition of the rinse water as to determine the number of cycles to be effected in the dishwasher, as well as to determine the dryness condition of the dishes in the final, drying cycle as a function of the decrease in the quantity of water remaining in the shallow collecting receptacle. The decrease in the depth of this collected water is caused by the drying action of the heating element in the dishwashing chamber, the receptacle being in communication with the chamber so as to cause evaporation of the collected water at a rate proportional to the rate of drying of the dishes in the chamber.

Thus, the dishwasher of the present invention provides effectively maximum efficiency in the dishwashing operation in providing only the necessary number of cycles, thereby minimizing use of washing liquid and heat energy in heating the washing liquid to the washing temperature. Further, maximum efficiency is obtained by limiting the drying operation only to that necessary to complete the drying of the dishes, thereby again avoiding unnecessary energy use in the drying of the dishes as occurs in conventional dishwashers where the drying cycle is timer controlled.

Another object of the invention is to provide a control which performs periodic diagnostic checks on the sensor to determine if the sensor is functioning properly, with reversion of the control to a pre-programmed fail safe rinse and wash cycle with a timed dry period if during the check the sensor is found to be not functioning properly.

BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a fragmentary perspective view of a dishwasher having a control embodying the invention;
FIG. 2 is a front elevation of the dishwasher;
FIG. 3 is a front vertical section illustrating the sensing means in association with a sump portion of the dishwashing chamber means;
FIG. 4 is a fragmentary enlarged vertical section of the sensing means;
FIG. 5 is a top plan view thereof.
FIG. 6 is a schematic wiring diagram of the control; and FIG. 7 is a block diagram illustrating the selective functioning of the dishwashing apparatus as effected by the control.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as shown in the drawing, a dishwasher generally designated 10 is shown to comprise a cabinet 11 defining a washing chamber 12 having a front opening 13 which is selectively closed by a front door 14. The dishes to be washed may be carried on suitable racks 15 in chamber 12. The door may be provided on its front surface with a handle 16 for swinging the door between the closed position of FIG. 2 and the open position of FIG. 1. A single pushbutton switch 17 of the momentarily switch type is mounted on the door to provide for manual control of the operation of the dishwasher. On its inner surface, the door carries a conventional silverware basket 18 and a pair of detergent cups 19 and 20. As illustrated schematically in FIG. 2, a normally open lid switch 21 is associated with detergent cup 19 so as to be closed as the result of a closing of the lid 19a after a suitable quantity of detergent is placed in the cup 19 by the user. Cup 20 may comprise an open cup whereby placement of detergent therein causes the first cycle of operation of the dishwasher to be a wash cycle if desired by the user.

As shown in FIG. 3, the dishwasher may further include a conventional spray arm 22 for forcibly spraying the dishes carried in the racks 15 in chamber 12. During the dish washing operation, the dishes may be contacted with rinse liquid or a washing liquid including a detergent. A drying element in the form of a sheathed electric resistance heating element 23 is provided in a sump portion 24 of the tub 25 defining chamber 12 for heating the chamber suitably to dry the dishes therein at the completion of the dish treating operation.

As discussed above, operation of the dishwasher to effect a substantial number of different dish treating operations is effected herein automatically by the use of the single control button 17. To provide such automatic functioning, the dishwasher further includes a sensing element 26 which is adapted to determine both the turbidity of the washing liquid and the dryness condition of the dishwasher in different times in the operation thereof. As indicated above, the sensor 26 is disclosed in my pending application Ser. No. 380,101 in detail. For a complete understanding of the present invention, however, it is not necessary to understand that sensor 26, as best seen in FIG. 4, defines a transducer including a light directing means 27, a light gathering means 28 and means 29 defining a well or receptacle 30 for holding a quantity of the dishwashing liquid at the bottom of chamber 12 after the remainder of the liquid has been pumped out of the chamber 12. Portions 27 and 28 of the sensor consist of cylindrical transparent glass or plastic windows and are connected by a body portion 31. The cylindrical light directing means 27 and the cylindrical light gathering means 28 have angular end portions flush with the bottom of well or receptacle 30 to define a pair of light openings 33 and 34 spaced apart a preselected distance. In the operation of sensor 26, the motor is stopped so that the water covers the sensor to a depth of about 1 inch. The sensing of the turbidity of the liquid is effected by light radiation from a lamp 32 mounted in the sensor portion 27a passing upwardly through glass window 27 and emanating from window 27 at the opening 33 and reflected by the solid material which may be in the dishwashing liquid L, back downwardly through opening 34 consisting of the top end portion of window 28 to a photocell 35 mounted in the sensor 26 below light gathering means 28. The variation in the amount of light reflected back to photocell 35 provides a variable resistance signal corresponding to the turbidity of the liquid L above the well 30.

In the operation of the sensor as a dryness sensing means, the liquid L has been pumped out of the chamber 12 and light energy from lamp 32 is reflected from the underside of the upper surface of the liquid in well 30 to the photocell. The amount of light varies substantially as the level of the liquid drops from the top of the well during the drying operation so that the resistance of the photocell varies substantially to provide a positive drying cycle termination signal when the liquid level drops substantially to the bottom of the well. The control 36 for the dishwasher is illustrated in FIG. 6. The control is generally similar to that shown in Joseph Karklys United States letters Patent 3,662,186, issued May 9, 1972 for "Electronic Control Circuit for Appliances," which patent is incorporated by reference herein. The control 36 hereof differs from that shown in the Karklys patent in elimination of a number of the input elements of the Karklys patent control and the substitution therefor of the pushbutton start switch 17 and the detergent cup lid switch 21. Thus, as shown in FIG. 6, switch 17 includes a first single pole, double throw switch 17a having a first fixed contact 17b connected to ground and a second fixed contact 17c connected to the negative supply voltage as will appear. The moving contact 17d is connected to terminal M of the control.

Switch 17 includes a second single pole, double throw switch 17e having its moving contact 17f connected to terminal K, and one fixed contact 17g connected to ground. Switch 17e is associated with switch 17a so that the moving contacts are connected to ground respectively in the different positions of the switch.

The detergent cup lid switch 21 comprises a single pole, single throw switch having a fixed contact 21a (FIG. 6) connected to the negative supply voltage and moving contact 21b connected to terminal H of the control. A resistor 21c is connected from contact 21b to ground. The photocell 35 (FIGS. 4 and 6) of turbidity sensor 26 is connected between terminals P and R of the control 36. The lamp 32 of sensor 26 is connected between the negative supply terminal R and ground.

Thus, briefly, control 36 functions as follows. Control circuit 36 is energized from a suitable source as a 60Hz, AC power source connected with terminals N (ground) and L1. An interlock switch 37 is connected between power lead 38 and terminal L1. This interlock switch may be associated with the door 14 or handle 16 of the dishwasher, breaking the power circuit when the door is opened, thereby interrupting the energization of the dishwasher components such as the pump motor, heater, solenoids, etc. The power supply for a control circuit block 39 remains energized, but there is no 60 Hz input to the clock portion of circuit 39 via resistor
and control circuit terminal T14, the status of control circuit block 39 is maintained and when the dishwasher door is closed, connecting power lead 38 to terminal L1 via interlock switch 37, the dishwasher program will resume starting from the portion of the program which was interrupted on opening of the door.

Several power switching circuits control the application of power to functional elements of the apparatus. The circuit enclosed in broken line box 41, which actuates the fill solenoid valve 42, is typical. A driver transistor 43 has its base connected with control circuit terminal T13 which provides a signal causing the transistor to conduct when the fill solenoid 42 is to be energized. Transistor 43 is connected with the gate terminal of a bi-directional current-conducting semiconductor 44 commonly known as a Triac. Triacs, which are well known in the electronics art, normally exhibit a high impedance between their end terminals and exhibit a low impedance therebetween in response to the application of a signal, having an amplitude greater than a predetermined magnitude to their third or gate terminal. When transistor 43 conducts, it connects the gate of Triac 44 with a source of operating potential to be described below. This causes the Triac 44 to conduct, connecting the fill solenoid 42 from power line 38 to ground N. Connected in series with fill solenoid 42 is an overfill limit switch 45 which opens if the dishwasher is overfilled to a predetermined level. Normally the actuation of fill solenoid 42 is timed by the duration of the signal from control circuit block 39. When the signal is not present, transistor 43 ceases conducting and the power circuit through Triac 44 is broken.

The power supply for the various control circuits includes a transformer 46 having a primary winding 46a connected across the power line. Two rectifier circuits are connected with secondary winding 46b. A half-wave rectifier diode 47 provides a negative operating potential for control circuit 39. Capacitor 48, shunted by series connected resistor 49 and zener diode 50 and returned to ground N, filters the output of the rectifier Zener diode 50, which is connected in parallel with a resistor 51, provides a regulated output voltage at junction 52 for the control circuit 39. Power input terminal T5 of circuit block 39 is connected with the anode of zener diode 50 and terminal T1 is connected with ground N.

A timing reference input for control circuit 39 is obtained from the 60Hz power line through current limiting resistor 40 connected with control circuit terminal T14. A diode 53 is connected from terminal T14 to the power supply junction 52 clamping the negative half-cycle of the input signal to provide an essentially square wave drive for the timing circuit.

Diodes 54 and 55 are connected in a full wave rectifier circuit, the output of which is filtered by capacitor 56. The circuit is completed through transformer tap 57 of the portion of transformer secondary winding 46b to which diodes 54 and 55 are connected. The full wave rectifier circuit provides a negative operating potential for the transistor drivers and the gate terminal of the triacs are connected with the switching circuits which actuate the various elements of the apparatus. The connection of transformer tap 57 to ground N, completing the rectifier circuit, includes switching means which initiate and terminates the operating cycle of the dishwasher.

Switching circuits 58 and 59, connected with terminals T12 and T11, respectively, of control circuit block 39, operate Triacs 60 and 61 to control the operation of the pump motor 62 in the drain and circulate modes. Motor 62 includes starting windings 62A which are switched out during run by opening relay contacts 62b. The switching circuit 63, connected with terminal T10 of control circuit 39, operates Triac 64 to control energization of heater 23.

Switching circuit 65 operated from terminal T4 of the control circuit, actuates Triac 66 controlling solenoid 67 which dispenses wetting agent during the final rinse. Switching circuit 69 connected with control circuit terminal T3, actuates Triac 71 to operate detergent dispensing solenoid 73 which opens lid 19 of detergent cup 19.

Switching circuit 74 connected to control circuit terminal T2 and Triac 75 is a part of the cycle control for the full wave rectifier.

Various conditions of the dishwasher provide inputs to control circuit 39 by connecting the control circuit terminals either with ground N (logic 0) or negative power supply at junction 52 (logic 1). The photocell 35 of sensor 26 is connected to an analog to digital signal conditioning circuit enclosed in broken line box 77 of FIG. 6. The digital output of the signal conditioning circuit 77 is connected to terminal T9 of control circuit 39. A resistor 78 is connected between the negative supply junction 52 and the cathode of silicon diode 80 and forward biases the two series connected silicon diodes 79 and 80 thereby establishing a fixed reference voltage at the emitter 76a of transistor 76. A resistor 81 is a load resistor for transistor 76 and is connected between the collector of transistor 76 and the negative supply junction 52. A resistor 82 is connected between ground and the base of transistor 76. Transistor 76 conducts and provides a logic 0 at the input terminal T9 of circuit 39 whenever the photocell 35 resistance is below a fixed value, say 30K ohms. When the photocell 35 resistance is above 30 K ohms transistor 76 is off and a negative voltage (logic 1) is present at input terminal T9. The resistance of photocell 35 is low when it is illuminated by light, and high when the light level is low or absent. Hence, a logic zero is present at input terminal T9 of control 39 when the turbidity of the dishwashing liquid L is high or when the level of water in receptacle 30 is high (dishes not dry). A logic one is present at T9 when the dishwashing liquid L is not turbid or when the level of water in receptacle 30 is low (dishes dry).

Control circuit 39 may be programmed to automatically interrogate the sensor 26 to determine whether the sensor 26 is functioning properly. During the last few seconds of each drain period a considerable amount of light will be reflected from the surface of the water trapped in receptacle 30 and will illuminate photocell 35 no matter whether the water is turbid or clear and a logic zero will be present at terminal T9 if the sensor is functioning properly. However, if the lamp 32 fails, or if the window surfaces 33 or 34 become abnormally coated with sediment the photocell 35 resistance will be high and a logic one signal will be present at terminal T9. Thus the control circuit 39 can determine if the sensor is not working and provide a suitable rinse or wash cycle with a timed dry period if the sensor 26 is not working properly.

Control 36 functions to provide automatically a number of different operations of dishwasher 10 eliminating the need for multiple pushbuttons to be selectively ma-
Manipulated by the user to provide the desired different operations. Thus, as shown in FIG. 7 the operation of the dishwasher is effected by the user manipulating pushbutton 17 to the "Start" position. If the detergent cup lid 19a (FIG. 1) is not closed, this is indicated to the control by the open condition of switch 21 (FIGS. 2 and 6). Under this condition, the user would desire either a rinse only, or a rinse-dry cycle. As indicated in FIG. 7, the first cycle under these conditions is a fill of chamber 12 for 1½ minutes followed by a pumping of the washing liquid against the dishes by the spray arm 22 for 1 minute. The spray is then discontinued for 15 seconds while the turbidity dryness sensor 26 is utilized to determine the turbidity of the water. If the turbidity so sensed is above a preselected amount, control 36 causes a rinse only cycle to be completed by again pumping the rinse water through spray arm 22 for an additional 4 minutes. At the end of this time, after a 2 second pause, the water is drained in a minute draining operation and a second charge of rinse water is delivered to the chamber by a ¾ minute delivery operation. The water is then sprayed in a 4 minute spray cycle and after a 4 second pause, this second quantity of rinse water is drained in a 1 minute drain operation. Thereupon, the control de-energizes the dishwasher.

If the turbidity of the rinse water sensed in the 1½ second pause of the first rinse cycle has a turbidity less than the preselected turbidity, the control causes the cycle to be completed by a 4 minute spray operation followed by a 4 second pause and a 1 minute drain. The control then determines whether the sensor is operating properly as described above and if so the sensor is energized and a dry cycle is initiated by energization of the heater 23. The drying cycle is continued for 35 minutes, or until the sensor indicates that the water level in well or receptacle 30 has dropped substantially to the bottom of the well to indicate the completion of the drying of the dishes, whichever occurs first. The dishwasher is then de-energized to complete the operation. If the sensor is not working properly, the drying cycle is established for the 35 minute period in the manner of the conventional time-controlled drying dishwasher operation.

If the user closes the detergent cup lid 19a, indicating that detergent has been placed in the cup for effecting a washing cycle, the first cycle comprises a fill for 1½ minutes, a pump spray operation for 4 minutes, a pause for 4 seconds, and a drain of the first rinse water for 1 minute. The second cycle is then automatically initiated comprising a refill of the tub for 1½ minutes, a pump spray for 1 minute, and a pause for 15 seconds, during which time the turbidity dryness sensor is operated to determine the turbidity of the second rinse water. If the second rinse water turbidity is less than the preselected turbidity, a four-fill cycle is completed by releasing the detergent cup lid to deliver the detergent into the rinse water, thereby converting this cycle from a rinse to a wash cycle. This wash cycle is then continued with the second fill water for 4 minutes followed by a 4 second pause and a 1 minute drain. Two successive rinse operations are then effected by a refill of the chamber for 1½ minutes, a pump spray for 4 minutes, a pause for 4 seconds, a drain for 1 minute, a refill of rinse water for 1½ minutes, a pump spray for 4 minutes, a pause for 4 seconds, and a drain for 1 minute. The completion of the washing operation then is effected by determining whether the sensor 26 is functioning properly and effecting a final drying operation as discussed above wherein the dishes are dried either under the control of the sensor 26 or for a maximum period of 35 minutes.

If the turbidity determination made in the second rinse cycle indicates that the water is turbid, the second rinse cycle is continued as a rinse operation for 4 minutes followed by a pause for 4 seconds, a drain of the second rinse water from the tub for 1 minute, and a refill of the tub with a third fill or charge of water for 1½ minutes followed by a pump spray for 1 minute. The turbidity is then redetermined during a pause for 15 seconds, and if the turbidity is now less than the preselected turbidity, the operation is completed by a completion of the third fill as a wash cycle by releasing the detergent cup lid to deliver the detergent into the rinse water, thereby converting the third fill from a rinse to a wash cycle. This wash cycle is then continued with third fill water for 4 minutes followed by a 4 second pause and a 1 minute drain. A five fill cycle is then achieved by two successive rinses and a dry period.

If the turbidity sensed during this second turbidity determination is greater than the preselected turbidity, a third rinse cycle is effected by completing the cycle subsequent to the turbidity determination by a pump spray for 4 minutes, a pause for 4 seconds, and a drain for 1 minute. Upon completion of the third rinse cycle, the wash cycle is automatically initiated with fourth fill water by filling of the tub with hot water for 1½ minutes, opening the cup lid, continuing the pump spray for 4 minutes with the water now constituting a detergent solution to wash the dishes, pausing for 4 seconds, and draining the wash water for 1 minute. The completion of the operation is then effected as above by providing two additional rinse cycles and a dry cycle. Thus, the two additional rinse cycles result in a six fill cycle.

In the event that the user places detergent in the cup 19 and closes the lid, the dishwasher automatically effects and initial rinse cycle, one or two subsequent rinse cycles, depending on whether or not additional dirt is being removed from the dishes during the first minute of the second rinse cycle, and automatically initiating the wash cycle after either the first, second or third rinse so provided, followed by automatically providing two rinse cycles and a drying cycle. As discussed above, the drying cycle may be under the control of the sensor 26 so as to terminate the drying operation as soon as the dishes are dry, which, depending on the ambient conditions, may be substantially prior to the end of the maximum 35 minute drying period provided for by the control. As only the number of pre-rinses is provided wherein removal of dirt from the dishes is being effected, optimum use of the hot water supply and operation of the dishwasher is also effected in the dish cleaning operation.

As discussed briefly above, the detergent cup 20 may be an open cup so that if the user also places detergent therein, the first dish treating cycle may comprise a wash cycle, thereby automatically providing in the operation of the dishwasher two dishwashing cycles. The sensing of the turbidity is effected during the first part of the second cycle which, at this point, comprises a rinse operation as the detergent cup lid of cup 19 remains closed until opened under the control of the turbidity sensor as discussed above in the second, third or fourth dish treating cycle.
It has been found that at times the user selects an operation of a dishwasher with a greater number of fill cycles than is necessary to be sure that the dishes are effectively cleaned. The present control eliminates such waste by assuring that only the necessary number of fills is used.

As will be obvious to those skilled in the art, the amount of drying can be adjusted at the time the sensor is manufactured by altering the depth of the well. The pause required to permit the making of the turbidity determination may also be varied as desired. It has been found, however, that approximately 15 seconds is desirable to permit the treating liquid to become quiescent in the sump area, thereby assuring a proper sensing operation. It has been found that the determination of the turbidity is substantially unaffected by the presence of detergent in the washing liquid which may carry over from a first wash cycle where detergent is placed in the open cup.

As will be appreciated by those skilled in the art the single start pushbutton 17 of the present invention may be employed to replace five separate pushbuttons conventionally required for the following cycles: Rinse Only, Rinse-Dry, and 4, 5, or 6 Fill Wash cycles. If additional cycles or options are desired such as Dry Only, Hot Rinse, Cancel & Drain, etc. these options may be provided by including extra pushbuttons on the control panel without departing from the spirit of the invention.

The dishwasher is extremely simple and economical of construction while yet providing an improved simplified method of operation effectively optimizing the energy use of the dishwasher in effecting desirable treatments of the dishes not only for washing purposes, but also for rinsing or heating purposes. Because of the simplicity of the apparatus, long trouble-free life is provided.

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

I claim:

1. In a dishwasher having means defining a chamber for holding dishes to be washed, means for providing water fills to said chamber, means for pumping the water against the dishes in the chamber, means for draining the water from the chamber, and means for heating the chamber to dry dishes therein, structure comprising:
   - means defining a liquid collecting receptacle communicating with said chamber;
   - means for selectively sensing the turbidity of a water fill in the chamber and the depth of a collected portion of the water fill in said receptacle; and
   - control means responsive to said sensed turbidity and depth for controlling the dishwashing operation to operate in such a way as to effect a first fill of the chamber, operate said pumping means to rinse the dishes with the fill water, interrupt the rinse and operate said pumping means to effect a second fill of the chamber, operate said pumping means to rinse the dishes with the second fill water, operate the draining means to remove the second fill from the chamber, and permit the dishes to air dry.

2. In a dishwasher having means defining a chamber for holding dishes to be washed, means for providing water to said chamber, means for pumping the water against the dishes in the chamber, means for draining the water fills from the chamber, means for heating the chamber to dry dishes therein, and a cup having a lid and means for releasably locking the lid in a disposition closing the cup for releasably holding detergent which when dispensed into the chamber forms with a water fill a detergent solution for washing the dishes therein, structure comprising:
   - means defining a liquid collecting receptacle communicating with said chamber;
   - means for selectively sensing the turbidity of a water fill in the chamber and the depth of a collected portion of the water fill in said receptacle;
   - means for sensing the disposition of the detergent cup lid; and
   - control means responsive to said sensed turbidity, fill depth, and lid position for controlling the dishwashing operation to operate in such a way as to effect a first fill of the chamber, in the event the detergent cup lid is disposed to close the cup operate said pumping means to provide a complete first rinse of the dishes with the fill water, operate the draining means to remove said fill water from the chamber, operate said pumping means to effect a second fill of the chamber, operate said pumping means to initiate a second rinse of the dishes, interrupt the rinse and operate the sensing means to determine the turbidity of the second rinse fill water, selectively:
     - a. in the event the sensed turbidity of the second fill water is below said preselected level, release said cup lid to open the cup and deliver detergent from the cup into the second fill water for forming a detergent washing solution, operate said pumping means to effect a washing of the dishes therewith, operate said draining means to remove the washing solution from the chamber, operate said water-providing means and pumping means to effect a further rinsing of the dishes, and operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle, and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level; or
     - b. in the event the sensed turbidity of the second fill water is at least a preselected level operate said pumping means to complete the second rinse of the dishes, operate the draining means to remove the second rinse fill water from the chamber, operate said pumping means to initiate a third rinse of the dishes, interrupt the rinse and operate the sensing means to determine the turbidity of the third rinse fill water, selectively:
c. in the event the sensed turbidity of the third fill water is at least said preselected level operate said pumping means to complete the third rinse of the dishes, operate the draining means to remove the third rinse fill water, operate said water-providing means to effect a fourth fill of the chamber, release said cup lid to open the cup and deliver detergent from the cup into the fourth fill water, operate said pumping means to effect a washing of the dishes, operate said draining means to remove the washing solution, operate said water-providing means and pumping means to effect a further rinsing of the dishes, operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle, and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level; or

d. in the event the sensed turbidity of the third fill water is below said preselected level, release said cup lid to open the cup and deliver detergent from the cup into the third fill water for forming a detergent solution, operate said pumping means to effect a washing of the dishes, operate said draining means to remove the washing solution, operate said water-providing means and pumping means to effect further rinsing of the dishes, operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level.

3. The dishwasher structure of claim 2 wherein means are provided for introducing detergent into the first fill water to form a detergent solution for washing the dishes during the first pumping operation.

4. In a dishwasher having means defining a chamber for holding dishes to be washed, means for providing water fills to said chamber, means for pumping the water against the dishes in the chamber, means for draining water from the chamber, means for heating the chamber to dry dishes therein, and a cup having a lid and means for releasably locking the lid in a disposition closing the cup for releasably holding detergent which when dispensed into the chamber forms with a water fill a detergent solution for washing the dishes therein, structure comprising:

means defining a liquid collecting receptacle communicating with said chamber;
sensing means for selectively sensing the turbidity of a water fill in the chamber and the depth of a collected portion of the water fill in said receptacle;
means for sensing the disposition of the detergent cup lid; and
control means responsive to said sensed turbidity, depth, and lid position for controlling the dishwashing operation to operate seriatim said water-providing means to effect a first fill of the chamber, in the event the detergent cup lid is disposed to close the cup said pumping means to provide a complete first rinse of the dishes with the fill water, operate the draining means to remove said fill water from the chamber, operate said water-providing means to effect a second fill of the chamber, operate said pumping means to initiate a second rinse of the dishes, interrupt the rinse and operate the sensing means to determine the turbidity of the rinse fill water, selectively

a. in the event the sensed turbidity of the second fill water is below said preselected level, release said cup lid to open the cup and deliver detergent from the cup into the second fill water for forming a detergent solution, operate said pumping means to effect a washing of the dishes, operate said draining means to remove the washing solution, operate said water-providing means and pumping means to effect a further rinsing of the dishes, operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle, and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level; or

b. in the event the sensed turbidity of the second fill water is at least a preselected level, operate said pumping means to complete the second rinse of the dishes, operate the draining means to remove the second rinse fill water, operate said water-providing means to effect a third fill of the chamber, operate said pumping means to initiate a third rinse of the dishes, interrupt the rinse and operate the sensing means to determine the turbidity of the third fill water, or selectively

c. in the event the sensed turbidity of the third fill water is at least said preselected level operate said pumping means to complete the third rinse of the dishes, operate the draining means to remove the third rinse fill water, operate said water-providing means to effect a fourth fill of the chamber, release said cup lid to open the cup and deliver detergent from the cup into the fourth fill water; operate said pumping means to effect a washing of the dishes, operate said draining means to remove the washing solution, operate said water-providing means and pumping means to effect further rinsing of the dishes, operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle, and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level.

d. in the event the sensed turbidity of the third fill water is below said preselected level release said cup lid to open the cup and deliver detergent from the cup into the third fill water for forming a detergent solution, operate said pumping means to effect a washing of the dishes, operate said draining means to remove the washing solution, operate said water-providing means and pumping means to effect further rinsing of the dishes, operate said heating means to heat dry the dishes in the chamber and evaporate fill water from said receptacle, and terminate the heating step when the sensed depth of fill water in said receptacle drops to a preselected level, or

e. in the event the detergent cup lid is not disposed to close the cup at the time of the first fill seriatim, operate said water-providing means to effect a first fill of the chamber, operate said pumping means to rinse the dishes with the fill water, interrupt the rinse and operate said sensing means to determine the turbidity of the rinse fill water, operate the pumping means to complete the rinse with said fill water, operate the draining means to
remove said fill water from the chamber, and selectively
if in the event the turbidity sensed in step (e) is at
least a preselected level, operate said waterprov-
idng means to effect a second fill of the cham-
ber, operate said pumping means to rinse the
dishes with the second fill water, operate the
draining means to remove the second fill from
the chamber, and permit the dishes to air-dry, or
g in the event the turbidity sensed in step (e) is below
said preselected level, operate said heating means
to heat dry the dishes in the chamber and evapo-
r rate fill water from said receptacle, and terminate
the heating step when the sensed depth of fill water
in said receptacle drops to a preselected level.
5. The dishwasher structure of claim 4 wherein said
sensing means comprises a sensor responsive to light
reflected from rinse fill water in the chamber to provide
a turbidity determination and to light reflected from
the underside of rinse fill water in said receptacle
to provide a dryness determination corresponding to
the depth of water in the receptacle.
6. The dishwasher structure of claim 4 wherein said
control means includes a switch for manually initiating
the said series of operations and means for selectively
effecting each of the said alternative series of opera-
tions to completion without additional manual input.
7. In a dishwasher having means defining a chamber
for holding dishes to be washed, means for providing
water fills to said chamber, means for pumping the
water against the dishes in the chamber, means for
draining water from the chamber, means for heating
the chamber to dry dishes therein, and a cup having a
lid and means for releasably locking the lid in a dispo-
sition closing the cup for holding detergent to be dis-
pensed into the chamber to form with a water fill a de-
tergent solution for washing the dishes therein, the
improvement comprising: a sensing element for sensing
the turbidity of a water fill and a dryness condition; and
control means responsive to a single operation-initiation
manipulation, and dryness conditions obtaining as a result
of the dishwashing operations for seriatim effecting pre-
wash rinse operation until said sensing means senses a
turbidity less than a preselected amount, wash, post-
wash rinse, and drying operations until said sensing means senses a preselected resultant
dryness condition.
8. The dishwasher structure of claim 7 wherein said
sensing means comprises means responsive to different
reflective agencies of the fill water to sense selectively
the turbidity and dryness conditions.
9. The dishwasher structure of claim 7 wherein
means are provided for effecting a wash operation prior
to the initial rinse operation.
10. The dishwasher structure of claim 7 wherein said
control includes means for determining the turbidity of
fill rinse water after a preselected amount of rinse oper-
ation and causing the dispensing of the detergent from
said cup into the rinse water to convert the rinse opera-
tion to a wash operation in the event the sensed turbid-
ity is less than said preselected amount.
11. In a dishwasher having means defining a chamber
for holding dishes to be washed, means for supplying a
charge of water to said chamber, means for contacting
dishes in the chamber with dish treating liquid, means
for draining water from the chamber, and means for
dispensing detergent into the chamber to form with a
water charge a detergent solution for washing dishes
therein, the improvement comprising: a sensing ele-
ment for sensing the turbidity of a water fill and a dry-
ness condition; and control means responsive to a sin-
gle operation-initiation manipulation, and the sensed
turbidity and dryness conditions obtaining as a result
of the dishwashing operations for seriatim effecting pre-
wash rinse operation until said sensing means senses a
turbidity less than a preselected amount, wash, post-
wash rinse, and drying operations until said sensing
means senses a preselected resultant dryness condition.
12. The dishwasher structure of claim 11 wherein the
control means is programmed to check periodically if
the sensing means is functioning properly, and to pro-
vide a fail safe alternative cycle including a timed dry
period in the event that the check of the sensing means
determines that it is not functioning properly.
13. The dishwasher structure of claim 11 wherein said
control means includes only a single control button
for effecting automatically as a result of said single ma-
nipulation the different dish treating operations as may
be required, depending on the sensed condition of the
dishes when they are in the dishwasher.
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