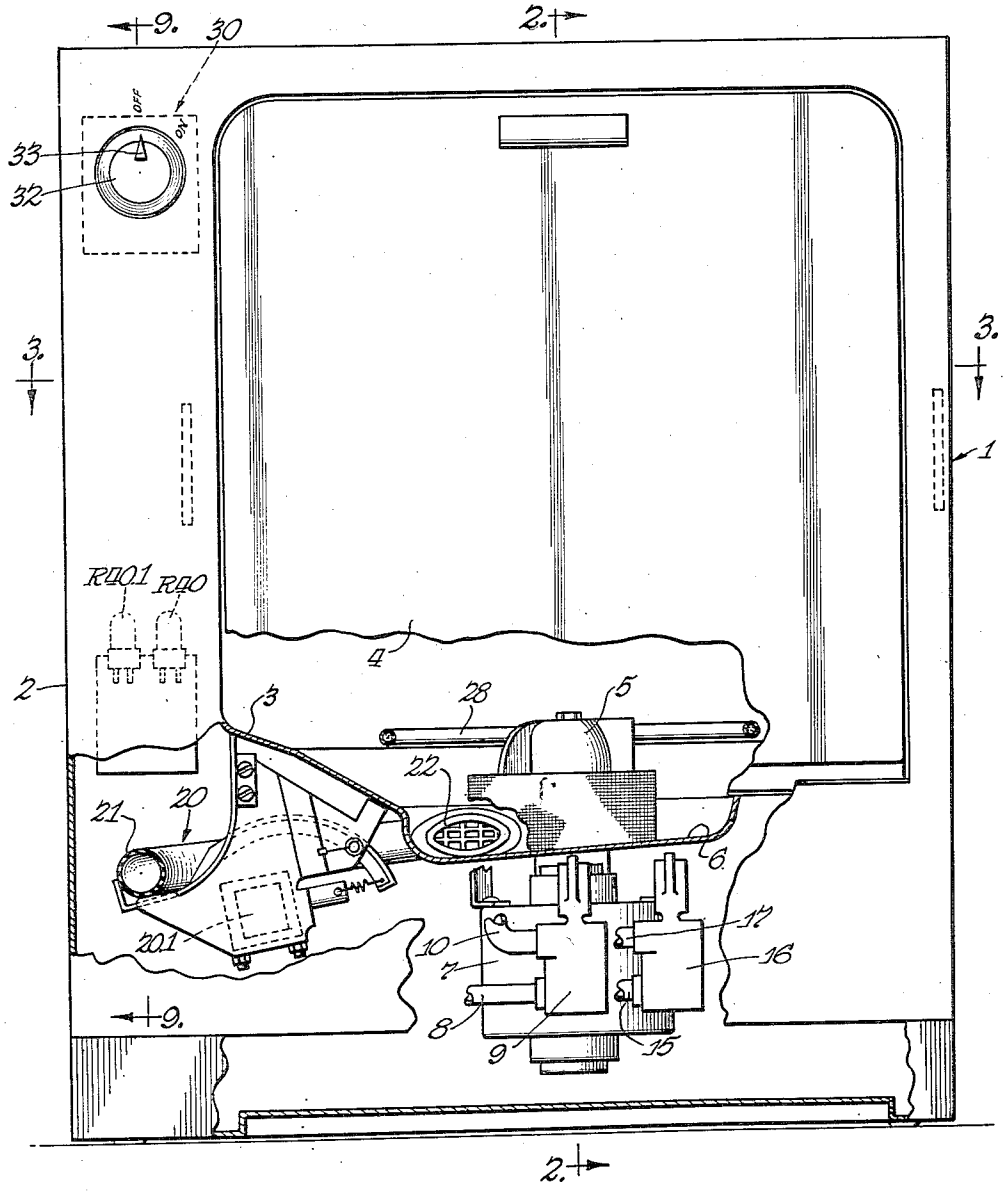
March 4, 1958 E. S. STODDARD 2,825,665

DISHWASHER APPARATUS AND METHOD

Filed Sept. 29, 1953 7 Sheets-Sheet 1

FIG. 1



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DISHWASHER APPARATUS AND METHOD

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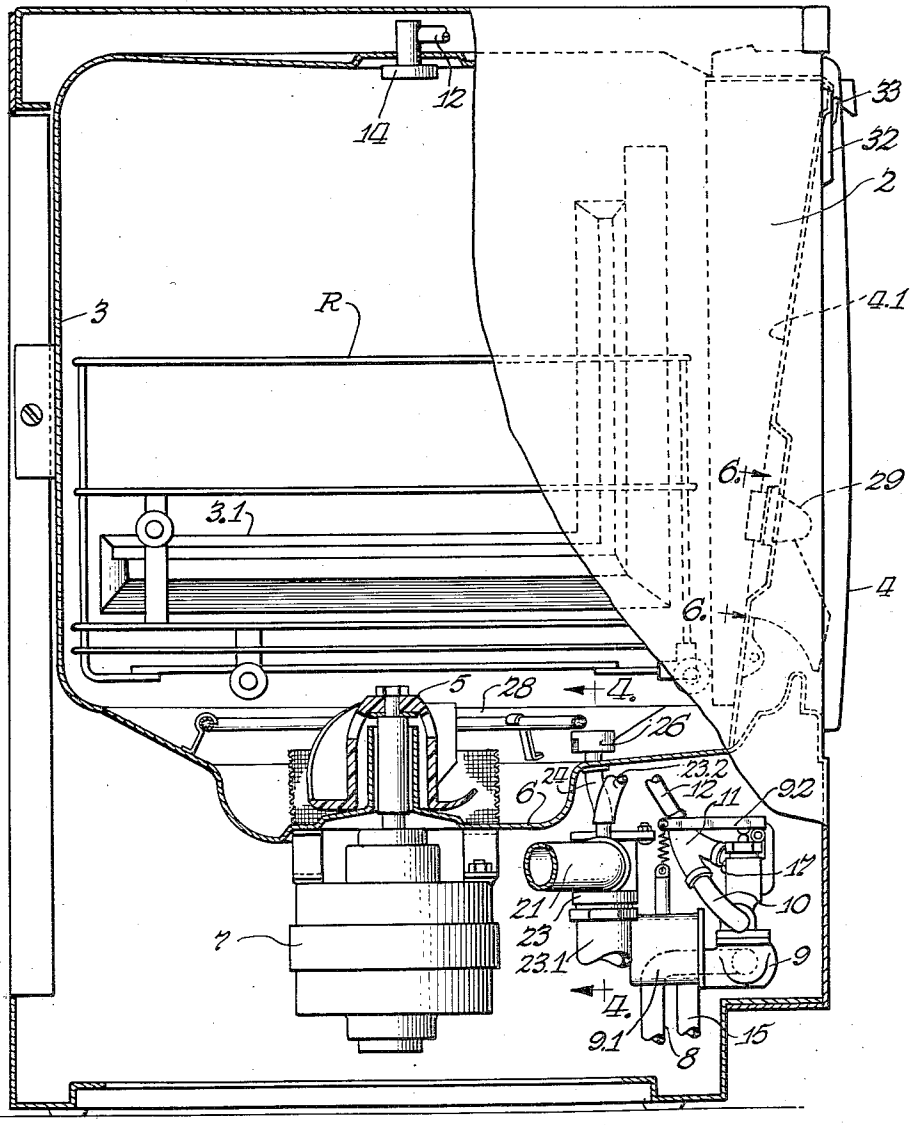
FIG. 2



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DISHWASHER APPARATUS AND METHOD

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FIG. 3

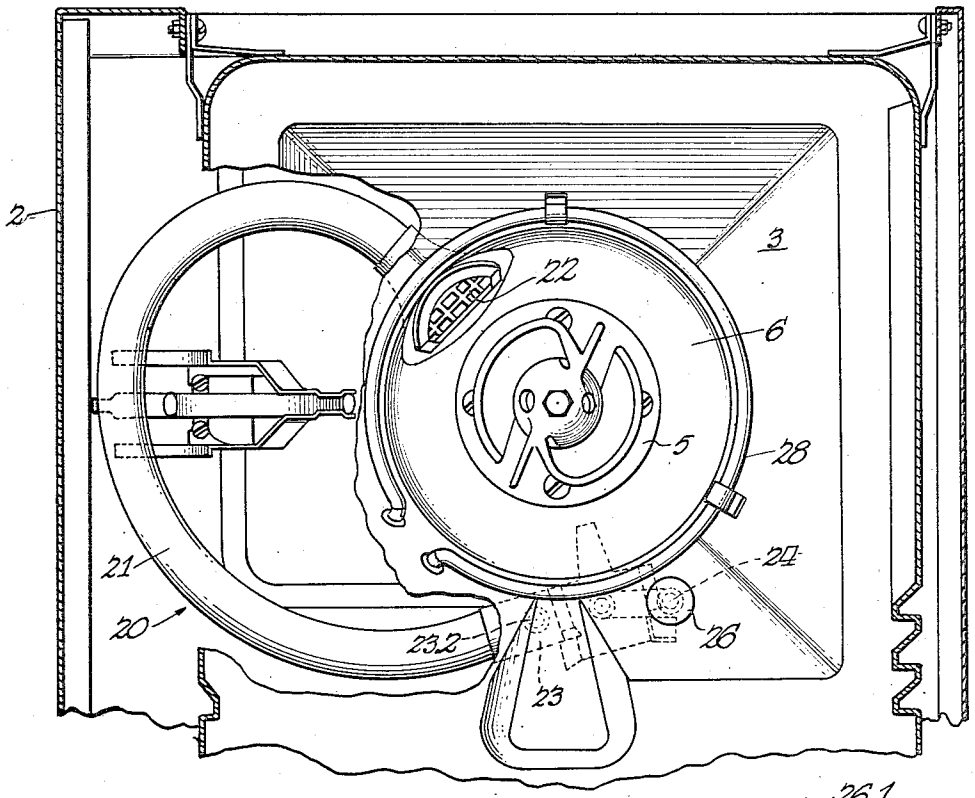


FIG. 4

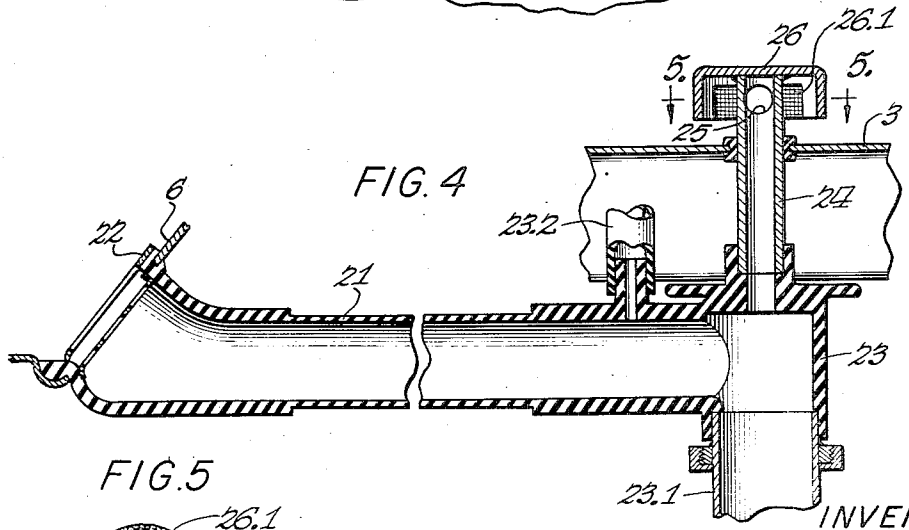
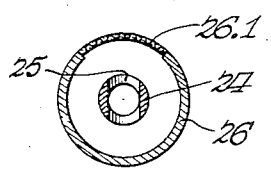


FIG. 5



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DISHWASHER APPARATUS AND METHOD

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FIG. 6

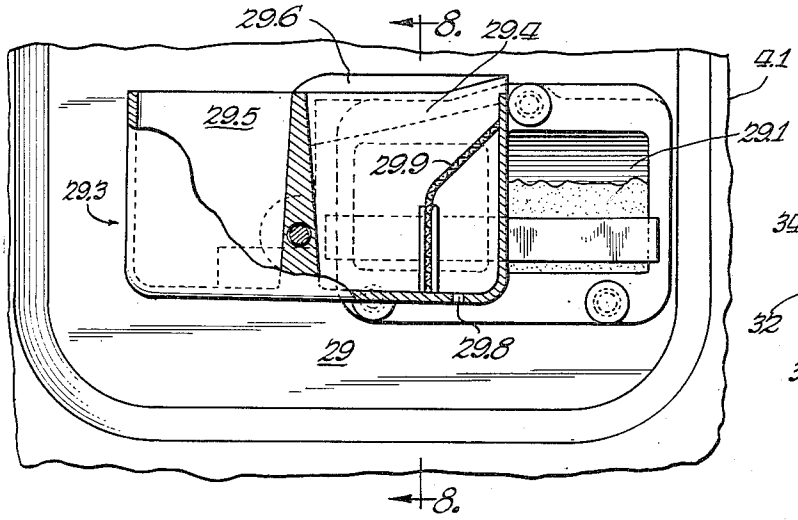


FIG. 9

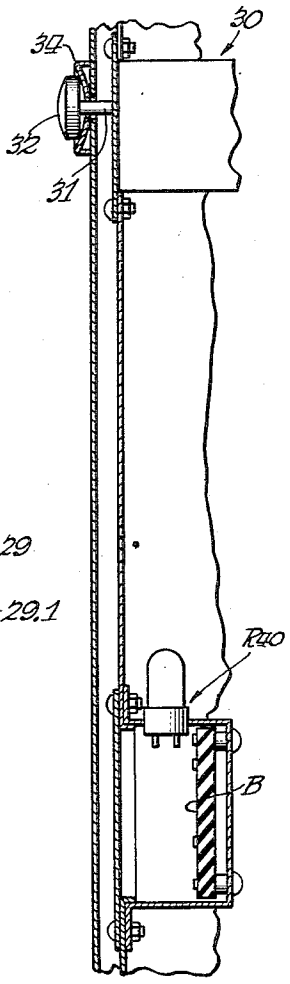


FIG. 7

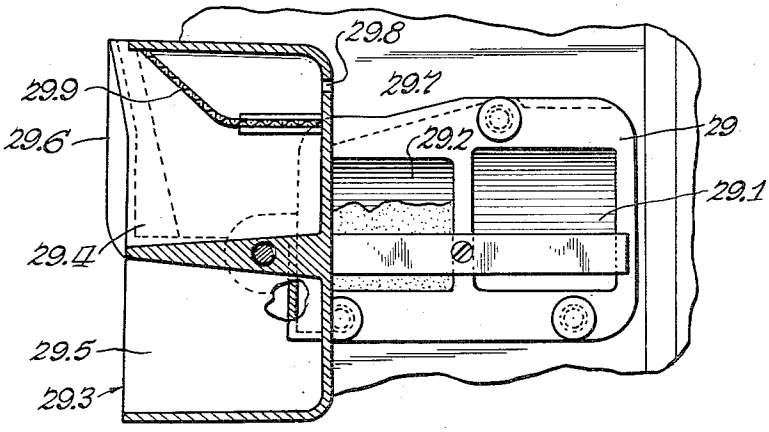
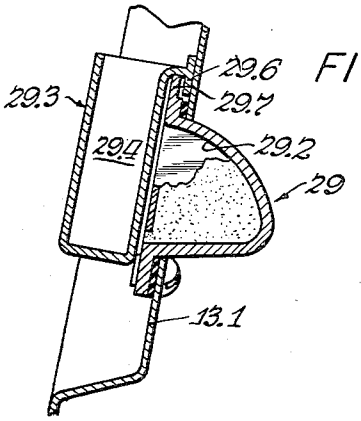


FIG. 8



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DISHWASHER APPARATUS AND METHOD

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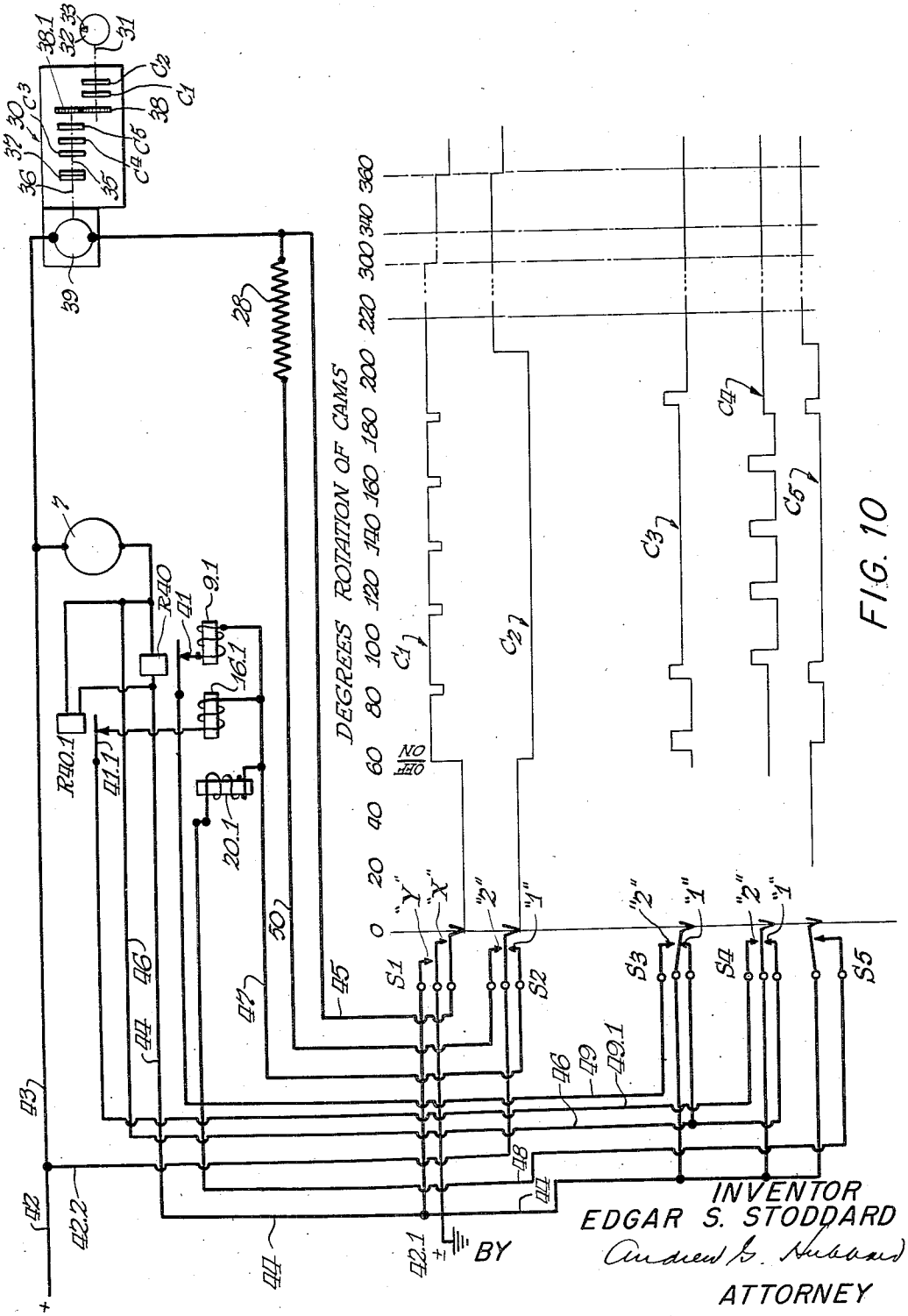

FIG. 10

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DISHWASHER APPARATUS AND METHOD

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FIG. 11

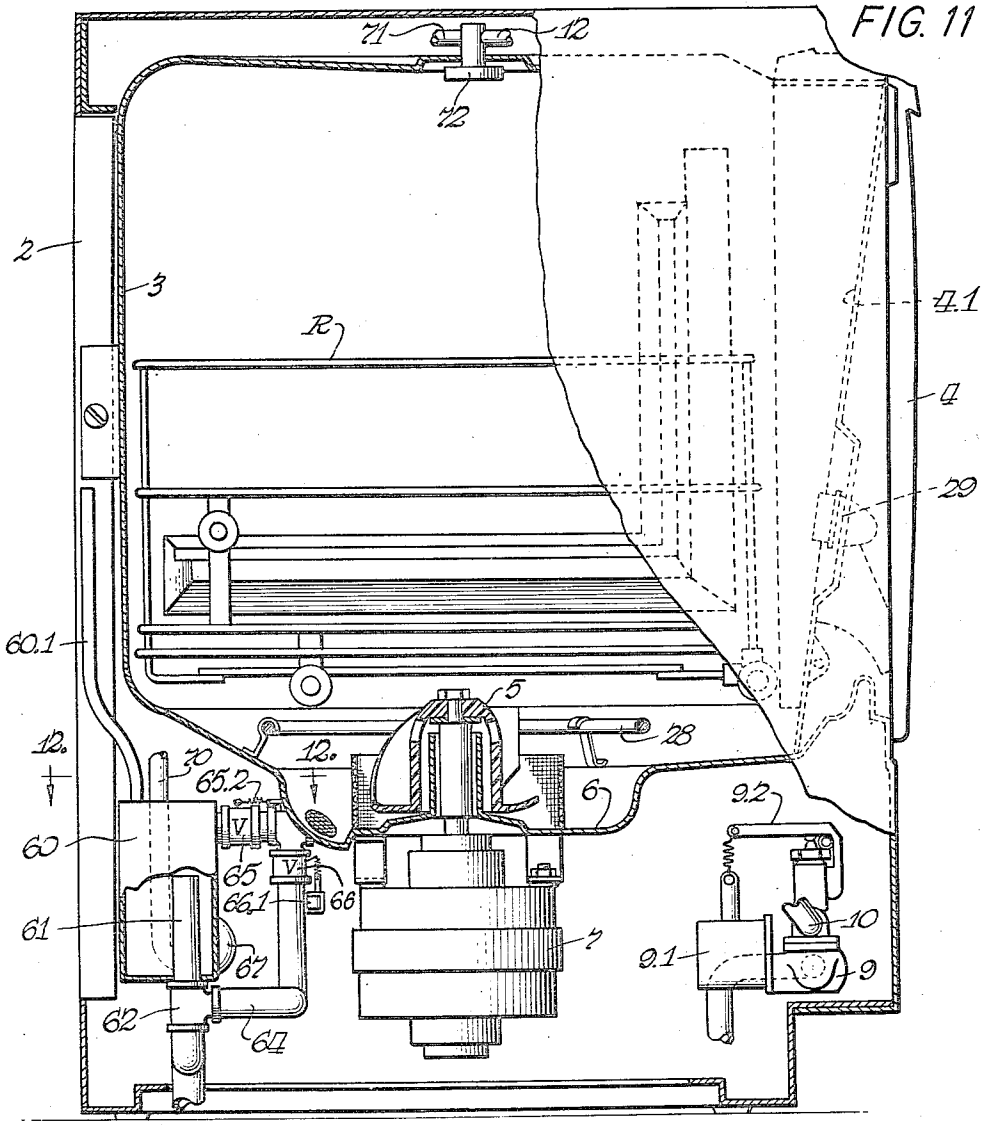


FIG. 12

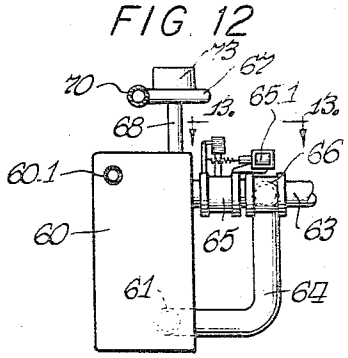
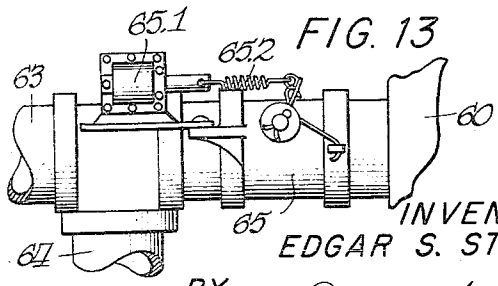


FIG. 13



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DISHWASHER APPARATUS AND METHOD

Filed Sept. 29, 1953 7 Sheets-Sheet 7

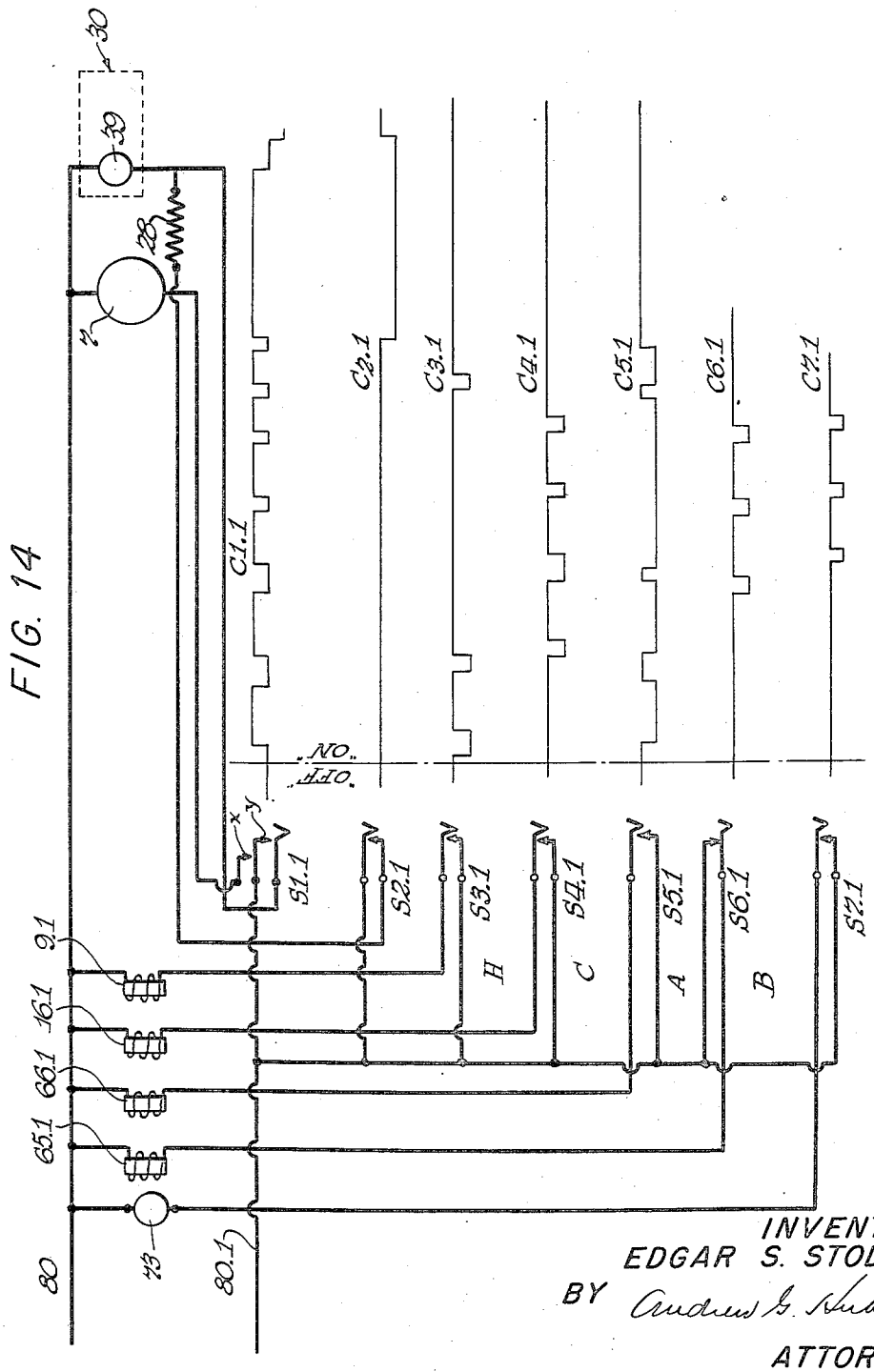

FIG. 14

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United States Patent Office 2,825,665 Patented Mar. 4, 1958

2,825,665

DISHWASHER APPARATUS AND METHOD

Edgar S. Stoddard, Berwyn, Ill., assignor to General Electric Company, a corporation of New York

Application September 29, 1953, Serial No. 382,901

16 Claims. (Cl. 134—25)

This invention relates to dishwashing apparatus, and to methods of washing dishes and the like.

It is an object of the invention to provide dishwashing apparatus embodying means for effecting a new cycle of operation for washing, rinsing, and drying dishes, cooking utensils, table silver and the like.

It is an object of the invention to provide dishwashing apparatus which will produce superior cleaning results with less use of heated water than in present dishwashing machines.

It is another object of the invention to provide dishwashing apparatus which will make more efficient use of detergent than present dishwashing machines.

It is an object of the invention to provide a method of washing dishes which will substantially eliminate the retention on the dishes and the like of soil which may have been redeposited during earlier stages of the dishwasher operation.

It is an object of the invention to provide a method of washing dishes which includes the steps of removing the gross soil from the dishes by washing with heated detergent solution, draining said solution from the apparatus and subsequently washing the dishes with a substantially equal quantity of unheated washing liquid of substantially equivalent detergent concentration.

It is another object of the invention to provide a method of washing dishes which includes the steps of washing the dishes a plurality of times with fresh charges of washing liquid of substantially equal detergent strength and then washing the dishes an additional number of times with charges of washing solution of successively lessened detergent strength without limitation as to the relative temperatures of the washing solution.

It is still another object of the invention to provide a method of washing dishes which includes a plurality of washing and rinsing steps in which selected steps may use heated washing liquid and other steps may use unheated washing liquid.

It is a further object of the invention to provide a method of washing dishes in which at least one washing step is carried out with a detergent solution at a temperature effectively minimizing the precipitation of calcium carbonate or like "hard water" constituents from the washing liquid onto the dishes and the like.

Workers in the dishwasher art know that a dishwasher user appears to judge the performance of the machine mainly by the appearance of the washed glassware. Many of the complaints received by dishwasher manufacturers have to do with spotty or filmy glassware. It has been popular to ascribe this unclean glassware appearance to "hard" water and the precipitation on the glassware of calcium carbonate and other substantially insoluble components of such water. Unquestionably, such precipitation is a factor, but after extensive research, I have determined that a very large percentage of glassware spotting —and of course spotting is present, although less noticeable, on chinaware and other opaque articles—results from redeposition of soil previously removed from the

articles by the detergent solution. Redeposition results from the inability of the detergent solution, during a single washing operation, to sequester and carry away all of the soil load, with the result that soil which separates from the solution is caught by articles in the vat, or deposits on the walls and bottom of the vat. I, therefore, employ a succession of washing operations, in each of which the temperature and detergent concentration of the detergent solution is adapted to the soil condition at the commencement of the washing operation.

In preferred embodiments of the invention, dishwashing apparatus which is conventional in many respects is arranged to carry out the plurality of washing operations with minimum expenditure of heated water and detergent. The method of washing dishes embodying the invention provides a cycle of operations which operates to remove loose soil from the dishes by a heated water spray rinse which is also effective to raise the temperature of animal fats in the food soil at least close to the softening or liquefaction point thereof; to wash the articles in a detergent solution having a temperature and detergent composition effective to complete the liquefaction and emulsification of the animal fats and to support the food soil for complete drainage from the machine; to rinse the articles with clear, heated water; to wash the articles a second time with a full strength detergent solution comprised of unheated water; to effect successive washes of the articles with detergent solutions comprised of approximately one-half of the effluent from the immediately previous wash and one-half clear, unheated water; to provide a final clear, heated water rinse; and to provide a subsequent drying period.

The advantages of such a cycle of operations are apparent. The gross soil, which may contain a large amount of animal fats, is subjected to the washing action of a detergent having a concentration capable of sequestering a large proportion of the soil, and a temperature which enables the detergent solution to hold and transport the soil load to the drain. The immediately succeeding clear, heated rinse disposes of food soil which may have dropped out of the detergent solution during passage to the drain and hence deposited on the walls or base of the vat. Thus, a large amount of the total soil is removed during the first two operations. However, because of the heterogeneous nature of the contents of the dishwasher, and the large number of individual items, there is ample opportunity for a redeposition of food soil particles on the contents. The next wash operation permeates the washing vat with another detergent solution of full detergent concentration. The sequestering effect of the solution is high. Initially, the temperature of the solution is low because it is comprised of unheated water, but its temperature rises during the second washing operation by heat transfer from the vat and its contents, which had, at this stage of operation, been subjected to two heated water rinses and one heated water washing operation. Therefore, the capacity of the second washing solution to sequester and support the soil load as it existed at the commencement of the second wash is entirely adequate. The remaining unheated water rinses, and wash operations with successively lessened detergent concentrations, are directed primarily to removing any redeposited particles of food soil. The vat and its contents have now given up their heat, and the detergent solutions have no appreciable temperature rise. The unheated solutions, however, are adequate to support and carry to the drain the relatively small amounts of food soil as yet undisposed of. It is important to note that unheated detergent solutions do not precipitate calcium carbonates to any objectionable degree, thus preventing the spotting of the dishes and glassware from this source. The final clean water rinse flushes away

the last traces of detergent solution. Although an unheated rinse would be adequate, the surface tension of heated water is less than that of unheated water, and by using a heated water final rinse I reduce the number of large droplets of water which may be retained on the dishes and other articles. The increase in temperature of the articles by absorption of heat from the final rinse water also improves the effectiveness of the hot-air drying cycle which follows.

The illustrated mechanical embodiments of the invention relate specifically to means for forming the later-stage solutions by mixing with unheated clear water, approximately one-half of the detergent solution remaining from a previous wash and discarding the remainder of said previous detergent solution.

Other features and advantages of the invention will be apparent from the following detailed description of the preferred embodiments read in connection with the accompanying drawings, in which:

Fig. 1 is a front elevation of a dishwasher embodying my invention, with certain portions of the dishwasher housing and vat broken away to reveal underlying structure;

Fig. 2 is a fragmentary side elevation thereof;

Fig. 3 is a plan section, looking in the direction of the arrows 3—3 of Fig. 1;

Fig. 4 is a side sectional elevation of the drainage system shown in Fig. 3;

Fig. 5 is a detail of the supplemental drainage tube;

Figs. 6, 7, and 8 are details of a detergent dispenser which may be used in dishwashing apparatus embodying the present invention;

Fig. 9 is a side elevation, in section on lines 9—9 of Fig. 1, showing a suitable arrangement of the timing and other control mechanism;

Fig. 10 is a schematic control circuit diagram for the dishwashing apparatus of the type shown in Fig. 2;

Fig. 11 is a front elevational view, partly in section, of a second embodiment of dishwashing apparatus;

Fig. 12 is a top plan view of a drainage system employed in the dishwashing apparatus of Fig. 11;

Fig. 13 is a side elevation of a valve mechanism suitable for use with the drainage system of Fig. 12; and

Fig. 14 is a schematic control circuit for the dishwashing apparatus of Fig. 11.

General description

Referring now to Figs. 1 and 2 of the drawings, the dishwasher apparatus 1 is of the general type of that disclosed in my U. S. Patent 2,635,941, granted April 21, 1953, for washing apparatus, but embodying a new drainage system, later described. The apparatus also includes a multiple detergent dispenser as disclosed in the pending application of John C. Sharp and Leonard J. Martiniak, Serial No. 309,588, filed September 15, 1952, now Patent 2,711,178, granted June 21, 1955, for Dishwashing Apparatus with Automatic Detergent-Dispensing Means, and assigned to my present assignee. The dishwashing apparatus cabinet 2 houses a substantially vertically disposed vat 3. The cabinet and vat have aligned front openings that are closed by a front door 4. The front door is preferably provided with ventilation louvers (not shown) as described and claimed in my said patent; and it is pivotally mounted adjacent the lower edge thereof within the lower portion of the vat 3 so as to be movable between a substantially vertical closed position and a substantially horizontal open position. It will be understood that suitable means (not shown) prevent leakage of liquid about the margins of the closed door. The dishwashing apparatus has in the side walls of its vat an arrangement of embossed rails 3.1 on which is slidably mounted a rack "R." Said rack is formed with a plurality of wire loops and other structures to support in mutually spaced relation a quantity of dishes, cups, saucers, cooking utensils, articles of table silver, and other items (not shown) normally associated with the preparation and serving of a meal. In the following description, these articles, of whatever nature, will be referred to merely as "dishes." The rack "R" is movable into and out of the vat 3 through the front openings when the door 4 occupies its open position. An arrangement of this sort is described and claimed in the Forrest A. Walker application S. N. 57,448, filed October 30, 1948, for Dishwashing Apparatus and Cabinet Structure, now U. S. Patent 2,657,697, granted November 3, 1953, and also assigned to my present assignee. An impeller 5 is arranged within a sump 6 formed in the lower portion of the vat and is rotated by an associated electric motor 7 for establishing a washing action within the vat 3 by picking up liquid from the sump and discharging it in a generally upward direction among the dishes racked within the vat.

For supplying heated water to the vat, there is provided an inlet conduit 8 connected to a suitable source, such as the storage tank (not shown) of a water heater capable of delivering water at a temperature of the order of 150° F. to the inlet port of an inlet valve 9 of the solenoid operated type; and the outlet conduit 10 of valve 9 communicates by way of a Y connection 11 (Fig. 2) with a conduit 12 that is connected to a vat inlet fitting such as a spraying device 14 arranged substantially centrally of the top wall of the vat 3. The inlet valve 9 is of the fast-opening, slow-closing type, being governed by an associated dashpot to prevent water hammer in the plumbing communicating with the heated water inlet conduit 8. The inlet valve 9 is normally biased to its closed position and when the solenoid 9.1 thereof is energized, the valve is operated by the lever system 9.2 to open position to supply water from the conduit 8 to the device 14, whereby the heated water is sprayed downwardly from the top of the vat, circulates forcefully among the racked dishes, and accumulates in the sump 6. Subsequently, when the solenoid 9.1 of the valve is de-energized, the valve moves slowly from its open position to its closed position.

For supplying unheated water to the vat, there is provided an inlet conduit 15 communicating with the "cold" water supply piping (not shown) of the building, and connecting to a solenoid operated valve 16, see Fig. 1, similar to the valve 9. The outlet conduit 17 of the said valve communicates by way of the other branch of the Y connection 11 with the conduit 12 serving the spraying device. When the solenoid 16.1 (Fig. 10) associated with valve 16 is energized, said valve is opened to supply unheated water to the dishwashing apparatus.

Drainage control

For the purpose of controlling the escape and retention of washing liquid in the sump 6, I provide primary and secondary drain systems. The primary system may advantageously be of the type disclosed in my presently pending application, S. N. 86,291, filed April 8, 1951, for "Drain Control Mechanism for Washing Apparatus," now U. S. Patent 2,652,854, granted September 22, 1953, and assigned to my present assignee. For example, the primary system 20 may comprise a flexible conduit 21, Figs. 1, 3, and 4, one end of which communicates with a drain fixture 22 provided in the lower portion of the sump 6 and the other end of which communicates by way of a T fitting 23 with a drain pipe 23.1 connected by way of a trap or the like (not shown) to drainage plumbing, not shown. The flexible conduit 21 is normally biased into its lower position in order to place the interior of the sump 6 into draining communication with the drain conduit so that any washing liquid accumulating in the sump 6 runs through the flexible conduit into the drainage plumbing. When the solenoid 20.1 thereof is energized, the central portion of the flexible conduit 21 is elevated into a raised position in order to cut off the draining communication between the interior of the sump 6 and the drainage plumbing, so that washing liquid may be re-

tained in the sump. Subsequently, when the solenoid **20.1** is de-energized, the drain conduit **21** returns automatically to its draining position. The T fitting **23** is provided with a vent pipe **23.2** to prevent air or vapor lock.

The secondary drain system may comprise a simple standpipe **24** communicating directly with the T fitting **23**, as shown in Fig. 4. The standpipe passes through the bottom wall of the vat **3** adjacent the sump **6** and of course the joint between the wall of the vat and the standpipe is made water-tight by any suitable means. An inlet opening **25** near the upper end of the standpipe faces the sump. A ventilated cap **26** prevents inflow of liquid except through the opening **25**. Said cap may be screened, as indicated at **26.1**, Fig. 5. As is well understood in the dishwasher art, when the impeller **5** is rotating during the washing and rinsing operations, the washing or rinsing liquid is thrown violently about by the impeller, and although the usual quantity of water in the vat at those times is of the order of 12 pints, and, as such, sufficient to submerge the inlet opening only a small portion of it is actually in the sump **6** or evident on the bottom of the vat **3** about the standpipe when the impeller is operating. The liquid returning to the sump is quickly caught up by the impeller and thrown upwardly through the stacked dishes. The return to the sump is mainly a matter of flow in relatively thin sheets along the side walls and bottom of the vat and along the inner panel of the front door. There is also, of course, a considerable amount of drippage from the dishes directly into the sump.

In any event, the relatively shallow layer of water passing about the pipe **24** will not overflow in any substantial amount into the opening **25** thereof. When the impeller is operating and the primary drainage system **20** is in non-draining position, very little liquid will escape from the vat into the drain pipe **23.1**. When the impeller is still and the primary drainage system is in non-draining position, the liquid accumulates in the sump and in the bottom portion of the vat communicating therewith. As the liquid rises to the opening **25**, it passes through pipe **24** to the drainage fitting **23**. By an appropriate location of the standpipe and its opening **25**, approximately one-half of the liquid in the vat may be caused to pass through the opening before the level of free liquid falls below said opening. There will thus be left in the vat approximately six pints of liquid for reuse as later described.

For the purpose of drying the dishes and other utensils supported by the rack "R" within the vat **3**, there is preferably provided a heating unit **28** of the sheathed resistance conductor type. Said heating unit is disposed in the lower portion of the vat surrounding the impeller **5** so that air circulated over the heating unit by the blades of the rotating impeller abstracts heat from the unit and then circulates among the dishes to dry the same.

Detergent introduction

Within a depression formed in the inner door panel **4.1**, there is mounted a multiple detergent dispenser **29** as disclosed in the above noted Sharp and Martiniak patent. The dispenser is formed with two chambers, **29.1** and **29.2**, as best appears in Figs. 6 and 7, opening toward the interior of the vat **3**, and each chamber is arranged to receive a charge of powdered detergent. Pivotally mounted on the front of the dispenser is a gate **29.3** having two water receiving cups **29.4** and **29.5**; the pivot point is in the wall separating said cups as shown in Fig. 6. The gate is arranged so that the weight of cup **29.4** rotates the gate into the position in which a wall of said cup covers the chamber **29.2**. A flange **29.6** at the top of cup **29.4** freely fits behind a wall **29.7** of the dispenser (see Fig. 8) and the combination of the top wall and the interfitting flange and wall formation prevents water from entering chamber **29.2** while the gate is in its closed position. It will be noted that there is a drainage opening **29.8** at the bottom of cup **29.4**; said drainage opening is protected by the removable screen **29.9** against clogging by particles of food soil which may enter the cup **29.4** during the operation of the dishwasher.

When the user returns the loaded rack "R" to the vat, he places a substantially equal charge of detergent in each of the chambers **29.1** and **29.2**, moves the gate to its Fig. 6 position and closes the door **4**. In anticipation of the hereinafter detailed description of the control mechanism and operation of the dishwasher, it may be noted here that the operation of the detergent dispenser is as follows:

During the preliminary rinse period when the drain valve is in its drainage position, the water passing among the dishes stacked in the rack "R" does not produce a flow pattern sufficient to cause any appreciable amount of water to enter the chamber **29.1** and the detergent therein is substantially undisturbed. When the drain valve is closed (that is, moved to non-draining position) water accumulates within the sump **6** and is thrown violently among the dishes; there is at this time a total quantity of about 12 pints of water within the vat and there is a strong water action within the vat. Water flows into the open chamber **29.1**, bringing the detergent into solution to produce, quickly, the desired washing liquid within the vat. During this operation, the respective cups **29.4** and **29.5** are being filled with water, and because the water is entering cup **29.4** faster than it may drain through the opening **29.8**, the gate **29.3** will remain in its Fig. 6 position in which the detergent in chamber **29.2** is adequately protected against water action. Following the first washing operation, which may last for two minutes or more, the impeller is stopped and the drain valve returned to drainage position. During the drainage interval the spent washing liquid is evacuated from the vat, and during said period, also, water is escaping from the cup **29.4** through its drainage opening **29.8**. The gate then attains a condition wherein the water remaining in cup **29.5** overbalances the gate, which rotates to the Fig. 7 position and exposes the detergent charge in chamber **29.2**. During a subsequent washing action, water enters the chamber **29.2** and causes the detergent charge therein to be introduced into the vat **4** to provide a second substantially full-strength, washing solution.

Operational cycle and control system

The following operational cycle (it being understood that the time charged against each individual operation is by way of example only) produces excellent dishwashing results and minimum spotting of glassware with the machine of the Fig. 2 embodiment using detergent of the type sold under the trade name "Calgonite," comprising about 40% hexamethaphosphate or similar material, about 55% sodium metasilicate, and about 1% of an appropriate wetting agent:

A. Heated water inlet valve open for 45 second spray rinse; drain open; impeller operation optional.

B. Close drain valve; heated water inlet valve remains open to admit full amount (approximately 12 pints) of heated water and effect addition of detergent; impeller in operation.

C. Close inlet valve and wash for two minutes.

D. Open drain valve for complete evacuation of wash liquid. Impeller operation optional, but preferably still.

E. 45 second heated water spray rinse to remove residue from dishes and walls of vat; drain open; impeller rotation optional.

F. Close drain valve at end of spray rinse.

G. With impeller running, open unheated water inlet valve to admit full amount of unheated water and effect addition of second detergent charge.

H. Close inlet valve and wash for two minutes.

I. Stop impeller, permitting secondary drain facility to evacuate about one-half of the wash liquid.

J. Start impeller; open inlet valve to add unheated make-up water to re-establish 12 pints of wash liquid.

K. Close inlet valve and wash for two minutes. Repeat "I," "J," and "K" for additional washings with successively weakened detergent solutions.

L. Stop impeller; open drain valve for complete evacuation of final wash liquid.

M. Close drain valve.

N. Start impeller; open heated water inlet valve to add approximately 12 pints of heated clear water for rinsing.

O. Rinse for two minutes, with impeller rotating.

P. Stop impeller; open drain valve for complete evacuation of rinse water.

Q. Drying operation with heater on coincident with admission of final rinse water or following end of final rinse, as desired. Impeller operating through major portion of drying period.

The foregoing sequence of operations and modifications thereof may be accomplished by appropriately contoured switch operating cams in a suitable timer-motor-operated program selector switch, based for example on the disclosure of the Ralph L. Berg Patent No. 2,536,256, granted January 2, 1951, for "Program Selector Switch," or on other types of switches now well known in the art. The cam operated switches of the program selector switch (hereinafter referred to as the "timer") will effect the properly coordinated operation of the impeller motor 7, inlet valves 9 and 16, drain valve 29, and heater 28, to accomplish the desired operational program. It will be assumed that the apparatus and control devices are powered from a common source of electric power, usually 115 v. 60 cycle A. C.

The timer 30 is conveniently mounted at an upper portion of the cabinet exteriorly of the vat 3, as shown in Figs. 1 and 9. It is appropriately wired in a circuit control network including the motor 7, the solenoids 9.1, 16.1 and 20.1, the heating element 28, and the measuring coil or relay R40. It is often the practice to include in the control circuit a door-operated switch (not shown) which comprises merely a switch wired into one side of the line and operated by the door 4 from a closed circuit position effected by closing the door to an open circuit position as the door reaches an ajar position as it is being opened. Such a switch exercises a primary control over the operation of the machine and insures, for example, that all operations will be stopped at any mid-cycle position to permit one to open the dishwasher door to add articles to be washed, etc. However, the door switch has no actual function in the control cycle, and it has not been included in the control circuit shown in Fig. 10. The heated water measuring coil R40 and the unheated water measuring coil R40.1 are also suitably supported within the cabinet 2 exteriorly of the vat, preferably convenient to an insulated connector block B comprising a back panel of a connection box at a low point of the casing. The respective measuring coils are of the marginal relay type, each being provided with an armature (not shown) respectively controlling a pair of contacts 41 and 41.1 in the control circuit. The timer housing provides journaling points for the rotatable shaft 31 which projects forwardly through an opening provided in the front wall of the cabinet. A manual control knob 32 is removably secured to the end of said shaft and carries a pointer 33 which cooperates with indicia such as the "off" index and the "on" index marked on an escutcheon plate 34 fixed to the cabinet wall. There is a second rotatable shaft 35 and a stub shaft 36 appropriately journaled within the housing. These shafts are adjacent shaft 31 and carry a friction clutch 37 of any conventional design permitting shafts 35 and 36 to be rotated relative to each other. Shafts 31 and 35 are interconnected by gearing including the meshed pinions 38 and 38.1. Pinion 38 is secured to shaft 31 and has "N" times as many teeth as the pinion 38.1 secured to shaft 35. Timer 30 is driven by a motor unit 39 of the well known "Telechron" type driving shaft 36 at a rate of "N" revolutions per hour by means of suitable intermediary speed reducing gearing. By reason of the pinions 38 and 38.1, shaft 31 is rotated at 1:N revolutions per hour. The friction clutch 37 permits the shaft 31 to be manually rotated by means of the knob 32 without damage to the motor unit 39. As later appears when the shaft 31 is manually rotated slightly more than 60 degrees, pointer 33 is brought from its "off" index to the "on" index and the dishwashing cycle begins.

Two insulated cams C1 and C2 are rigidly secured to shaft 31 and respectively cooperate with the sets of switch springs diagrammatically illustrated at S1 and S2. Similarly, three insulating cams C3, C4 and C5 are rigidly secured to the shaft 35 and respectively cooperate with sets of switch springs diagrammatically illustrated at S3, S4 and S5. The contacts "X" and "Y" of the timer switch S1 may be referred to as "timer contacts" and the contacts of switches S2, S3, S4 and S5 as "switching contacts." It will be noted that in switch S1, timer contacts "X" are closed before contacts "Y," and contacts "Y" are opened before contacts "X" in the two movements of the main spring of said switch. Each of the switches "S2," "S3," and "S4" is of the single pole, double throw type, and switch "S5" is of the single pole, single throw type. For simplicity of illustration, the pinions 38 and 38.1 are in 1:1 ratio, although it will be understood that in practice cams C3, C4 and C5 would be driven at twice or three times the speed of cams C1 and C2 so as more effectively to use the peripheries of said cams C3, C4 and C5.

In the "off" position of knob 32, cam C1 establishes switch S1 with its contacts "X" and "Y" in open circuit condition; cam C2 establishes switch S2 with its contacts "1" and "2" in open circuit condition; cam C3 establishes switch S3 with its contact "1" closed and its contact "2" open; cam C4 establishes switch S4 with its contacts "1" and "2" in open circuit condition; and cam C5 establishes switch S5 with its contacts in open circuit condition.

It will be understood that rotation of shaft 31 to its "on" position has the effect of moving the diagrammatic representations of the cams to the left relative to the sets of switch springs and that the timer motor drive continues said cams in their leftward movement. When shaft 31 is brought to its "on" position, therefore, the lowermost spring of switch S1 is engaged by the high portion of cam C1 closing the contacts "X" and "Y" of switch S1; and the intermediate spring of switch S2 drops to the lowest position of cam C2 causing closure of the contacts "1" of said switch. Also at this time, the intermediate spring of switch S3 is on the lowest portion of cam C3 maintaining the closed circuit position of contacts "1" of said switch S3; in the set of switch springs S4, the intermediate spring is on the median point of cam C4 maintaining the contacts "1" and "2" of said switch S4 in open circuit position; and in the set of switch springs S5, the upper spring is engaged by the high portion of cam C5 which causes separation of the associated contacts.

These switch relationships establish an operating circuit, as follows:

Conductor 42.1, contacts "Y" of switch S1, conductor 44, contacts "1" of switch S3, conductor 46, motor 7 and conductors 43 and 42. The impeller is then being rotated by motor 7 at its operating speed. Also in switch S1, the closure of contacts "X" energizes the timer motor 39 through the obvious circuit. After a brief interval, a high portion of cam C3 engages the intermediate spring of the set of switch springs S3 to separate the contacts "1" and close the contacts "2" thereof. When said contacts "1" open, the previously traced circuit energizing motor 7 is interrupted and the conductors 44 and 46 no longer provide the shunt circuit for the

measuring coils R40 and R40.1. Instead, the motor operating circuit includes the measuring coils; the circuit may be traced from conductors 43 and 44 through contacts "Y" of switch S1 to the neutral conductor 42.1. The measuring coils, each comprising a marginal relay, will not open their contacts at this time, because there is no water in the sump 6 and the current demand of the motor 7 is light.

The closure of contacts "2" of switch S3 completes a circuit to energize solenoid 9.1 of heated water inlet valve 9; said circuit includes conductor 42.2, contacts "1" of switch S2, conductor 47, solenoid 9.1, closed contacts 41 of the measuring coil R40, conductor 49, contacts "2" of switch S3, conductor 44, timer contacts "Y," and conductor 42.1. Solenoid 16.1 of the unheated water inlet valve 16 will remain de-energized because the control contacts "2" of switch S4 are open.

Energizing the solenoid 9.1 operates the inlet valve 9 to open position, whereupon heated water is supplied to the vat inlet device 14. The water sprays downwardly through the stacked dishes and enters the sump 6. Some of the water is caught by the impeller and flung against the dishes, aiding in the removal of loose soil. The rinsing liquid drains throught the drain valve organization 20, it being then in its drain position. The first spray operation continues for about 45 seconds, as previously noted.

As the conclusion of this spray operation, the upper spring of switch S5 drops to a low point of cam C5, closing a circuit which energizes solenoid 20.1 to operate the drain valve to closed position. This circuit includes conductor 42.2, contacts "1" of switch S2, conductor 47, solenoid 20.1, conductor 48, switch S5, conductor 44, timer contacts "Y," and conductor 42.1. The liquid continues to enter the vat through the inlet device and accumulates in the sump. The impeller 5 is still operating; and as the load imposed upon motor 7 increases, the current traversing the motor and the measuring coils increases. When the vat has accumulated the full quantity of washing liquid (approximately 12 pints), the current drawn by the motor is at the operating level of the respective measuring coils, which thereupon open their respective contacts. The opening of contacts 41 interrupts the circuit to the heated water inlet valve solenoid 9.1 and water inflow ceases.

The measuring coils insure that the inlet will remain open until the proper fill is made even though low water pressures may reduce the rate of inflow of water. If domestic water pressures were uniform throughout the country, a simple time control would suffice for a fill valve having an orifice calculated to deliver the desired amount of water to the vat in a predetermined amount of time. As a safety measure against failure of coil R40 to open its contacts 41, however, cam C3 is configurated to cause the intermediate spring leaf of switch S3 to open its contacts "2" and close its contacts "1" about 45 seconds after the drain valve has been operated to non-draining position. This re-establishes the original direct motor circuit for motor 7 and again shunts out the measuring coils, which thereupon drop the respective contacts 41 and 41.1, to closed circuit position. This is without effect on the heated water inlet valve, because the circuit to the solenoid 9.1 thereof is broken at the contacts "2" of switch S3. It is likewise without effect on the unheated water inlet valve. The first washing step continues for about two minutes during which time the water evacuates the detergent from chamber 29.1 and provides within the vat an effective detergent solution.

At the conclusion of the first washing step, a high point of cam C5 engages the spring of switch S5, opening the contacts of said switch and thus interrupting the circuit to the drain valve solenoid, whereby the drain valve returns to draining position. It is advantageous to stop the motor 7 during this drainage in order to prevent redeposition of soil on the dishes. Accordingly, cam C1 is configurated to drop the lowermost spring of the set of switch springs S1 to effect the opening of contacts "Y" thereof, thereby breaking the motor circuit without interrupting the timer motor circuit established by contacts "X." The liquid drains quickly from the vat. At this stage, cam C1 again closes the timer contacts "Y" to re-energize the motor 7 to drive the impeller associated therewith. Also at this time, the contacts "2" of switch S3 are closed, re-establishing the measuring coil in the motor circuit and energizing the heated water inlet valve coil 9.1 in the manner previously explained. The dishes are again sprayed with heated rinsing water for approximately 45 seconds during which the drain valve is open. Cam C3 thereupon drops the central spring of switch S3 to the intermediate position at which contacts "1" and "2" of said switch are open. The drain valve is closed as the spring of switch S5 drops to the low point of cam C5 again to complete the circuit to the drain valve operating solenoid 20.1. In overlapping relationship with the operation of cam C3, cam C4 rises from its intermediate position to close contacts "2" of switch S4, energizing the unheated water inlet valve coil 16.1. This admits unheated water into the vat. The measuring coil R40.1 assumes primary control over the quantity of water introduced, but after about 45 seconds, the intermediate spring of switch S4 drops to a low point of cam C4 to open the circuit to solenoid 16.1, and establish the motor circuit through conductors 42, 43, motor 7, conductor 46, contacts "1" of switch S4, conductor 44, contacts "Y" of switch S1, and conductor 42.1. The second washing operation is then under way and the second charge of detergent mixes with the unheated water to form a second substantially full strength, detergent solution.

As indicated by the foregoing schedule of operations, only about one-half of the washing solution is to be discarded at the end of this second wash period. This is accomplished by stopping the motor 7 to permit the solution to flow into the drain pipe 23.1 only through the standpipe 24. As previously noted, the inlet to said standpipe is so placed that when about one-half of the liquid has discharged to the drain, the level of the liquid remaining in the sump will be below the inlet. Cam C1 is configurated to maintain the open circuit of the motor as previously described for a time interval insuring desired drainage. The motor starts again, and substantially coincidentally therewith cam C4 again closes contacts "2" of switch S4 to energize the inlet coil solenoid 16.1. It is obvious that a shorter fill time is required for completing the fill for the next wash period. The duration of the closure of contacts "2" of switch S4 may be suitably shortened, although with the fill control provided by the measuring coil R40.1, the closure periods may be kept uniform if desired. Cam C4 then causes contacts "2" of switch S4 to open, and contacts "1" thereof to close, shunting out coil R40.1 and breaking the circuit to coil 16.1.

A third wash then proceeds with an unheated water detergent solution. The solution is at approximately one-half strength, but is nevertheless effective to support the food soil remaining in the vat after the preceding washing and rinsing operations.

A fourth and fifth wash with successively less concentrations of detergent are carried out in the manner described above. At the end of the fifth wash, however, the drain valve solenoid is energized to effect complete removal of the final wash liquid. As previously, the motor is de-energized during draining. Cam C4 finally causes the intermediate switch spring of switch S4 to place both of the contacts "1" and "2" thereof in open circuit condition, inactivating the unheated water inlet valve.

The motor is then restarted and very shortly thereafter, heated rinse water is introduced by the action of cam C3, and after a fill period as previously described, cam C3 drops to close contacts "1" of switch S3, main-

taining the motor circuit but inactivating solenoid **9.1**. In suitable relation to the introduction of heated rinse water, cam **C5** causes the contacts of switch **S5** to close the circuit to solenoid **20.1**. As previously, the energized solenoid operates the drain valve system to non-draining position.

At the end of a final power rinse period of about two minutes, the drain valve solenoid is again de-energized, permitting complete and final drainage of the liquid from the machine. The motor **7** remains in operation. At this time, or prior thereto if desired, cam **C2** opens the contacts "1" of switch **S2** and closes the contacts "2" thereof, thus completing a circuit to the heating element **28**. The motor **7** and timer motor **39** remain in operation by reason of the continued closure of contacts "X" and "Y" of switch **S1** and the impeller is therefore effective to circulate heated air among the dishes to facilitate the drying thereof. After a suitable interval cam **C1** causes the contacts "Y" of switch **S1** to open, thus interrupting the motor **7** circuit while maintaining closed the circuit of timer motor **39** through contacts "X" of said switch. Drying then continues without air circulation for a predetermined time at the end of which the cam **C1** opens contacts "X" of switch **S1** and cam **C2** restores both contacts of switch **S2** to open circuit position. This operation coincides with the completion of the full rotation of the cams and the return of the pointer **33** to "off" position.

Although at the completion of the several washing operations of the complete operational cycle, there is so little food soil remaining in the final washing solution that a clear unheated water rinse would adequately serve the mechanics and objectives of the final rinse, I prefer the heated water rinse because of the lower surface tension of heated water as compared to unheated water, and the lessened possibility of retention of large drops on the dishes. Also, the heat released by the water raises the temperature within the vat and in this way assists the heating element in its drying function.

The total elapsed time for washing and rinsing is of the order of 25 minutes and the remaining time represented by the cam chart is devoted to drying. The friction clutch of the time control mechanism makes it possible manually to advance the control knob to eliminate or shorten any phase of the operation, as is now well understood in the art.

A second embodiment

In the embodiment of Figs. 11 through 14, all elements in common with the Fig. 2 embodiment carry the same reference characters. In lieu of the drain valve organization **20** of Fig. 2, however, the drainage system of the present embodiment comprises a tank **60**, the capacity of which is more than one-half of the full washing liquid charge of twelve pints, a pipe **61** communicating between said tank and the trap fitting **62**, a valved pipe **63** from the sump **6** to the tank **60**, and a valved drain **64** communicating between pipe **63** upstream of its valve and entering the trap fitting **62** below the tank. Pipe **61** performs a function similar to that of the standpipe **24** of the earlier embodiment, in that when all of the wash water is brought into the tank, about one-half of it will overflow into the pipe **61** for elimination. This makes the remainder of the liquid available for reuse as presently described. The provisions for the introduction of heated and unheated water are retained because such an arrangement is representative of the preferred embodiment of the invention. It should be understood, however, that all washing and rinsing operations may be carried out with heated water only. The primary objective of hot water economy is realized by the retention of approximately one-half of the previous washing solution and the resulting necessity for adding only a one-half portion of fresh water to restore the full volume of washing liquid.

Valve **65** in pipe **63** and valve **66** in drain **64** may be of any conventional solenoid operated gate type, although I prefer appropriate structural modifications of the valve shown in my Patent 2,271,993, granted February 3, 1942, for "Valve Construction for Washing Apparatus." The valves respectively have the solenoids **65.1** and **66.1** and spring biased as by the coil spring or equivalent **65.2**, Fig. 13, when the associated solenoid is de-energized, to establish the valve element thereof (not shown) in a free swinging position which corresponds to a "normally open" condition.

The effluent remaining in the tank **60** is made available for reuse by a pump **67** having its intake **68** communicating with the tank and its discharge connected by means of the tube **70** to an inlet fitting **71** of the device **72** through which the liquid is introduced into the vat. A second inlet portion of the device **72** comprises the terminus of the conduit **12** to which the outlet ports of the respective heated and unheated water inlet valves are connected as previously described. Tthe pump is driven by a suitable motor **73**, shown in Fig. 12 as mounted directly on the pump casing. It will be understood, of course, that the tank **60** is suitably vented as by the vent tube **60.1** which rises within the outer casing of the dishwasher to a point substantially above the maximum free water level in the vat.

It will therefore be seen that the valving arrangement of the drainage system of the present embodiment makes it possible completely to discharge to the plumbing drain, the effluent from a previous operation or to retain approximately one-half of the effluent for reuse in a future operation. Any number of complete drainages may be interposed between the operational stage at which the effluent is stored for reuse, and the actual time of such reuse.

The features of the instant embodiment will be apparent from the operational diagram of Fig. 14. With respect to said diagram, it may be noted that for simplification, all inlet valves are considered to be open for a fixed time interval calculated to provide the necessary quantities of water. It will be understood, however, that the circuit may be established to include, if desired, the measuring coil control system embodying the marginal relays **R40** and **R40.1** previously described.

It will be assumed that the control has a manual adjustment knob, such as the knob **32** of the earlier embodiment, and a timer motor **39** driving a series of cams arranged on one or more cam shafts within the control casing. Switch **S1.1** controlled by cam **C1.1** has a switch spring stack in which the lowermost switch spring will first close the "Y" contacts and then the "X" contacts as said spring rises on the cam, and will open these contacts in reverse order as the spring descends on the cam; and the single sets of switch springs of the remaining switches **S2.1** through **S7.1** will operate to closed or open position as the indicated springs thereof follow the cam contours.

Assuming that rotation of the knob **32** to its "on" position has the effect of moving the cam bank to the left, as viewed in Fig. 14, and that the operation of timer motor **39** continues such leftward movement, it will be noted that as the intermediate rise portion of cam **C1.1** engages and lifts the indicated spring of switch **S1.1** the timer motor is energized across line conductors **80** and **80.1** through contacts "Y" of switch **S1.1** but the main drive motor **7** is not energized because the contacts "X" of said switch are not closed.

In suitable timed relation therewith, the uppermost switch spring of switch **S3.1** drops as it follows a downslope on cam **C3.1**, thus energizing the heated water inlet solenoid **9.1** to admit clear, heated rinse water through tube **12** to the inlet fitting **72**, whence it flows about the dishes in the rack (not shown) and enters the sump **6**. This is known in the art as a "spray rinse." The impeller **5** is not rotating during this rinsing operation. Al-

though motor operation during the spray rinse is optional, many prefer that the impeller be still, so as to avoid the redeposit of soil removed by the spray action. Switch S5.1 holds open the circuit to solenoid 66.1 by reason of the contour of cam C5.1 and valve 66 remains open to permit all of the rinse water to pass through pipe 64 to the plumbing waste line. Solenoid 65.1 is energized by reason of the relation of cam C6.1 to switch S6.1, and its associated valve 65 is therefore held closed. Pump motor 73 is inactive. At the end of about 45 seconds, cam C5.1 causes the contacts of switch S5.1 to close energizing the solenoid 66.1 and positively closing the valve 66. The contacts of switch S3.1 remain closed however for a further period of 45 seconds (it being understood that this has been arbitrarily selected as the length of time an inlet valve should remain open to admit the full 12 pint charge of water) to accumulate the first required quantity of heated wash water. Cam C1.1 closes the contacts "X" of switch S1.1, energizing the motor 7 to drive the impeller and thus produce the water flow necessary to wash the first detergent charge out of chamber 29.1 of the detergent dispenser. The second-wash detergent charge is protected by the gate 29.3 as previously described.

At the end of the time allowed to the first wash—for example, two minutes—cam C1.1 causes the separation of contacts "X" of switch S1.1 while continuing contacts "Y" thereof closed. The drive motor 7 circuit is thus opened while the timer motor 39 circuit remains closed. Cam C5.1 again causes switch S5.1 to open the circuit to solenoid 66.1 and the spent wash liquid passes through pipe 64 to the plumbing drain. Allowing a suitable time—say, 45 seconds—for complete drainage from the vat, all of the gross soil sequestered and supported by the first detergent solution will have passed from the vat with said solution. Valve 66 remains open, however, while cam C3.1 closes the contacts of switch S3.1 to energize the heated water inlet valve solenoid 9.1 for another spray rinsing period. The impeller remains out of operation. At the end of this second heated water rinse, cam C1.1 closes the circuit to motor 7, the circuit to heated water inlet valve solenoid 9.1 opens and the circuit to the unheated water inlet valve solenoid 16.1 will be closed to effect the introduction of unheated water for the second washing operation. As clearly appears in Fig. 14, cam C5.1 closes the contacts of switch S5.1, energizing solenoid 66.1 to close valve 66. Valve 65 remains closed.

During the second washing operation, the detergent in chamber 29.2 is brought into solution with the unheated water to provide a second washing solution substantially equal in strength to the first solution. The termination of the second wash is signified by the opening of the motor circuit to halt impeller rotation, and the opening of valve 65 to admit the washing solution to the tank 60, in which approximately one-half will be retained, the remainder escaping through pipe 61, as previously explained. Valve 65 opens upon de-energization of solenoid 65.1 as cam C6.1 opens the contacts of switch S6.1, whereas valve 66 remains closed by reason of the continued energization of solenoid 66.1.

After an appropriate drainage period, cam C6.1 again energizes solenoid 65.1 to close valve 65, and cam C5.1 opens the contacts of switch S5.1, de-energizing solenoid 66.1 and causing valve 66 to be in open position. At this time, cam C4.1 closes contacts S4.1 to energize solenoid 16.1, and for a period of about 45 seconds, clear, unheated rinse water is introduced into the vat. The impeller is not operating. The dishes are again thoroughly spray rinsed for a third time.

At the end of this third rinse period, solenoid 66.1 is energized for closure of its associated valve 66. Cam C1.1 operates to return the impeller to operation and cam C4.1 maintains the switch contacts S4.1 closed. Solenoid 16.1 continues energized to maintain the inflow of unheated water. Also at the end of the rinse period, cam C7.1 closes the contacts to switch S7.1, energizing the pump motor 73. The portion of the second wash liquid in tank 60, representing about one-half of the total wash liquid as above explained, is thus pumped through fitting 72 into the vat where it mixes with the incoming charge of unheated, clear water. After about 25 seconds—a period which, for purposes of illustration, represents the time required to introduce approximately 6 pints of unheated, clear water and to empty the tank 60—cams C4.1 and C7.1 cause their respective circuits to open. This third washing liquid contains only that detergent which was present in the retained second wash liquid, but the resulting detergent solution is adequate in view of the small amount of food soil remaining on the dishes and vat walls. At the end of the third wash, valve 65 is permitted to open to direct the effluent into tank 60. Valve 66 remains closed.

A fourth and fifth wash may thereafter follow, with no rinses after the third and fourth wash periods. Between the third and fourth and fourth and fifth washes, therefore, only the valve 65 is operated. As previously noted, the operation of the impeller during any drainage operation is a matter of preference. In preparation for the fourth and fifth wash operations, the unheated water inlet valve is opened at appropriate times to add 6 pints of clear water to the 6 pints of liquid transferred by the pump from the tank 60 to the vat inlet 72.

At the end of the fifth wash, the impeller is stopped, and valve 66 is opened to effect complete removal of the last washing liquid. Valve 65 is of course closed. The dishes are then given a final heated water "power rinse" with the impeller operating. Valves 65 and 66 are closed. At the end of the final rinse period, the motor may, if desired, be stopped, and valve 66 opened, to effect complete drainage. The motor is thereafter started and cam C2.1 closes the circuit to heating element 29. A drying cycle thereupon proceeds as previously described, and near the end of the complete cycle cam C1.1 drops the spring leaf of switch S1.1 to an intermediate position which opens the circuit to the motor 7. The timer remains in operation, and at the end of the drying period cam C1.1 drops to open contacts "Y" of switch S1.1 and cam C2.1 opens the heating coil circuit.

The complete operational cycle has then been completed and the dishes are ready for removal from the machine.

From the foregoing descriptions, it is apparent that dishwashers embodying the inventions provide methods of washing dishes in which the dishes are subjected to multiple washes with detergent solutions having temperature and detergent factors suitable for the conditions existing at a particular phase of the operation; and that said multiple washing operations are carried out economically, as respects expenditures of water and detergent.

While there have been described what is at present considered to be the preferred embodiments of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. The method of washing dishes arranged within a washing vat, comprising the steps of rinsing the loose soil from the dishes by circulating rinsing liquid among the dishes while effecting continuous drainage from the vat; introducing into and retaining in said vat a quantity of water having a temperature of the order of 150° F., mixing with said water a quantity of detergent to provide a first detergent solution and circulating said solution among the dishes for a first predetermined period; rinsing the dishes a second time by circulating rinsing liquid among the dishes while again effecting continuous

drainage of said rinsing liquid from said vat; introducing into and retaining in said vat a quantity of water having a temperature less than 100° F., mixing with said water a quantity of detergent to form a second detergent solution and circulating said solution among said dishes for a predetermined period; draining said solution completely from the vat; introducing into and retaining within said vat a quantity of rinsing liquid substantially equal to the quantity of the second detergent solution and circulating said liquid among the dishes for a predetermined period; stopping said rinsing liquid circulation; and permitting said rinsing liquid to drain from the vat substantially coincidentally with the interruption of said rinse liquid circulation.

2. The method of washing dishes arranged in mutually spaced relation in a washing vat, comprising the steps of rinsing the loose soil from the dishes by circulating rinsing liquid among said dishes while effecting continuous drainage from said vat; introducing into said vat a quantity of heated water and a quantity of detergent and circulating the resultant mixture among said dishes for a predetermined interval while substantially preventing drainage from said vat; permitting said mixture to drain from the vat; rinsing said dishes with clear water; draining said rinse water from said vat; introducing into said vat a quantity of unheated water and a second quantity of detergent and circulating the resultant mixture among said dishes for a predetermined interval while substantially preventing drainage from said vat; interrupting said circulation and draining the mixture from said vat; introducing into said vat and circulating among said dishes a quantity of heated rinsing water and finally draining said rinse water from said vat.

3. The method of washing and drying dishes arranged in mutually spaced relation in a washing vat, comprising the steps of rinsing the loose soil from the dishes by circulating heated rinsing liquid among the dishes and permitting said rinsing liquid continuously to drain from the vat; introducing into said vat a quantity of heated water and a quantity of detergent and circulating the resultant mixture among said dishes for a predetermined period; permitting said mixture to drain from said vat; introducing into said vat a quantity of unheated rinsing liquid and permitting the same to permeate the dishes to abstract heat therefrom; draining said rinsing liquid from said vat; introducing into said vat a quantity of unheated water and mixing the same with a quantity of detergent to provide a second washing mixture substantially equal in volume and detergent concentration as the first washing mixture; circulating said second washing mixture among the dishes for a predetermined interval; removing said second washing mixture from the vat; raising the temperature of the dishes within the vat by circulating therein a quantity of heated rinsing liquid; draining said rinsing liquid; and finally circulating air among the dishes to evaporate the moisture therefrom.

4. The method of washing dishes arranged in mutually spaced relation in a washing vat, which includes the steps of rinsing the loose soil from said dishes by circulating heated rinse liquid among said dishes; introducing into said vat a quantity of washing liquid and circulating said liquid among said dishes for a predetermined interval during which substantially all of said liquid is maintained in said vat; draining from said vat substantially one half of the said quantity of washing liquid; introducing into said vat a quantity of washing liquid sufficient to increase any undrained portion of the first washing liquid substantially to the initial quantity of said first liquid and circulating the same among said dishes while substantially preventing drainage of said liquid from said vat; again interrupting said circulation while permitting complete drainage of said liquid from said vat; introducing rinsing liquid into said vat and circulating the same among said dishes while substantially preventing drainage from said vat; draining said rinsing liquid from said vat; and permitting said dishes to dry while remaining in said vat.

5. The method of washing dishes arranged in mutually spaced relation in a washing vat, comprising the steps of rinsing loose soil from said dishes by circulating rinsing liquid among said dishes while effecting continuous drainage from said vat; introducing into said vat a quantity of detergent solution and circulating said solution among said dishes for a predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation of said liquid and permitting the same to drain from said vat; introducing into and circulating within said vat a second quantity of rinsing liquid and permitting said liquid to drain from said vat; introducing a second quantity of detergent solution into said vat and circulating said solution among said dishes for a second predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation and discarding a substantially predetermined portion of said solution from said vat to retain in said vat a residual portion of said second detergent solution to serve as the basis for a third detergent solution; adding liquid to said residual portion of said solution to produce a washing solution substantially equal in volume to said second-named solution but having a lesser concentration of detergent and circulating said resultant washing solution among said dishes while preventing any substantial drainage from said vat; interrupting said circulation and completely draining said solution from said vat; and thereafter rinsing said dishes with liquid containing no appreciable amounts of detergent.

6. The method of washing dishes arranged in mutually spaced relation in a washing vat, comprising the steps of rinsing the loose soil from said dishes by circulating rinsing liquid among said dishes while effecting continuous drainage from said vat; introducing into said vat a quantity of heated detergent solution and circulating said solution among said dishes for a predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation of said liquid and permitting the same to drain from said vat; introducing into and circulating within said vat a second quantity of rinsing liquid and permitting said liquid to drain from said vat; introducing into said vat a quantity of unheated detergent solution and circulating said solution among said dishes for a second predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation and discarding a substantially predetermined portion of said solution from said vat; adding liquid to the residual portion of said solution to produce a washing solution substantially equal in volume to said second-named solution but having a lesser concentration of detergent and circulating the resultant solution among said dishes for a third predetermined interval while preventing any substantial drainage from said vat; interrupting said circulation and completely draining said last-named solution from said vat; and thereafter rinsing said dishes with heated liquid containing no appreciable amounts of detergent.

7. The method of washing dishes arranged in a washing vat, comprising the steps of rinsing the loose soil from said dishes by introducing rinsing liquid from the upper portion of said vat and spraying said liquid downwardly among said dishes while effecting continuous drainage from said vat; introducing into said vat a quantity of heated detergent solution and circulating said solution upwardly among said dishes for a predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation of said liquid and permitting the same to drain from said vat; introducing into and spraying within said vat a quantity of unheated rinsing liquid and permitting said liquid to

drain from said vat; introducing a quantity of unheated detergent solution into said vat and circulating said solution upwardly among said dishes for a second predetermined interval during which drainage from said vat is substantially prevented; interrupting said circulation and discarding a substantially predetermined portion of said solution from said vat; adding unheated liquid to the residual portion of said solution to produce a washing solution substantially equal in volume to said second-named solution but having a lesser concentration of detergent and circulating said washing solution among said dishes while preventing any substantial drainage from said vat; interrupting said circulation and completely draining said washing solution from said vat; introducing and retaining within said vat a quantity of liquid containing no appreciable amounts of detergent and circulating said liquid upwardly among said dishes; draining said rinsing liquid; and circulating heated air among said dishes to dry them.

8. The method of washing and drying dishes arranged within a vat, which includes the steps of rinsing said dishes with clear water and thereafter washing said dishes with a heated detergent solution by circulating said solution mechanically over said dishes; draining said solution completely from said vat; rinsing said dishes with clear, unheated water and draining the same from the vat; washing said dishes a second time by mechanically circulating unheated detergent solution over said dishes, said detergent solution having substantially the same volume as said first-named solution and substantially the same quantity of detergent therein; then subjecting said dishes to a succession of washing operations, using for each said washing operation a portion of the detergent solution of the immediately preceding wash and a sufficient quantity of unheated water to restore the volume of liquid within the vat to substantially that of the second-named detergent solution; finally removing all of the solution from said vat; rinsing said dishes with rinsing liquid; and air drying the dishes while they remain in the vat by circulating heated air throughout the vat.

9. Dishwashing apparatus, including a vat having means for supporting a plurality of dishes to be washed; water inlet valve means for introducing into said vat, at separated periods of a complete washing operation, a quantity of heated water and a quantity of unheated water; impeller means operable to circulate said water about the dishes in said vat; means comprising individual containers disposed within said vat for accommodating quantities of detergent; means including said impeller means for causing said detergent to be mixed into said heated and said unheated water to provide a detergent solution; drain valve means for controlling the removal of spent detergent solution from said vat following a washing operation; and cycle-control means for effecting operation of said water inlet valve means, said impeller means, and said drain valve means in a desired operational sequence.

10. Dishwashing apparatus, including a vat having means for supporting a plurality of dishes to be washed; water inlet valve means for introducing into said vat, at separate periods of a complete washing operation, a quantity of heated water and a quantity of unheated water; impeller means operable to circulate said water about the dishes in said vat; means comprising individual containers disposed within the vat for accommodating quantities of detergent; means including said impeller means for causing said detergent in certain of said containers to be mixed with heated water and for causing detergent in other of said containers to be mixed with unheated water, to form in each case a detergent solution; a first drainage system for effecting a complete drainage of detergent solution from said vat; a second drainage system for effecting only a partial drainage of detergent solution from said vat; and cycle-control means effecting operation of said water inlet valve means, said impeller means, and said first and second drainage systems in a desired operational sequence.

11. Dishwashing apparatus, including a vat having means for supporting a plurality of dishes to be washed; inlet valve means for introducing into said vat, at widely spaced periods of a complete washing operation, a quantity of heated water, and a quantity of unheated water; impeller means for circulating said water about the dishes in said vat; means for introducing detergent into said heated water and into said unheated water, to establish, at said spaced periods, a heated and an unheated detergent solution for washing said dishes; means providing a sump in the lower portion of said vat; a first drainage means communicating between said sump and a plumbing drain system to provide for complete evacuation of detergent solution; a second drainage system communicating between said sump and said plumbing drain to provide a predetermined partial evacuation of detergent solution; and means for operating said first and second drainage means in predetermined sequence.

12. Dishwashing apparatus, including a vat arranged to receive a quantity of dishes to be washed; inlet valve means for introducing into said vat quantities of water for the washing operation; means for adding detergent to said water to provide a detergent solution; an impeller disposed in a sump portion of said vat to circulate said detergent upwardly and outwardly from said sump and among the dishes to wash the same; a first drainage system communicating between said sump and a plumbing drain, said drainage system having valving means operable to permit or prevent the drainage of said sump; a second drainage system having an open-ended standpipe communicating between said sump and said plumbing drain, said standpipe opening being substantially above the free level of said detergent solution in said sump during operation of said impeller and substantially below said free level during non-operation of said impeller whereby during periods of non-operation of said impeller and non-draining status of said first-system valving means a predetermined portion of said solution may be drained from said sump; and control means for effecting operation of said inlet valve, said impeller, and said first-system valving means in a desired sequence.

13. Dishwashing apparatus, including a vat arranged to receive a quantity of dishes to be washed, said vat having a sump portion at a low point thereof; inlet valve means for introducing into said vat quantities of water for the washing operation; means for adding detergent to said water to provide a detergent solution; an impeller disposed in said sump portion to circulate said solution among said dishes; a liquid collection chamber disposed externally of said vat and having a capacity of more than one-half of the detergent solution used in a washing operation; a conduit communicating between said vat and said chamber; a valve in said conduit and operable between open and closed positions; a standpipe in said chamber communicating directly with a plumbing drain, said standpipe having an opening within said chamber to withdraw a predetermined quantity of liquid therefrom; a second conduit communicating between said plumbing drain and said first conduit upstream of said valve; a valve in said second conduit operable between open and closed positions to permit or prevent drainage of the liquid in said vat directly to said plumbing drain; a third conduit communicating between said collection chamber and said vat above the sump thereof; a pump in said third conduit to pump liquid from said chamber to said vat; and control means for effecting operation of said inlet valve, said impeller, said first and second-named drainage control valves, and said pump, in a desired operational sequence.

14. Dishwashing apparatus, including a vat having means for supporting a plurality of dishes to be washed; inlet valve means for introducing into said vat a quan-

tity of heated water for washing dishes; inlet valve means for introducing into said vat a quantity of unheated water for washing dishes; impeller means for circulating said water throughout said vat during said washing operations; a plurality of containers within said vat for accommodating separate charges of detergent; means for introducing a charge of detergent into said heated water and into said unheated water, whereby to create heated and unheated washing solutions respectively; drain valve means for controlling removal of spent detergent solution from said vat following each of said washing operations; and cycle control means for effecting operation of the respective inlet valve means, the impeller means, and the drain valve means in desired operational sequence.

15. The method of washing and drying dishes arranged within a vat, which includes the steps of washing said dishes with a detergent solution by circulating said solution mechanically over said dishes; draining said solution completely from said vat; rinsing said dishes with clean water and draining the rinsing liquid from the vat; washing said dishes a second time by mechanically circulating a second quantity of detergent solution over the dishes, said quantity of solution being substantially the same in volume as the first-named solution; then subjecting said dishes to a succession of washing operations by circulating over the dishes, a detergent solution comprised of a portion of the solution of the immediately preceding washing operation and a sufficient quantity of clean water to restore the volume in each case to that of the preceding solution; completely draining and discarding the solution following the final washing operation; rinsing said dishes with rinsing liquid; and air

drying said dishes while they remain in the vat by circulating air throughout said vat.

16. Dishwashing apparatus, including a vat having means for supporting a plurality of dishes to be washed; water inlet valve means for introducing into said vat, at separated periods of a complete washing operation, a quantity of heated water and a quantity of unheated water, respectively; means for circulating the respective quantities of water among the dishes in said vat; means for introducing into said vat a first predetermined quantity of detergent for mixture with said heated water during the circulation thereof, and a second predetermined quantity of detergent for mixture with said unheated water during the circulation thereof, whereby to effect separated washing operations with a heated detergent solution and an unheated detergent solution; drain valve means for controlling the removal of said detergent solutions; and cycle-control means for effecting operation of said inlet valve means, said water circulating means and said drain valve means in a predetermined operational sequence.

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