June 7, 1955 R. J. LENGVENIS 2,710,010

CONTROL CIRCUITS FOR DISHWASHING APPARATUS

Filed Feb. 6, 1953 2 Sheets-Sheet 1

Fig. 1

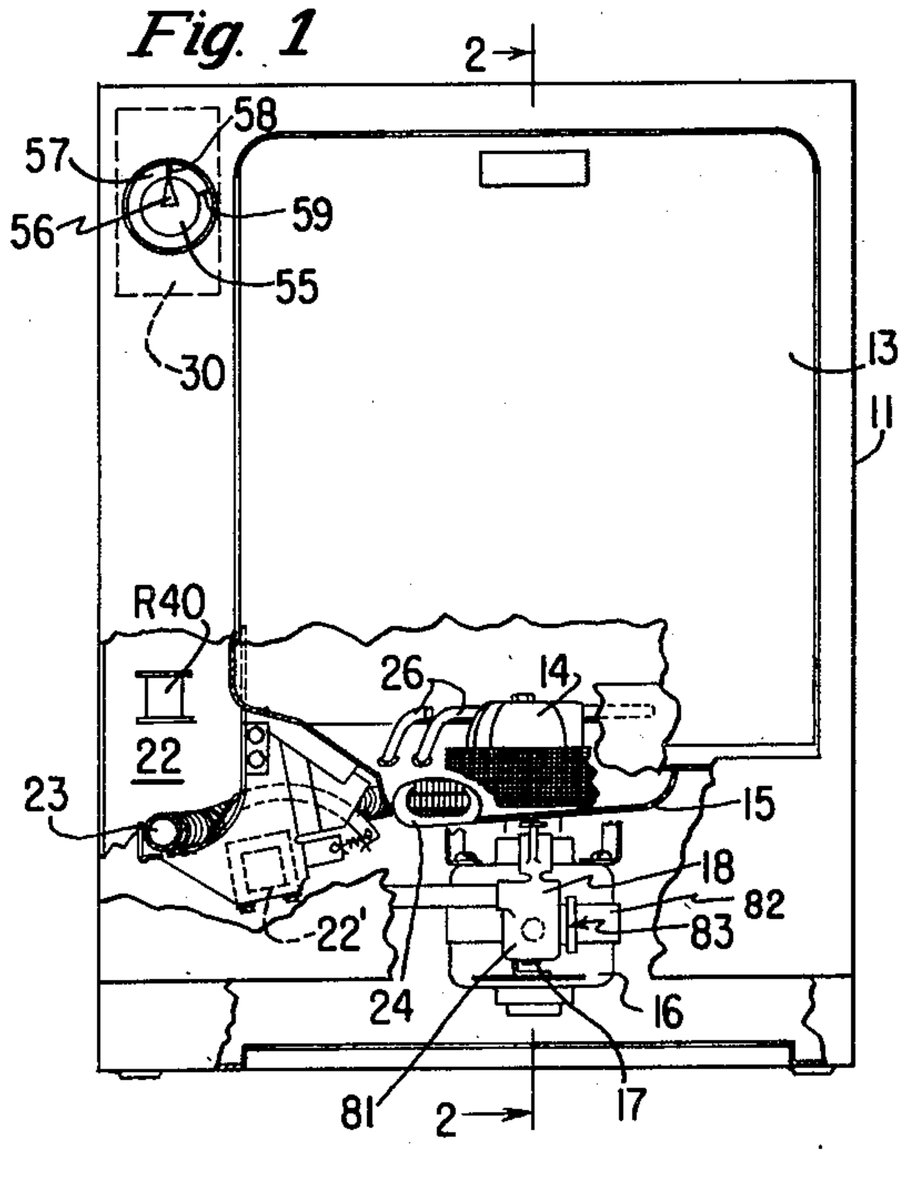


Fig. 2

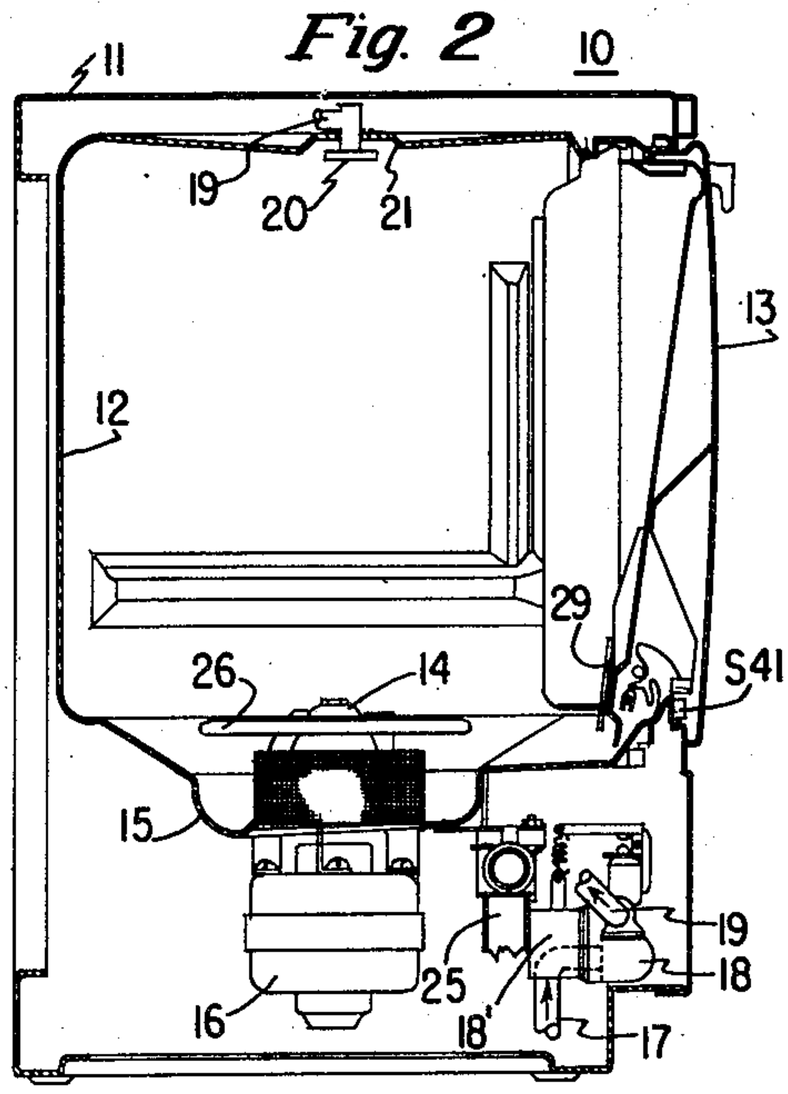
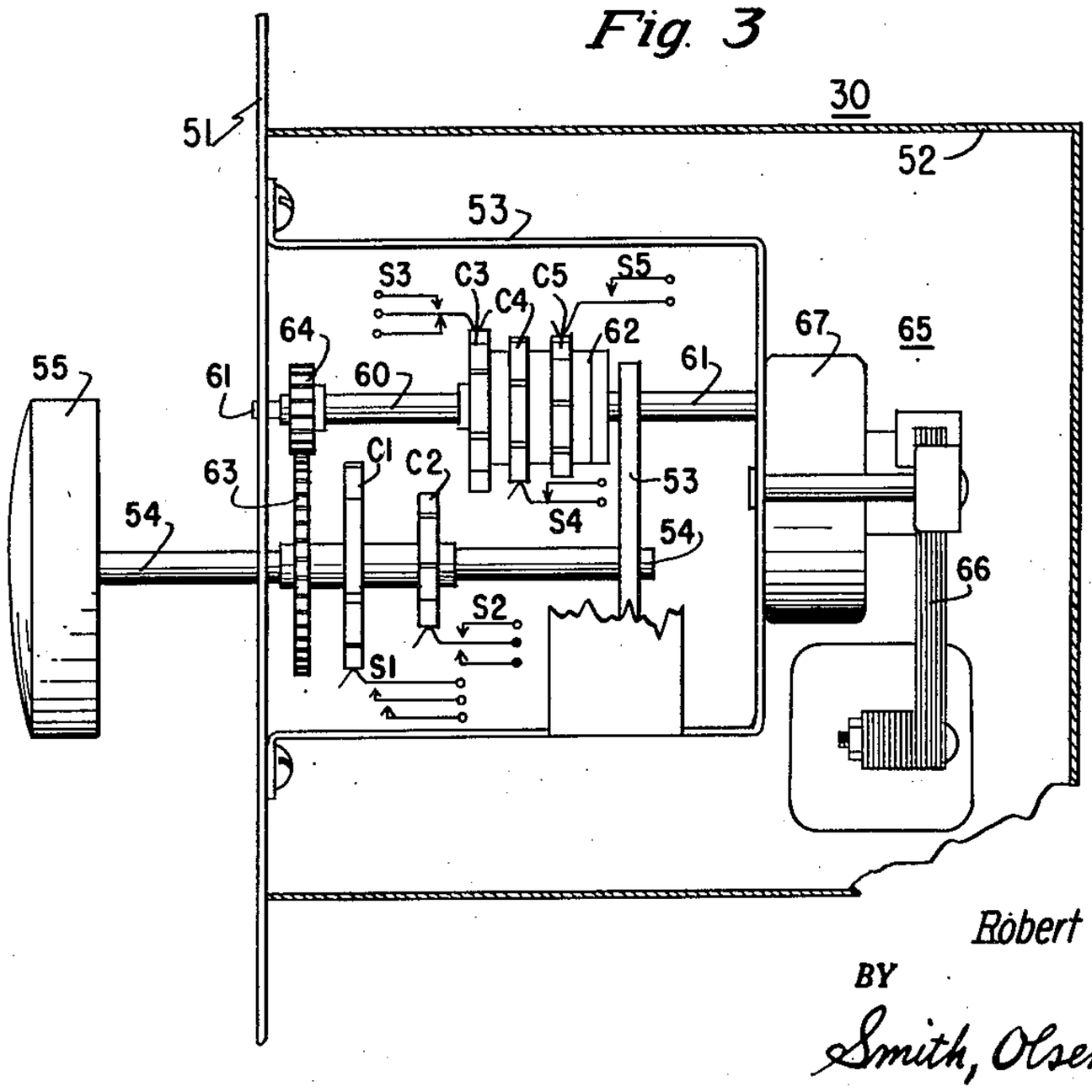


Fig. 3



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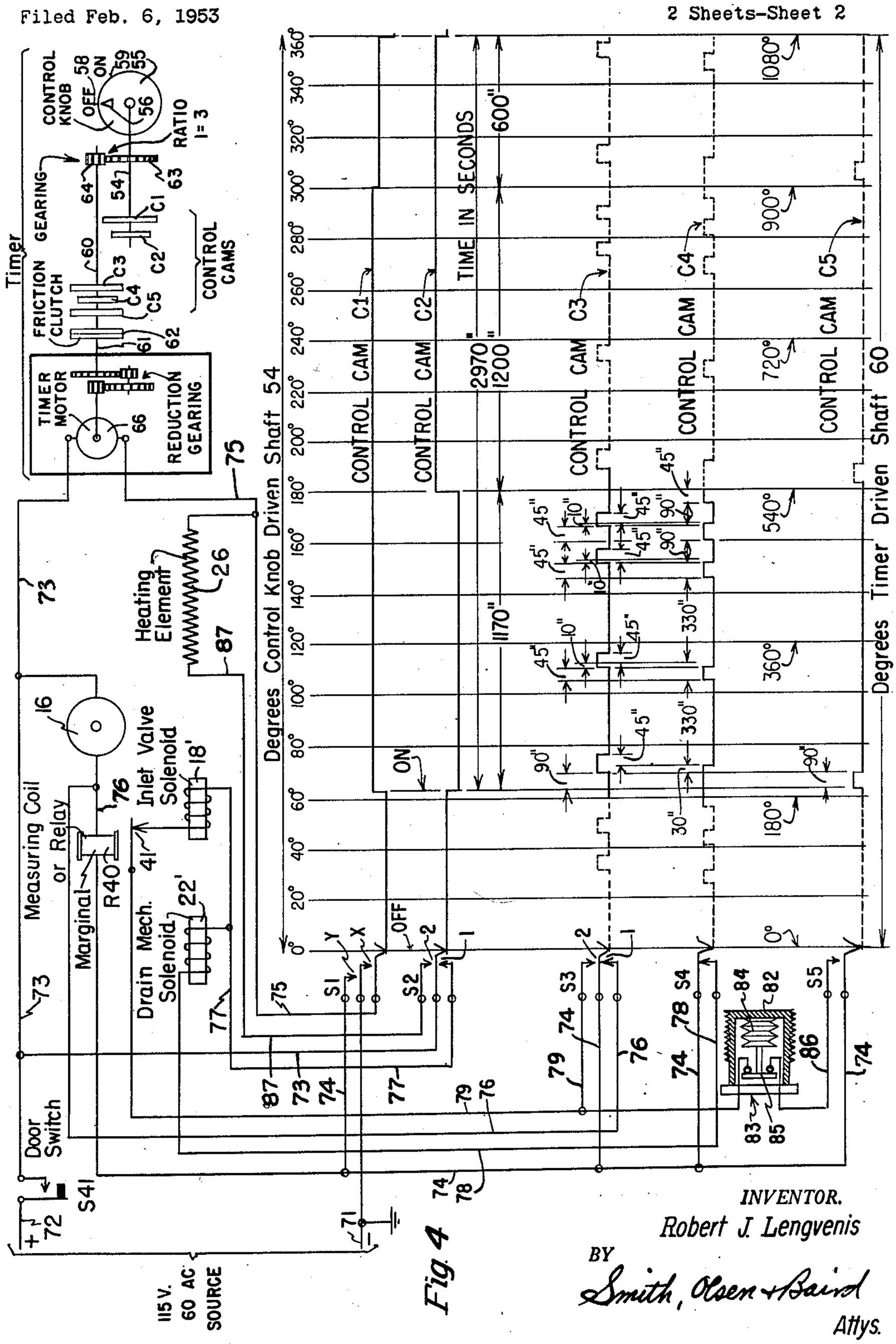

Fig. 4

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United States Patent Office

2,710,010

Patented June 7, 1955

2,710,010

CONTROL CIRCUITS FOR DISHWASHING APPARATUS

Robert J. Lengvenis, Chicago, Ill., assignor to General Electric Company, a corporation of New York

Application February 6, 1953, Serial No. 335,441

5 Claims. (Cl. 134—57)

The present invention relates to control circuits for dishwashing apparatus, and more particularly to improved control circuits of the character disclosed in United States Patent No. 2,624,352, granted on January 6, 1953, to Douglas F. Illian.

The dishwashing apparatus disclosed in the Illian patent mentioned comprises an upstanding vat of the front-opening type provided with an inlet conduit adjacent to the top thereof and a drain conduit adjacent to the bottom thereof, the inlet conduit being connected to a hot water supply system (a hot water storage tank, or the like), and the drain conduit being connected to suitable drain plumbing. An inlet valve is arranged in the inlet conduit and biased into a closed position and operative against its bias into an open position by an associated solenoid; and drain mechanism is arranged in the drain conduit and biased into a draining position and operative against its bias into a non-draining position by an associated solenoid. A motor driven impeller is arranged in the bottom of the vat for the purpose of circulating wash liquid therein; and a program control switch is provided for the purpose of selectively controlling the motor mentioned, as well as the inlet valve solenoid and the drain mechanism solenoid, so as selectively to supply and to retain in the vat the water from the inlet conduit, and otherwise to establish an automatic cycle of operation for the washing apparatus. The program control switch is manually operated by a manual dial from its off position into its first control position, and is then automatically operated by an associated electric timer motor from its first control position through its other control positions and back into its off position so as automatically to carry out the cycle mentioned on a time basis.

In the cycle of this control circuit, when the program control switch is first operated from its off position into its first control position, the inlet valve solenoid is energized, while the drain mechanism solenoid is deenergized, so that the water is supplied from the inlet conduit into the vat and flushed therethrough into the drain conduit for a time interval of about 30 seconds so as to flush from the hot water supply system preceding the inlet conduit any cold or warm water therein; then the drain mechanism solenoid is energized for a time interval of about 45 seconds, while the inlet valve solenoid is energized, so as to effect the accumulation of a first charge of wash water in the vat; and then the inlet valve solenoid is deenergized, while the drain mechanism solenoid is energized, so that the first washing of the dishes in the vat is effected with the first charge of wash water mentioned, the first washing time interval proceeding for about 330 seconds.

While this cycle is entirely satisfactory in the usual installation of the dishwashing apparatus, it is subject to the criticism that in an unusual installation, where there is considerable piping in the hot water supply system preceding the inlet conduit, all of the cold or warm water therein may not be flushed through the vat in the 30 second time interval mentioned; whereby some of the

first charge of wash water accumulated in the vat is not as hot as is desirable and as is subsequently available in the hot water supply system. Now the extension of this 30 second time interval in the washing apparatus would result in the wasting of considerable hot water from the hot water supply system in the usual installation of the washing apparatus.

Accordingly, it is a general object of the present invention to provide a control circuit for dishwashing apparatus of the character noted, that incorporates an arrangement for insuring the flushing of cold or warm water through the vat from the hot water supply system preceding the accumulation of the first charge of wash water therein and without wasting any considerable amount of hot water from the hot water supply system.

Another object of the invention is to provide an improved control circuit for dishwashing apparatus of the character noted, wherein the flushing arrangement mentioned is governed by a thermal switch operatively associated with the inlet valve so that the flushing step mentioned may be arrested directly in response to the supply of hot water to the inlet valve.

A further object of the invention is to provide an improved control circuit for dishwashing apparatus of the character noted, wherein the control of the inlet valve for flushing purposes and for filling purposes is governed over two corresponding multiple and independent circuits.

Further features of the invention pertain to the particular arrangement of the elements of the control circuit for the dishwashing apparatus; whereby the above-outlined and additional operating features thereof are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

Figure 1 is a front elevational view, partly broken away, of dishwashing apparatus incorporating a control circuit embodying the present invention;

Fig. 2 is a vertical sectional view of the dishwashing apparatus, taken in the direction of the arrows along the line 2—2 in Fig. 1;

Fig. 3 is an enlarged fragmentary vertical sectional view of the program control switch that is incorporated in the control circuit of the dishwashing apparatus shown in Figs. 1 and 2, certain of the elements of the program control switch being diagrammatically illustrated; and

Fig. 4 is a combined electric diagram of the elements of the program control switch and the circuit control arrangement incorporated in the dishwashing apparatus, shown in Figs. 1 and 2, and diagrammatic time-sequence chart of the operation of the elements of the program control switch.

Referring now to Figs. 1 and 2 of the drawings, there is generally illustrated dishwashing apparatus **10** of the character of that disclosed in the copending application of Edgar S. Stoddard, Serial No. 86,291, filed April 8, 1949, now Patent No. 2,678,051, granted May 11, 1954, and incorporating a control circuit embodying the features of the present invention. The dishwashing apparatus **10** is of the gasketless-door-front-opening type including a cabinet **11** housing a substantially vertically disposed vat **12**, the cabinet **11** and the vat **12** having substantially aligned front openings that are closed by a front door **13**. The front door **13** is pivotally mounted adjacent to the lower edge thereof within the lower portion of the vat **12** and is movable between a substantially vertical closed position and a substantially horizontal open position. Also, the dishwashing apparatus **10** comprises removable rack structure, not shown, that is adapted to support dishes and other utensils within the vat **12** for washing

purposes, the rack structure being movable into and out of the vat **12** through the front openings when the front door **13** occupies its open position. An impeller **14** is arranged within the sump **15** formed in the bottom of the vat **12** and is rotated by an associated electric operating motor **16** for the purpose of producing a washing action within the vat **12** when the front door **13** occupies its closed position and wash liquid is contained in the sump **15**.

For the purpose of supplying wash liquid to the vat **12**, there is provided an inlet conduit **17** connected to a suitable source of wash liquid, such for example, as a hot water tank, by intervening pipe, not shown. The inlet conduit **17** communicates with the inlet port of an inlet valve **18** of the solenoid controlled type; and the outlet port of the inlet valve **18** communicates with a conduit **19** that is connected to a spray device **20** arranged in a depression **21** formed substantially centrally within the top wall of the vat **12**. The inlet valve **18** is of the fast-opening, slow-closing type and is governed by an associated dashpot so as to prevent water-hammer in the plumbing communicating with the inlet conduit **17**. The inlet valve **18** is biased to its closed position; and when the solenoid **18'** thereof is energized, it is operated against its bias into its open position in order that wash liquid may be supplied from the inlet conduit **17** to the spray device **20**; whereby the wash liquid is sprayed downwardly from the top of the vat **12** through the rack structure, not shown, and accumulates in the sump **15**. Subsequently, when the solenoid **18'** of the inlet valve **18** is deenergized, it moves slowly from its open position back into its closed position in order to cut off the supply of wash liquid from the inlet conduit **17** to the spray device **20**.

More particularly, the inlet valve **18** is provided with a casing **81** defining a valve chamber therein and having a threaded opening in the side thereof that receives the threaded casing **82** of a thermal switch **83** that is employed for a purpose more fully explained hereinafter. As shown in Fig. 4, the casing **82** of the thermal switch **83** is hollow and houses an expansible bellows **84** arranged in good heat exchange relation with the water contained in the valve chamber defined in the casing **81** of the inlet valve **18**; which expansible bellows **84** carries a contact bridging member **85** that controls an associated pair of contacts. In the arrangement, the bellows **84** is contracted to move the bridging member **85** into its closed circuit position, when the water in the valve chamber of the inlet valve **18** is cold or merely warm; whereas the bellows **84** is expanded to move the bridging member **85** into its open circuit position, when the water in the valve chamber of the inlet valve **18** is hot or at a predetermined relatively high temperature. The purpose of the thermal switch **83** and the control exercised thereby are explained more fully hereinafter in conjunction with the automatic cycle of the dishwashing apparatus **10**.

For the purpose of controlling the retention of wash liquid in the sump **15**, there is provided drain mechanism **22** of the solenoid controlled type. The drain mechanism **22** comprises a flexible conduit or hose **23**, one end of which communicates with a drain fixture **24** provided in the lower portion of the sump **15**, and the other end of which communicates with a drain conduit **25** that is connected via a trap, not shown, to associated drain plumbing. The flexible hose **23** is biased into its lower or draining position in order to place the interior of the sump **15** into draining communication with the drain conduit **25** so that any wash liquid accumulating in the sump **15** runs through the flexible hose **23** into the drain conduit **25**; and when the solenoid **22'** thereof is energized, the flexible hose **23** is elevated against its bias into its upper or non-draining position in order to cut off the draining communication between the interior of the sump **15** and the drain conduit **25** so that wash liquid may be retained in the sump **15**. Subsequently when the solenoid **22'** is deenergized, the drain mechanism **22** is returned from its non-draining position back into its draining position.

For the purpose of effecting drying of the dishes and other utensils supported by the rack structure, not shown, within the vat **12**, there is provided a heating unit **26** that is preferably of the sheathed resistance conductor type. The heating unit **26** is disposed in the lower portion of the vat **12** in surrounding relation with respect to the impeller **14** so that air blown by the blades of the rotating impellers **14** contacts the heating unit **26** and then moves upwardly into the vat through the dishes and other utensils supported by the rack structure mentioned.

The lower portion of the front door **13** carries a detergent cup **29** opening toward the interior of the vat **12** and adapted to receive a charge of detergent. Preferably the detergent that is employed in the dishwashing apparatus **10** is of the type sold under the trade name "Calgonite" that comprises about 40% sodium hexametaphosphate and 60% sodium metasilicate.

For the purpose of effecting coordinate operation of the operating motor **16**, the inlet valve **18**, the drain mechanism **22** and the heating unit **26**, so that a washing cycle, including predetermined flushing, spraying, washing, rinsing and drying steps is carried out, a program controller or control switch **30** is incorporated in the dishwashing apparatus **10**, the program control switch **30** being arranged in the upper left-hand front portion thereof and disposed between the adjacent left-hand side of the cabinet **11** and the adjacent left-hand side wall of the vat **12**. Of course, the program control switch **30** is arranged exteriorly of the vat **12** and is appropriately wired in a circuit control network including the operating motor **16**, the solenoids **18'** and **22'**, the heating unit **26**, a measuring coil or relay **R40**, a door switch **S41** and the thermal switch **83**. As indicated in Fig. 2, the door switch **S41** may be carried adjacent to the front lower portion of the upstanding ledge disposed adjacent to the front opening provided into the vat **12** and in cooperating relation with the front door **13**. More particularly, when the front door **13** is respectively moved into its closed and open positions, the door switch **S41** is respectively operated into its closed and open positions. Finally, the circuit network includes a source of current supply that may be of 115-volts, 60 cycle, single-phase A. C.

As best shown in Figs. 1 and 3 the program control switch **30** is of the combination manual and timer controlled type and comprises a front supporting plate **51** that is carried by the cabinet **11** rearwardly of the extreme front wall thereof. The front plate **51** is provided with a casing **52** detachably secured thereto, as well as a supporting bracket **53**. A first rotatable shaft **54** is suitably journalled within the front plate **51** and in the bracket **53** and projects forwardly through a hole provided in the front wall of the cabinet **11** to the exterior. A manual control knob **55** is removably secured to the extreme front end of the shaft **54** and carries a pointer **56** that cooperates with a trim ring **57** secured upon the outer surface of the front wall of the cabinet **11**. The trim ring **57** carries indicia cooperating with the pointer **56** and including the "off" index **58** and the "on" index **59**. Also the program control switch **30** comprises a second rotatable shaft **60** and a stub shaft **61**. The stub shaft **61** is suitably journalled in the front plate **51** and in the bracket **53**; and the second shaft **60** constitutes a sleeve journalled on the stub shaft **61**. The shafts **60** and **61** are disposed above the shaft **54** and carry a friction clutch indicated at **62**. The details of the friction clutch **62** are not shown, but the adjacent face plates thereof are urged into frictional engagement with each other and are respectively rigidly secured to the shafts **60** and **61** for a purpose more fully explained hereinafter. The shafts **54** and **60** are interconnected by speed-change gearing including two meshed pinions **63** and **64** respectively rigidly secured thereto. The

pinion 63 secured to the shaft 54 has precisely N times as many teeth as the pinion 64 secured to the shaft 60, where N equals to 3. Accordingly, the gearing effects a 1:3 speed ratio between the shafts 54 and 60; whereby one revolution of the shaft 54 effects three revolutions of the shaft 60 and one revolution of the shaft 60 effects ⅓ revolution of the shaft 54. Further, the program control switch 30 comprises a timer motor unit 65 of the electro-responsive type that is carried by the bracket 53. The timer motor unit 65 comprises a motor proper 66 of the single-phase, 115 volts, 60 cycle, A. C., synchronous type, and preferably of the "Telechron" type, and a gear box 67 housing the usual speed reduction gearing, the speed reduction gearing housed within the gear box 67 interconnecting the stub shaft 61 and the motor proper 66. The gearing within the gear box 67 is so constructed and arranged that when the motor proper 66 is energized from the 115 volts 60 cycle A. C. source the stub shaft 61 is rotated at a speed of precisely three revolutions per hour.

In view of the foregoing description of the program control switch 30, it will be understood that the shaft 54 may be manually rotated by the manual control knob 55 in order to effect rotation of the shaft 60 through the gearing 63—64; however, this rotation of the shaft 60 is not imparted to the stub shaft 61 directly connected by the gearing in the gear box 67 to the motor proper 66, the friction clutch 62 accommodating relative rotation between the shaft 60 and the stub shaft 61 by slipping action. On the other hand, when the motor proper 66 is energized, the stub shaft 61 is rotated at three revolutions per hour through the gearing in the gear box 67 and drives the shaft 60 through the friction clutch 62 at the speed noted. The consequent rotation of the shaft 60 at three revolutions per hour effects rotation of the shaft 54 at one revolution per hour by virtue of the interposed gearing 64—63. Accordingly, operation of the motor proper 66 is normally effective to rotate the shaft 60 at three revolutions per hour in the counterclockwise direction and to rotate the shaft 54 at one revolution per hour in the clockwise direction, as viewed in Fig. 1. The shaft 54 comprises an "off" position and an "on" position respectively corresponding to the "off" and "on" indicia 58 and 59 respectively carried by the trim ring 57 and cooperating with the pointer 56 provided on the manual control knob 55. In the arrangement the "on" index 59 is disposed slightly more than 60 degrees in the clockwise direction from the "off" index 58 so that when the manual control knob 55 is grasped and rotated in the clockwise direction through this angle slightly greater than 60 degrees, the pointer 56 is moved from its normal position cooperating with the "off" index 58 into an advanced position cooperating with the "on" index 59. As explained more fully hereinafter, the motor proper 66 is energized at this time, whereby the stub shaft 61 and the shaft 60 are driven at the previously noted speed in the counterclockwise direction effecting further rotation of the shaft 54 in the clockwise direction. Specifically, the shaft 54 is further rotated at the speed of one revolution per hour from its "on" control position in the clockwise direction back into its "off" control position, whereby the pointer 56 carried by the manual control knob 55 again cooperates with the "off" index 58 provided on the trim ring 57. Thus, it will be understood that after the shaft 54 is rotated from its "off" control position into its "on" control position in the clockwise direction by the manual control knob 55, it is automatically rotated further in the clockwise direction back into its "off" control position by the motor proper 66 in a time interval slightly less than 50 minutes. Further, the shaft 54 comprises a prepare position and a plurality of control positions angularly disposed between its "on" position and its "off" position through which it proceeds sequentially as it is rotated in the clockwise direction. Also, the shaft 60 comprises a prepare position and a plurality of angularly disposed control positions through which it proceeds three times

incident to one complete revolution of the shaft 54, as a consequence of the gearing 63—64 interconnecting the shafts 54 and 60. Two insulating cams respectively indicated at C1 and C2 are rigidly secured to the shaft 54 and respectively cooperate with two sets of switch springs diagrammatically illustrated at S1 and S2. Similarly, three insulating cams respectively indicated at C3, C4 and C5 are rigidly secured to the shaft 60 and respectively cooperate with three sets of switch springs diagrammatically illustrated at S3, S4 and S5.

The construction and arrangement of the program control switch 30 is disclosed and claimed in the copending application of Douglas F. Illian, Serial No. 247,866, filed September 22, 1951, now Patent No. 2,668,589, granted February 9, 1954.

The connection and arrangement of the control network for the various elements of the dishwashing apparatus 10 will best be understood by reference to Fig. 4, wherein there is illustrated diagrammatically both the elements previously mentioned, as well as a time-sequence operating chart therefor, indicating the coordinate controls exercised by the cams C1 to C5, inclusive, upon the associated sets of switch springs S1 to S5, inclusive. In the circuit network, it is assumed that the negative line conductor 71 of the source of current supply is connected to ground potential and that the positive line conductor 72 of the source of current supply is insulated from ground potential.

When the dishwashing apparatus 10 is at rest, the manual control knob 55 occupies the position illustrated in Fig. 1, whereby the pointer 56 carried by the manual control knob 55 registers with the legend "off" carried by the trim ring 57 and the shaft 54 occupies its normal "off" position and the shaft 60 occupies its normal position. At this time the cam C1 governs the set of switch springs S1 to effect opening of the contacts X and Y; while the cam C2 governs the set of switch springs S2 to effect opening of the contacts 1 and 2 thereof. Similarly, the cam C3 governs the set of switch springs S3 to effect respective closing and opening of the contacts 1 and 2 thereof; the cam C4 governs the set of switch springs S4 to effect closing of the contacts thereof; and the cam C5 governs the set of switch springs S5 to effect opening of the contacts thereof.

Considering now the cycle of operation of the dishwashing apparatus 10, the person loads the dishes and other utensils into the rack structure, not shown, and moves the rack structure into the vat 12, and then places a charge of detergent into the detergent cup 29. The person then moves the door 13 from its open position into its closed position effecting closure of the door switch S41, and then rotates the manual control knob 55 in the clockwise direction from its "off" position into its "on" position. When the manual control knob 55 is thus rotated in the clockwise direction the shaft 54 is rotated in the clockwise direction and the shaft 60 is rotated in the counterclockwise direction. In Fig. 4, the elements of the program control switch are diagrammatically illustrated; and entirely for the purpose of facilitating the description of the time-sequence of operation of these elements, and without reference to the actual structure thereof, the peripheries of the control cams C1 to C5, inclusive, are developed along parallel horizontal lines, and are assumed to be movable, in their cycle of operation, toward the left with respect to the associated relatively stationary sets of switch springs S1 to S5, respectively. During this preliminary rotation of the shaft 54 in the clockwise direction from its "off" position into its "on" position, the control cams C3 and C4, respectively operate the sets of switch springs S3 and S4; however, without effect since the set of switch springs S2 retains both of the contacts 1 and 2 in their open positions; this ineffective operation of the sets of switch springs S3 and S4 by the respectively associated cams C3 and C4 being brought about by virtue of the fact that the shaft 60 is

rotated slightly greater than 180 degrees while the shaft 54 is rotated slightly greater than 60 degrees. In Fig. 4, the ineffective controls of the cams C3 and C4 with respect to the sets of switch springs S3 and S4, respectively, are indicated in dotted lines on the left-hand side and on the right-hand side of the effective control thereof, indicated in solid lines, as explained more fully hereinafter. When the shaft 54 is rotated into its "on" position, slightly over 60 degrees in the clockwise direction from its "off" position, the cams C1 and C2 respectively operate the sets of switch springs S1 and S2. Specifically, at this time, in the set of switch springs S1, the lowermost spring engages the highest portion of the cam C1 effecting closure of the contacts X and Y; and in the set of switch springs S2, the intermediate spring engages the lowest portion of the cam C2 effecting closure of the contacts 1. Also, at this time, in the set of switch springs S3, the intermediate spring engages the low portion of the cam C3 effecting respective closure and opening of the contacts 1 and 2; and in the set of switch springs S4, the upper spring engages the high portion of the cam C4 effecting opening of the associated contacts. In the set of switch springs S1, when the contacts Y are thus closed, a direct circuit is completed for initiating operation of the operating motor 16; this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the operating motor 16, the conductor 76, the contacts 1 of the set of switch springs S3, the conductor 74 and the contacts Y of the set of switch springs S1 to the conductor 71. Also, in the set of switch springs S1, when the contacts X are thus closed, a circuit is completed for initiating operation of the timer motor 66; this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the timer motor 66, the conductor 75 and the contacts X of the set of switch springs S1 to the conductor 71. Upon operating, the operating motor 16 rotates the impeller 14 in the counterclockwise direction, as viewed from the top of the vat 12. Upon operating, the timer motor 66 rotates, through the gearing in the gear box 67, the stub shaft 61 in the counterclockwise direction; whereby the shaft 60 is rotated in the counterclockwise direction through the friction clutch 62, effecting continued rotation of the shaft 54 in the clockwise direction from its "on" position by virtue of the gearing 63—64. Finally, the cam C5 operates the set of switch springs S5, the lower spring engaging the high portion of the cam C5 closing the contacts thereof so as to complete an auxiliary circuit for energizing the inlet valve solenoid 18', this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the contacts 1 of the set of switch springs S2, the conductor 77, the inlet valve solenoid 18', the contacts 41 of the measuring coil R40, the conductor 79, the bridging member 85 and associated contacts, the conductor 86, the contacts of the set of switch springs S5, the conductor 74 and the contacts Y of the set of switch springs S1 to the conductor 71. Accordingly, the inlet valve solenoid 18' is energized via its auxiliary circuit effecting operation of the inlet valve 18 into its open position; whereby water is supplied from the inlet conduit 17 to the spray device 20, the water passing through the valve chamber in the casing 81 of the inlet valve 18 that is arranged in good heat exchange relationship with the casing 82 of the thermal switch 83. At this time, it is assumed that the water thus supplied through the casing 81 of the inlet valve 18' is below the predetermined relatively high temperature previously mentioned, so that the thermal switch 83 occupies its closed position, as previously noted. The water sprays downwardly from the spray device 20 through the dishes supported by the rack structure, not shown, and accumulates in the sump 15. This water drains from the sump 15 through the drain mechanism 22 in its draining position and thence into the drain conduit 25. This arrangement insures that any cold or merely warm water in the piping disposed between the inlet conduit 17 and the hot water supply system (the hot water storage tank) is flushed therefrom preceding the active control cycle of the dishwashing apparatus 10. As time proceeds, the cold or merely warm water mentioned is flushed from the piping noted; whereby the water entering the casing 81 of the inlet valve 18 is at the predetermined relatively high temperature previously mentioned; whereby the bellows 84 is expanded effecting operation of the bridging member 85 to disengage its associated contacts so that the thermal switch 83 is operated into its open circuit position to interrupt the auxiliary circuit for energizing the inlet valve solenoid 18' in order to bring about the return of the inlet valve 18 slowly back into its closed position under the control of the associated dashpot.

After an elapsed time interval of approximately 90 seconds, the lower spring of the set of switch springs S5 disengages the high portion of the cam C5 effecting opening of the contacts thereof and the consequent opening of another point in the auxiliary circuit for energizing the inlet valve solenoid 18'. Also at this time, in the set of switch springs S3, the intermediate spring engages the high portion of the cam C3 effecting opening of the contacts 1 and closing of the contacts 2 thereof. When the contacts 1 of the set of switch springs S3 are thus opened, the previously-traced direct circuit for energizing the operating motor 16 is interrupted; and a normally completed shunt, including the conductors 74 and 76, for short-circuiting the measuring coil R40 is interrupted; whereby the measuring coil R40 is inserted in series circuit relation with the operating motor 16. This series circuit for the operating motor 16 and the measuring coil R40 extends from the conductor 72 via the door switch S41, the conductor 73, the operating motor 16, the conductor 76, the measuring coil R40, the conductor 74 and the contacts Y of the set of switch springs S1 to the conductor 71. Accordingly, the measuring coil R40 is now energized in series circuit relation with the operating motor 16 and meters the current drawn by the operating motor 16, which current is not excessive at this time, since the operating motor 16 has already had an opportunity to gain full speed and there is no wash liquid in the sump 15 in the vat 12. In passing, it is noted that the measuring coil R40 is of the marginal type and is not operated to open its contacts 41 when light currents are drawn by the operating motor 16, as explained more fully hereinafter.

Also, in the set of switch springs S3, when the contacts 2 are closed, a main circuit is completed for energizing the inlet valve solenoid 18'; this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the contacts 1 of the set of switch springs S2, the conductor 77, the inlet valve solenoid 18', the contacts 41 of the measuring coil R40, the conductor 79, the contacts 2 of the set of switch springs S3, the conductor 74 and the contacts Y of the set of switch springs S1 to the conductor 71. When the inlet valve solenoid 18' is thus energized via its main circuit, the inlet valve 18 is again operated to its open position, as previously explained; whereby hot water is again supplied from the inlet conduit 17 to the spray device 20 and thence sprayed downwardly through the dishes supported by the rack structure, not shown, and accumulates in the sump 15. Again the water drains from the sump 15 through the drain mechanism 22 and thence into the drain conduit 25. However, at this time the water is hot, since any cold or merely warm water has been previously flushed from the system, as explained above. Some of the water in the sump 15 may be caught and flushed upwardly and outwardly through the dishes supported by the rack structure, not shown, by the blades of the impeller 14, although this action is not considerable at this time, since the drain mechanism 22 occupies its draining position. Accordingly, the dishes supported by the rack structure, not shown, in the vat 12 are subjected to a first hot water spray step that is car-

ried out through a time interval of approximately 30 seconds.

At the conclusion of this first spray step the upper spring of the set of switch springs S4 engages the low portion of the cam C4 closing the associated contacts and completing a circuit for energizing the drain mechanism solenoid 22'; this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the contacts 1 of the set of switch springs S2, the conductor 77, the drain mechanism solenoid 22', the conductor 78, the contacts of the set of switch springs S4, the conductor 74 and the contacts Y of the set of switch springs S1 to the conductor 71. When the drain mechanism solenoid 22' is thus energized the drain mechanism 22 is operated into its non-draining position; whereby the water accumulating in the sump 15 is retained therein after the adjacent section of the flexible conduit 23 is first filled with the water. At this time the inlet valve 18 still occupies its open position and the operating motor 16 is running. Accordingly, the hot water sprayed through the rack structure, not shown, from the spray device 20 accumulates in the sump 15, since the drain mechanism 22 occupies its non-draining position. The water accumulating in the sump 15 of the vat 12 is caught by the blades of the impeller 14 and is flung upwardly and outwardly through the rack structure, not shown, and the dishes supported thereby against the walls of the vat 12 and the door 13 and again returns to the sump 15. The water as it is flung upwardly and outwardly has a generally rotary motion in the counterclockwise direction, as viewed from the top of the vat 12, since the impeller 14 is rotated in this direction, as previously noted.

The supply of hot water from the spraying device 20 continues and as the quantity of water accumulating in the sump 15 increases, the load imposed upon the impeller 14 and consequently upon the operating motor 16 is gradually increased; whereby the current traversing the operating motor 16 and the measuring coil R40 is gradually increased. When a predetermined quantity of water accumulates in the sump 15, a corresponding predetermined load is imposed upon the operating motor 16; whereby the current traversing the operating motor 16 and the measuring coil R40 reaches a predetermined value. When this current traversing the measuring coil R40 reaches the predetermined value mentioned indicating that the vat 12 now contains a full and predetermined quantity of water, the measuring coil R40 effects opening of its contacts 41, since the measuring coil R40 is of the marginal type, as previously noted. When the contacts 41 are thus opened, the main circuit for energizing the inlet valve solenoid 18' is interrupted; whereby the inlet valve 18 is slowly returned to its closed position under the control of the associated dashpot. Shortly thereafter, the inlet valve 18 is completely closed cutting off the supply of hot water from the inlet conduit 17 to the spray device 20.

Approximately 45 seconds after the drain mechanism 22 is operated into its non-draining position, the intermediate spring of the set of switch springs S3 engages the low portion of the cam C3 opening the contacts 2 and reclosing the contacts 1. When the contacts 2 of the set of switch springs S3 are thus opened, another point in the main circuit for energizing the inlet valve solenoid 18' is interrupted; and when the contacts 1 of the set of switch springs S3 are thus closed, the path for short-circuiting the measuring coil R40 is again complete, together with the direct circuit for operating the operating motor 16. Accordingly, the measuring coil R40 is deenergized bringing about reclosure of its contacts 41; however, without effect at this time, since the contacts 2 of the set of switch springs S3 are open. The arrangement above described provides a timed control for effecting the deenergization of the inlet valve solenoid 18' and the consequent return of the inlet valve 18 to its closed position in the event this result has not already been

brought about by opening of the contacts 41 as a consequence of operation of the measuring coil R40 within the 45 seconds period mentioned.

The first washing step continues for a total time of approximately 330 seconds following the operation of the drain mechanism 22 into its non-draining position, and within this time interval and in response to the accumulation of a predetermined quantity of water in the sump 15, the charge of detergent contained in the detergent cup 29 is introduced into the water, in order that the first washing step may be effective to remove grease and other foreign materials from the dishes supported by the rack structure, not shown. The arrangement for introducing the detergent is disclosed in the copending application of Forrest A. Walker, Serial No. 57,448, filed October 30, 1948, now Patent No. 2,657,697 granted November 3, 1943, and is based upon the accumulation of a predetermined quantity of water in the sump 15, whereby the water accumulating in the sump 15 is flushed or washed into the detergent cup 29 carried by the inner wall of the door 13 causing the detergent to be washed into the body of water contained in the vat 12. This introduction of the detergent into the water is accomplished shortly following the operation of the drain mechanism 22 into its non-draining position so that the detergent is present in the water during a substantial part of the time interval of the first washing step.

At the conclusion of the first washing step the upper spring of the set of switch springs S4 engages the high portion of the cam C4 opening the associated contacts and interrupting the circuit for energizing the drain mechanism solenoid 22'; whereby the drain mechanism 22 is returned into its draining position. At this time the water and the carried detergent drain from the sump 15 into the drain conduit 25. The water contained in the sump 15 is drained in a very short interval of time; and approximately 45 seconds after the drain mechanism 22 is operated into its draining position, the intermediate spring of the set of switch springs S3 engages the high portion of the cam C3 again opening the contacts 1 and reclosing the contacts 2. When the contacts 1 are thus opened, the measuring coil R40 is again inserted in series with the operating motor 16; and when the contacts 2 are reclosed, the inlet valve solenoid 18' is again energized via its main circuit; all in the manner previously explained. At this time the inlet valve 18 is operated to its open position effecting the supply of hot water from the liquid supply conduit 17 to the spray device 20; whereby the dishes supported by the rack structure, not shown, are again sprayed with hot water and the water accumulating in the sump 15 drains through the drain mechanism 22 in its draining position and thence into the drain conduit 25. This second spray step is carried out for a time interval of approximately 10 seconds; whereupon the upper spring of the set of switch springs S4 engages the lower portion of the cam C4 reclosing the associated contacts and effecting reenergization of the drain mechanism solenoid 22'. The drain mechanism 22 is again operated into its non-draining position causing the water to be retained in the sump 15, initiating a second washing step.

The second washing step proceeds in the manner of the first washing step described above; whereby the inlet valve 18 is subsequently operated back into its closed position, under the load control of the measuring coil R40, or under the time control of the cam C3 and the associated set of switch springs S3; all in the manner previously explained. In any case, after a time interval of approximately 45 seconds following operation of the drain mechanism 22 into its non-draining position, the intermediate spring of the set of switch springs S3 engages the low portion of the cam C3 opening the contacts 2 and closing the contacts 1 in order positively to insure deenergization of the inlet valve solenoid 18' and short-circuiting of the measuring coil R40. At this time the

inlet valve 18 occupies its closed position and the drain mechanism 22 occupies its non-draining position; whereby the second washing step continues in the manner previously explained. The second washing step continues for a time interval of approximately 330 seconds following operation of the drain mechanism 22 into its non-draining position; whereupon the upper spring of the set of switch springs S4 engages the high portion of the cam C4 opening the associated contacts and effecting deenergization of the drain mechanism solenoid 22' and the consequent operation of the drain mechanism 22 into its draining position.

The water accumulated in the sump 15 is drained into the drain conduit 25 in the manner previously explained in a very short time interval; and approximately 45 seconds after the drain mechanism 22 is operated into its draining position, the intermediate spring of the set of switch springs S3 engages the high portion of the cam C3 again opening the contacts 1 and reclosing the contacts 2. Opening of the contacts 1 effects reinsertion of the measuring coil R40 in series with the operating motor 16; and reclosure of the contacts 2 effects reenergization of the inlet valve solenoid 18' via its main circuit. The inlet valve 18 is again operated to its open position in order to initiate a third hot water spray step. The hot water supplied from the liquid supply conduit 17 to the spray device 20 is sprayed through the dishes supported by the rack structure, not shown, and is drained from the sump 15 into the drain conduit 25. This third spray step continues through a time interval of 10 seconds following operation of the inlet valve 18 into its open position; whereupon, the upper spring of the set of switch springs S4 reengages the low portion of the cam C4 reclosing the associated contacts and the circuit for energizing the drain mechanism solenoid 22'. The drain mechanism 22 is operated to its non-draining position in order again to cause the water to accumulate in the sump 15, initiating a first rinsing step.

The first rinsing step proceeds in a manner substantially identical to the first washing step described above; whereby the inlet valve 18 is subsequently operated to its closed position, under the load control of the measuring coil R40, or under the time control of the cam C3 and the associated set of switch springs S3; all in the manner previously explained. In any case, after a time interval of approximately 45 seconds following operation of the drain mechanism 22 into its non-draining position, the intermediate spring of the set of switch springs S3 engages the low portion of the control cam C3 effecting opening of the contacts 2 and closing the contacts 1 in order positively to insure deenergization of the inlet valve solenoid 18' and short-circuiting of the measuring coil R40. At this time the inlet valve 18 occupies its closed position and the drain mechanism 22 occupies its non-draining position; whereby the first rinsing step continues for a time interval of approximately 90 seconds following the operation of the drain mechanism 22 into its non-draining position; whereupon the upper spring of the set of switch springs S4 engages the high portion of the cam C4 opening the associated contacts and effecting deenergization of the drain mechanism solenoid 22' and the consequent return of the drain mechanism 22 to its draining position.

The water accumulated in the sump 15 is drained into the drain conduit 25 in the manner previously explained in a short time interval; and approximately 45 seconds after the drain mechanism 22 is operated into its draining position, the intermediate spring of the set of switch springs S3 engages the high portion of the cam C3 opening the contacts 1 and closing the contacts 2 in order to effect insertion of the measuring coil R40 in series with the operating motor 16 and energization of the inlet valve solenoid 18' via its main circuit. The inlet valve 18 is again operated to its open position in order to initiate a fourth hot water spray step. The hot water supplied from the liquid supply pipe 17 to the spray device 20 is sprayed through the dishes supported by the rack structure, not shown, and is drained from the sump 15 to the drain conduit 25. This fourth spray continues through a time interval of 10 seconds following operation of the inlet valve 18 into its open position; whereupon the upper spring of the set of switch springs S4 engages the low portion of the cam C4 closing the associated contacts and effecting energization of the drain mechanism solenoid 22'. The drain mechanism 22 is operated to its non-draining position in order again to cause the water to accumulate in the sump 15, imitiating a second rinsing step.

The second rinsing step proceeds in a manner identical to the first rinsing step described above; whereby the inlet valve 18 is subsequently operated to its closed position under the load control of the measuring coil R40, or under the time control of the cam C3 and the associated set of switch springs S3; all in the manner previously explained. In any case, after a time interval of approximately 45 seconds following operation of the drain mechanism 22 into its non-draining position, the intermediate spring of the set of switch springs S3 engages the low portion of the cam C3 opening the contacts 2 and closing the contacts 1 in order positively to insure deenergization of the inlet valve solenoid 18' and short-circuiting of the measuring coil R40. At this time the valve 18 occupies its closed position and the drain mechanism 22 occupies its non-draining position; whereby the second rinsing step continues for a time interval of approximately 90 seconds following operation of the drain mechanism 22 into its non-draining position; whereupon the upper spring of the set of switch springs S4 engages the high portion of the cam C4 opening the associated contacts in order to effect deenergization of the drain mechanism solenoid 22' and the consequent return of the drain mechanism 22 to its draining position.

The water accumulated in the sump 15 is drained into the drain conduit 25 in the manner previously explained in a short time interval; and approximately 45 seconds after the drain mechanism 22 is operated into its draining position, the intermediate spring of the set of switch springs S2 engages the highest portion of the cam C2 opening the contacts 1 and closing the contacts 2. When the contacts 1 of the set of switch spring S2 are thus opened, a common point in the main circuit for energizing the inlet valve solenoid 18' and in the circuit for energizing the drain mechanism solenoid 22' is interrupted, thereby positively to insure that the inlet valve 18 occupies its closed position and the drain mechanism 22 occupies its draining position in the remainder of the washing cycle. In other words, the operation of the set of switch springs S2 to open the contacts 1 positively disables further effective control of the sets of switch springs S3, S4 and S5, notwithstanding further operation thereof by the respective cams C3, C4 and C5. In the set of switch springs S2, closure of the contacts 2 completes a circuit for energizing the heating element 26; this circuit extending from the conductor 72 via the door switch S41, the conductor 73, the contacts 2 of the set of switch springs S2, the conductor 87, the heating element 26, the conductor 75 and the contacts X of the set of switch springs S1 to the conductor 71; whereby heat produced by the heating element 26 in the vat 12 is circulated in the vat 12 by the blades of the impeller 14, since operation of the operating motor 16 is continued at this time. The hot air circulated in the vat 12 by the impeller 14 is directed into contact with and through the dishes supported by the rack structure, not shown, and thence back into contact with the heating element 26.

This initial drying step is continued for a time interval of approximately 1200 seconds; whereupon the lowermost spring of the set of switch springs S1 engages the intermediate portion of the cam C1 effecting opening of the contacts Y while the contacts X are retained closed.

Opening of the contacts Y of the set of switch springs S1 interrupts the circuit for operating the operating motor 16; while the closed contacts X of the set of switch springs S1 retains completed the circuit for energizing the heating element 26. Accordingly, the operating motor 16 stops, arresting the rotation of the impeller 14, while the supply of heat to the heating element 26 continues. Thus drying of the dishes supported by the rack structure, not shown, continues through a final drying step after operation of the impeller 14 has been arrested. The final drying step continues for a time interval of approximately 600 seconds; whereupon the lowermost spring of the set of switch springs S1 engages the lowest portion of the cam C1 opening the contacts X; and the intermediate spring of the set of switch springs S2 engages the intermediate portion of the cam C2 opening the contacts 2. Opening of the contacts X of the set of switch springs S1 interrupts the circuit for energizing the heating element 26 and interrupts the operating circuit for the timer motor 66. Also, opening of the contacts 2 of the set of switch springs S2 interrupts another point in the circuit for energizing the heating element 26; whereby both terminals of the heating element 26 are disconnected at this time from the line conductors 71 and 72 of the source of current supply.

At this time the shaft 54 of the program control switch 30 has been rotated from its "on" position in the clockwise direction back into its "off" position; operation of the program control switch 30 has been arrested; and the washing cycle of the dishwashing apparatus 10 has been completed. Thus it will be understood that when the manual control knob 55 of the circuit controller 30 is rotated from its "off" position, slightly greater than 60 degrees in the clockwise direction into its "on" position, further operation of the program control switch 30 is automatically continued under the control of the timer motor 66. More particularly, the timer motor 66 effects continued rotation of the manual control knob 55 in the clockwise direction from its "on" position back into its "off" position; whereby operation of the program control switch 30 is automatically arrested. As the shaft 54 is rotated from its "on" position back into its "off" position in the clockwise direction, it is rotated sequentially through the different control positions thereof causing the cams C1 and C2 to effect the operations of the sets of switch springs S1 and S2, respectively, as described above. Also the shaft 60 is rotated in the counterclockwise direction causing the cams C3, C4 and C5 to effect the sequential operations of the sets of switch springs S3, S4 and S5, respectively, as described above.

Since the shaft 60 is rotated three revolutions in the counterclockwise direction while the shaft 54 is rotated only one revolution in the clockwise direction, non-controlling operations by the cams C3, C4 and C5, are effected at the beginning and at the end of the washing cycle; however, without effect, since the actual controls exerted by the sets of switch springs S3, S4 and S5 are negated by the set of switch springs S2, except during one revolution of the shaft 60 in the intermediate portion of the washing cycle. More particularly, the sets of switch springs S3, S4 and S5 are rendered operative to effect controls only when the set of switch springs S2 is operated to close the contacts 1; which circumstance is presented in the cycle only during rotation of the shaft 54 through the segment of its revolution between about 60° and 180° thereof from its "off" position. This rotation of the shaft 54 through about 120° corresponds to about a complete revolution of the shaft 60, as clearly indicated in Fig. 4. Following this rotation of the shafts 60 and 54 and when the shaft 54 reaches the 180° position, the cam C2 operates the set of switch springs S2 in order to open the contacts 1, thereby again to negate operation of the sets of switch springs S3, S4 and S5.

This arrangement is very advantageous as it permits utilization of the complete 360° of periphery of the

cams C3, C4 and C5 to effect the required operations of the sets of switch springs S3, S4 and S5, respectively, during the corresponding 120° of rotation of the cams C1, C2 and C3. Thus the arrangement permits the desired fine and accurate controls of the inlet valve solenoid 18' and the drain mechanism solenoid 22' repeatedly in the intermediate 1170 seconds within the washing cycle where these controls are required. Thus the cams C1 to C5, inclusive, effect coordinate operations of the sets of switch springs S1 to S5, respectively, in order to effect the automatic cycle of the dishwashing apparatus 10 through the various flushing, spraying, washing, rinsing and drying steps, as explained above.

As previously explained, the friction clutch 62 arranged between the shafts 60 and 61 permits rotation of the shaft 60 in either direction by the manual control knob 55 with respect to the stub shaft 61 at any time and independently of the timer motor 66 so that any one or more of the steps in the above described washing cycle may be selectively omitted or repeated by appropriate manual rotation of the manual control knob 55 in the proper direction. For example, the final drying step may be omitted from the above-described washing cycle by rotating the manual control knob 55 in the clockwise direction back into its "off" position, when the cam C2 first operates the set of switch springs S2 to close the contacts 2; thereby reducing the length of the washing cycle by approximately 30 minutes. This facility is especially useful when it is desired to wash a number of loads of dishes and automatic drying thereof is not important to the operator, or hand-drying thereof is particularly wished by the operator.

During the operation of the dishwashing apparatus 10 in the timed washing cycle above described, the door 13 must be retained in its closed position as previously explained, in order to retain the door switch S41 in its closed position, as it will be observed that the door switch S41 occupies an interlock position in the control network, and that any time the door 13 is operated into its open position, the door switch S41 is operated into its open position, arresting all operations of the dishwashing apparatus 10. Finally, at the conclusion of the timed washing cycle, the dishes supported by the rack structure, not shown, have not only been thoroughly washed and rinsed, but they have also been dried. Subsequently, the door 13 may be moved from its closed position into its open position, and the rack structure, not shown, may be moved out of the vat 12 over the door 13 in its open position, so that the dishes may be removed from the rack structure and placed in a kitchen cabinet, or the like, if desired.

In view of the foregoing, it is apparent there has been provided in dishwashing apparatus an improved cycle of operation of the electroresponsive elements thereof that permits flexibility of operation and achieves accurate and positive response and that positively insures the flushing of any cold or warm water from the hot water supply system preceding the principal washing cycle of the dishwashing apparatus, so that the principal washing cycle mentioned is always carried out with hot water.

While there has been described what is at present considered to be the preferred embodiment 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.

What is claimed is:

1. In dishwashing apparatus including a vat, an inlet conduit communicating with said vat, a hot water supply system connected to said inlet conduit, a valve included in said inlet conduit and biased into its closed position, electro-responsive means effective when energized to actuate said valve against its bias into its open position, and a normally open drain conduit communicating with said vat; the combination comprising a program controller

having an off position and a prepare position and a plurality of control positions, a manually operable member for operating said program controller from its off position into its prepare position, a timer for operating said program controller through its prepare position and then through its control positions back into its off position, means responsive to operation of said program controller into its prepare position for initiating operation of said timer and responsive to operation of said program controller back into its off position for arresting operation of said timer, first and second multiple circuits for energizing said electro-responsive means, a control switch biased into its closed position, thermal means operatively associated with said inlet conduit and responsive to the supply of hot water at a predetermined relatively high temperature from said hot water supply system to said inlet conduit for operating said control switch against its bias into its open position, first control contacts closed by said program controller in its prepare position, said first circuit including in series relation said control switch and said first control contacts, second control contacts selectively opened and closed by said program controller in certain of its control positions, said second circuit including said second control contacts, whereby said first circuit is normally closed by operation of said program controller into its prepare position and normally opened by operation of said control switch into its open position and said second circuit is subsequently selectively opened and closed by operation of said program controller through its certain control positions, so that any cold water in said inlet conduit is flushed therefrom through said vat into said drain conduit incident to operation of said program controller from its off position into its prepare position and prior to operation thereof into its control positions, and means responsive to operation of said program controller into particular ones of its control positions for selectively closing said drain conduit in order selectively to retain in said vat the water supplied thereto from said inlet conduit.

2. The dishwashing apparatus combination set forth in claim 1, wherein said means for selectively closing said drain conduit essentially comprises drain mechanism having draining and non-draining positions and biased into its draining position and operative against its bias into its non-draining position.

3. The dishwashing apparatus combination set forth in claim 2, and further comprising means responsive to operation of said program controller into said particular ones of its control positions for circulating in said vat the water retained therein so as to produce a washing action therein.

4. The dishwashing apparatus combination set forth in claim 1, and further comprising relay means responsive to the accumulation of a predetermined quantity of water in said vat for opening said second circuit independently of said second control contacts.

5. The dishwashing apparatus combination set forth in claim 1, wherein said valve is provided with a first casing defining a valve chamber and having an opening therein, and said thermal means is provided with a second casing arranged in said opening and in watertight relation with said first casing and in good heat exchange relation with the water in said valve chamber.

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