

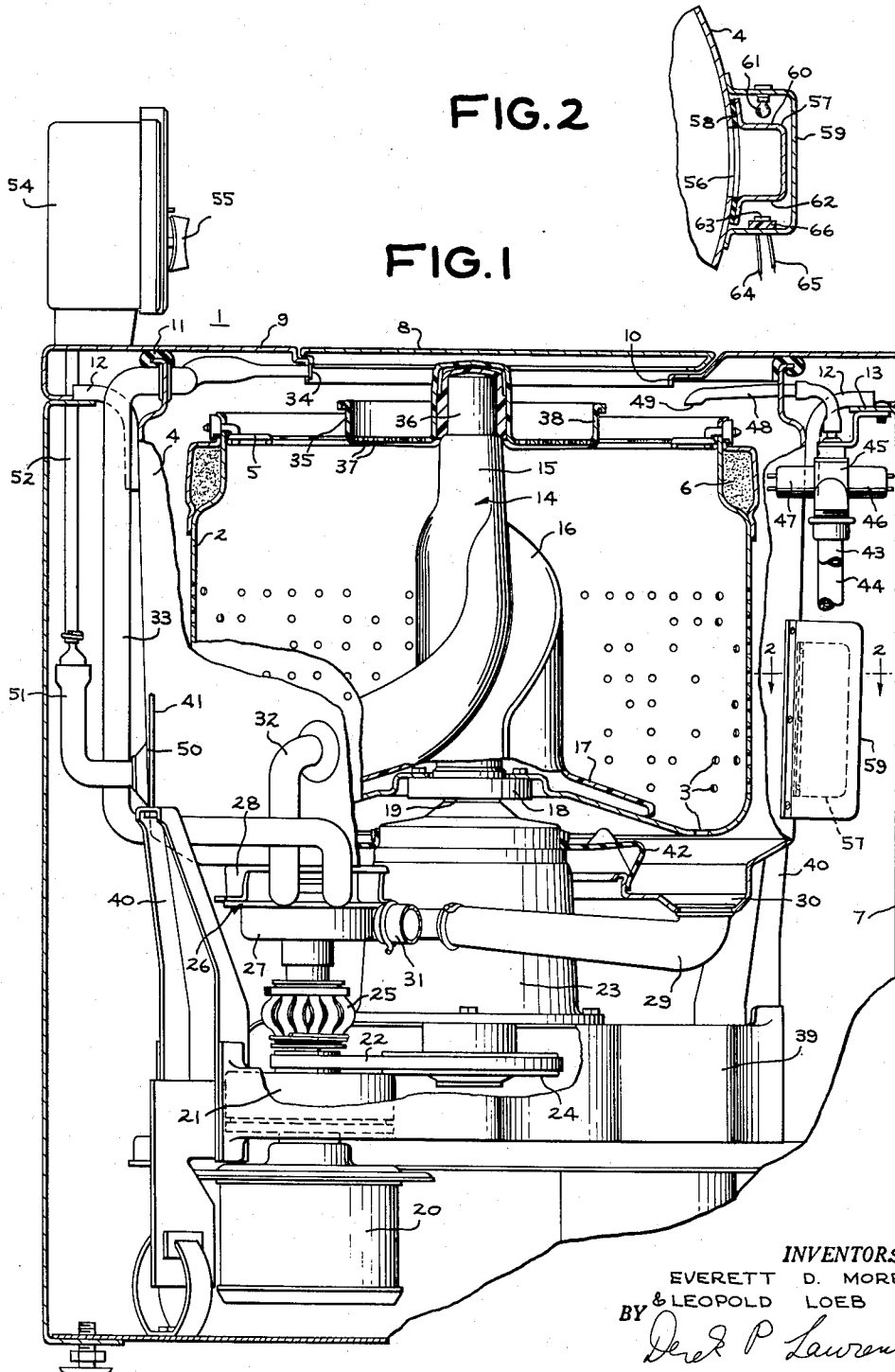
Dec. 17, 1963

E. D. MOREY ET AL
AUTOMATIC WASHING MACHINE HAVING MEANS TO
MEASURE THE RATE OF CHANGE OF TURBIDITY

3,114,253

Filed Sept. 13, 1962

3 Sheets-Sheet 1



INVENTORS
EVERETT D. MOREY
& LEOPOLD LOEB
BY *David P. Lawrence*
THEIR ATTORNEY

Dec. 17, 1963

E. D. MOREY ETAL
AUTOMATIC WASHING MACHINE HAVING MEANS TO
MEASURE THE RATE OF CHANGE OF TURBIDITY

3,114,253

Filed Sept. 13, 1962

3 Sheets-Sheet 3

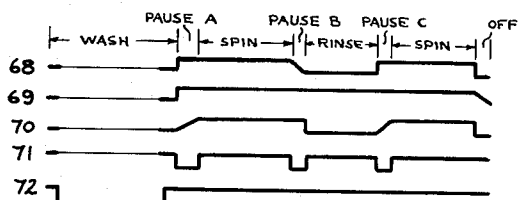


FIG. 4

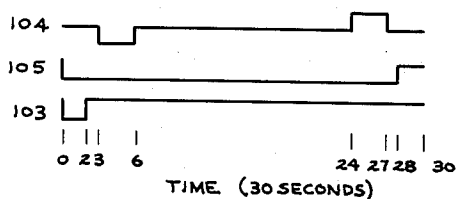


FIG. 5

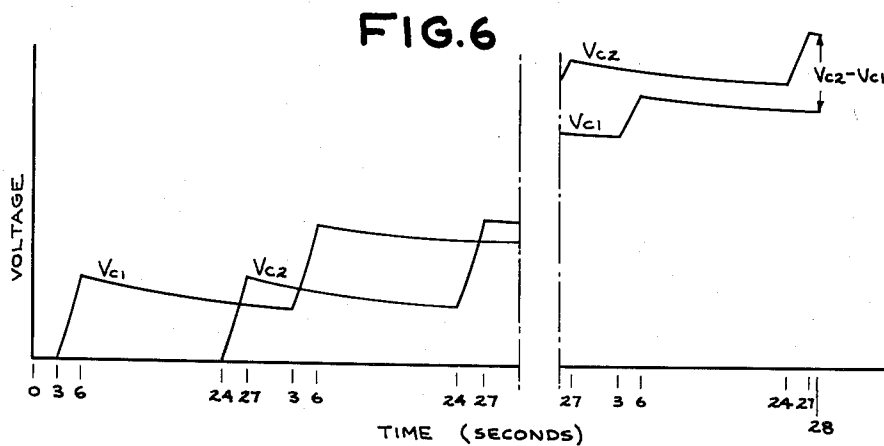


FIG. 6

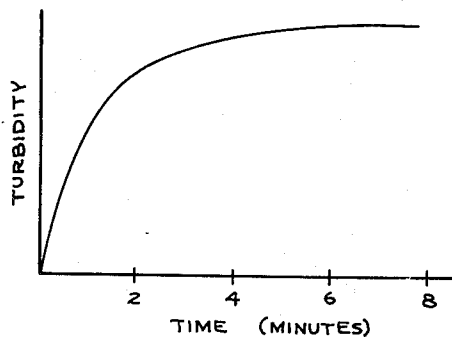


FIG. 7

INVENTORS
EVERETT D. MOREY
& LEOPOLD LOEB
BY *De P. Lawrence*
THEIR ATTORNEY

1

3,114,253

AUTOMATIC WASHING MACHINE HAVING MEANS TO MEASURE THE RATE OF CHANGE OF TURBIDITY

Everett D. Morey and Leopold Loeb, Louisville, Ky., assignors to General Electric Company, a corporation of New York

Filed Sept. 13, 1962, Ser. No. 223,312

9 Claims. (Cl. 68—12)

This invention relates to automatic washing machines, and more particularly to such machines which include structure responsive to the rate of change of turbidity of the liquid used in such machines.

In automatic washing machines available at the present time, the washing operation, as well as all other operations, is a timed function. In other words, the operator estimates how long it will take for articles to get clean and sets the machine accordingly. As a result the machine proceeds to wash the articles by relative motion of the articles and the liquid for the predetermined time. In clothes washing machines, for instance, this involves an estimate of the size of the clothes load, the type of fabric, the type and amount of soil, the difficulty of removing such soil from that type of fabric, efficiency of the washing solution, and other such factors; with so many factors, it is virtually impossible to estimate the needed time with accuracy.

A much more satisfactory solution is to cause an operation to be terminated when appropriate measurements show that it has been successfully completed. In the case of clothes, this would mean that the clothes would continue to be washed as long as the washing was having a beneficial effect, and that as soon as further washing ceased to have any advantage, the washing operation would cease and the machine would then proceed through the remainder of its cycle.

It has long been known that, with a particular type of article having a particular amount of soil, and with a known type of washing solution present in a predetermined amount, the amount of soil extracted from the articles may be measured by the turbidity, or cloudiness, or the liquid washing medium. However, for practical purposes in appliances such as clothes washers, this does not represent an adequate solution to the problem because of all the varying factors.

It is, accordingly, an object of our invention to provide an improved means for automatically terminating an operation in a washing machine once said operation has been successfully completed.

A further, more specific, object of our invention is to achieve this goal by utilizing the turbidity phenomenon in a novel manner.

Specifically, it is an object of our invention to utilize the rate of change of turbidity to indicate what is happening in the machine and the need for one type of controlling action or the other.

In one aspect of our invention, for instance, we provide a washing machine which has, in the usual way, container means for articles to be washed and the liquid, together with suitable means for providing the articles and the liquid with relative motion to each other. As an important feature of our invention we provide means for measuring the rate of change of turbidity of the liquid. When a predetermined rate of change is reached, it causes operation of control means which then effects a suitable change in the condition of the washing machine.

As a specific example, in the washing of clothes the detergent solution ordinarily used will have an increasing turbidity until soil ceases to be removed from the clothes. At this point, the turbidity of the wash solution will cease to change and will remain fairly constant.

2

Accordingly, if the control means is actuated when the rate of change of turbidity of the solution almost approaches zero, full effectiveness of the machine in a minimum amount of time will be insured insofar as the washing of all clothes is concerned.

The subject matter which we regard as our invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention itself, however, both as to its organization and method of operation, together with further advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

In the drawings, FIGURE 1 is a side elevational view of a clothes washing machine which includes our invention, the view being partially broken away and partially in section to illustrate details;

FIGURE 2 is a view along line 2—2 in FIGURE 1; FIGURE 3 is a schematic diagram of an electric control circuit including our invention, which circuit is incorporated in the machine of FIGURE 1;

FIGURE 4 is a schematic view of a development of the cam surfaces used in the control of the main timer operated switches of FIGURE 3, thereby indicating the operation of the switches by the cams throughout a cycle;

FIGURE 5 is a schematic view of a development of the cam surface of the auxiliary timer cam surface used in the control of the switches in the turbidity measuring portion of the circuit of FIGURE 3;

FIGURE 6 is a graph showing the voltage differential phenomenon, provided by the circuit of FIGURE 3 and which is utilized to sense the rate of change of turbidity; and

FIGURE 7 is a graph showing a typical curve of the rate of change of turbidity for a washing solution in the clothes washing machine of FIGURE 1.

Referring now to FIGURE 1, we have shown therein an agitator type clothes washing machine 1 having a conventional basket or clothes receiving receptacle 2 provided over its side and bottom walls with perforations 3 and disposed within an outer imperforate tub or casing 4 which serves as a liquid receptacle, the basket and tub together serving in effect as container means for clothes and the liquid in which they are to be washed and rinsed. Basket 2 may be provided with a suitable clothes retaining member 5 for preventing clothes from being floated over the top of the basket and with a balance ring 6 to help steady the basket when (as will be explained) it is rotated at high speed.

Tub 4 is rigidly mounted within an appearance cabinet 7 which includes a cover 8 hingedly mounted on the top portion 9 of the cabinet for providing access to an opening 10 to the basket 2. A gasket 11 may be provided so as to form a seal between the top of tub 4 and portion 9 of the cabinet thereby to prevent escape of moisture and moist air into the cabinet around the tub. The rigid mounting of tub 4 within the cabinet 7 may be effected by any suitable means. As a particular example of one such means we have provided strap members 12, each of which is secured at one end to an interned flange 13 of the cabinet and at its other end to the outside of tub 4. At the center of basket 2 there is positioned a vertical axis agitator 14 which includes a center post 15 and a plurality of curved water circulating vanes 16 joined at their lower ends by an outwardly flared skirt 17.

Both the clothes basket 2 and the agitator 14 are rotatably mounted. The basket is mounted on a flange 18 of a rotatable hub 19, and the agitator 14 is mounted on a shaft (not shown) which extends upwardly through the hub 19 and through the center post 15 and is secured to the agitator so as to drive it. During the cycle of opera-

3

tion of the machine 1, water is introduced into the tub 4 and basket 2, and the agitator 14 is then oscillated back and forth on its axis, that is, in a horizontal plane within the basket. This causes washing of the clothes by effecting relative motion of the clothes to the liquid, as well as suitable flexing of the fabric of the clothes. Then, after a predetermined period of this washing action, basket 2 is rotated at high speed to extract centrifugally the washing liquid from the clothes and discharge it to drain. Following this extraction operation, clean water is introduced into the basket for rinsing the clothes and the agitator is again oscillated. Finally, the basket is once more rotated at high speed to extract the rinse water.

Basket 2 and agitator 14 may be driven through any suitable means from a reversing motor. By way of example, we have shown them as driven from a reversible motor 20 through a system including a clutch 21 mounted on the motor shaft. A suitable belt 22 transmits power from clutch 21 to a transmission assembly 23 through a pulley 24. Thus, depending upon the direction of motor rotation, pulley 24 of transmission 23 is driven in opposite directions. The transmission 23 is so arranged that it supports and drives both the agitator drive shaft and basket mounting hub 19. When motor 20 is rotated in one direction the transmission causes agitator 14 to oscillate in a substantially horizontal plane within the basket 2. Conversely, when motor 20 is driven in the opposite direction, the transmission rotates the wash basket 2 and agitator 14 together at high speed for centrifugal liquid extraction. While the specific type of transmission mechanism used does not form part of our invention, reference is made to Patent 2,844,225 issued to James R. Hubbard, et al. on July 22, 1958 and owned by the General Electric Company, assignee of the present invention. That patent discloses in detail the structural characteristics of a transmission suitable for use in the illustrated machine.

In addition to operating the transmission 23 as described, motor 20 also provides a direct drive through a flexible coupling 25 to a pump structure generally indicated at 26 which may include two separate pumping units 27 and 28 both operated simultaneously in the same direction by motor 20. Pump 27 has an inlet which is connected by a conduit 29 to an opening 30 formed at the lowermost point of tub 4. Pump 27 also has an outlet which is connected by a conduit 31 to a suitable drain (not shown). Pump 28 has an inlet connected by a conduit 32 to the interior of tube 4 and an outlet connected by a conduit 33 to a nozzle 34. The pumps are formed so that in the spin direction of motor rotation pump 27 will draw in liquid from opening 30 through conduit 29 and then discharge it through conduit 31 to drain, and in the other direction of rotation pump 28 will draw in liquid through conduit 32 and discharge it through conduit 33 and nozzle 34, each of the pumps being substantially inoperative in the direction of rotation in which it is not used.

Nozzle 34 is positioned to discharge into a filter pan 35 secured on the top portion 36 of agitator 14 so as to be movable therewith. With this structure then, when the motor is rotating so as to provide agitation pump 28 draws liquid through conduit 32 from tub 4 and discharges it through conduit 33 so that the liquid passes from nozzle 34 into filter pan 35, and then down through a number of small openings 37 provided in the bottom of the filter pan and back into basket 2. In this manner, the filter pan 35 with its small openings 37 and its upstanding side wall 38 causes lint which is separated from the clothes during a washing operation to be filtered out of the water, and thus prevents it from being redeposited on the clothes. This type of structure is more fully described and claimed in Patent 2,481,979 issued to Russell H. Colley on September 13, 1949 and assigned to General Electric Company, owner of the present invention.

The motor 20, clutch 21, transmission 23, basket 2 and

4

agitator 14 form a suspended washing and centrifuging system which is supported by the stationary structure of the machine so as to permit isolation of vibrations from the stationary structure. It will be understood that such vibrations occur primarily as a result of high speed spinning of basket 2 and the load of clothes therein, as mentioned above. While any suitable suspension structure may be used, one suitable structure includes a bracket member 39 with transmission 23 mounted on top thereof and motor 20 mounted to the underside thereof. The bracket member in turn is secured to upwardly extending rigid members 40, and each of the two upwardly extending members 40 is connected to a cable 41 supported from the top of the machine. While only a portion of the suspension system is shown in the drawing, such a vibration isolating system is fully described and claimed in Patent 2,987,190 issued on June 6, 1961 to John Bochan and assigned to General Electric Company, assignee of the present invention.

In order to accommodate the movement which occurs between basket 2 and tub 4 without any danger of leakage between them, the stationary tub 4 is joined to the upper part of transmission 23 by a flexible boot member 42. Boot 42 may be of any suitable configuration, many of which are known in the art, to permit relative motion of the parts to which it is joined without leakage therebetween.

Hot and cold water may be supplied to the machine through conduits 43 and 44 which are adapted to be connected respectively to sources of hot and cold water (not shown). Conduits 43 and 44 extend into a conventional mixing valve structure 45 having solenoids 46 and 47 so that energization of solenoid 46 permits passage of hot water through the valve to a hose 48. Energization of solenoid 47 permits passage of cold water through the valve and energization of both solenoids permits mixing of hot and cold water in the valve and passage of warm water into hose 48. Hose 48 has an outlet 49 positioned to discharge into basket 2 so that when one or both of the solenoids 46 and 47 are energized water passes into basket 2 and tub 4.

The level to which water rises in the basket and tub may be controlled by any suitable liquid level sensing means. One typical arrangement for doing this is to provide an opening 50 in the side of tub 4 adjacent the bottom thereof, the opening 50 being connected through a conduit 51 and a tube 52 to a conventional pressure sensitive switch (shown schematically in FIGURE 3 by the number 53) which may be positioned within the backsplasher 54 of machine 1. In the conventional manner, as the water rises in basket 2 and tub 4 it exerts increasing pressure on a column of air trapped in tube 52, and at a predetermined pressure level the column of air then trips switch 53 to shut off whichever of solenoids 46 and 47 may be energized. The backsplasher 54 may have suitable manual controls, such as that shown at 55. Controls 55 are used to control, for instance, washing and spin speeds, water temperatures, water level within the tub 4 and basket, etc., for the washing of different types of fabrics.

It will be noted that, in accordance with one aspect of our inventive concept, we provide an opening 56 in the wall of tub 4 (FIGURE 2). Opening 56 leads into an enclosure surrounded by a member 57 formed of transparent material such as, for instance, glass or clear plastic. Member 57 may be secured through an appropriate sealing gasket 58 to the tub 4 so that it cooperates therewith to form a water tight connection. Also secured to the tub wall 4 around member 47 is a support member 59. On one side 60 of member 57, member 59 supports a source of light 61, such as, for instance, an ordinary incandescent light bulb. On the other side 62 of member 57 the member 59 supports a resistor 63 having conductors 64 and 65 connected thereto, and appropriately insulated from member 59 as shown by insulating block 66.

Referring now to FIGURE 3 the electrical control

5

system for the machine of FIGURE 1 will be described. In connection with the circuit of FIGURE 3 it will be understood that present day washers often include various improvements such as two speed mechanisms, control panel lights, bleach dispenser controls, etc., which do not relate to the present invention, and that, to some extent, these have been omitted for the sake of simplicity and ease of understanding.

In order to control the sequence of operations of the components of machine 1, the circuit includes a main automatic sequence control assembly which incorporates a timer motor 67 driving a plurality of cams 68, 69, 70, 71 and 72. These cams, during their rotation by the timer motor, actuate various switches, as will be described, causing the machine to pass through an appropriate cycle of operations, first washing the clothes, next extracting water from them by centrifuging, then rinsing the clothes in clean water, and finally centrifuging the rinse water from the clothes. The operating surfaces of the different cams are shown in developed form in FIGURE 4 and will be further discussed herebelow in connection with the description of the operation of the machine. The electric circuit as a whole is energized from a power supply (not shown) through a pair of conductors 73 and 74. Cam 68 controls a switch 75 which includes contacts 76, 77 and 78. When the cam has assumed the position where all three contacts are separated, machine 1 is disconnected from the power source and is inoperative. When operation of machine 1 is to be initiated, as will be explained below, switch 75 is controlled by cam 68 so that contacts 76 and 77 are engaged. When the main switch 79 is closed (by one of the controls 55), power is then provided to the control circuit of the machine from conductor 73 through contacts 76 and 77.

From contact 77 the circuit extends through a conductor 80 and a manually operated switch 81 to the valve controlled solenoid 47. In addition, a circuit is completed from conductor 80 through a switch 82 controlled by cam 69. In the "up" position shown, switch 82 completes a circuit for solenoid 47 independently of switch 81, and in the "down" position switch 82 completes a circuit for solenoid 46. Thus, when switch 81 is open energization of solenoids 46 and 47 is under the control of switch 82, but when switch 81 is closed the cold water solenoid 47 may be energized independently of the position of switch 82.

From the hot and cold water solenoids the energizing circuit then extends through a conductor 83 and then through a coil 84 of a relay 85, the main winding 86 of motor 20, a conventional motor protector 87, a switch 88 controlled by cam 71, switch 79, and the conductor 74. Motor 20 is of the conventional type which is provided with a start winding 89 which assists the main winding 86 during starting of the motor and is energized in parallel therewith. When a relatively high current passes through the relay coil 84, it causes the relay contact 90 to be closed. This permits an energizing circuit for the start winding to be completed in parallel with the main winding through a contact 91 of a switch generally indicated at 92 and which is controlled by cam 70, contact arm 93, the relay contact 90, start winding 89, contact arm 94, and contact 95 of switch 92. A circuit is also completed in parallel with motor 20 from conductor 83 through a switch 96 controlled by cam 72, and then through the timer motor 67.

Relay coil 84 is designed to close contact 90 when a relatively high current, of the level demanded by the motor when it is rotating below a predetermined speed, is passing through it. At other times, when there is no current passing through the relay coil 84, or when the current is below the required energizing level as is true in the running speed range of the motor, the contact 90 is open.

When the main winding 86 of motor 20 is in series with the valve solenoids 46 and 47 as described, a much lower

6

impedance is presented in the circuit by the motor 20 than is presented by the valve solenoids. As a result, the greater portion of the supply voltage is taken up across the solenoids and relatively little across the motor. This causes whichever of the solenoids is connected in the circuit to be energized sufficiently to open its associated water valve. As a result, water at a selected temperature is admitted to the machines through outlet 49, motors 20 and 67 remaining inactive. This action continues with the circuitry thus arranged, so that the water pours into the basket 2 and tub 4. Because of the perforations 3 the water rises in both basket and tub at substantially the same rate. As the head of water acting on the column of air trapped in the tube 52 increases, the pressure of this air increases until it actuates the switch 53 provided with the backplasher 54.

When switch 53 closes, it then provides a short circuit across the solenoids directly from conductor 80 to conductor 83 so that, with the solenoids thus excluded from the effective circuit, they become de-energized and a high potential drop is provided across winding 86 of the motor 20. This causes the relay coil 84 to close contact 90 and start the motor 20, while at the same time motor 67 starts so as to initiate the sequence of operations. It will thus be observed that the energization of the valve solenoids 46 and 47 and the energization of the drive motor 20 are alternative in nature. In other words, when there is sufficient potential across the valve solenoids to energize them, the motor remains de-energized, and it is necessary to short the solenoids out of the circuit so that they are de-energized before the drive motor can be energized.

It is to be observed that switch 88 is in series with the main motor 20 but is not in series with the timing motor 67. Thus, by the opening of this switch, the operation of motor 20 is stopped. The timer motor may nonetheless continue to operate as a result of the fact that the timer motor 67 is deliberately provided with an impedance much greater than that of the valve solenoids so that it will take up most of the supplied voltage and will continue in operation, leaving so little voltage across the solenoids that they do not operate their respective valves.

Our invention contemplates the use of switch 96 in series with timer motor 67, so that when cam 72 opens switch 96 the timer motor 67 may be de-energized, and the main motor 20 will nonetheless continue to operate independently thereof. This particular feature and its purpose will be further explained herebelow.

A further point of the circuit of FIGURE 3 is that when switch arms 93 and 94 are moved by cam 70 to engage contact 95 and a contact 97 respectively, the polarity of the start winding is reversed. The circuit from conductor 83 then proceeds through contact 97, contact arm 94, the start winding 89, relay contact 90, contact arm 93 and contact 95 to the protector device 87 and conductor 74. Thus, provided motor 20 is stopped or slowed down so that relay contact 90 is closed, the reversal of switch 92 is effective to cause the motor 20 to rotate in the opposite direction when the motor starts it up again.

In order to energize motor 20 independently of the water level switch 53 and the valve solenoids, so that a spin operation may be provided without regard to the absence of a predetermined water level, cam 68 is formed so that it may close all three contacts 76, 77 and 78 of switch 75 during centrifugal liquid extraction steps. When this occurs, it causes the power to be supplied from conductor 73 directly through contact 78 to conductor 83 and the motors, rather than through the water level switch or the valve solenoids.

It will be observed that the cam 72, as well as controlling switch 96, also controls a second switch 98 ganged to switch 96. When switch 96 is closed, switch 98 is in engagement with a contact 99, and when switch 96 is opened switch 98 is in engagement with a contact 100. When switch 98 engages contact 100, it is effective to energize an auxiliary timer motor assembly 101 which

7

controls a cam 102. Cam 102 controls the condition of a switch 103, in addition to other functions to be hereinafter described; when contact arm 98 engages contact 99 and switch 103 is closed, energization of the timer motor 101 may be completed just as if switch arm 98 engaged contact 100. However, if switch 103 is open then engagement of contact arm 98 with contact 99 does not effect energization of the timer assembly 101.

Referring now to FIGURE 4 in conjunction with FIGURES 1 and 3, a sequence of operation of machine 1 will be described. It will be assumed that the timer has been set at "Wash" so that cam 68 has caused contacts 76 and 77 to be closed, cam 69 has moved switch 82 to its down position, cam 70 has positioned switch 92 as shown, cam 71 has closed switch 88, and cam 72 has closed switch 96 and moved switch 98 into engagement with contact 99.

At this point, the first step which takes place is the filling of the machine with hot water by the energization of solenoid 46. If switch 81 has been manually closed, solenoid 47 will also be energized and cold water will be provided as well as the hot water, to provide warm water in the machine. The energization of the solenoids, as previously explained, causes motors 20 and 67 to remain inactive, and this status continues until the closure of switch 53, at a predetermined level, at which point the solenoids are de-energized and consequently motor 20 and 67 are energized, the energization of motor 20 being in the direction to cause an agitation operation (because of switch 92).

After a washing operation has started, the timer motor 67 will, after a brief period of operation, on the order of one minute or so, cause the cam 72 to open switch 96 and move switch 98 down into engagement with contact 100 thereby to energize auxiliary timer assembly 101. As will be explained herebelow, this then provides an automatic control for the washing operation causing it to terminate when it has been completed rather than after some predetermined length of time. In effect, what happens is that the timer motor is re-energized when it is sensed that no further cleaning of the clothes is necessary, and then proceeds to terminate the wash operation by causing cam 71 to open switch 88.

This provides pause A by stopping operation of motor 20, and consequently there is no further agitation although, as explained above, the timer motor 67 continues to operate. The operation of the timer motor is insured because, after the re-starting of the timer motor (as will be explained herebelow) it causes cam 72 to re-close switch 96 and return switch 98 into engagement with contact 99. During pause A, cam 69 moves contact 82 to its "up" position, and cam 70 reverses the position of the contact arms of switch 92. In addition, switch 68 closes the three contacts 76, 77 and 73 of switch 75 so as to provide, in effect, a direct connection from line 73 to line 83, thereby by-passing the solenoids 46 and 47.

The reversal of switch 92 reverses the polarity of start winding 89 relative to main winding 81. As a result, when, at the end of pause A, switch 88 is closed by cam 71, motor 20 is energized once again but in the opposite direction. The energization of motor 20 and the continued state of de-energization of the valve solenoids results from the closure of all three contacts of switch 75, bypassing the solenoids and causing the motor to be energized directly across the source of power. As a result, motor 20 starts to operate pump 27 to effect rapid removal of water from tub 4.

In addition, the basket 2 is accelerated to a high rotational speed which effects centrifuging of liquid out of the clothes, so that a substantial part of the washing solution is removed by the cooperative action of the spinning basket and the pump 27. The full rotational speed may, for instance, be on the order of 600 r.p.m., a speed sufficient to extract a very substantial part of the wash solution from the clothes for removal by the pump

8

27. This spin operation continues until pause B, as shown in FIGURE 4, at which time switch 88 it again opened by cam 71 to de-energize motor 20. At this time cam 68 returns switch 75 to the wash position, with contact 78 disengaged from the other two contacts, and the motor connections are reversed to provide agitation rather than spin action. The rinse operation, with cold water as a result of the position of switch 82, then proceeds in the same manner as the washing operation when switch 88 re-closes.

Then, at the end of the rinse operation, there is another pause C provided by the opening of switch 88, at which time the switches 75 and 92 are returned to the position necessary for a spin operation to be provided. When switch 88 re-closes, a second spin operation is provided, and at the end of this second spin operation all three contacts of switch 75 are separated to terminate the operation.

Having outlined the general operation of washing machine 1, the specific feature which provides the use of our invention in the machine will be described. In connection with this feature, the various components of the circuit provided for effecting the desired purpose will be set forth. In addition to controlling the switch 103, cam 102 also controls a switch 104 and a switch 105. The time for assembly 101 to cause a full rotation of cam 102 is relatively short, and may, for example, be on the order of thirty seconds.

Viewing FIGURE 5, it can be seen that the switch 104 is in its down position engaging a contact 106 during seconds three to six, and is in its up position engaging a contact 107 during seconds twenty-four to twenty-seven. The remainder of the time, this switch 104 is in a neutral position between contacts 106 and 107. Switch 105 can be seen to be closed once for each revolution of cam 102 for a period of two seconds from the twenty-eighth second to the thirtieth second. This insures, in effect, that the closure of switch 105 occurs after both contacts 106 and 107 have been engaged by contact arm 104.

The switch 103 is closed from the second second through the thirtieth second of each rotation of cam 102. What this does, in effect, is to insure that, whenever switch 98 is moved out of engagement with contact 100 and up into engagement with contact 99 (except during the first two seconds of the cycle of cam 102), the assembly 101 will continue to be energized through switch 103 until the end of a full cycle of cam 102 is reached; at that time, the opening of cam 103 will provide for the de-energization of assembly 101 with all three contacts 103, 104 and 105 in the correct position for the initiation of another operation. This, as will appear below, is important to the successful operation of the particular illustrated embodiment of our invention.

The entire turbidity sensing circuit generally indicated by the numeral 108 is energized through a transformer 109 which has a primary winding 110 connected across conductors 80 and 74 so as to be energized across the conventional 110 volt source of alternating current power. The secondary winding 111 of transformer 109 thus provides an alternating current voltage across its ends. This current is rectified by a half wave rectifier 112, and the fluctuations are somewhat smoothed out, in a conventional manner, by the provision of a capacitor 113 and a resistor 114; these tend to provide for controlled discharge of the capacitor during periods when the rectifier is preventing current from flowing, and thus result in a fluctuating direct current.

The lamp 61, previously referred to in FIGURE 2, is connected for energization across this source of direct current power, preferably in series with a resistor 115 so that a desired low voltage may be used for energization of the lamp 61 without affecting the voltage supply to the remainder of the sensing circuit.

When contact 104 is in its down position, as shown in engagement with contact 106, a circuit for charging a

capacitor 116 is provided as follows: Starting at the resistor 114, the circuit proceeds through the light sensitive resistor 63, contact arm 104, contact 106, a biasing resistor 117 (to be further discussed herebelow) the capacitor 116 and then back to the other side of the secondary winding 111. Thus, during the first three seconds of closure of switch 104 there is charging of capacitor 116. In the same fashion, during the three seconds of closure of switch 104 with contact 107, there is charging of a capacitor 118 through a circuit which proceeds from resistors 114 and 63 through the contact arm 104, contact 107, a biasing resistor 119 (also to be hereinafter further discussed), the capacitor 118, and then back to the other side of secondary winding 111.

During the twenty-eighth and twenty-ninth seconds of a rotation of cam 102 the switch 105 is closed and this completes an energizing circuit for a glow tube 120 which is of the conventional type, that is, it is substantially non-conductive until a certain voltage across it is reached, at which time it fires and emits light as long as there is an adequate voltage drop across it. When switch 105 is closed, a circuit for firing the glow tube 120 is completed as follows: Starting from side 121 of capacitor 116, the circuit proceeds to the glow tube, then through the switch 105 to side 122 of capacitor 118. What this means, in effect, is that if the capacitors are not charged, or are charged the same, there is no voltage across the glow tube, but if the capacitors are charged to a substantially different extent, then upon closure of switch 105 there will be a voltage differential across the glow tube 120, and when this differential is great enough the glow tube will fire.

When the glow tube 120 fires, it causes a light sensitive resistor 123, which is normally virtually non-conductive, to become conductive, and this in turn permits energization of a relay coil 124, it being understood that such firing always occurs during a washing operation at a time when switch 53 is closed so as to place the resistor 123 and coil 124 across the conductors 73 and 74. Energization of coil 124 closes the two switch contacts 125 and 126. The closure of contact 126 locks the relay 124 in independently of resistor 123 so that even after the glow tube stops firing, and resistor 123 returns to a very high resistance, the relay 124 will continue to be energized.

This continued energization of relay 124 causes, through its closed contact 125, energization of the timer 67 with which contact 125 is in series. It is as a result of this that the timer starts to operate again, as briefly mentioned hereabove, and then reclose switch 96 so that the remainder of the timer operation is independent of the circuit 108.

Returning now to the circuit 103 to describe the manner in which it achieves its desired purpose, the capacitors 116 and 118 are so designed that for a given voltage across them, the capacitor 118 will charge slightly faster than the capacitor 116. This may, of course, be achieved by the characteristics of the capacitors themselves, or by the length of charging time as determined by cam 102, or, probably most easily, in the manner shown by providing appropriate resistors 117 and 119 in series respectively with the two capacitors and adjusted to obtain the desired effect.

At this point it is desirable to refer to FIGURE 7 in which there is shown a typical rate of change of turbidity of the washing solution in tub 4 for a representative clothes load. It will be observed that the turbidity of the water changes, initially, at a relatively substantial rate as the result of the removal of soil from the fabrics and its addition to the washing solution. In other words, as the clothes are washed and the soil is removed from them, the washing solution becomes more and more cloudy.

This change continues at an appreciable rate, as shown by the relatively steep part of the curve in FIGURE 7,

until the point is reached where the amount of soil removed from the clothes becomes less and less, finally decreasing to virtually nothing. As this happens, the turbidity of the liquid ceases to change since there is no further soil being added to the washing solution to cause any change of turbidity. In other words, a condition of the clothes in which no further soil is being removed from them can be determined from the fact that the turbidity has virtually ceased to change, as shown in FIGURE 7.

It is this phenomenon that is used to effect the desired purpose; while this may be done in various ways, the particular system including circuit 108 is shown as one representative means of achieving the desired goal. What has been done is that the capacitors 116 and 118 are so calibrated that during a fairly rapid change in turbidity, as shown by the steep part of the curve in FIGURE 7, they will charge at substantially the same rate even though for the same voltage the capacitor 118 would charge faster. This results from the inclusion in the circuit of the light sensitive resistor 63 which, as the turbidity increases, receives less and less light from lamp 61 because of the increasing cloudiness of the washing solution in tub 4.

In other words, during the period of eighteen seconds from the time that capacitor 116 ceases to be charged until capacitor 118 starts to be charged, the resistance of resistor 63 increases due to the fact that less light is reaching it, and therefore the voltage available to charge capacitor 118 is less than that available to charge capacitor 116.

Therefore, during a change of turbidity, after both capacitors have been charged and the switch 105 closes, there is very little difference between the voltages across them; consequently, there is virtually no voltage across the glow tube 120 and it does not fire. This can best be seen by reference to FIGURE 6. In that FIGURE, during seconds three, four and five capacitor 116 charges as shown, and then very slowly discharges a small amount during the next few seconds. This is primarily due to the presence of a very high resistance 127 in parallel with the capacitor; resistance 127 is provided to insure that the capacitor will be discharged prior to the start of another washing operation so that it will be fully effective to perform its measuring function. In other words, the resistor 127 is effective to discharge capacitor 116 over a period of about twenty minutes to one-half hour, but has a very minor effect on it in the few seconds which elapse between chargings of the capacitor 116 during a washing operation. The same function, incidentally, is provided for capacitor 118 by a very high resistance 128.

As a result of the charging of both capacitors, at the twenty-eighth second when switch 105 is closed the voltage across the first capacitor is a point on the curve V_{C1} in FIGURE 6, while the voltage across the second capacitor is at a point on the curve V_{C2} . This is a very small voltage differential, and does not operate to fire glow tube 120.

As long as the turbidity continues to increase as a result of soil removal from the clothes, the capacitors continue to charge at about the same rate and therefore the voltage across them at the time of attempting to fire glow tube 120 remains very small. However, as the rate of change of turbidity decreases because the removal of soil from the fabrics in the machine is slowing down, the change in resistor 63 becomes less and less between the charging of capacitor 116 and the charging of capacitor 118. As a result, because capacitor 118 has the predetermined characteristic of charging faster than capacitor 116 for a predetermined voltage across it, the voltage differential between the two capacitors during the time of closure of switch 105 increases quickly until it reaches the level shown in FIGURE 6 as $V_{C1}-V_{C2}$. This differ-

ential of the voltages of capacitors 116 and 118 is sufficient to fire the glow tube 120.

As a result, the glow tube is fired to cause conductivity of light sensitive resistor 123, relay 124 is energized, and the timer motor close its switch 96 and then open the eration very shortly thereafter. This is done by having the timer motor close its switch 96 and then open the switch 98 as previously described. The closing of switch 96 also moves switch 98 into its up position and in engagement with contact 99. This ensures operation of the timer assembly 101 until the end of its cycle unless it is in the first two seconds of its cycle. It will be seen that this is important since it is necessary for proper operation of the system disclosed that the capacitor 116 always be the first to be charged during a washing operation.

Broadly, what has been done is to determine that the rate of removal of soil from fabrics in a washing machine has a direct relationship to the rate of change of turbidity of the washing solution, and to utilize this knowledge to cause the washing operation to be terminated when the rate of change of turbidity approaches zero.

It will be recognized that while we have shown a particular arrangement for achieving sensitivity to the rate of change of turbidity and providing operation of a control member in response to it, our invention is not restricted to the particular system shown. Rather, it encompasses broadly systems designed to respond to the rate of change of turbidity of any liquid washing medium in order to effect a control function when a predetermined rate of change is reached. It will further be recognized that while we have shown this in particular connection with a clothes washing machine, it is readily conceivable that the washing of other articles may be made dependent upon the rate of change of turbidity of the washing solution. This is also true as to rinsing of articles which need to be rinsed such as, for instance, clothes, since the water will become turbid at a rapid rate during the early part of a rinse operation, but only at a relatively slow rate, decreasing toward zero, as the effective removal of washing solution from the clothes decreases.

In addition, it is readily conceivable that other ways of utilizing the rate of change of turbidity of a washing solution may be found. For instance, in a machine which washes for a fixed length of time, small amounts of detergent could be repeatedly added. With a lightly soiled load, the turbidity would rapidly reach a steady state and thereby give a signal to cease addition of detergent. With a heavily soiled load, detergent addition would continue for a longer period because the turbidity would continue to change for a longer period than in the case of the lightly soiled load.

All of these are possibilities that readily come to mind as a result of the particular structure and concept disclosed hereabove. Therefore, it will be understood that while in accordance with the patent statutes we have described what at present is considered to be the preferred embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications (such as, but not exclusively, those set forth above) may be made therein without departing from our invention, and it is therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A washing machine comprising:

- (a) container means for articles to be washed and a liquid;
- (b) means for effecting relative motion of the articles and the liquid;
- (c) means for measuring the rate of change of turbidity of the liquid;
- (d) control means for effecting a change in the condition of said washing machine;

(e) and means for operating said control means when said measuring means senses a predetermined rate of change of turbidity.

2. The apparatus defined in claim 1 wherein said means for measuring the rate of change of turbidity of the liquid includes a source of light positioned so that light rays are caused to pass through a predetermined thickness of the liquid, and a light-sensitive resistor positioned in spaced relation to said source of light so that the rays from the light have to traverse the liquid to reach it.

3. The apparatus defined in claim 2 wherein said container means includes a projection formed of transparent material, and said light source is positioned on one side of said projection outside said container means and said light sensitive resistor is positioned on the other side of said projection outside said container means.

4. A washing machine comprising:

- (a) container means for articles to be washed and a washing solution;
- (b) means for effecting relative motion of the articles and the washing solution;
- (c) means for measuring the rate of change of turbidity of the washing solution;
- (d) means for terminating operation of said means for effecting relative motion;
- (e) control means for actuating said terminating means;
- (f) and means for operating said control means when said measuring means senses a rate of change of turbidity decreasing toward zero.

5. The apparatus defined in claim 4 including means for rendering inoperative said means for operating said control means during a brief initial period of operation of said means for effecting relative motion.

6. The apparatus defined in claim 4 wherein said washing machine is a clothes washer.

7. The apparatus defined in claim 6 wherein said container means includes a perforated inner container for retaining the clothes and an imperforate outer container for retaining the liquid.

8. The apparatus defined in claim 6 wherein said control means is a timer assembly effective to cause the remainder of a clothes washing operation to be provided after a washing step has been completed.

9. A washing machine comprising:

- (a) container means for articles to be washed and a liquid;
- (b) means for effecting relative motion of the articles and the liquid;
- (c) means for measuring the rate of change of turbidity of the liquid including a source of light positioned to send light rays through a predetermined thickness of the liquid, a light sensitive resistor positioned in spaced relation to said source of light so that the rays from the light have to traverse said predetermined thickness of the liquid to reach it, and first and second capacitors and means for alternately charging said first and second capacitors in circuit with said resistor so that said resistor decreases the charging rate of said capacitors as the turbidity of the liquid increases, said second capacitor charging a greater amount each time for the same predetermined voltage and approximately the same amount when a lower voltage is applied across said second capacitor than across said first capacitor so that said capacitors charge at approximately the same rate when the liquid turbidity is changing rapidly but becomes charged to an increasingly differential degree as the rate of change of turbidity slows down;
- (d) control means for effecting a change in the condition of said washing machine;
- (e) and means for operating said control means when said measuring means senses a predetermined decrease in the rate of change of turbidity, comprising

3,114,253

13

a device operative upon a predetermined voltage drop thereacross, and means for connecting said device across said capacitors after each charging of said first and second capacitors so that said device operates when said capacitors are charged to a predetermined differential degree.

5

14

References Cited in the file of this patent

UNITED STATES PATENTS

2,218,698	Clark	Oct. 22, 1940
2,361,235	Pick	Oct. 24, 1944
2,430,668	Chamberlin	Nov. 11, 1947