

Aug. 19, 1952

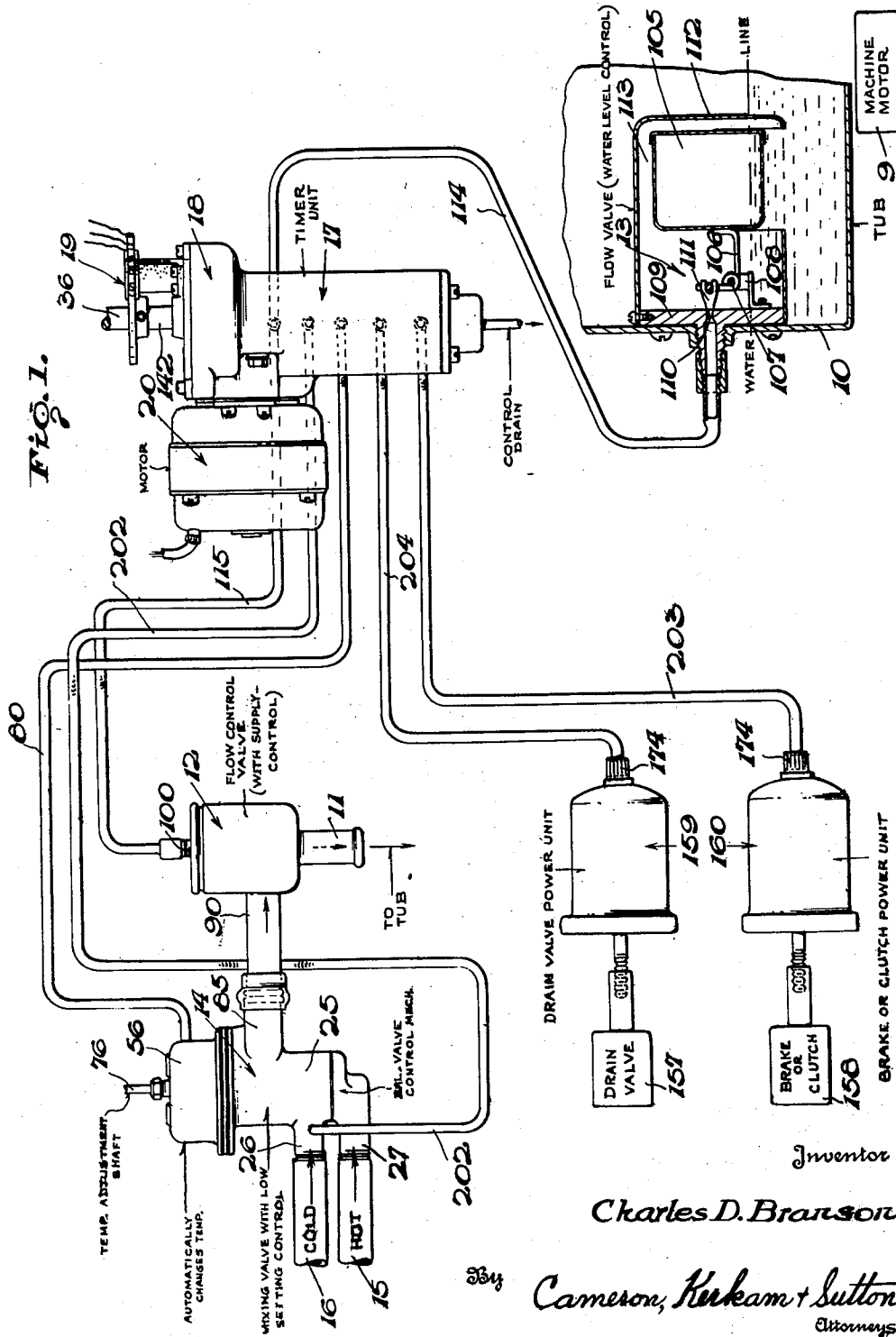
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2,607,207

HYDRAULIC CONTROL FOR AUTOMATIC WASHING MACHINES

Filed Nov. 27, 1946

6 Sheets-Sheet 1



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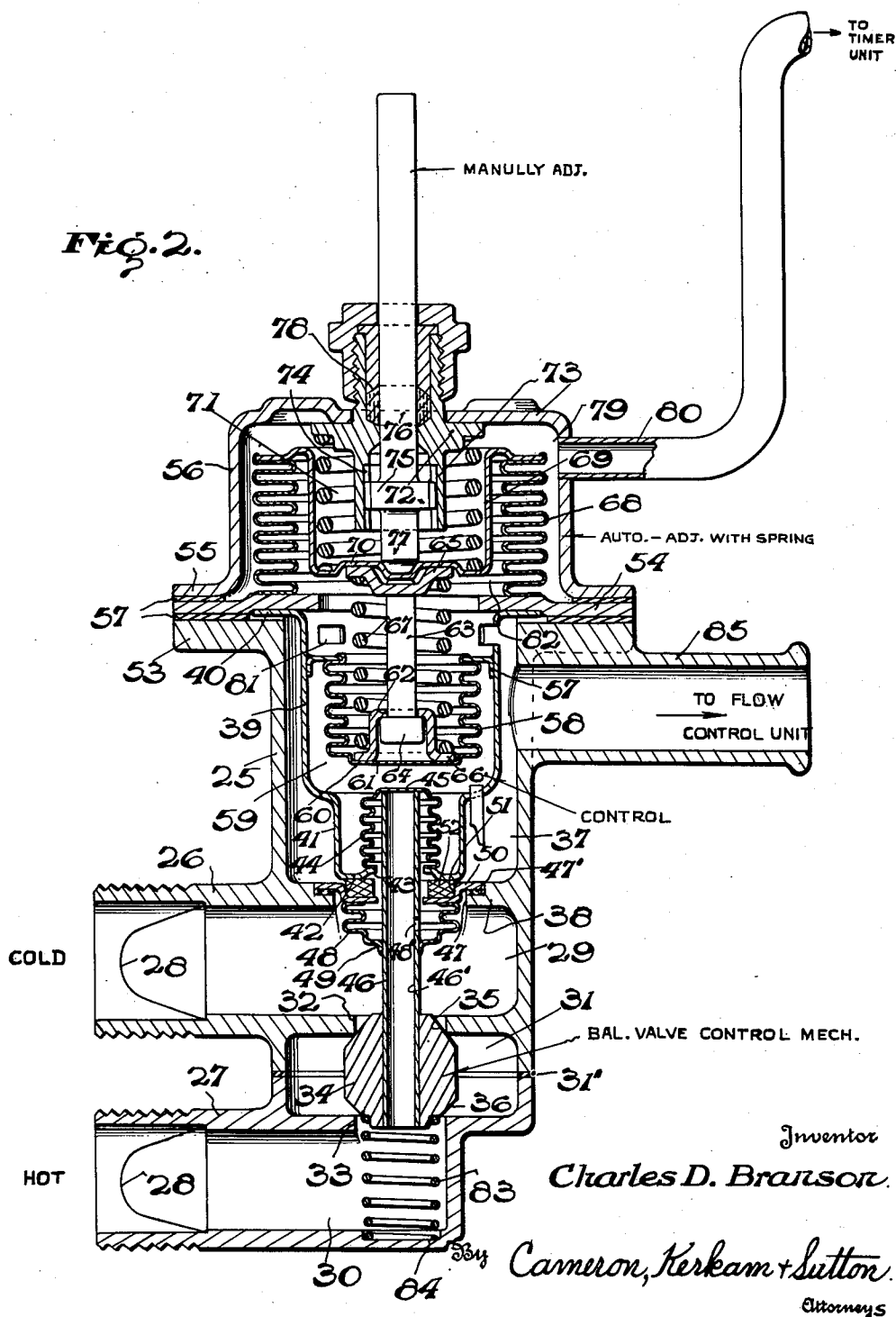
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6 Sheets-Sheet 3

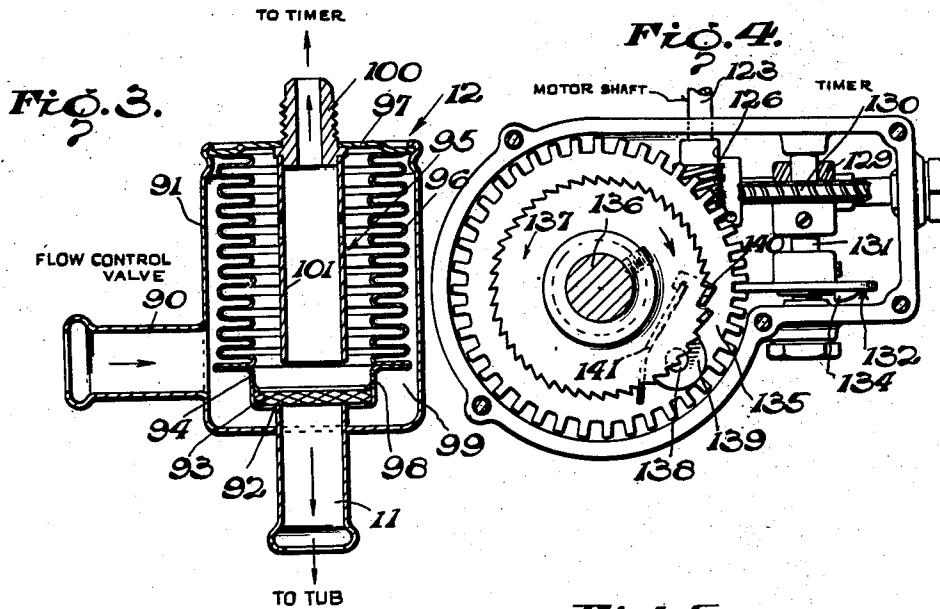


FIG. 6.

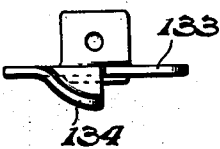


FIG. 7.

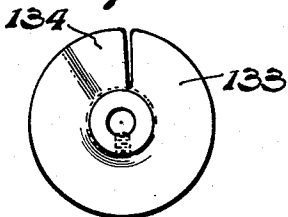
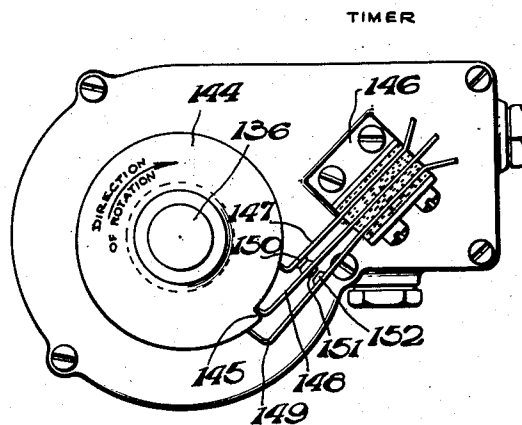


FIG. 5.



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FIG. 8.

TIMER UNIT

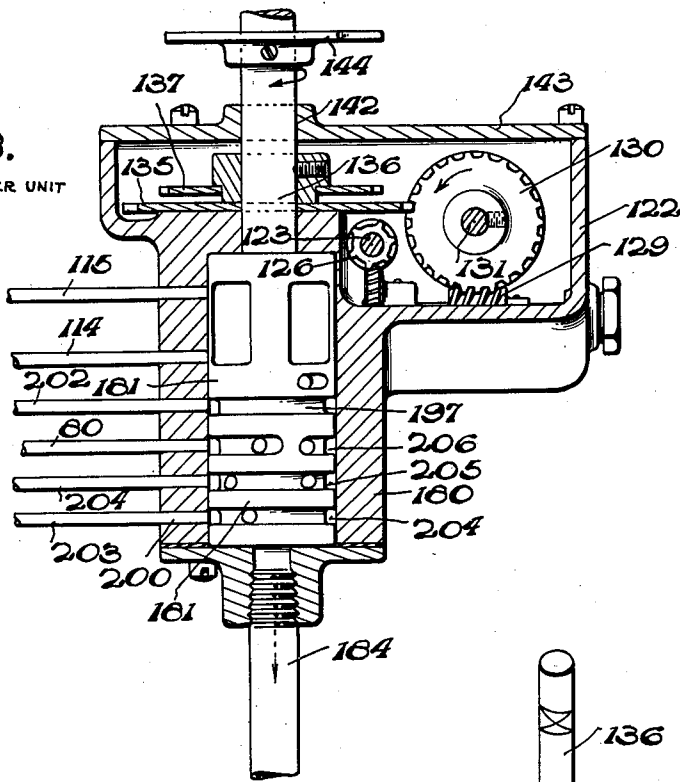


FIG. 9.

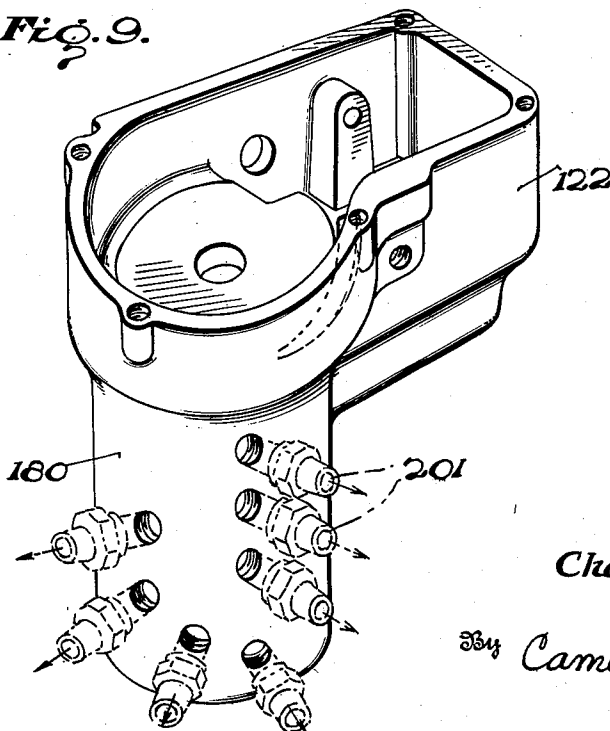
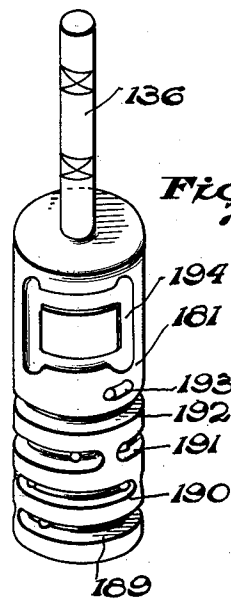


FIG. 10.



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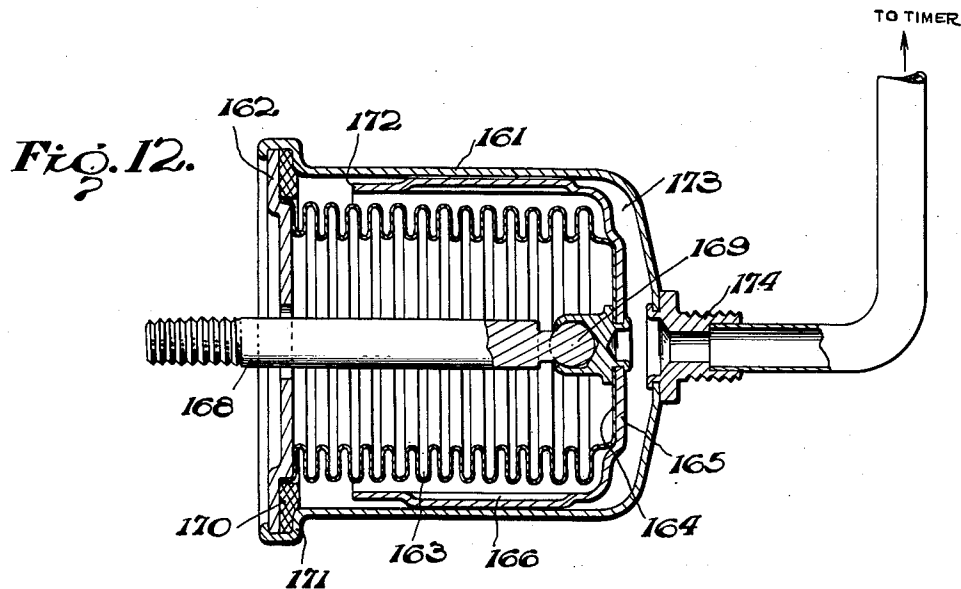
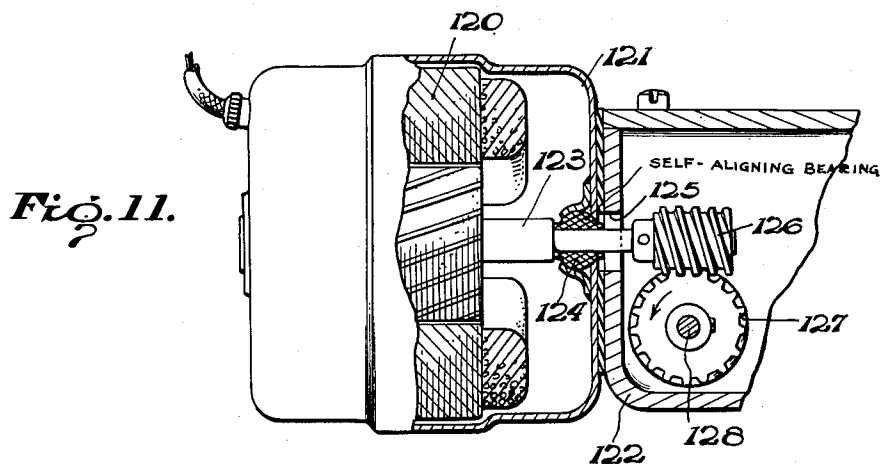
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HYDRAULIC CONTROL FOR AUTOMATIC WASHING MACHINES

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FIG. 14.

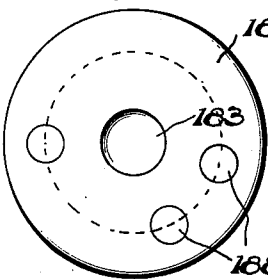


FIG. 13.

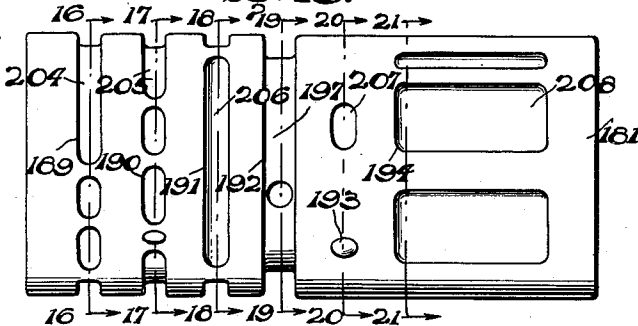


FIG. 16.

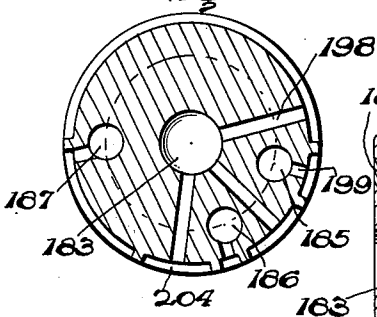


FIG. 15.

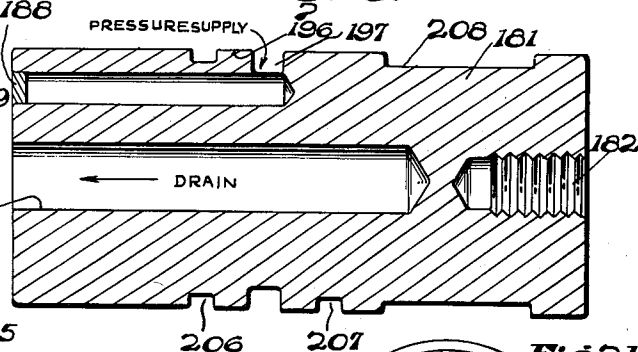
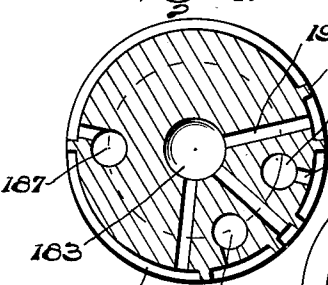


FIG. 17.



UNITED STATES PATENT OFFICE

2,607,207

HYDRAULIC CONTROL FOR AUTOMATIC
WASHING MACHINES

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Application November 27, 1946, Serial No. 712,643

4 Claims. (Cl. 68—12)

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This invention relates to hydraulic controls, and more particularly to hydraulic devices which are adapted to control the operation of automatic washing machines, although certain of the sub-combinations used in the control, while possessed of particular utility when embodied in a control for an automatic washing machine, have wider utility and are capable of use in other relationships as will be evident to those skilled in the art.

It is an object of this invention to provide an improved control which is wholly hydraulic in its operation except that the motor employed to drive the same may be of any suitable character as an electric motor, although a hydraulic motor could be used if preferred.

Another object of this invention is to provide a hydraulic control for automatic washing machines which may use any suitable source of liquid under pressure, as water from the usual water main, for determining the beginning and the end of each of the steps constituting the automatic cycle of the machine.

Another object of this invention is to provide an improved control for automatic washing machines whereby one or more of the steps in the automatic cycle of the machine may be readily omitted.

Another object of this invention is to provide an improved control as just characterized which assures against reverse operation of the control.

Another object of this invention is to provide an improved control wherein each of the steps of the automatic cycle of the machine is initiated and terminated by the use of changes in fluid pressure, thereby avoiding the complexity introduced by solenoid valves and other electrical systems for effecting the control.

Another object of this invention is to provide a control of the type just characterized wherein the several steps of the automatic cycle are under the control of a motor-driven pilot valve which can be readily manipulated to predetermine which of the steps of the automatic cycle of the machine shall be performed.

Another object of this invention is to provide an improved mixing valve which may be readily set so as to predetermine the temperature of the mixture, for example that at which the washing is done, so that the washing temperature may be set to be appropriate for the character of the fabrics being washed.

Another object of this invention is to provide an improved mixing valve which is automatically operated at predetermined times to adjust the valve so that fluid can be delivered at a lower temperature for predetermined periods.

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Another object of this invention is to provide an improved mixing valve wherein the valve is balanced against variations in and differences between the pressures of the fluids being mixed.

Another object of this invention is to provide an improved thermostatically controlled mixing valve for washing machines wherein the mixing valve, as for example a rinsing period, can be operated so that colder rinse water may flow through the valve.

Another object of this invention is to provide a device of the type last characterized wherein actuation of the mixing valve to permit flow of colder water therethrough is effected automatically by the use of water pressure.

Another object of this invention is to provide an improved pressure operated valve.

Another object of this invention is to provide an improved control for automatic washing machines wherein the level of the water in the tub is automatically predetermined so as to assure a certain water level therein irrespective of how much water may be absorbed by the fabrics being washed.

Another object of this invention is to provide an improved control for automatic washing machines wherein the flow of water to the tub is controlled by hydrostatic pressure that in turn is regulated by the water level in the tub.

Another object of this invention is to provide an improved hydrostatic control for washing machines which assures that no injury will occur to the parts even though there may be wide variations in the water pressure available for operating the machine.

Another object of this invention is to provide an improved control for automatic washing machines which assures against injury to the thermostatic control even though the temperature of the water should rise after the valve controlled thereby has reached its seat.

Another object of this invention is to provide a hydraulic control with an improved pilot valve which not only exactly predetermines the sequence of hydrostatic operation but also effects rapid transition from stage to stage so as to avoid the sluggish action incident to a gradual change in pressure.

Another object of this invention is to provide an improved timing mechanism which exactly predetermines the beginning and end of the respective steps in the automatic cycle of a machine and avoids sluggish transition from one step to another.

Another object of this invention is to provide an improved pilot valve for predetermining the

operation of a plurality of devices actuated by fluid pressure.

Another object of this invention is to provide an improved control utilizing hydrostatic pressure which is composed throughout of parts that may be readily standardized, that are relatively inexpensive to manufacture, that are easy to assemble and service, and that are certain and efficient in operation.

Other objects will appear as the description of the invention proceeds.

The invention is capable of receiving a variety of mechanical expressions only one of which has been illustrated on the accompanying drawings, but it is to be expressly understood that the drawings are for purposes of illustration only, and are not to be construed as a definition of the limits of the invention, reference being had to the appended claims for that purpose.

Referring in detail to the accompanying drawings, wherein the same reference characters are employed to designate corresponding parts in the several figures,

Fig. 1 is a diagrammatic view to illustrate the component elements of a hydrostatic control embodying the present invention;

Fig. 2 is an axial section through a preferred form of automatic mixing valve;

Fig. 3 is an axial section through a preferred form of flow control valve;

Fig. 4 is a plan view of a preferred timing mechanism;

Fig. 5 is a plan view of the automatic switch controlled by said timing mechanism;

Figs. 6 and 7 are respectively edge and face views of the cam used in the timing mechanism of Fig. 4;

Fig. 8 is an axial section through the timing mechanism of Fig. 4 and the pilot valve associated therewith;

Fig. 9 is a perspective view of the casing, with its fluid connections, for said timing mechanism and said pilot valve;

Fig. 10 is a perspective view of the cylinder of said pilot valve removed from its casing;

Fig. 11 is an elevation partly in section of the motor drive for the timing mechanism;

Fig. 12 is an axial section through a preferred form of pressure responsive motor unit;

Fig. 13 is an elevation of the cylinder of the pilot valve;

Fig. 14 is an end view of said cylinder;

Fig. 15 is an axial section through said cylinder; and

Figs. 16 to 21, inclusive, are sections through said cylinder on lines 16—16 to 21—21, respectively.

Referring first to the diagram of Fig. 1, 10 designates a fragment of a washing machine tub of any suitable character and construction and with which may be associated any suitable motor, suggested diagrammatically by the rectangle 9, for imparting any appropriate motion to the movable parts which are driven to effect the washing operation. While any suitable motor, as for example a hydraulic motor, may be used, it will be assumed for the purpose of exemplifying the present invention that an electric motor is employed. As this motor and the elements driven thereby constitute no part of the present invention, they have not been illustrated in the interest of clarity.

Tub 10 is supplied with water through a suitable pipe or passage, a fragment of which is illustrated at 11, after passing through a flow control valve generally indicated at 12. This valve

is in turn operated by hydrostatic pressure under the control of a float valve in or associated with the tub and generally indicated at 13. The water passing through the flow control valve first passes through a mixing valve generally indicated at 14 and which is supplied with hot and cold water from any suitable sources through pipes 15 and 16 respectively. The admission of wash water, rinse water, etc., to the tub 10, and also the other steps in the automatic cycle to be performed by the machine, are automatically controlled through use of hydrostatic pressure, as hereinafter explained in detail, under the control of a pilot valve generally indicated at 17, which in turn is operated by a timing mechanism generally indicated at 18. The timing mechanism also operates the mechanism, here assumed to be a switch and generally indicated at 19, for starting and stopping the motor 9. The timing mechanism and pilot valve are motor driven, and while as before indicated any suitable motor, such as a hydraulic motor, may be used, it is here assumed that the timing mechanism and pilot valve are driven by an electric motor generally indicated at 20 under the control of the switch mechanism generally indicated at 19.

Referring now to Fig. 2, a preferred form of thermostatically operated and manually adjustable mixing valve is shown in detail, but while the structure here illustrated is particularly adapted for use in an automatic washing machine, the valve disclosed possesses utility in other applications, and therefore it is to be expressly understood that it is the intention to protect the improved valve construction as applicable to various uses as well as a subcombination of the control here disclosed.

As shown in Fig. 2, the valve includes a casing 25 of any suitable size, construction and material provided with inlet nipples 26 and 27 respectively connected in any suitable way to the pipes for cold and hot water designated 16 and 15 in Fig. 1. Each of these inlet nipples is preferably provided with a filter 28 to prevent scale or other foreign matter from entering the hydraulic system hereinafter described. Any suitable sources of cold and hot water may be connected with said nipples 26 and 27 respectively, as the cold water main of the building and the building's system for supplying hot water to various outlets, as conventionally provided. Nipples 16 and 17 lead to cold and hot water chambers 29 and 30 respectively, and said chambers in turn communicate with an intermediate mixing chamber 31 through ports 32 and 33 respectively, provided in any suitable way, but here shown as merely apertures formed in the walls dividing the chambers 29 and 30 from the chamber 31, although suitable members providing ported valve seats may be provided in said apertures if preferred. To facilitate manufacture the portion of the casing including the chamber 30 may be made separate from the portion containing the chamber 29 and the two portions connected in any suitable way, with or without interposed packing, as shown at 31'. Disposed in the chamber 31 for cooperation with the valve ports 32 and 33 is a balanced valve member 34 of any suitable construction but here shown as provided at its opposite extremities with beveled seating faces 35 and 36 respectively adapted to cooperate with the ports 32 and 33 for proportioning the flow of hot and cold water into the mixing chamber 31. Mixing chamber 31 communicates through any suitable passage or passages (not shown) and formed in the casing 25 leading to a thermostat

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chamber 37 separated from the cold water chamber 29 by a partition 38.

Disposed in chamber 37 is a thermostat of any suitable construction but preferably having an external cup-shaped wall 39 having a flanged open end 40 and here shown as also reduced in diameter at its opposite end 41. End wall 42 of said cup-shaped wall 39 is provided with an aperture at 43, and hermetically sealed to said end wall around said aperture is an expansible and collapsible corrugated tubular wall or bellows 44. The movable end wall 45 of said bellows 44 has attached thereto in any suitable way a hollow valve stem 46 which passes through the aperture 43 and to which the valve member 34 is attached in any suitable way. The passage 46' through said stem opens at one end into chamber 30 but its opposite end is closed by movable end wall 45. Partition 38 has an aperture 47 therein through which said valve stem extends, and a flexible wall shown as an expansible and collapsible corrugated tubular wall or bellows 48 has one end secured in any suitable way to the valve stem 46, as shown at 49, while its opposite end is secured in any suitable way to a flanged plate 50 mounted in a seat surrounding said aperture 47 with interposed packing as shown at 47'. As shown, said flanged plate 50 is formed to provide a seat 51 in which is carried a yieldable annular pad 52 against which the end wall 42 of the thermostat is seated when its flange 40 is mounted on or adjacent the flange 53 of the casing 25, in which position it is secured in any suitable way, as by an annular plate 54 that is in turn held in position by the flange 55 of a bonnet member 56 hereinafter described. Packing 57 may be interposed between the members 53, 54 and 55 as illustrated, and said members may be connected together in any suitable way, as by bolts and nuts, screws, etc., which have been omitted from the drawing in the interest of simplicity. With the parts assembled as shown annular plate 54 presses on the flange 40 of the thermostat, and hence end wall 42 of the thermostat presses pad 52 onto its seat 51 and thereby presses flanged plate 50 against packing 47' so that all leakage of water between chambers 29 and 37 is prevented. Bellows 48 has the same effective area as valve port 32 so that variations in the cold water pressure are balanced out. On the other hand the chamber inside of the communicating bellows 44 and 48 is in communication with the passage 46', as through one or more apertures 43', so that bellows 48 is subjected on its opposite sides to the pressures of the hot and cold water. Thereby valve member 34 is balanced against pressure variations in and pressure differences between the hot and cold water.

Spaced from the flange 40 of the cup-shaped wall 39 is an interior flanged member 57 secured to the wall 39 in any suitable way, and attached to the inner periphery of said flanged member 57 is an expansible and collapsible corrugated tubular wall or bellows 58 which extends into the chamber 59 of the thermostat. The inner side of the opposite and movable end wall 60 of said bellows 58 is engaged by but unattached to a cup-shaped member 61 having an aperture 62. Extending through said aperture 62 to slide therein is a post 63 having a head 64, while the opposite end of said post has attached thereto in any suitable way a flange 65 providing a spring seat. A coil spring 67 extends between the flange 66 on said cup-shaped member 61 and spring seat 65. Spring 67 normally holds the cup-shaped

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member 61 in engagement with the head 64 or the movable end wall 60, but if the pressure in chamber 59 continues to increase after valve member 34 has engaged its seat at port 33, the bellows 58 may contract, lifting member 61 against the tension of spring 67, the cup-shaped member 61 sliding on post 63. The depth of the depression in member 61 is such that the head 64 will not be engaged by wall 60 under the maximum displacement contemplated.

Attached to the annular plate 54 in any suitable way is one end of an expansible and collapsible corrugated tubular wall or bellows 68 whose opposite end is formed as or attached in any suitable way to a reentrant cup-shaped movable wall 69. The end wall 70 of cup-shaped wall 69 engages the flanged member 65 heretofore referred to, and a coil spring 71 reacts between said bottom wall 70 and a stationary member 72 formed by or carried on the end wall of the bonnet member 56 heretofore referred to. Member 72 as shown has an inwardly extending tubular portion 73 having internal threads 74, and mounted for rectilinear movement in said portion 73 is the threaded enlargement 75 of a stem 76 which has its inner end 77 extending into contact with the end wall 70 of cup-shaped member 69. Stem 70 is here shown as provided with a packing gland 78 which may be of any suitable construction or, if preferred, a packless construction may be employed instead. Stem 76 extends outwardly to any suitable distance where is provided with any suitable mechanism for moving the stem in the direction of its axis. In the case of a washing machine this would be a location where it is easy of access, and the mechanism for moving the stem 76 in the direction of its axis may be associated with any suitable indicating means calibrated in temperature so that by reference thereto the operator will be able to set the temperature of the wash water as desired within the range provided, as will appear from the ensuing description.

The chamber 79 within the bonnet member 56 is in communication with a pipe 80 leading to a source of pressure fluid for a purpose to be explained. The cup-shaped wall 39 is provided with one or more apertures 81 in the area between the flanged member 57 and the flange 40 so as to provide a means of communication between the chamber 82 interiorly of the bellows 68 and the chamber 37. Thereby the pressure of the water in the chamber 37 is transmitted to the chamber 82 where it acts on cup-shaped member 69 attached to the movable end of bellows 68 to hold end wall 70 in contact with the end 77 of stem 76. The valve member 34 is preferably urged toward its seat at port 32 by a suitable spring 83, here shown as a coil spring reacting between the valve member 34 and a suitable valve seat 84 provided in the wall of the hot water chamber 30. The chamber 59 heretofore referred to in the thermostat is charged with any suitable thermosensitive fluid, the same being preferably filled with a suitable thermosensitive liquid. Chamber 37 has a suitable outlet nipple 85 leading therefrom and through which the mixture of hot and cold water flows from the thermostat chamber 37.

Explaining the operation of the mixing valve as so far described, cold and hot water flow respectively into the chambers 29 and 30, and assuming that the valve member 34 is in an intermediate position, the cold and hot water flow through the ports 32 and 33 respectively to the

mixing chamber 31. From chamber 31 the mixed cold and hot water flows into the chamber 37 where it is in intimate heat interchanging relationship with the exterior wall 39, 41 of the thermostat. If desired any suitable baffling means may be provided in chamber 37 to assure flow of the mixture into intimate contact with the thermostat. Thence the mixture flows from the chamber 37 through the outlet 85.

Assuming a predetermined setting for the thermostat as hereinafter explained, if the temperature of the mixture rises above the predetermined temperature the thermosensitive fluid in chamber 59 expands to contract bellows 44, bellows 58 with its spring 67 being so constructed as to afford greater opposition to movement under the pressure in the chamber 59 than bellows 44 with its spring 83. Contraction of bellows 44 causes the valve stem 46 to move downwardly as viewed in Fig. 2, decreasing the flow through port 33 but increasing the flow through port 32 so as to restore the temperature of the mixture to its predetermined degree. Conversely, if the temperature of the mixture drops below the predetermined temperature the thermosensitive fluid in chamber 39 contracts, and spring 83 acts through the valve member 34 and stem 46 to expand the bellows 44, moving the valve member 34 to decrease the flow of cold water through the port 32 and increase the flow of hot water through the port 33. If the temperature of the mixture causes the thermostat to engage valve member 34 with its seat at port 33, further expansion of chamber 59 by compression of the bellows 44 is prevented, and if for any reason the temperature of the mixture should rise thereafter to increase the pressure in chamber 59, this pressure acting on the movable end wall 60 of bellows 58 will lift the cup-shaped member 61, against the tension of the spring 67, off of the head 64 until such time as the temperature decreases sufficiently to permit the spring 67 to restore engagement between the cup-shaped member 61 and head 64. The apertures 81 permit free circulation of the liquid between the chamber 37 and the chamber 82 interiorly of bellows 68, so that the latter chamber is full of liquid at the same pressure as the liquid in the chamber 37. Thereby the movable wall 70 is held by the water pressure against the end 77 of stem 76, spring 71 being of such strength that it yields to assure this engagement.

As is well understood, different fabrics should be washed at different temperatures. By way of example, woolen fabrics may be washed at a temperature around 90° F., and cotton goods may be washed at a temperature around 150° F., while silks, rayon, etc., may be washed at intermediate temperatures. In order to set the machine at the temperature best suited for the fabrics being washed the thermostatically operated valve so far described is adjustable within the limits of a predetermined range selected to include the lowest and highest temperatures at which the washing of different fabrics should be effected. To this end the stem 76 as heretofore explained is manually settable by any suitable mechanism so as to adjust it in the direction of its axis. If stem 76 is moved downwardly as viewed in Fig. 2 the end wall 70 of cup-shaped member 69 is moved downwardly, moving the post 63, cup-shaped member 61 and spring 67, which act as a unit, downwardly and expanding the bellows 58 by action against its movable end wall 60. This tends to contract the chamber 59, but as the chamber 59 is preferably full of a thermosensitive

liquid the pressure is transmitted to the movable end wall 45 of bellows 44 causing the valve member 34 to move downwardly so as to decrease the flow of hot water through port 32 and increase the flow of cold water through port 32, thereby maintaining a lower temperature of the mixture because valve member 34 will close port 33 when a lower temperature of the mixture has been reached. Conversely, movement of the stem 76 upwardly as viewed in Fig. 2 will cause valve member 34 to approach the port 32 so that a higher temperature will be maintained because valve member 34 will not close its port 33 until a higher temperature has been reached. Thereby, by a simple manual manipulation of the stem 76, the temperature of the mixture may be nicely predetermined to suit the particular fabrics being washed.

In the case of a washing machine there are one or more periods during the automatic cycle of operation during which, in the interest of conserving hot water, colder water should be admitted to the tub for rinsing purposes. To avoid the necessity of a separate cold water line leading to the tub with a separate automatically actuated valve for admitting rinse water to the tub, the mixing valve as so far described may be used to perform the operation of admitting rinse water. If the rinsing is to be performed with water at the temperature at the lower end of the range for which the machine is set the thermostat for predetermined periods must be automatically adjusted to maintain the entering water at its lower temperature. To this end, at predetermined times as hereinafter explained, water under pressure is admitted to the chamber 79 through pipe 80. Bellows 68 is now subjected on its opposite sides to the pressure of the water so that spring 71 is free to expand. This contracts the bellows 68 moving the end 70 of cup-shaped member 69 away from the inner end 77 of stem 76 and transmitting its movement through flange 65, post 63 and spring 67, which act as a unit, to the movable end wall 60 of the bellows 58. As the chamber 59 is full of liquid, pressure is transmitted therethrough to the movable end wall 45 of bellows 44, whereby the valve member 34 is moved downwardly as viewed in this figure to its extreme position as determined by the engagement of the movable wall 70 with the plate 54. Thereby the water flowing out of the chamber 37 is kept at the lowest temperature of the available range, and as is apparent this position, if preferred, could be one in which the hot water port 33 is entirely closed. As long as the pressure is maintained in chamber 37, the colder water may thus flow through the outlet 85 to the tub for rinsing purposes. Therefore chamber 79 with its expansible and collapsible wall 68 functions as a fluid-pressure motor for operating the mixing valve as a valve controlling the flow of rinse water.

The water flowing through the outlet 85 of the mixing valve, whether wash water or rinse water, first flows through any suitable passages or piping to the inlet nipple 90 of a flow control valve generally indicated at 12 in Fig. 1 and shown in detail, though somewhat schematically, in Fig. 3. As here illustrated the flow control valve includes a casing 91 from which extends the outlet 11 heretofore referred to. Associated with the outlet 11 is any suitable valve seat 92 with which cooperates a valve member 93 of any suitable construction. Valve member 93 is carried by the movable end wall 94 of an expansible and collapsible

ible chamber 95 whose peripheral wall is shown as composed of an expansible and collapsible corrugated tubular wall or bellows 96 having one end formed as or attached in any suitable way to the movable end wall 94 and its opposite end attached in any suitable way to a stationary wall 97, here shown as constituting the closure for the end of the casing 91. The movable end wall 94 is provided with a bleed opening 98 for a purpose to be explained, so that the interior chamber 95 is in communication through said bleed opening with the chamber 99 exteriorly of the bellows 96. Stationary end wall 97 is provided in any suitable way with a nipple 100 forming a passage through which the chamber 95 is in communication with a line leading to a float controlled valve next to be described. Stationary end wall 97 or nipple 100 also preferably carries a tubular stop 101 so as to predetermine the extent to which the bellows 96 may be contracted.

Referring now to Fig. 1, a float controlled valve generally indicated at 13 is mounted in or associated with the interior of the tub 10 so as to respond to the level of the water therein. Any suitable float controlled valve may be used. As shown, a float 105 of any suitable construction is connected to a pivoted link 106 whose pivot pin 107 is mounted in any suitable way, as by a bracket 108, on a wall 109 in which is a valve port 110. Cooperating with said valve port is a poppet valve member 111 carried by the link 106. The float valve is preferably enclosed in a casing 112 which is so constructed that the water level may rise within the same as it rises in the tub while minimizing passage of lint or the like into the chamber 113 to interfere with the operation of poppet valve 111. Port 110 is connected through any suitable passages or piping 114 and 115 with the nipple 100 of the flow control valve, the connection as shown being through the pilot valve generally indicated at 17 as will be explained hereinafter in detail.

To explain the operation of the flow control and float valves, chamber 95, either by reason of the inherent resiliency of the bellows 96 or by reason of any suitable spring associated with chamber 95, is normally expanded to engage valve member 93 with its seat 92 so that the port at 92 is normally closed. When water under pressure enters the chamber 99 an excess pressure is built up on the movable end wall 94. The water entering the casing 91 through nipple 90 accordingly lifts the valve member 93 and flows out through outlet 11 to the tub 10. During this period water can pass through the bleed opening 98 into the chamber 95, but as chamber 95 is in communication through the passages 115 and 114 with the chamber 113 at the float valve, and therefore with the atmosphere, pressure cannot be built up in said chamber 95 as long as the float valve is open. Hence the differential pressure acting exteriorly on movable end wall 94 holds valve member 93 open. The water will accordingly continue to flow into the tub until the predetermined level has been reached, and without respect to the quantity of water that may be absorbed by the clothes in the tub. When the predetermined water level in the tub has been reached, however, float 105 moves link 106 around its pivot 107 to cause valve member 111 to close port 110. Now water entering the bleed opening 98 into the chamber 95 builds up the pressure in the latter until the pressure therein becomes equalized with the pressure in the chamber 99, whereby the bellows 96, by reason of its inherent

resiliency or any suitable spring associated therewith, expands to cause valve member 93 to close the port at 92 and discontinue the flow of water from the mixing valve to the tub. Thus the flow control valve 93 is operated by a pressure motor 95 under the control (through the pilot valve to be described) of the float operated valve 13.

While the pressure operated valve as described possesses marked utility as applied to an automatic washing machine it is apparent that it has utility in other applications, and therefore it is to be expressly understood that it is the intention to protect the improved valve as applicable to various uses as well as a subcombination of the control here disclosed.

An automatic washing machine as so far referred to has an automatic cycle of operation composed of a plurality of steps or stages carried out in sequence. The number of steps may be varied as apparent to those skilled in the art, but for the purpose of illustrating the invention it will be assumed that the sequence of operation includes the steps of "start," "wash," "first rinse," "second rinse," "third rinse," "dry," "fluff," and "stop." This sequence must never be capable of reversal, but it is desirable that if the operator so wishes one or more of the intermediate steps can be omitted. To this end the hydraulic control of the present invention is subject to a manual setting which can never reverse the sequence of steps but which can predeterminately omit intermediate steps, whereupon the succeeding steps of the sequence are performed in proper order automatically.

Referring now to Figs. 4 to 8 inclusive, there is disclosed a preferred form of manually settable timing mechanism associated with a pilot valve of any suitable construction for predetermining the beginning and end of the respective steps or stages in the sequence of the automatic cycle. While the timing mechanism and the pilot valve now to be described are each of particular utility as applied to an automatic washing machine it is apparent that each has utility in other applications, and therefore it is to be expressly understood that it is the intention to protect each of these improved devices as applicable to other uses as well as a subcombination of the hydraulic control here disclosed.

As before noted, said timing mechanism is motor driven and while any other suitable form of motor may be employed, an electric motor of any suitable size and construction is shown at 120 and has its casing 121 mounted in any suitable way on the wall of the timer housing 122, as shown in Fig. 11. The shaft 123 of motor 120 preferably has a self-aligning bearing 124 provided in any suitable way, and said shaft extends through an opening 125 into the interior of the timer housing where it is provided with a worm 126. Worm 126 is in mesh with a worm wheel 127 fixed on a stub shaft 128 which in turn (see Fig. 8) has fixed thereon a second worm 129 in mesh with a worm wheel 130 fixed on stub shaft 131. Stub shaft 131 (see Fig. 4) carries a cam 132 which is shown in detail in Figs. 6 and 7 and which is composed of a disk 133 that is flat for most of its circular extent but has an offset or deflected portion 134 extending through an arc of a few degrees leading to a free radial edge spaced from the plane of the disk. Disk 132 fits rotatably in the interdental spaces of a gear wheel 135, and the offset 134 is spaced from the plane of the disk 133 by the width of one tooth on gear wheel 135. Adjustably fixed in any suitable way to the shaft 136

of the pilot valve to be described, and in adjacency to gear wheel 135, is a ratchet wheel 137, having the same number of teeth as gear wheel 135, said teeth being inclined in the direction opposite to that in which cam 132 drives gear wheel 135, and pivotally mounted at 138 on said gear wheel 135 is a pawl 139 whose tooth 140 is urged into engagement with the teeth of the ratchet wheel by a suitable spring 141 attached at its opposite ends to the pawl and to the gear wheel 135.

Shaft 136 extends through an aperture 142 in the cover 143 of the timer housing 122, and extends to any desired location that is conveniently accessible to the operator where it is provided with a manually operable knob and indicating means so that shaft 136 with its ratchet wheel 137 may be rotated manually, in the direction of the arrow in Fig. 4, to any suitable extent, pawl 139 preventing rotation of the shaft 136 in the opposite direction but slipping over the teeth of the ratchet wheel 137 when said shaft is rotated in the direction of the arrow.

Shaft 136 is also shown as provided with the means for controlling the starting and stopping of the motors. Where as illustrated the motors are electric the starting and stopping means takes the form of a cam operated switch. Referring particularly to Fig. 5, shaft 136 is shown as provided with a cam 144 which is circular for the greater part of its circumference but rises to a high point followed by a step at 145. Mounted on any suitable support as the cover plate 143 for the housing 122 is a block 146 which carries three spring contact elements 147, 148 and 149 carrying contacts 150, 151 and 152 respectively. Contact element 149 is in the circuit leading to the main motor 9 which operates the washing mechanism, contact element 148 is in the circuit of the timing motor 120, and contact element 147 is common to both of said circuits.

When the machine stops the contact elements 148 and 149 are on the high point 145 of the cam but contact element 147 has dropped down the step. When shaft 136 is rotated manually to the station designated "Start" cam 144 is rotated in the direction of the arrow shown in Fig. 5 to the position wherein the contact element 148 also drops down the step, bringing contact 151 into engagement with contact 150 and thereby closing the circuit through the timing motor 120. The timing motor drives the cam 132 through the reduction gearing composed of the two worms and worm wheels, and at each full revolution of the cam 132 the deflected portion 134 on the disk 133, by cooperation with the teeth on gear wheel 135, advances the latter by the amount of one tooth. Cam 104 carried by the shaft 136 is thereby rotated in the direction of the arrow in Fig. 5 until contact element 149 drops down the step 145, engaging contact 152 with contact 151 and thereby completing the circuit through the main motor associated with the tub. As the cam 144 continues to rotate the contacts remain in engagement throughout the automatic cycle of the machine and until the station marked "Stop" is reached, at which time contact element 147 drops down the step 145, while contact elements 148 and 149 are still on the high point of the cam, thereby separating contact 150 from both contacts 151 and 152, and thus interrupting the circuits of both motors.

Thus the machine proceeds through its automatic cycle, each revolution of the cam 132 advancing the gear wheel 135 by the amount of

one tooth, the pawl 139 driving the ratchet 137 and the pilot valve member to which it is attached. Because of the character of the cam 132 it will be observed that the advancement of the gear wheel 135 is not only a step by step motion but each advance is abrupt, and can only occur at the one point determined by the engagement of the offset 134 on the cam with the tooth with which it is then cooperating. This assures that the pilot valve, which is driven by the shaft 136, is advanced from one position to the next by an abrupt movement, a matter of importance in passing from one step or stage to another where as here the several operations of the machine are under the control of a pressure fluid and the sluggish action consequent on a gradual building up or release of pressure would be highly undesirable.

While the machine is adapted to go through its entire automatic cycle without intervention of the operator, it sometimes occurs that the operator may wish to omit one or more of the intervening steps, say the second and third rinses above assumed. Shaft 136 can be rotated manually relatively to the gear wheel 135 to the extent required to skip the specified intermediate stages, the ratchet wheel 137 slipping over the pawl 139 during such manual manipulation of the shaft 136 but the latter preventing any reverse movement of the pilot valve. Thereby the pilot valve is advanced so as to skip the referred-to stages, whereupon the automatic cycle is resumed and continued to its end. As the shaft 136 cannot be rotated in a direction opposite to the arrow in Fig. 4 the pilot valve cannot be moved to produce operations in the automatic cycle out of their proper order.

Other operations in the automatic cycle of the machine, such as the opening and closing of the drain valve, diagrammatically suggested at 157, the operation of a clutch or brake when mechanism is to be started or stopped, diagrammatically suggested at 158, etc., are effected by power units in the form of fluid-pressure motors, two of which are shown generally at 159 and 160 in Fig. 1, but while only two such motors are illustrated in the embodiment selected to exemplify the present invention it is to be expressly understood that any suitable number of such motors may be employed depending upon the number of operations to be effected. A preferred form of such motor is illustrated in detail in Fig. 12, but as such fluid motor is of wide utility, it is not claimed per se herein, the same being the subject matter of my copending application Serial No. 669,439, filed May 13, 1946, and entitled Pressure Responsive Device, now Patent No. 2,554,659, and of which the present application is therefore a continuation in part. Stated generally, this fluid-pressure motor includes a cup-shaped housing 161 in the opening end of which is secured an apertured plate 162 to which is attached in any suitable way one end of an expansible and collapsible corrugated tubular wall or bellows 163. The opposite movable end 164 of said bellows carries a second cup-shaped element 165 which has a freely sliding fit in the interior cylindrical surface of housing 161 and, to reduce friction, it is shown as of substantially smaller diameter than said interior surface on the housing and as provided with a plurality of ribs or beads 166 extending in the direction of the axis of said cylindrical surfaces so as to reduce the rubbing contact therebetween to the lines or narrow surfaces afforded by the outer surfaces

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of said ribs or beads. The movable end wall 164 of the bellows 163 also carries a post or stem 168, which may be connected to the wall 164 in any suitable way, here shown as by a flexible or universal joint indicated at 169, post 168 extending to any suitable distance and being connected to any suitable mechanism to be actuated. Associated with the plate 162 is a seating member or gasket 170 of any suitable yieldable material, such as rubber or neoprene, the same being shown as gripped between the plate 162 and a shoulder 171 on the housing 160. The free end 172 of cup-shaped member 165, when the bellows 163 is in its fully expanded position, is spaced from the seating member 170 by a distance equal to the throw of the member to be actuated by post 168, so that when post 168 moves to the desired operating position, said free end 172 will firmly seat on member 170 and provide a substantially fluid-tight enclosure for the bellows 163. The chamber 173 within the housing 161 exteriorly of the bellows 163 is in communication through a suitable nipple 174 with a source of pressure-liquid controlled by the pilot valve to be described.

When pressure fluid is admitted to the chamber 173 it acts on the movable end of the bellows 163, collapsing the latter and moving the post 168 to the left as viewed in Fig. 12 to actuate the mechanism connected thereto. As the post 168 completes its stroke the free end 172 of cup-shaped member 165 engages the seat 170 providing a complete enclosure for the bellows 163. Therefore, if the pressure on the liquid in the chamber 173 continues to rise, this pressure does not reach the bellows 163 to injure the same. This is important where the control fluid may be water taken from the public mains and have a normal pressure sufficiently high so that if applied directly to the bellows 163 there would be danger of distortion or injury thereof.

From the foregoing description it will be observed that all of the controls determining the initiation and termination of each of the steps or stages in the automatic cycle of the machine are effected by hydrostatic pressure, and to predetermine the initiation and termination of the several steps or stages in their proper sequence a single pilot valve is shown as driven by the timing mechanism heretofore described for predetermining when hydrostatic pressure shall be supplied to and released from the several control mechanisms.

To this end the casing 122 for the timing mechanism has attached thereto or integrally formed therewith a tubular casing 180, and rotatably mounted in said casing 180 is a cylindrical valve member 181 suitably attached to the shaft 136 for rotation therewith. The details of said valve member are shown in Figs. 13 to 21 inclusive. As illustrated, said valve member 181 has at one end a threaded opening 182 in which the end of the shaft 136 is secured. Centrally of said valve member and extending from one end thereof to the requisite depth for communication with the several control areas hereinafter referred to is a passage 183 which is in communication with a suitable pipe or passage 184 leading to any suitable drain. The valve member 181 also contains a suitable number, here shown as three, axially extending passages 185, 186 and 187. For convenience of manufacture said passages are bored to the requisite depth from one end of the valve member and thereafter the end of each passage is closed by a plug 188.

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Disposed circumferentially around the periphery of the valve member 181 is a suitable number of, here shown as six, control areas or zones designated 189, 190, 191, 192, 193 and 194. Except as to the control area 192, said control areas take the form of grooves of longer or shorter extent separated by regions 195 of the full diameter of the valve member, the respective grooves being also spaced from each other axially by cylindrical regions 196 which are also of the full diameter of the valve member 181. Control area 192, however, is constituted by a single groove 197 that extends through 360°, as shown in Fig. 19, and it is of such depth that it breaks into each of the passages 185, 186 and 187. Certain of the grooves have passages 198 extending therefrom to the central drain passage 183, while other grooves have passages 199 leading to one of the three passages 185, 186 and 187. The valve member 181 fits snugly but rotatively in the casing 180 so that the regions 195 and 196 prevent flow of liquid from one groove to another, and extending through the wall of the casing 180 are passages 200 leading to nipples 201 mounted exteriorly on said casing and which are at proper times brought into communication with the several grooves of the control areas by the step by step advancement of valve member 181.

The pressure fluid used in the several hydrostatic controls heretofore described is preferably water taken from the cold water main, and to this end a pipe 202 (see Fig. 1) is tapped into the cold water inlet 16 or nipple 26 and leads to that nipple 201 which is opposite groove 197. Therefore, water at pressure in the main enters groove 197, and as this groove is of 360° extent it is always filled with water substantially at main pressure. As groove 197 breaks into each of the passages 185, 186 and 187 these passages are also filled with water substantially at main pressure, and said water under pressure may flow through the passages 199 to the grooves in communication therewith, whereby, when the respective nipples and lines communicating therewith are brought into communication, during the rotation of said valve member 181, with given grooves in the valve member, pressure fluid may flow to the corresponding control mechanism as long as said communication is maintained. On the other hand, when a groove in communication with a passage 198 is opposite any given nipple the line in communication with said nipple is placed in communication through said passage 198 with the drain passage 183 whereby the pressure in said line is released. As will now be apparent the length of a groove in communication with a passage 199 determines how long fluid under pressure is applied to a given line, while a groove in communication with the passage 198 determines when the pressure in a given line will be released. When a portion of the valve member between grooves is opposite a nipple the previously existing pressure is retained, as is apparent.

The casing of the fluid motor 160 for operating any suitable clutch or brake is connected through line 203 with the nipple opposite the grooves 204 which together constitute the control area 189 and determine when the mechanism controlled thereby shall be started or stopped. The casing of the fluid motor 159 which controls the main drain valve is in communication through line 204 with the nipple opposite the grooves 205 which together constitute the control area 190 and determine when the drain valve shall be opened and closed. The pipe 80

from the chamber 97 leads to the nipple opposite the grooves 206 which together constitute the control area 191, whereby said grooves determine the application of pressure fluid to the fluid-pressure motor chamber 79 to cause movement of the valve member 34 to that position in which colder water is permitted to flow through the mixing valve for the rinse period as heretofore explained. The groove or grooves 207 constituting control area 193 are opposite a nipple 201 communicating through any suitable piping or passages with any appropriate control, such as a pressure motor of the character shown in Fig. 3 but omitted from the diagram of Fig. 1 for the sake of simplicity, whereby the expansible and collapsible chamber thereof will develop or release internal pressure dependent on whether the outlet of the chamber is closed by valve member 181 or placed in communication thereby with the drain through passages 198 and 183 (see Fig. 20). Such a control for example may be connected to an automatic balancing device which operates when the machine is spinning at high speed to centrifuge water from the clothes. The line 115 heretofore referred to as running from the flow control valve 12 is connected to the nipple opposite the grooves 208 which together constitute the control area 193, and the line 114 extending to the float valve port 110 is connected to a second nipple opposite the same grooves 208, so that said grooves determine when the chamber 95 of the flow control valve is in communication with said port 110 through lines 115 and 114. Instead of arranging lines 115 and 114 on opposite sides of the valve 181 as shown in the diagram of Fig. 1 they are preferably arranged on the same side as shown in Fig. 8, and therefore these grooves are rectangularly shaped grooves that not only extend circumferentially but also axially a sufficient distance, as shown in Fig. 13, to connect the nipples in communication with lines 115 and 114, and thereby place these lines in direct communication. While to illustrate the invention the drawings show diagrammatic pipes as connecting the various elements of the hydraulic system it is to be expressly understood that in practice at least some of the provisions for communication between constituent elements of the system may be provided as passages formed in or associated with the walls of the involved structures.

As the operation of the component elements of the system has been explained in detail in connection with the description of the detailed structure of such elements, it will be sufficient here to summarize briefly the operation of the hydraulic control as a system.

The operator of the washing machine first determines the temperature at which the washing should be carried out and by manipulation of the rod 76 the thermostat 39 is adjusted to so position the valve member 34 with respect to its ports 32 and 33 that a mixture of hot and cold water of predetermined temperature is maintained by the mixing valve. The operator then turns shaft 136 to the position designated "Start," whereupon the contact member 148 drops down the step 145 bringing contacts 150 and 151 into engagement whereby the circuit through the timer motor 120 is completed. This motor starts to rotate and through the gearing heretofore explained and the coaction between cam 132 and gear wheel 135 shaft 136 is started in its step by step motion, each advancement being effected abruptly when the deflection or offset 134 passes

through the space between two teeth on gear wheel 135. Rotation of the shaft 136, after a proper lapse of time, brings the cam 144 to the position wherein the contact member 149 drops down the step 145 to complete the circuit through the main motor 9 associated with the tub. Rotation of the shaft 136 also effects rotation of the valve member 181 in a step by step motion, and because of the abruptness of these steps the respective grooves of the several control areas are moved into or out of position for communication with one of the nipples abruptly, so that the water under main pressure flowing through the pipe 202, groove 197 and passages 185, 186 or 187 to the several control areas is applied abruptly to the respective control elements or exhausted therefrom with equal abruptness.

Water at a predetermined temperature leaving the chamber 37 of the mixing valve through nipple 85 flows to the casing 91 of the flow control valve and as the interior of the chamber 95 at this time is in open communication with the port 110 of the float valve 13 by reason of the location of a groove 206 in control area 191, a differential pressure is applied exteriorly to the end wall 94 of said chamber 95 lifting the valve member 93 to open wide the port at seat 92. The water therefore flows through the pipe 11 to the tub 10 and gradually rises therein until the float 105 causes the valve member 111 to close the port 110. Thereafter the water flowing through the bleeder opening 98 equalizes the pressure on the opposite sides of the movable end wall 94 of chamber 95 whereby, as before explained, the valve member 83 is moved to close its port 92 and terminate the flow of water to the tub.

After the washing step of the cycle the appropriate groove 204 of control area 189 supplies fluid under pressure to the chamber 173 of the fluid motor 160 to open the drain valve. When the wash water has drained from the tub a groove 207 in control area 193 moves into position to convey fluid under pressure to the chamber 79 whereby the valve member 34 is moved so that colder water may flow through the mixing chamber 37 and thence to the interior of the chamber 99 in the flow control valve, again opening valve member 93 to permit the rinse water to flow to the tub. When the rinse water has reached its proper level in the tub the float valve 111 is again closed to cause the flow control valve member 93 to again close its port 92 as heretofore explained. At the close of the rinsing operation the tub is drained by application of fluid pressure to the fluid motor 160. Then the succeeding steps of the automatic cycle are performed in proper order, the control areas in valve member 181 predetermining when fluid under pressure shall be applied to or withdrawn from the respective controls. Finally, at the end of the automatic cycle the contact member 150 drops down the step 140, leaving the contact members 148 and 149 on the high point of cam 144, whereby the circuits through both the main motor and the timer motor are interrupted.

The control area 191 is of such construction that communication is maintained between the lines 114 and 115 at all times during the washing and rinsing periods, so that the inflow of water to the tub is determined by flow control valve 12 is under the control of the float operated valve 13 to the end that during the washing and rinsing periods the latter is free to effect the addition

of water to the tub if the level of the water in the tub falls below the desired level. The pilot valve through operation of the control area 191 therefore closes the connection between lines 114 and 115 only when the tub is to be drained or it is desired to have the tub empty without fresh water coming in, under which circumstances the float operated valve 13 may open without causing water to flow into the tub because lines 114 and 115 are not in communication and therefore pressure can not be relieved in chamber 95.

If the operator wishes to omit any of the steps in the automatic cycle he observes the indicating mechanism associated with shaft 136, and when the step which he desires to omit has been reached, he turns the shaft 136 through one step, if one step only is to be omitted, or through as many steps as he desires to omit, the ratchet 137 sliding under the pawl 139 until the beginning of the next step to be performed is reached. Thereafter the automatic cycle is continued until the motors are stopped. By reason of the coaction of the ratchet 137 and the pawl 139 it will be noted that it is impossible to turn the control knob in the wrong direction so as to upset the automatic cycle.

By providing appropriate control areas on the valve member 181 the automatic cycle may include any desired number of steps in sequence, and by properly proportioning the grooves in the control areas the instant of application of pressure fluid to any given control or the release of pressure therefrom can be exactly predetermined, and owing to the manner in which valve member 181 is moved step by step, it moves quickly from one step to another so that there are no prolonged periods of time during which pressure is gradually being built up or gradually being released.

It will therefore be perceived that an improved control particularly adapted for use in conjunction with automatic washing machines has been provided wherein all of the control functions are effected by water under pressure, which may be taken from the usual water mains, the component elements of the system being so constructed that injury will not be caused thereto even though the pressure in the main be relatively high. The control provides for readily omitting desired steps in the automatic cycle of the machine with assurance that the predetermined order of said steps shall not be upset. The control also facilitates predetermining the temperature at which the washing shall be done, while any abnormal rise in temperature will not injure the thermostat for predetermining such temperature. The need for a separate valve to control the flow of rinse water has been avoided, the mixing valve being automatically actuated at predetermined times to operate as a valve to admit rinse water. The water always rises to the predetermined level in the tub irrespective of how much water may be absorbed by the fabrics being washed, while the admission of water to the tub is controlled by a pressure operated valve that in turn is actuated by means responsive only to the water level. The complexity incident to the use of electric systems has been avoided, and at the same time any undesirable action incident to the gradual building up or release of pressure has been avoided. The system is composed throughout of parts which are easy to standardize, inexpensive to manufacture, easy to assemble and service, and certain and efficient in operation.

It will also be perceived that an improved mix-

ing valve, an improved pressure operated valve, an improved timing mechanism and an improved pilot valve have been provided which, while possessing particular utility in effecting the desired steps in the cycle of an automatic washing machine, or other suitable hydraulic control, are also capable of other applications, and therefore it is to be expressly understood that it is within the contemplation of the present invention that such devices are applicable to other uses than as subcombinations of the hydraulic control herein disclosed.

While the embodiment of the invention illustrated on the drawings has been described with considerable particularity it is to be expressly understood that the invention is not to be limited thereto, as the same is capable of receiving a variety of mechanical expressions, some of which will now be apparent to those skilled in the art, while within the broader aspects of the present invention one or more of the improved structures constituting component elements of the system as herein disclosed may be replaced by other suitable forms of devices to perform comparable functions. Changes may also be made in the details of construction, arrangement, proportion of parts, sizes, etc., some of the improved features may be used without others, the control may be adapted to a smaller or a larger number of steps or stages in the automatic cycle of the machine or to effect other steps than herein discussed by way of example, and the control system as a whole, while particularly adapted to use with an automatic washing machine, is also susceptible to other applications. Reference is therefore to be had to the appended claims for a definition of the invention.

What is claimed is:

1. In a hydraulic control for automatic washing machines having a tub, a motor associated therewith and a plurality of elements to be controlled, the combination of a plurality of pressure motors respectively associated with said elements, a single pilot valve for predetermining the admission and release of liquid under pressure to and from the respective pressure motors, connections for conducting liquid between said pilot valve and said pressure motors, a timing mechanism for moving said pilot valve through a plurality of stages to initiate and terminate the actuation of said pressure motors in predetermined sequence, a motor for driving said timing mechanism, and means actuated by said timing mechanism for initiating the operation of said first named motor and terminating the operation of both of said motors.

2. In a hydraulic control for automatic washing machines having a tub, a motor associated therewith and a plurality of elements to be controlled, the combination of a plurality of pressure motors respectively associated with said elements, a single pilot valve for predetermining the admission and release of liquid under pressure to and from the respective pressure motors, connections for conducting liquid between said pilot valve and said pressure motors, a timing mechanism for moving said pilot valve through a plurality of stages to initiate and terminate the actuation of said pressure motors in predetermined sequence, a motor for driving said timing mechanism, and motor-control means for initiating the operation of said first named motor and terminating the operation of both said motors and actuated by said timing mechanism, said timing mechanism including means for manually ad-

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vancing said pilot valve with respect to said timing mechanism to omit stages in the automatic cycle of the machine.

3. In a hydraulic control for automatic washing machines having a tub, a motor associated therewith and a plurality of elements to be controlled, the combination of a thermostatically controlled mixing valve for predetermining the temperature of the water to be supplied to said tub and having a water connection with the tub, a plurality of pressure motors operatively connected to said elements and said mixing valve respectively, a single pilot valve for predetermining the admission and release of liquid under pressure to and from the respective pressure motors, connections for conducting liquid between said pilot valve and said pressure motors, a timing mechanism for moving said pilot valve through succeeding stages to predetermine the initiation and termination of the operation of said pressure motors, and a motor for driving said timing mechanism, that one of said pressure motors operatively associated with said thermostatically controlled mixing valve including means operatively connected thereto and operable when pressure is admitted to said motor for holding said mixing valve in a position to admit rinsing water to the machine.

4. In a hydraulic control, in combination with a source of liquid under pressure, a plurality of pressure motors adapted to be operatively connected to the elements to be controlled, a single pilot valve for predetermining when said source of pressure shall be connected to and disconnected from the respective motors, connections for conducting liquid between said pilot valve and said motors, a timing mechanism for moving said pilot valve through its respective stages, a motor for driving said timing mechanism, and a thermo-

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statically operated valve for controlling the temperature of said liquid, one of said pressure motors being associated with said thermostatically operated valve and including means operatively connected thereto when liquid under pressure is admitted to said motor to move said thermostatically operated valve to a limit position.

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