A circuit arrangement for a direct-current motor for a washing machine, which motor is equipped with permanent magnets for starting the spinning operation from a predetermined direction of rotation of the oscillatory washing movement for the washing operation, irrespective of any manual operation of the timer.

The operation of the timer and of the voltage change-over device of the motor are effected independently of one another by means of one or two motors.

The arrangement may be used in washing machines equipped with direct-current motors which permit of starting the spinning operation either with the tub filled or with the tub empty.
METHOD OF SWITCHING A DIRECT-CURRENT MOTOR OF A WASHING MACHINE

This invention relates to a device for switching a direct-current motor intended for driving a drum of a washing machine at a low washing speed in two directions of rotation and at a high spin-drying speed in one direction of rotation. In this device use is made of a timer which determines the sequence and the durations of the various operations, while a reversing switch is provided which includes switching means for the electric supply of the motor, both for switching to the low washing speed in two directions of rotation and for switching to the high spin-drying speed.

In known washing machines the oscillatory rotation movement of the wash-drum is obtained by reversing the direction of rotation of the motor of the machine. It is also known for a washing machine to be driven by a change-pole alternating-current motor in which, by changing over the poles, two speeds are obtainable, the washing speed and the spin-drying speed, the latter being considerably higher than the former. The reversal of the direction of rotation of the motor at the washing speed is achieved by means of a reversing switch included in the control unit of the machine. In automatic or semi-automatic washing machines this control unit ensures the sequence and the duration of the operations to be performed according to a selected program, such as washing, heating, rinsing and spin-drying. In such a cycle, switching from washing to spin-drying is to be effected when the reversing switch is out of the circuit. Frequently this will give rise to locking of the drum because the reversing switch is rendered inoperative before the change-over to the spin-drying speed has been effected.

The commonly used control units comprise a timer which determines the sequence and the duration of the operations and a reversing switch. The timer and the reversing switch are mechanically coupled together and are driven by a single motor. This embodiment permits a saving both in the space occupied and in material used.

In the so-called “thermostatic” machines, the timer is stopped during the heating period, i.e. during the time in which the wash-water has not yet reached the desired temperature. However, during this time, the wash-water must continue to be agitated and hence the wash drum has to perform its oscillatory movement. Consequently, during the stationary period of the program, another driving device is required to rotate the cams which control the reversing contacts until the desired water temperature has been reached. In the timers available so far, either a device which disengages the program part or a two-speed motor is used. The part of the timer which controls the reversal of the movement generally comprises a limited number of switches since the reversal of the direction of rotation in alternating current motors requires only single-pole commutation.

In washing machines equipped with direct-current motors, the motor can be made to run not only in two directions but also at different speeds by merely controlling the electric supply. Although this a highly interesting property, realization gives rise to great switching and safety problems. This problem may be explained with reference to FIGS. 1 and 2 of the accompanying diagrammatic drawings.

The invention will now be described in greater detail with reference to the accompanying drawing, in which:

FIG. 1 schematically shows a double pole switching arrangement for a DC motor,

FIG. 2 schematically shows a modified form of the arrangement of FIG. 1,

FIG. 3 shows a preferred form of the invention, and

FIG. 4 illustrates the cyclical operation of the various switches of the arrangement of FIG. 3.

Double-pole switching of a direct-current motor is shown schematically in FIG. 1. In order to reverse the direction of rotation of the motor, the polarity of the voltage at the motor terminals is reversed by closing either the switches 1 and 3 or 2 and 4.

For example, to bring the wash drum from the washing speed (say 50 rev/min) to the spin-drying speed (from 500 to 1,000 rev/min) it is sufficient to change the supply current at the motor terminals and to render the reversing arrangement inoperative. If the timer is equipped with a single motor, the reversing switches will rotate continuously. Hence the reversing arrangement must be rendered inoperative, resulting in a circuit diagram as shown in FIG. 2. In this circuit arrangement the program part comprises two switches 15 and 16 which are present to enable the supply circuit, including the reversing switches, to be interrupted, and two switches 17 and 18 which must be closed to feed the motor so as to obtain the required spin-drying speed and the proper direction of rotation, which must be maintained during the entire spin-drying period. The switches 15, 16, 17 and 18 are controlled by the timer. However, they may lead to an uncontrolled speed when the timer button is manually operated, and they also may cause the wrong polarity to be switched into circuit when the polarity has not yet been reversed. The broken lines of FIG. 2 show the paths which the current takes when the switches are too quickly operated.

Before the spinning period begins the switches 15 and 16 are closed and the motor is fed through switches 12 and 14. The negative polarity then occurs at 14 and the positive polarity at 12, which is also the case at one of the contacts of the switches 17 and 18. When the latter switches are closed, a double short-circuit occurs, namely in the circuit including the elements 17, 15 and 14 (the switch 17 closes, the switch 15 has not yet been opened and the switch 14 is in the closed position) and also in the circuit including the elements 12, 16 and 18 (the switch 18 closes, the switch 16 has not yet been opened and the switch 12 is in the closed position).

Since the electric supply for the direct-current motor is taken from the alternating-current lines through a rectifier bridge comprising semiconductor elements, the latter will act as fuses and the supply arrangement of the motor will be badly damaged.

The problem of changing the speed and reversing the direction of rotation of a direct-current motor by means of a timer in which the functions “sequence and duration” and “reversal” are combined would appear to be insoluble when very fast operation of the reversing switches by manual turning of the times button is possible.

It is an object of the present invention to avoid this disadvantage and to make the switching of the sequence and duration independent of the reversal.
The invention is characterized in that in switching from the washing speed to the spinning speed, initially switching means, which appertain to the timer and control the motor supply and the drive of the reversing switch, and which short-circuit switching means having the same functions but appertain to the reversing switch, are rendered inoperative by means driven by the timer, whereupon the said switching means appertain to the reversing switch are rendered inoperative at an instant which is determined by the reversal of the direction of movement of the wash-drum. The arrangement according to the invention ensures that the spinning operation is started under predetermined conditions, and that the direct current is switched by means of a reliable device operating at a degree of safety, irrespective of any manual operations.

British Patent specification No. 244,026 describes a washing machine including a control arrangement for reversing the direction of rotation of the motor independently of the program arrangement which determines the duration of the various stages of the washing cycle and also the supply of water and the washing ingredients. Each of these arrangements includes a drum provided with segments which is driven by a motor and travels past carbon brushes which control the various operations. The safety of the circuits upon reversal of the direction of rotation of the motor is ensured by switching into circuit electric starting resistances by means of the drum switch which determines the reversal of the movement. The reason for separating the operation of the timer and of the reversing switch is to permit the wash drum to be stopped with its door registering with the door of the machine. No provision is made for a spin-drying operation and hence for variation of the motor supply voltage.

In an embodiment of the present invention, the washing machine includes a direct-current motor equipped with permanent magnets. The motor is fed from the alternating current supply through a known supply arrangement providing current rectified by semiconductor elements. The automatic coordination arrangements which are used for performing the reversing and timer functions and which usually are controlled by a single alternating-current motor are separated so as to be independent of one another, the reversing arrangement and the timer arrangement each being operated by a separate motor. The use of alternating-current motors for these automatic coordination devices provides the advantages of simple design and at the same time of a particularly constant speed, e.g., by using a synchronous motor.

The method and the arrangement according to the invention will now be described more fully with reference to a circuit diagram shown, by way of example, in FIG. 3. The switches represented by two parallel lines form part of the reversing arrangement and those represented by a single line form part of the timer. The reversing switches 21 and 23 relate to a first direction of rotation during the washing operation and to the preferential direction of rotation during spin-drying, and the switches 22 and 24 relate to the second direction of rotation during the washing operation.

Furthermore, it is assumed that spinning is started while the tub still is filled with water.

It is desirable to have a preferential direction of rotation for the spinning in view of certain constructional details of the machines, one such detail being that the location of the draining system of the machine permits it to be emptied faster when the drum rotates in a predetermined direction.

Starting of the spinning in a preferential sense is a known problem, the solution of which will be different for different electrical arrangements used.

The reversing switch 25 controls the AC supply of a motor M. When this switch 25 is closed, the characteristics of the current supplied to the motor correspond to the washing speed. When the switch 25 is open, these characteristics correspond to the spinning speed. The switch is opened in an accurately predetermined condition of the reversing arrangement (for example, when the switches 21 and 23 are closed).

In order to maintain a given direction of rotation during spinning, the motor of the reversing arrangement is stopped by opening the switch 26. The switch 27, which controls the pump for draining the tub, is closed when the motor of the reversing arrangement is stopped. This switch 27 may alternatively be operated by the timer part when spinning is started with the tub empty.

The switches 25', 26' and 27' are the timer switches which provide for normal operation when spinning is not required.

The machine operates as follows:

Washing: the switches 25, 26, and 27 are short-circuited by switches 25', 26' and 27' which are controlled by the timer with the reversing arrangement rotating; the direct-current motor operates in a predetermined rhythm in two directions of rotation.

Spinning: the start of a spin cycle is effected in two stages. First the timer orders the timer switches 25', 26' and 27' to be opened. The switch 26 of the reversing motor remains closed, and the voltage corresponding to the washing speed continues to be applied to the direct-current motor, while the reversing motor continues to rotate.

At a given instant of the reversing cycle (when the switches 21 and 23 are closed) the switch 25 is opened (see FIG. 4) so that the spinning operation may start and then the switch 26 is opened so that the reversing motor is stopped. Opening the switch 25 ensures the start of the spinning operation. As soon as the reversing motor stops (in response to the open condition of switch 26), all of the reversing switch contacts remain in the positions shown in FIG. 4 with switches 25 and 26 open, switch 27 closed, switches 21 and 23 closed and switches 22 and 24 open. The spin cycle continues until the timer orders a new set of conditions by operating the timer switches 25', 26', and 27'.

FIG. 4 shows the reversing cycle and the positions of the various switches of the reversing arrangement during this cycle, i.e., the program of the reversing switch and the condition of its various contacts, open or closed, brought about by the reversing switch cam discs during their rotation. The opening and closing of these contacts have no effect as long as the corresponding timer contacts such as 25' and 26' remain closed.

Contacts 25' and 26' open only if the timer orders a spin cycle and the reversing switch alone takes over briefly to insure that the spin cycle will begin only
5 if contacts 21 and 23 are closed and 25 is open. Switch 26 then opens shortly thereafter to stop the reversing switch motor whereupon the various reversing switch contacts are held in position until the timer takes over control of the remaining operations in the washer program cycle via the timer switches such as 25', 26' etc.

The reversing arrangement is of conventional design: a shaft which is integral with a motor (1 rev/min) carries cams the protuberances of which operate either directly or through levers upon a contact element. The protuberances which effect the closure of the switches 21 and 22 are arranged at diametrically opposed points on the same cam, a second cam carrying the protuberances which operate the switches 23 and 24. The protuberances which operate the switches 21 and 23 are rigidly disposed opposite one another. The contact period, i.e., the time of rotation in the same direction is 12 seconds and is followed by a stationary period of 3 seconds. The cams which ensure switching on of washing and spinning operations (switch 25) and stopping of the reversing motor (switch 26) ensure a permanent contact during the entire time of rotation except for a short interval during which the switch 25 is open to enable the application of the spinning voltage while, only fractions of a second later, the switch 26 is opened, which enables the reversing arrangement to be stopped. The recesses of these cam are rigidly arranged in the center positions of these protuberances for the switches 21 and 23 which provide the preferential direction of rotation. The interval between the instants at which the switches 25 and 26 are opened enable the reversing motor to be stopped as soon as the spinning speed has been switched on.

The cam which carries the protuberance for operating the switch 27 is located opposite the recess of the cam operating the switch 25 and ensures the starting of the draining pump and also the starting of the spinning operation.

The switch 27' is provided only if it is desired to drain the tub on termination of a washing operation without subsequent spin-drying or if draining of the tub is to commence before spinning is started.

The advantages of this method of starting from the washing speed to the spinning speed are many.

The starting of the spin-drying operation is tied only to the reversing arrangement. Manual operation of the timer does not influence the manner of switching of the spinning operation (since the operation of the reversing arrangement is separate from that of the timer).

In this manner the problem of switching for reversal is simplified as far as possible since the system uses a smaller number of contacts than the circuit arrangement of FIG. 2, and moreover, complete safety is obtained, preventing a short-circuit.

In a conventional reversing arrangement it would not be possible to obtain intervals of precise duration as short as one second, for the diameter of the cams is comparatively small (about 15 mm). In the reversing arrangement according to the invention, however, this diameter is about 60 mm, while the motor speed is 1 rev/min, so that a second corresponds to about 3 mm of the circumference. Thus, if short-duration intervals are desired, a cam having a diameter of this order may be notched with a sufficient degree of accuracy.

In another embodiment of a washing machine operating in the aforesaid manner, the timer and the reversing arrangement are independently driven by a single motor by means of a known appropriate gearing which may be mechanical, electromagnetic, electronic or hydraulic.

Such a switching method may be used in washing machines equipped with a direct-current motor which may be switched to spinning speed either when the tub is filled or when it is empty.

What is claimed is:

1. A washing machine comprising, a direct-current motor for driving a drum of the washing machine at a low washing speed in two directions of rotation and at a high spin-drying speed in one direction of rotation, a timer for controlling the sequence and the time duration of the various washing machine operations, a reversing switch which includes first switching means for selectively controlling the electric supply for the motor so as to provide switching to the low washing speed and two directions of rotation and for switching to the high spinning speed, said timer controlling second switching means which control the motor electric supply and the energization of the reversing switch and which short-circuit said first switching means having the same functions but appertaining to the reversing switch, means driven by the timer for initially rendering said second switching means inoperative when switching the machine from a low speed wash cycle to a high speed spin cycle, whereupon the part of said first switching means appertaining to the reversing switch are rendered inoperative at an instant determined by the reversal of the direction of movement of the wash-drum.

2. A washing machine as claimed in claim 1, characterized in that the timer and the reversing switch are independently driven by appropriate means.

3. A washing machine as claimed in claim 2, characterized in that the timer and the reversing switch are driven by at least one alternating current motor.

4. A washing machine control system comprising, a reversible DC motor for driving the washing machine drum at a low reversible wash speed and at a high spin-drying speed in one predetermined direction of rotation, reversing switch means that includes first, second and third switching means coupled to the motor terminals, to the motor electric supply, and to a control winding for controlling the reversing switch means, respectively, said first switching means controlling the direction of motor rotation, said second switching means controlling the motor speed and said third switching means controlling said control winding, a timer for controlling the sequence of washer operations and the time duration thereof and including fourth and fifth switching means connected in parallel with said second and third switching means, respectively, said timer being operative to open said fourth and fifth switching means prior to the start of a spin-drying cycle so that said second and third switching means assume control of the motor speed and the reversing switch, respectively, said second and third switching means then being operated in a predetermined relation to the operation of said first switching means to a condition to provide said predetermined direction of motor rotation whereby said second switching means adjusts the elec-
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7. A control supply to provide said high spin-drying speed and said third switching means deactivates the reversing switch means.

5. A control system as claimed in claim 4 further comprising a pair of input terminals connected to a source of AC supply voltage, rectifier means coupling said AC supply terminals to the motor via said first switching means to provide a reversible DC voltage to the motor, and means connecting said parallel connected third and fifth switching means in series with said control winding across said input terminals.

6. A control system as claimed in claim 5 wherein said timer is arranged to close said fourth and fifth switching means during a wash cycle thereby to operate the motor alternately in both directions of rotation and at said low washing speed.

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