

- [54] **REVERSING MOTOR SYSTEM FOR A LAUNDRY APPLIANCE**
- [72] Inventors: **Joseph Karklys**, St. Joseph; **Stephen A. Becker**, Benton Harbor, Mich.
- [73] Assignee: **Whirlpool Corporation**, Benton Harbor, Mich.
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- [51] Int. Cl. **H02p 1/42**
- [58] Field of Search... 318/207 A, 207 R, 221 R, 225, 318/227, 289

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Primary Examiner—Gene Z. Rubinson
Attorney—Hill, Sherman, Meroni, Gross & Simpson

[57] **ABSTRACT**

The motor of a laundry appliance is selectively driven in either a unidirectional or an alternating rotary manner by a single phase induction motor to rotate a clothes basket during a fluid extraction operation and to oscillate an agitation device during a laundry agitation period. The motor is provided with a pair of stator windings connected in opposite polarity sense, one of these windings being connected to an alternating voltage source for continuously receiving an alternating voltage wave while the other winding is selectively and/or cyclically connected across the voltage input terminals for a very brief period to reverse the motor. The motor with an electronic control circuit forms the basis of a simplified drive system for an automatic laundry appliance.

18 Claims, 8 Drawing Figures

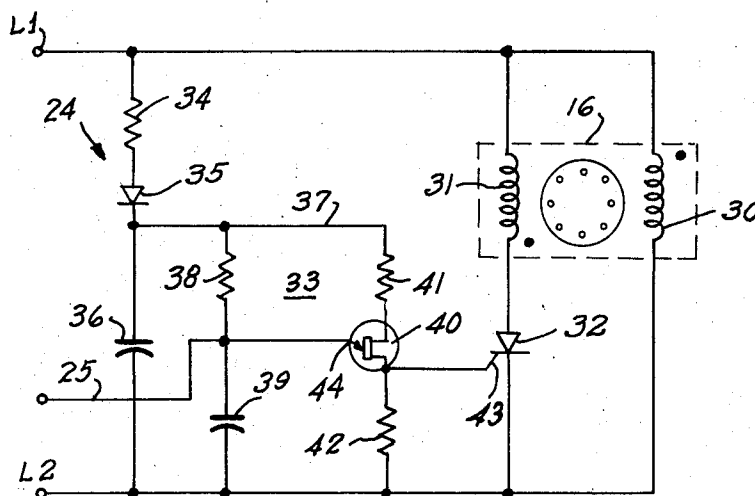
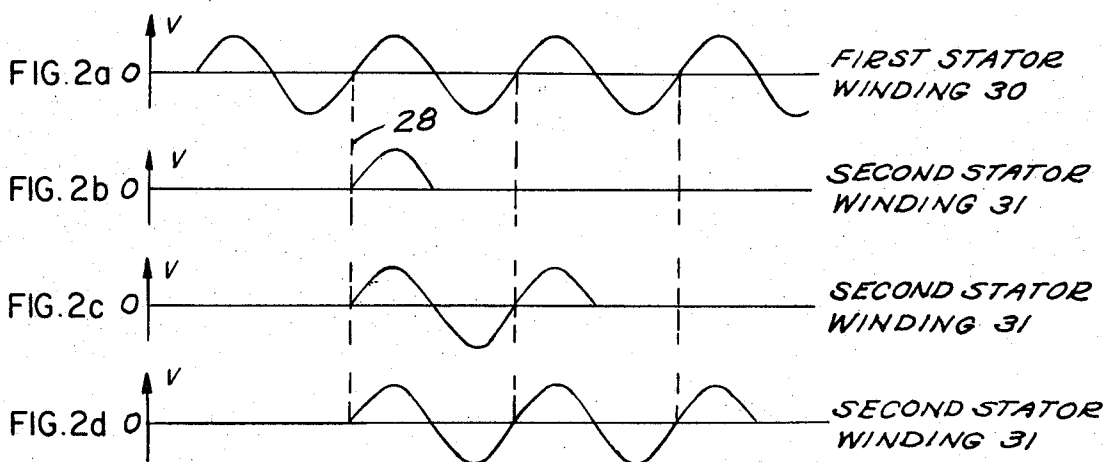
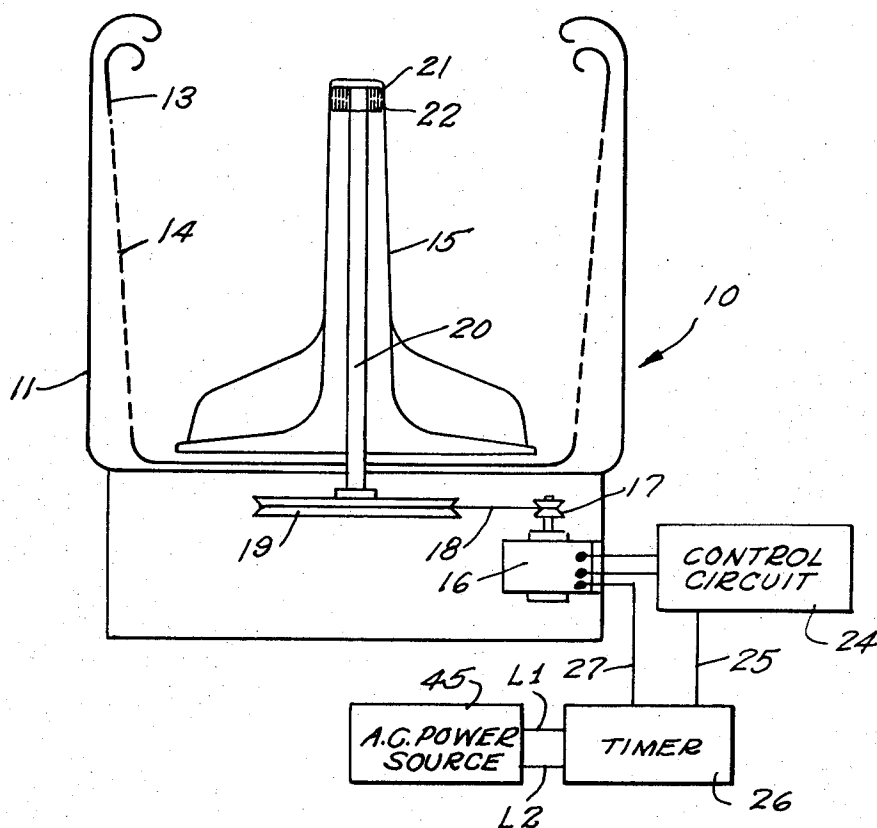
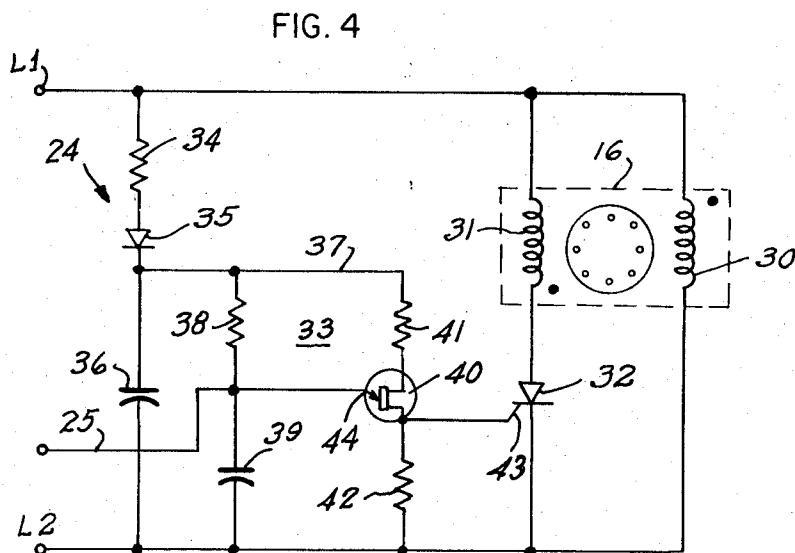
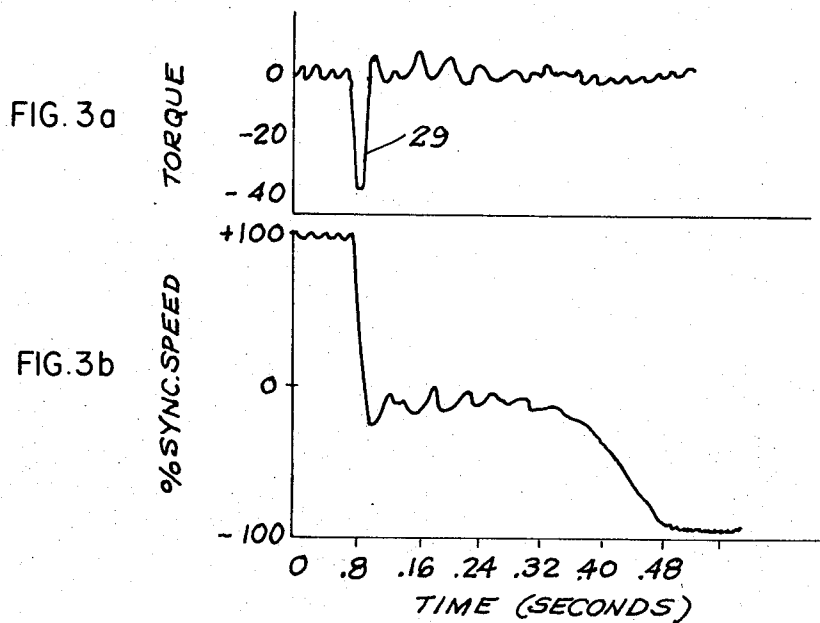


FIG. 1



INVENTORS
Joseph Karklys
Steven A. Becker

BY *Hill, Sherman, Menon, Chase & Singer* ATTORNEYS



INVENTORS
Joseph Karklys
Steven A. Becker

BY *William Sherman Moore, Jr.* ATTORNEYS

REVERSING MOTOR SYSTEM FOR A LAUNDRY APPLIANCE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to drive systems for automatic washers, and in particular to a modified induction motor and associated control circuitry and drive system components which form an automatic washer drive mechanism.

2. Description of the Prior Art

Heretofore, drive systems for automatic laundry appliances which utilize an alternating rotary type of agitation generally have included transmissions which convert unidirectional motion created by a motor to the desired oscillatory motion. Alternatively, DC motors have been used in various direct drive systems which suffer from a requirement for relatively elaborate control circuitry to effect the desired agitation and spin operations. In addition, the art recognizes the utilization of an energy storage device between the drive source and agitator in an automatic washer.

Generally, the various techniques for reversing single phase motors have a number of disadvantages when the techniques are applied to laundry appliance drive systems which require frequent periodic reversal. These disadvantages include: overheating of the motor due to operation for long periods at low efficiency and low self-ventilating speeds; poor switch life; high cost due to requirements for large capacitors, switches, complex feedback circuitry and additional ventilating means; and difficulty in providing a drive system which has good agitator action as well as good spin characteristics.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved drive system for an automatic washer utilizing a reversing induction motor in a direct driving relationship with an agitator.

It is also an object of the invention to provide an improved method for reversing an induction motor.

It is a further object of the invention to provide a modified induction motor and a control circuit for effecting very rapid reversal of the motor in a controlled cyclic manner.

As set forth in a copending application of Nystuen entitled "Induction Motor Structure and Method of Operation," Ser. No. 134,579 and filed on an even date herewith, a modified induction motor construction and method of operating the modified motor are provided to effect controlled reversal of the motor in an extremely rapid and reliable manner. The foregoing and other objectives are realized through practice of the instant invention which utilizes this type of motor construction and an additional method of energizing the motor along with an appropriate control circuit to provide a drive system for an automatic laundry appliance.

According to the invention a motor is provided with a rotor and a pair of stator windings, each of the stator windings taking a general form which is typical of conventional stator windings for induction motors. The two stator windings are connected in opposite polarity sense with respect to each other and, contrary to the switching of applied voltage from one winding to the other as done in the aforementioned Nystuen applica-

tion, one of the windings is connected to an alternating voltage power source to continuously receive an alternating voltage wave, while the other winding is selectively and cyclically connected across the voltage source at or near time spaced zero crossings of the alternating voltage wave. Such energization of the motor creates a very rapid reversal of the direction of rotation of the motor, and the motor is periodically reversed in this manner to provide the alternating drive for the agitator of an automatic washing apparatus.

The motor may be connected to the agitator by means of a torsion spring which is intended to absorb mechanical transients and promotes a smooth agitating operation.

A unijunction transistor relaxation oscillator is included in a control circuit connected to the motor, and conduction of the unijunction transistor is utilized to develop a gating pulse for a controlled conduction device which serves as a switch to connect and disconnect the second stator winding from the voltage input terminals at appropriate times.

DESCRIPTION OF THE DRAWING

Other objects, features and advantages of the invention, its organization, construction and operation will become apparent and the invention will best be understood by reference to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic elevational view of a laundry appliance which may advantageously employ a reversing motor system constructed in accordance with the principles of the present invention;

FIGS. 2a-2d are graphical illustrations of several voltage wave forms which may be applied to the stator windings to effect a rapid reversal of the motor;

FIGS. 3a and 3b are graphical illustrations of motor torque and synchronous speed with respect to time illustrating the speed of motor reversal according to the invention; and

FIG. 4 is a schematic circuit diagram of a motor having two stator windings and the associated control circuit according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A complete description of a winding arrangement and method by which an induction motor may be rapidly reversed utilizing a phenomenon associated with properly synchronized polarity reversal of the applied voltage can be found in the aforementioned Nystuen application, Ser. No. 134,579. Sufficient description of this phenomenon for an understanding and appreciation of the present invention is given below.

In FIG. 1, a laundry appliance is generally illustrated at 10 as comprising a tub portion 11 carried on a base 12. The tub 11 has mounted therein a spin basket 13 including a perforate portion 14 facilitating communication of washing liquid between the tub 11 and the interior of the spin basket 13.

Also mounted within the tub 11 and further within the interior of the spin basket 13 is an agitator 15. The agitator 15 and the spin basket 13 are driven by a drive motor 16 which is coupled thereto by way of a pulley

17, a belt 18, a pulley 19 and a drive shaft 20. The spin basket 13 and the agitator 15 may be secured for common movement, or a clutch mechanism (not shown) may be provided as is well known in the art to drivingly engage the spin basket 13 and the agitator drive shaft 20.

The agitator 15 may be resiliently coupled to the agitator drive shaft 20 as illustrated by means of a pair of torsion springs 21 and 22. The springs may be housed in an upper portion of the agitator 15 and coupled to this portion of the agitator and to the upper portion of the agitator drive shaft 20. One of the springs 21 and 22 couples motion to the agitator 15 when the drive shaft 20 is rotating in a first direction and the other of springs 21 and 22 couples motion to the agitator when the drive shaft 20 is rotating in the opposite direction. Different types of springs or other resilient driving connections may be used to couple the drive shaft 20 to the agitator 15 to ease the dynamic torsional loading of the motor 16 during its cyclic reversals.

The drive motor 16 has a first winding connected across an alternating voltage power source 45 and is operated in a unidirectional or in an oscillator mode by means of a control circuit 24 which is effective to apply voltage pulses to a second winding of the motor at or near zero crossings of the applied voltage. The net effect of a properly synchronized voltage pulse from the control circuit 24 is to create a negative torque pulse of large magnitude and brief duration. The impulse created by the negative torque pulse is sufficient to overcome the inertia of the rotor and the driven load to provide an extremely rapid reversal of the motor.

The control circuit 24 is operative only during the agitation portion of a washing cycle in accordance with a signal supplied via a lead 25 by an appliance timer 26. The timer 26 may be of the conventional electromechanical type in which a series of switch contacts are sequentially operated by a set of rotatably driven cams. Such timers are well known in the art, and the timer 26 effectively controls the various machine operations including spin, as indicated by a lead 27 to the motor 16. The lead 27 may serve to energize an additional winding, a high speed winding, of the motor 16 to achieve a high spin speed during the extract portion of a washing cycle.

As set forth above and in the aforementioned Nystuen application, reversal of polarity of the voltage applied to an induction motor will produce a rapid reversal of the motor rotor if care is taken that the polarity reversal occurs in the vicinity of zero crossings of the voltage. Due to a lagging power factor in motor operation, the necessary switching points occur at times when the current is at or near its maximum value. Therefore, high voltages which may be damaging to solid state switches are likely to be generated due to the amount of energy stored in the inherent inductance of the system. In order to advantageously utilize solid state switching without the fear of detrimental effects of such high voltages, the induction motor may be provided with two windings, both located on the same axis and connected in opposite polarity sense to each other. A rapid reversal of the motor may be effected by simply energizing one of the stator windings continuously in the normal fashion and applying a voltage pulse to the second winding at a zero crossing point of the applied

voltage. It has been found that a rapid motor reversal can be obtained by energizing the second winding for 1/2 cycle, 3/2 cycle, or 5/2 cycle of the applied voltage. These modes of energization are illustrated in FIG. 2, the motor reversal being initiated at 28. The inertia of the rotor and machine load, usually are important in the selection of the most optimum of the aforementioned modes for fast reversal.

Energizing both stator windings for extended periods does not enhance the motor reversal and, in fact, this may result in stalling and an excessive current draw. It has also been found that energizing both stator windings for a period comprising an even number of half cycles does not enhance the motor reversal, and in fact under appropriate circumstances such energization may preclude reliable reversal. This is due to the fact that after the first half cycle of energization, each successive half cycle which is of opposite polarity has an opposing effect on the transients which effect the reversal. Therefore, it is preferable to energize the motor windings for a period comprising an odd number of half cycles, thereby insuring that the number of half cycles aiding the initial half cycle will be greater than the number of half cycles opposing it, and that the last half cycle will be of the same polarity as the initial half cycle.

Generally, within the limitations dictated by the environment of a domestic laundry appliance, energization of the second stator winding for 1/2 cycle or 3/2 cycle of the applied alternating voltage has been found most desirable.

FIG. 3a illustrates the nature of the torque pulse which is developed within the motor 16 when the windings are energized by one of the methods of FIGS. 2a-2d. The torque pulse illustrated at 29 always opposes the previous direction of motor rotation, and is of large magnitude and short duration. The attendant rapid motor reversal is depicted by the lower curve of FIG. 3b, and as illustrated the motor can almost immediately achieve synchronous speed in the opposite direction, typically within approximately 100 milliseconds.

FIG. 4 illustrates the motor 16 having two stator windings 30 and 31 of the type described in connection with a control circuit 24 for effecting a periodic or cyclic reversal of the motor. The control circuit 24 is economical and operates directly 45) a conventional alternating current input line L1, L2 (source 45) and eliminates the necessity for any additional power supplies. The control circuit 24 employs a unijunction transistor connected in a relaxation oscillator configuration for timing the reversal pulses; however, other means, as for example digital 60Hz countdown, could be utilized for the same purpose. In addition, a position sensing device for initiating motor reversal could also be employed when synchronized to the positive half cycle of the input line voltage.

More specifically, the circuit illustrated in FIG. 4 comprises a pair of stator windings 30, 31 for providing the excitation field of the motor 16. The first winding 30 is connected across the alternating voltage input terminals L1, L2 and the second winding 31 is connected in series with a controlled conduction device, here illustrated a silicon controlled rectifier 32, the series combination being connected across the input terminals L1, L2.

A relaxation oscillator 33 is provided for controlling the conduction of the controlled conduction device 32. The relaxation oscillator 33 includes a resistor 34, a diode 35 and a capacitor 36 connected in series across the input terminals L1, L2 for deriving a bias potential at conductor 37 by charging of the capacitor 36 through the diode 35 and the resistor 34. The direct current potential on conductor 37 is utilized for charging a capacitor 39 through a resistor 38 to provide the firing potential at the emitter of a unijunction transistor 40. The unijunction transistor 40 has one base thereof connected by way of a resistor 41 to the conductor 37 and the DC potential thereat, and the other base thereof connected to the input terminal L2 by way of a resistor 42.

The resistor 42 is employed to develop a gating pulse thereacross upon conduction of the unijunction transistor 40, which gating pulse is applied to a gate electrode 43 of the controlled conduction device 32 to render that device conductive and connect the second winding 31 across the input terminals L1, L2.

The RC time constant of the resistor 38 and the capacitor 39 determines the periodic firing of the unijunction transistor 40 and accordingly the periodic application of line voltage to the second stator winding 31. As is well understood by those skilled in the art, once the SCR 32 is energized by means of a pulse on its gate electrode 43, current will continue to flow through winding 31 and through the SCR 32 until the magnitude of the current drops substantially to zero, at which time the SCR will shut off and prevent further current flow through winding 31. Thus, it is seen that winding 31 can be energized only during positive half cycles of the AC voltage.

The periodic firing of the unijunction transistor 36 as determined by the resistor 38 and the capacitor 39 is synchronized to voltage zero crossings preceding positive half cycles of the AC line voltage by the supply voltage ripple. Depending upon the values selected for resistor 38 and capacitor 39, the time between timings of transistor 36 may comprise numerous half cycles of the AC line voltage. Such synchronization to the zero crossing points of the AC voltage waveform is important if reliable and repeatable motor reversals are to be obtained.

The lead 25 from the electromechanical timer referred to earlier is seen as connected to the junction of the resistor 38, the capacitor 39, and the emitter lead 44 of the unijunction transistor 40. This enables the emitter of the unijunction transistor to be shorted to power supply lead L2 by means of an appropriate timer contact (not shown), thereby stopping operation of the relaxation oscillator 33 and preventing the periodic energization of SCR 32 and stator winding 31. Thus, the periodic reversal of motor 16 can be halted as desired to perform other portions of a washing cycle.

It should be understood that although the present control circuit is designed to energize the second stator winding 31 only during positive half cycles of the applied voltage, as illustrated by of FIG. 2b, energizing this winding during only the negative half cycles of the applied voltage will also effect similar rapid reversal of the motor. Further, it should be understood that energizing the winding 31 for both positive and negative half cycles of the applied voltage, as illustrated in the FIGS. 2c and 2d, will result in reversal of the motor,

although the present control circuit is not designed to operate in this manner. An explanation of why those modes of energizing the winding 31 also produces a rapid reversal can be found in the aforementioned Nystuen application Ser. No. 134,579

The apparatus disclosed herein provides a simple and economical driving system for a laundry appliance which operates equally well in a unidirectional rotational mode and in an oscillatory mode. Further, the system eliminates the necessity for complex feedback networks and additional cooling and ventilating apparatus previously required in prior art reversible motor systems in that the mechanical transients are short lived and reversal is almost instantaneous so that motor speed is sufficiently high to prevent overheating and to provide conventional self-ventilating action.

While we have described our invention by reference to a specific illustrative embodiment thereof, changes and modifications of the invention may become apparent to those skilled in the art and it is to be understood that we wish to include within the patent warranted hereon all such changes and modifications as may reasonably and properly be included within the scope of our invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A motor reversing circuit comprising: input terminals for receiving an alternating voltage wave having cyclic zero crossover points; a rotor; first and second stator windings inductively coupled to said rotor and wound in opposite polarity sense to each other and respectively connected across said input terminals; and reversing means including switching means serially interposed in the connection between said second winding and one of said input terminals, and switch control means connected across said input terminals and connected to said switching means for actuating said switching means in response to and at selected zero crossover points to effect controlled reversal of said rotor.

2. A motor reversing circuit, comprising: input terminals for receiving an alternating voltage wave having cyclic zero crossover points; a rotor; first and second stator windings inductively coupled to said rotor and wound in opposite polarity sense to each other and respectively connected across said input terminals; and reversing means including switching means serially interposed in the connection between said second winding and one of said input terminals, and switch control means interconnected between said input terminals and connected to said switching means for actuating said switching means to effect controlled reversal of said rotor, wherein said switch control means includes a relaxation oscillator circuit connected to said switching means.

3. A motor reversing circuit according to claim 1, wherein said switching means includes a semi-conductor switch connected in circuit, with said second winding and having a gate electrode connected to said switch control means.

4. A motor reversing circuit, comprising: input terminals for receiving an alternating voltage wave having cyclic zero crossover points; first and second stator windings inductively coupled to said rotor and wound

in opposite polarity sense to each other and respectively connected across said input terminals; and reversing means including switching means serially interposed in the connection between said second winding and one of said input terminals, and switch control means inter-
 5 connected between said input terminals and connected to said switching means for actuating said switching means to effect controlled reversal of said rotor, wherein said switching means includes a semi-conduc-
 10 tor switch connected in circuit with said second winding and having a gate electrode connected to said switch control means, wherein said switch control means includes a unijunction transistor having an emitter and a pair of bases, first circuit means including a diode and a first capacitor connected in series across
 15 said input terminals so as to develop a bias potential for said transistor, second circuit means including an RC circuit connected across said first capacitor to develop the firing potential of said transistor in response to the direct current potential derived across said first capacitor, and a resistance connected in circuit with one of
 20 said bases and connected to said switching means for developing a switch operating pulse upon conduction of said transistor.

5. A motor reversing circuit according to claim 4, comprising means connected to said RC circuit and operable to inhibit the development of the firing potential for providing unidirectional rotation of said rotor.

6. A motor circuit for a laundry appliance having a
 30 movable part comprising: alternating voltage input terminals for receiving an alternating voltage wave of positive and negative polarity; a first winding connected across said input terminals; a second winding; a rotor inductively coupled to said first and second
 35 windings and connected to the movable part of said laundry appliance; switch means having a control terminal, said switch means and said second winding connected in series across said input terminals with said
 40 second winding in an opposite polarity sense relative said first winding; and circuit means connected to said input terminals and to said control terminal to cyclically close said switch means during predetermined time-spaced half cycles of the alternating voltage wave to effect cyclic reversals of direction of rotation of said rotor and said movable part of said laundry appliance.

7. A motor circuit for a laundry appliance according to claim 6, further including means for inhibiting the cyclic operation of said switch means to effect
 50 unidirectional rotation of said rotor and said movable part.

8. A motor reversing circuit according to claim 6, wherein said circuit means includes a unijunction transistor having an emitter and a pair of bases, first circuit means including a diode and a first capacitor connected in series across said input terminals to provide a bias potential for said transistor, second circuit means including an RC circuit connected across said first capacitor to develop the firing potential for said transistor in response to the direct current potential derived across said first capacitor, and a resistance connected in circuit with one of said bases and connected to said switching means for developing a switch operating pulse upon conduction of said transistor.

9. A laundry appliance comprising: means defining a laundry treatment zone for receiving laundry including

a rotatable member; a motor including a rotor connected to said rotatable member, and a pair of field windings inductively coupled to said rotor; a pair of input terminals for receiving an alternating voltage
 5 wave, said input terminals connected to one of said windings and connectable to the other of said windings in an opposite polarity sense relative said one winding; and reversing means connected to said input terminals and to said other winding for periodically connecting
 10 said other winding to said input terminals for at least one half cycle of the alternating wave to provide a reversing torque to periodically reverse the direction of rotation of said rotor and rotatable member for agitating the laundry in said treatment zone.

10. A laundry appliance according to claim 9, wherein said reversing means includes a control terminal, and said appliance includes a timer circuit connected between said input terminals and said control terminal for controlling the initiation and duration of operation of said reversing means.

11. A motor reversing circuit comprising: alternating voltage input terminals for receiving an alternating voltage wave of positive and negative polarity; a motor including a first stator winding connected to said input terminals for constant energization, a second stator winding disposed in opposite polarity sense to said first stator winding for connection across said input terminals, and a rotor inductively coupled to said first and
 30 second windings; and reversing means for reversing the direction of rotation of said rotor, said reversing means including switch means connected in circuit with said input terminals and said second winding and having a control terminal, and switch control means connected to said input terminals and synchronized with the zero crossings of the alternating wave and operable to cyclically operate said switch means at a frequency less than that of the alternating wave to cyclically reverse the
 40 direction of rotation of said rotor.

12. A motor reversing circuit according to claim 11, wherein said switch control means includes a relaxation oscillator circuit connected to said switch means.

13. A motor reversing circuit according to claim 11, wherein said switching means includes a semi-conductor switch connected in circuit with said second windings and having a gate electrode connected to said switch control means.

14. A motor reversing circuit according to claim 11, wherein said switch control means includes a unijunction transistor having an emitter and a pair of bases, first circuit means including a diode and a first capacitor connected in series across said input terminals to apply a bias potential to said transistor, second circuit means including an RC circuit connected across said first capacitor to develop the firing potential for said transistor in response to the direct current potential derived across said first capacitor, and a resistance connected in circuit with one of said bases and connected to said switching means for developing a switch operating pulse upon conduction of said transistor.

15. A motor reversing circuit according to claim 11, wherein said switch control means includes means operable to close said switch means for substantially one-half cycle of the alternating wave.

16. A method of cyclically reversing the direction of rotation of the rotor of a single phase induction motor

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having first and second oppositely wound field windings, comprising the steps of: continuously applying an alternating voltage wave of positive and negative polarity across said first field winding; and periodically applying one-half cycle of the alternating voltage wave to said second field winding simultaneously with the application of the same half cycle voltage to said first winding.

17. The method of cyclically reversing the direction of rotation of a single phase induction motor having first and second oppositely wound field windings, comprising the steps of: continuously applying an alternating voltage of positive and negative polarity across the

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first field winding; generating a periodic series of motor reversal signals; and periodically applying at least one-half cycle of the alternating voltage wave to the second winding simultaneously with the application of the same to the first winding in response to each of said motor reversal signals.

18. The method according to claim 17, wherein the step of generating is further defined as including the step of synchronizing the generation of motor reversal signals with zero voltage points of the alternating voltage.

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