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3,152,462

CLOTHES WASHING MACHINE AND CONTROL MEANS THEREFOR

Filed Dec. 13, 1961

3 Sheets-Sheet 1

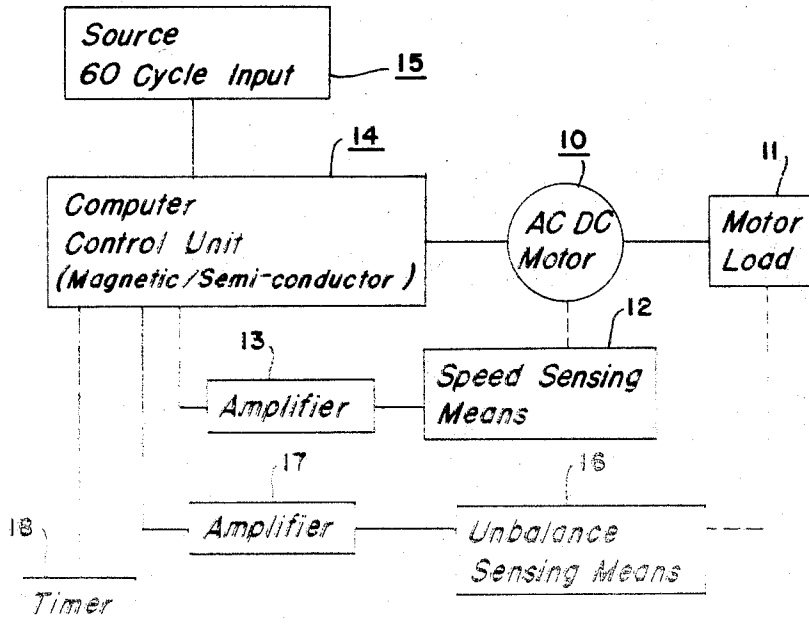


Fig. 1

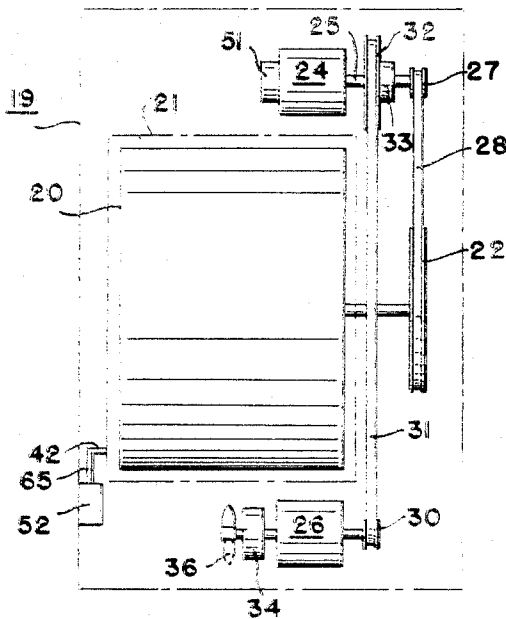


Fig. 2

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3 Sheets-Sheet 2

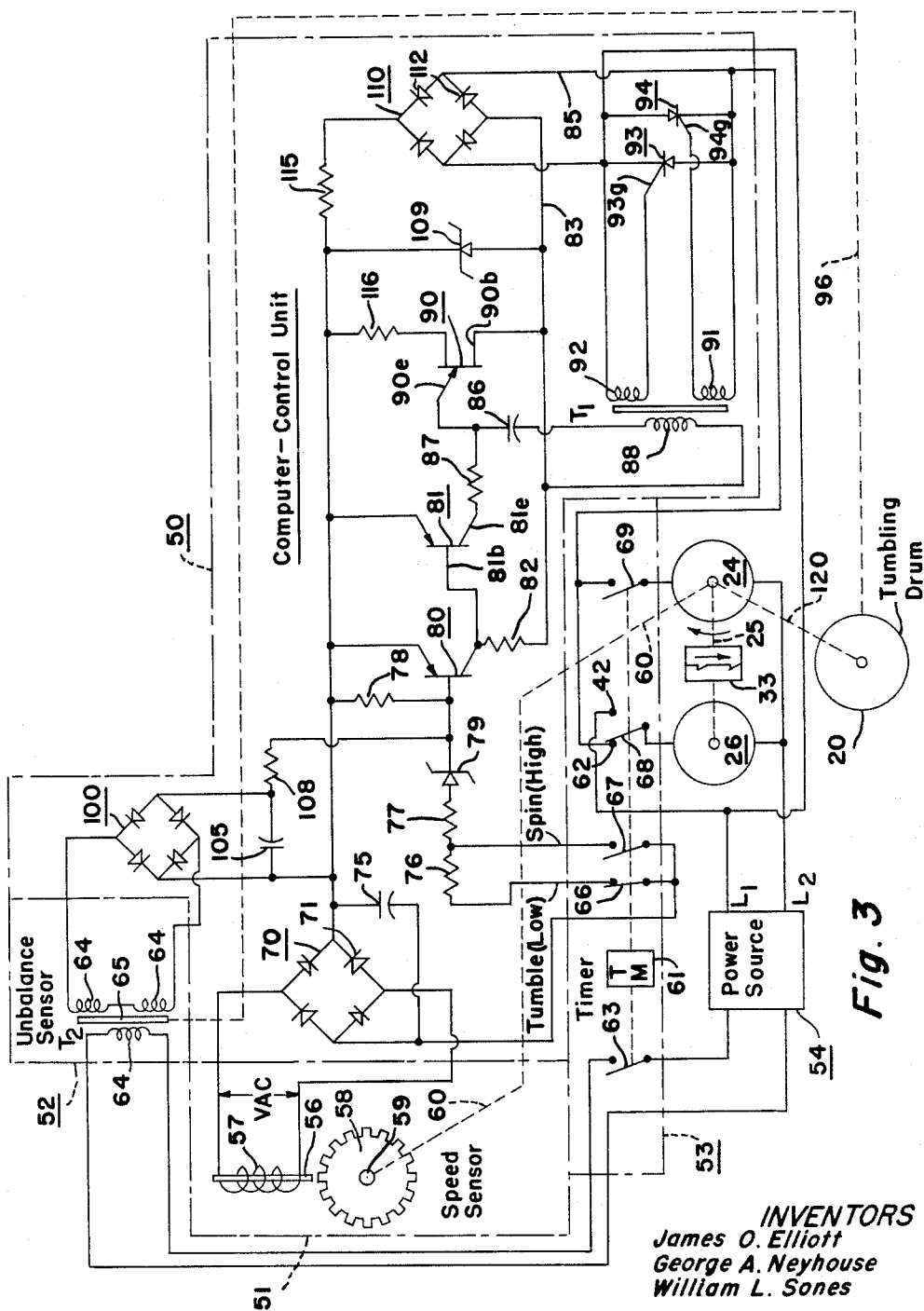


Fig. 3

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3 Sheets-Sheet 3

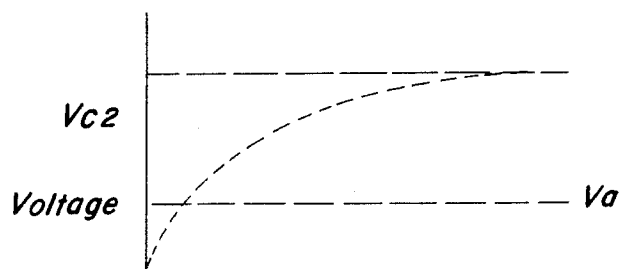


Fig. 4

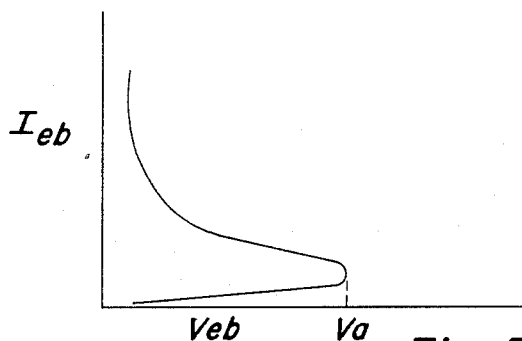


Fig. 5

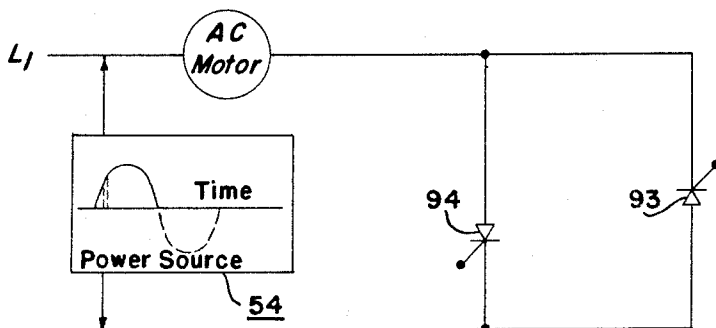


Fig. 7

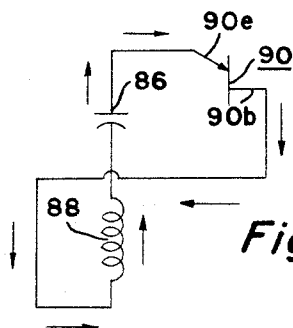


Fig. 6

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CLOTHES WASHING MACHINE AND CONTROL MEANS THEREFOR

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12 Claims. (Cl. 68—12)

This invention relates to a domestic appliance and more particularly to a transistorized servo-control for a combination washer-dryer.

As laundry appliances have become more complex, so the controls therefor have grown in size and complexity. In those laundry appliances utilizing a horizontal tumbling drum for the washing and centrifuging process, it has been common practice to provide various mechanical means, transmissions and multiple speed motors to effect a variable speed of rotation for the tumbling drum. The transistorized control of this invention embodies all of the prior art needs in a control of reduced size and improved operation which may be housed easily in the console of the appliance.

Throughout an operating cycle in a combination washer-dryer, the tumbling drum is operated at various speeds to accomplish the different wash functions. For instance, the tub or drum may be rotated at a low speed of around 46 r.p.m. to tumble the clothes for washing, an intermediate speed of approximately 55 r.p.m. to distribute the clothes evenly about the periphery of the tumbling drum, and at speeds of 135 r.p.m. and 525 r.p.m. for spinning or centrifuging the moisture from the clothes. At higher speeds balancing of the rotary mass becomes critical and it is essential to limit drum speeds at values within the stress tolerances of the appliance.

Accordingly, it is an object of this invention to provide a control system for a horizontal tumbling drum which will hold precisely any predetermined speed of drum rotation.

A further object of this invention is the provision of a transistorized computer control for a motor to effectively maintain a reduced drum spin speed until the clothes are properly balanced and then to condition the motor to bring the tumbling drum to high speed spin for centrifuging.

Another object of this invention is the provision of a computer speed control for a rotating drum and its associated drive motor wherein the speed control includes a differential transformer means to limit drum speed to amplitudes which are tolerable to the transformer.

A more particular object of this invention is the provision of a motor system belted directly to a tumbling drum and a control for varying the motor speed by altering the voltage thereto—the voltage variations occurring as the result of signals fed into a transistorized computer in response to variable conditions, such as unbalance or vibration, temperature, moisture content, degree of cleanliness, acceleration, pressure, velocity and the like. A constant reference signal is provided to which the variable condition signals are compared and proportioned in the computer—a resultant control signal thereby emitted to maintain the motor speed at predetermined values throughout a wide range.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

FIGURE 1 is a block diagram representing a control system for a motor driven tumbling drum in accordance with this invention;

FIGURE 2 is a schematic diagram of a prime moving system for a horizontal tumbling drum;

FIGURE 3 is a circuit diagram of a computer control unit having semi-conductor components for use in the control of the prime moving system of FIGURE 2;

FIGURE 4 is a graphic representation of a voltage charge upon a capacitor in the circuit of FIGURE 3;

FIGURE 5 is a graphic representation of the input characteristics of a unijunction semi-conductor in the circuit of FIGURE 3;

FIGURE 6 is a portion of the FIGURE 3 diagram including a pulse transformer coil and its associated pulsing circuit discharging to produce motor control signals in accordance with this invention; and

FIGURE 7 represents another portion of the control circuit of FIGURE 3 illustrating the use of semi-conductor or silicon controlled rectifier means to control a motor.

In accordance with this invention and with reference to FIGURE 1, a block diagram is used to illustrate generally a motor means 10 for driving a load 11, such as a rotatable clothes tumbling drum on laundry equipment. The block diagram provides means 12 and 16 for sensing conditions of drum unbalance and motor speed to initiate signals which, in turn, can be used for control of power supply to the motor 10 in accordance with the computations of a computer control unit 14. The computer takes into account differences in the size and orientation of loads such as clothes and water—factors which can change the torque requirements of the motor 10. In other words, output speed of the motor 10 is controlled by this invention in accordance with loading; and a measurement of motor speed can be used as one variable to signal deviations from desired performance norms.

A speed discriminator or tachometer means 12 is provided with suitable mechanism to convert motor speed into electrical signals which can be strengthened if necessary by an amplifier 13 and fed into the computer-control unit 14. The computer or servo-control 14 is completely static in that no moving part other than the motor itself is employed. Electrical circuit components are included in the computer which are adapted to meter a sixty cycle power supply to the motor from a power source 15 by means of varying voltage values to effect desired motor speed.

The load 11 can vary due to conditions of unbalance and vibration which may become excessive and which may exceed a desired value. Accordingly, an unbalance sensing means 16 can be provided to convert mechanical impulses of vibration into electrical signals which can be strengthened if necessary by an amplifier 17 before being fed into the computer-control unit 14.

The control system represented by FIGURE 1 is incorporated by the teachings of this invention in a combination washer-dryer 19 shown schematically in FIGURE 2. In most cases the combination machines being currently marketed include a horizontally rotatable tumbling drum which is rotated at a low speed for tumbling the clothes in the presence of water for washing the clothes and, subsequently, at a plurality of higher speeds for rotating the tumbling drum to distribute the clothes and to centrifuge the water therefrom—a timer being provided to energize the motor in accordance with the desired function throughout the wash and drying cycle. Between the tumble or wash speed and the centrifuging speed is an intermediate speed used to distribute the clothes about the periphery of the drum prior to energizing the system for higher speeds. This distribution period effects a minimal balance within the rotary drum and, thus, permits higher speeds of drum rotation without undue vibration and unbalance.

Considering FIGURE 2, a horizontal tumbling drum 20 is included which has a diameter of approximately

twenty-nine inches. A drum pulley 22 is connected directly to the tub in order to rotate the tub within an enclosing conventional appliance cabinet 19 and water container 21 (shown in phantom). In general, it is desired in this system to rotate the tub 20 at approximately 46 r.p.m. for tumble throughout the washing cycle. Then the drum or tub is rotated at approximately 55 r.p.m. to distribute the clothes about the periphery of the drum and, once this distribution is accomplished, the drum is accelerated into an intermediate spin speed of approximately 135 r.p.m., this being followed by the high speed spin of 525 to 540 r.p.m. Of course, it should be realized that these design parameters are conditioned upon the size of the tumbling drum—the end result being a proper fall or tumble of clothes during the tumble cycle and a proper spin for water removal during the high speed spin. These end results are accomplished in a prime moving system including a two-pole spin motor 24 and a four-pole tumble motor 26. Both the spin and tumble motors may be of the permanent capacitor type. The powershaft 25 of the spin motor 24 is connected to the drum pulley 22 by means of a drive pulley 27 and a V-belt 28. The tumble motor, on the other hand, is the workhorse of the pair and is connected through its drive pulley 30 and a belt 31 to a pulley 32 which incorporates an overrunning clutch portion 33 to permit the spin motor, when energized, to run away from the tumble motor after the tumble motor has powered the clothes distribution function and the system is conditioned for high speed spin.

With the foregoing motors 24 and 26, the proper speeds of drum rotation are achieved with a 4.6 to 1 ratio between the pulley 30 and the pulley 32 and a 6.5 to 1 ratio between the pulley 27 and the pulley 22. In addition to operating the tumbling drum, the tumble motor 26 may also be used to rotate a water pump 34 throughout the wash and drain portions of the cycle and the fan 36 during the drying portion of the cycle. In general, the tumble, distribution and two spin speeds are accomplished as follows. The tumble motor 26 is energized at a reduced and controlled voltage by the computer to operate at 1400 r.p.m., thereby producing a 46 r.p.m. tumble in the twenty-nine inch drum. With the tumble motor operating on line frequency with the computer out of the circuit, the motor speed is 1725 r.p.m. and a 55 r.p.m. distribution speed is accomplished at the tumbling drum. The intermediate drum spin speed of 135 r.p.m. is effected through a controlled voltage energization of the spin motor 24 at 1100 r.p.m.—this being accomplished by a tachometer or motor speed sensor 51 and a resistor in series with the computer input. Lastly, the spin motor 24 is energized for two-pole operation at 3450 r.p.m. to produce the high spin speed of 525 r.p.m. at the drum.

This invention improves over the prior art in the provision of a novel transistorized computer-control unit 50 (FIGURE 3) which senses and controls the tumble and spin speeds and maintains them at a reference norm in the manner of a servo-control. To this end, sensors for motor speed and tumbling drum unbalance are in position to feed signals of these conditions into the computer-control unit which, in turn, controls voltage supply to the motors 24 and 26. Always, the computer limits drum speeds to amplitudes which are tolerable in view of the signals sensed by the system. In this way, the drum speed is restrained at a lower value until the clothes are distributed so as to produce a balanced drum condition. The spin speed will continue only at a computer permissible drum r.p.m. and is limited only by the top speed of the motor itself.

It should be recognized that a timer 53 may be used to control in conventional fashion the various functions of the combination washer-dryer. In other words, cycle portions devoted to washing, distribution and centrifuging will be set up by cam actuated switches in the timer 18. It is after the timer calls for a particular function that the computer-control unit 14 comes into play to regulate

and control the drive motors 24 and 26 in accordance with either a programmed or computer permissible speeds.

The major sections of this laundry appliance control system having static semi-conductor means can be seen in FIGURE 3. In the example given by this illustration, the computer-control unit 50 receives information from three sources, such as the speed discriminator or speed sensing means 51, the vibration discriminator or unbalance sensing means 52, and the appliance timer or speed programming means. As aforesaid, variable conditions other than these just mentioned can be transformed into electrical impulses or signals which can be supplied to the computer-control unit—these other conditions including temperature, humidity, wash fluid clarity and the like. The computer-control unit 50 uses the signals or impulses to determine what power should be supplied to the tumble motor 26 and spin motor 24 from a power source 54. In general, when the drum is rotating with an unbalance condition wherein excessive vibration occurs, the computer-control unit includes circuitry and components to effect lowering of A.C. voltage applied to the motor or motors so as to reduce the speed thereof and to maintain the reduced speed until the unbalance condition has been subjected to correction as in the case of a washer with dynamic balancing provisions. For speed variations due to loading, line voltage, and the like, the computer-control unit can effect lowering and raising of motor voltage as required to maintain a constant speed and permits control of motor speed over a wide range on either A.C. or D.C. motors. Devices for sensing variable parameters, as well as the components of the computer-control unit 50, are set forth in further detail next following with reference to FIGURE 3.

In order to control tumbling drum r.p.m. the drum speed must be sensed, a signal produced in proportion to the speed and the signal fed into the computer-control unit where it can be interpreted in the light of programmed speed requirements—speed corrective action being then effected as needed. For this purpose the speed discriminator section or tumbling drum speed sensor 51 can have a permanent magnet pickup means similar to a type used in dynamometers and comprised of a number of turns of wire 57 wound on a small magnet 56 as shown in FIGURE 3. This permanent magnet pickup 56 is located in radial alignment adjacent to an outwardly toothed wheel means 58 suitably journaled on a shaft 59 driven by a connection 60 to the shaft 25 of the spin motor 24. The spin and tumble motors 24 and 26 may work either independently or in combination to rotate the tumbling drum 20 at the timer prescribed speed, but, for purpose of clarity, this teaching uses the motors independently. It should be noted that the spin motor shaft 25 will reflect drum speed irrespective of which motor or motors is driving—the over-running clutch or jackshaft 33 effecting this result. As the toothed wheel means 58 rotates, the permanent magnet means 56 is subjected to varying air gaps and the effective reluctance change causes flux changes in the magnet which induce a voltage in the coil 57. This voltage varies both in frequency and amplitude depending on the speed of the wheel means 58 and thus in response to tumbling drum r.p.m. The speed signal produced thereby is rectified or converted by a full-wave bridge 70 and capacitive filter unit 75 to allow the signal to be fed into the computer-control unit 50.

The vibration discriminator or unbalance sensor 52 includes a differential transformer T_2 having coils 64 and a movable core 65 mechanically connected to a reference point on the water container 21 which encloses the tumbling drum. The vibration of a centrifugal load in the rotating drum is transmitted through the water container to the movable member 65 which is mechanically attached to the container 21 to pick up disturbances in the tumbling drum. A full-wave bridge 100 and capacitive

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filter unit 105 is included to allow the "unbalance signal" to be fed into the computer-control unit 50. Further reference to the bridge and filter unit portions will be provided in the description of the operation of the computer-control unit 50.

The appliance timer or speed programming means 53 may include single pole, single throw cam actuated switches 63, 66, 67 and 69 and a single pole, double throw switch 68 sequentially closable by a timer motor 61 to program the proper motor speed for a given cycle of wash, distribution or spin. When the timer motor 61 closes the tumble circuit switch 66 and moves the tumble motor switch 68 into engagement with the computer contact 62, the computer-control unit 50 is conditioned for controlling a wash operation and the four-pole tumble motor 26 is selected as the prime mover for this operation. On the other hand, when the timer motor acts to close the spin circuit switch 67, the unbalance sensor circuit switch 63 and the spin motor switch 69, the computer-control unit is conditioned for controlling a spin or centrifuging operation and the two-pole spin motor 24 is selected as the prime mover. In between wash and spin the timer motor 61 closes switch 66, moves switch 68 to a line contact 42 and opens timer switches 63, 67 and 69. This places tumble motor 26 across the line to rotate the drum 20 at approximately 55 r.p.m. for a sufficient time to distribute the clothes about the periphery of the drum.

A brief preliminary description of the computer-control unit 50 will enhance the subsequent understanding of its collective components. The computer includes a pair of bridge circuits 70 and 100 which rectify signals from the speed sensor 51 and the unbalance sensor 52, respectively. In conjunction with the variable signals produced in response to speed and unbalance, resistances or speed effecting means 76 and 77 are placed selectively into the circuit depending on whether the timer 53 calls for wash or spin. These signals are then processed through a network of amplifying transistors 80, 81 and 90 which cooperate to produce a motor control signal in the primary coil of a pulse transformer T_1 . This resultant control signal serves merely as the intelligence for operating a power supply switch to the motor comprised of a pair of oppositely facing silicon controlled rectifiers (SCR) 93 and 94. In order to supply the input voltage to the transistorized computer network, a bridge 110 of diodes 112 rectifies A.C. to D.C. power and a Zener diode 109 in conjunction with resistor 115 regulates the voltage across the output of the bridge. In other words, the timer 53 selects a particular motor 24 or 26 to rotate the tumbling drum 20 at a particular speed and the computer 50, through its semi-conductor switch means 93 and 94, supplies power to the selected motor in an amount or voltage regulated by the intelligence resulting from the speed sensor 51, the unbalance sensor 52 and resistance selection of the timer.

More particularly, the computer control unit 50 during wash and spin includes the first bridge portion 70 having rectifiers 71 for conversion of A.C. signal voltage from the coil 57 of the speed sensor 51 into full wave direct current filtered by a capacitor 75 before application of the signal through a network including resistances 76, 77 and 78 and a Zener diode 79. The resistance means 76 and 77 selected by timer switches 66 or 67 serve to regulate power to the extent that the prime mover may operate at the desired speed for wash (tumble) or spin (centrifuge).

In operation the speed sensor signal is fed into the bridge 70 where it is rectified or converted into full wave direct current. This signal is filtered by the capacitor 75 and applied through the resistance Zener diode network to the input terminals of the transistor 80. If we consider that the voltage across its input terminals is zero, the transistor 80 will effectively open forcing the transistor 81 to conduct emitter 81e to base 81b through the resistance

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82 and back to the supply by way of conductors 83 and 85. This base current flow through the transistor 81 effectively shorts the output terminals of the transistor 81 allowing the capacitor 86 to charge through the resistance 87 and the primary coil 88 of the transformer T_1 . In this circuit the capacitor 86 will charge to a voltage V_a (FIGURE 4) in order to cooperate with the unijunction transistor 90, connected emitter to base across the capacitor and having an input characteristic shown in FIGURE 5. For a given voltage V_a (FIGURE 5) the impedance of the unijunction transistor 90, emitter 90e to base 90b, drops very rapidly toward zero furnishing the capacitor 86 with a low impedance discharge path through the transistor 90 and the transformer coil 88 as shown in FIGURE 6. This fast discharge of the capacitor 86 produces a spike of voltage across the transformer primary coil 88 which is induced into the two secondary coils 91 and 92. These secondary coils are connected respectively such that the positive lead on the two secondary coils is connected to the gates 93g and 94g of the silicon controlled rectifiers 93 and 94. Each time that the capacitor 86 discharges through the unijunction transistor 90 and the transformer coil 88, there will appear a positive spike of voltage at each of the silicon controlled rectifier gates. If the voltage across the anode and cathode of each silicon controlled rectifier is such as to allow firing of either rectifier 93 or rectifier 94, it will fire or switch the power to the ON condition to energize the particular motor placed into control relationship with the computer 50 by the timer switches 63 or 69. Thus the sooner in a given A.C. cycle that the capacitor 86 discharges, the greater the proportion of motor ON time to OFF time.

For summarizing the above semi-conductor switching arrangement for an appliance motor, reference may now be had to FIGURE 7. If we consider that the silicon controlled rectifier 94 as switched ON and the SCR 93 OFF, there is now a path from L_1 to L_2 for line voltage to reach the motor. Since this line voltage consists of only one-half of an A.C. cycle as shown in the upper half of the sine wave in FIGURE 7, the voltage applied to the motor is positive or in the forward direction of the SCR 94. When the SCR 94 is ON it may be considered a normal diode and will pass current in this forward direction limited only by the impedance of the motor. On the other half cycle (dotted) the SCR 93 will be ON while the SCR 94 is OFF.

Returning now to FIGURE 3, let us assume that the speed of the motor being controlled has decreased from the desired norm. The decrease in motor speed will be attended by a decrease in the output signal from the speed sensor 51 and its related bridge circuit 70. This will reduce the voltage at the input terminals of the transistor 80 and thus the collector current of the transistor will decrease while the voltage across the output terminals of the transistor 80 will increase. As this voltage increases the current through the next transistor 81 will increase to allow the capacitor 86 to charge at a faster rate, i.e., the voltage V_a is reached at a faster rate. This means that a positive gate 93g will be present at the silicon controlled rectifier 93 and at the gate 94g of the silicon controlled rectifier 94 at an earlier time than would occur if the proper motor or drum speed were maintained. In other words, the SCR 93 or SCR 94 can now fire at an earlier time to increase the amount of line voltage applied during any given half-wave cycle to whatever motor 24 or 26 is in the circuit thereby causing the speed of this selected motor to rise.

In the same manner an increase in motor speed will be reflected at the speed sensor 51 and the signals produced through the transistorized computer network will result in a lesser voltage supply on the motor. It should be appreciated that this type of regulation adjusts motor voltage each half cycle of the power supply so that speed control is from half cycle to half cycle.

The foregoing operation was explained with reference to the speed sensor 51, however, a similar, but offsetting or modifying, signal is produced at the same time or simultaneously in the bridge network 100 of the unbalance sensor 52. In other words, the call for additional supply voltage to increase motor speed by the speed sensor 51 will be unheeded so long as the unbalance sensor 52 is looking at undesirable vibration through its tumble drum related transformer core 65. It is only when the tumbling drum 20 is in proper balance that the speed sensor 51 can condition the computer-control network to permit the selected motor to operate at the timer programmed speed.

It should now be seen that an improved control system has been devised for laundry appliances wherein various signals pertinent to laundry operation are sensed and processed through a transistorized computer to control the appliance motor for operation at prescribed speeds only insofar as these speeds are tolerable by the variable condition sensors in the system.

While the embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In combination, means for tumbling clothes in the presence of a washing fluid, means for rotating said tumbling means including a first and second prime mover means, said first prime mover means having a power shaft connected to said tumbling means, said second prime mover being connected to said power shaft in overrunning relationship thereto, a power source, timer means for selectively conditioning said first and second prime mover means for energization from said power source, means for deriving a first control voltage responsive to the speed of said tumbling means, means for deriving a second control voltage responsive to the balance of said tumbling means, semi-conductor switch means in power supply relationship to said first and second prime mover means, and computer means simultaneously processing said first and second control voltages for controlling the conductivity of said semi-conductor switch means in accordance with said first and second control voltages.

2. In combination, means for tumbling clothes in the presence of a washing fluid, means for rotating said tumbling means including a prime mover means, a power source, timer means for selectively conditioning said prime mover means for energization from said power source, means for deriving a first control voltage responsive to the speed of said tumbling means, means for deriving a second control voltage responsive to the balance of said tumbling means, semi-conductor switch means in power supply relationship to said prime mover means, and computer means simultaneously processing said first and second control voltages for controlling the conductivity of said semi-conductor switch means in accordance with said first and second control voltages.

3. In combination, means for agitating material in the presence of a cleaner, means for actuating said agitating means including a prime mover means, a power source, means for selectively conditioning said prime mover means for energization from said power source, means for deriving a first control voltage responsive to the speed of said agitating means, means for deriving a second control voltage responsive to the balance of said agitating means, semi-conductor switch means in power supply relationship to said prime mover means, and means simultaneously processing said first and second control voltages for controlling the conductivity of said semi-conductor switch means in accordance with said first and second control voltages.

4. The combination of claim 3 wherein at least one of said deriving means includes a rectifying bridge network and a capacitor means.

5. The combination of claim 3 wherein at least one of said deriving means includes a rectifying bridge net-

work and a capacitor means, and a differential transformer means motion responsively connected to said agitating means.

6. In a clothes washer, the combination of wash means adapted to wash a load, prime mover means for driving said wash means, a power source, means for selectively conditioning said prime mover means for energization from said power source, means for sensing at least two conditions for said wash means and adapted to produce at least two signals in proportion respectively to each of said sensed conditions, and a computer-control means including a semi-conductor switch means in power supply relationship to said prime mover means, said computer-control means including means for simultaneously processing said signals together to control the voltage characteristic of power supplied through said semi-conductor switch means to said prime mover means.

7. In a clothes washer, the combination of agitate and spin means adapted to agitate and spin a load, prime mover means for driving said agitate and spin means, a power source, means for selectively conditioning said prime mover means for energization from said power source, means for sensing at least two conditions of said agitate and spin means and adapted to produce at least two signals in proportion respectively to each of said sensed conditions, and a computer-control means including a semi-conductor switch means in power supply relationship to said prime mover means, said computer-control means including common means for processing both of said signals in the same manner to control the voltage characteristic of power supplied through said semi-conductor switch means to said prime mover means.

8. In combination, rotatable means adapted to contain a load of fabrics, prime mover means for rotating said rotatable means, a power source, timer means for selectively conditioning said prime mover means for energization from said power source, means for sensing the speed of said prime mover means and adapted to produce a signal in proportion to the sensed speed, means for sensing the balance of said rotatable means and adapted to produce a signal in proportion to the sensed balance, a computer-control means including a semi-conductor switch means in power supply relationship to said prime mover means, said computer-control means including means for simultaneously processing said signals together to control the voltage characteristics of power supplied through said semi-conductor switch means to said prime mover means.

9. In a clothes washer, the combination of means adapted to agitate and spin a load of fabrics, prime mover means for driving said agitate and spin means at first and second speeds, a power source, timer means including means for selectively conditioning said prime mover means for energization from said power source, speed effecting means including a first and second resistance selectable for effecting energization of said selectively conditioned prime mover means at said first or second speed, said timer means including means for selecting one of said first and second resistances to select one of said first and second speeds, means for sensing the selected speed of said prime mover means and adapted to produce a signal in proportion to the sensed speed, and a computer-control means including a semi-conductor switch means in power supply relationship to said prime mover means, said computer-control means including common means in controlling relationship with the selected one of said first and second resistances for processing said signal in the same manner to control the voltage characteristic of power supplied through said semi-conductor switch means to said prime mover means.

10. In combination, rotatable means adapted to drive a load, prime mover means for rotating said rotatable means, a power source, means for selectively conditioning said prime mover means for energization from said power source, means for sensing at least two conditions for

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said rotatable means and adapted to produce at least two signals in proportion respectively to each of said sensed conditions, and a computer-control means including a semi-conductor switch means in power supply relationship to said prime mover means, said computer-control means including means for simultaneously processing said signals together to control the voltage characteristic of power supplied through said semi-conductor switch means to said prime mover means.

11. The combination of claim 10 wherein said prime mover means is an alternating current motor.

12. In combination, means for agitating material in the presence of a cleaner, means for actuating said agitating means including a prime mover means, a power source, means for selectively conditioning said prime mover means for energization from said power source, means for deriving a first control voltage responsive to the speed of said agitating means, means for deriving a second control voltage responsive to the balance of said agitating

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means, semi-conductor switch means in power supply relationship to said prime mover means, and means for controlling the conductivity of said semi-conductor switch means in accordance with said first and second control voltages, at least one of said deriving means including a rectifying bridge network and a capacitor means, and a differential transformer means motion responsively connected to said agitating means.

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