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(54) Arrangement for measuring and balancing out-of-balance washloads in the drum of washing machines.

(57) Electronic arrangement for measuring and balancing out-of-balance washloads in the rotating drum of washing machines, as they may be caused to occur by an uneven distribution of the clothes in the drum when it rotates at its wash and spin-extraction speeds.

Arrangement that measures the active power input to the drum driving motor (1), said active power input being in a proportional relationship with the mechanical stresses that are being placed on the drum itself, and that compares, in a comparator circuit (27), the value of said measured active power input with a pre-determined value of a reference power corresponding to the active power input to the drive motor (1) at the moment when the out-of-balance condition of the washload in the rotating drum starts occurring.

As a result of this comparison, said comparator circuit (27) will either allow the drum driving motor (1) to run regularly, if no such out-of-balance condition is detected, or changes the rotational speed of said drum driving motor (1) in the case that said out-of-balance condition is on the contrary detected, and keeps varying the motor's rpm parameter until the washload actually manages to get evenly redistributed in the rotating drum and the out-of-balance condition is therefore removed.

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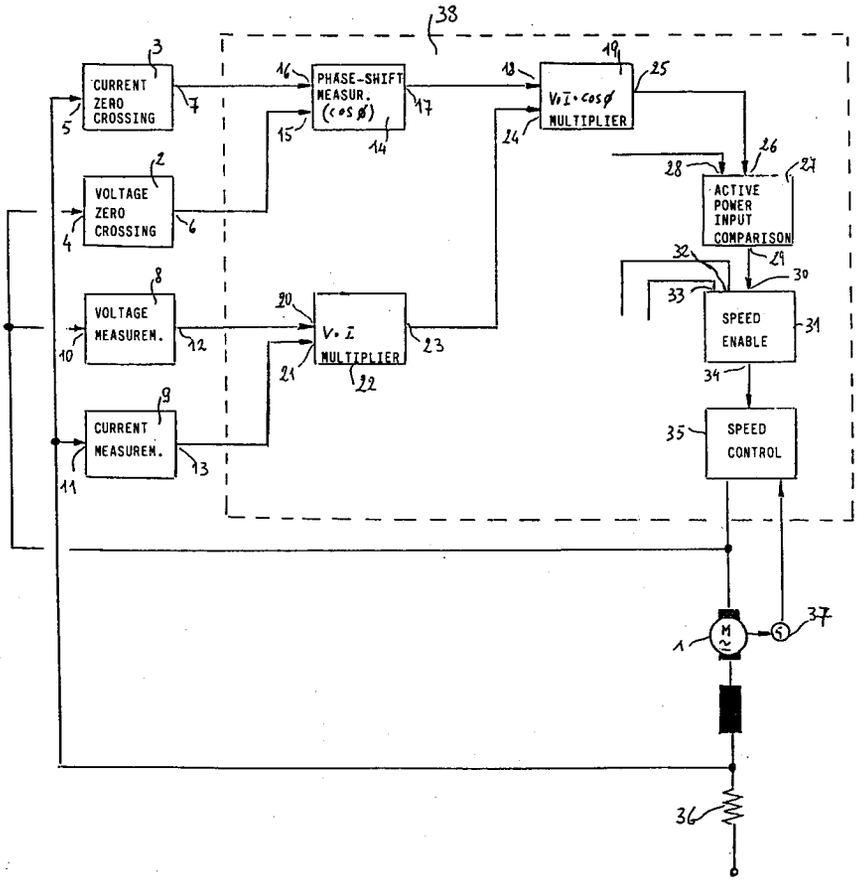
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CURRENT ZERO CROSSING
PHASE-SHIFT MEASUR. (cos φ)
V·I·cosφ MULTIPLIER
VOLTAGE ZERO CROSSING
ACTIVE POWER INPUT COMPARISON
VOLTAGE MEASUREM.
V·I MULTIPLIER
SPEED ENABLE
CURRENT MEASUREM.
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The present invention relates to an electronic arrangement that is provided in washing machines, particularly clothes washing machines and combined clothes washing and drying machines, and is adapted to measure and balance out-of-balance washloads in the drum of such washing machines when performing their laundering processes.

It is commonly known that, when machines of the afore mentioned kind are performing any of their washing cycles, the washload in their rotating drum sometimes tends to distribute in a more or less uneven way in the same drum, thereby giving rise to unbalance moments generating such strong vibrations and mechanical stresses in the washing machines that, if exceeding certain pre-determined critical levels, may also cause the mechanical structure of said machines to suffer damages.

In order to prevent such situations, and their consequences, from occurring, it is in practice necessary that the level of the mechanical stresses being brought about depending on the rotational speed of the drum be known in advance and instantaneously, ie. in such a way as to be able to prevent said stresses from rising to their critical levels. This is usually performed by varying the rotational speed of the drum accordingly, ie. by lowering the rpm of the drum to such an extent as to promote better distribution of the washload inside the drum itself and at the same time cause the out-of-balance condition of the same washload to be in this way reduced or wholly removed.

It is the purpose of the present invention to provide an arrangement of the electronic type which, when used and appropriately wired in washing machines of the afore mentioned kind, is capable of instantaneously detecting and measuring the mechanical stresses that are generated during the rotation of the drum containing a washload, and which is capable, when any out-of-balance condition arises owing to an irregular or uneven distribution of such a washload inside the drum, of automatically acting on the motor driving said drum so as to cause it to adequately change its rotational speed in view of in this way promoting re- distribution of said washload inside the drum for regaining a more satisfactory balance condition.

In particular, said arrangement according to the present invention is based on the principle according to which mechanical stresses generated in the machine are in a definite proportion to the rotational speed and the unbalanclng moment of the drum containing the washload, as well as the rotational speed of the drum is in a definite proportion to the active power input to the electric motor driving said rotating drum.

From all these considerations it therefore ensues that said mechanical stresses are in a proportion to the actual active power input to said electric motor used to rotatably drive said drum containing the washload, so that by using the arrangement according to the present invention to measure the actual active power input to said electric motor at each moment during the washing cycle performed by the machine, when said motor is rotating at a relatively low speed, it is possible to determine in advance the level of the mechanical stresses which the machine is likely to undergo when the rotating speed of the driving motor, and hence of the drum, will next be increased up to the highest rpm rating provided for spin-extraction. The unbalancing moment of the drum is in this way determined and, based on this information, it will then be possible to perform, under the control and through the action of the electronic arrangement according to the present invention, the variation in the rotating speed of the motor such as this is required to evenly re-distribute the clothes and restore in this way the balanced condition of the washload inside the drum.

This electronic arrangement is embodied with such construction and operating features and characteristics as essentially described with particular reference to the appended claims.

The invention will be further described by way of non-limiting example with reference to the accompanying drawing, in which the Figure shows the schematic circuit diagram of the electronic arrangement according to the present invention.

Referring now to said Figure, the electronic arrangement shown there is installed and wired into a washing machine, particularly a clothes washing machine or a combined clothes washing and drying machine provided with a rotating drum adapted to contain the washload and capable of being rotatably driven by a universal-type electric motor 1, in view of instantaneously and automatically detect and measure any possible unbalancing moment as brought about by an uneven distribution of the washload inside the drum when the latter is being rotatably driven by said motor at its various wash and spin-extraction RPMs, in such a way as to restore a balanced condition in the distribution of the washload according to the method described below.

The afore cited arrangement is essentially formed by two electronic zero-crossing detecting circuits 2 and 3 for the sine-wave alternating voltage and current, respectively, of the power supply to the electric motor 1, said electronic zero-crossing detecting circuits being connected with their respective inputs 4 and 5 in parallel and in series to the electric motor 1 so as to generate at their corresponding outputs 6 and 7 a related electrical pulse at each zero-crossing of the corresponding electrical quantity, at the very instant at which this occurs.

The arrangement further comprises two electronic circuits 8 and 9 of a *per sè* known type for measuring the electric voltage and current, the respective inputs 10 and 11 of said circuits 8 and 9 being connected in parallel and in series with the electric motor 1, whereas said circuits 8 and 9 are adapted to measure the electric voltage and current of said electric motor, thereby generating at their respective outputs 12 and 13 an electric signal which is proportional to the measured value of the corresponding electrical quantity.

The arrangement according to the present invention further includes an electronic time-measurement circuit 14 of a *per sè* known type, which is provided with two inputs 15 and 16, that are connected with the outputs 6 and 7, respectively, of the afore cited zero-crossing detecting circuits 2 and 3, as well as with an output 17 that is connected with a first input 18 of a voltage and current multiplier circuit 19 of a traditional type.

The purpose of said electronic time-measurement circuit 14 is to instantaneously calculate the time elapsing from the zero-crossing of the electric voltage and the zero-crossing of the electric current, as detected by the respective zero-crossing detecting circuits 2 and 3 and corresponding to the phase shift existing between said electric voltage and said electric current, by measuring the time elapsing between either of the electric pulses that are generated by said zero-crossing detecting circuits 2 and 3 and correspond to said zero-crossings of the voltage and the current, thereby generating a corresponding electric signal at the output 17 of the time-measurement circuit 14, said signal being proportional to said phase shift.

The outputs 12 and 13 of the respective circuits 8 and 9 for the measurement of the electric voltage and the electric current are in turn connected with the corresponding inputs 20 and 21 of a further multiplier circuit 22 of a traditional type, the output 23 of which is connected with a second input 24 of the previously mentioned multiplier circuit 19.

The purpose of said multiplier circuit 22 is to multiply by one another the electric voltage and current that are detected by the respective measurement circuits 8 and 9, thereby generating at the output 23 of said multiplier circuit an electric signal which is proportional to the product of said multiplication, ie. to the apparent power input to the electric motor 1, said signal being then sent to the corresponding second input 24 of the previously cited multiplier circuit 19.

In this way, owing to the fact that to said first input 18 of the multiplier circuit 19 is applied the electric signal generated by said time measurement circuit 14 and which corresponds, as already indicated, to the shift in phase existing between the electric voltage and the electric current of the electric motor 1, it therefore ensues that said multiplier circuit 19 operates actually to moltiply said phase shift by the apparent power as detected by the multiplier circuit 22 in the afore described way, thereby determining the active or real power input to said electric motor and generating at said output 25 of said multiplier circuit 19 an electrical signal which corresponds to said active power input.

Said output 25 of said multiplier circuit 19 is in turn connected with a first input 26 of an electronic comparator circuit 27 of a traditional type, which is further provided with a second input 28 which is supplied with a pre-selected reference voltage corresponding to the active or real power input to said electric motor 1 when it is rotating at that washing or spin-extraction rpm at which the washload in the drum just undergoes an out-of-balance condition giving rise to a mechanical stress which the structure of the washing machine is still able to safely withstand without suffering any impairment or damage.

Said comparator circuit 27 is further provided with an output 29 which is connected with a first input 30 of a further electronic comparator circuit 31 of a traditional type, the latter being also provided with a second and a third input 32 and 33 that are respectively connected with pre-set, different reference voltages as further described in the following, as well as with an output 34 which is connected, through an electronic motor rpm regulation circuit 35 of a *per sè* known type, with said electric motor 1 which is in turn supplied by the electrical circuit of the washing machine through at least a properly rated load resistor 36.

Said electronic comparator circuit 27 has the task of mutually comparing the afore mentioned reference voltage, which is being applied to its second input 28, with the voltage which is being applied to its first input 26 and corresponds to the active or real power input to the electric motor 1 during its operation, as calculated by said multiplier circuit 19 in the afore described way, in view of gaining the ability of controlling , in the way as it will be further described below, said motor rpm regulation circuit 35, through said comparator circuit 31, according to the actual result of said comparison.

Said comparator circuit 31 is in turn adapted and set to perform the comparison of the voltage of the electrical signal generated at the output 29 of the preceding comparator circuit 27, and resulting from the comparison between the values of the reference and actual power being applied to the inputs 28 and 26 of the comparator circuit 27, with either of the reference voltages being applied to the inputs 32 and 33 of the same comparator circuit 31 and respectively corresponding to a de-

termined critical mechanical stress exceeding the afore cited safe mechanical stress level, which is originated in the washing machine under uneven distribution of the washload in the drum to the extent that it gives rise to an unbalancing moment within pre-set highest allowable values, and to a determined hypercritical mechanical stress exceeding said critical mechanical stress when said unbalancing moment originated by the out-of-balance condition of the washload inside the drum possibly increases to a level above said pre-set highest allowable values.

In this way, as a result of the afore cited comparison the comparator circuit 31 reacts by generating, or failing to generate as the case may be, at its output 34 an electrical signal which enables, or disenables as the case may be, the operation of the electric motor 1 through the motor rpm regulation circuit 35, in the manner that is further described below.

Said motor rpm regulation circuit 35 is in turn set and wired to rotatably drive the electric motor 1 at different pre-set rotational speeds during the various washing cycles performed by the washing machine, and it further is connected. as in usual arrangements, with a tachymetric generator 37, which is rotatably driven by said electric motor 1 and is adapted to generate an electric voltage that is proportional to the actual, instantaneous rotational speed of said electric motor 1, in such a way as to ensure that said motor rpm regulation circuit is constantly in such a position as to rotatably drive the electric motor 1 at exactly the respective rotational speeds that are each time determined according to *per sè* known criteria.

In the case in which the active or real power input to the electric motor 1 is lower than the highest allowable active power input to the same motor, ie. reflecting a condition in which the washload inside the rotating drum of the washing machine is actually distributed in an even, uniform way in the same drum and does therefore not originate any unbalancing moment during the rotation of said drum, the output 29 of said comparator circuit 27 generates an electrical signal with a determined voltage that is applied to said first input 30 of the comparator circuit 31 and that takes on such a level as to be detected as being lower than the reference voltages applied to said second and third Inputs 32 and 33 of this comparator circuit. Under these circumstances, the output 34 of said comparator circuit 31 will therefore generate such an electrical signal as to enable the electric motor 1 to operate and said electric motor 1 will as a consequence be rotatably driven during each washing cycle at the rotational speeds that are determined by said motor rpm regulation circuit 35 accordingly.

In the opposite case, ie. when the active power input to the electric motor 1 possibly rises to the highest possible value that can be reached by the active or real power input to the same motor, ie. reflecting a condition in which the washload inside the rotating drum of the washing machine is actually distributed in an uneven, non-uniform way in the same drum so as to therefore originate an unbalancing moment during the rotation of said drum, the output 29 of said comparator circuit 27 generates an electrical signal with a corresponding voltage that is applied to said first input 30 of said comparator circuit 31. If said unbalancing moment turns out to be lower than or equal to the pre-set highest allowable values at which the washing machine is expected to undergo said critical mechanical stress, in the comparator circuit 31 a comparison is performed of said voltage applied to its first input 30 with said reference voltage applied to its second input 32, and corresponding to said critical mechanical stress level, so as to generate at the output 34 of said comparator circuit a corrective electrical signal which is sent to said motor rpm regulation circuit 35 so as to have the latter decrease the rotational speed of said electric motor 1 accordingly as long as said corrective electrical signal persists, ie. until it is cancelled to indicate that a condition has been restored in which the washload has redistributed evenly in the drum and the out-of-balance condition has therefore been removed.

If on the contrary said unbalancing moment turns out to exceed the pre-set highest allowable values, so that the washing machine is expected to be subjected to said hypercritical mechanical stress level, in the comparator circuit 31 a comparison is performed of said voltage being applied to its first input 30 with said reference voltage being applied to its third input 33, and corresponding to said hypercritical mechanical stress level, so as to generate at the output 34 of said comparator circuit a corrective electrical signal which is sent to said motor rpm regulation circuit 35 so as to have the latter cause the electric motor 1 to stop and subsequently to start again, thereby cancelling said corrective electrical signal and bringing about an even, uniform re-distribution of the washload in the drum so as to remove its disturbing out-of-balance condition.

Said comparator circuit 31 is further adapted to stop and start again said electric motor 1 in the same way and according to the same criteria as described afore, also in the case in which, after a regulation of the rotational speed of said motor, the speed itself would prove too low, ie. reduced to such an extent as to make it impossible to increase it to the high speed rates required for spin-extraction.

It will be appreciated that the measurement and balancing arrangement according to the present invention may also be embodied through the use of a microprocessor 38 integrating all afore cited electronic measurement, multiplier, comparator and rpm regulation circuits 14, 19, 22, 27, 31 and 35, respectively.

Claims

1. Arrangement for measuring and balancing out-of-balance washloads in the rotating drum of a washing machine, in particular a clothes washing machine or a combined clothes washing and drying machine, comprising at least an electric drive motor for rotatably driving said rotating drum, and means of a *per sè* known type, and connected with said motor, to regulate the rotational speed of said motor, **characterized in that** it includes measurement means (2, 3, 14) to measure the phase shift between the electric voltage and the electric current of said drive motor (1), measurement means (8, 9, 22) to measure said electric voltage and said electric current of said drive motor (1), multiplier means (19) adapted to multiply among them said phase shift, said voltage and said current so as to determine the active power input to said drive motor (1), said active power input being proportional to the mechanical stresses placed on said clothes containing drum and therefore to the balanced or unbalanced condition of the same drum, as well as comparison means (27, 31) adapted to govern the rotational speed of said drive motor (1) through said speed regulation means (35) based on the detected level of said active power input to said drive motor (1).

2. Arrangement according to claim 1, **characterized in that** said measurement means to measure the phase shift comprise a first and a second electronic zero-crossing detecting circuits (2, 3) for the sine-wave alternating voltage and current, respectively, of the power supply to said drive motor (1), said circuits having their respective inputs (4, 5) connected with said drive motor (1), and further comprise an electronic time-measurement circuit (14) provided with a first and a second input (15, 16) that are respectively connected with the outputs (6, 7) of said first and said second zero-crossing detecting circuits (2, 3), said electronic time-measurement circuit (14) being adapted to instantaneously calculate the time elapsing from the zero-crossing of the voltage to the zero-crossing of the current as detected by said first and said second zero-crossing detecting circuits (2, 3) and corresponding to said phase shift.

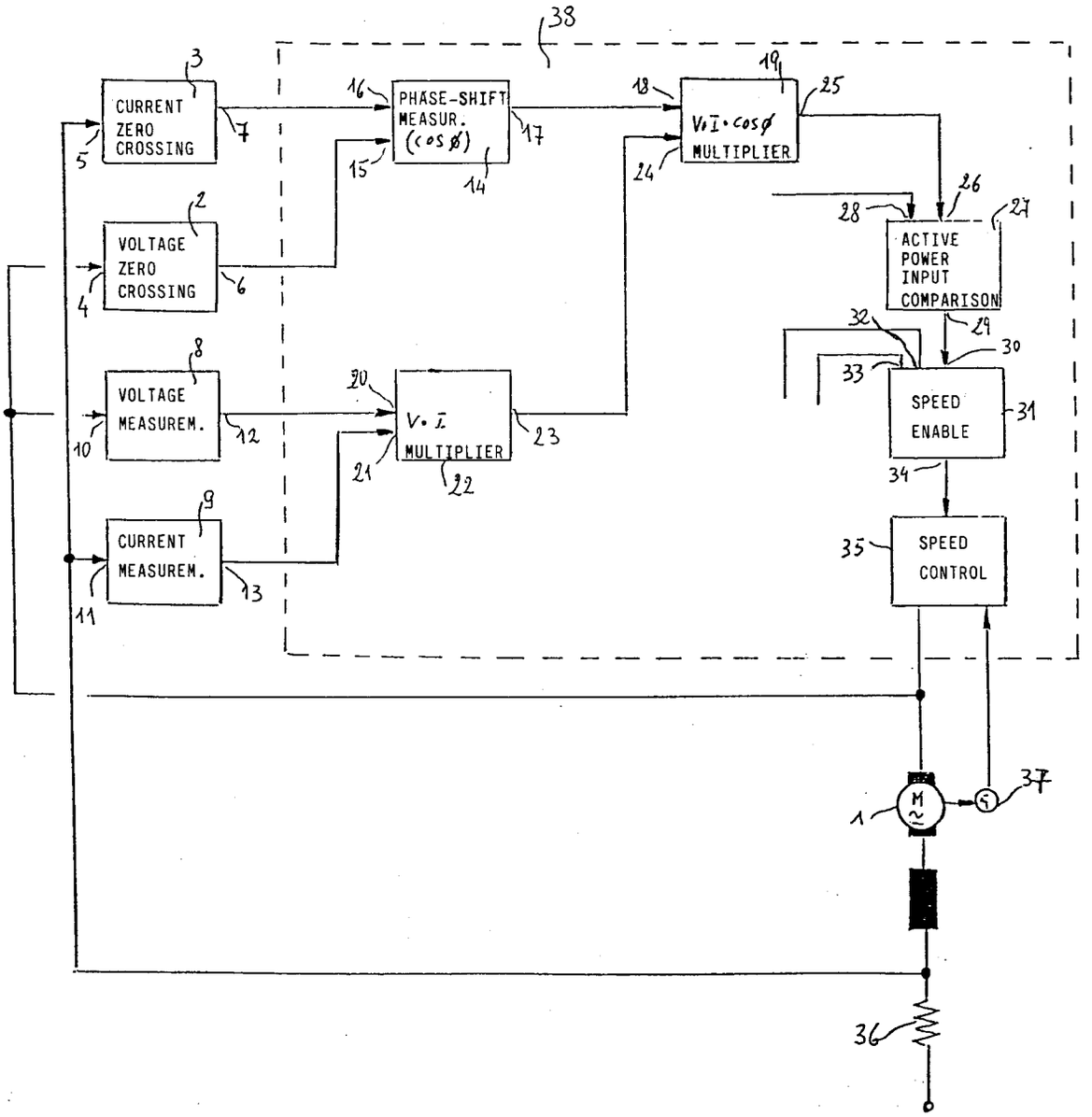
3. Arrangement according to clam 2, **characterized in that** said measurement means to measure said electric voltage and said electric current comprise a first and a second electronic measurement circuit (8, 9) of a *per sè* known type, the respective inputs (10, 11) of which being connected with said drive motor (1), and further comprise a multiplier circuit (22) of a *per sè* known type provided with a first and a second input (20, 21) respectively connected with the corresponding outputs (12, 13) of said first and said second measurement circuits (8, 9), said multiplier circuit being adapted to multiply by each other the values of said voltage and said current as detected by said first and said second measurement circuits (8, 9), respectively, so as to determine the apparent power input to said drive motor (1).

4. Arrangement according to claim 3, **characterized in that** said multiplier means comprise a multiplier circuit (19) of a *per sè* known type, provided with a first and a second input (18, 24) respectively connected with the corresponding outputs (17, 23) of said electronic time-measurement circuit (14) and said multiplier circuit (22), said multiplier circuit (19) being adapted to multiply said phase shift by said apparent power input so as to obtain the active power input to said drive motor (1).

5. Arrangement according to claim 4, **characterized in that** said comparison means comprise a first and a second electronic comparator circuit (27, 31) of a *per sè* known type.

6. Arrangement according to claim 5, **characterized in that** said first electronic comparator circuit (27) is provided with a first input (26) connected with the output (25) of said multiplier circuit (19), and a second input (28) connected with a pre-set reference voltage corresponding to the highest allowable active power input to said drive motor (1), at which an out-of-balance condition of the washload in said clothes containing drum arises, said comparator circuit (27) being further provided with an output (29) adapted to enable or disenable the operation of said drive motor (1) through said motor rpm regulation circuit (35) based on the comparison of the voltage being applied to said first input (26), and corresponding to the active power input to said drive motor (1), and the reference voltage being applied to said second input (28).

7. Arrangement according to claim 6, **characterized in that** said second electronic comparator circuit (31) is provided with a first input (30) connected with the output (29) of said first electronic comparator circuit (27), and is further provided with a second and a third input (32, 33) connected with a first and a second pre-set reference voltage differing from each other and corresponding to two different levels of unbalance of the washload in said rotating drum, said second comparator circuit (31) being provided with an output (34) adapted to control said drive motor (1), when disenabled by said first comparator circuit (27), through said motor rpm regulation circuit (35) based on the comparison of the voltage being applied to said first input (30) and either of the reference voltages being applied to said second and said third inputs (32, 33).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V·I MULTIPLIER
SPEED ENABLE
CURRENT MEASUREM.
SPEED CONTROL
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EUROPEAN SEARCH REPORT

Application Number

EP 92 10 4458

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 313 339 (AMERICAN LAUNDRY MACHINERY INC.) * column 4, line 23 - column 5, line 13 *	1,6	D06F37/20
A	US-A-2 917 175 (J.W.TOMA) * column 7, line 18 - column 10, line 52 *	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 JULY 1992	GOODALL C.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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