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(54) Method for verifying the laundry load conditions in a laundry washing and/or drying machine, and machine which implements such method

(57) It is described a method for verifying the laundry load conditions in a washing and/or drying machine, comprising a drum containing the laundry, rotated by a motor (M), wherein a high spin speed (MC) is gradually reached during an operating phase ; the main characteristics of said method consists in the fact that before reaching said high spin speed (MC) the load entity is verified and if the load exceeds a predetermined mass, also the load balancing conditions are verified, and that, in order to avoid any risks for the mechanical structure of the machine, the maximum spin speed (1400 rpm) is inhibited if a load higher than said predetermined mass and an out-of-balance condition of said load are detected.

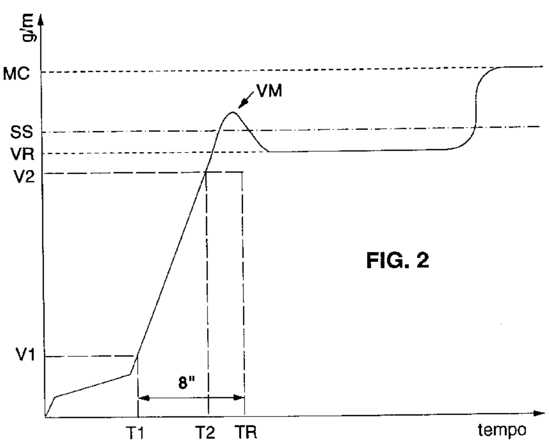

FIG. 2

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The present invention refers to a method for verifying the laundry load conditions in a washing and/or drying machine and to a machine using said method.

It is known that washing and/or drying machines can include in their washing program one or more spinning cycles, i.e. phases of drum rotation gradually bringing the drum to a much higher speed than that normally foreseen during the actual washing cycles; in some types of machine, the drum can reach a speed up to 1100 rpm.

However, due to special requirements and applications, an increasing interest has recently developed for spin speeds in the order of 1400 rpm, i.e. by far higher than the one mentioned above. In view of this requirement, manufacturers have to face the problem of adapting their present production of washing machines reaching 1100 rpm speed to the new requirements, i.e. 1400 rpm speed.

If on one hand the motor and its relevant control system can be adapted in a relatively simple way to reach 1400 rpm, on the other hand this is rather more complex from a mechanical standpoint. As a matter of fact, it is clear that the mechanical stresses the machine is submitted to at 1100 rpm are by far lower than the ones a machine with the same structure has to withstand when reaching 1400 rpm, specially under severe and/or out-of-balance load conditions. In particular, to the purpose of this description a severe load defines a quantity of laundry in the drum approaching the maximum quantity of laundry the machine can wash, whereas an out-of-balance load defines an irregular distribution of the laundry inside the drum, which may cause significant oscillations and mechanical damages to the machine during high speed rotation.

By way of example, according to practical tests carried out on conventional structured machines with 5-kg drum capacity, it has been ascertained that a rotating speed over 1100 rpm may cause damages to the drum containing the laundry; drum failures typically occur already at 1200 rpm speed and 500 to 800 gram unbalance with loads over 80% the drum capacity (i.e. over 4 kg).

Said problem can obviously be solved by changing the mechanical structure of the machine, e.g.. by strengthening the drums and relevant hubs, but this would involve very high investments for the remaking of complete production lines.

Accordingly, it is the object of the present invention to provide a control method for a machine of the above type, that allows to solve the above problem in a low-cost manner and with no substantial changes to the mechanical structure of the machine; accordingly, it is the main object of the present invention to indicate a control method through which it is possible to verify whether the laundry load contained in the drum of a washing machine exceeds a predetermined mass and is out of balance, thus allowing the machine drum to reach speeds over 1100 rpm only if there are no such dangerous conditions for the mechanical structure of the machine. Therefore, it is the object of the present invention to let a normally structured machine reach high spin speeds only under balanced load conditions, i.e. without any risk of mechanical failures.

To this purpose, it is the object of the present invention to provide a method for controlling the load in a washing and/or drying machine and a machine implementing such a method, incorporating the characteristics of the annexed claims.

Further characteristics and advantages of the present invention will be apparent from the following description and annexed drawings, which are supplied only as an explanatory and non limiting example, wherein :

- Fig. 1 shows a simplified block diagram of a section of the machine control circuit implementing the method according to the present invention;
- Figs. 2 to 5 show graphically some explanatory curves of the rotating speed analysis of the machine shown in Fig. 1, based on the method according to the present invention;
- Fig. 6 shows the block diagram of a section of the control logic circuit of the machine shown in Fig. 1, implementing the method according to the present invention.
- Fig. 7 shows the block diagram of another section of the control logic circuit of the machine shown in Fig. 1, implementing the method according to the present invention.

The present invention will be further described with reference to a laundry washing machine equipped with all known elements for its operation; in particular said machine is assumed to have a standard mechanical structure, i.e. reaching a spin speed around 1100 rpm and a 5 kg capacity drum; however, said machine is equipped with a motor having a control system, in particular an electronic digital control system, which allows the drum to reach a rotating speed up to 1400 rpm.

Fig. 1 shows the simplified block diagram of a section of the machine control circuit implementing the method according to the present invention. In this figure M is the washing-machine motor generating the drum rotation in a known manner, by means of belts and pulleys; D is an electronic digital control module for the motor M; MP is an electronic microcontroller comprising a counter or internal clock, indicated with CLOCK, with associated permanent memory means, named ROM, and read-and-write memory means named RAM; in the embodiment shown by way of example said microcontroller MP is the one already available in the digital module D for motor M control.

In the ROM memory, the programs for handling the motor M in the various phases are codified, according to the different machine cycles, which can be selected by the user through proper control elements (e.g. electromechanical timer and/or selection keys). Module D controls motor M operation - in particular through microcontroller MP and associated ROM memory - based on the signals received by the above control elements and other machine components, such as a pressure switch, control keys, a speedometer dynamo, etc.

T indicates a device capable of generating a signal representative of the rotating speed reached by the drum during machine operation, and consequently by motor M; in the figure T is shown as a speedometer dynamo but other similar devices can obviously be used for the purpose of measuring the motor and consequently the drum rotating speed (e.g. a magnetic reed type sensor).

According to the invention, a suitable program in the ROM permanent memory of the microcontroller MP allows the microcontroller itself to decide whether the laundry load and/or its eventual out-of-balance extent should be considered dangerous for the mechanical structure of the machine in view of the spin speed to be reached; such decisions are taken by the microcontroller MP based on the data representative of the drum speed detected by speedometer T, and on the time required to reach given speed thresholds, detected by the speedometer T and the counter CLOCK.

In particular, according to the present invention, the control system of the motor M verifies during the high speed spinning phase and before reaching 1200 rpm (assumed as the threshold of a likely critical speed), whether the laundry load is either severe or out of balance. As mentioned above, to the purpose of the present invention severe load defines a quantity of laundry in the drum assumed to be potentially dangerous in view of an out-of-balance condition, e.g. over 80% drum capacity (over 4 kg in the example); whereas out-of-balance load defines an irregular weight arrangement of the laundry inside the drum, which could in fact getting the whole machine "out of balance" during the spinning cycles: in the embodiment shown by way of example this situation is assumed to be a critical one in case of 500 to 800 gram load unbalance.

According to the present invention, since motor M and drum characteristics are known, the entity of the laundry load is determined by measuring the time required to reach 900 rpm speed (hereafter called V2) from 150 rpm speed (hereafter called V1); said measurements is made by microcontroller MP through speedometer T and the counter CLOCK.

More specifically, it has been ascertained, based on practical tests, that if the time required for speed V1 to reach speed V2 is below a predetermined time TR of eight seconds, the laundry load is assumed not to be a severe one and consequently a non critical one: in this instance, after measuring speed V2, the microcontroller MP can give release to reach a maximum spinning speed of 1400 rpm apart from an eventual unbalance. Viceversa, if the time interval from V1 to V2 is higher than the predetermined time TR, then the load is a severe one, and potentially critical for the mechanical structure of the machine due to unbalance.

Therefore, if the laundry load is detected to be a severe one, its out-of-balance condition will be verified according to the invention; if no unbalance is detected (or in case of a fair non-critical unbalance, i.e. such not to jeopardize the machine from a mechanical standpoint), then the spinning speed can reach 1400 rpm.

Viceversa, if an out-of-balance condition over the established limit is detected, then microprocessor MP will provide for the necessary correction and decrease the maximum spinning speed to a lower value, e.g. only 1000 rpm, which is low enough to avoid jeopardizing the machine from a mechanical standpoint.

According to the invention, unbalance is detected by verifying the degree of the so-called over-elongation, i.e. a laundry load inertia entraining the drum at a higher rotating speed (VM) than a predetermined speed (VR). Also in this case, according to practical tests, it has been ascertained that the over-elongation entity is representative of the laundry distribution quality inside the drum.

According to the present invention, the verification of the over-elongation and consequently of the laundry distribution inside the drum, takes place as follows.

During speed rise, the microcontroller MP detects the speed reached by the motor M through the speedometer T, starting from 150 rpm for a predetermined time measured by the counter CLOCK (e.g. 40 secs); maximum speed VM reached during this time is temporarily stored in the RAM memory associated with the microcontroller MP (typically, the maximum speed is reached about 10-15 secs after exceeding 150 rpm).

Said maximum speed VM, stored in the volatile RAM memory, is compared with the predetermined speed VR in the permanent ROM memory of the microcontroller MP; the predetermined speed VR can be for example equal to 1000 rpm.

The difference between the predetermined speed VR and the detected maximum speed VM indicates the over-elongation entity. As mentioned, practical tests have indicated that within certain limits, the over-elongation is higher under very good load balance conditions; viceversa, no over-elongation or just a minimum over-elongation or the detection of a speed VM lower than the speed VR within predetermined time (40 secs) indicates an out-of-balance laundry load: as a matter of fact, it is evident how at high speeds an irregular laundry distribution in the drum may determine a braking effect.

Therefore, according to the invention, if the time from V1 to V2 is higher than TR (8 secs), the microcontroller MP verifies the presence of a predetermined over-elongation value, calculating the difference between VM and VR; if over-elongation is lower than a predetermined value, or if there is no over-elongation, then the microcontroller itself assumes an out-of-balance load condition: this means that there is a condition of severe and out-of-balance load, i.e. surely a critical and dangerous condition such to cause drum failures or damages to the machine structure; in this case the final spin speed is lowered to 1000 rpm, i.e. a value low enough not to jeopardize the machine from a mechanical standpoint. On the contrary, if over-elongation is higher than a predetermined value representative of a good load balance, the microcontroller MP will enable 1400 rpm final spin speed since due to its correct balance there is no mechanical risk for the machine also in the event of a severe load.

Figs. 2-5 show by way of example some curves representative of the analysis of the rotating speed of the machine motor according to the method object of the present invention. In said graphs the axis of the abscissas indicates time, whereas the axis of the ordinates indicates the value of the rotating speed of the drum and, consequently, of the washing-machine motor.

The graph in Fig. 2 shows an ideal operating condition of the machine according to the present invention. As it can be noted, in fact, in this case time T1-T2 required from speed V1 (150 rpm) to V2 (900 rpm) is below 8 secs, i.e. below the predetermined time TR, indicating the presence of a non severe load, so that the machine is enabled to reach its maximum spin speed MC (1400 rpm). In any case, the graph also indicates an over-elongation, since the maximum speed VM that has been reached, e.g. 1080 rpm, is higher than the predetermined 1000 rpm speed VR. Such an over-elongation of 80 rpm - which is higher than a predetermined threshold SS - indicates a balanced load, so that Fig. 2 shows a situation under ideal load conditions.

The graph in Fig. 3 also shows a very good operating condition of the machine according to the present invention. As it can be seen, in this case-time T1-T2 required from speed V1 to speed V2 is higher than 8 secs, i.e. higher than TR, indicating a severe load condition; therefore the microcontroller MP has to verify unbalance through the measurement of over-elongation. As it can be seen from the graph in Fig. 3, such an over-elongation is due to the fact that the maximum speed VM is higher than the predetermined speed VR. Such an over-elongation higher than the predetermined threshold SS indicates a good balanced load: thus, the machine has a severe but good balanced load and can be enabled to reach its maximum spin speed MC without any risk from a mechanical standpoint.

The graph in Fig. 4 indicates a non ideal but still acceptable operating condition of the machine according to the present invention. As it can be seen, time T1-T2 required from speed V1 to speed V2 is lower than TR, indicating a non severe load; thus, the machine is enabled to reach 1400 rpm spin speed. The graph also shows an over-elongation under threshold SS (as it can be seen the maximum speed VM is slightly over the predetermined speed VR). Such a minimum over-elongation indicates an out-of-balance load; however, such an out-of-balance but non severe load condition is not critical for the machine mechanical structure, so that the motor can reach 1400 rpm spin speed (MC); operating vibrations are acceptable because they are not dangerous for the machine mechanical structure.

Finally, the graph in Fig. 5 shows a non acceptable operating condition of the machine, according to the present invention. As it can be seen, time T1-T2 required from speed V1 to reach speed V2 is higher than TR, indicating a severe load; in this case the out-of-balance load needs to be verified by measuring its over-elongation. According to the graph in Fig. 5 there is a minimum over-elongation, below the predetermined threshold SS, since the maximum speed VM reached by the motor is slightly higher than the predetermined speed VR. This lack of over-elongation indicates as said an out-of-balance load, so that the situation shown in Fig. 5 is assumed highly critical for the machine mechanics due to the presence of a sever out-of-balance load; therefore the control system will decrease the spin speed to a predetermined value below MC, which is low enough not to jeopardize the machine from a mechanical standpoint.

Always by way of example, Fig. 6 shows a block diagram of a section of the logic circuit for the machine shown in Fig. 1 and in particular a program, by way of example, contained in the microprocessor MP for the implementation of the method according to the invention.

In this program block 100 is the starting block yielding control to block 101, in line with the start of a gradual spinning phase reaching final 1400 rpm speed; block 101 transfers control to block 102, which is a test block; said block 102 measures the drum rotating speed; if said speed reaches 150 rpm (V1) control is transferred to the subsequent block 103; in the negative, control returns to block 102 itself.

Block 103 starts counting time T (point T1) and yields control to the subsequent block 104, which is a test block.

Block 104 takes a new measurement of the drum rotating speed; if said speed reaches 900 rpm (V2), then control goes on to the subsequent block 105; in the negative, it returns to block 104.

Block 105 stops time T count (point T2) and transfers control to the subsequent block 106; block 106 is a test block comparing the time T (or if preferred T2-T1 difference) with the stored time TR equal to 8 secs; if the time T (or T1-T2 difference) is below TR, then the control goes over to block 107; block 107 enables 1400 rpm spin and at the end of it control goes over to block 108, which is the end-of-operation block.

If time T (or T1-T2 difference) on block 106 is higher than TR, control is yielded to block 109, which is a test block and verifies the unbalance by controlling over-elongation as described above; if there is no out-of-balance condition, control is yielded to block 107 to enable 1400 rpm spin, then the program ends on block 108. If, on the contrary, there is an out-of-balance condition, control goes over to subsequent block 110.

Block 110 enables a decreased spin sequence, e.g. 1000 rpm, i.e. a speed low enough to avoid jeopardizing the machine from a mechanical standpoint.

The program will then end on block 108. Fig. 7 shows the block diagram of a logic circuit section controlling the machine shown in Fig. 1, related to out-of-balance control, i.e. the phase substantially occurring on block 109 of the previous figure.

In said Fig. 7 block 201 indicates program start (which substantially coincides with block 101 of Fig. 6); control is yielded to block 202, which is a test block; said block 202 measures the drum rotating speed, if the speed reaches 150 rpm control goes over to subsequent block 203, whereas in the negative it goes back to block 202.

Block 203 starts counting a time TT and yields control to subsequent block 204; block 204 measures the drum rotating speed and stores the detected speed value in the RAM memory of the microcontroller MP.

Control is then yielded to block 205, which verifies if time TT has reached 40 secs; in the affirmative, control goes over to subsequent block 206, whereas in the negative it will return to block 204 for a new measurement of the drum rotating speed; if the new speed value is higher than the previously stored one, then the new value will replace the previously stored one in the RAM memory. Practically, blocks 204 and 205 detect drum speed on a cyclic base to reach the maximum speed value VM within the predetermined 40 secs stored in RAM memory .

Block 206 is a block comparing the maximum speed value VM stored in RAM memory with a maximum reference speed value VR for the predetermined 40 secs. If speed VM is higher than speed VR there will be an over-elongation indicating a balanced load condition, provided it exceeds a predetermined threshold (SS); on the contrary, if over-elongation is below the predetermined threshold (or no over-elongation) it means an out-of-balance load. Thus, according to the condition detected on block 206, the control system will either enable or inhibit 1400 rpm spin (practically as described with reference to blocks 109-107-108 or 109-110-108 of Fig. 6).

The characteristics of the method object of the present invention as well as its advantages are apparent from the given description.

Exhaustive testing has indicated how the present invention allows achievement of the intended purposes, i.e. a simple and low-cost method for a washing and/or drying machine to operate at high spin speed through a simple test method of the laundry load conditions, without any substantial changes to the machine mechanical structure and no risks for it.

It is obvious that many changes, adaptations, integrations and modifications - without prejudice to the protective claims of the present invention - are possible to the method and the machine described by way of non limiting example, without departing from the novelty spirit of the innovative solution, and it is also clear that in practical actuation of the invention the components may often differ in form and size from the ones described and may be replaced with technical equivalent elements.

As an example, it is evident that, upon detecting any critical conditions as shown in Fig. 5, the control system may be designed to incorporate a correction phase for the out-of-balance condition instead of enabling a decreased spin speed: this can be easily achieved through the program stored in the ROM memory associated with microcontroller MP; e.g. if a severe out-of-balance condition is detected, the microcontroller MP can stop the speed increase run, execute a re-balancing load step and attempt a new spinning cycle to reach the maximum 1400 rpm speed; this could take place even several times.

The same may be foreseen to solve non-critical conditions, however troublesome as shown in Fig. 4.

Moreover, it is also clear that the method used to detect unbalance as described herein - based on over-elongation measurement - may also be profitably used separately from time measurement from 150 to 900 rpm. Storage possibility for microcontroller MP of a considerable quantity of data based on experience in an extremely compact format in ROM permanent memory, which can be processed even using low-cost devices (4 and 8 bit limited process capacity microcontrollers), allows development of the over-elongation based method also for an exact determination of out-of-balance extent. Thus, it is also obvious that other techniques are available for automatic load verification, i.e. the quantity of laundry in the washing-machine drum; reference is made e.g. to the Italian Patent Application for Industrial Invention no. TO93A000798 in the name of the same Applicant, describing and commenting several techniques for automatic load information, among which: method of the analysis of the duration time and number of the fluid level restorations in the washing tub, controlled by a first-level pressure switch; power measurement method (associated with torque) absorbed by the washing-machine motor to start the drum containing the laundry; measurement method for the energy required to switch over from a given inertial state as defined by a determined speed of the washing-machine drum to another inertial state, defined by a different drum speed.

Claims

1. A method for verifying the laundry load conditions in a washing and/or drying machine comprising a drum containing the laundry, rotated by a motor (M), wherein a high spin speed (MC) is gradually reached during an operation phase, characterized in that, before reaching said high spin speed (MC), the load entity is verified, and if the load exceeds a predetermined mass, also the load balance conditions are verified, and that, in order to avoid any risks for the machine mechanical structure, the achievement of the maximum spin speed (1400 rpm) is inhibited if a load exceeding said predetermined mass and an out-of-balance condition are detected.

2. A method according to Claim 1, characterized in that the laundry load entity is determined by comparing against a reference value (TR) the time (T2-T1) required for passing from a first predetermined speed (V1) to a second predetermined speed (V2) during the gradual spin speed increase.

3. A method, according to the previous Claim, characterized in that when said time (T2-T1) is higher than the reference value (TR), then the laundry load is assumed to be a severe one, i.e. higher than said predetermined mass.

4. A method according to Claim 1, characterized in that the load balance conditions are verified by testing the over-elongation, i.e. the laundry load inertia entraining the drum at a rotating speed (VM) higher than a predetermined theoretic speed threshold (VR).

5. A method according to the previous Claim, characterized in that the load balance conditions are verified by measuring the maximum speed (VM) reached by the motor (M) or by the machine drum during a predetermined time interval (40 secs) and comparing said maximum speed (VM) with a predetermined maximum theoric speed (VR) for said time interval, whereby the over-elongation extent is obtained by the difference between the predetermined maximum theoric speed (VR) and the measured maximum speed (VM).

6. A method according to Claims 4 or 5, characterized in that a balanced load condition is gathered when there is an over-elongation exceeding a predetermined threshold (SS) and an out-of-balance load condition is gathered when there is an over-elongation below a predetermined threshold (SS).

7. A method according to one or more of the previous Claims, characterized in that when the load is higher than said predetermined mass and an out-of-balance condition of said higher load exceeds a predetermined threshold, then the achievement of the maximum spin speed (1400 rpm) is inhibited and/or corrective actions are foreseen, such as at least an attempt to restore the load balance or the spinning at a lower speed (1000 rpm), which is low enough not to jeopardize the machine from a mechanical standpoint.

8. A method according to one or more of the previous Claims, characterized in that when a non severe load and a balanced condition of said load is detected, the motor (M) is enabled to reach the maximum spin speed (1400 rpm).

9. A method according to one or more of the previous Claims, characterized in that when a non severe load and an unbalanced condition of said load is detected, the motor (M) is equally enabled to reach the maximum spin speed (1400 rpm).

10. A method according to Claim 1, characterized in that the laundry load entity is determined by
    - the analysis of the duration time and the number of the fluid level restorations in the washing tub, realized under control of a first-level pressure switch, and/or
    - the measurement of the power absorbed by the machine motor to start the drum containing the laundry to be washed, and/or
    - the measurement of the power required for passing from a first inertial state, being defined by a determined machine drum speed, to a second inertial state, being defined by a different speed of same drum.

11. A method for verifying the laundry load balance conditions in a washing machine, characterized in that it provides for the verification of the over-elongation, i.e. of the laundry load inertia entraining the drum at a rotation speed (VM) higher than a predetermined theoretic speed threshold (VR), the verification of the load balance conditions being realized by measuring the maximum speed (VM) reached by the motor (M) or by the machine

drum, in a predetermined time interval (40 secs) and by comparing said maximum speed (VM) with a predetermined maximum theoretic speed (VR) for said time interval, where the difference between the predetermined maximum theoretic speed (VR) and the maximum detected speed (VM) gives the over-elongation entity, the load balance condition being gathered from an over-elongation exceeding a predetermined threshold (SS) and the load out-of-balance condition being gathered from an over-elongation below a predetermined threshold (SS).

12. A method for determining the laundry load entity in a washing machine comprising a drum rotated by a motor (M) and a device (T) capable of generating a signal representative of the speed reached by the motor (M) or by the drum, characterized in that, during the gradual spin speed increase, the time (T2-T1) required for passing from a first predetermined motor (M) or drum rotation speed (V1) to a second predetermined speed (V2) is measured and the laundry load entity is determined by comparing said time required for said first speed to reach said second speed (V1,V2) with a reference time (TR).

13. Laundry washing and/or drying machine, comprising all known operation elements, including a drum rotated by a motor (M), a device (T) generating a signal representative of the achieved motor (M) or drum speed and an electronic control device (D,MP), which implements the methods according to one or more of the previous claims.

14. Laundry washing and/or drying machine according to the previous Claim, characterized in that said electronic control device comprises a microcontroller (MP) to which permanent memory means (ROM) and read-and-write memory means (RAM) are associated.

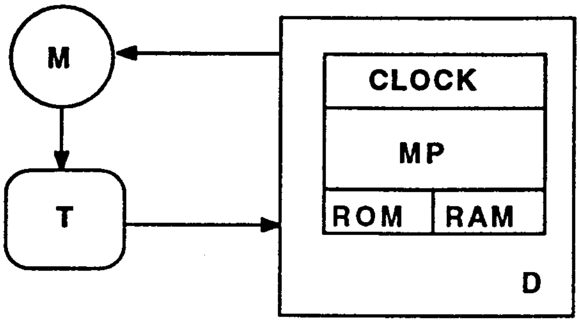

FIG. 1

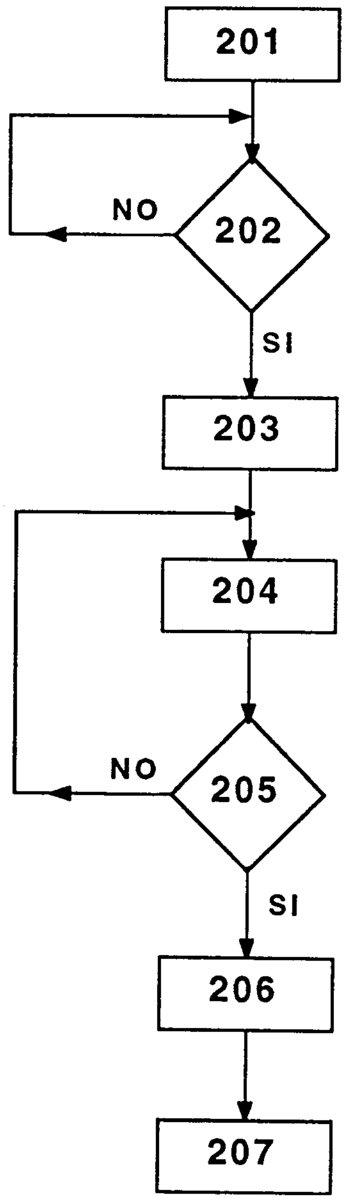

FIG. 7

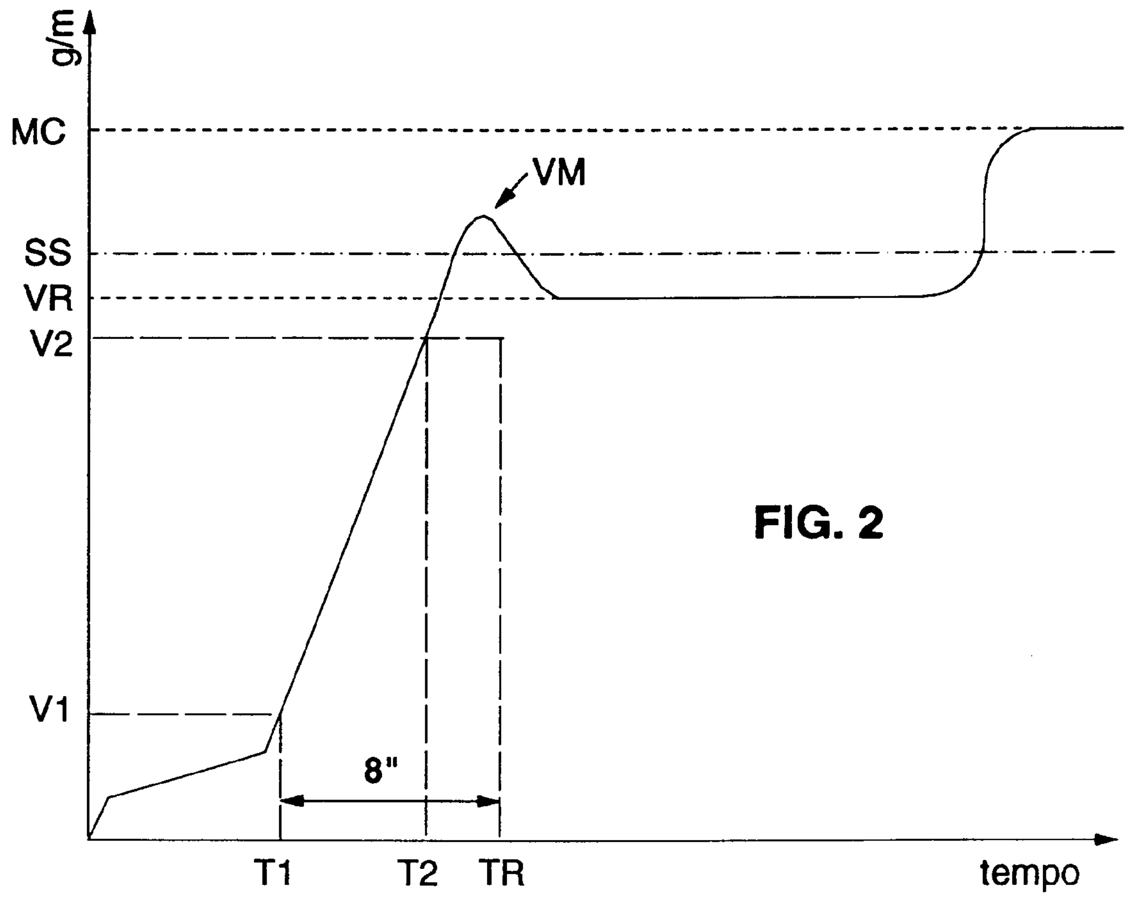
g/m
MC
VM
SS
VR
V2
V1
8"
T1
T2
TR
tempo

FIG. 2

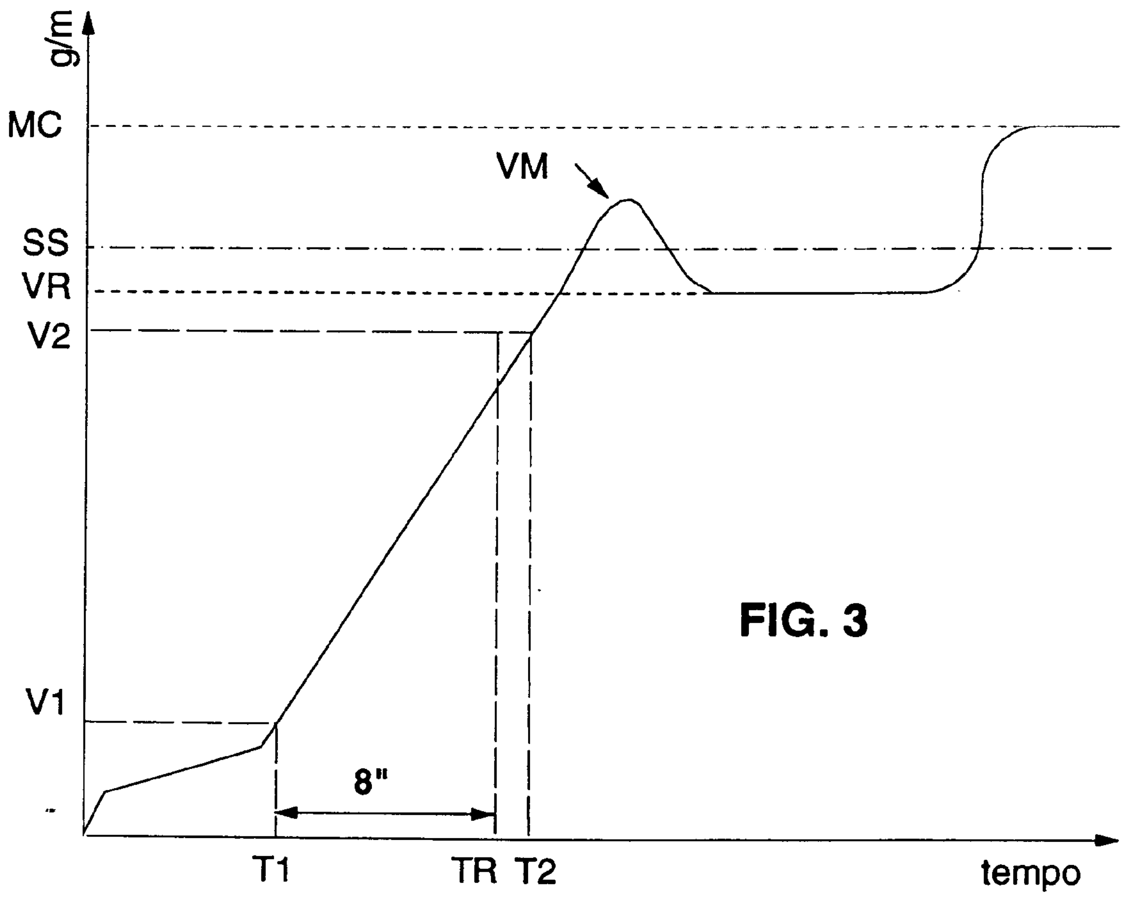
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FIG. 3

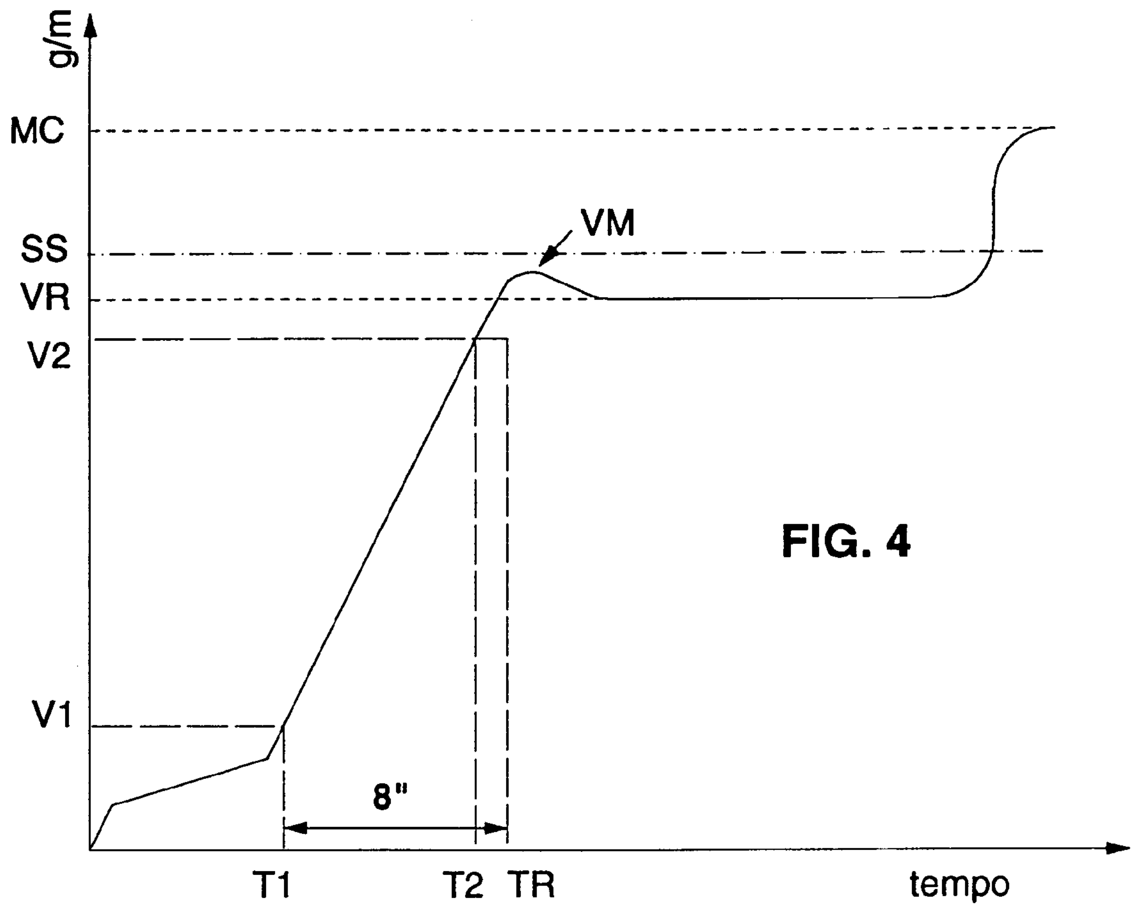
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FIG. 4

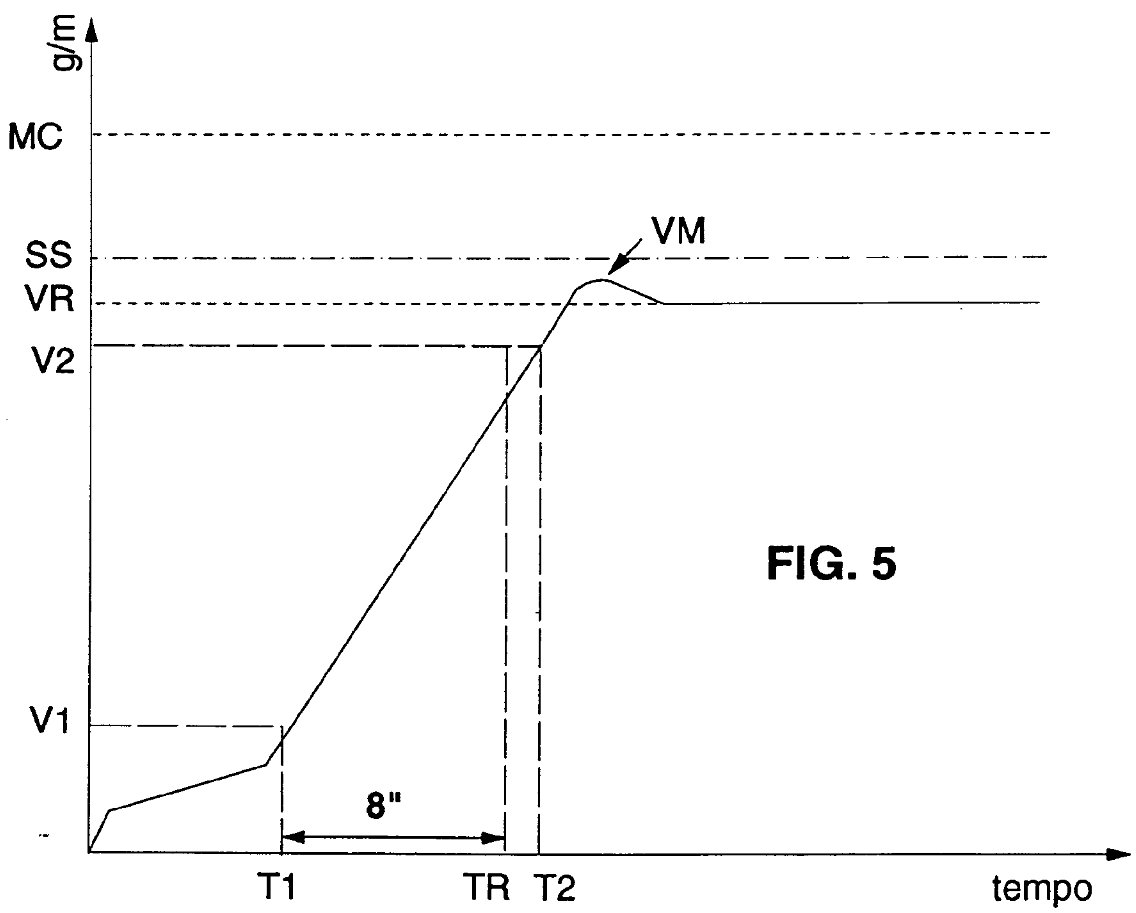
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FIG. 5

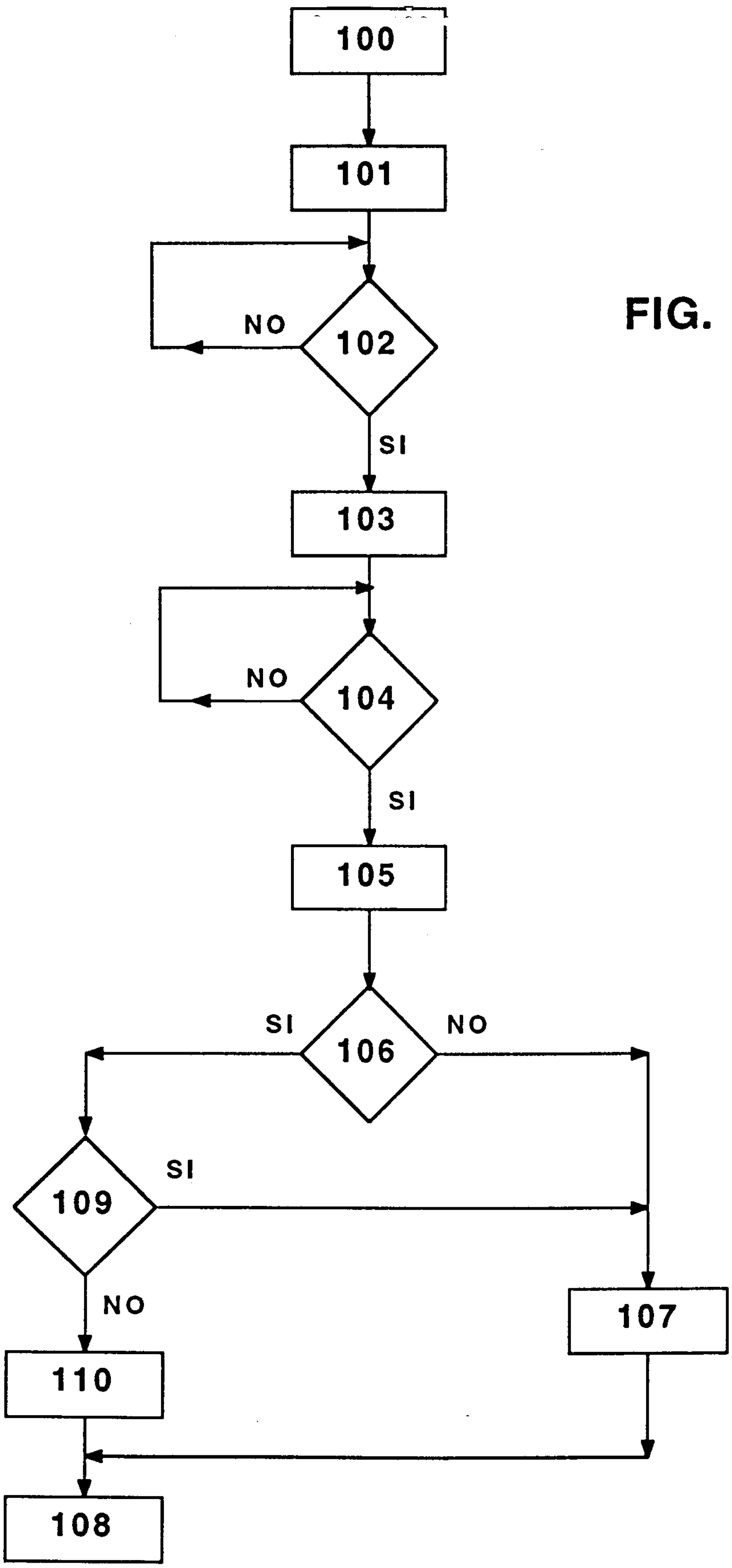

FIG. 6