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(54) **Weft-brake control apparatus for weaving looms**

(57) A weft-brake control apparatus for weaving looms includes a weft feeder (AT) provided with a stationary cylinder (TA) on which are wound loops of yarn forming a weft reserve (RT), and with a weft-stopping member (PTF) adapted to release predetermined quantities of yarn (F) per each insertion cycle. The apparatus also comprises a loom (TE) downstream of the weft feeder (AT), and a weft-brake (FE) arranged between the cylinder (TA) and the loom (TE) and controlled by a

control loop comprising a subtracting node (1) adapted to receive desired angular position signals (Pos_{ref}) and measured position signals of the motor (M) of the brake, and to generate a position error signal ($Perr$) from their difference. The measured position signal (Pos_{mis}) is calculated by a position estimator (SP) from a signal proportional to the current across the motor (I_{mis}) and a signal proportional to the voltage on the power leads ($V(t)$) of the motor.

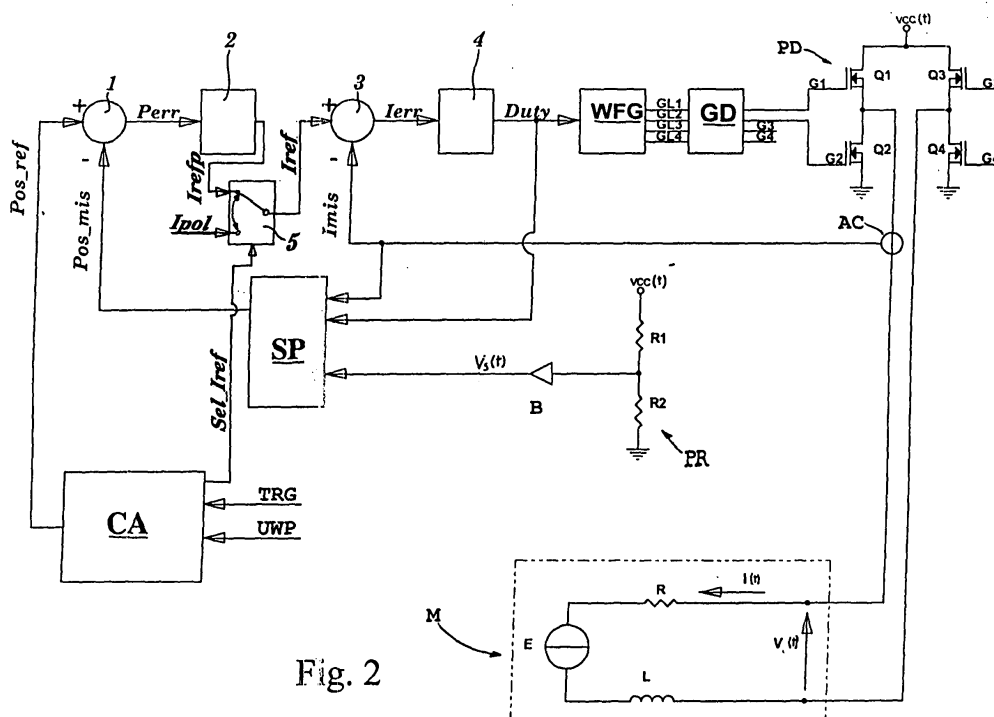


Fig. 2

Description

[0001] The present invention relates to a weft-brake control apparatus for weaving looms, particularly fluid-jet looms.

[0002] A generic weaving loom includes a weft feeder comprising a motor housing and a stationary cylinder on which a swivel arm, which is keyed to a hollow driving shaft of a motor, winds a plurality of yarn loops forming a weft reserve. Fluid-jet looms (air, water) are provided with a pre-measurer comprising an electro-operated weft-stopping member capable of releasing predetermined quantities of yarn from the reserve, on request from the loom. To this purpose, the loom generates a request signal which exactly enables the insertion at a desired angular position (usually when the reed is opened). Downstream of the cylinder is arranged a photoelectric cell adapted to measure the quantity of yarn unwinding from the cylinder by generating one pulse per each unwound loop. When a predetermined quantity of yarn has been released, the insertion is stopped by shutting said weft-stopping member.

[0003] Because of the high insertion rates of the modern weaving looms, a braking device is arranged between the pre-measurer and the loom in order to slow down the weft speed before the weft-stopping member abruptly stops the weft at the end of the insertion, thereby preventing any break of the yarn and enabling higher insertion rates. A known weft-brake comprises at least a pair of stationary, coaxial yarn-guide eyelets through which the yarn runs. The yarn follows a rectilinear path between the eyelets. A U-shaped braking member is arranged between the eyelets at right angle to their axis and, during braking, it is adapted to engage the yarn in the free lengths between the eyelets. To this purpose, the braking member is keyed at right angle to the driving spindle of a rotary motor which, when being operated, causes the braking member to be rotated. The U-shaped braking member, by deviating the yarn from its rectilinear path, causes it to be braked by friction. The angular displacement of the U-shaped braking member is delimited by two limit stops.

[0004] The braking force depends on the deviation angle of the yarn, which is controlled by a position sensor which generates a signal of the angular position of the driving spindle of the braking device. A controller of the weft feeder receives the request signal from the loom and the pulses from the photoelectric cell downstream of the cylinder, and processes them to generate a desired angular position, which continuously changes over time and is followed by a current/position control loop system.

[0005] Consequently, the braking apparatus is very sophisticated, and the need for a reduction of its manufacturing costs and maintenance costs, as well as of the weight and sizes of its parts, drives the operators in this field to seek a simplification of its structure.

[0006] Accordingly, a main object of the present invention is to provide a weft-brake control apparatus which is easier to be manufactured and which does not require said position sensor, and by which the position signal can be accurately determined.

[0007] The above object and other aims and advantages, which will better appear below, are achieved by the control apparatus having the features recited in claim 1, while the dependent claims state other advantageous features of the invention.

[0008] The invention will be now described in more detail with reference to a preferred, non-exclusive embodiment, which is shown by way of non limiting example in the attached drawings, wherein:

Fig. 1 diagrammatically shows a weaving loom with a weft-brake control apparatus according to the prior art;

Fig. 2 diagrammatically shows a weft-brake control apparatus according to this invention;

Fig. 3 is a time diagram showing the signals processed by the control apparatus according to the invention.

[0009] With initial reference to Fig. 1, a generic fluid-jet weaving loom includes a weft feeder AT comprising a motor housing MO and a stationary cylinder TA onto which a swivel arm BR, which is keyed to a hollow driving shaft operated by a motor, winds a plurality of loops of yarn F forming a weft reserve RT. The loom is provided with a pre-measurer comprising an electro-operated weft-stopping member PTF capable of releasing predetermined quantities of yarn F from the reserve RT, on request of loom TE. To this purpose, the loom generates a request signal TRG which exactly enables the insertion at a desired angular position (usually at the opening of the reed). A photoelectric cell UWPS is arranged downstream of the stationary cylinder TA and is adapted to measure the quantity of yarn Y unwinding from the cylinder by generating a pulse UWP per each unwound loop. When a predetermined quantity of yarn has been released, the insertion is stopped by shutting said weft-stopping member PTF.

[0010] A weft-brake FE is arranged between the pre-measurer and loom TE, and is adapted to slow down the weft speed before weft-stopping member PTF abruptly stops the weft at the end of the insertion. Such weft-brake FE comprises a pair of stationary, coaxial yarn-guide eyelets, respectively an inlet eyelet OI and an outlet eyelet OU, through which the yarn F runs. The yarn follows a rectilinear path between the eyelets. A U-shaped braking rod AF is arranged between eyelets OI, OU at right angle to their axis and, during braking, it is operated to engage the yarn in the free

length between the eyelets. To this purpose, braking rod AF is keyed at right angle to the spindle of a rotary motor M which, when being operated, causes the rod to be rotated. Braking rod AF, by deviating the yarn F from its rectilinear path, causes it to be braked by friction. The angular displacement of braking member AF is delimited by an upper limit stop FI and a lower limit stop FF.

[0011] The braking force depends on the deviation angle of the yarn. According to the prior art, the deviation angle is controlled by a position sensor SE which is connected to the spindle of motor M and is adapted to generate a signal Pos_mis of the angular position of the spindle and, consequently, of braking rod AF. A controller CA of the weft feeder receives the request signal TRG from the loom and the pulses UWP from the photoelectric cell UWPS arranged downstream of cylinder TA, and processes them to generate a signal of the desired angular position Pos_ref, which continuously changes over time and is followed by a position-control block.

[0012] The latter comprises a position-control loop consisting of a subtracting node 1 that receives the signals Pos_ref and Pos_mis and generates a position error signal Perr from their difference. The position error signal Perr is sent to a position compensator 2 that generates a corresponding reference current signal Iref. A second subtracting node 3 receives the signal Iref and a current signal Imis measured across the load, and generates a current error signal Ierr from their difference. Current signal Imis is measured by means of a current sensor AC connected to one of the power leads to motor M. The signal Ierr is sent to a current compensator 4 that generates a corresponding wave clipping index to control the power supply to the motor, i.e. a duty cycle signal Duty reflecting the ratio of the time during which the signal is active and the total period of the wave.

[0013] The above signal is applied to a wave-form generator WFG, which generates four low-level control signals GL1, GL4 on the basis of the duty cycle signal Duty, for enabling field-effect transistors MOS Q1-Q4, known as MOSFETs (Metal Oxide Semiconductor Field Effect Transistor), of a H-shaped bridge PD. A gate driver GD between wave-form generator WFG and H-shaped bridge PD is designed to match the signals GL1-GL4 with the voltage levels G1-G4 that are compatible with the gate of the MOSFETs Q1-Q4 of H-shaped bridge PD.

[0014] Fig. 2 shows the position-control block according to the invention. The motor M is indicated by its equivalent electric circuit, which comprises a resistor R, an inductor L and an electromotive force E. Power to motor M is supplied by a voltage V(t) giving rise to a current I(t). The parts of this block corresponding to the prior art will be not further described. As well known to persons skilled in the art, the following relation holds:

$$V(t) = R \cdot I(t) + L \cdot \frac{dI}{dt} + E(t),$$

where dI/dt is the derivative of the current over time. Moreover,

$$E(t) = K \cdot \text{vel}(t),$$

where K is a characteristic constant of the motor and $\text{vel}(t)$ is the speed of the motor.

[0015] Finally,

$$p(t) = \int \text{vel}(t) \cdot dt,$$

where $p(t)$ is the angular position of the motor. By combining the three relations above, the following relation is obtained

$$p(t) = \int \left(\frac{V(t) - R \cdot I(t) - L \cdot \frac{dI}{dt}}{K} \right) dt.$$

[0016] The position $p(t)$ of the motor and, consequently, of the braking rod, can be determined on the basis of the relation above. Such calculation is performed in real time by a position estimator SP, e.g. by means of DSP devices (Digital Signal Processor) which are well known to the persons skilled in the art. The measured current value Imis is obtained similarly to the prior art, while the voltage on the power leads of motor M is obtained by multiplying the duty cycle signal Duty at the output of current compensator 4 by the power supplying voltage, according to the relations

$$V(t) = \text{DutyCycle} \cdot V_s(t) \cdot \frac{R1+R2}{R1} \text{ and } V_s(t) = V_{cc}(t) \cdot \frac{R1}{R1 + R2},$$

where $V_s(t)$ is a voltage that is proportional to the power supply voltage $V_{cc}(t)$. Since the latter is subjected to fluctuations over time, it is filtered by a resistive potential divider PR followed by a decoupling buffer B.

[0017] It should be noted that, although voltage $V(t)$ is not the real voltage measured at the input of the motor, it differs from it by only a negligible error.

[0018] Although the system of Fig. 2 is similar to the system of Fig. 1, the former is basically different from the latter in that, according to this invention, the feedback position signal Pos_mis is obtained by position estimator SP, which calculates the position of the motor on the basis of the signals Imis, Duty Cycle and $V_s(t)$ according to the above equations.

[0019] Preferably, for better accuracy in the calculation of the integral that gives the position $p(t)$ of the motor, a predetermined definite value, e.g. 60ms, is assumed as integration time. Accordingly, the feedback is enabled only during this time, i.e. at the end of the insertion, when the position signal Pos_ref is changed to modulate the braking action. This purpose is achieved by means of a selector 5, which is activated by a reference current signal Sel_Iref sent by controller CA, and is adapted to select the reference current signal Iref between a biasing current Ipol, which keeps the weft-brake disabled, and the enabling current Irefp at the output of position compensator 2 (position of Fig. 2), which enables the position-control loop.

[0020] Fig. 3 is a time diagram showing the signals processed by the system according to the invention. By way of example, an insertion of five loops is considered. The signal TRG, which is sent by the loom at time t_0 , enables the beginning of the insertion, so that sensor UWPS starts detecting the signals UWP1-UWP5 of the unwinding loops. The position-control loop is inactive, while the current loop is on and receives a negative reference current Ipol from controller CA, which causes braking member to engage stop member FI, thereby leaving the weft free between eyelets OI and OU. In this description, positive currents are conventionally considered to produce torques that increase the braking action, and negative currents torques that lessen the braking action. Controller CA is set to take into account the delay time of the weft-brake FE and to calculate the instant of the end of the insertion. At time t_1 , before the end of the insertion, controller CA enables the position control loop by sending a signal Sel_ref that switches selector 5 from the position allowing the transit of the current signal Ipol to the position allowing the transit of the enabling signal Irefp, and also by sending a position signal Pos_ref of the desired braking

Claims

1. A weft-brake control apparatus for weaving looms including:

- a weft feeder (AT) provided with a stationary cylinder (TA) on which are wound loops of yarn forming a weft reserve (RT), and with a weft-stopping member (PTF) adapted to release predetermined quantities of yarn (F) per each insertion cycle,
- a loom (TE) downstream of the weft feeder (AT),
- a weft-brake (FE) arranged between the cylinder (TA) and the loom (TE) and provided with a braking member (AF) operated by an electric motor (M) to engage a length of the yarn, thereby causing it to be braked by friction,
- a position-control loop for the motor, comprising a subtracting node (1) adapted to receive a desired angular position signal (Pos_ref) and a measured position signal of the motor (M), and to generate a position error signal (Perr) from their difference,

characterized in that said position error signal (Pos_mis) is calculated by a position estimator (SP) from a signal proportional to the current across the motor (Imis) and a signal proportional to the voltage on the power leads ($V(t)$) of the motor.

2. The apparatus of claim 1, **characterized in that** said signal proportional to the current through the motor (Imis) is obtained by a current sensor (AC) connected to one of the power leads to the motor (M).

3. The apparatus of claim 1 or 2, wherein the power to said motor (M) is supplied through a H-shaped bridge (PD) controlled by a clipping index (Duty Cycle) through a control loop for the current through the motor (Imis), **characterized in that** said signal proportional to the voltage on the power leads ($V(t)$) of the motor is obtained by the

position estimator (SP) by multiplying the clipping index (Duty Cycle) by the power supply voltage (Vcc(t)).

4. The apparatus of claim 3, **characterized in that** said power supply voltage (Vcc(t)) is calculated by the position estimator (SP) by multiplying a signal (Vs(t)), which is proportional to the power supply voltage and is generated by a resistive potential divider (PR) supplied by the power supply voltage (Vcc(t)), by a coefficient of the potential divider.

5. The apparatus of anyone of claims 1 to 4, **characterized in that** said position estimator (SP) calculates the position signal (Pos_mis) of the motor by the following equation:

$$p(t) = \int_{t1}^{t3} \left(\frac{V(t) - R \cdot I(t) - L \cdot \frac{dI}{dt}}{K} \right) dt$$

where p(t) is the measured position of the motor (Pos_mis), t1 and t3 are the calculation start time (t1) and the calculation end time (t3) respectively, V(t) is the signal proportional to the voltage on the power leads (V(t)) of the motor, R and L are the resistance and the inductance of the equivalent electric circuit of the motor (M) respectively, K is a constant that links the electromotive force (E(t)) of the motor to the motor speed (vel(t)), I(t) is the current across the motor (Imis) and dI/dt is the derivative of the current over time.

6. The apparatus of anyone of claims 1 to 5, wherein said control loop for the current comprises a subtracting node (3) adapted to receive a reference current signal (Iref) into a first input and the current signal (Imis) through the load into a second input, and to generate a current error signal (Ierr) from their difference, **characterized in that** the reference current signal (Iref) is given by a selector (5), which is controlled by a selection signal (Sel_Iref) generated by the controller (CA) and is adapted to transmit an enabling signal (Irefp) generated by a position compensator (2) on the basis of said position error signal (Perr), during the time range between said calculation start time (t1) and said calculation end time (t3), and a biasing current signal (Ipol) adapted to keep the brake disabled, during the remaining time.

7. The apparatus of claim 5 or 6, **characterized in that** the time range between said calculation start time (t1) and calculation end time (t3) is set to encompass the last loops unwinding from the loom (TA) in the insertion cycle.

8. The apparatus of anyone of claims 5 to 7, **characterized in that** said calculation start time (t1) and calculation end time (t3) define a time range astride of the last unwinding loop.

9. The apparatus of anyone of claims 1 to 8, **characterized in that** said position estimator (SP) is a digital processing device.

10. The apparatus of anyone of claims 1 to 9, **characterized in that** said position estimator (SP) comprises a DSP device (Digital Signal Processor). angle. Instantaneously, the current signal Iref, which now equals Irefp, is varied by the position-control loop in order to make signal Pos_mis, which is calculated by estimator SP, correspond to signal Pos_ref, except for a negligible error. At time t2, after a delay time dt0 with respect to the last loop UWP5, controller CA controls the return of braking member AF by changing the reference value Pos_ref into a value that is slightly higher than the value corresponding to FI, in order to prevent collisions of the braking member against limit stop FI. At time t3, when a delay time dt1 has elapsed since the signal Pos_mis has reached said value Pos_ref, except for a negligible error, the position-control loop and estimator SP are disabled, and the value Ipol is set at the input of the current loop. Accordingly, a further advantage is achieved, because the braking member is softly driven to its resting position against stop member FI, thereby compensating any prior position error and minimizing the integration errors.

Moreover, by enabling the position-control loop and position estimator SP only during the short definite time t1 to t3, the integration is made over a time range sufficiently short that the results are satisfactorily accurate.

Of course, the above described operations may be performed by digital processing means which may be supported, when needed, by analogical/digital signal converters (not shown and described for better clarity), according to techniques that will be obvious to the persons skilled in the art.

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A preferred embodiment of the invention has been described, but certainly many changes can be made by a person skilled in the art, depending on the requirements, within the scope of the inventive concept.

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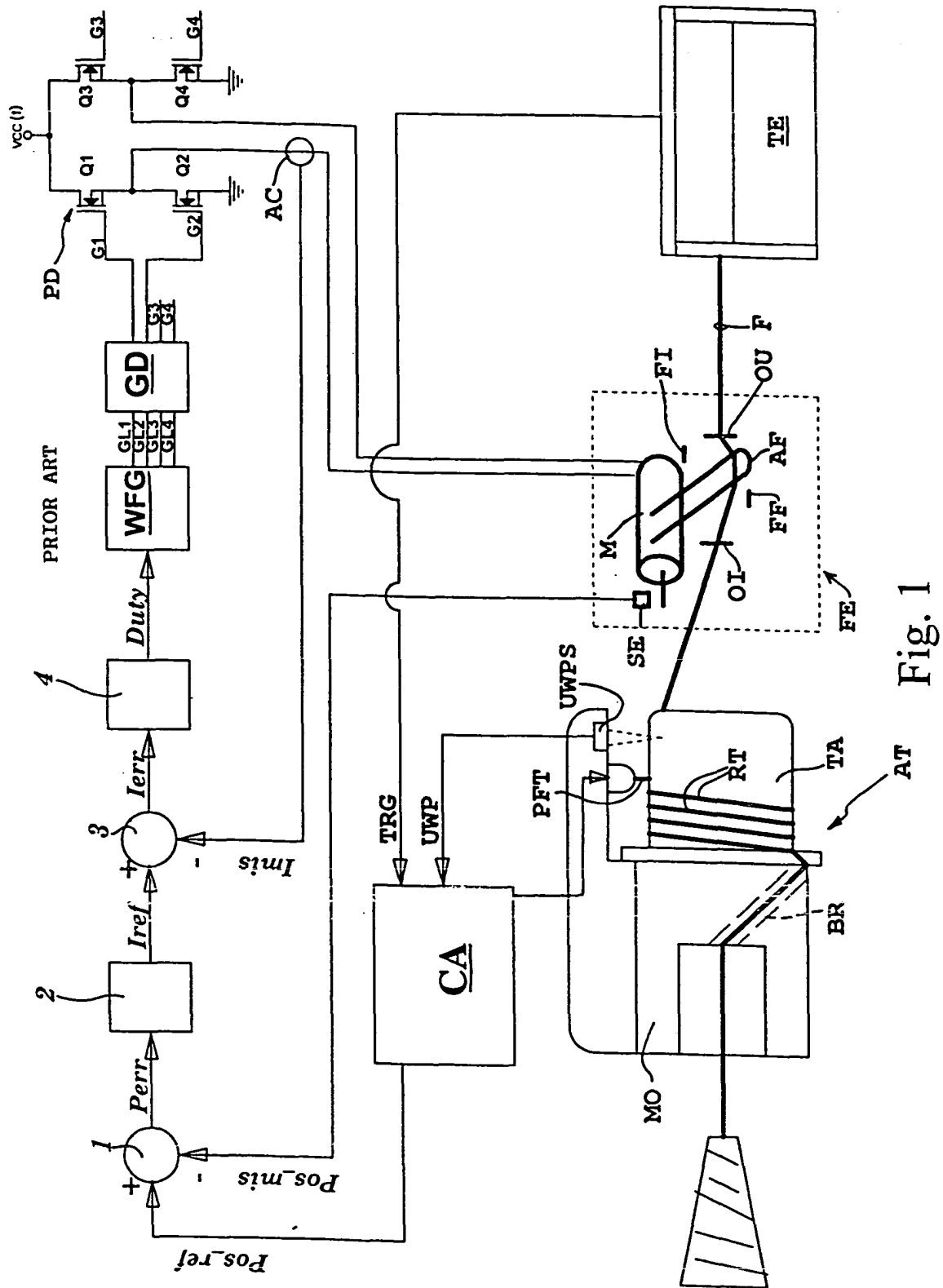


Fig. 1

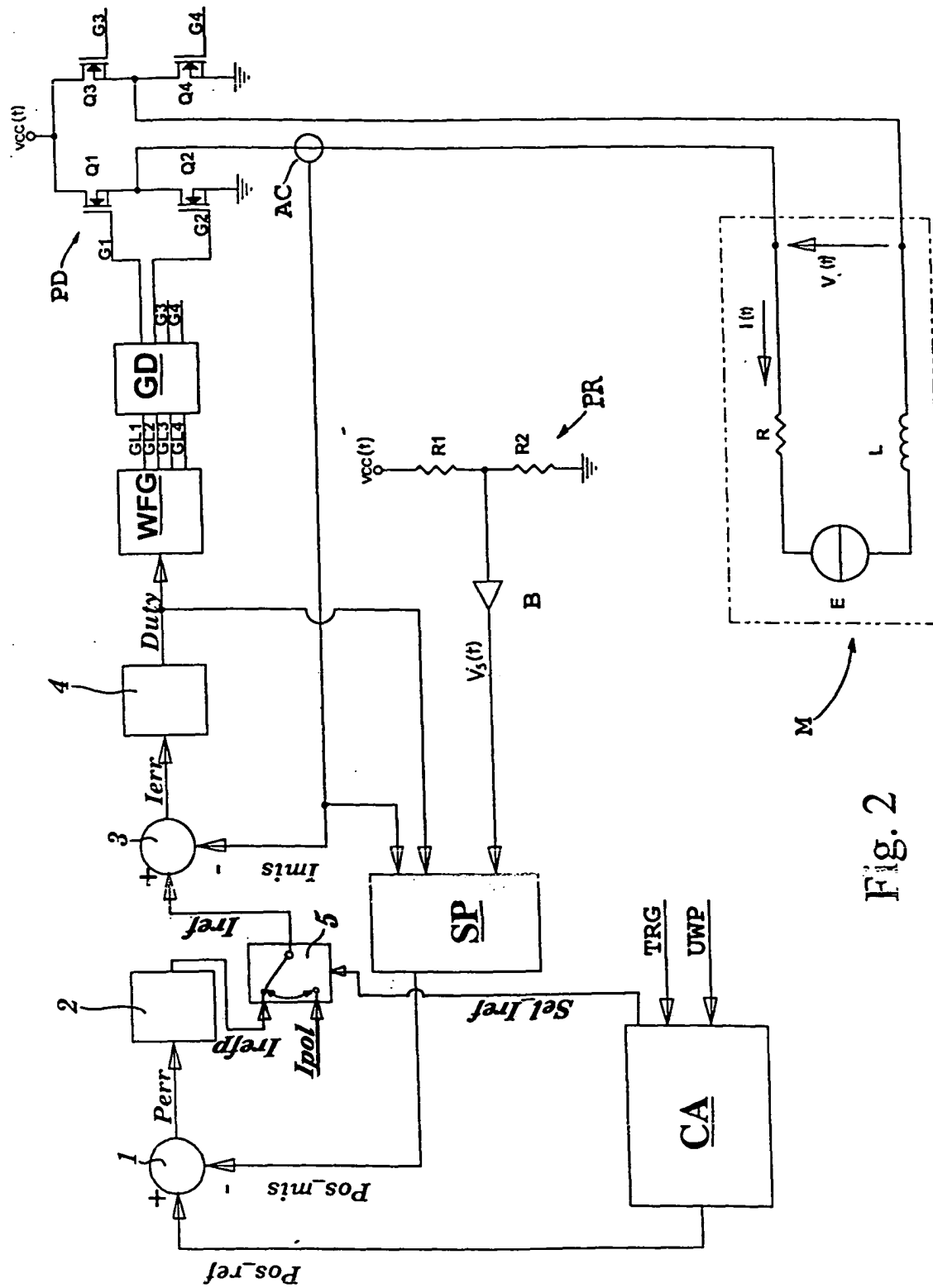
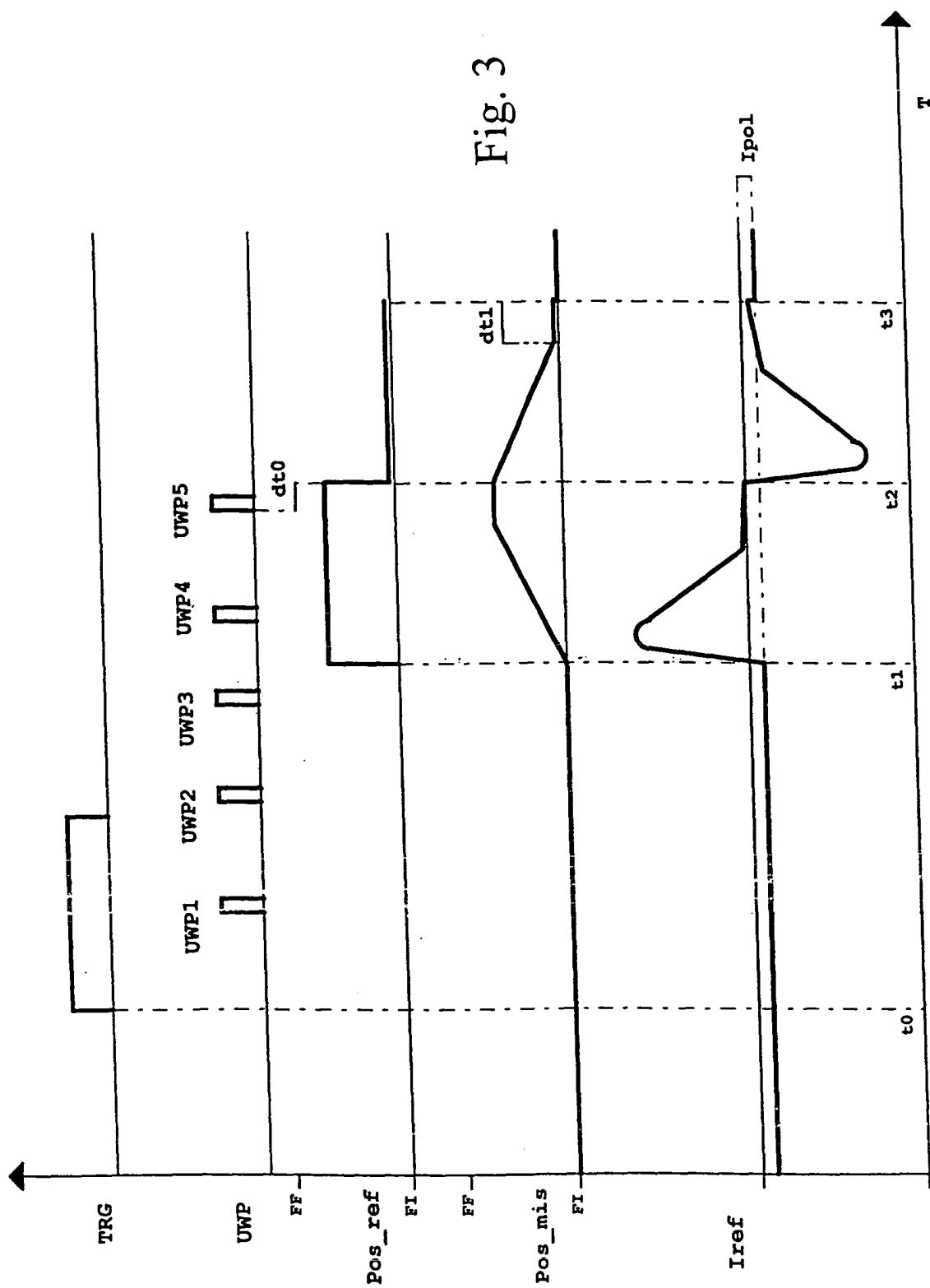


Fig. 2





European Patent
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Application Number
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Place of search THE HAGUE		Date of completion of the search 8 January 2004	Examiner Rebiere, J-L
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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