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(54) **Device and method for adjusting the gram force applied to the thread, for feeding thread to a knitting machine with constant tension**

Vorrichtung und Verfahren zum Regeln der Fadenspannung, für die Fadenlieferung mit konstanter Fadenspannung zu einer Strickmaschine

Dispositif et procédé pour le réglage de la tension de fil, pour l'alimentation en fil à tension constante dans une machine à tricoter

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Description

[0001] The present invention relates to a device and a method for adjusting the gram force applied to the thread, capable of feeding thread of a knitting machine so as to ensure its constant tension.

[0002] More particularly, the invention relates to a device and a method for adjusting the gram force applied to the thread to be fed to the knitting machine so as to maintain the tension of the thread always constant, in order to provide a manufactured article of optimum quality.

[0003] As is known, in knitting machines one of the most important characteristics for the operation of the machine is the gram force applied to the thread, i.e., the tension to which the thread fed to the knitting machine is subjected.

[0004] Substantially, if such tension varied suddenly and were not compensated in some way, by rapidly feeding more or less thread to the knitting machine, such thread might break, or otherwise the quality of the knitting would not be optimum, indeed because of the fact that fluctuating variations of the tension of the thread cause the knitting machine to produce an article that does not comply with the required quality standards.

[0005] Currently, various solutions are used to adjust the gram force applied to the thread; one of them provides for sensing, by means of a load cell, the gram force applied to the thread, comparing the detected value with a reference value, and issuing a gram force error signal, which in combination with a speed error signal of the motor that controls the unwinding of the spool of thread is used to control said motor so as to accelerate or slow its rotation, thereby increasing or decreasing the thread fed to the knitting machine.

[0006] Substantially, the control described above uses two control parameters, i.e., the gram force applied to the thread together with the feed rate of such thread, i.e., the rotation rate of the motor.

[0007] Although this control is effective, it suffers drawbacks caused by the complexity of the sensing of the variables to be controlled, i.e., the gram force applied to the thread and most of all the rotation rate of the motor. The second variable in fact requires the presence of Hall sensors in order to detect the position of the motor and therefore determine its speed at each instant.

[0008] This entails a cost as well as a reduction of the reliability of the adjustment device owing to an increased number of components.

[0009] US-6,010,052 discloses a yarn supply apparatus with electronic control as defined in the preamble of claim 1.

[0010] The aim of the present invention is to provide a device and a method for controlling the gram force applied to the thread, in order to feed the thread to the knitting machine so as to ensure that its tension is always constant and conforms with a preset tension set by the machine.

[0011] Within this aim, an object of the present invention is to provide a device and a method for adjusting the gram force applied to a thread that substantially allows to predict the behavior of such thread without the need to obtain a precise value for the gram force applied to the thread.

[0012] Another object of the present invention is to provide a device and a method for adjusting the gram force applied to a thread in a knitting machine that allows to eliminate speed control yet is able to keep constant the gram force required with any type of thread.

[0013] Another object of the present invention is to provide a device and a method for adjusting the gram force applied to a thread that is highly reliable, relatively simple to provide, and at competitive costs.

[0014] This aim and these and other objects that will become better apparent hereinafter are achieved by a device for adjusting the gram force applied to a thread in knitting machines, as defined in claim 1.

[0015] Further characteristics and advantages of the invention will become better apparent from the description of a preferred but not exclusive embodiment of the device according to the present invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a block diagram of the control device according to the present invention; and

Figure 2. is a chart that plots the behavior of the parameter used to adjust thread gram force.

[0016] With reference to the figures, the adjustment device according to the present invention, shown schematically as a block diagram in Figure 1 and generally designated by the reference numeral 1, comprises a control unit 2, which is adapted to drive power supply means 3 of at least one motor 4, which is adapted to unwind a thread 5 from a spool of thread in order to feed said thread to the knitting machine 6.

[0017] The thread that exits from the spool is passed through gram force sensor means 7, which detect the gram force applied to the thread, i.e., its tension, and emit a gram force signal 8, which is compared in comparator means 9 with a reference signal 10 (refgr.) in order to emit a gram force error signal errgr., which is sent to the control unit 2.

[0018] The particularity of the invention consists in that the control unit 2 comprises a controller 11, for example of the PID type, which receives in input the gram force error signal errgr., together with the derivative of the gram force signal 8 (gr.) that arrives from the gram force sensor means 7.

[0019] Substantially, the control unit 2 predicts the behavior of the thread on the basis of the evaluation of the derivative of the gram force signal, designated by the reference numeral 12 in Figure 1, and of at least one threshold, preferably a plurality of thresholds, designated

by the reference signs S1, S2 and S3 in Figure 2, set on the gram force error errgr. 9.

[0020] The derivative of the gram force signal 12, however, is not calculated here precisely, since it is sufficient to calculate exclusively its sign in order to determine whether the thread 5 is tensioning (with the risk of snapping) or slackening, a situation which entails the need to reduce the rotation rate of the motor.

[0021] Therefore, the gram force adjustment device according to the invention uses a single parameter to control the rotation rate of the motor, i.e., the gram force signal 8 obtained by the gram force sensor means 7.

[0022] The second signal that is used is a signal that is strictly correlated to the gram force signal 8, since it is the derivative thereof with respect to time.

[0023] Accordingly, the adjustment device according to the invention uses, differently from the background art, a single parameter to control the gram force applied to the thread, and therefore the rotation rate of the motor 4, and can be used with any type of thread used by the machine. The fact of not having to determine the exact value of the derivative with respect to time of the gram force signal, merely determining its sign instead, makes the device highly reliable.

[0024] With reference now also to Figure 2, operation of the device, and therefore the corresponding method, according to the present invention, is as follows.

[0025] First of all the thread 5 is passed through the gram force sensor means 7, which are constituted for example by a load cell and are capable of emitting a gram force signal 8 that indicates therefore the tension of the thread at a given instant. The gram force signal is compared in the comparator means 9 with a reference gram force, i.e., tension, which is preset for the machine, and the gram force error signal errgr. is then emitted.

[0026] At this point, the control unit 2, by using the gram force error signal errgr., together with the derivative with respect to time of the gram force signal 8, and by using at least one threshold or preferably more than one threshold, determines whether the motor 4 is to be supplied with power at the maximum speed, disabled or braked, or whether a control of the PID type is to be performed by means of the controller 11.

[0027] Figure 2 shows three separate thresholds of the gram force error, designated by the reference signs S1, S2 and S3. The chart plots the gram force error errgr. on the axis of the ordinates and the type of control to be performed for the motor 4 on the axis of the abscissae.

[0028] The curve shown in the chart of Figure 2 represents the error of the gram force signal 8.

[0029] As can be clearly noticed, there are different chart regions, designated by the reference letters A, B, C, D, E, F, G, into which said curve is divided.

[0030] In particular, in the region designated by the reference letter A, the curve intersects the threshold designated by S 1 with a rising trend, and in this region a control of the PID type of the motor 4 is performed.

[0031] In the region designated by the reference letter

B, the curve instead reaches a maximum, and control of the motor 4 with maximum current is performed in this region.

[0032] In the region designated by the reference letter C, the curve of the signal changes inclination and the motor is disabled.

[0033] In the region designated by the reference letter D, there is again a control of the PID type, in which the curve transitions from intersecting the threshold S 1 to intersecting the negative threshold S2.

[0034] In the region designated by the reference letter E, in which the curve of the signal 8 intersects the threshold S3, the motor control indicates that the motor must be braked.

[0035] In the region designated by the reference letter F, instead, the curve of the signal 8 reaches a negative minimum and in this step the motor is supplied with no current.

[0036] Finally, in the region designated by the reference letter G, the motor is disabled, as in step C.

[0037] The power supply means 3 of the motor 4 modulate, on the basis of the chart shown in Figure 2, the motor current in an open loop, performing only a control of current limiting.

[0038] The advantage of this type of control is the maximum promptness in motor response, without delay.

[0039] In practice it has been found that the device and method according to the present invention fully achieve the intended aim and objects, since they allow to provide a control with adjustment of the gram force applied to the thread by using a single parameter, i.e., the tension of said thread, without resorting to a detection of the speed of the thread and therefore of the rotation rate of the motor.

[0040] The device and the method thus conceived are susceptible of numerous modifications and variations, all of which are within the scope of the appended claims.

Claims

1. A device for adjusting the gram force applied to a thread in knitting machines, comprising a control unit (2) that is adapted to drive power supply means (3) of at least one motor (4) for unwinding a thread (5) to be fed to the knitting machine, gram force sensing means (7) adapted to detect the gram force applied to said thread (5) and to emit a gram force signal (8), comparator means (9) adapted to compare said gram force signal (8) with a reference signal (10) in order to obtain a gram force error signal (engr), said control unit (2) comprising means (11) adapted to emit a signal for driving said power supply means (3) of the motor, **characterized in that** said signal for driving said power supply means is emitted according to the gram force error signal (errgr) of said thread and to a signal (12) that is the derivative with respect to time of the gram force signal (8) emitted

by said gram force sensing means (7) and **in that** the control unit (2) predicts the behaviour of the thread on the basis of the evaluation of said derivative of the gram force signal (8) and of at least one threshold (S1, S2, S3) set on the gram force error signal (errgr).

2. The device according to claim 1, **characterized in that** said control unit (2) comprises a controller (11) of the PID type, which is adapted to receive in input said _ gram force error signal (errgr) together with said derivative signal (12) with respect to time of the gram force signal (8).

3. The device according to claim 1, **characterized in that** said means adapted to determine the derivative (12) with respect to time of said gram force signal (8) are adapted to detect the sign of said derivative.

4. The device according to claim 2, **characterized in that** said controller (11) is adapted to drive said motor power supply means (3) so as to supply said motor (4) in order to maintain a constant value of said gram force applied to the thread (5).

5. A method for adjusting gram force applied to the thread of a knitting machine, comprising the steps of:

adjusting the gram force applied to said thread (5) according to a reference gram force (10) and equalizing tension discontinuities of said thread on the basis of a prediction of the behavior of said thread, said prediction being based on a derivative (12) with respect to time of a gram force signal (8) and at least one threshold (S1, S2, S3) that is set in relation to a gram force error signal (errgr) obtained by comparing a gram force value detected by gram force sensing means (7) with the reference gram force value (10).

6. The method according to claim 5, **characterized in that** said gram force error signal (errgr), together with said time derivative signal (12) of the gram force applied to said thread (5), are sent to a controller (11) that is adapted to drive power supply means (3) of said motor (4) in order to keep the tension of said thread constant.

7. The method according to claim 5, **characterized in that** said time derivative signal (12) of the gram force (8) applied to said thread (5) is evaluated as regards the sign of said derivative.

Patentansprüche

1. Eine Vorrichtung zur Einstellung der Fadenspan-

nung, die auf einen Faden in Strickmaschinen ausgeübt wird, Folgendes umfassend: eine Steuereinheit (2), die ausgebildet ist, um ein Stromversorgungsmittel (3) mindestens eines Motors (4) zum Abwickeln eines Fadens (5) anzutreiben, der der Strickmaschine zugeführt werden soll, ein Fadenspannungs-Erfassungsmittel (7), das ausgebildet ist, um die Fadenspannung zu erfassen, die auf den Faden (5) ausgeübt wird, und um ein Fadenspannungssignal (8) zu senden, ein Komparatormittel (9), das ausgebildet ist, um das Fadenspannungssignal (8) mit einem Referenzsignal (10) zu vergleichen, um ein Fadenspannungs-Fehlersignal (errgr) zu erhalten, wobei die Steuereinheit (2) ein Mittel (11) umfasst, das ausgebildet ist, um ein Signal zum Antreiben des Stromversorgungsmittels (3) des Motors zu senden, **dadurch gekennzeichnet, dass** das Signal zum Antreiben des Stromversorgungsmittels entsprechend dem Fadenspannungs-Fehlersignal (errgr) des Fadens und entsprechend einem Signal (12) gesendet wird, welches die Ableitung mit Bezug auf die Zeit des Fadenspannungssignals (8) ist, das von dem Fadenspannungs-Erfassungsmittel (7) gesendet wird, und dadurch, dass die Steuereinheit (2) das Verhalten des Fadens anhand der Bewertung der Ableitung des Fadenspannungssignals (8) und anhand mindestens eines Schwellenwertes (S1, S2, S3) vorhersagt, der für das Fadenspannungs-Fehlersignal (errgr) gesetzt ist.

2. Die Vorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** die Steuereinheit (2) einen Controller (11) des PID-Typs umfasst, der ausgebildet ist, um als Eingabe das Fadenspannungs-Fehlersignal (errgr), gemeinsam mit dem Ableitungssignal (12) mit Bezug auf die Zeit des Fadenspannungssignals (8) zu empfangen.

3. Die Vorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** das Mittel, das ausgebildet ist, um die Ableitung (12) mit Bezug auf die Zeit des Fadenspannungssignals (8) zu bestimmen, ausgebildet ist, um das Vorzeichen der Ableitung zu bestimmen.

4. Die Vorrichtung gemäß Anspruch 2, **dadurch gekennzeichnet, dass** der Controller (11) ausgebildet ist, um das Motor-Stromversorgungsmittel (3) anzutreiben, um den Motor (4) zu versorgen, um einen konstanten Wert der Fadenspannung aufrechtzuerhalten, die auf den Faden (5) ausgeübt wird.

5. Ein Verfahren zur Einstellung der Fadenspannung, die auf den Faden einer Strickmaschine ausgeübt wird, das folgende Schritte umfasst:

Einstellung der Fadenspannung, die auf den Faden (5) ausgeübt wird, entsprechend einer Re-

ferenz-Fadenspannung (10) und Ausgleich von Spannungs-Diskontinuitäten des Fadens anhand einer Vorhersage des Verhaltens des Fadens, wobei die Vorhersage auf einer Ableitung (12) mit Bezug auf die Zeit eines Fadenspannungssignals (8) und mindestens einem Schwellenwert (S1, S2, S3) basiert, der in Bezug auf ein Fadenspannungs-Fehlersignal (errgr) festgelegt wird, welches durch den Vergleich eines Fadenspannungs-Werts, der vom Fadenspannungs-Erfassungsmittel (7) erfasst wird, mit dem Referenz-Fadenspannungswert (10) gewonnen wird.

6. Das Verfahren gemäß Anspruch 5, **dadurch gekennzeichnet, dass** das Fadenspannungs-Fehlersignal (errgr), gemeinsam mit dem Zeitableitungssignal (12) der Fadenspannung, die auf den Faden (5) ausgeübt wird, an einen Kontroller (11) gesendet wird, der ausgebildet ist, um das Stromversorgungsmittel (3) des Motors (4) anzutreiben, um die Spannung des Fadens konstant zu halten.
7. Das Verfahren gemäß Anspruch 5, **dadurch gekennzeichnet, dass** das Zeitableitungssignal (12) der Fadenspannung (8), die auf den Faden (5) ausgeübt wird, im Hinblick auf das Vorzeichen der Ableitung bewertet wird.

Revendications

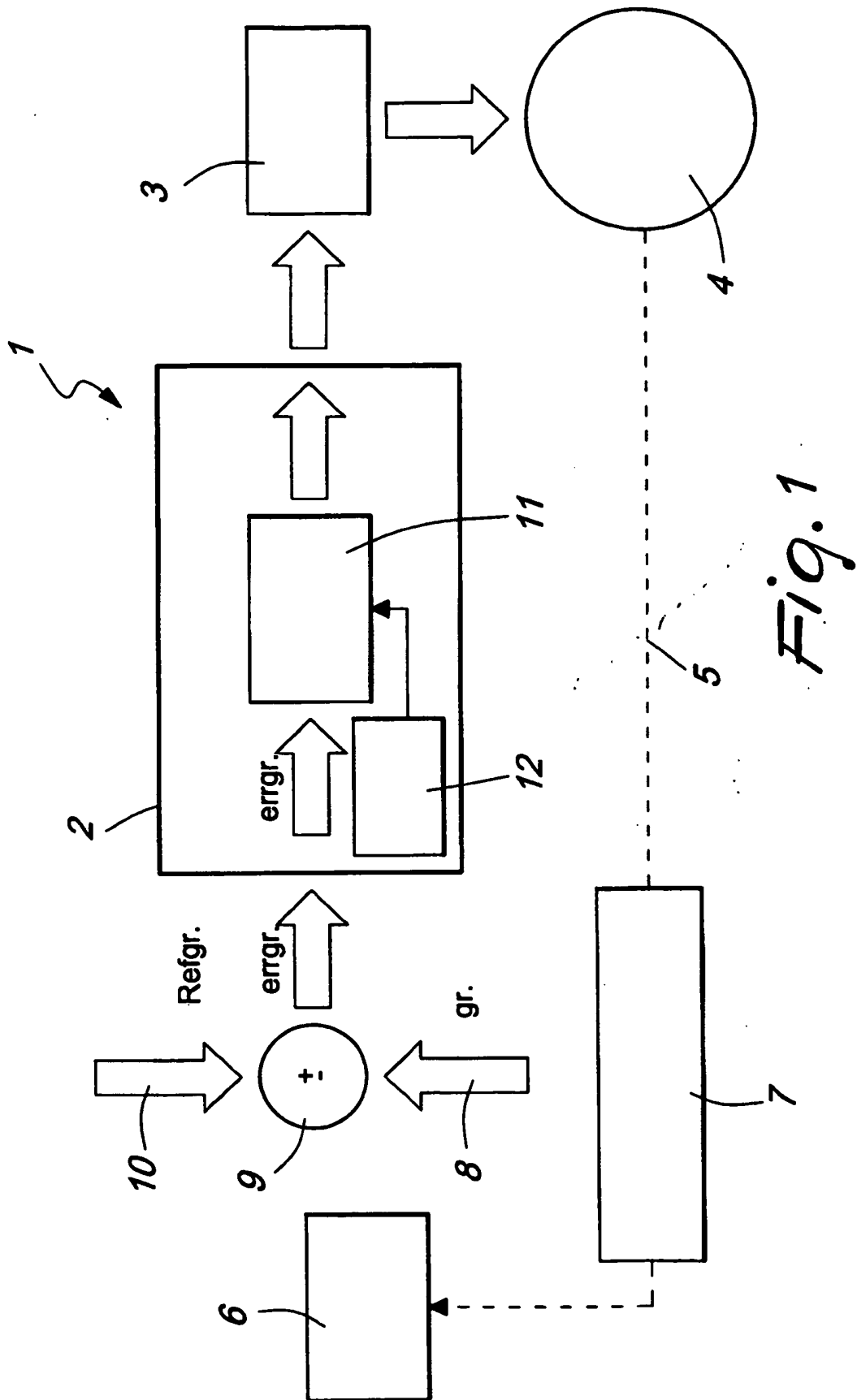
1. Dispositif pour régler la tension appliquée à un fil dans des machines à tricoter, comprenant une unité de commande (2) qui est adaptée pour actionner des moyens d'alimentation (3) d'au moins un moteur (4) pour dérouler un fil (5) devant être délivré à la machine à tricoter, des moyens de détection de tension (7) adaptés pour détecter la tension appliquée audit fil (5) et à émettre un signal de tension (8), des moyens formant comparateur (9) adaptés de façon à comparer ledit signal de tension (8) à un signal de référence (10) afin d'obtenir un signal d'erreur de tension (errgr), ladite unité de commande (2) comprenant des moyens (11) adaptés pour émettre un signal pour actionner lesdits moyens d'alimentation (3) du moteur, **caractérisé en ce que** ledit signal pour actionner lesdits moyens d'alimentation est émis en fonction du signal d'erreur de tension (errgr) dudit fil et d'un signal (12) qui est la dérivée par rapport au temps du signal de tension (8) émis par lesdits moyens de détection de tension (7), et **en ce que** l'unité de commande (2) prédit le comportement du fil en fonction de l'évaluation de ladite dérivée du signal de tension (8) et d'au moins un seuil (S1, S2, S3) appliqué au signal d'erreur de tension (errgr).
2. Dispositif selon la revendication 1, **caractérisé en**

ce que ladite unité de commande (2) comprend un dispositif de commande (11) du type proportionnelle-intégrale-dérivée, qui est adapté pour recevoir en entrée ledit signal d'erreur de tension (errgr) avec ledit signal de dérivée (12) par rapport au temps du signal de tension (8).

3. Dispositif selon la revendication 1, **caractérisé en ce que** lesdits moyens adaptés pour déterminer la dérivée (12) par rapport au temps dudit signal de tension (8) sont adaptés pour détecter le signe de ladite dérivée.
4. Dispositif selon la revendication 2, **caractérisé en ce que** ledit dispositif de commande (11) est adapté pour actionner lesdits moyens d'alimentation de moteur (3) pour alimenter ledit moteur (4) afin de maintenir une valeur constante de ladite tension appliquée au fil (5).
5. Procédé pour régler une tension appliquée au fil d'une machine à tricoter, comprenant les étapes consistant à :

régler la tension appliquée audit fil (5) en fonction d'une tension de référence (10) et égaliser des discontinuités de tension dudit fil en fonction d'une prédiction du comportement dudit fil, ladite prédiction étant basée sur une dérivée (12) par rapport au temps d'un signal de tension (8) et sur au moins un seuil (S1, S2, S3) fixé en relation avec un signal d'erreur de tension (errgr) obtenu en comparant une valeur de tension détectée par des moyens de détection de tension (7) à la valeur de tension de référence (10).

6. Procédé selon la revendication 5, **caractérisé en ce que** ledit signal d'erreur de tension (errgr), avec ledit signal de dérivée dans le temps (12) de la tension appliquée audit fil (5), est envoyé à un dispositif de commande (11) qui est adapté pour actionner des moyens d'alimentation (3) dudit moteur (4) afin de maintenir constante la tension dudit fil.
7. procédé selon la revendication 5, **caractérisé en ce que** ledit signal de dérivée dans le temps (12) de la tension (8) appliquée audit fil (5) est évalué en ce qui concerne le signe de ladite dérivée.



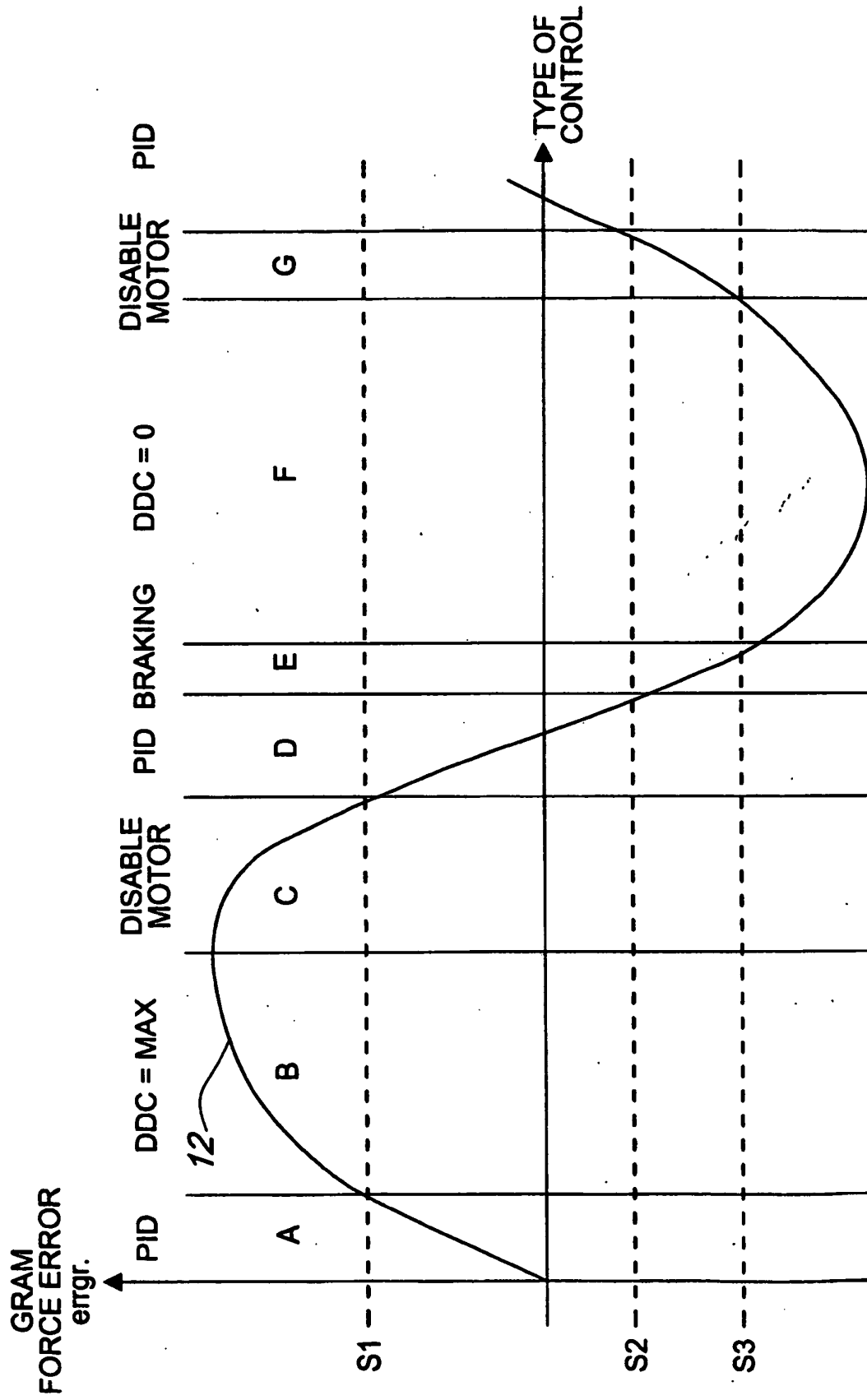


Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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