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Lamm

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(54) **METHOD FOR CONTROLLING AN ADJUSTMENT PROCESS OF A PART**

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(73) Assignee: **Robert Bosch GmbH**, Stuttgart (DE)

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(52) **U.S. Cl.** **318/283**; 318/456; 318/466; 318/434; 318/468; 318/282; 49/26; 49/28
(58) **Field of Search** 318/280, 282, 318/286, 283, 256, 445, 466, 468, 456, 434; 49/26, 28

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(57) **ABSTRACT**

In the method of controlling a process for moving a part **(20)** by an electric motor **(12)** against an end stop, pinching events are detected by monitoring a motor operating variable, such as a motor rpm, and if pinching is detected the motor **(12)** is stopped and/or reversed. The electric power triggering the motor **(12)** at the start of and during a startup phase while system slack is taken up is controlled so that it is constant and lower than the power triggering the motor in an ensuing operating phase **(54)** in which the part **(20)** moves. Preferably power during the startup phase is reduced to power values that are just barely enough to move the motor while system slack is taken up. In a preferred embodiment the applied motor voltage is reduced and controlled by a power end stage that includes a bipolar transistor or a field effect transistor.

11 Claims, 3 Drawing Sheets

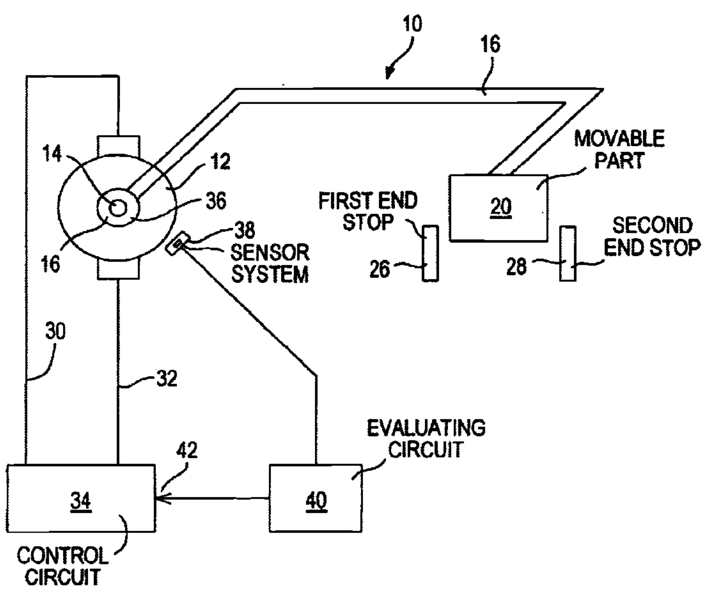

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Exhibit 2027

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Petitioner
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Case:
IPR2014-00648
Patent: 8,217,612

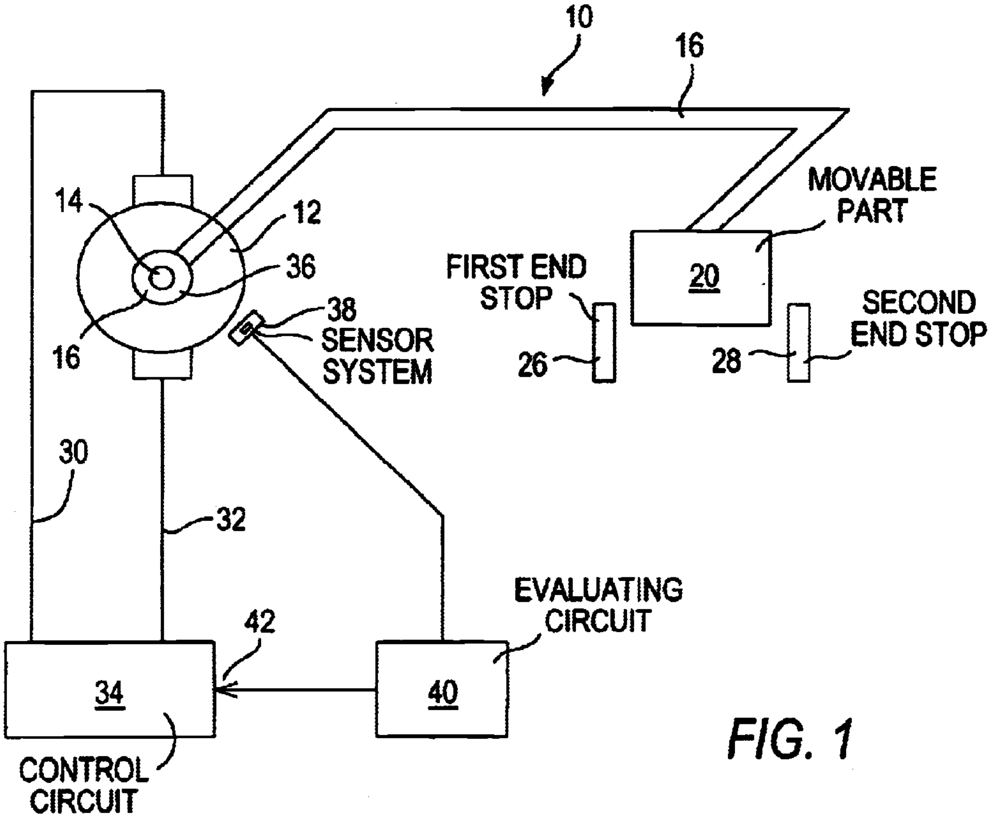

10
16
14
12
36
38
SENSOR SYSTEM
16
MOVABLE PART
20
FIRST END STOP
26
SECOND END STOP
28
30
32
EVALUATING CIRCUIT
42
34
40
CONTROL CIRCUIT

FIG. 1

FIG. 2

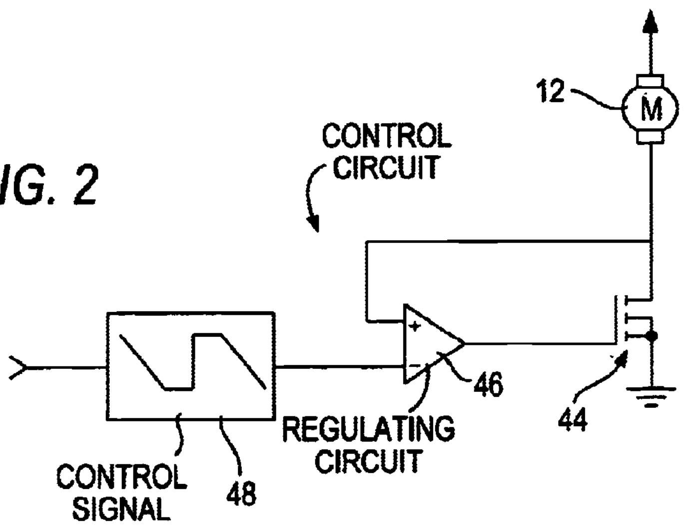
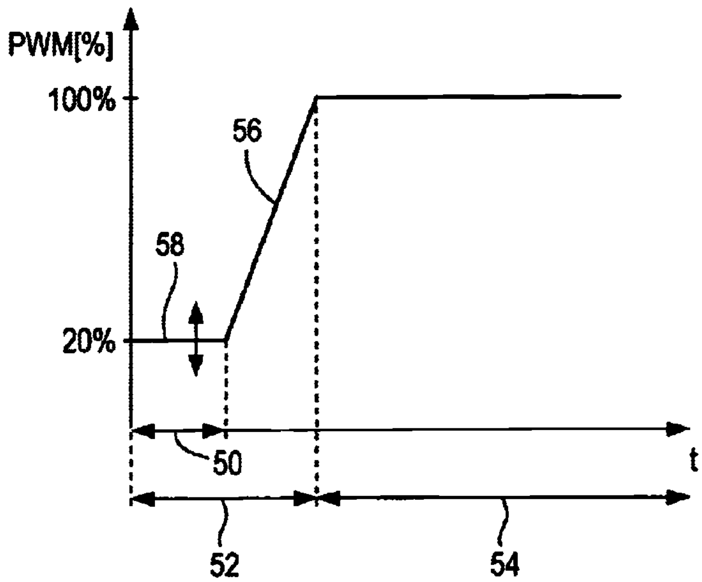

12
M
CONTROL CIRCUIT
46
44
REGULATING CIRCUIT
CONTROL SIGNAL
48

FIG. 3


PWM[%]
100%
20%
56
58
50
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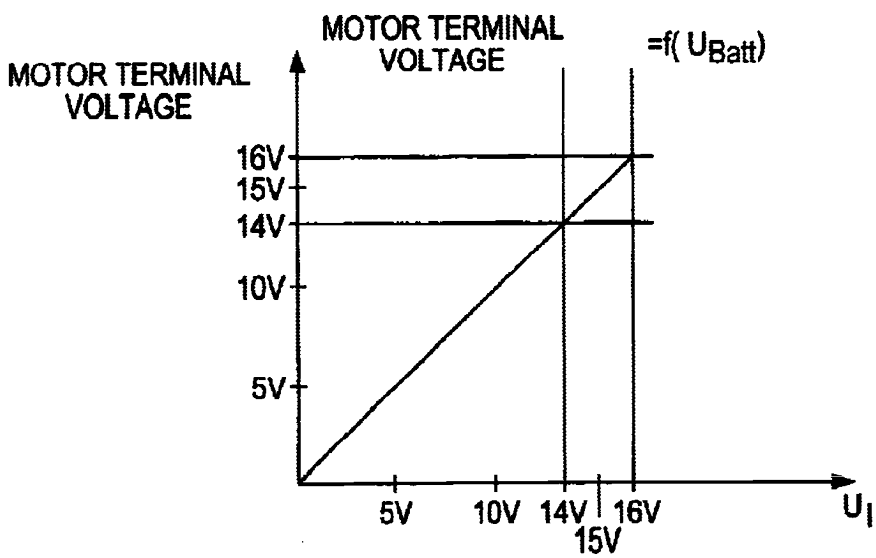
52
54

FIG. 4


MOTOR TERMINAL VOLTAGE
MOTOR TERMINAL VOLTAGE
=f(UBatt)
16V
15V
14V
10V
5V
5V
10V
14V
16V
15V
UI

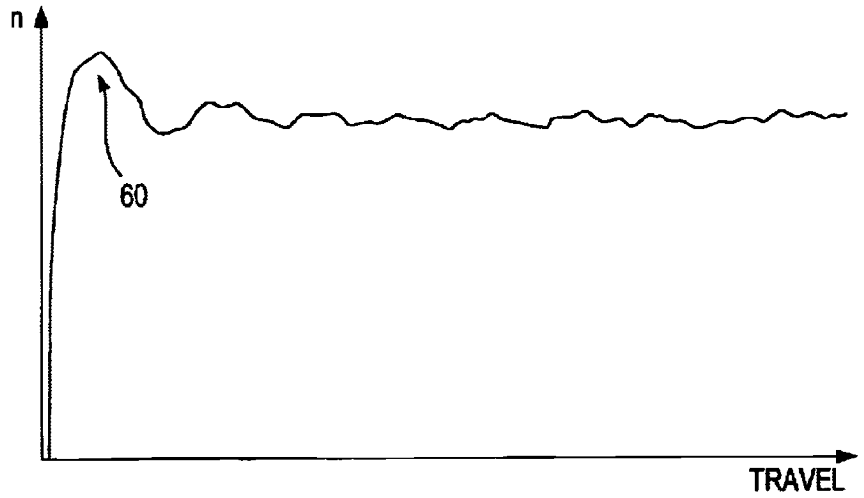


FIG. 5a

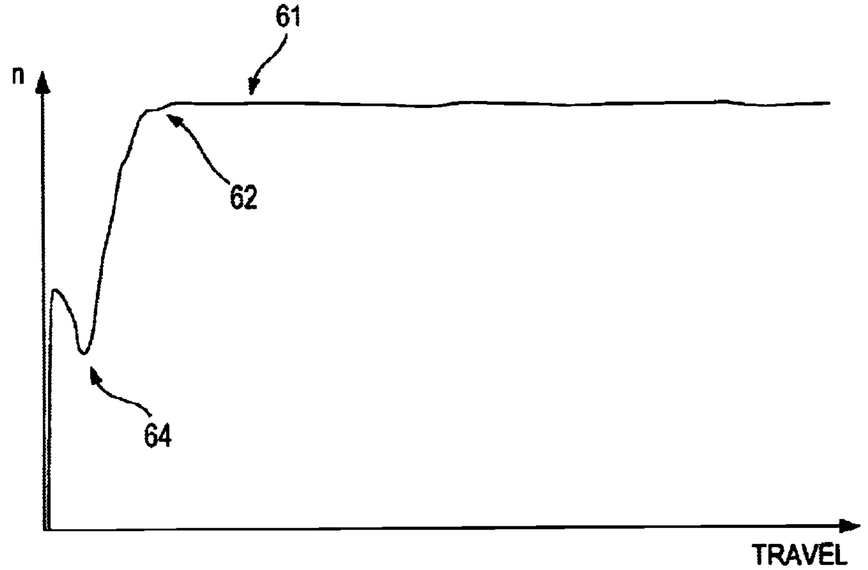


FIG. 5b

METHOD FOR CONTROLLING AN ADJUSTMENT PROCESS OF A PART

PRIOR ART

The invention relates to a method for controlling an adjustment process as generically defined by the preamble to the main claim.

It is known for parts to be combined with a motor drive mechanism that moves the parts along an adjustment path. The parts can be moved against at least one terminal position, and in particular can be moved back and forth between two terminal positions. Such movable parts are used in motor vehicles, for instance, as power windows or electrically actuated sliding roofs or seat adjusters. Electric closing devices for motor vehicles must by law provide a pinch protection function, which should largely preclude injuries to users from getting body parts caught.

It is especially problematic to achieve the pinch protection in the motor startup phase, since overswings in the motor rpm occur then, causing the pinch protection to be tripped by mistake. The overswinging is caused because the rpm first rises very quickly until the system slack is overcome and then suddenly drops once the part begins to move. The system slack is a composite of the production-dictated mechanical play among the individual components of the adjusting system.

German Patent DE 195 14 257 C1 has disclosed a method of monitoring an adjusting system that assures a pinch protection function even in the startup phase of the motor. By means of a sensor (Hall sensor), the rpm or speed is dictated; a period value is stored in memory and compared with a specified limit value. Since in the startup phase the motor period varies quite sharply, a steady state or in other words uniform motor operation exists only after about three motor periods, so that only then can satisfactory security against excessive development of force be assured. The initial period limit value during the motor startup phase is therefore calculated in advance, on the basis of the memorized reference values from the prior actuation of the motor. The initial period limit value (PGW*) is determined preferably on the basis of the most recent period value (PWvn) of the preceding adjustment, in accordance with the formula $PGW^*=2^*\ PWvn^*(0.5+E^{-t/\tau})$. This process is quite complex and expensive and is dependent on the preceding adjustment process. A prerequisite for such a method is that the measured values (period values) can be stored in memory continuously and made available the next time the motor is started. Moreover, this method is limited to using the rpm or speed as a sensor signal for the pinch protection function.

ADVANTAGES OF THE INVENTION

The method of the invention having the characteristics of the main claim has the advantage that an event involving pinching upon adjustment of a part can already be detected securely in the startup phase of the motor. The object of the invention is attained by triggering the motor in the startup phase at lesser power, for the sake of effectively preventing an overswing in the motor rpm and thus a problematic erroneous tripping of the pinch protection. It is therefore unnecessary to deactivate the pinch protection in the startup phase of the motor. With the method of the invention, an event involving pinching can be detected with high certainty even whenever an object or body part, when the window is open, for instance, is introduced with an exact fit into the window opening and the closing device of the window is activated only then. An especially advantageous feature is that this method can be employed in many currently used adjusting systems without major effort or expense, despite various more-complex evaluation algorithms for the pinch protection function.

By the characteristics recited in the dependent claims, advantageous refinements of the method of the main claim are possible. If the power of the motor is reduced, by triggering the motor via a power end stage operated with pulse width modulation, the advantage is attained that no power loss and thus no heat occur at the power end stage. Precise power regulation without additional expense for cooling is thus assured.

Alternatively, the power of the motor can be reduced by means of an applied variable voltage. Variable resistors, transistors, or similarly known components are suitable for this purpose. It is especially advantageous that in this precise type of power reduction, no electromagnetic interference that would require complicated interference suppression provisions in the control circuit occur.

It is advantageous if the power at the onset of the startup phase is controlled such that the motor just begins to move and the mechanical play of the adjusting system is overcome, but the movable part is not yet adjusted. Because the system slack is overcome with less power, no overswings in the motor revolution or in the sensor signal for the pinch protection function occur. Thus safer pinch protection is possible without erroneous tripping in the startup phase of the motor.

If, once the system slack has been overcome, the motor is triggered at maximum power (rated power), the part is adjusted quickly and efficiently without a perceptible time lag.

It is especially simple to increase the power linearly up to the rated power in order to prevent an overswing in the motor rotation. Moreover, unpleasant noise in the adjustment process is also avoided thereby.

By taking the actual battery voltage into account in triggering the power, the power can be set exactly in such a way that the system slack is overcome yet the movable part is not yet adjusted. The terminal voltage applied to the motor can be regulated by means of power triggering, independently of the actual battery voltage, in such a way that the power and thus the adjusting force do not increase undesirably.

The same is true if in the power triggering the ambient temperature is taken into account, since as a result its influence on the adjusting system and the control circuit can be eliminated. An undesired increase in the power or the adjusting force is thus prevented.

If the pinch protection is activated immediately as soon as the part begins to move, then the adjusting device offers optimal safety, as is increasingly demanded by motor vehicle manufacturers.

In a preferred feature of the invention, a variable inverse to the adjusting force of the part is used as the operating variable of the motor. Such operating variables can be measured in a simple way using Hall sensors. Thus no additional sensor expense for conventional adjusting systems is necessary.

If the rpm is used as the inverse variable, then it can be detected simultaneously with the adjustment path. The rpm is a very clear measurement variable that directly indicates the overswing in the motor revolution, or the avoidance thereof.

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