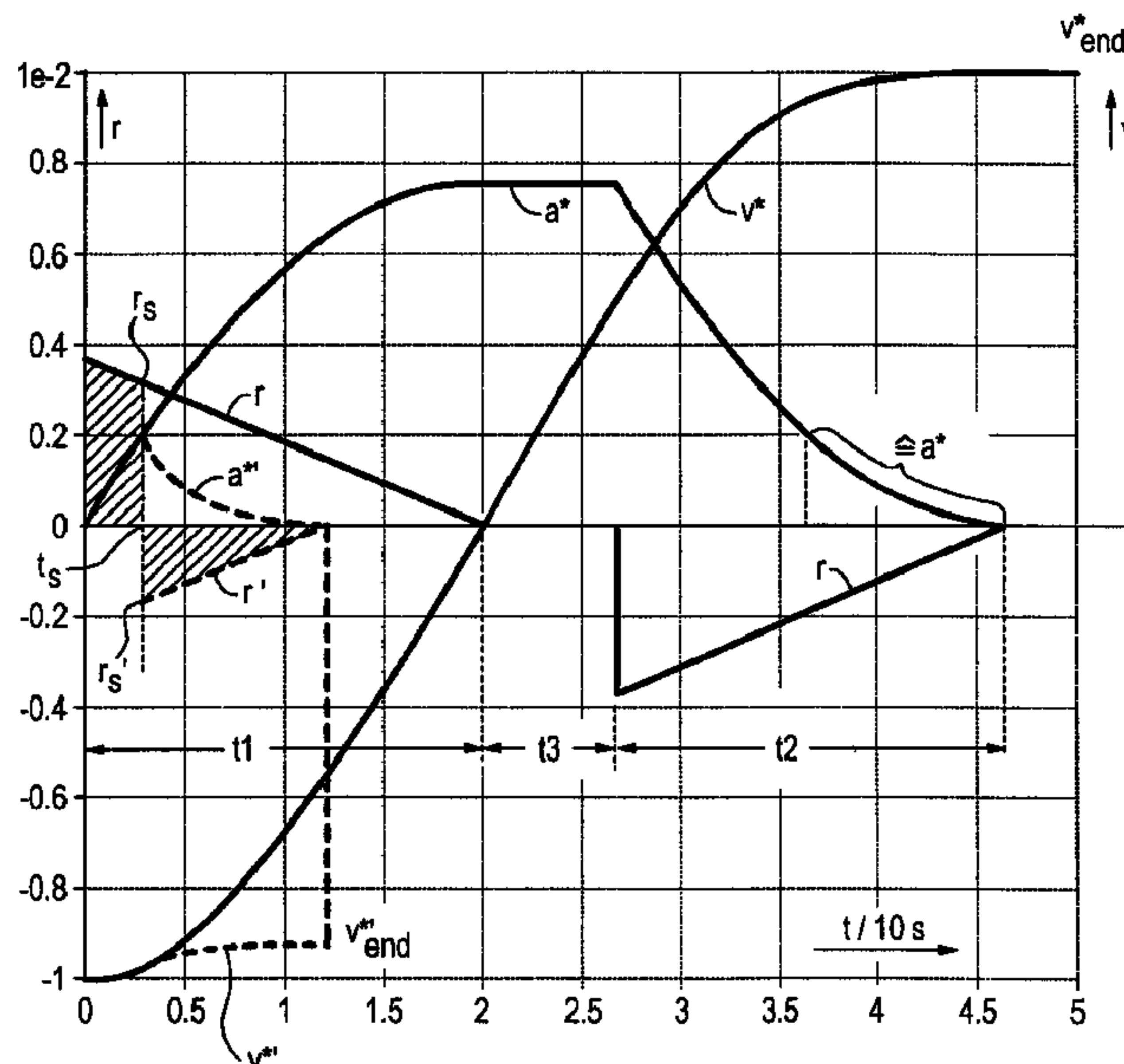
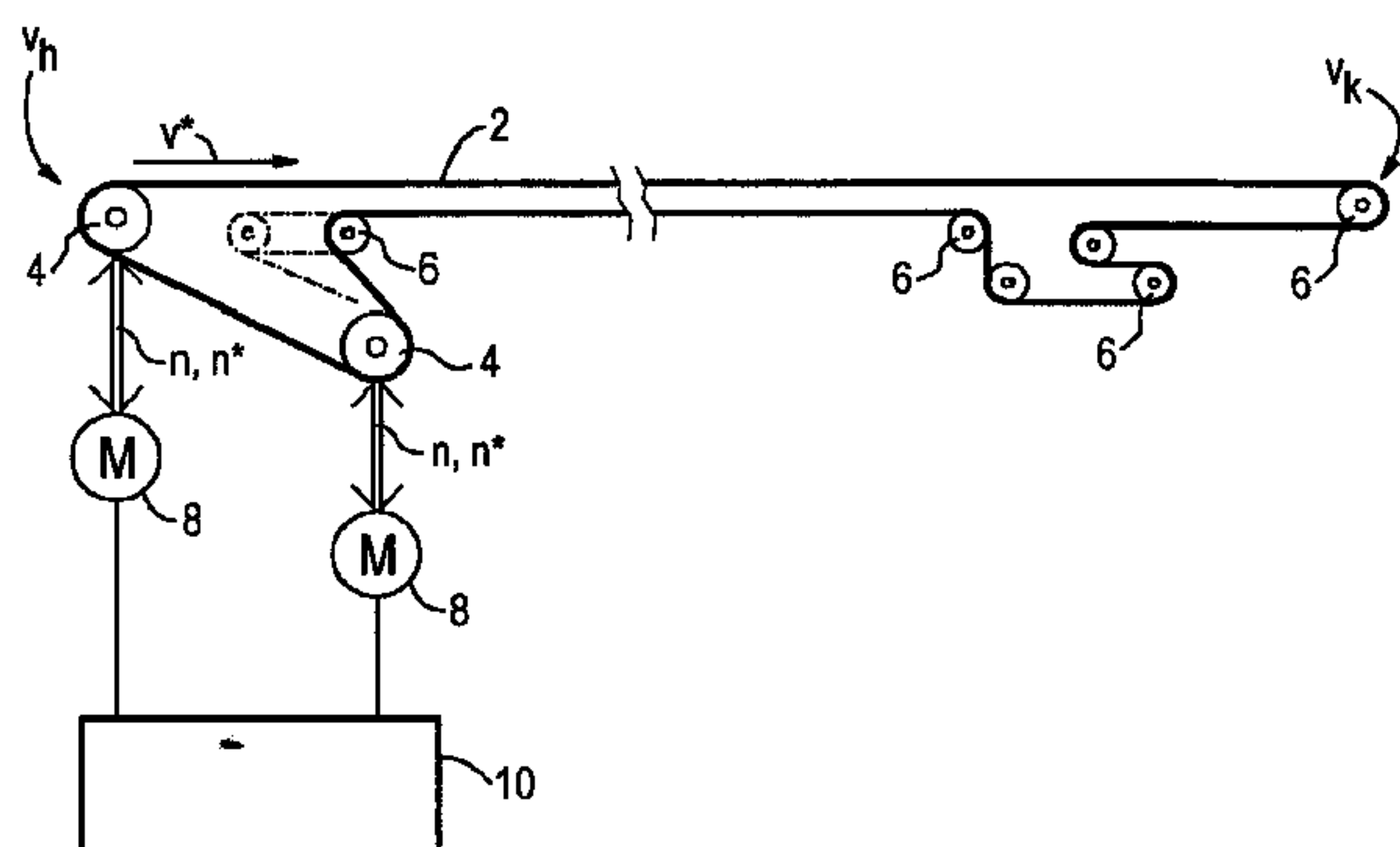




(86) Date de dépôt PCT/PCT Filing Date: 2001/01/05
(87) Date publication PCT/PCT Publication Date: 2001/07/26
(45) Date de délivrance/Issue Date: 2009/11/10
(85) Entrée phase nationale/National Entry: 2002/07/19
(86) N° demande PCT/PCT Application No.: DE 2001/000026
(87) N° publication PCT/PCT Publication No.: 2001/053174
(30) Priorité/Priority: 2000/01/21 (DE100 02 563.3)

(51) Cl.Int./Int.Cl. *B65G 23/00* (2006.01),
B65G 43/00 (2006.01), *G05B 19/416* (2006.01),
G05D 13/00 (2006.01), *G05D 13/62* (2006.01),
H02P 5/00 (2006.01)
(72) Inventeurs/Inventors:
BECKER, NORBERT, DE;
NEUFFER, INGEMAR, DE
(73) Propriétaire/Owner:
SIEMENS AKTIENGESELLSCHAFT, DE
(74) Agent: FETHERSTONHAUGH & CO.

(54) Titre : PROCEDE DE COMMANDE DE LA MONTEE EN REGIME D'UNE BANDE TRANSPORTEUSE ET
DISPOSITIF D'ENTRAINEMENT D'UNE BANDE TRANSPORTEUSE
(54) Title: METHOD FOR CONTROLLING THE RUN-UP OF A CONVEYOR BELT AND DRIVE DEVICE FOR A
CONVEYOR BELT



(57) Abrégé/Abstract:

A method for controlling the run-up of a conveyor belt (2), wherein the set point value of the speed of the belt (v^*) of a driving drum (4) is increased over a first period of time (t_1) by means of rising acceleration (a^*) and over a second period of time (t_2) by means of falling acceleration (a^*). The curve of acceleration (a^*) in relation to time (t) is positive for the second time period (t_2).

Abstract

A method for controlling the run-up of a conveyor belt (2), wherein the set point value of the speed of the belt (v^*) of a driving drum (4) is increased over a first period of time (t_1) by means of rising acceleration (a^*) and over a second period of time (t_2) by means of falling acceleration (a^*). The curve of acceleration (a^*) in relation to time (t) is positive for the second time period (t_2).

Description

Method for controlling the run-up of a conveyor belt and drive device for a conveyor belt

5

The invention relates to a method for controlling the run-up of a conveyor belt and to a drive device for a conveyor belt.

- 10 Conveyor belt systems with a great length, for example in the range of some kilometers, have to be run up and braked particularly gently, in order that belt oscillations and excessively high belt tensions are avoided. The rotational speed of the drive motors is
15 therefore controlled by a control device, a soft run-up controller, as it is called, in order to enable a gentle run-up of the rotational speed.

- For example, "M.B. Singh, The Role of Drive System
20 Technology in Maximizing the Performance and Economics of Long Belt Conveyors", bulk solids handling, vol. 14, 1994, pp. 695-702, for example, discloses running up the rotational speed of the drive drum and therefore the belt speed u^* with a linearly rising acceleration a^*
25 in a first time interval. In order to end the acceleration phase, in a second time interval t_2 the acceleration a^* is reduced to zero again. This reduction is likewise carried out linearly. In other words: the first time derivative r of the acceleration
30 a^* , also referred to in specialist language as the jerk, is constant and positive in a first time interval t_1 and likewise constant and negative in a second time interval t_2 . The curve of the rotational speed or speed v^* against time is therefore formed by quadratic
35 functions with inverse curvature which follow each other directly, that is to say in which the first time interval t_1 with a rising acceleration a^* and the

second time interval t_2 with a falling acceleration a^*
follow each other directly.

The time curve used in the known method of the setpoint value of the acceleration a^* , of the setpoint value of the speed v^* and of the first time derivative r of the setpoint value of the acceleration a^* (jerk) is plotted
5 in a graph in FIG. 4.

FIG. 5 shows, in a graph, the motor torque M which results in the known method and also the real head and tail speed v_k and v_h of a conveyor belt having a length
10 of 5000 m given a time duration of the first time interval and of the second time interval of 20s and a maximum standardized acceleration of $0.05s^{-1}$, such as is the result during such a run-up operation. In this case, the standardized acceleration is to be understood
15 as the ratio of the actual acceleration to the final speed of the belt. In the figure, it can clearly be seen that significant fluctuations occur both in the motor torque M and in the conveyor belt itself and, in the case of great conveying lengths, can lead to
20 disruptive operating states.

As an alternative to this, it is also known to drive the band drive with an acceleration-time curve which runs in accordance with a sinusoidal curve. In the case
25 of this method, the acceleration is likewise increased continuously up to a maximum value and reduced continuously from there, the first time derivative of the acceleration at the maximum, that is to say the jerk, being zero. In this method, too, belt and torque
30 fluctuations occur in particular at the end of the run-up.

In both methods, the result is therefore the problem that, in particular at the end of the run-up operation,
35 overswings or underswings in the motor torque occur, which also result in a greater belt tension. Furthermore, in particular in the case of the method

mentioned second, it not possible to move to a different rotational speed during the run-up with the same curve characteristic, since the curve characteristic is defined unambiguously by the run-up
5 time, which in this known method is equal to the sum

20365-4628

3

of the time duration of the first time interval and of the time duration of the second time interval, and of the predefined final speed.

The invention is, then, based on the object of specifying a method for controlling the run-up of a conveyor belt in which the aforementioned problems are largely avoided. In addition, the invention is based on the object of specifying a drive device for implementing the method.

In the method according to the invention for controlling the run-up of a conveyor belt, the setpoint value of the belt speed is increased with a continuously increasing acceleration in a first time interval and is increased with a continuously decreasing acceleration in a second time interval, the curve of the acceleration plotted against the time having a positive curvature in the second time interval. Since, as a result of the positive, that is to say upwardly concave, curvature of the acceleration, the jerk decreases continuously in the second time interval, belt oscillations at the end of the acceleration phase can largely be eliminated by a run-up program configured in this way.

In a particularly preferred refinement of the method according to the invention, the first time derivative of the acceleration is at least approximately equal to zero at the end of the second time interval. This ensures that the conveyor belt moves particularly gently and softly to its final speed.

In particular, the second time derivative of the acceleration in the first and in the second time interval is in each case at least approximately constant and in particular equal and opposite. This measure makes it

20365-4628

4

possible to interrupt the run-up program at any time and, during the run-up, it is possible to change the predefined final rotational speed or final speed, without a different characteristic of the acceleration-time curve resulting from
5 this.

The second-named object is achieved by a drive device. Such a drive device contains a motor for driving a driving drum, to which motor a control device is assigned which permits the setpoint value of the belt speed to be
10 controlled during the run-up of the conveyor belt in such a way that said belt speed increases continuously with continuously increasing acceleration in a first time interval and decreases with a continuously decreasing acceleration in a second time interval, in such a way that
15 the curve of the acceleration plotted against the time has a positive curvature.

In accordance with one aspect of this invention, there is provided a method for controlling the run-up of a conveyor belt (2), in which a setpoint value of the belt
20 speed (v^*) is increased with an increasing acceleration (a^*) in a first time interval (t_1) and is increased with a decreasing acceleration (a^*) in a second time interval (t_2), a curve of the acceleration (a^*) plotted against a time (t) having a positive curvature in the second interval (t_2), a
25 second time derivative of the acceleration (a^*) in the first and in the second time interval (t_1, t_2) being at least constant and at least equal and opposite.

In accordance with another aspect of this invention, there is provided a drive device for a conveyor
30 belt (2), having a motor (8) for driving a driving drum (4)

20365-4628

4a

and a control device (10) for controlling a setpoint value of the belt speed (v^*) during the run-up of the conveyor belt (2), in such a way that the acceleration (a^*) of the latter increases continuously in a first time interval (t_1) and
5 decreases continuously and with a positive curvature in a second time interval (t_2), a second time derivative of the acceleration (a^*) in the first and in the second time interval (t_1, t_2) being in each case at least constant and at least equal and opposite.

10 In order to explain the invention further, reference is made to the exemplary embodiment in the drawing, in which:

FIG. 1 shows a drive device according to the invention in a schematic basic representation,

15 FIG. 2 shows a graph in which the setpoint value of the speed, the acceleration and the first time derivative of the acceleration of the conveyor belt are in each case plotted against the time, and

FIG. 3 shows a graph in which the true belt speed
20 at the tail and at the head, the setpoint value of the belt speed, the acceleration and the motor torque are likewise plotted against the time,

FIGS 4 and 5 in each case show graphs analogous to FIGS 2 and 3 with a method known from the prior art for controlling the run-up of a conveyor belt.

5

According to FIG. 1, a conveyor belt 2 is driven by two driving drums 4. Deflection drums 6 are used to tension or deflect the conveyor belt 2. The driving drums 4 are assigned a motor 8, generally an electric motor, it not
10 being necessary for each driving drum 4 to be driven by a separate motor 8, as distinct from the exemplary embodiment illustrated.

The motors 8 are connected to a control device 10,
15 which controls the motor rotational speed n to the set point value n^* in accordance with a predefined run-up program. The setpoint value of the motor rotational speed n^* is proportional, depending on the transmission ratio of the gearbox, to the setpoint value of the
20 rotational speed of the driving rollers 4, which is in turn proportional to the setpoint value of the belt speed v^* of the conveyor belt 2. In practice, during the run-up or braking, the setpoint value of the belt speed v^* , predefined by the setpoint value of the motor
25 rotational speed n^* , does not agree with the real belt speed v_h and v_k at the tail (drive side) or head (deflection drum at the end of the belt), since the conveyor belt 2 is not an ideal rigid body but a real, elastically deformable body.

30

According to FIG. 2, the acceleration a^* , that is to say the first time derivative of the setpoint value of the speed v^* , increases continuously with a constant convex curvature during the run-up and reaches its
35 maximum value at the end of a first time interval t_1 (first jerk time). The acceleration a^* plotted in the figure in this case does not correspond to the real

acceleration of the conveyor belt 2, but is only the differential of the predefined time curve of the setpoint value of the belt speed v^* .

The first time derivative of the acceleration a^* , the jerk r , is positive and is reproduced by means of a straight line with a negative slope, which intersects the abscissa at the end of the first time interval t_1 .

- 5 The second time derivative of the acceleration a^* is therefore constant and negative, and the jerk r is equal to zero at the end of the first time interval t_1 .

- 10 In a second time interval t_2 , the acceleration operation is completed, the curve of the setpoint value of the acceleration a^* having a positive, that is to say an upwardly concave, curvature. The acceleration a^* decreases continuously and, at the end of the second time interval t_2 (second jerk time) reaches the
15 abscissa tangentially, that is to say the first time derivative of the acceleration a^* is equal to zero at the end of the second time interval t_1 .

- Likewise, the speed setpoint v^* ends gently in the
20 final setpoint value v_{end}^* , the final setpoint value v_{end}^* being driven particularly gently by the jerk r decreasing continuously down to zero. The second time derivative of the acceleration a^* is constant and positive in the second time interval. In the exemplary
25 embodiment, the jerk r in the first time interval t_1 and the jerk r in the second time interval t_2 are in each case predefined by straight lines whose slopes are equal and opposite.

- 30 Provided between the first time interval t_1 and the second time interval t_2 is a third time interval t_3 , in which the setpoint value of the belt speed v^* increases with a constant acceleration, that is to say linearly. Depending on the duration of the first jerk time t_1 or
35 of the third time interval t_3 , it is then possible to move to any desired end speeds without changing the characteristic of the curve. This is illustrated in the

figure by the curves drawn dashed for a situation in which the first jerk time is ended at the time t_s . The jerk r then jumps (in the ideal case) from a value r_s to a value r_s' . The second time

derivative of the jerk r for $t > t_s$ is constant and, in terms of magnitude, is equal to the second time derivative of the jerk r for $t < t_s$. The value r_s' then has to be determined in such a way that the time integral (hashed areas) over the jerk r vanishes. The reduction of the acceleration a^* to zero is then carried out with exactly the same curve as that also present in the end phase (curly bracket) of the curve a^* . With the course of the end phase of the run-up according to the invention, with a constant curve shape, it is therefore possible to drive to any desired final speeds v_{end}^* and the run-up can be terminated at any time without changing the curve characteristic when moving towards the final speed.

15

In FIG. 3, by using the plotted curves for the motor torque M and the actual speed of a conveyor belt at the head and at the tail, v_k , v_h , it can be seen that belt and torque fluctuations are virtually completely suppressed. The relationships represented in the FIG. reproduce the run-up operation for a conveyor belt on a typical belt system with a total jerk time of 20 seconds and a maximum standardized acceleration of $0.05s^{-1}$.

20

20365-4628

8

CLAIMS:

1. A method for controlling the run-up of a conveyor belt (2), in which a setpoint value of the belt speed (v^*) is increased with an increasing acceleration (a^*) in a first
5 time interval (t_1) and is increased with a decreasing acceleration (a^*) in a second time interval (t_2), a curve of the acceleration (a^*) plotted against a time (t) having a positive curvature in the second interval (t_2), a second time derivative of the acceleration (a^*) in the first and in
10 the second time interval (t_1 , t_2) being at least constant and at least equal and opposite.
2. The method as claimed in claim 1, in which a first time derivative of the acceleration (a^*) is at least equal to zero at the end of the second time interval (t_2).
- 15 3. The method as claimed in claim 1 or 2, in which the second time derivative of the acceleration (a^*) is positive in the second time interval (t_2).
4. The method as claimed in any one of claims 1 to 3, in which the second time derivative of the acceleration (a^*)
20 is negative in the first time interval (t_1).
5. The method as claimed in any one of claims 1 to 4, in which, between the first time interval (t_1) and the second time interval (t_2), a rotational speed setpoint (n^*) is increased with an at least constant acceleration (a^*) in a
25 third time interval (t_3).
6. A drive device for a conveyor belt (2), having a motor (8) for driving a driving drum (4) and a control device (10) for controlling a setpoint value of the belt speed (v^*) during the run-up of the conveyor belt (2), in
30 such a way that the acceleration (a^*) of the latter increases

20365-4628

9

continuously in a first time interval (t_1) and decreases continuously and with a positive curvature in a second time interval (t_2), a second time derivative of the acceleration (a^*) in the first and in the second time interval (t_1, t_2) being in each case at least constant and at least equal and opposite.

7. The drive device as claimed in claim 6, in which a first time derivative of the acceleration (a^*) is at least equal to zero at the end of the second time interval (t_2).

10 8. The drive device as claimed in claim 6 or 7, in which the second time derivative of the acceleration (a^*) is positive in the second time interval (t_2).

9. The drive device as claimed in claim 7 in conjunction with claim 8, in which the second time derivative of the acceleration (a^*) is negative in the first time interval (t_1).

15

FETHERSTONHAUGH & CO.

OTTAWA, CANADA

PATENT AGENTS

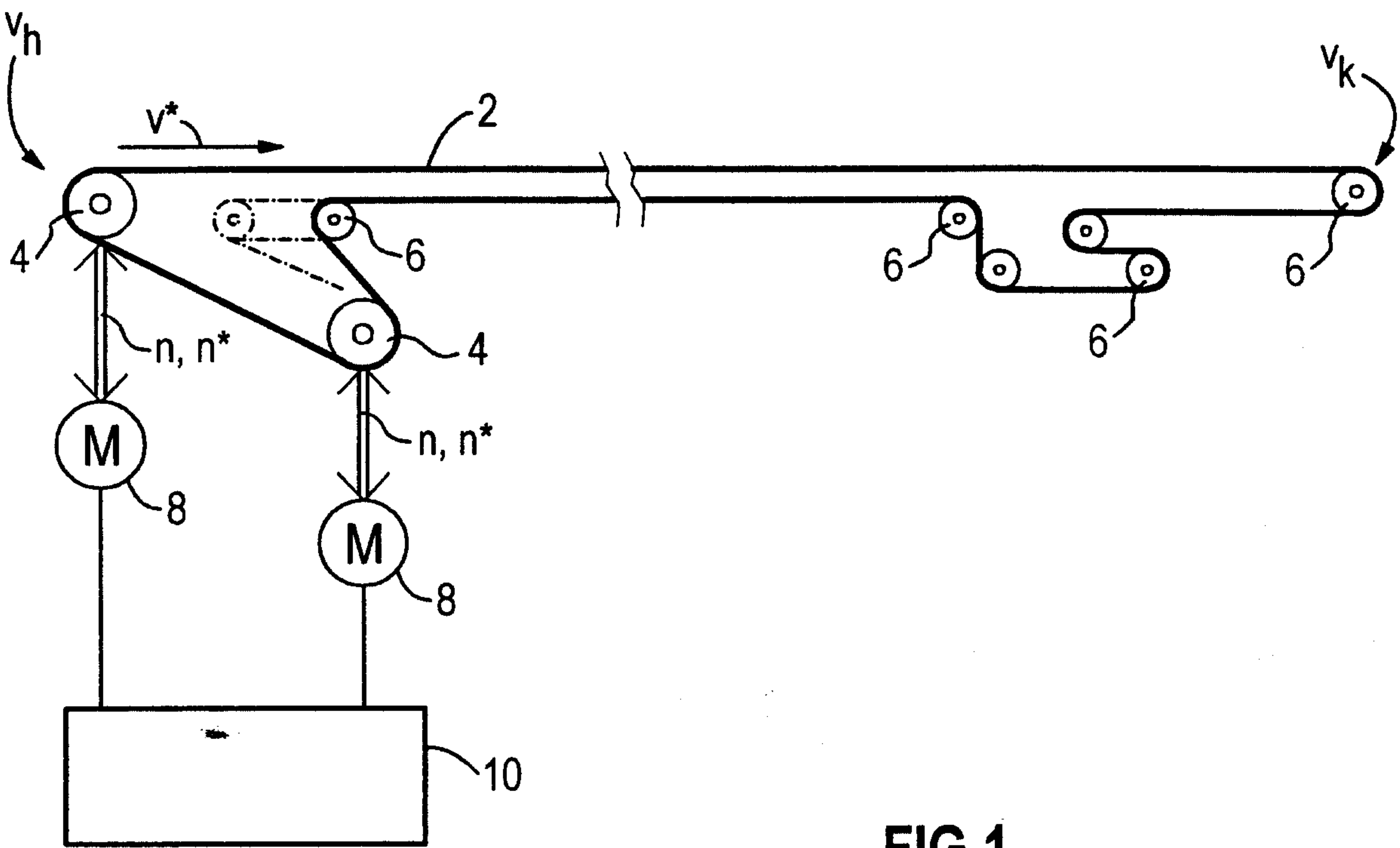


FIG 1

2/5

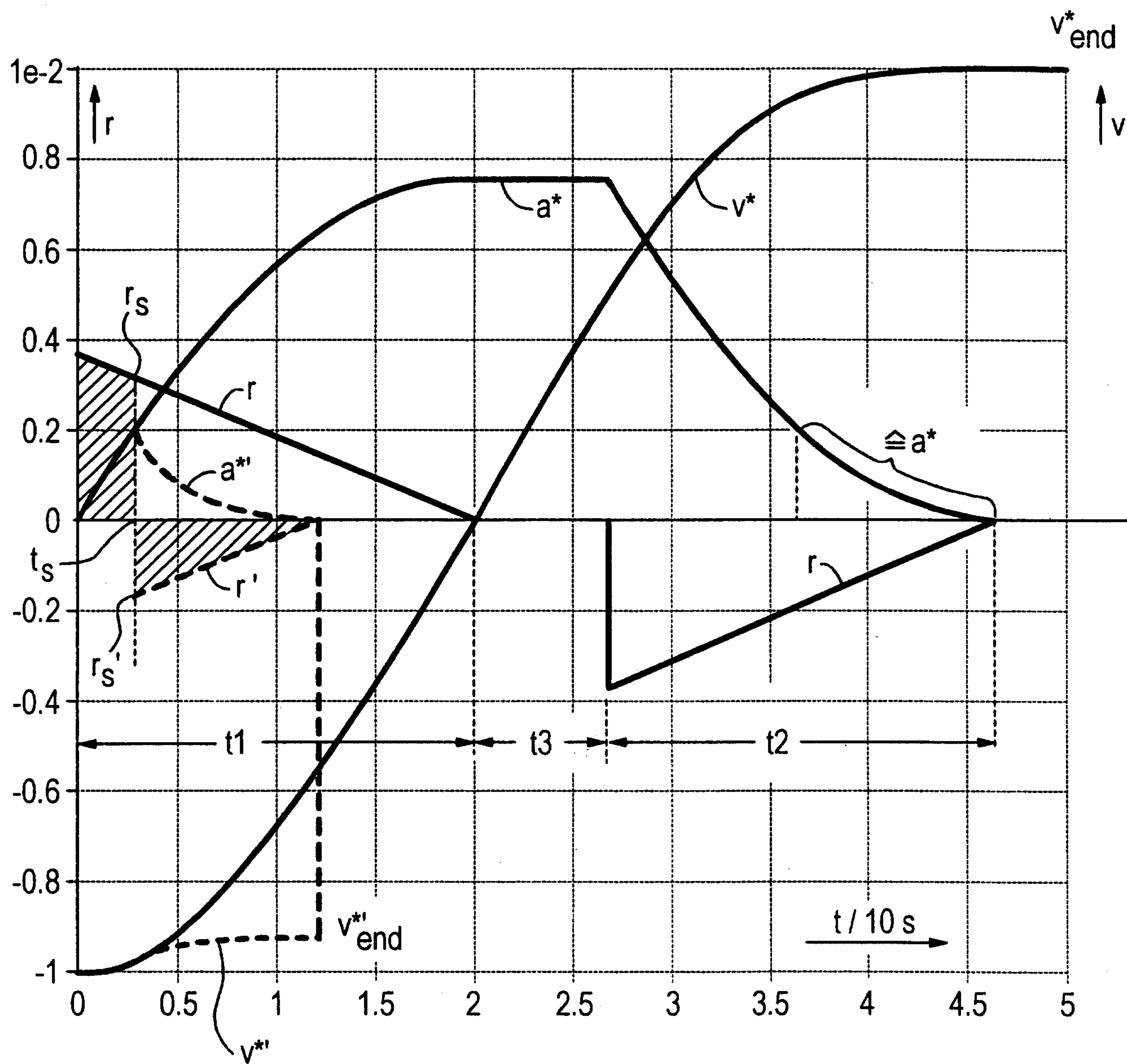


FIG 2

3/5

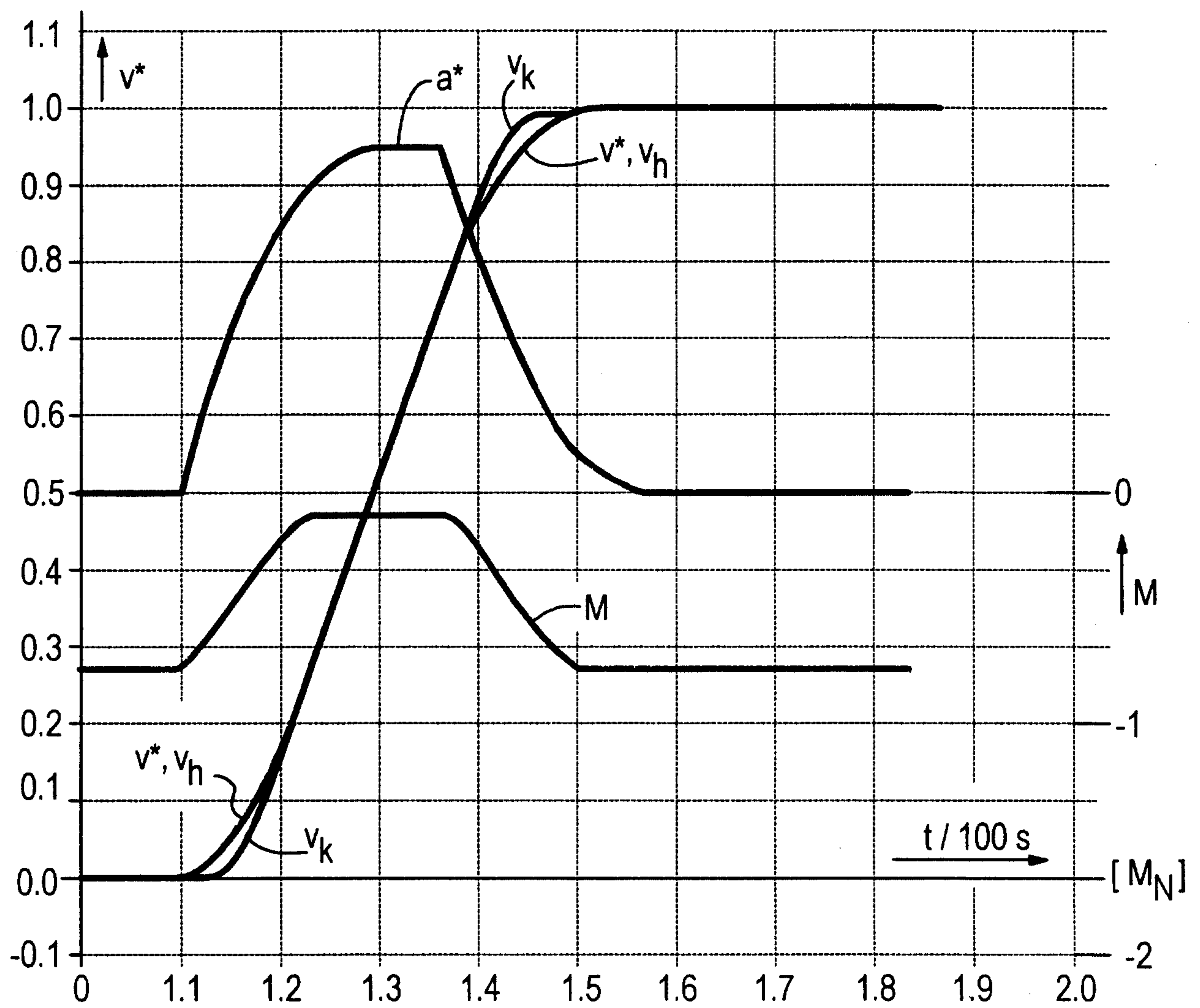


FIG 3

4/5

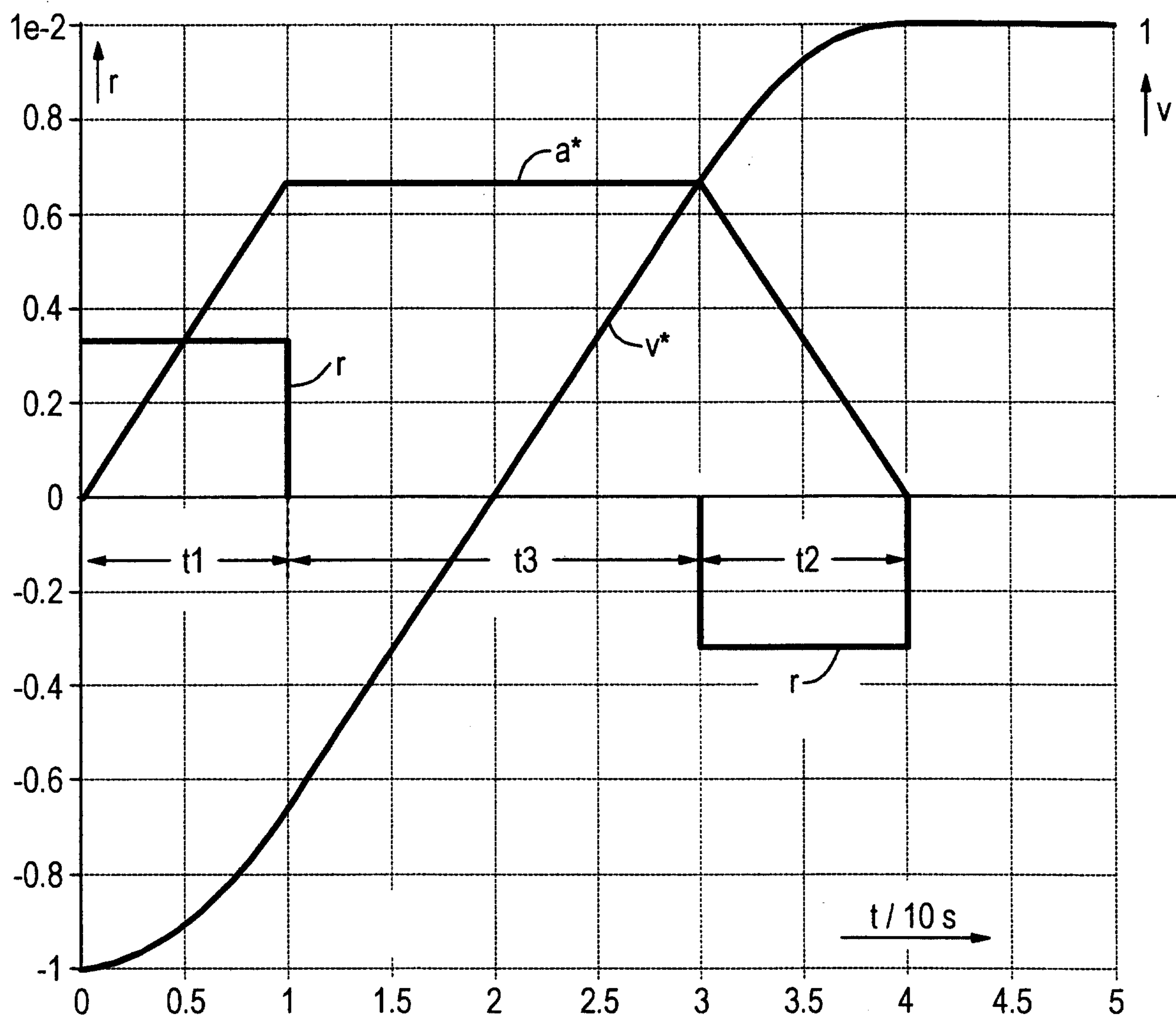


FIG 4
Stand der Technik

5/5

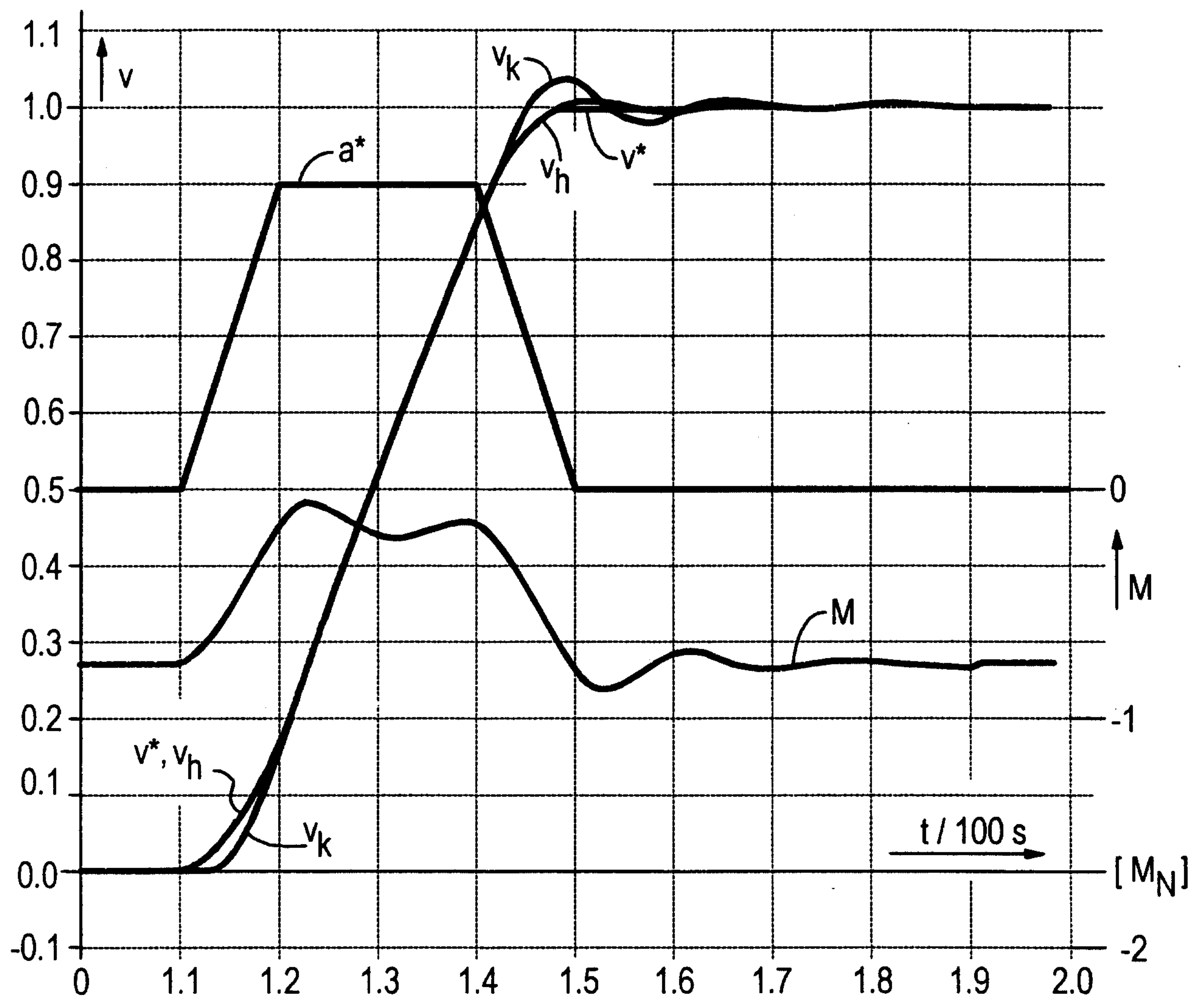


FIG 5
Stand der Technik

