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Description

The present invention relates to a method of continuous casting of steel and an apparatus therefor, or more in particular to a method and an apparatus for compression continuous casting of steel in which steel cast is drawn along a path including a curved reforming section and the driving force is applied to the steel cast upstream of the reforming section while the braking force is applied thereto downstream of the reforming section.

Compression continuous casting of steel of this type is disclosed in Japanese Patent Publications No. 34025/70, No. 39227/71, No. 9972/79, No. 9973/79, No. 10925/79 and No. 51664/80, and Japanese Patent Applications Laid-Open No. 128358/80 and No. 133855/80.

Reference is also made to US—A—4148349 also showing a compression continuous casting method and apparatus with the possibility to reduce the braking force in case of a slip between the cast and the drive rollers.

It is the object of the present invention to provide a method and apparatus for continuous casting in which the casting speed is maintained stable and the drive rollers are driven with a torque which is as near to the critical torque as possible, but not so large as to cause the drive rollers to slip.

In conventional methods of compression continuous casting, the steel drive torque or steel pressing force of the drive rollers upstream of the reforming section is controlled in such a manner as to apply a predetermined compressive force to the steel cast at the steel reforming section under given casting conditions. As disclosed in Japanese Patent Application Laid-Open No. 133855/80, for example, the torque of the drive rollers is increased progressively with advancement of the steel cast. In view of the basic arrangement of the continuous casting such that stable operation is achieved by speed control of the drive rollers, however, it is desirable to maintain the drive torque of the drive rollers constant on the one hand and to maintain the compressive force as large and stable as possible on the other hand.

The present invention provides a method of compression continuous casting comprising the steps of drawing a steel cast along a path including a curved reforming section by applying a driving force to driver rollers for feeding the cast upstream of said reforming section, applying a braking force to the cast downstream of said reforming section thereby subjecting said cast to a compressive force at said reforming section, and reducing the braking force when a slip occurs between said cast and at least one of said drive rollers, characterized by:

controlling said braking force so that said driving force does not exceed but approaches as near as possible a predetermined limit chosen to prevent a slip between said drive rollers and said cast.

In this way, the casting speed is stabilized and the compressive force is maintained at a high value within a predetermined range. In this case, it is necessary to take into consideration the slip of the drive rollers which may be caused by variations of frictional resistance between the steel cast and the drive rollers. Such a slip, if caused, changes the casting speed. According to a preferred embodiment of the present invention, said braking force is increased when the slip ceases, so that said driving force again approaches said predetermined limit.

In the case where a brake roller slips, on the other hand, the compressive force decreases, and if the slip is considerable, the casting speed changes momentarily. The decrease in the brake force due to a slip is larger than the reduction of the brake force which is provided for eliminating the slip. According to another preferred embodiment of the present invention, therefore, the drive roller and the brake roller are monitored for a slip, and if any of the rollers slips, the brake force of the brake roller is reduced, and when the slip ceases, the brake force thereof is increased again.

The invention also provides an apparatus for compression continuous casting in which steel cast is drawn along a path including a curved reforming section, while a drive force is applied to driver rollers means for feeding the cast upstream of said reforming section and a braking force is applied to the cast downstream of said reforming section thereby subjecting said cast to a compression force at said reforming section, said apparatus comprising means for detecting a slip between said cast and said driver roller means and means for controlling said braking force so that said braking force is reduced when the slip is detected, characterized by:

means for comparing the actual drive torque of said drive roller means with a predetermined limit of said drive torque thereby producing a control signal according to the difference therebetween,

means responsive to said control signal for controlling the braking force so that said actual drive torque of said driver roller means approaches said predetermined limit, when the slip is not detected.

One way of carrying out the invention is described in detail below with reference to drawings which illustrate only one specific embodiment, in which:

Fig. 1 is a block diagram showing the construction of an apparatus for performing a method according to the present invention;

Fig. 2 is a block diagram showing a circuit of the brake control device shown in Fig. 1; and

Figs. 3a to 3e are graphs of measurement data obtained in an actual application using the method of the present invention, in which Fig. 3a shows the drawing speed of the steel cast, Fig. 3b shows a target drive torque, Fig. 3c shows the drive current of the drive motor and Figs. 3d and 3e show the control current of the brake motor.

In Fig. 1, guide rollers including drive rollers and brake rollers are divided into a drive group upstream of a curved reforming section 1 and brake groups I and II downstream thereof. The drive force of motors (not shown) coupled to the drive rollers (black circles) of the drive group and the brake force of motors (not shown) coupled to the brake rollers (black circles) of the brake groups I and II are controlled by the brake control device 2.

The slip, if any, of the drive group is detected by slip sensors 3_1 and 3_2, while the slip of the brake group I is detected by slip sensors 3_3 and 3_4, and that of the brake group II is detected by slip sensors 3_5 and 3_6. Each of these slip sensors is supplied with a signal generated by a tacho-generator coupled to one of the drive or brake rollers and a signal generated by a tacho-generator coupled to one of non-drive guide rollers. The two signals are smoothed and compared with each other by the slip sensor, and if the rotational speed of the drive roller is higher than that of the non-drive guide roller by more than a predetermined value, or if the rotational speed of the non-drive roller is higher that that of the brake roller by more than a predetermined value, then the slip sensor generates a signal of high level "1", which signal is applied through an OR gate to the brake control device 2.

A steel cast sensor 4_1 is arranged at a predetermined position in the brake group I, so that when the leading end of the steel cast entering the particular region reaches that position, it is detected and a signal of high level "1" is generated. This "1" signal is applied to the brake control device 2 as a brake start signal for the brake group I. This is in order not to start the braking operation of the brake group I before the steel cast enters the region of the brake group I by more than a certain distance (hereinafter called the effective brake distance) in view of the fact that a sufficient braking effect does not act on the steel cast unless the steel cast enters the region of the brake group I by more than the effective brake distance. Similarly, the region of the brake group II includes a steel sensor 4_2 for generating a signal of high level "1" when the steel cast enters the region by the effective brake distance. This "1" signal is applied to the brake control device 2 as a brake start signal for the brake group II.

A configuration of the brake control device 2 is shown in Fig. 2. The brake control device 2 is impressed with a target value indicative of the critical drive torque or motor current which is sufficiently large to maintain the speed of the motors (drive group) determined by the casting conditions, and provides the steel cast portion of the curved reforming section with a desired compressive force but not so large as to cause any slip between the steel cast and the drive rollers or the brake rollers. The brake control device 2 is also supplied with an actual drive torque or motor current for driving the drive rollers. The difference (error) between the critical drive torque and the actual drive torque is computed at the device 2 and an error signal representing the difference is applied to a slow ramp circuit 2a. The slow ramp circuit 2a includes a limiter LMC1 and an integrator INT1. The portion of the error signal above the positive limit which is predetermined by taking into consideration the characteristics of the apparatus and the operating conditions thereof and the portion thereof lower than the negative limit similarly predetermined are cut off by the limiter LMC1 so that an error signal confined within the two critical limits is applied to the integrator INT1. The integrator INT1 integrates this error signal by a comparatively long predetermined time constant so that sharp variations of the error signal level are absorbed, thereby producing a stable signal level with moderate variations, if any.

The error signal T thus stabilized is applied to brake force proportional distributors $2b_1$ and $2b_2$ including operational amplifiers. The distributors $2b_1$ and $2b_2$ are supplied, through a switch SW1a, with the load share or ratio A of the brake torque or motor current of the motors for the brake group I and, through a switch SW2a, with the load share or ratio B of the brake torque or motor current of the motors for the brake group II. When the input T is applied to the distributors $2b_1$ and $2b_2$, the distributors $2b_1$ and $2b_2$ produce outputs

$$\frac{A}{A+B}\cdot T \quad \text{and} \quad \frac{B}{A+B}\cdot T$$

respectively. The output of the distributor $2b_1$ makes up a brake control signal for controlling the brake current for the motors for the brake group I, while the output of the distributor $2b_2$ provides a brake control signal for controlling the motors for the brake group II. These signals are applied to the slow ramp circuits $2c_1$ and $2c_2$ respectively, which are constructed similarly to the slow ramp circuit 2a and include a limiter for cutting off those portions of the brake current for each brake group which exceed a predetermined critical value, above which a slip may occur, and an integrator for smoothing the brake control current to minimize the unfavorable effect on the casting speed control. The control signal thus smoothed is applied through the switches SW1b and SW2b to brake current control loops $2d_1$ and $2d_2$ respectively. The drive speed control loops $2e_1$ and $2e_2$ are provided for driving the motors for the brake groups I and II under non-braking conditions, and are supplied with a speed indication signal for indicating the rotational speed through the switches SW1c and SW2c respectively.

The integrators or the slow ramp circuits $2c_1$ and $2c_2$ are connected with a brake reducing circuit 2f, which includes a brake cancel level setter DCV and a switch SW3. When this switch SW3 is closed, a signal corresponding to the setting of the setter DCV is applied to the integrators of the circuits $2c_1$ and $2c_2$. Each of the integrators operates in such a manner as to suspend the integration of a first input from the corresponding limiter and integrate a second input from the setter DCV negatively. As a result, the output of the integrators is rapidly reduced at a rate corresponding to the second input, so that the indication value of the brake current (generation current) to the brake current loops $2d_1$ and $2d_2$ is reduced thereby to lower the brake torque of the brake motor. This switch SW3 is closed when the output of the OR gate is high at "1", namely, when one of the drive rollers or brake rollers slips, and is opened when the output of the OR gate is reduced to "0" after the slip. When the switch SW3 opens, the integrators of the circuits $2c_1$ and $2c_2$ resume the integration of the first input from the limiters, so that the output thereof increases at a rate corresponding to the first input.

The switches SW1a to SW1c are operatively interlocked with each other; the switches SW1a and SW1b being normally open, the switch SW1c being normally closed. When the output of the steel cast sensor 4_1 (Fig. 1) increases to high level of "1" indicating the detection of steel cast, the switches SW1a and SW1b are closed and the switch SW1c is opened. The switches SW2a to SW2c are also operatively interlocked with each other in such a manner that when the output of the steel cast sensor 4_2 increases to high level of "1" indicating the detection of steel cast, the switches SW2a and SW2b are closed while the switch SW2c is opened. In Fig. 2, SW4a and SW4b designate normally-open switches for controlling the drive of the steel cast at the time of drawing thereof.

Now, the operation of the brake control device 2 will be explained with reference to Figs. 1 and 2. Immediately before the steel cast enters the braking region of the brake group I, a torque setting of the motors of the drive motor group perdetermined as mentioned above according to the casting conditions and the actual torque or current value of the motors are applied to the brake control device 2. Also, the switches SW4a and SW4b are closed. Since the steel cast sensors 4_1 and 4_2 have not yet detected the steel cast, the switches SW1c and SW2c are closed while the switches SW1b and SW2b are open, and the motors of the brake groups I and II are activated as motors at a speed corresponding to a speed indication.

When the steel cast enters the braking region of the brake group I and the steel cast sensor 4_1 is turned on, the switches SW1a and SW1b are closed and the switch SW1c is opened. Since the switch SW2a is still open, B=0, and the ouput

$$\frac{A}{A}\cdot T=T$$

of the distributor $2b_1$ is applied to the slow ramp circuit $2c_1$, so that the torque or dynamic braking current limited by the limiter thereof is applied to the brake current control group $2d_1$. As a result, the motors of the brake group I are switched to dynamic braking, thus starting the brake control as controlling the brake torque toward the target brake torque T determined as above-mentioned or toward a maximum brake torque determined by the limiter of the circuit $2c_1$, when the target torque T is higher than the brake critical value.

When the steel cast enters the braking region of the brake group II, the switches SW2a and SW2b are closed and the switch SW2c is opened. The distributor $2b_1$ produces an output of

$$\frac{A}{A+B}\cdot T$$

and the distributor $2b_2$ produces an output of

$$\frac{B}{A+B}\cdot T.$$

With these outputs as a target, both the brake groups I and II exert the braking force on the steel cast. In any case, the braking force does not exceed the above-mentioned upper critical value, in view of the fact that this force is controlled to a target value lower than the upper critical value in consideration of the slip of the drive motors. The limiter and the integrator prevent a sudden change of the total torque applied to the steel cast, and therefore the speed of the motors for the drive group is not changed greatly. Depending on the surface conditions of the steel cast, a slip may occur, and when such a slip occurs, the switch SW3 is closed, so that the output of the integrators of the slow ramp circuits $2c_1$ and $2c_2$ is sharply reduced and the braking dynamic current of the brake groups I and II is decreased thereby to sharply reduce the braking force. The slip is rapidly eliminated. Also, the switch SW3 is opened, and the outputs of the integrators of the circuits $2c_1$ and $2c_2$ are restored at a slow rate by the difference between the braking current target value and actual braking current, thus increasing the braking force.

Before the last steel cast passes the drive zone of the drive group, the switches SW4a and SW4b are opened, while the switches SW1b and SW2b are opened and the switches SW1c and SW2c are closed, with the result that the motors of the brake groups I and II are driven as motors at the designated speed. The outputs of the steel cast sensors 4_1 and 4_2 and the output of the OR gate are applied to a control board and a drive group motor control system.

The motor torque and the motor current are proportional to each other and, in the above description of the embodiment, the motor torque has the same meaning as the motor current.

Measurement data obtained by controlling the braking operation by the above-mentioned controlling method as shown in Figs. 3a to 3b. Fig. 3a shows the drawing speed of the steel cast, Fig. 3b shows a drive torque setting of the motor for the drive group, Fig. 3c shows an energizing current (corresponding to torque) of the motors for the drive group, and Figs. 3d and 3e show a drive current (+) for speed control and a generation current (corresponding to the braking torque) for braking operation of the motors of the brake groups I and II respectively. These drawings share a time axis or abscissa.

Comparison of Figs. 3c, 3d and 3e shows that the energization current (torque) of the motors of the drive group undergoes only a small change after starting of braking by the group I and that the motors of the brake groups I and II perform a predetermined braking operation in stable manner.

Claims

1. A method of compression continuous casting comprising the steps of drawing a steel cast along a path including a curved reforming section (1) by applying a drive force to driver rollers for feeding the cast upstream of said reforming section, applying a braking force to the cast downstream of said reforming section thereby subjecting said cast to a compressive force at said reforming section, and reducing the braking force when a slip occurs between said cast and at least one of said drive rollers, characterized by:

controlling said braking force so that said driving force does not exceed but approaches as near as possible a predetermined limit chosen to prevent a slip between said drive rollers and said cast.

2. A method according to Claim 1, including increasing said braking force when the slip ceases, so that said driving force again approaches said predetermined limit.

3. A method according to Claim 2, further comprising:

the step of dividing the portion downstream of the curved reforming section into a plurality of braking regions (I, II) and predetermining the ratio of braking force to be shared by each of said regions, and

the step of distributing the control amount of brake force among said regions according to said ratio in order to control the brake force of each region in accordance with the brake force to be shared thereby.

4. A method according to Claim 3, further comprising:

the step of controlling the brake force of each of said regions by smoothing the control amount of the brake force distributed among the regions in order not to cause a sudden change of the brake force.

5. An apparatus for compression continuous casting in which steel cast is drawn along a path including a curved reforming section (1) while a drive force is applied to the driver roller means for feeding the cast upstream of said reforming section and a braking force is applied to the cast downstream of said reforming section thereby subjecting said cast to a compression force at said reforming section, said apparatus comprising means (3_1, 3_2) for detecting a slip between said cast and said drive roller means and means (2f) for controlling said braking force so that said braking force is reduced when the slip is detected, characterized by:

means (2a) for comparing the actual drive torque of said drive roller means with a predetermined limit of said drive torque thereby producing a control signal (T) in accordance with the difference therebetween, means ($2b_1$, $2b_2$, $2c_1$, $2c_2$, $2d_1$, $2d_2$) responsive to said control signal for controlling the braking force so that said actual drive torque of said driver roller means approaches said predetermined limit, when the slip is not detected.

6. An apparatus according to Claim 5, in which said control signal generator means includes first means (LMC1) for preventing said control signal from exceeding a predetermined value and second means (INT1) for smoothing said control signal.

7. An apparatus according to Claim 6, further comprising:

means ($2b_1$, $2b_2$) for dividing the portion of said apparatus downstream of said section into a plurality of brake regions (I, II) and distributing said control signal among said regions according to a predetermined ratio of the brake force to be shared by each of said regions; and

means ($2c_1$, $2c_2$) provided for each of said regions for generating a region control signal for controlling the brake force of said regions in response to said distributed control signal.

8. An apparatus according to Claim 7, in which said region control signal generator means includes third means (SLMC1, SLMC2) for preventing said region control signal from exceeding a predetermined value and fourth means (SINT1, SINT2) for smoothing said region control signal.

Patentansprüche

1. Verfahren zum Druchstranggießen mit den folgenden Verfahrensschritten:

Ziehen eines Stahlstrangs entlang eines Wegs einschließlich eines gekrümmten Umformabschnitts (1) durch Anwenden einer Antriebskraft auf Antriebswalzen zum Zuführen des Strangs oberhalb des Umformabschnitts, Anwenden einer Bremskraft auf den Strang unterhalb des Umformabschnitts, wodurch dor Strang am Umformabschnitt einer Druckkraft ausgesetzt wird, und Verringern der Bremskraft, wenn zwischen dem Strang und mindestens einer der Antriebswalzen ein Schlupf auftritt, gekennzeichnet durch:

Steuern der Bremskraft derart, daß dei Antriebskraft einen vorbestimmten Grenzwert, der zur Verhinderung eines Schlupfs zwischen den Antriebswalzen und dem Strang gewählt wurde, nicht überschreitet, aber sich dem Grenzwert so nahe als möglich annähert.

2. Verfahren nach Anspruch 1, wobei die Bremskraft erhöht wird, wenn der Schlupf beendet ist, so daß sich die Antriebskraft wieder dem vorbestimmten Grenzwert annähert.

3. Verfahren nach Anspruch 2, ferner Gekennzeichnet durch die folgenden Verfahrensschritte:

Aufteilen des Abschnitts unterhalb des gekrümmten Umformabschnitts in mehrere Bremsbereiche (I, II) und Bestimmen des Verhältnisses der Bremskraft, die von jedem der Bereiche Übernommen wird, und

Verteilen des Steueranteils der Bremskraft auf die Bereiche gemäß diesem Verhältnis, so daß die Bremskraft jedes Bereichs gamäß der von diesem Bereich übernommenen Bremskraft gesteuert wird.

4. Verfahren nach Anspruch 3, ferner gekennzeichnet durch folgenden Verfahrensschritt:

Steuern der Bremskraft jedes Bereichs durch Glätten des Steueranteils der Bremskraft, der auf die Bereiche aufgeteilt wird, um eine plötzliche Änderung der Bremskraft zu verhindern.

5. Vorrichtung zum Druckstranggießen, wobei ein Stahlstrang entlang eines Wegs einschließlich eines gekrümmten Umformabschnitts (1) gezogen wird, während eine Antriebskraft auf eine Antriebswalzeneinrichtung zum Zuführen des Strangs oberhalb des Umformabschnitts und eine Bremskraft auf den Strang unterhalb des Umformabschnitts ausgeübt wird, wodurch der Strang am UMformabschnitt einer Druckkraft ausgesetzt wird, und wobei die Vorrichtung eine Einrichtung (3_1, 3_2) zum Erfassen eines Schlupfs zwischen dem Strang und der Antriebswalzeneinrichtung und eine Einrichtung (2f) zum Steuern der Bremskraft derart aufweist, daß die Bremskraft verringert wird, wenn der Schlupf erfaßt wird, gekennzeichnet durch:

eine Einrichtung (2a) zum Vergleichen des tatsächlichen Antriebsdrehmoments der Antriebswalzeneinrichtung mit einem bestimmten Grenzwert des Antriebsdrehmoments, wodurch ein Steuersignal (T) gemäß dem Unterschied zwischen den beiden Werten erzeugt wird, und

eine auf das Steuersignal ansprechende Einrichtung ($2b_1$, $2b_2$, $2c_1$, $2c_2$, $2d_1$, $2d_2$) zum Steuern der Bremskraft derart, daß das tatsächliche Antriebsdrehmoment der Antriebswalzeneinrichtung sich dem bestimmten Grenzwert nähert, wenn kein Schlupf erfaßt wird.

6. Vorrichtung nach Anspruch 5, wobei die Steuersignalerzeugungseinrichtung eine erste Einrichtung (LMC1) aufweist, die verhindert, daß das Steuersignal einen bestimmten Grenzwert überschreitet, und eine zweite Einrichtung (INT1) zum Glätten des Steuersignals.

7. Vorrichtung nach Anspruch 6, ferner gekennzeichnet durch:

eine Einrichtung ($2b_1$, $2b_2$) zum Aufteilen des Teils der Vorrichtung unterhalb des Abschnitts in mehrere Bremsbereiche (I, II) und Verteilen des Steuersignals auf diese Bereiche gemäß einem bestimmten Verhältnis der Bremskraft, die von jedem Bereich übernommen wird; und

eine für jeden der Bereiche vorgesehene Einrichtung ($2c_1$, $2c_2$) zum Erzeugen eines Bereichssteuersignals zum Steuern der Bremskraft jedes Bereichs als Antwort auf das verteilte Steuersignal.

8. Vorrichtung nach Anspruch 7, wobei die Erzeugungseinrichtung für das Bereichssteuersignal eine dritte Einrichtung (SLMC1, SLMC2) aufweist, die verhindert, daß das Bereichssteuersignal einen bestimmten Grenzwert übersteigt, und eine vierte Einrichtung (SINT1, SINT2) zum Glätten des Bereichssteuersignals.

Revendications

1. Procédé de coulée continue avec compression comprenant les opérations consistant à extraire l'acier coulé suivant une trajectoire comportant une section de refaçonnage courbe (1), en appliquant une force d'entraînement à des rouleaux entraîneurs assurant l'amenée de l'acier coulé en amont de ladite section de refaçonnage, à appliquer une force de freinage à l'acier coulé en aval de ladite section de refaçonnage ce qui soumet l'acier coulé à une force de compression au niveau de ladite section de refaçonnage, et à réduire la force de freinage lorsqu'un patinage apparaît entre ledit acier coulé et l'un au moins desdits rouleaux entraîneurs, caractérisé en ce qu'on règle ladite force de freinage de façon que cette force de freinage ne dépasse pas mais approche d'aussi près que possible une limite déterminée choisie pour éviter un patinage entre lesdits rouleaux entraîneurs et ledit acier coulé.

2. Procédé selon la revendication 1, comportant l'augmentation de ladite force de freinage lors de la cessation du patinage, de façon que ladite force d'entraînement se rapproche de ladite limite déterminée.

3. Procédé selon la revendication 2, comprenant encore:

— opération consistant à diviser la partie d'aval de la section de refaçonnage courbe en une série de régions de freinage (I, II) et à préfixer le rapport de prise en charge de force de freinage pour chacune desdites régions, et
— opération de répartition du degré réglé de force de freinage entre lesdites régions d'après ledit rapport en vue de régler la force de freinage de chaque région d'après la force de freinage que celle-ci doit prendre en charge.

4. Procédé selon la revendication 3, comprenant encore:

— l'opération consistant à régler la force de freinage de chacune desdites régions en lissant le degré de réglage de force de freinage réparti entre les régions en vue de ne pas provoquer une modification brusque de la force de freinage.

5. Appareil de coulée continue avec compression dans lequel l'acier coulé est extrait suivant une trajectoire comportant une section de refaçonnage courbe (1), tandis qu'une force d'entraînement est appliquée à des rouleaux

entraîneurs assurant l'amenée de l'acier coulé en amont de ladite section de refaçonnage et qu'une force de freinage est appliquée à l'acier coulé en aval de ladite section de refaçonnage ce qui soumet l'acier coulé à une force de compression au niveau de ladite section de refaçonnage, ledit appareil comprenant des moyens (3_1, 3_2) de détection d'un patinage entre ledit acier coulé et lesdits rouleaux entraîneurs et des moyens (2f) propres à régler ladite force de freinage de façon que cette force de freinage soit réduite quand le patinage est détecté, caractérisé par:

— des moyens (2a) propres à comparer le couple réel d'entraînement desdits rouleaux entraîneurs avec une limite déterminée dudit couple d'entraînement en engendrant par là un signal de réglage (T) en fonction de la différence les séparant, des moyens ($2b_1$, $2b_2$, $2c_1$, $2c_2$, $2d_1$, $2d_2$) agissant en réponse audit signal de réglage pour régler la force de freinage de façon que ledit couple réel d'entraînement desdits rouleaux entraîneurs se rapproche de ladite limite déterminée, quand le patinage n'est pas détecté.

6. Appareil selon la revendication 5, dans lequel lesdits moyens générateurs de signal de réglage comportent de premiers moyens (LMC1) propres à empêcher ledit signal de réglage de dépasser une valeur déterminée et de second moyens (INT1) propres à lisser ledit signal de réglage.

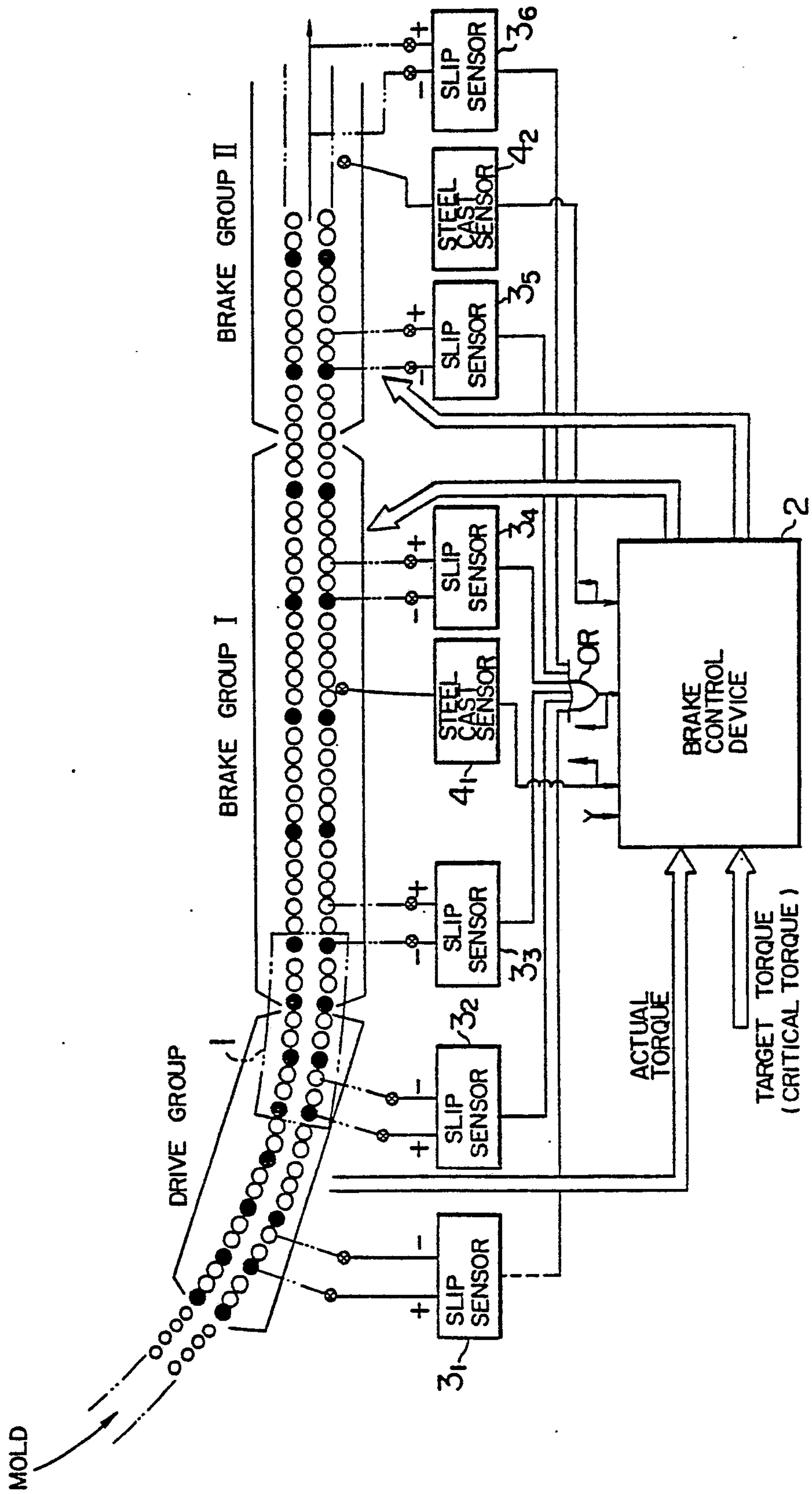
7. Appareil selon la revendication 6, comprenant encore:

— des moyens ($2b_1$, $2b_2$) propres à diviser la partie dudit appareil située en aval de ladite section en une série de régions de freinage (I, II) et à répartir ledit signal de rélage entre ces régions en fonction d'un rapport déterminé de prise en charge de la force de freinage par chacune desdites régions; et

— des moyens ($2c_1$, $2c_2$) affectés à chacure desdites régions pour engendrer un signal de réglage de région propre à régler la force de freinage desdites régions en réponse audit signal de réglage réparti.

8. Appareil selon la revendication 7, dans lequel lesdits moyens générateurs de signal de réglage de région comportent de troisièmes moyens (SLMC1, SLMC2) propres à empêcher ledit signal de réglage de région à dépasser une valeur déterminée et de quatrièmes moyens (SINT1, SINT2) propres à lisser ledit signal de réglage de region.

FIG. I


MOLD
DRIVE GROUP
1
BRAKE GROUP I
BRAKE GROUP II
SLIP SENSOR
3_1
3_2
3_3
3_4
3_5
3_6
STEEL CAST SENSOR
4_1
4_2
OR
BRAKE CONTROL DEVICE
2
ACTUAL TORQUE
TARGET TORQUE (CRITICAL TORQUE)

F I G. 2

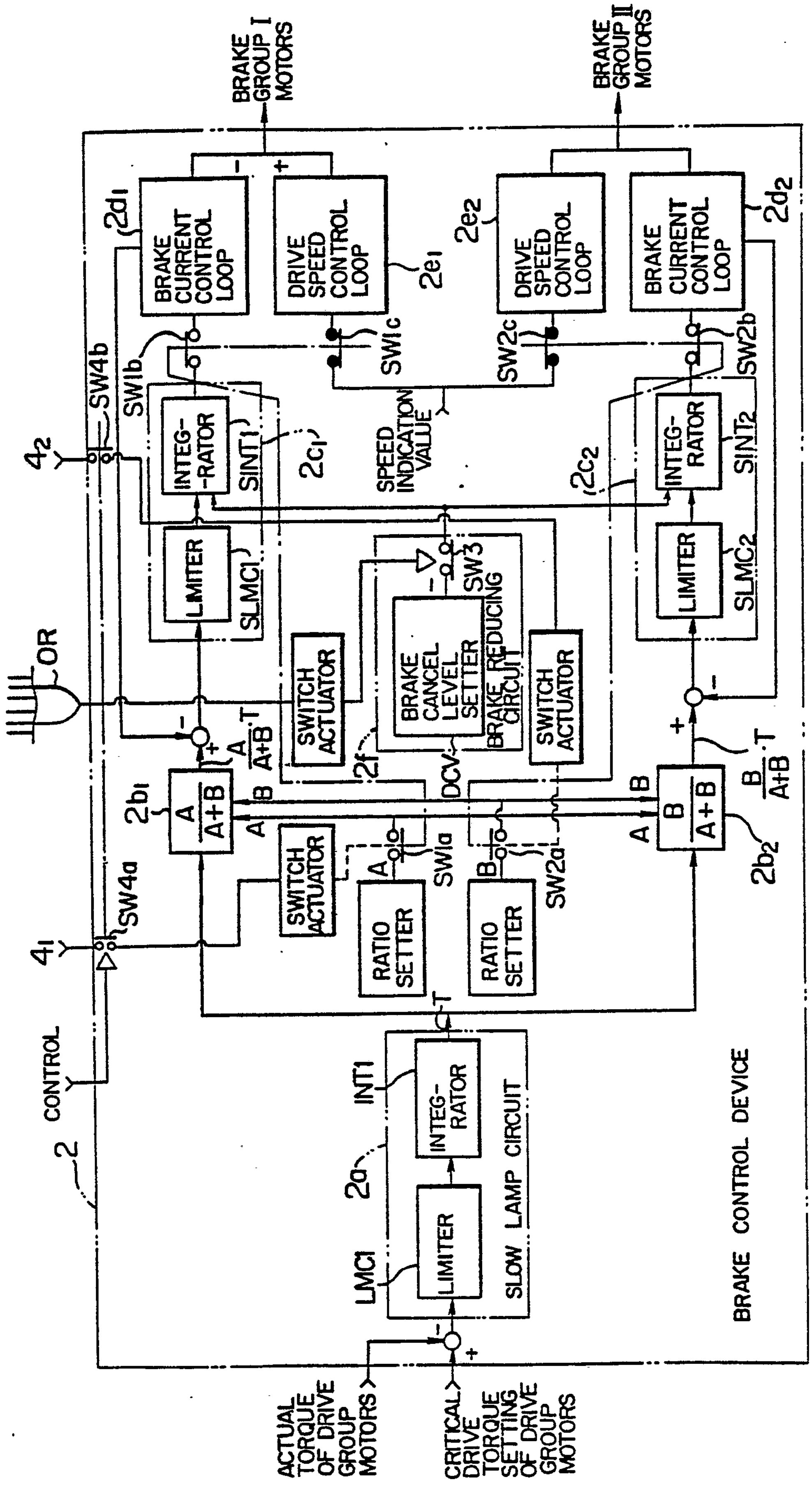

BRAKE GROUP I MOTORS
BRAKE GROUP II MOTORS
BRAKE CURRENT CONTROL LOOP
DRIVE SPEED CONTROL LOOP
DRIVE SPEED CONTROL LOOP
BRAKE CURRENT CONTROL LOOP
2d1
2e1
2e2
2d2
SW4b
SW1b
SW1c
SW2c
SW2b
SPEED INDICATION VALUE
INTEG-RATOR
SINT1
2c1
INTEG-RATOR
SINT2
2c2
LIMITER
SLMC1
LIMITER
SLMC2
SW3
BRAKE CANCEL LEVEL SETTER
BRAKE REDUCING CIRCUIT
SWITCH ACTUATOR
SWITCH ACTUATOR
2f
DCV
3₁ ~ 3₆
OR
4₂
4₁
SW4a
CONTROL
2b1
A / A+B
A / (A+B) · T
B / A+B
B / (A+B) · T
2b2
SWITCH ACTUATOR
RATIO SETTER
RATIO SETTER
SW1a
SW2a
T
INT1
INTEG-RATOR
2a
LIMITER
LMC1
SLOW LAMP CIRCUIT
2
BRAKE CONTROL DEVICE
ACTUAL TORQUE OF DRIVE GROUP MOTORS
CRITICAL DRIVE TORQUE SETTING OF DRIVE GROUP MOTORS

FIG. 3a

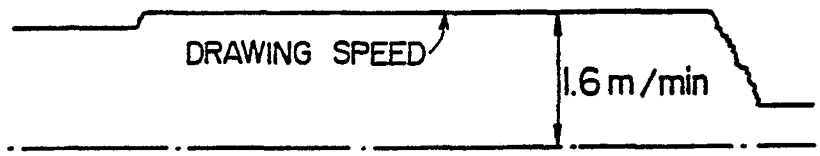


FIG. 3b

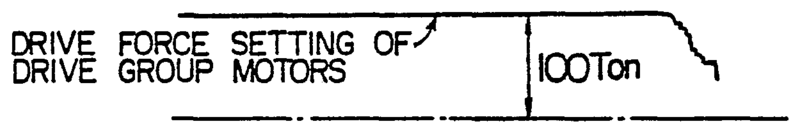


FIG. 3c

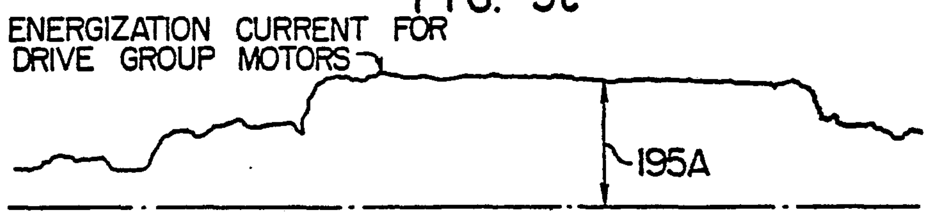


FIG. 3d

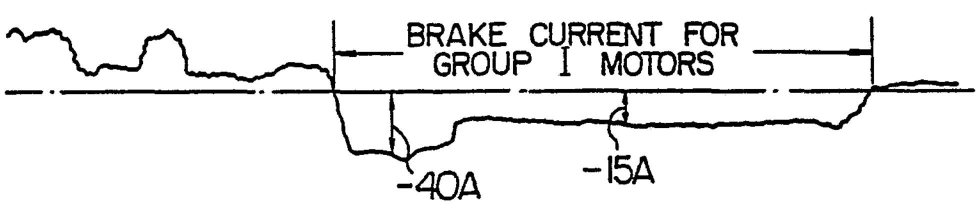


FIG. 3e