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BRAKE, IN PARTICULAR FOR A DRIVE OF A HOIST**CROSS-REFERENCES TO RELATED APPLICATIONS**

This application claims the priority of German Patent Application, Serial No. 199 16 413.4, filed April 1, 1999, the subject matter of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to a brake. The present invention further relates to a hoist having incorporated such a brake.

It is generally known, especially in typical electricity meters, to generate for speed-dependent braking action a corresponding counter torque by means of an electrically conductive flat brake disk and a magnetic field which is produced by a horseshoe-shaped permanent magnet and oriented transversely to the brake disk. The magnetic field acts on a portion of the brake disk, whereby the brake disk moves through an air gap of the U-shaped permanent magnet. This leads in the brake disk to an inducement of a current which is approximately proportional to the rotational speed whereby the current circuit is closed across the portion of the brake disk that is not located in the magnetic field. The current flow generates an opposing magnetic field and, as a consequence of the resultant magnetic forces, the counter torque, to thereby effect a deceleration of the brake disk. The counter torque is dependent on the mean radial distance of the magnetic field from the rotation axis of the brake disk since the portion of the brake disk, penetrated by the magnetic field, moves, at constant rotational speed of the brake disk, through the magnetic field at growing radius and increasing velocity.

It is further known to provide drives for hoists for lifting and lowering loads with a squirrel-cage type induction motor as power driven and generator torque producing electric motor (so-called four-quadrant motor), and in addition with a brake, in particular to effect a delay and to hold a load. The rotational speed of squirrel-cage

1 type induction motors is independent from the rotation direction of the brake disk and
2 from the load, and generates by itself a desired braking torque when the load is
3 lowered, i.e. when the load drives the motor. Typically, electromagnetic brakes or
4 friction disk brakes are utilized as mechanical brakes.

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9 **SUMMARY OF THE INVENTION**

10
11 It is an object of the present invention to provide an improved rotation-direction
12 dependent brake which is cost-efficient, compact and wear-resistant.

13
14 It is another object of the present invention to provide an improved brake, which is
15 applicable for a drive of a hoist, in particular for a drive having a motor, e.g. a cost-
16 efficient universal motor, which does not produce a generator torque and/or runs at a
17 highly load-dependent rotational speed as well as includes a self-locking gear
18 mechanism.

19
20 These objects, and others which will become apparent hereinafter, are attained in
21 accordance with the present invention by providing an electrically conducting brake
22 disk rotating about a rotation axis; two magnetic poles positioned on both sides of the
23 brake disk and defining a magnetic north and a magnetic south; for establishing a
24 magnetic field directed transversely to the brake disk and acting, at least temporarily,
25 on a portion of the brake disk, wherein the magnetic field has an orientation which
26 depends on a rotation direction of the brake disk and generates a reactive force
27 which retards the movement of the brake disk and is dependent from the rotation
28 speed of the brake disk as well as from a radial distance from the rotation axis,
29 wherein the magnetic poles are movable by the reactive force, in opposition to a
30 return force applied by an elastic member, from a rest position along a predetermined
31 path in rotation direction of the brake disk, wherein the radial distance is preset
32 during movement along the path by a desired course of the rotation direction
33 dependent and rotational speed dependent braking force and adjustable by the
34 return force of the elastic member.

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1 A brake according to the present invention is configured as eddy-current brake which
2 is especially suitable for a rotary drive in the form of a dc motor or ac motor, without
3 producing a generator torque and with highly load-dependent rotational speed, i.e.
4 universal motors. In conjunction in particular with hoists, the use of such inexpensive
5 universal motors is problematic because as a consequence of the lacking generator
6 torque, universal motors cannot be decelerated in the normally simple way.
7 Moreover, operation of universal motors is greatly dependent on the load and the
8 rotational speed. When not subject to a load, universal motors exhibit a tendency to
9 easily "overspin", i.e. the rotational speed increases significantly. For that reason,
10 universal motors should always run with a load. Moreover, the braking action should
11 be dependent on the rotational speed, when used in hoists because a braking
12 moment is only required during lowering of a load. Therefore, in accordance with the
13 present invention, the magnetic poles are initially in a rest position. Only when the
14 brake disk revolves will the magnetic poles move along the predetermined path as
15 defined by a constraining guidance. The movement along this path is carried out in
16 opposition to the return force applied by the elastic member, whereby the radial
17 distance of the magnetic poles from the rotation axis of the brake disk varies during
18 movement of the magnetic poles along the path. For example, the radial distance
19 may steadily increase in proportional relation to the rotational speed of the brake
20 disk, with the extent of the increase in both rotation directions being of different
21 magnitude. During lifting, the braking moment of the brake disk can thus be set much
22 smaller.

23

24 Suitably, the elastic member may be configured as a helical spring which
25 automatically adjusts the predetermined radial distance with its spring tension
26 according to the spring characteristic. This represents a simple solution and requires
27 merely a selection of a helical spring of desired spring characteristic.

28

29 According to one aspect of the present invention, both magnetic poles may be
30 located on a U-shaped permanent magnet.

31

32 According to another aspect of the present invention, the constraining guidance for
33 conducting the magnetic poles along the predetermined path can be implemented by
34 locating both magnetic poles on a free end of a swivel member which embraces the
35 brake disk in a U-shaped manner and swings about a pivot axis extending in parallel

1 relation to the rotation axis. Suitably, the swivel member swings at a pivot angle
2 which is limited by a stop member. Thus, during swinging from a predetermined
3 rotation speed, the greatest possible braking moment may be effective, with the
4 magnetic poles positioned at a location of relatively great radial distance from the
5 rotation axis.

6
7 The brake characteristic of the eddy-current brake can be configured for directional
8 dependency by providing a second magnetic field which is aligned in a direction
9 transversely to the brake disk and formed by further two magnetic poles. The
10 provision of this second magnetic field is effective only in one rotation direction, i.e. in
11 the event of a hoist only in the rotation direction that implements a lowering of a load.

12
13 According to another feature of the present invention, the swivel member includes
14 two arms, with the magnetic poles of the two magnetic fields being located,
15 respectively, on the free ends of both arms of the swivel member. A simplification can
16 be realized when the second magnetic field acts only in one rotation direction of the
17 brake disk and is located outside the brake disk when the brake disk rotates in the
18 other rotation direction.

19
20 It is still another object of the present invention to provide an improved hoist which
21 includes a simple brake.

22
23 This object is attained in accordance with the present invention by providing a lifting
24 mechanism, which includes an electric motor configured as a dc motor or ac motor,
25 which does not produce a generator torque and/or has a highly load-dependent
26 rotation speed, and with a brake mechanism which is comprised of a self-locking
27 gear mechanism, e.g. a worm gear, and an eddy-current brake. The eddy-current
28 brake supports the gear mechanism which does not apply a braking action in the
29 upper rotational speed range. At standstill, the statically self-locking gear mechanism
30 solely provides the braking and holding functions.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will be more readily apparent upon reading the following description of a preferred exemplified embodiment of the invention with reference to the accompanying drawing, in which:

FIG. 1 is a simplified illustration of an eddy-current brake according to the present invention, for use with a hoist, with the brake shown in a position for lowering a load;

FIG. 2 is a simplified illustration of the eddy-current brake of FIG. 1, showing the brake in a position for lifting at full load or nominal load;

FIG. 3 is a simplified illustration of the eddy-current brake of FIG. 1, showing the brake in a position for lifting with no load;

FIG. 4 is a plan view of the eddy-current brake of FIG. 1; and

FIG. 5 is a partially sectional view of a hoist having integrated therein an eddy-current brake of FIG. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Throughout all the Figures, same or corresponding elements are generally indicated by same reference numerals.

Turning now to the drawing, and in particular to FIG. 1, there is shown a simplified illustration of an eddy-current brake according to the present invention, including a flat circular disk which is made of an electrically conducting material, e.g. aluminum, and serves as a brake disk 1. The brake disk 1 is driven by an electric motor 1a (FIG. 5), which is configured as universal motor, for rotation about a rotation axis 4. The

1 eddy-current brake further includes a swivel member 2 which is rotatable about a
2 pivot axis 3 extending parallel to the rotation axis 4. The swivel member 2 embraces
3 the brake disk 1 in a U-shaped manner, as best seen in FIG. 4, thereby defining two
4 parallel legs which have located thereon two magnetic poles 5 arranged in spaced-
5 apart relationship at formation of an air gap, and forming a magnetic north 5a and a
6 magnetic south 5b in confronting disposition. Both magnetic poles 5 generate a
7 magnetic field which is oriented transversely to the brake disk 1 and passes through
8 the brake disk 1 locally in the area of the magnetic poles 5.

9
10 When the brake disk 1 revolves, an electric current is induced in the brake disk 1 in
11 the area of the magnetic poles 5, with the electric current being directed radially and
12 closing across those portions of the brake disk 1 which are not located in the
13 magnetic field. This current in turn generates an opposing magnetic field which
14 generates a reactive force and counteracts its cause, which means that the rotational
15 movement of the brake disk 1 is retarded. The strength of the opposing magnetic
16 field depends on the rotational speed of the brake disk 1 as well as on the radial
17 distance of the magnetic poles 5 from the rotation axis 4 of the brake disk 1, and the
18 orientation of the opposing magnetic field is determined by the rotation direction of
19 the brake disk 1. The opposing magnetic field swings hereby the swivel member 2
20 with the magnetic poles 5 about the pivot axis 3.

21
22 The swivel member 2 forms a constraining guidance, i.e. the swivel member 2
23 describes about the pivot axis 3 an arc of a circle for defining a predetermined path
24 for the magnetic poles 5 to move across the brake disk 1. During movement across
25 the brake disk 1, the radial distance of both magnetic poles 5 from the rotation axis 4
26 of the brake disk 1 varies.

27
28 As further shown in FIG. 1, the swivel member 2 is acted upon by an elastic element
29 in the form of a helical spring 6 which is secured on both its ends on respective pins
30 11 and applies a return force that resists a movement of the magnetic poles 5 from
31 their rest position as a result of the induced opposing magnetic field. The rest
32 position is not shown in the drawing and represents the position of the swivel
33 member 2 when the brake disk 1 is at a standstill. Although not shown in the drawing,
34 it is certainly conceivable to replace a single helical spring 6 with two such helical
35 springs, located on each side of the swivel member 2, with the effective characteristic

1 curve being established through superimposition of both individual characteristic
2 curves of these helical springs.

3

4 The swivel member 2 further interacts with a stop member 7 by which the pivot angle
5 of the swivel member 2 is so restricted on one side that the radial distance of the
6 magnetic poles 5 from the rotation axis 4 assumes a greatest possible value.

7

8 As shown in FIG. 1, the swivel member 2 is configured as two-armed lever, having a
9 long arm 8 and a short arm 9 which extends perpendicular to the arm 8. The radial
10 distance between the point of attachment of the arm 9 to the arm 8 and the pivot axis
11 3 is significantly shorter than the radial distance of the magnetic poles 5 from the
12 pivot axis 3. The short arm 9 has a free end for supporting a further pair of magnetic
13 poles 10 which define a magnetic north 10a and a magnetic south 10b in a same
14 manner as the magnetic poles 5 on the arm 8.

15

16 The entire magnetic field of both magnetic poles 10 acts in FIG. 1 fully on the brake
17 disk 1 as a load (not shown) is lowered, whereas in FIGS. 2 and 3, the magnetic
18 poles 10 are located outside the brake disk 1 and therefore cannot apply a braking
19 action during lifting of a load. The two-armed swivel member 2 thus realizes in a
20 simple manner a greater braking action in one rotation direction. In FIGS. 2 and 3,
21 the swivel member 2 is shown in two dispositions in the opposite rotation direction
22 and at two different rotational speeds, with the rotational speed in FIG. 2 being
23 smaller than the rotational speed of the brake disk 1 in FIG. 3, and thus application of
24 a respectively smaller braking action.

25

26 FIG. 4 shows a plan view of the eddy-current brake of FIG. 1. For sake of simplicity,
27 the electromotor 1a is shown here only by way of its motor shaft 41 which is
28 operatively connected to the brake disk 1.

29

30 Turning now to FIG. 5, there is shown a partially sectional view from above of a hoist
31 having integrated therein the eddy-current brake of FIG. 1, generally designated here
32 by reference numeral 53. For the sake of simplicity, the eddy-current brake will be
33 described in the context of FIG. 5 only in connection with those parts that are
34 necessary for the understanding of the present invention. Parts of the eddy-current

1 brake corresponding with those in FIG. 1 are denoted by identical reference
2 numerals and not explained again.

3
4 The hoist has a block-shaped housing 51 which accommodates in a common plane
5 the electric motor 1a in the form of a universal motor which can be operated with DC
6 and AC, the eddy-current brake 53, a self-locking worm gear 54 having a rotary shaft
7 59, and a traction drive 55 which may be configured as rope drive or chain drive. The
8 motor shaft 41 extends in parallel relation to the rotary shaft 59 of the worm gear 54
9 and is operatively connected with the rotary shaft 59 via a belt drive 60 having a belt
10 60a which is trained over a drive pulley 61 in the form of a gear, and a driven gear
11 62. The pulley 61 is mounted on the output side to the motor shaft 41 and the driven
12 gear 62 is mounted to the rotary shaft 59 of the worm gear 54. The traction drive 55
13 is driven directly by the worm gear 54 and secured within a carrier frame 56 between
14 the electric motor 1a and the worm gear 54. As further shown in FIG. 5, the traction
15 drive 55 rotates about a rotation axis which is oriented perpendicular to the rotary
16 shaft 59 of the worm gear 54, and has a roller or drum for a traction member 63
17 which is guided to the outside via a suitable opening (not shown) in the housing 51.

18
19 The housing 51 has an inlet opening 64 and an outlet opening 65 for circulation of
20 cooling air, as indicated by the arrows in FIG. 5, by means of a fan 68 mounted on
21 the output-distal end of the motor shaft 41. A partition wall 66 subdivides the interior
22 of the housing 51 into a compartment that includes the electric motor 1a and is
23 cooled by the circulating air, and an adjacent compartment in which the worm drive
24 54 and the traction drive 55 are located. Only a small opening 57 for the passage of
25 the belt 60a is provided in the partition wall 66. The fan 68 draws cooling air through
26 the inlet opening 64 and forces air through the housing compartment being cooled in
27 a direction longitudinally of the motor shaft 41. Thus, cooling air cools the electric
28 motor 1a as well as the brake disk 1 during operation of the motor. The brake disk 1
29 is arranged anteriorly of the outlet opening 15 so that cooling air necessarily flows
30 across the brake disk 1.

31 The worm drive 54 has a static self-locking action which is so adjusted that the worm
32 drive 54 is capable to hold even a greatest load when the electric motor 1a is at a
33 standstill. The braking action is at a maximum at small rotational speed and
34 decreases with increasing rotational speed of the worm. Through combination of the
35 self-locking worm gear 54 with the eddy-current brake 53, a desired speed-

1 dependent and rotation-direction-dependent braking torque can be established in a
2 simple manner and at a fairly wide adjustment range, including the rotational speed
3 zero.
4

5 The configuration of the electric motor 1a in the form of a very inexpensive universal
6 motor is advantageous. The universal motor 1a includes a stator winding and a rotor
7 winding and does not produce a generator torque and can therefore not be braked by
8 the generator torque. The windings are connected in series, and can be operated
9 with DC and AC. The rotational speed behavior of the universal motor 1a is highly
10 load-dependent. This characteristic can be reduced to an acceptable level through
11 the integration of the eddy-current brake 53. The hoist is hereby operated by means
12 of the eddy-current brake 53 and the worm gear 54 at a base load torque so that the
13 universal motor 1a runs stable when no load is applied despite its tendency under
14 these conditions to overspin. This means that the eddy-current brake 53 assumes in
15 a hoist in conjunction with the self-locking gear mechanism, preferably a worm gear
16 54, the braking function, with the eddy-current brake 53 supporting the worm gear 54
17 in the higher rotational speed range when the braking action of the worm gear 54
18 weakens or is ineffective altogether. At standstill, the static self-locking worm gear 54
19 solely applies the braking action.
20

21 While the invention has been illustrated and described as embodied in a brake, in
22 particular for a drive of a hoist, it is not intended to be limited to the details shown
23 since various modifications and structural changes may be made without departing in
24 any way from the spirit of the present invention.
25

26 What is claimed as new and desired to be protected by Letters Patent is set forth in
27 the appended claims:

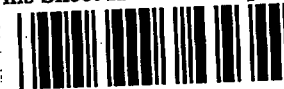


CLAIMS

What is claimed is:

1. A brake, in particular for a hoist drive of a type including an universal motor and a self-locking worm gear mechanism, comprising:
 - an electrically conducting brake disk rotating about a rotation axis;
 - magnetic means including a first pair of magnetic poles, positioned on both sides of the brake disk and defining a magnetic north and a magnetic south, for establishing a first magnetic field directed transversely to the brake disk and acting, at least temporarily, on a portion of the brake disk, said magnetic field having an orientation which depends on a rotation direction of the brake disk and generating a reactive force which retards the movement of the brake disk and is dependent on the rotation speed of the brake disk as well as a radial distance from the rotation axis;
 - a constraining mechanism for guiding the magnetic poles along a predetermined path; and
 - an elastic member, said magnetic poles being movable by the reactive force, in opposition to a return force applied by the elastic member, from a rest position along the predetermined path in rotation direction of the brake disk, wherein the radial distance is preset during movement along the path by a desired course of the rotation direction dependent and rotational speed dependent braking force and adjustable by the return force of the elastic member.
2. The brake of claim 1, wherein the elastic member is a spring applying a spring force which automatically adjusts the predetermined radial distance in correspondence to its spring characteristic.
3. The brake of claim 1, wherein the magnetic means includes a U-shaped permanent magnet having free ends, one of the magnetic poles located on one free end and the other one of the magnetic poles located on the other





- 1 free end.
- 2
- 3 4. The brake of claim 1, wherein the constraining mechanism includes a swivel
- 4 member which embraces the brake disk in a U-shaped manner and has free
- 5 ends, one of the magnetic poles located on one free end and the other one of
- 6 the magnetic poles located on the other free end, said swivel member
- 7 swinging about a pivot axis oriented in parallel relation to the rotation axis.
- 8
- 9 5. The brake of claim 4, wherein the swivel member swings at a pivot angle, and
- 10 further comprising a stop member for limiting the pivot angle.
- 11
- 12 6. The brake of claim 1, wherein the magnetic means includes a second pair of
- 13 magnetic poles for generating a second magnetic field which is aligned in a
- 14 direction transversely to the brake disk.
- 15
- 16 7. The brake of claim 4, wherein the magnetic means includes a second pair of
- 17 magnetic poles for generating a second magnetic field which is aligned in a
- 18 direction transversely to the brake disk, said swivel member having two arms,
- 19 each of the arms defining a free end, with the magnetic poles of the first
- 20 magnetic field located on the free end of one of the arms of the swivel
- 21 member, and with the magnetic poles of the second magnetic field located on
- 22 the free end of the other one of the arms of the swivel member.
- 23
- 24 8. The brake of claim 6, wherein the second magnetic field acts upon the brake
- 25 disk only in one rotation direction and is located in the other rotation direction
- 26 outside the brake disk.
- 27
- 28 9. A hoist, in particular small hoist, comprising a lifting mechanism including an
- 29 electric motor configured as a dc motor or ac motor, which does not produce
- 30 a generator torque and/or has a load-dependent rotation speed; and a brake
- 31 mechanism which includes a self-locking gear mechanism and an
- 32 eddy-current brake.
- 33
- 34 10. The hoist of claim 9, wherein the self-locking gear mechanism is a worm gear.
- 35



1 11. The hoist of claim 9, wherein the eddy-current brake is a brake according to
2 claim 1.

3

4 12. The hoist of claim 9 wherein the electric motor is a universal motor.

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