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(19) **United States**(12) **Patent Application Publication****Jonen et al.**(10) **Pub. No.: US 2006/0102317 A1**(43) **Pub. Date: May 18, 2006**(54) **ELECTROMAGNETIC BRAKING DEVICE
FOR MOLTEN STEEL THAT FLOWS INTO A
CONTINUOUS CASTING MOLD****Publication Classification**(51) **Int. Cl.****B22D 27/02** (2006.01)**B22D 11/00** (2006.01)(52) **U.S. Cl.** **164/502; 164/466**(76) Inventors: **Peter Jonen**, Duisburg (DE); **Karl Rittner**, Hilden (DE); **Jurgen Muller**, Kaarst (DE); **Hans Streubel**, Erkrath (DE)

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ABSTRACT

The invention relates to an electromagnetic braking device for molten steel that flows into a continuous casting mould (1). Said device comprises at least one solenoid (2) with a ferromagnetic core (5) that is allocated to the broad sides (3, 4) of the mould. To reduce the oscillating mass and at the same time increase the strength of the magnetic field, the core (5) consists of a primary part (6) that houses the solenoid (2) and can be displaced at a distance from the broad side walls (3, 4) and attachments (8, 8') that are fixed in water tanks (7, 7') of the mould (1). When combined in their operating position, the core parts (6, 8) produce U-shaped yokes (9, 9') for generating a closed magnetic flux (10) and when moved apart, cause the magnetic flux (10) to be interrupted.

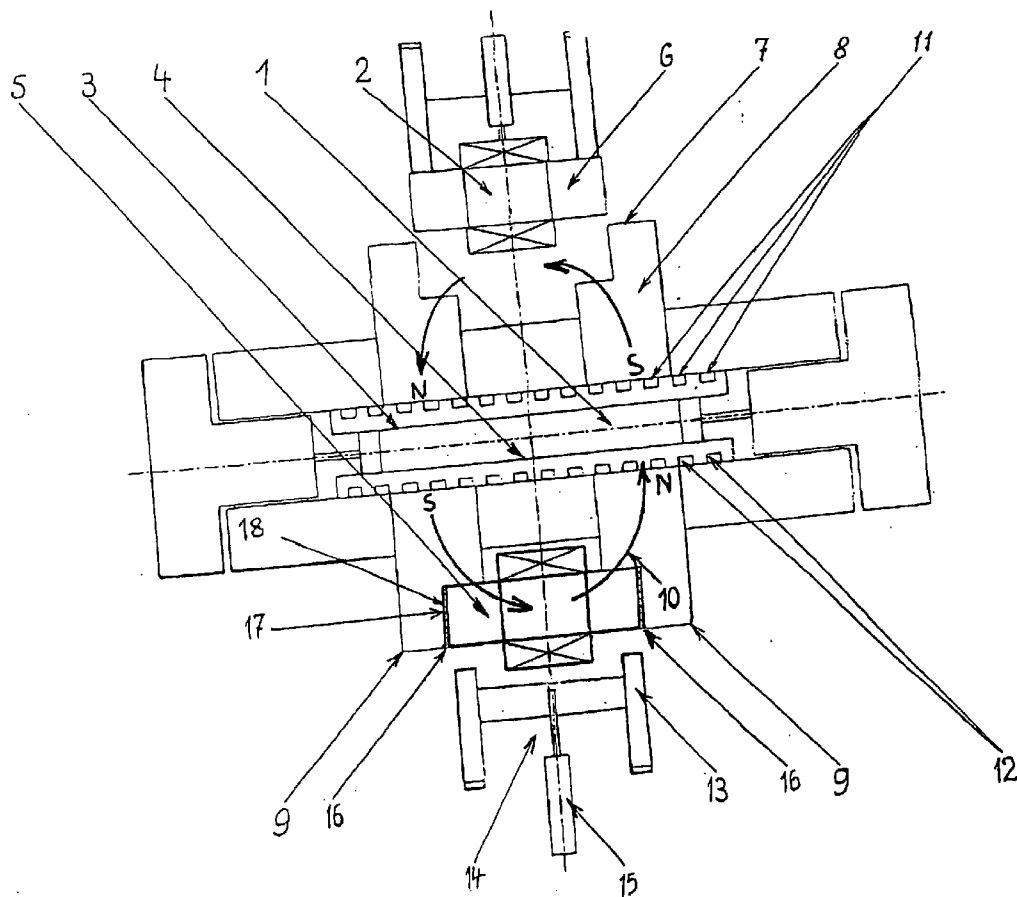
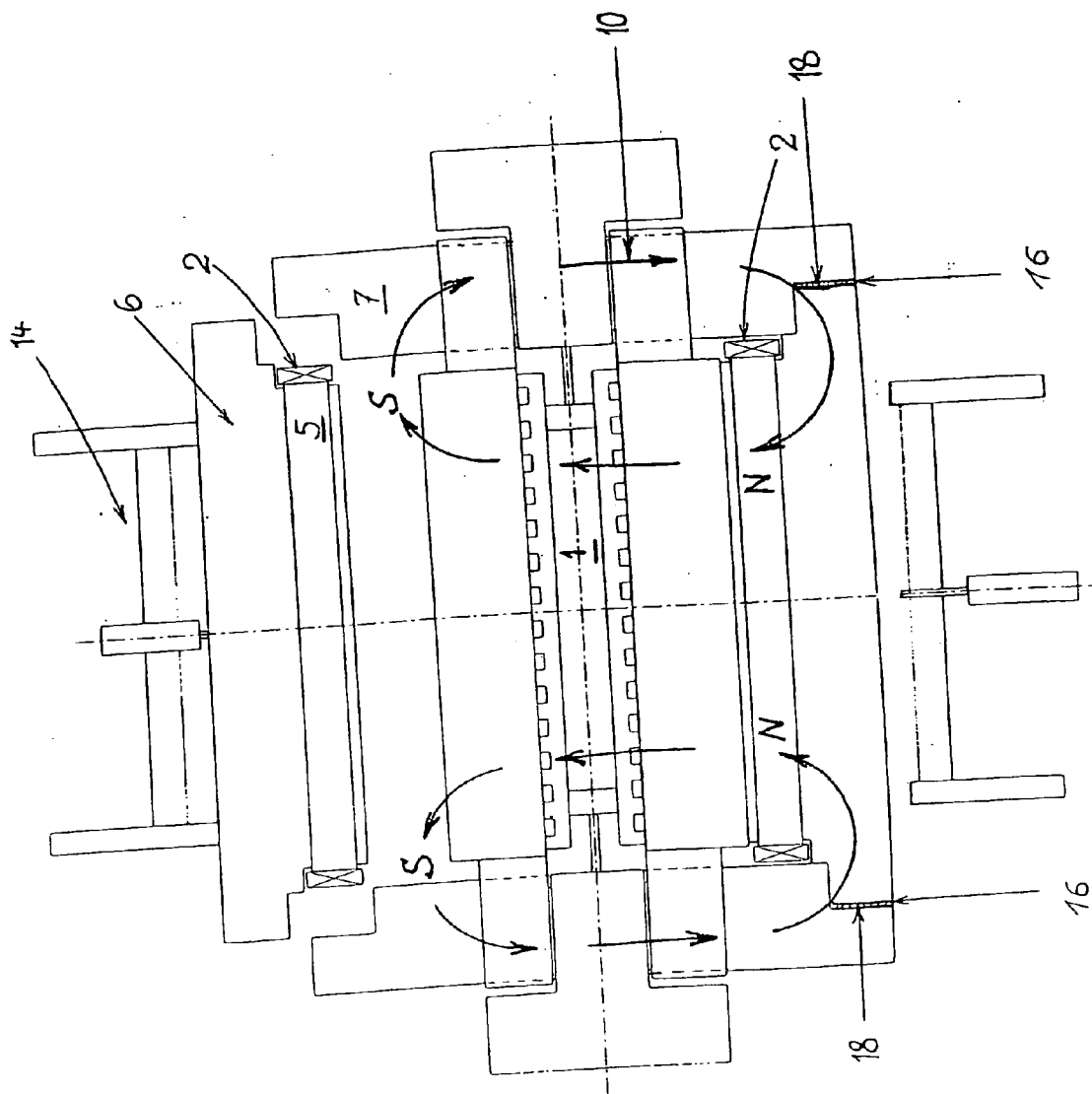


Fig. 2



ELECTROMAGNETIC BRAKING DEVICE FOR MOLTEN STEEL THAT FLOWS INTO A CONTINUOUS CASTING MOLD

[0001] The invention concerns an electromagnetic braking device for molten steel flowing into a continuous casting mold, which comprises at least one magnet coil with a ferromagnetic core assigned to the broad sides of the mold.

[0002] When charged in a continuous casting plant with an electromagnetic braking device, in order to reduce turbulence, the casting stream flowing into the mold is braked and straightened by a magnetic field acting between the broad sides of the continuous casting mold. To generate the magnetic field, ferromagnetic cores are mounted on copper plates on the broad side of the continuous casting mold and are energized by coils surrounding them. The braking and straightening of the casting stream effected by the magnetic field quiets the steel bath and reduces turbulence in it for the purpose of achieving uniform casting of steel strands.

[0003] Electromagnetic brakes that are permanently integrated in molds are well known. A disadvantage of this solution to the problem is that, due to the electromagnetic brake, the oscillating masses of the mold are significantly increased. In addition, an electromagnetic brake is required for each mold, which results in high capital costs. Whenever a mold change is carried out, the electrical connections must be disconnected and connected, which considerably increases the changing times. An improvement is achieved by the so-called window solution, in which an electromagnetic brake is assigned to each strand and remains in the machine when the mold is changed. To carry out a mold change, the electromagnetic brake is moved out of the mold, and after the new mold has been installed, it is moved back into its operating position. This eliminates the time-consuming disconnection and connection of the electrical connections and significantly reduces capital costs. However, a disadvantage of this window solution is that subsequent retrofitting in an existing plant can be accomplished only by very time-consuming and expensive modification of the support structure of the casting platform. Furthermore, the space requirement for a conventional window solution is extremely great and expensive, especially in the case of multiple-strand plants.

[0004] The document DE 198 07 842 A1 describes a continuous casting plant with an electromagnetic braking device, which consists of at least one coil which has a ferromagnetic core and is assigned to the broad sides of the mold, and of at least one associated yoke. At least individual parts of the electromagnetic braking device are load-bearing members of the continuous casting mold. The magnetic field generated by the electromagnetic braking device is divided into at least an upper and a lower magnetic field relative to the continuous casting mold. At least the interior of the electromagnetic cores simultaneously constitutes cooling chambers, through which cooling water can be supplied and removed. By integrating the electromagnetic braking device in the continuous casting mold as a load-bearing member, the weight is considerably reduced, but the oscillating masses are still relatively high.

[0005] A not-yet-published patent application with the file number 101 46 993.4 describes the construction of an electromagnetic braking device that is characterized by the fact that the electromagnetic braking device, which consists

of a yoke, coil, and ferromagnetic core, can be swiveled into or up to and out of or away from the continuous casting mold by at least one adjusting device. Due to the swiveling by swiveling levers on the mold, the electromagnetic braking device cannot oscillate together with the continuous casting mold.

[0006] The document EP 0 577 831 B1 describes an electromagnetic braking device for a continuous casting mold with an electromagnet, which has magnetic poles that are mounted on the long sides of a casting mold with a rectangular cross section and are arranged opposite each other. The magnetic poles have a width that is generally the same as the width of the long sides of the casting mold and coils that are wound around the outer edges of the magnet coil. The electromagnet is arranged inside the vertical extent of the casting mold, and an iron core is mounted in such a way that it surrounds the casting mold.

[0007] The document EP 0 820 824 A1 describes a continuous casting plant with a magnetic field formed in the area of the continuous casting mold. The magnetic field is divided into at least an upper and a lower magnetic field relative to the continuous casting mold. Each of the magnets that are used has a central core that divides on the mold side into at least an upper core for the upper magnetic field and a lower core for the lower magnetic field.

[0008] The document EP 0 698 434 A1 describes an electromagnetic braking device for a continuous casting plant that consists of a coil with a ferromagnetic core assigned to each of the broad sides of the mold and a yoke that surrounds the mold. To create a simple, inexpensive braking device that can be adjusted in a well-defined way, the cores are formed by a main core and a partial core on the side of the cast strand, such that different partial cores can be optionally used to adapt the magnetic field to varying casting conditions.

[0009] [The document WO 01/17,713 A1 describes a continuous casting plant with an electromagnetic braking device, which comprises at least two magnet] cores arranged on each side of a casting mold and thus joined, as well as a yoke, which is removably joined with the two magnet cores and interconnected with them. The yoke carries at least one coil, which is arranged between the magnet cores and connected by the yoke.

[0010] Proceeding from this prior art, the objective of the invention is to specify an electromagnetic braking device which has a design that is as uncomplicated as possible and creates the possibility of reducing the oscillating masses of the mold, including the braking device, and especially the possibility of providing uncomplicated means for guiding and influencing the active magnetic field and thus of increasing considerably the magnetic field strength at the same installed power.

[0011] In accordance with the invention, this objective is achieved with an electromagnetic braking device of the type specified in the introductory clause of claim 1, in which the core consists, on the one hand, of a primary part that houses the magnet coil, that can be moved by a drive unit to within a certain distance of the broad-side walls, and that is disconnected from the oscillation and, on the other hand, of additional parts that are permanently installed in water tanks of the mold. When brought together in their operating

position, the parts of the core form U-shaped yokes for generating a closed magnetic flux, and when the parts of the core are moved apart, the magnetic flux is interrupted.

[0012] This design allows easy exchanging of the magnet coil and the movable primary part as necessary in order to adapt the action of the electromagnetic braking device to the given casting conditions without any difficulties.

[0013] In accordance with a refinement of the invention, the ferromagnetic additional core parts installed in water tanks are assigned to the yokes.

[0014] In accordance with another refinement of the invention, vertical recesses are formed in the broad-side walls on the lateral surfaces that face the water tanks, and ferromagnetic filler pieces are fitted into these recesses. These filler pieces can be of variable length or width and/or depth. This provides a simple means of adapting the electromagnetic field strength to existing continuous casting conditions with gradual variations.

[0015] The primary part of the core with the magnet coil can be moved in a simple way in guides by means of a hydraulic actuator or electric drive in the direction perpendicular to the broad-side walls.

[0016] In accordance with another advantageous refinement of the design of the invention, the movable partial core with its primary part and the magnet coil, drive unit, and guides, on the one hand, and the additional parts, which are permanently installed, especially by welding, in water tanks of the mold, on the other hand, do not form a fixed mechanical connection at their contact points but rather are held together by magnetic forces. This makes it possible for the masses of the device that can oscillate and those which cannot oscillate to be separated from each other during operation.

[0017] In this regard, the contact points can then be advantageously designed as friction bearings or roller bearings, whose parts assigned to the water tanks are caused, together with the water tanks, to oscillate with the mold, while the parts assigned to the primary part of the core and the magnet coil, including the drive unit and guides, are disconnected from the oscillation. To achieve significant improvement of the operating behavior, the sliding friction of a friction bearing can be at least mostly eliminated in the region of the contact points by an antifriction layer, especially an air cushion. The air cushion can be maintained without any difficulty by introducing compressed air into the central region of the contact points.

[0018] Further details, features, and advantages of the invention are explained below with reference to the specific embodiment that is schematically illustrated in the drawings.

[0019] FIG. 1 shows a top view of a continuous casting mold with an electromagnetic braking device.

[0020] FIG. 2 shows the mold with the braking device of FIG. 1 with somewhat modified dimensions.

[0021] FIG. 1 shows an electromagnetic braking device for molten steel flowing into a continuous casting mold 1. The electromagnetic braking device comprises at least one magnet coil 2 with a ferromagnetic core 5 that can be assigned to the broad sides 3, 4 of the mold. The core 5 consists, on the one hand, of a primary part 6 that houses the

magnet coil 2 and can be moved to within a certain distance of the broad-side walls 3, 4 and, on the other hand, of additional parts 8, 8' that are permanently installed in water tanks 7, 7' of the mold 1. When brought together in their operating position, the parts 6, 8 of the core 5 form U-shaped yokes 9, 9' for generating a closed magnetic flux 10, and when the parts 6, 8 of the core 5 are moved apart, as shown in the upper half of FIG. 1, the magnetic flux 10 is interrupted.

[0022] FIG. 2 shows that the ferromagnetic additional parts 8, 8' of the core 5, which are installed in water tanks 7, 7', can be assigned to the yokes 9, 9'.

[0023] In the electromagnetic braking device, vertical recesses 11, 11' are formed in the broad-side walls 3, 4 on the lateral surfaces that face the water tanks 7, 7', and ferromagnetic filler pieces 12, 12' can be fitted into these recesses. These filler pieces 12, 12' can be of variable length or width and/or depth if the field strength of the magnetic field is to be adapted to customary operating parameters of the casting operation of the mold.

[0024] The primary part 6 of the core 5 with the magnet coil 2 can be moved in guides 13, 13' by means of a hydraulic actuator 15 or electric drive 14 in the direction perpendicular to the broad-side walls 3, 4 of the mold 5. The magnet coil 2 and magnet core 5 can be easily exchanged in this way and can be adapted to the current operating conditions with little expense and work time.

[0025] An essential refinement of the device with mold and braking device in accordance with the invention is that the movable partial core with its primary part 6 and the magnet coil 2, drive unit 14, and guides 13, on the one hand, and the additional core parts 8, 8', which are permanently installed, especially by welding, in water tanks 7, 7' of the mold 1, on the other hand, do not form a fixed mechanical connection at their contact points 16, 16' but rather are held together by magnetic forces. The contact points 16, 16' are designed as friction bearings or roller bearings 17, 17', whose parts 8, 8' assigned to the water tanks 7, 7' are caused, together with the water tanks, to oscillate with the mold 1, while the parts assigned to the primary part 6 of the core 5 and the magnet coil 2, including the drive unit 14 and guides 13, are disconnected from the oscillation. In this regard, the expenditure of force required for the oscillation is released from the load by co-oscillating additional loads of the braking device. The sliding friction of a friction bearing 17, 17' is at least mostly eliminated in the region of the contact points 16, 16' by an antifriction layer 18, 18', especially an air cushion. The air cushion can be simply and reliably maintained by introducing compressed air into the central region of the contact points 16, 16'.

LIST OF REFERENCE NUMBERS

- [0026] 1 mold
- [0027] 2 magnet coil
- [0028] 3 broad side of mold
- [0029] 4 broad side of mold
- [0030] 5 core
- [0031] 6 primary part of the core
- [0032] 7 water tank

- [0033] 8 additional parts of the core
- [0034] 9 yoke
- [0035] 10 magnetic flux
- [0036] 11 recesses
- [0037] 12 filler pieces
- [0038] 13 guides
- [0039] 14 drives of the core/drive unit
- [0040] 15 hydraulic cylinder
- [0041] 16 contact point
- [0042] 17 friction bearing/roller bearing
- [0043] 18 antifriction layer

1. Electromagnetic braking device for molten steel flowing into a continuous casting mold (1), which comprises at least one magnet coil (2) with a ferromagnetic core (5) assigned to the broad sides (3, 4) of the mold, wherein the core (5) consists, on the one hand, of a primary part (6) that houses the magnet coil (2), that can be moved by a drive unit (14) to within a certain distance of the broad-side walls (3, 4), and that is disconnected from the oscillation and, on the other hand, of additional parts (8, 8') that are permanently installed in water tanks (7, 7') of the mold (1), such that, when the parts of the core (6, 8) are brought together in their operating position, they form U-shaped yokes (9, 9') for generating a closed magnetic flux (10), and when they are moved apart, the magnetic flux is interrupted.

2. Braking device in accordance with claim 1, wherein the ferromagnetic additional parts (8, 8') installed in water tanks (7, 7') are assigned to the yokes (9, 9').

3. Braking device in accordance with claim 1, wherein vertical recesses (11, 11') are formed in the broad-side walls

(3, 4) on the lateral surfaces that face the water tanks (7, 7'), and ferromagnetic filler pieces (12, 12') are fitted into these recesses.

4. Braking device in accordance with claim 1, wherein the primary part (6) of the core (5) with the magnet coil (2) can be moved in guides (13, 13') by means of a hydraulic actuator or electric drive (14) in the direction perpendicular to the broad-side walls (3, 4).

5. Braking device in accordance with claim 1, wherein the filler pieces (12, 12') are of variable length or width and/or depth.

6. Braking device in accordance with claim 1, wherein the movable partial core with its primary part (6) and the magnet coil (2), drive unit (14), and guides (13), on the one hand, and the additional core parts (8, 8'), which are permanently installed, especially by welding, in water tanks (7, 7') of the mold (1), on the other hand, do not form a fixed mechanical connection at their contact points (16, 16') but rather are held together by magnetic forces.

7. Braking device in accordance with claim 1, wherein the contact points (16, 16') are designed as friction bearings or roller bearings (17, 17'), whose parts (18, 18') assigned to the water tanks (7, 7') are caused, together with the water tanks, to oscillate with the mold (1), while the parts assigned to the primary part (6) of the core (5) and the magnet coil (2), including the drive unit (14) and guides (13), are disconnected from the oscillation.

8. Braking device in accordance with claim 1, wherein the sliding friction of a friction bearing (17, 17') is at least mostly eliminated in the region of the contact points (16, 16') by an antifriction layer (18, 18'), especially an air cushion.

9. Braking device in accordance with claim 8, wherein the air cushion is maintained by introducing compressed air into the central region of the contact points (16, 16').

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