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Von Starck

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[54] **LINEAR MOVING FIELD INDUCTOR FOR ELECTROMAGNETIC PUMPS, CONVEYOR TROUGHS OR AGITATOR REELS FOR LIQUID METALS**

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[51] **Int. Cl.**[2] **H01F 27/08**

[58] **Field of Search** 336/55, 5, 60, 61, 62, 336/205; 417/50, 372, 367; 310/12, 11, 13, 14, 64, 65

[56] **References Cited**

UNITED STATES PATENTS

3,645,646 2/1972 Von Starck 417/50

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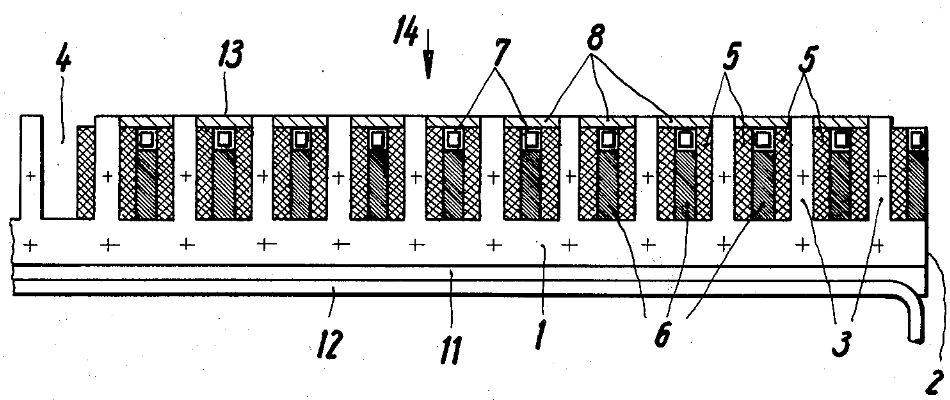
[57] **ABSTRACT**

A linear moving field inductor for an electromagnetic conveyor trough or the like in which each of the teeth of the lamina bundle — defining the grooves in which a multiphase induction coil is arranged — is bounded by two grooves and encloses a single winding having a height less than the depth of the grooves. In each groove a heat elimination device, such as copper blocks, is inserted and connected at least on the side facing the groove opening with a groove cooling unit comprising one or more cooling pipes connected thermally with a groove closing plate closing off the groove opening.

8 Claims, 2 Drawing Figures



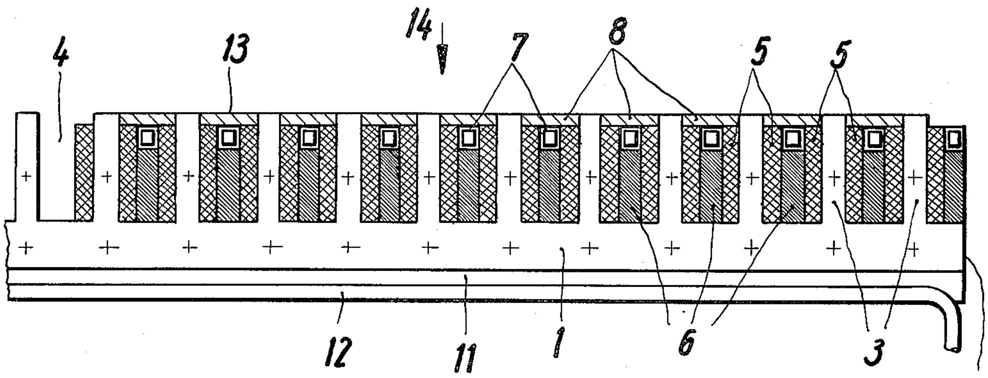


Fig. 1

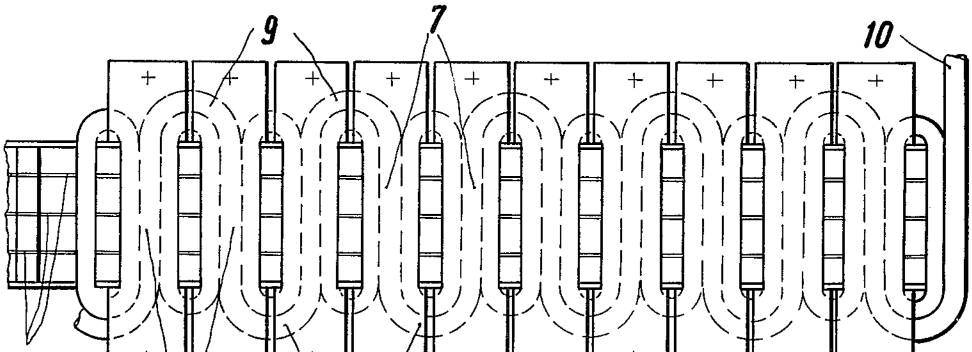


Fig. 2

LINEAR MOVING FIELD INDUCTOR FOR ELECTROMAGNETIC PUMPS, CONVEYOR TROUGHS OR AGITATOR REELS FOR LIQUID METALS

The invention concerns a linear moving field inductor for electromagnetic pumps, conveyor troughs or agitator reels for liquid metals with a laminated grooved inductor plate packet, in the grooves of which a multiphase inductor coiling for producing an electromagnetic moving field is arranged.

A moving field inductor if this sort, as is familiar to us from the German Pat. No. 1,959,979, usually includes a two-layer bar winding made of copper hollow sections through which coolants have passed. This winding can – as described in the German Pat. No. 1,908,457 — be in the form of a wave winding, for example. These moving field inductors are used especially in the case of electromagnetic conveyor troughts, which usually have a fireproof chute that riese obliquely from a melting or warming vessel. Under this chute is found the moving field inductor, which when in operation, conveys liquid metal from the melting or warming vessel into the chute by means of its moving field that moves along the length of the chute and works contrary to the force of gravity and moves the metal upwards in an open flow. Moving field inductors of this type have proved very useful in practice. However, one disadvantage is the fact that their operating voltage generally cannot be voluntarily selected, but is rather essentially determined by the inductor or chute dimensions and the type of metal to be conveyed. A transformer constitutes a relatively large part of the total system.

Besides this, in the case of these familiar bar windings, whenever a higher voltage is needed for larger chute dimensions, insulation problems that are very difficult to overcome always occur. The design of these bar windings, which, because of the generally small light cross-sections of the hollow bar conductors usually include a relatively large number of independent cooling cycles for cooling the winding, requires great manual dexterity, because it is usually activated by hand, and extreme caution in use. Thus, repair of inductors at the place where they are used is impossible in most cases.

The task of the invention is to provide a linear moving field inductor for electromagnetic pumps, conveyor troughts or agitator reels, containing, in contrast to the known inductors with bar winding, a winding system in which, regardless of the chute arrangement and dimensions, the inductor voltage can be freely selected from a broad range; this inductor, in contrast to the known moving field inductors, is much more easily reparable, the number of required cooling cycles is greatly reduced, and the same conveying capacity is achieved at significantly less real power consumption.

This task is solved by the moving field inductor of the invention, which is characterized by the fact that each tooth of the lamination bundle arranged on both sides of two grooves is enclosed in a single winding, the height of which is less than the depth of the grooves; that in each groove between the side surfaces of two adjacent single windings, a heat-conduction device connected thermally to these windings is inserted, and is connected at least on its side facing the groove opening with a groove-cooling unit that has one or more cooling pipes that are connected thermally to a groove-closing plate that closes o-f the groove opening. It is preferable that the single windings be wire coils and/or be cast in insulating material to form a frame-shaped block. The heat-conduction devices are preferably made of copper blocks.

According to a preferred model of the invention, several heat-conduction lamina are placed between the transformer lamina in the laminated stack of sheets in order to assist in the cooling of the inductor. On the side facing the grooved side, they are connected with sinks. The heat sinks can preferably be copper pipes through which a coolant has passed.

According to another preferred model of the invention, cooling pipes of the cooling units of several grooves are connected by means of bridge-like or bow-shaped pipe pieces to meander-shaped cooling coils, and to each other.

In the following, the invention is described thoroughly with reference to the diagrams.

FIG. 1 shows a preferred model of the moving field inductor of the invention in schematic partial representation;

FIG. 2 is the corresponding design cross-section.

In the grooved inductor lamina bundle **1**, of which the diagrams show only the part connected to the beginning of the inductor **2**, each tooth **3** of the lamina bundle **1**, which is bounded by two grooves **4**, is enclosed by a single winding **5**, the height of which is less than the depth of the groove and which in this model consist of wire coils cast in insulating material to form a frame-shaped block. In the space remaining in the groove **4** between the two adjacent single windings **5**, a heat-conduction device preferably consisting of a copper block **6** is inserted; this heat-conduction device is connected thermally with the side surfaces of these two single windings **5**.

Connected to these heat-conduction devices **5** is a groove cooling unit, that consists of a copper square pipe **7** and a groove-closing plate **8** connected with that pipe. These groove-closing plates **8** extend over the width of the lamina bundle (see FIG. **2**) and at these ends are braced against the lamina bundle **1** in a manner not explained in greater detail, for instance by means of clamp bolts.

The cooling pipes **7** of the grooves **4** shown in the diagrams are connected by means of bow-shaped pipe pieces **9** to a meander-shaped cooling coil, one connection **10** of which can be seen in FIG. **2**, on the right. For cooling the lamina bundle **1**, several heat conduction lamina **11** are placed between the transformer sheets; these heat conduction sheets are connected on the side of the lamina bundle **1** facing the grooved side to copper pipes **12** through which a coolant flows, which act as heat sinks.

The electromagnetic moving field in the active inductor surface **13** of such a moving field inductor supplied with these distinct single coils has a high harmonic content in contrast to normal rotary current bar winding inductors. Such an inductor could not, for example, be used as a stator for electric rotary current machines, as these harmonic waves would disrupt the effective ground wave of the moving field considerably in the generally relatively narrow air gap.

In the case of a linear moving field inductor for pumps, conveyor troughts or agitator reels for liguid metals, the "air gap" is determined by the required separation of liquid metal and the inductor by fireproof material, insofar that the harmonic waves that, with increasing distance from the active inductor surface are far more weakened than the ground waves, no longer significantly disrupt the moving field.

For cooling during operation, the moving field inductor is intended to eliminate quantities of heat that come from three sources. First, the heat given off by the liquid metal in the directection of the arrow **14** to the inductor is emitted through the groove-closing plates **8** to the cooling pipe **7** and from there eliminated with the help of the flowing coolant. Secondly, the major portion of the heat due to energy losses that arises in the single windings is emitted through the copper blocks **6** to the cooling pipe **7** and the coolant flowing through it. Thirdly, the heat due to energy losses that forms in the lamina bundle is eliminated through the lamina bundle cooling, which contributes thereby to a small part of the cooling of the single windings.

Finally, it should also be mentioned that the electromagnetic groove transverse field produces eddy currents in the copper blocks **6** serving as heat-elimination devices, so that the blocks act in an advantageous manner also as amortisseur windings. The effect of the copper blocks **6** in this respect can be regulated advantageously by cutting slits of various depths in them; their heat elimination capacity is not significantly affected by this.

Many changes and modifications in the above described embodiment of the invention can be carried out without departing from the scope thereof. Accordingly, that scope is intended to be limited only by the scope of the appended claims.

What is claimed is:

1. In linear moving field inductor for apparatus for moving molten metal having a laminated grooved inductor lamina bundle of magnetic material, in the grooves of which a multiphase induction coil is arranged, the improvement wherein each of the teeth of the lamina bundle is bounded on both sides by two grooves and enclosed in a single winding, the height of which is less than the depth of the grooves; and in each groove between the side surfaces of two adjacent single windings a heat-elimination device is inserted and connected thermally with the windings and connected at least on its side facing the groove opening with a groove cooling unit with one or more cooling pipes that are connected thermally with a groove-closing plate that closes off the groove opening.

2. In a moving field inductor as in claim **1**, the further improvement wherein the single windings are wire coilings.

3. In a moving field inductor as in claim **1**, the further improvement wherein the single windings are cast in insulating material to form a frame-shaped block.

4. In a moving field inductor as in claim **1**, the further improvement wherein the heat elimination devices are copper blocks.

5. In a moving field inductor as in claim **1**, the further improvement wherein the groove-closing plates extend over the width of the lamina bundle and are braced against this lamina bundle.

6. In a moving field inductor as in claim **1**, the further improvement wherein in the lamina bundle, several heat eliminating lamina are arranged between the lamina of magnetic material, and these heat eliminating lamina are connected on the side of the lamina bundle facing the grooved side to heat sinks.

7. In a moving field inductor as in claim **6**, the further improvement wherein the heat sinks are copper pipes through which a coolant passes.

8. In a moving field inductor as in claim **1**, the further improvement wherein the cooling pipes of the cooling units of several grooves are connected to each other to form meander-shaped cooling coils by means of pipe pieces.

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