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[54] ELECTROMAGNETIC PUMP FOR
LIQUID METALS[72] Inventors: Henri Carbonnel, Anthony; Jean Le Frere,
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H02k 1/12[58] Field of Search417/50; 310/11, 254, 258, 259,
310/260[56] References Cited
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[57] ABSTRACT

An electromagnetic pump comprising an impelling duct for liquid metals having a symmetry axis, made of a refractory material and equipped with preheating means and thermal insulation, a stator consisting of two magnetic yokes arranged on both sides of the duct and comprising laminated cores in parallel relation to a plane containing the axis of the duct and having deep and uniformly spaced slots, each of which receives a flat coil in a direction perpendicular to the axis of the duct. In this manner, each of the coils can be removed by translation in a direction parallel to the axis of the duct after unclamping in a perpendicular direction.

3 Claims, 2 Drawing Figures

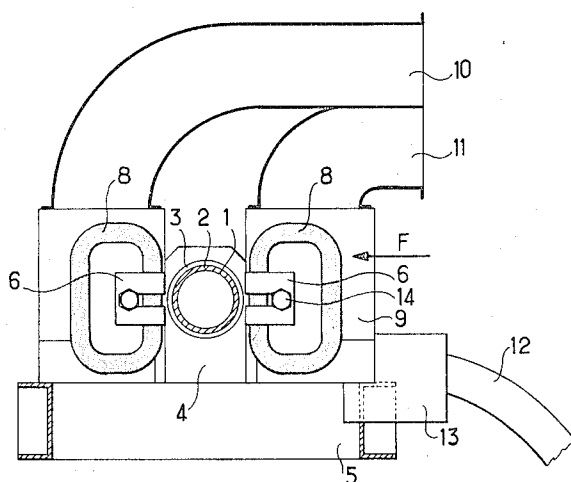


FIG. 1

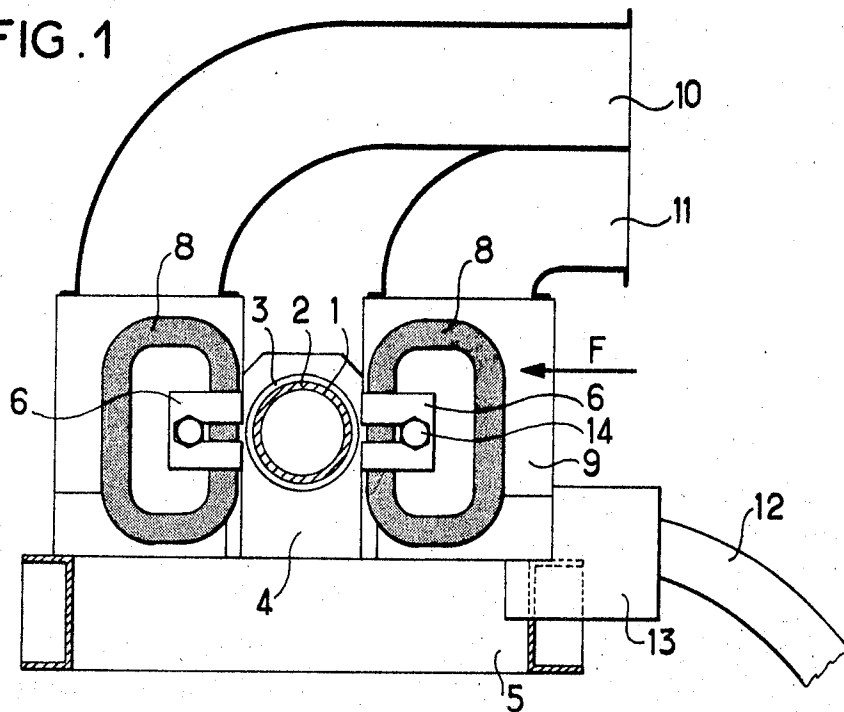
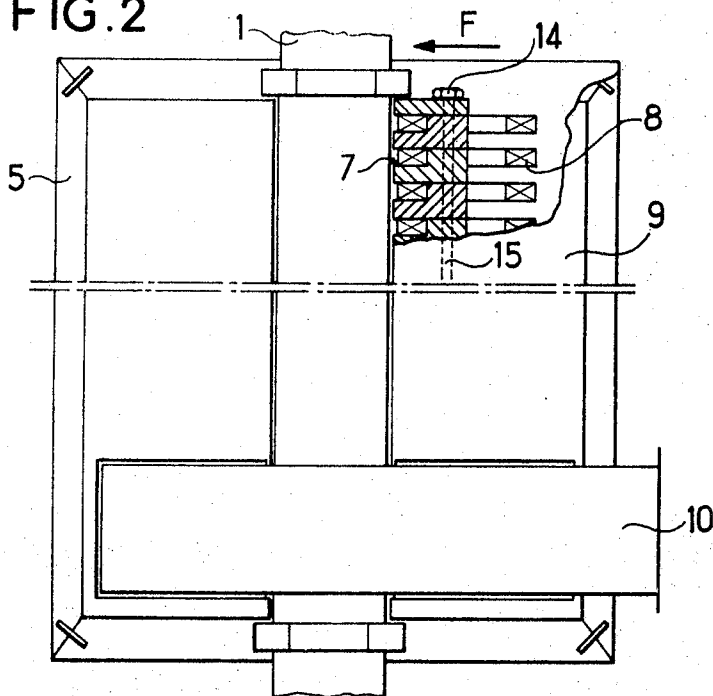


FIG. 2



ELECTROMAGNETIC PUMP FOR LIQUID METALS

BACKGROUND OF THE INVENTION

This invention involves an improvement in electromagnetic pumps employed for impelling liquid metals.

Electromagnetic pumps of a known type generally consist in principle of a magnetic circuit and a metal duct, e.g., of stainless steel. Such pumps are known to be unable to impel such ordinary metals as zinc or aluminum because the latter attack the metal or alloy of the pump duct. In the French Pat. PV 127,426 of 1 July 1968, the inventors already suggested making the impelling duct of a refractory material provided on the outside with a metal layer facilitating preheating of the duct. This prevents the duct both being attacked by the usual metals and also eliminates the risk of solidification of the metal in the piping during discharge of the metal.

This solution leads, however, to some difficulties caused by the increase of the air gap between stators. This makes it necessary to provide thermal insulation for the heating device of the refractory duct from against the environment and may also require protection of the refractory duct against the chemical action of the environment by covering it with a metal sheath resistant to oxidation at high temperature as described by the petitioner in French Pat. No. 69 42 788 of 10 Dec. 1969 and the amendment No. 69 45 218 of 29 December 1969 to this patent. Induction heating of the metal sheath on the outside of the duct for the liquid metal may be further aided by winding heated conductors of any known type around it. The air gap is thus ultimately multiplied by a factor of 5 in relation to pumps of standard type. In order to impel the liquid metal, sufficient magnetic induction must be maintained within the duct. Accordingly, the number of ampere-turns applied to the magnetic circuit per unit length of pump must be increased. If this is done by using standard procedures, we then have to arrange for wide and deep slots in the magnetic core utilized. Consequently, the involutes between successive pole tips would assume too large a volume. In pumps for ordinary metals such as aluminum, it is also advantageous to utilize a duct where the ratio between the width of duct (its largest dimension) and its thickness (its smallest dimension) is relatively low. Since the thickness of the laminated cores of the magnetic circuit does not exceed the width of the duct (its largest dimension), it is not possible as a result of this to increase the active volume of the magnetic circuit.

SUMMARY OF THE INVENTION

The present invention provides an original design for the stators of electromagnetic pumps in order to remedy the above disadvantages and imperfections.

It has been noted that, wherever a failure occurs in the operation of the pump, it may be necessary to provide rapid access to the duct of the pump before discharge is arrested and the metal solidifies in the piping. It therefore appeared absolutely necessary to construct pumps with coils whose involutes occupy as small a volume as possible and can, at the same time, be disassembled rapidly by a sequence of very simple steps.

This invention involves an improved electromagnetic pump constituted by an impelling duct for liquid metals presenting a symmetry axis, made of refractory material and equipped with means for preheating and thermal insulation; a stator consisting of two magnetic yokes arranged on both sides of the duct and constituted by laminated cores placed parallel to a plane containing the axis of the duct and having deep and uniformly spaced slots each of which holds a flat coil perpendicular to the axis of the duct where each of these coils can be removed by translation in a direction parallel to the axis of the duct after unclamping in a perpendicular direction.

In order to lower costs and fabricate, according to the same method, several types of pumps suitable for different users, each yoke comprises identical elements with two or three slots depending on whether the pump is powered by single-phase or

three-phase current. This makes it possible to constitute as many independent identical elements with two or three coils where these elements are assembled to each other by any appropriate means.

An improved magnetic pump in accordance with the present invention is characterized in that the yoke of each of the magnetic circuits is made of independent elements having as many coils as slots where these elements are assembled to each other by any appropriate means.

This device makes it possible to construct compact coils with a large number of ampere-turns around a yoke element and to assemble the desired number of such standard elements in order to adapt the length of the stator to the characteristics of the electromagnetic pump.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of an electromagnetic pump according to this invention; and

FIG. 2 is a top plan view of the pump shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, an electromagnetic pump for particularly corrosive liquid metals constructed in accordance with the present invention, comprises a tube 1 made of an insulating and refractory material e.g. graphite) with a metal sheath 2 resistant to oxidation and having high electric resistance, and a concentric envelope 3 constituted of a thermal-insulation material for protecting the magnetic circuit against the heat of the liquid metal. In order to simplify the drawing, the heating elements for preheating the tube prior to introducing the liquid metal are not shown. The tube 1 also is slightly tapered to facilitate removal of solidified metal in case of failure. The whole is suitably arranged on a cradle mounted on the base 5 of the pump by any appropriate means.

On either side of the tube 1 are arranged two identical magnetic circuits constituted each by a magnetic yoke 6 with slots 7 (FIG. 2) and of a number of coils 8 fitting into these slots. Each of the magnetic circuits is placed in a ventilation duct 9 to which fresh air is supplied through the ducts 10 and 11. Electric power is supplied to the coils 8 through cable 12 across a junction box 13.

FIG. 2 shows certain details and components not described in reference to FIG. 1. Specifically, it shows the extremity of the slots 7 of the magnetic yoke described in the preceding figure and also the coils engaged in these slots.

Where the magnetic yoke 6 of each of the magnetic circuits consists of a number of elements, the latter are assembled to each other by means of a threaded rod 15, or a bar threaded at the ends, and two terminal nuts 14. They can also be assembled with dovetailed devices or with U-shaped rods (not shown) sliding in seats provided in the yoke where the elements are assembled by the pressure of a nut at each end. Each of the magnetic yoke elements, therefore, has one or more slots in which are engaged one or more coils.

All things being equal, this type of construction permits a considerable reduction on the volume of the coils and appreciable savings in the consumption of electric power.

The electromagnetic pump of this invention has the advantage of being easily disassembled, which permits rapid access either to tube 1 in cases where the liquid metal has solidified or any other failure, or to the magnetic circuit when it is desired to replace a defective coil.

In order to obtain access to tube 1, it is only necessary to remove the ventilation ducts 9 and to displace the magnetic circuits laterally.

When it is desired to dismount the coils of one of the magnetic circuit, it is only necessary, after having removed this circuit from tube 1, to slip each of the coils 8 out of the corresponding slot 7 in which it is engaged, by pushing it in the direction of the arrow F when it can be withdrawn by sliding it along the yoke 6.

By reason of mechanical necessity, it may become necessary to increase the thickness of the metal sheath of the tube, and possibly greatly reduce the thickness of the tube of refractory material in cases where the impelled materials are not highly corrosive.

We claim:

1. An electromagnetic pump comprising an impelling duct for liquid metals having a symmetry axis and being made of a refractory material, said duct having means for preheating the refractory material; and a stator formed of two yokes arranged on either side of said duct, said yokes each comprising a laminated core arranged parallel to a plane containing the symmetry axis of said duct and provided with deep slots facing the duct and uniformly spaced along the duct, and a flat coil

perpendicular to the symmetry axis mounted in each of said slots, whereby said coils can be removed by translation in a direction parallel to the axis of the duct after removing them from the slots in a direction perpendicular to the axis of the duct.

2. The pump as in claim 1 in which each of said yokes is made of a plurality of independent elements defining said slots, and means are provided for assembling said elements to each other.

3. The pump as in claim 1 in which the duct is surrounded by thermal insulation material for protecting the coils against the heat of the liquid metal.

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