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UK CL (Edition M) **H2A AKC2 AKF2 AKH2 AKR1 AKR9**
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(54) Permanent magnet linear motor

(57) A linear motor comprises two parallel laminated ferromagnetic core elements (1, 1) wound with coils (not shown), and a slider (7) of magnetically permeable material encircling both core elements and having a main permanent magnet (5) mounted across its centre and between the two core elements (1, 1), with opposite poles (N, S) of the permanent magnet (5) facing the respective core elements (1, 1).

Further magnets 10 are carried by the slider and compensating coils to prevent magnetic saturation of the stator may be present. Alternatively the core may comprise a wound ribbon of amorphous metal encapsulated in epoxy resin.

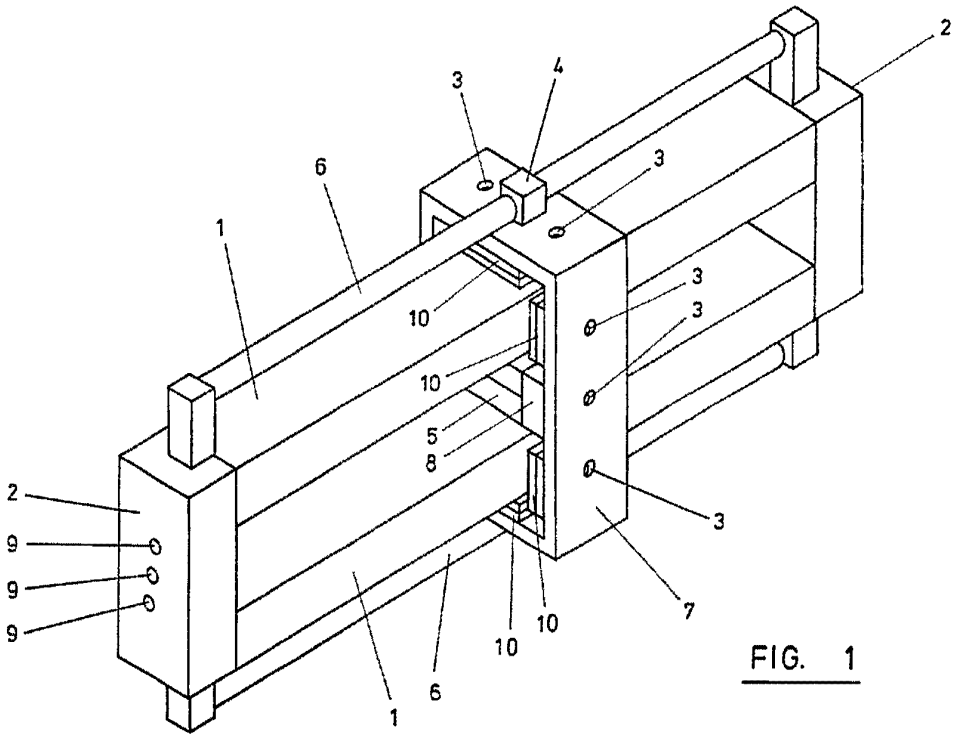

FIG. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

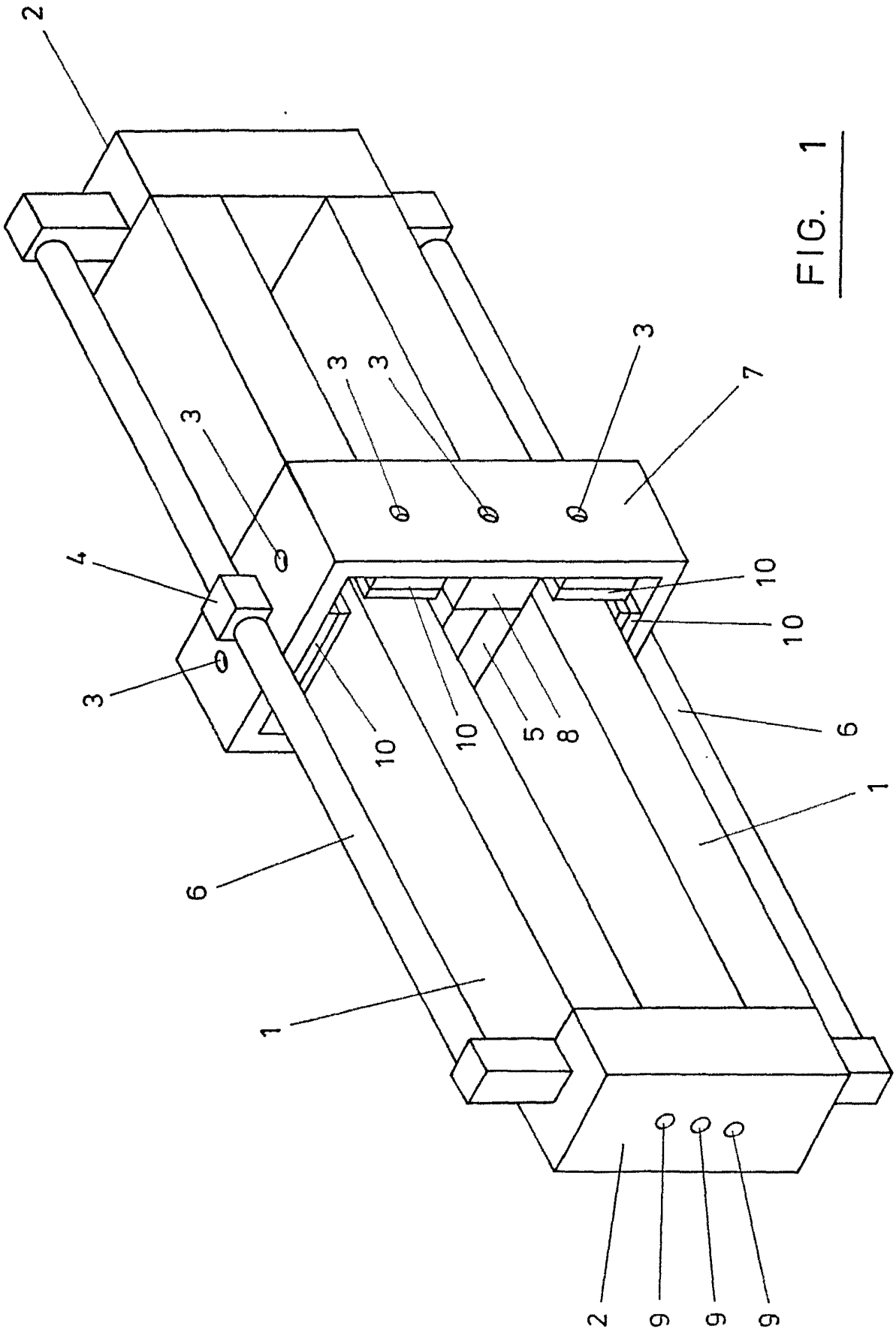

FIG. 1

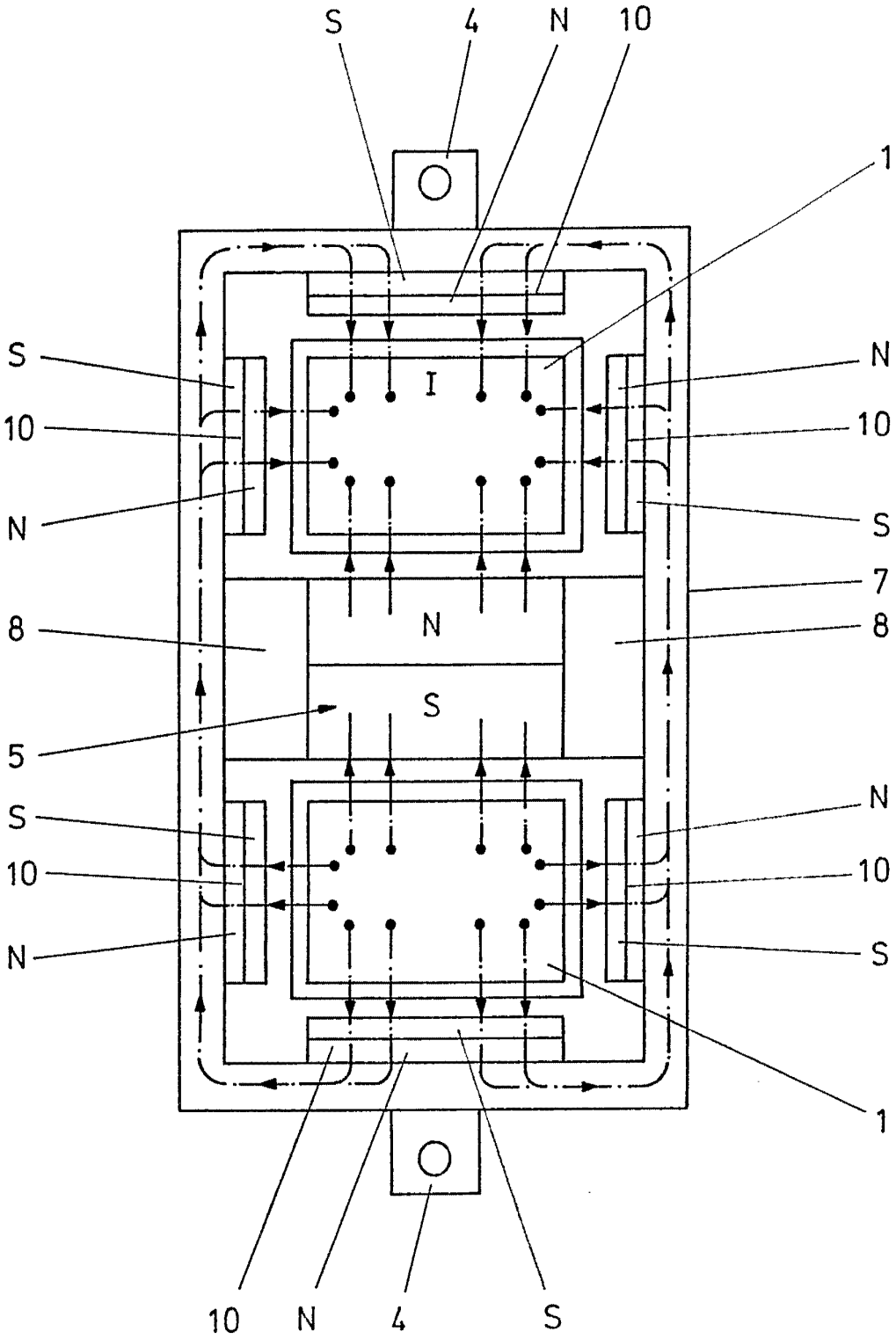

FIG. 2

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LINEAR ELECTRIC MOTOR

This invention relates to a linear electric motor.

A variety of different constructions of linear electric motor have been proposed hitherto. These have exhibited a number of limitations, such as thrust-to-weight ratio and variations in thrust according to the armature position along the length of the motor.

We have now devised a linear electric motor which can achieve a high thrust-to-weight ratio, uniform thrust along the motor's length, and a good time response.

In accordance with this invention, there is provided a linear electric motor comprising two parallel core elements wound with coils, and a slider of magnetically permeable material encircling both core elements and having a permanent magnet mounted across its centre and between the two core elements, with opposite poles of the permanent magnet facing the respective core elements.

Preferably the slider has auxiliary permanent magnets fixed to its inner surface, to co-operate with the respective core elements at different locations of their peripheries from the main permanent magnet.

The two elongate core elements may be wound with continuous coils, fed with direct current of opposite polarity to produce linear movement of the slider. Alternatively, each core element may be wound with a set of coils, the coils of one set being offset relative to the coils of the other set: in this case the coils are fed with switched currents in alternate manner to provide a linear stepping motor action.

The core elements may comprise solid or laminated bars of ferromagnetic material (e.g. low carbon iron). Two short back iron bars are preferably connected across the ends of such ferromagnetic bars. (Preferably non-magnetic material spacers or gaps are provided between the back iron bars and the ends of the ferromagnetic bars in order to avoid magnetic saturation in the core. Alternatively compensating coils are wound around the back iron bars (to produce a magnetic flux equal but opposite to the flux in the main core elements), to avoid

magnetic saturation.

Preferably however the core is formed from a ribbon of amorphous metal, wound to a plurality of turns defining the two elongate core elements and two short end elements. This amorphous ribbon core is encapsulated in e.g. epoxy resin to provide mechanical strength and protection.

The amorphous ribbon material is a high permeability material providing relatively low reluctance. The reluctance, as seen by the slider, changes with the position of the slider along the length of the core, and therefore the thrust on the slider varies with its linear position. However, with low reluctance due to the use of an amorphous metal core, the thrust on the slider is more uniform along the length of the core.

The amorphous ribbon is very thin and has a high resistivity, so that any eddy currents are much reduced. Such eddy currents are induced in response to switching and have a braking effect: but since the eddy currents are much reduced with the use of amorphous ribbon for the core, there is negligible braking effect and indeed the motor exhibits a quick response to changes in current.

An embodiment of this invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIGURE 1 is an isometric view of a linear electric motor in accordance with this invention; and

FIGURE 2 is a section through the linear motor of Figure 1.

Referring to the drawings, there is shown a linear motor comprising a core 1, 2 and a slider 7. In the example shown, the core comprises two solid bars 1 parallel to each other, and joined at their ends by two shorter bars 2, these bars 1, 2 being of ferromagnetic material. The bars may be laminated. Non-magnetic spacers may be positioned between bars 2 and the ends of bars 1, to avoid magnetic saturation. Preferably however the core comprises a ribbon of amorphous metal, wound to a plurality of turns and to achieve the shape which is shown: the core is then encapsulated e.g. in epoxy resin, to provide mechanical strength; in this case also

compensating coils are wound around the end elements 2 of the core to avoid magnetic saturation.

Coils are wound around the main core elements 1. These may comprise two continuous coils, one on each core element 1, but fed with currents of opposite polarity. Alternatively, each core element 1 may be wound with a set of coils, the coils of one set being offset relative to the coils of the other set: in this case, the coils are fed with switched currents in alternate manner to provide a linear stepping motor action.

The slider 7 comprises a rectangular frame of soft ferromagnetic material, encircling the core. Bearing blocks 4 are mounted on the opposite ends of the slider 7, and slide rods 6 pass through the bearing blocks 4 and are fixed to the core at their opposite ends. Thus, the slider 7 is supported for linear displacement on the slide rods 6.

A permanent magnet 5 is fixed to the slider 7 by non-magnetic support blocks 8, the magnet 5 extending across the centre of the slider 7 between the two main core portions 1, 1. The magnet 5 has its opposite poles directed towards the respective main core elements 1, 1, as shown in Figure 2. Permanent magnets 10 are bonded to the inwardly-facing surface of the slider 7, to co-operate with the opposite edges of the main core elements 1, 1 and also with the faces of the core elements 1, 1 opposite the magnet 5. As shown in Figure 2, the magnets 10 associated with one of the main core elements 1 are oppositely-poled relative to the magnets 10 associated with the other main core element 1. Figure 2 shows the magnetic circuit produced by the permanent magnets 5, 10, as follows: starting from magnet 5, the circuit extends through one main core element 1, its associated magnets 10, the slider 7, the magnets 10 associated with the other main core element 1, then through that other core element 1 and finally back to the permanent magnet 5. All of the permanent magnets 5, 10 are of the high energy type to ensure that the motor exhibits high thrust.

The end portions 2, 2 of the core are formed with screw-threaded bores 9 for attachment to fixed structure. The slider 7 is formed with screw-threaded bores 3 for attachment to a load to be displaced.

Claims

1) A linear electric motor comprising two parallel core elements wound with coils and a slider of magnetically permeable material encircling both core elements and having a main permanent magnet mounted across its centre and between the two core elements, with opposite poles of the permanent magnet facing the respective core elements.

2) A linear electric motor as claimed in claim 1, in which the slider has auxiliary permanent magnets fixed to its inner surface, to co-operate with the respective core elements at different locations of their peripheries from the main magnet.

3) A linear motor as claimed in claims 1 or 2, in which the core elements are wound with continuous coils, and means are provided for feeding the coils with direct current of opposite polarity to produce linear movement of the slider.

4) A linear motor as claimed in claims 1 or 2, in which each core element is wound with a set of coils, the coils of one set being offset relative to the coils of the other set.

5) A linear motor as claimed in claim 4, comprising means to feed the coils with switched currents in alternate manner.

6) A linear motor as claimed in any preceding claim, in which the core elements comprise solid or laminated bars of ferromagnetic material.

7) A linear motor as claimed in claim 6, comprising two short back iron bars connected across the ends of said ferromagnetic bars.

8) A linear motor as claimed in claim 7, comprising non-magnetic spacers or gaps between the back iron bars and the ends of said ferromagnetic bars.

9) A linear motor as claimed in claim 7, comprising

compensating coils would around the back iron bars.

10) A linear motor as claimed in any of claims 1 to 5, comprising a ribbon of amorphous metal, wound to a plurality of turns and having portions defining the two elongate core elements and short interconnecting end elements.

11) A linear motor as claimed in claim 10, in which the amorphous ribbon core is encapsulated.

12) A linear motor substantially as herein described with reference to the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9301174.0
Relevant Technical Fields (i) UK Cl (Ed.M) H2A (AKR1, AKR9, AKH2, AKC2, AKF2) (ii) Int Cl (Ed.5) H02K 01/34, 41/03	Search Examiner J COCKITT Date of completion of Search 14 MARCH 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-12

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Category	Identity of document and relevant passages	Relevant to claim(s)
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