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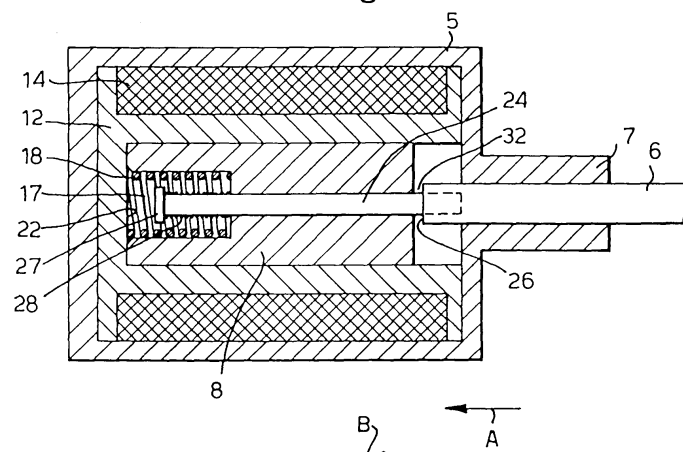
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(54) **Electromagnetic arrangements**

(57) An electromagnetic arrangement comprises an armature (12) mounted within a housing (5) and carrying an electrically energisable coil (14). A core (8) slides inwardly of a hollow space (10) against a compression spring (18) in response to electrical energisation of the coil (14), and slides in the opposite direction upon de-energisation of the coil in response to the stored energy of the spring (18). The core (8) is connected to an output member (6) by means of a control rod (24) freely slidable through the core (8) and which has an enlarged head (27) against which a second coil spring (28) acts. During inward movement of the core (8) in response to energisation of the coil (14), the core (8) pulls the output member (6) through the intermediary of a second spring (28) and a control rod (24) which is slidable through the core (8) and is fixed to the output member (6). During outward movement of the core (8) in response to de-energisation of the coil (14), an end face (15) of the core (8) pushes on an end face (26) of the output member (6). When the core (8) is at its innermost position, a predetermined amount of play (32) exists between the end (15) of the core (8) and the end face (26) of the output member (6). This allows the core (8) to accelerate before it abuts against the end face (26) of the output member (6).

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Fig.2.



Description

[0001] The invention relates to electromagnetic arrangements.

[0002] According to the invention, there is provided an electromagnetic arrangement, comprising a core movable in a first direction against the action of spring means in response to electromagnetic energisation of a coil and movable in a second, opposite, direction in response to stored energy in the spring means as the latter resiles, an output member mounted for movement in directions corresponding to the first and second directions, first force transmitting means for transmitting a force from the core to the output member as the core moves in the first direction whereby to cause movement of the output member in the corresponding direction, and second force transmitting means for transmitting a force from the core to the output member as the core moves in the second direction whereby to move the output member in the corresponding direction characterised in that the force transmitting means includes means for creating a predetermined amount of play as the core moves in one said direction whereby to permit accumulation of kinetic energy in the core before transmission of the force to the output member as the core moves into the opposite direction.

[0003] Electromagnetic arrangements embodying the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a cross-section through one of the arrangements in the state where it is electrically de-energised;

Figure 2 corresponds to Figure 1 but shows the arrangement in the state in which it is electrically energised; and

Figure 3 is a graph showing the force produced by the arrangement compared with the air gap within the assembly.

[0004] The electromagnetic arrangement shown in Figures 1 and 2 comprises a housing 5 containing an electromagnet which, in a manner to be described, moves an output rod 6 to and fro in the direction of the arrows A and B. Rod 6 slides in a guide 7 and is connected to a mechanism (not shown) which is to be actuated by the electromagnetic arrangement. The electromagnet comprises a core 8 slidable to and fro in the direction of the arrows A and B in a cylindrical space 10 which is defined within an armature 12 wound with an electrical coil 14. The core 8 has two end faces 15 and 16, with a cylindrical recess 17 formed in end 16. A compression spring 18 is located in the recess 17 and acts between the base 20 of the recess 17 and the closed end 22 of the cylindrical space 10.

[0005] As shown most clearly in Figure 2, the output rod 6 is rigid with a control rod 24. The control rod 24 is of lesser diameter than the output rod 6 so as to define an annular end face 26 of the output rod 6 which extends around the control rod 24. The control rod 24 is freely slidable within a bore through the core 8. The control rod 24 has an enlarged head 27, and a second compression spring 28 acts between the base 20 of the cylindrical recess 17 and the underside of this head 27, so as to urge the control rod to the left (as viewed in Figures 1 and 2) relative to the core 8.

[0006] Figure 1 shows the configuration of the electromagnet assembly when the coil 14 is de-energised. The core 8 is urged outwardly of the cylindrical space 10 by the compression spring 18 so that its end face 15 abuts against the housing 5 around the guide 7. The core 8 thus abuts against the end face 26 of the output rod 6 and forces the latter outwardly of the housing 5 to its maximum extent. In this position of the core 8, the air gap 30 has its maximum size.

[0007] When the coil 14 is electrically energised, the core 8 is electromagnetically attracted in the direction of the arrow A and moves inwardly of the cylindrical space 10, towards the end face 22, compressing the spring 18 and also compressing the spring 28. The force exerted by the compressed spring 28 thus drags the control rod 24 in the direction of the arrow A, thereby drawing the output rod 6 in the same direction. Movement of the core 8 in the direction of the arrow A stops when it abuts against the end face 22 of the cylindrical space 10, and the relative configuration shown in Figure 2 is achieved. However, the movement of the output rod 6 in the direction of the arrow A is limited by external means (not shown) so that, with the core 8 fully attracted by the electromagnetic field, a predetermined amount of play 32 exists between the end face 15 of the core 8 and the end face 26 of the output rod 6. The external means for limiting the travel of the output rod 6 can take any suitable form which is arranged so that the maximum travel of the output rod 6 in the direction of arrow A is less than the maximum travel of the core 6. The strength of the spring 28 is selected so that the core 6 can continue its travel after the movement of the output rod 6 has stopped but with the necessary force still being applied to the output rod.

[0008] The electromagnetic arrangement preserves the configuration shown in Figure 2 for so long as the coil 14 is electrically energised. When the coil 14 is de-energised, the core 8 starts to move in the direction of the arrow B under the action of the energy stored in the compression spring 18. Initially, the control rod 24 (and thus, also, the output rod 6) does not move, as the spring 28 resiles, or only moves slowly under the resiling action of spring 28. However, the core 8 freely moves in the direction of the arrow B, gaining kinetic energy as it travels through the play 32. When the core has travelled through a distance corresponding to the play 32, it will sharply impact strike the end face 26 of the output rod

6 thus instantaneously producing a substantial increase in the force applied to the output rod. This impact force will persist only momentarily, but the output rod 6 will continue to be moved thereafter in the direction of the arrow B by the force in the spring 18, until the end face 16 of the core 8 abuts against the housing as shown in Figure 1.

[0009] The operation is explained in more detail with reference to the graph of Figure 3.

[0010] In Figure 3, curve I shows the electromagnetic force developed during energisation of the coil 14. When the air gap 30 is a maximum, corresponding to Figure 1, the electromagnetic force is at a minimum. If desired, however, it is possible to provide a momentary increase in the electromagnetic force by temporarily augmenting the current flowing through the coil. This may be carried out electronically and produces a peak in the applied force as shown at 34 in Figure 3 when the core 8 begins to move on its inward stroke. This momentary increase in force helps to overcome the effect of inertia on the output rod 6, such as the inertia caused by its load (not shown). After this momentary increase in current, the applied force then decreases but thereafter increases as the air gap 30 is reduced, rising to a maximum force just before the air gap 30 is reduced to zero.

[0011] Curve II shows the operation during the return stroke of the core 8 under the action of the spring 18. The force exerted by the spring 18 will be relatively high when the air gap 30 is zero. As explained in conjunction with Figure 2, this initial force causes the core 8 to accelerate as the core travels through the extent of the play 32 (Figure 2). When the core 8 abuts against the end face 26 of the output rod 6, there will be a momentary and substantial increase in force applied to the output rod 6 as shown at 36 in Figure 3. Again, this will help to overcome the effects of any inertia acting against movement of the output rods 6. This peak force then falls, and thereafter the force applied to the output rod 6 reduces gradually as the spring 18 resiles.

[0012] The magnitude of the shock force produced when the core 8 comes into abutment with the end face of the output rod 6 depends on the amount of the play 32, the pre-stress in the spring 18, the strength of the spring 18, and the mass of the core 8. Each of these parameters can be adjusted to obtain a desired shape for the curves shown in Figure 3.

[0013] In this way, an electromagnetic arrangement can be produced which produces a substantial and momentary increase in applied force during the return stroke of the core movement. If combined with means for temporarily augmenting the current through the coil at the beginning of the inward stroke (as explained in conjunction with Figure 3), the electromagnetic arrangement produces a substantial and momentary increase of force at the beginning of each of its two strokes. In this way, any inertial effect in the mechanism being controlled by the electromagnetic arrangement is overcome. The arrangement remains monostable and there-

fore has a safety position if the coil becomes defective.

[0014] The maximum force exerted by the arrangement can be changed by adjusting the strengths of the two springs 18 and 28. The springs enable the return force (direction B) to be adjusted to be different from the output force (direction A).

[0015] In the electromagnetic arrangement described, the coil 14 can be sealed within the housing 5, enabling a waterproof structure.

Claims

1. An electromagnetic arrangement, comprising a core (8) movable in a first direction against the action of spring means (18) in response to electromagnetic energisation of a coil (14) and movable in a second, opposite, direction in response to stored energy in the spring means (18) as the latter resiles, an output member (6) mounted for movement in directions corresponding to the first and second directions, first force transmitting means (28) for transmitting a force from the core (8) to the output member (6) as the core (8) moves in the first direction whereby to cause movement of the output member (6) in the corresponding direction, and second force transmitting means (26,32) for transmitting a force from the core (8) to the output member (6) as the core (8) moves in the second direction whereby to move the output member (6) in the corresponding direction, characterised in that the force transmitting means (28;26,32) includes means for creating a predetermined amount of play (32) as the core (8) moves in one said direction whereby to permit accumulation of kinetic energy in the core (8) before transmission of the force to the output member (6) as the core (8) moves into the opposite direction.
2. An arrangement according to claim 1, characterised in that the core (8) is constrained for sliding movement in the first and second directions and the output member (6) is constrained for movement in the corresponding directions co-linearly with the core (8), the predetermined play (32) being defined between one end of the core (8) and an adjacent end of the output member (6) when the core (8) has moved to a limit position in the said one direction.
3. An arrangement according to claim 2, characterised in that the spring means comprises a compression spring (18) which is compressed by movement of the core in the said one direction.
4. An arrangement according to claim 3, characterised in that the compression spring (18) acts between the other end (16) of the core (8) and a fixed member (12) with respect to which the core (8) moves in

the first and second directions.

5. An arrangement according to any preceding claim, characterised in that the first force transmitting means comprises the means (28) for creating the play (32). 5
6. An arrangement according to claim 5, characterised in that the means in the first force transmitting means for creating the play (32) comprises second spring means (28). 10
7. An arrangement according to claim 6, characterised in that the output (6) member is connected to a control member (24) which is movable through and relative to the core (8) in the first and second directions, and in that the second spring means (28) acts between the control member (24) and the other end (20) of the core (8). 15
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8. An arrangement according to any preceding claim, characterised by an external housing (5) encompassing the core (8), the coil (14), the spring means (18,28), and the two force transmitting means (28; 26,32) including the means defining the play (32). 25
9. An arrangement according to claim 8, characterised by an armature (12) supporting the coil (14) and encompassed by the housing (5). 30

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Fig.1.

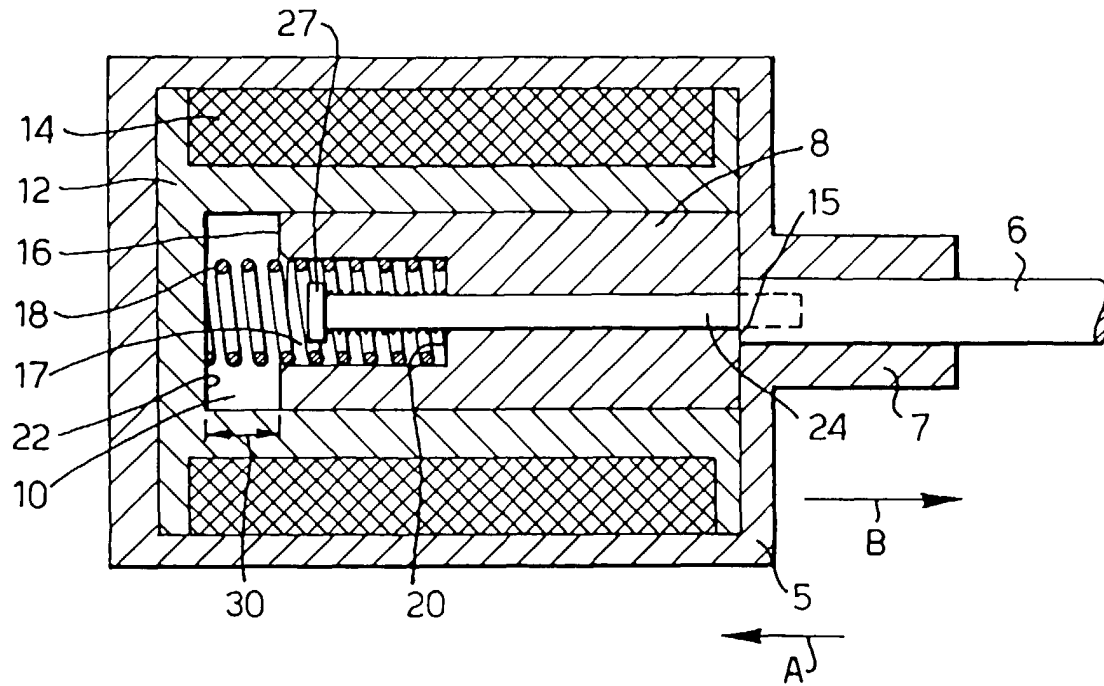


Fig.2.

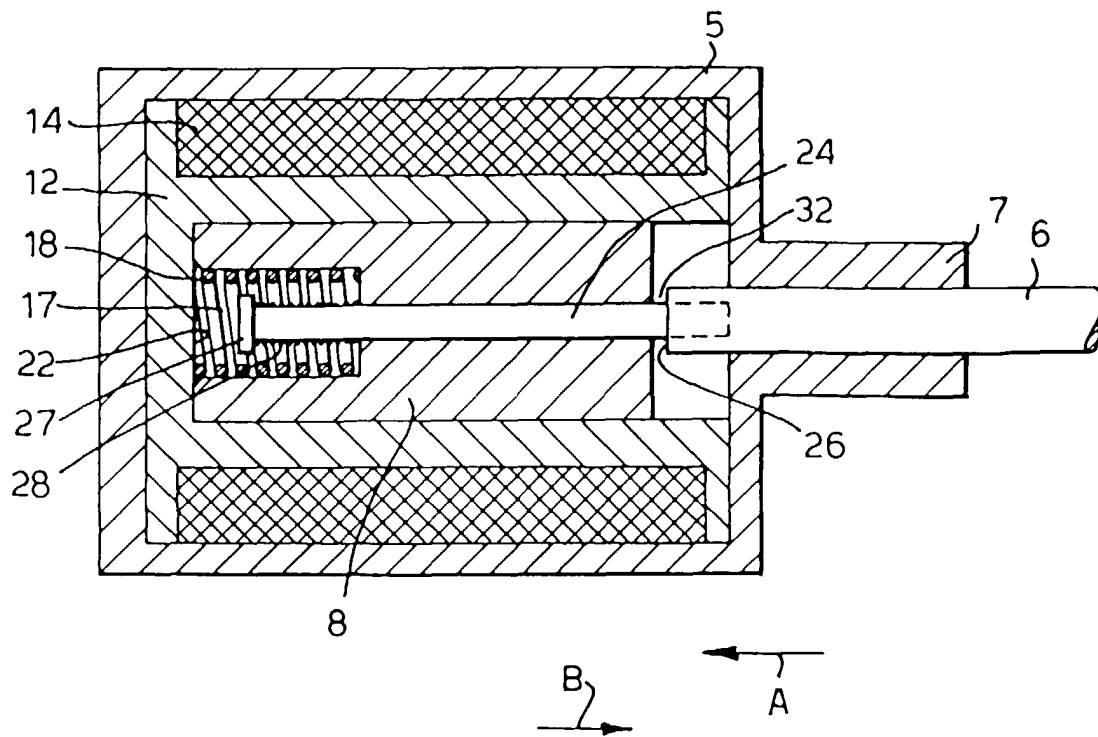


Fig.3.

