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EUROPEAN PATENT APPLICATION

21 Application number: **89311699.6**

51 Int. Cl.⁵: **H01F 7/08, H01F 7/16,
H01F 3/04, H01F 3/06**

22 Date of filing: **10.11.89**

30 Priority: **19.11.88 GB 8827108**

43 Date of publication of application:
30.05.90 Bulletin 90/22

84 Designated Contracting States:
DE FR GB IT

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54 **Electromagnetic actuator.**

57 An electromagnetic actuator comprises inner and outer annular pole pieces 13, 14 which define pole faces 13A, 14a presented to an armature 11, and which when a winding 12 is energised assume opposite magnetic polarity. An annular bridging member 17 is provided to interconnect the pole pieces at their ends remote from the armature. The pole pieces are formed by winding magnetic strip material. The bridging member 17 can be formed as a stock of laminations.

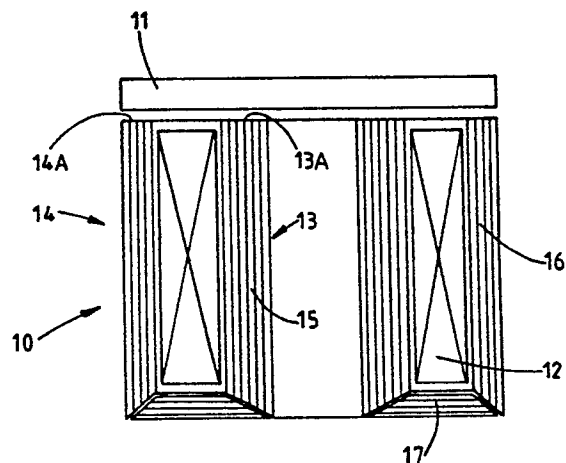


FIG. 1.

EP 0 370 666 A1

ELECTROMAGNETIC ACTUATOR

This invention relates to an electromagnetic actuator of the kind comprising a magnet structure and an armature, the magnet structure defining at least two pole pieces which when an electrical winding forming part of the magnet structure is energised, assume opposite magnetic polarity, the armature being presented to the pole faces and being attracted to the pole faces when the winding is energised.

It is known to form the magnet structure as a stack of laminations of generally "E" shape with the winding located about the centre limb. In this case the free end of the centre limb forms one pole face having one polarity when the winding is energised and the outer limbs define pole faces which both assume the opposite polarity. The armature is of generally rectangular section.

It is also known to form the magnet structure so that the centre limb is cylindrical and the outer limbs form part of an annular member, the winding being located about the centre limb. Such a magnet structure will have associated with it a circular armature.

British specification 2201039A discloses such an arrangement as described in the preceding paragraph and also describes a number of ways of constructing the structure in order to minimise the eddy currents.

The object of the invention is to provide an electromagnetic actuator of the kind specified in a simple and convenient form.

According to the invention in an electromagnetic actuator of the kind specified the magnet structure comprises inner and outer annular members formed from wound strip material and an annular bridging member interconnecting one end of the inner annular member with the adjacent end of the outer annular member.

According to a further feature of the invention the faces of said ends of the inner and outer annular members are chamfered and the inner and outer peripheral surfaces of the bridging member are shaped in a complementary manner.

An example of an electromagnetic actuator in accordance with the invention will now be described with reference to the accompanying drawing in which:

Figure 1 is a part sectional side elevation of the actuator,

Figure 2 is a similar view showing a modification,

Figure 3 is a similar view showing a further modification and

Figure 4 is a similar view showing a further modification of the arrangement shown in Figure 2.

The actuator comprises a magnet structure 10 and an armature 11. The magnet structure includes an annular winding 12 and defines annular pole faces 13A, 14A which when the winding is energised assume opposite magnetic polarity. The armature is spaced from the pole faces and the magnetic flux passing between the pole faces and the armature causes an attraction force to be developed between the armature and the magnet structure. The pole faces are defined at one end of pole pieces 13, 14 respectively.

The pole pieces are defined by, inner and outer annular members 15, 16 and the magnet structure further includes an annular bridging member 17 which provides magnetic coupling between the ends of the annular members remote from the armature. The members 15, 16 and the bridging member are formed from magnetic material.

Each of the annular members 15, 16 is formed by winding magnetic strip material about a mandrel, the material preferably being non-grain orientated or grain orientated across its width, adjacent layers of the strip being secured in any convenient manner such for example by adhesive or cement, and the adjacent layers of the strip being electrically insulated from each other by an insulating coating applied to one or both faces of the strip. The radial width of the annular member 16 is less than that of the member 15.

The bridging member 17 comprises a stack of laminations which may be formed from non-grain orientated material and in order to enhance the magnetic coupling between the bridging member and the annular members 15, 16 the inner and outer peripheral edges of the bridging member are chamfered and the adjacent end surfaces of the inner and outer annular members 15, 16 are chamfered in a complementary manner. The chamfering may be effected by grinding or by eroding techniques or in any other convenient manner.

The resultant actuator has a magnetic circuit a substantial part of which is of a laminated nature so that the eddy currents which arise due to changes in the magnetic flux during the use of the actuator, are minimised. The actuator is intended specifically to control a valve member of a fluid control valve and a connecting member to the armature can pass through the central opening in the inner annular member if so required.

In the arrangement shown in Figure 2, the outer annular member 16 is of reduced axial length and an annular pole piece 18 is provided which is magnetically coupled to the end face of the outer member and which extends towards the inner annular member 15. The inner face of the pole piece

is cut at an angle to reduce magnetic leakage. It will also be noted that the armature 11A is of reduced diameter and therefore lighter.

Figure 3 shows a further modification in that the bridging member 17A is constructed as an annular member from solid magnetic material. The inner and outer annular members 15A, 16A have flat ends for engagement with the flat surface of the member 17A. The modification as described with reference to Figure 2 can be applied to the modified actuator as shown in Figure 3.

Figure 4 shows a further modification of the example shown in Figure 2 and in this case as in the example of Figure 1, the inner and outer annular members 15, 16 are of the same axial length. The annular pole piece 18 is provided as also is an inner annular pole piece 19 which has an integral spigot 20 which is located in the central opening in the inner member 15. The spigot 20 is hollow and in the example a portion of the inner surface is provided with a screw thread. The thread in use can be engaged by a threaded bolt which can secure the magnet structure to a support. The bolt can be hollow to allow the passage therethrough of a connecting member. The outer periphery of the pole piece 19 is shaped in a manner complementary to the inner periphery of the pole piece 18.

An alternative way of constructing a magnet structure is to form the inner and outer annular members and also the bridging member from a plurality of lengths of wire which may be of square or round section. Each length of wire during the process of constructing the magnet structure is bent to "U" shaped form.

In one method of making the magnet structure a bundle of wires is assembled about a mandrel and in a central opening in an annular die. The wires are then bent radially outwardly and then axially in one or a series of press operations following which the wires are secured, relative to each other by for example a potting compound, before removal from the die. With this arrangement the thickness of the bridging member will decrease towards its outer peripheral edge and the outer annular member will be of reduced thickness as compared with the inner annular member, the cross sectional area of the magnetic circuit remaining constant.

Claims

1. An electromagnetic actuator of the kind comprising a magnet structure (10) and an armature (11), the magnet structure including inner and outer annular members (15, 16) which form pole pieces (13, 14) defining pole faces (13A, 14A) presented to the armature (11) and which assume opposite

magnetic polarity when a winding (12) is energised, and a bridging member (17, 17A) extending between the members (15, 16) at their ends remote from the armature (11) characterised in that the inner and outer annular members (15, 16) are each formed from wound strip material.

2. An electromagnetic actuator according to Claim 1 characterised in that the bridging member (17A) is of annular form and is formed from solid material and the adjacent ends of the inner and outer annular members (15, 16) are flat and are engaged with the end surface of the bridging member.

3. An electromagnetic actuator according to Claim 1 characterised in that the bridging member (17) is formed from an annular stack of laminations the ends of said inner and outer members (15, 16) being chamfered and the inner and outer peripheral edges of the bridging member (17) being of complementary shape.

4. An electromagnetic actuator according to Claim 2 or Claim 3 characterised in that the outer annular member (16) is of reduced axial length and at its end adjacent the armature (11) carries an annular pole piece (18) extending inwardly towards the inner annular member (15).

5. An electromagnetic actuator according to Claim 4 characterised by a further pole piece (19) mounted at the end of the inner annular member (15) adjacent the armature.

6. An electromagnetic actuator according to Claim 5 characterised in that said further pole piece (19) is provided with an integral spigot (20) extending within the inner annular member (15).

7. An electromagnetic actuator comprising a magnet structure and an armature the magnet structure including inner and outer annular members interconnected at one end by a bridging member characterised in that the inner and outer annular members and the bridging member comprise a plurality of lengths of wire of square or round section each length of wire of being shaped form.

8. A method of making a magnet structure having inner and outer annular members which are connected at one end by a bridging member comprising assembling a bundle of wires about a mandrel located in an opening in a die, bending the wires outwardly and then axially so that each assumes a "U" shaped form, securing the wires relative to each other and removing the wires from the die and the mandrel.

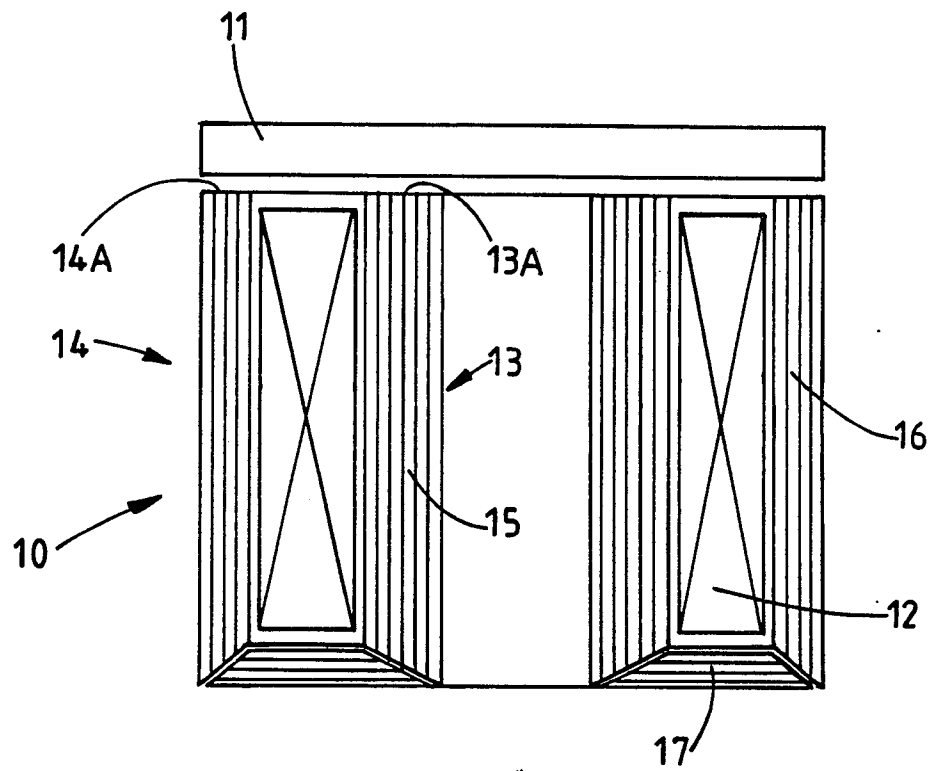


FIG. 1.

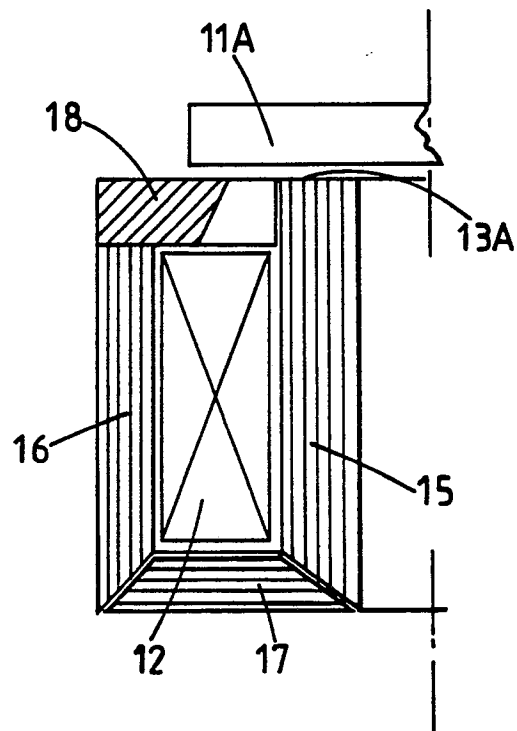


FIG. 2.

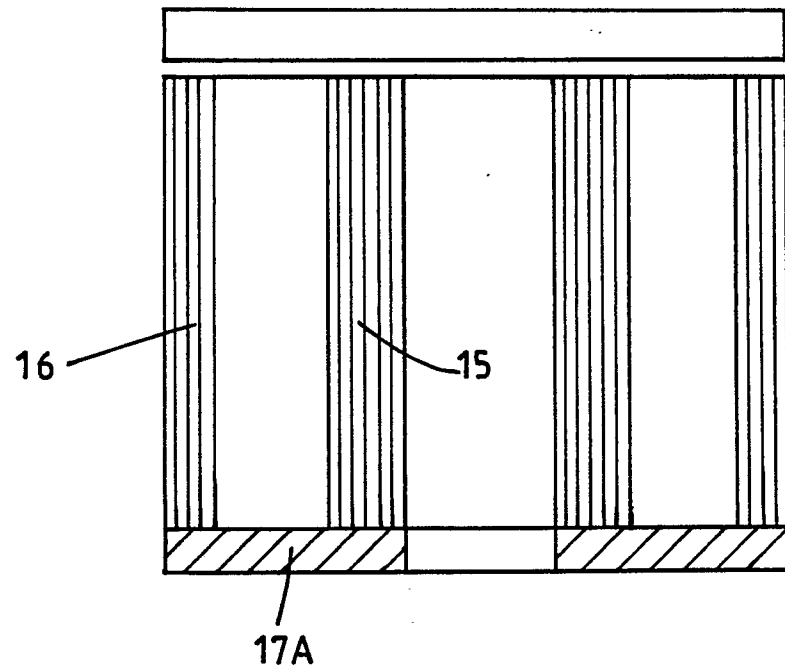


FIG.3.

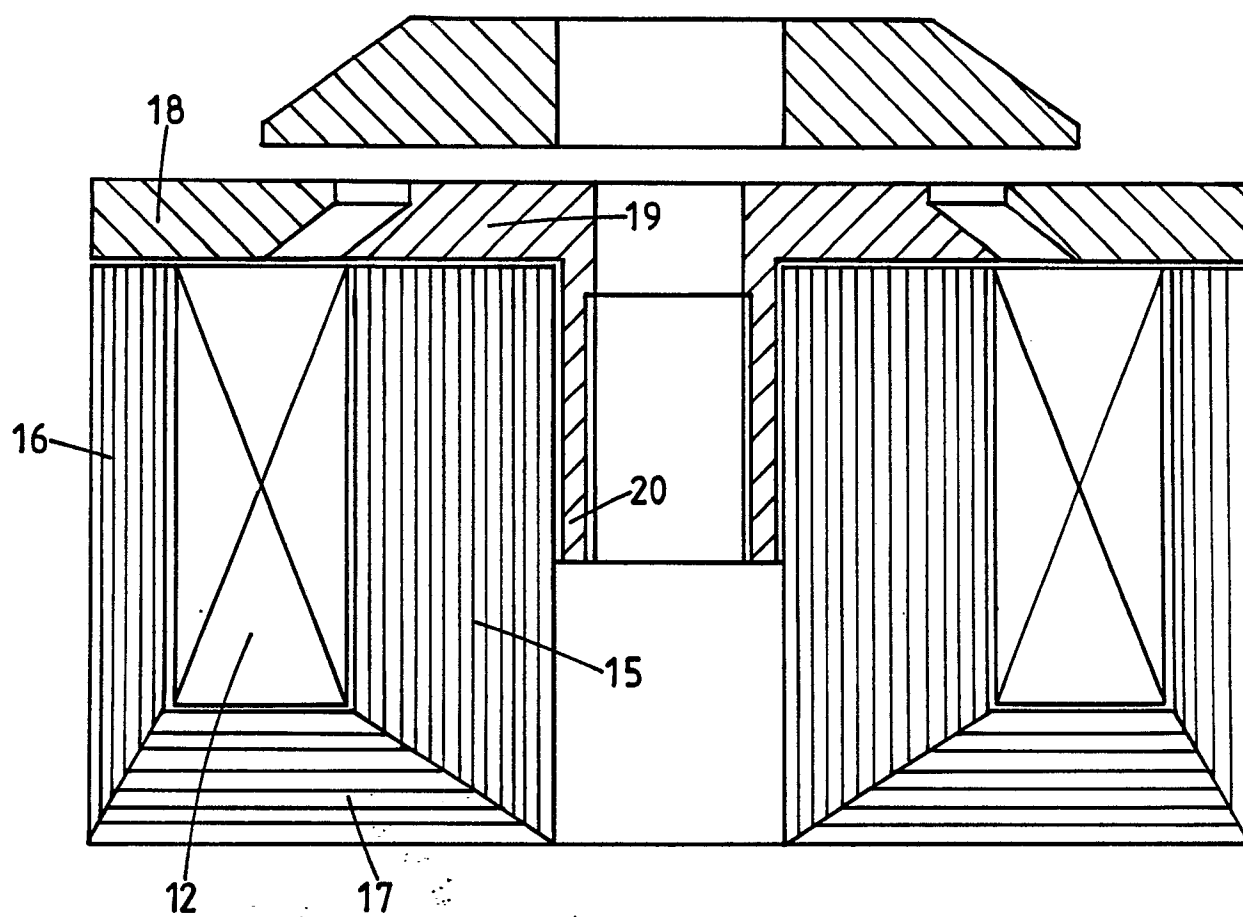


FIG. 4.



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3036247 (KOONTZ-WAGNER ELECTRIC COMPANY) * column 1, line 54 - column 3, line 21 * ---	1	H01F7/08 H01F7/16 H01F3/04 H01F3/06
X	Research Disclosure no. 274, February 1987, HAVANT GB page 58 "Partially Laminated Core Structure" * the whole document *	1	
A	---	2	
X	US-A-3304599 (TELETYPE CORPORATION) * column 2, line 14 - column 3, line 58 * ---	7, 8	
A	FR-A-1219327 (A.C.E.C.) * page 1, right-hand column, line 6 - page 2, left-hand column, line 7 * ---	1, 3	
A	GB-A-2144060 (JOSEPH LUCAS INDUSTRIES LIMITED) * page 1, lines 72 - 87 * ---	4	
A	US-A-2648124 (GEORGES DUYCK) * figure 2 * ---	5	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	FR-A-2344109 (UNGARI S., UNGARI Y.) ---		H01F
A	FR-A-1200567 (THE BRITISH THOMSON-HOUSTON COMPANY LTD.) ---		
A	GB-A-2046142 (SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE) ---		
A	DE-A-2014099 (FA. ROBERT THOMAS) -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 FEBRUARY 1990	Examiner VANHULLE R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			