Oct. 18, 1960 R. L. JAESCHKE 2,956,658

MAGNETIC COUPLINGS

Filed Feb. 19, 1958 2 Sheets-Sheet 1

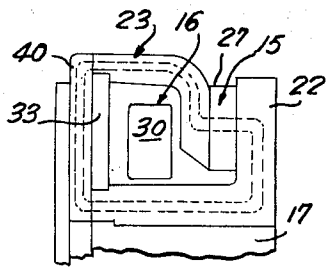


FIG. 3

FIG. 1

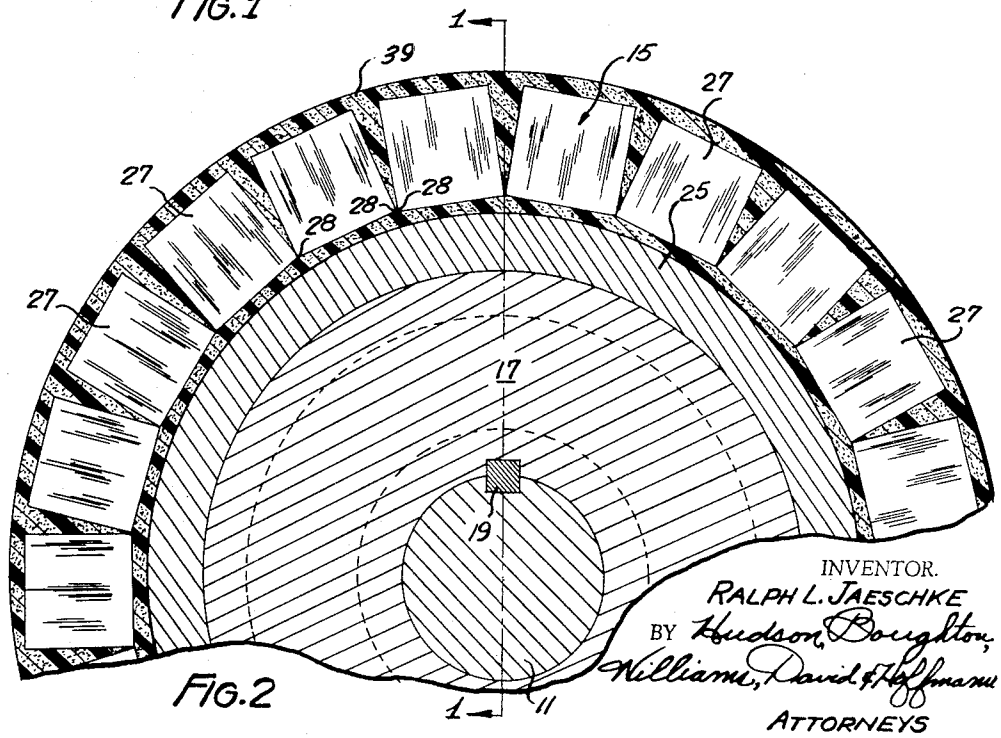


FIG. 2

INVENTOR.
RALPH L. JAESCHKE
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

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2 Sheets-Sheet 2

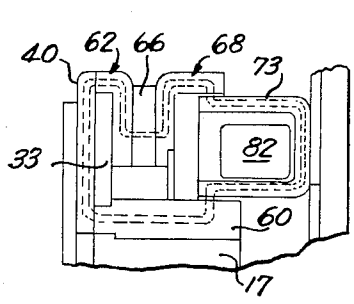


FIG. 6

FIG. 4

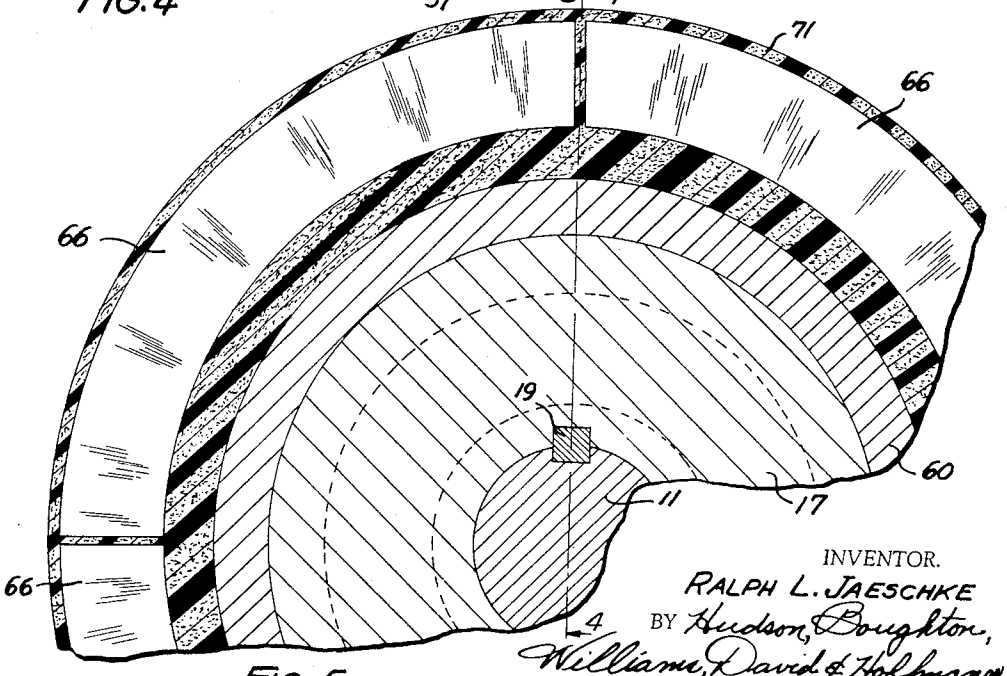


FIG. 5

INVENTOR.
RALPH L. JAESCHKE
BY Hudson, Boughton, Williams, David & Hoffmann
ATTORNEYS

United States Patent Office

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MAGNETIC COUPLINGS

Ralph L. Jaeschke, Kenosha, Wis., assignor to Eaton Manufacturing Company, Cleveland, Ohio, a corporation of Ohio

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4 Claims. (Cl. 192—84)

The present invention relates to a magnetic coupling of the torque transmitting type and, more particularly, to a magnetic coupling having dual excitation means, namely, a permanent magnet excitation means and an electromagnet excitation means, the magnetic coupling being useful in clutches and brakes as well as in various other applications known to those skilled in the art.

An object of the present invention is to provide a novel magnetic coupling having a permanent magnet excitation means and an electromagnet excitation means disposed in a series magnetic circuit with respect to the path of the flux produced by such dual excitation means.

Another object is to provide a magnetic coupling having such dual excitation means and which is disengageable by cancellation of the flux of the permanent magnet means by the flux from the electromagnet means.

Another object is to provide a magnetic coupling which is actuatable in one direction by permanent magnets located in a series magnetic circuit and is actuatable in the other direction in response to a cancelling out or bucking of the magnetic flux of the permanent magnets by the flux of a magnet coil.

Another object of the present invention is to provide an electromagnetic coil in the arrangement set forth in the preceding object where the coil connections are made in such a manner as to increase the effectiveness of the flux developed by the permanent magnets when the electromagnetic coil has been deenergized.

Another object of the present invention is to provide a magnetic coupling which is actuatable by the combined magnetic fluxes of an annular electromagnet and an annular group of permanent magnets located in a series magnetic circuit relation with the electromagnet.

Another object of the present invention is to provide a new and improved permanent magnet excited friction coupling device disengageable by energizing an electromagnetic coil arranged to buck the flux of the permanent magnets having essentially the same series path of minimum length in which the flux bucking takes place essentially along the entire series path which is free of devious bypass, minor, secondary and/or auxiliary paths, and low impedance reluctance or interrupter rings for keeper circuits.

Another object of the present invention is the provision of a magnetic coupling substantially in accordance with the preceding objects wherein the permanent magnets are carried by a rotatable pole structure and the coil of the electromagnet means is stationary, thereby obviating the necessity for using slip rings or brushes in connection with the electromagnet means.

Another object of the present invention is to provide a permanent magnet excited friction coupling device in which the magnets are of a simple configuration, need not be machined to a special curved shape or maintained within close tolerances, have a high reluctance to demagnetization, are easily replaced, and/or are capable of being magnetized in place.

Another object of the present invention is to provide

a new and improved magnetic coupling of simplified construction requiring a minimum number of parts and which is "fail-safe" due to the provision of magnets operatively independent of a power supply for purpose of engagement actuation of the coupling.

The invention further resides in certain novel features of construction, and combinations and arrangements of parts, and further objects and advantages thereof will be apparent to those skilled in the art to which it pertains from the following description of the preferred embodiments thereof described with reference to the accompanying drawing in which similar reference characters represent corresponding parts throughout the several views, and in which:

Fig. 1 is a partial axial section of one embodiment of a magnetic coupling in disengaged condition, the view being taken along a longitudinal axis of rotation thereof as indicated by section line **1—1** of Fig. 2;

Fig. 2 is a partial transverse section taken through the coupling on section line **2—2** of Fig. 1;

Fig. 3 is a diagram on a smaller scale and corresponding with a portion of Fig. 1, the view showing the coupling in engaged condition and illustrating the flux path of the magnetic circuit;

Fig. 4 is a partial axial view of a modification of the magnetic coupling in disengaged position, the view being taken along a longitudinal axis of rotation thereof as indicated by section line **4—4** of Fig. 5;

Fig. 5 is a partial transverse section taken through the coupling on section line **5—5** of Fig. 4; and

Fig. 6 is a diagram, similar to the diagram of Fig. 3, of a portion of Fig. 4, the view showing the coupling in engaged condition and illustrating the flux path of the magnetic circuit.

Before explaining in detail the preferred embodiments of the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangements of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for purpose of description and not of limitation, and it is not intended to limit the invention herein claimed beyond the requirements of the prior art.

The magnetic coupling **10** comprises, in general, a pair of axially aligned, rotatable shafts **11** and **12**, a pole structure **13** connected with the shaft **11** for rotation therewith, and an armature means **14** rotatable with the shaft **12** and axially shiftable to engaged and released positions relative to the pole structure. The coupling also comprises dual excitation means or flux producing means associated with the pole structure **13** and comprising permanent magnet means **15** and electromagnet means **16**.

Referring now to the drawings in greater detail and particularly to Fig. 1, the permanent magnet excited friction coupling device **10** comprises a driving shaft **11** and an annular carrier or wheel **17** having a peripheral shoulder **18**, the wheel **17** being keyed to the shaft **11** by means of a conventional key **19**. A coaxial annular recess **20** in a face **21** of wheel **17** reduces the weight thereof. The pole structure **13** comprises two annular magnetic polepieces **22** and **23** of angular cross section, the polepiece **22** being rigidly secured to the periphery **24** of wheel **17** in axial abutment with the shoulder **18**. The annulus **22** is comprised of an axial cylindrical portion **25** and a radial flange-like portion **26**.

As best seen in Figure 2, the permanent magnet means **15** consist of a plurality of flat permanent magnets **27** which have a high reluctance to demagnetization and form an annular group or ring about polepiece **22**. The perma-

nent magnet 27 are essentially quadrangular, and more particularly, square, with the radially inner corners 28 thereof contiguous with the respective corners 28 of the adjoining permanent magnets. Each of the magnets 27 is in surface contact with the radial face 29 of the flange-like portion 26 and spaced radially from the cylindrical portion 25 of polepiece 22 a predetermined radial distance for a reason which will become apparent hereinbelow.

The electromagnet means 16 consists of an electromagnetic coil 30 disposed over the cylindrical portion 25 of polepiece 22 and axially spaced from the permanent magnets 27. The second annular magnetic polepiece 23 has a radially extending leg 31 and a substantially axially extending leg 32, the leg 31 being in flat abutment against the exposed radial faces of the permanent magnets 27. The inner end of radially extending leg 31 is beveled at approximately 45° with the innermost end being spaced from cylindrical portion 25 of polepiece 22 the same distance as each of the magnets 27. The 45° bevel serves to reduce the possibility of and essentially prohibit any magnetic short circuit of flux across the polepieces 22 and 23. Polepiece 23 serves to partially enclose the electromagnetic coil 30. Suitable means (not shown) are provided for supplying energizing current to the coil 30.

A ring-like wear-resistant and nonmagnetic friction lining 33 is seated against two parallel and coplanar annular shoulders 34 and 36 formed in polepieces 22, 23 and has an outer engageable face coplanar with the ends of axially extending leg 32 of polepiece 23 and cylindrical portion 25 of the complementary polepiece 22. The corresponding ends of leg 32 and cylindrical portion 25, which embrace the friction lining 33 therebetween, are flush with or overhang the corresponding radial end surface 37 of wheel 17. The corresponding end 38 of shaft 11 may be flush with or terminate axially inwardly of the end surface 37.

Essentially nonmagnetic epoxy resin 39 or the like is used to bond the coil 30, lining 33, polepiece 23 and permanent magnets 27 together and hold the foregoing elements in assembly with polepiece 22 in the connected relation shown in the drawings, although any other suitable connecting medium or means could be used.

The armature means 14 comprises a flat, ring-like magnetic armature 40 operatively and coaxially disposed oppositely of the polepieces 22, 23 and lining 33. Armature 40 is connected to and carried by a disk 42 which is splined to a collar 44 and retained thereon for limited axial movement by a snap ring 46 engaged in a suitable annular groove of the collar. Collar 44 is drivingly connected to an end 48 of driven shaft 12 by means of a key 52 therebetween, the ends 38 and 48 of shafts 11 and 12, respectively, being essentially coaxial and spaced a relatively short distance from each other.

It is to be understood that one of the shafts 11 and 12 can be fixed and the other shaft rotated for use of the coupling as a brake or, alternatively, the shaft 12 can be the driving shaft and the shaft 11 the driven shaft, or vice versa, when the device is used as a torque transmitting coupling or clutch. The foregoing description is merely by way of describing a preferred embodiment and it is not intended that the invention be limited thereto.

Referring to Fig. 3, each permanent magnet 27 has suitably located magnet poles and causes magnetic lines of force to travel, preferably counterclockwise, about coil 30 through polepieces 22, 23 and armature 40. However, it is to be understood that the lines of force can also be caused to travel clockwise about the coil 30 in the aforedescribed path of travel. The coil 30 is so arranged with respect to the pole pieces 22, 23 and the armature 40, that it may be energized by connection with its source of energizing current in a manner to generate a flux in a direction opposite to that generated by the permanent magnets 27 so that the armature 40 will be released for disengaging the coupling. Although the coupling is engageable by the flux of the permanent magnets 27 alone, by changing the connections of the coil 30 with its source of energizing current, the flux generated by the coil can be made to flow in the same direction as that generated by the permanent magnets, thereby increasing the effective flux tending to engage the coupling. Moreover, since only one path of travel is provided for the fluxes of both the electromagnet and the permanent magnet means, a considerable savings is realized in weight, materials and cost of manufacture not possible in magnetic couplings which require bypass paths, minor, secondary and/or auxiliary paths for keeper circuits with the accompanying necessity for low impedance reluctance or interrupter rings in the keeper circuits.

In addition, due to the placement of the magnets 27 in flat abutment with the leg 31 of polepiece 23 and flange-like portion 26 of polepiece 22, the magnets 27 need only be substantially flat and can have any desirable shape in a plane normal to the rotation axis, although the magnets are shown to be preferably square in Fig. 2. This is advantageous, since it obviates the costly necessity of machining the magnets which are usually made of a material that is difficult to machine.

Also, the advantage of being able to assemble the coupling without having to magnetize the magnets in assembly cannot be overlooked, since many magnetic couplings require specially machined and fitted magnets which must be assembled with the coupling and then magnetized by applying electrodes thereto across the polepieces. Moreover, the provision of a single series circuit for conducting the flux of the permanent magnets and the electromagnetic coil not only increases the efficiency and value of the invention but permits the flux of the magnets to be bucked by the flux of the coil along a considerably longer path than permissible in other constructions.

A second embodiment of the present invention, shown in Figures 4 to 6, comprises a magnetic coupling which is ordinarily engaged, but the flux of the permanent magnets therein is capable of being substantially cancelled by the energization of a relatively stationary electromagnetic coil so that the flux generated by the same essentially bucks and cancels out the magnetic lines of force or flux of the permanent magnets for disengaging the magnetic coupling.

Essentially, the second embodiment comprises a substantially cylindrical sleeve 60 of magnetic material for forming a magnetic polepiece mounted upon the wheel 17 in a manner described in the first embodiment, which includes a shoulder portion 34 for preventing the cylindrical sleeve 60 mounted on wheel 17 from being lost off the end 38 of shaft 11. Friction lining 33 is seated against an annular radial shoulder 61 in the outer periphery of cylindrical portion 60. A magnetic polepiece 62, comprised of an annular, radially extending leg portion 63 and an axially extending cylindrical leg portion 64 disposed normal to each other, substantially encloses the outer periphery of the friction lining 33. The radial end face of lining 33 is substantially flush with but slightly overhangs the terminal end of cylindrical portion 64 of polepiece 62 and the corresponding end of cylindrical polepiece 60 for being spanned and engaged by the magnetic armature 40 which is secured to shaft 12 in a manner hereinbefore described.

In lieu of the large number of quadrangular permanent magnets 27 shown in the first embodiment of the present invention, four substantially coplanar arcuate permanent magnets 66 are arranged in a circle around the periphery of the cylindrical sleeve 60 and spaced therefrom. Each of the magnets have an arcuate length of about 90° with the adjacent ends of each of the arcuate magnets spaced a small distance from each other. One of the corresponding radial sides of each of the four magnets is flush with one of the sides of the radially extending leg portion of the polepiece 62 away from the lining 33.

Another annular magnetic polepiece 68, having a con-

figuration somewhat similar to the magnetic polepiece **62** is comprised of a radially extending leg portion **69** and an axially extending cylindrical leg portion **70**, each of the polepieces **62** and **68** being substantially coaxial with the radial leg portions **63** and **69** being substantially parallel, and with the cylindrical leg portions **64** and **70** lying in axial alignment. Leg portion **70** is slightly longer than leg portion **64** for a reason to be explained hereinafter. The radially extending leg portion **69** has one face flush with corresponding radial faces of the permanent magnets **66**. The two polepieces **62** and **68**, in combination with the permanent magnets **66**, are held in assembly with cylindrical sleeve **60** and the lining **33** by means of appropriate resin **71** similar to that used in the first embodiment shown in Figures 1 to 3 and, if desired, additional nonmagnetic fastening means may be used. The radial leg **69** of the polepiece **68** is counterbored for providing a coaxial annular recess **72** to aid in preventing a short circuit between the polepiece **68** and the radial sleeve **60**. Each of the polepieces **62** and **68** and the cylindrical sleeve **60** are made of a magnetic material which is preferably a ferromagnetic material.

A magnetic housing or annulus **73** of U-shaped, or channel-shaped, cross-section opening in an axial direction towards the friction lining **33** is rigidly connected to a flat metal ring **75**, which is secured to a relatively stationary member **77** by means of cap screws **79**, only one being shown, or by other appropriate fastening means. The relatively stationary member **77** is formed with a substantially cylindrical opening **80** coaxial with the axis of the rotatable shafts **11** and **12**.

An electromagnetic coil **82** is disposed within the channel-shaped housing **73** and permanently positioned therein by means of a resin **83** similar to the epoxy resin used for securing the permanent magnets **27** and **66** in place. The channel-shaped annulus is sufficiently large to accommodate the entire annular magnetic coil **82**, but has a radial dimension sufficiently small to be interposed between the radially extending leg portion **70** of polepiece **68** and over a rear portion of the cylindrical sleeve **60** so that the wheel **17** carrying the permanent magnets **66** is free to turn relative to stationary coil **82** and its housing **73**. The terminal ends of the axially extending sides of the channel-shaped housing **73** are spaced axially from the radially extending portion **69** of the magnetic polepiece **68** a sufficient distance to prevent a magnetic short circuit therebetween. However, it is desirable that the axially extending sides of the channel-shaped housing **73** be radially spaced from the cylindrical leg portion **70** of polepiece **68** and the cylindrical sleeve **60** by a very small distance so that air gaps **84** and **85** formed between the polepiece **68** and sleeve **60**, respectively, are maintained at a minimum for permitting the flux generated by the magnets **66** and the magnetic coil **82** to travel across the air gaps.

For example, referring to Fig. 6, should the poles of the permanent magnets be arranged in such a manner as to cause the flux to flow counterclockwise about the magnetic path, then the coil **82** is connected in such a manner as to generate, when energized, a flux which will buck or travel in a direction counter to the flux of the permanent magnets **66**, or clockwise about the toroidal flux path. As illustrated in Fig. 6, flux from the permanent magnets **66** will travel, for example, in a counterclockwise direction through polepiece **62**, armature **40**, magnetic sleeve **60**, across air gap **85**, through channel-shaped annulus **73**, across the air gap **84** to polepiece **68** and back to the permanent magnets **66**. As a result, the armature **40**, which spans polepieces **60** and **62**, is attracted to the polepieces **60** and **62** for engagement therewith.

The flux generated by the electromagnetic coil **82**, upon energization thereof, opposes the flux of the permanent magnets for bucking and essentially canceling out the flux of the latter for releasing armature **40** from polepieces **60** and **62** and disengaging the magnetic coupling.

The permanent magnets **66** preferably have a high permanence characteristic, hence the bucking or cancelling action of the coil **82** reduces the effective flux to permit the disengagement of the armature **40**, without demagnetizing the permanent magnets.

One of the advantages of the second embodiment of the present invention is that the number of permanent magnets is considerably reduced for simplifying the assembly of the magnetic coupling since the large number of small magnets is eliminated.

Another advantage resides in the elimination of the necessity for slip rings or brushes for conducting electrical energy to a coil mounted on a rotating shaft.

While I have shown and described two specific embodiments in accordance with my invention, it is understood that the same susceptible of many changes and modifications, as known to a person skilled in the art, and I intend to cover all such changes and modifications as defined in the appended claims.

Having described my invention, what I claim is:

1. A magnetic clutch comprising an annular armature and an annular pole structure, shaft means supporting said armature and pole structure for relative rotation about a common axis, said armature being shiftable along said shaft means toward and away from said pole structure for frictional engagement therewith and release therefrom, said pole structure including first and second pole members, said first pole member including an outer cylindrical portion extending axially toward said armature and having an inwardly extending leg portion, said second pole member including an inner cylindrical portion coaxial with said outer cylindrical portion and having an outwardly extending leg portion, said inwardly extending leg portion being disposed between said outwardly extending leg portion and said armature and with its innermost end spaced from said inner cylindrical portion, a plurality of permanent magnets disposed between said inwardly extending leg portion and said outwardly extending leg portion and forming part of a series magnetic flux path including said armature and said pole members, and coil means disposed between said pole members and within said series magnetic flux path and adapted to be electrically energized to produce a flux in said series magnetic flux path, the flux produced by said permanent magnets in said series magnetic flux path being effective to cause said frictional engagement of said armature and the flux produced by said coil means being in opposition to the flux of said permanent magnets and effective to cause said release of said armature.

2. A magnetic clutch as defined in claim 1 and wherein said coil means and pole members and said permanent magnets are all bonded together by an epoxy resin.

3. A magnetic clutch as defined in claim 1 and wherein said innermost end of said inwardly extending leg portion is beveled at an angle of 45 degrees with respect to said inner cylindrical portion to prevent short circuiting of said series magnetic flux path.

4. A magnetic clutch comprising a driving shaft and an axially aligned driven shaft, an annular armature secured for rotation with one of said shafts and adapted to be shifted axially therealong, an annular structure secured for rotation with the other of said shafts and adapted to be frictionally engaged by said armature, said structure including spaced concentric first and second polepieces having axially extending portions and inwardly extending leg portions, the axially extending portion of said first polepiece extending toward said armature and the axially extending portion of said second polepiece extending away from said armature, a plurality of permanent magnets disposed between said leg portions, a cylindrical sleeve concentric with said polepieces and spaced inwardly therefrom, a stationary annular channel shaped member disposed between said sleeve and said axially extending portion of said second polepiece, said channel shaped member forming a part of a series mag-

netic flux circuit with said magnets and polepieces and with said sleeve and armature, and a stationary electromagnetic coil disposed within said channel shaped member and adapted to be energized to generate a flux in said series magnetic flux circuit, said permanent magnets adapted to generate a flux in said circuit for shifting said armature into said engagement with said srtucture and said coil being adapted to create a flux in opposition to the flux of said permanent magnets for releasing said armature from said engagement, said polepieces and magnets and said sleeve all being bonded together by an epoxy resin, said stationary coil and channel shaped member being bonded together by an epoxy resin, and said inwardly extending leg portion of said second polepiece having an annular coaxial recess for preventing a

short circuit between said second polepiece and said cylindrical sleeve.

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